THE DISTRIBUTION OF SNAILS FAMILY AMPULLARIIDAE IN WETLANDS AT SARABURI PROVINCE

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ABSTRACT

The objective of this research was to study the distribution of snails in the family Ampullariidae in designated districts of Saraburi Province. All samplings were conducted at thirteen wetlands (ten rice fields, two canals, and one pond) in nine out of thirteen districts within Saraburi Province. Physical factors and geographical position were recorded at each sampling area. The snails were measured for shell width and length and were identified according to Brandt, 1974 and Burch and Keawjam, 1991.

This study found that there was no correlation between physical factors and richness value. But there were correlations between type of wetland and richness value. All snails were classified under the genus *Pomacea*. None of snails in genus *Pila* were found at any sampling site except a very old dead shell of *Pila ampullacea*. There were a total of three species in most study areas. *Pomacea canaliculata* was the most common *Pomacea* apple snail of this study because of its abundance in every study area. *Pomacea* sp. was the dominant species in canals, while *Pomacea canaliculata* was the dominate species in rice fields. The largest *Pomacea* shell size (6.9 cm. in width and 8.9 cm. in length) was a specimen of *Pomacea* sp. living in a canal and the smallest (1.5 cm. in width and 1.7 cm. in length) was a specimen of *P. insularus* found in a rice field. There was no significant difference between the total numbers of snail individuals and egg batches found in each site. The similarity index of Ampullariidae species between rice fields and canals was 100%, and 85.71% between canals and the pond, and also between rice fields and the pond. The site richness values of each wetland type were not significantly different between one another.

Pomacea sp. found in all types of wetlands were uniformly distributed and this could be used as foundational information for further study in terms of rice field pest control and food sources for bird migration.

KEY WORDS: DISTRIBUTION/ AMPULLARIDAE/ WETLANDS/ SARABURI PROVINCE

144 pages

การแพร่กระจายตัวของหอยวงศ์ Ampullariidae ในพื้นที่ชุ่มน้ำ จังหวัดสระบุรี

THE DISTRIBUTION OF SNAILS FAMILY AMPULLARIIDAE IN WETLANDS AT SARABURI PROVINCE

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บทคัดย่อ

วัตถุประสงค์ของการทำวิจัยนี้เพื่อศึกษาผลการกระจายตัวของหอยวงศ์ Ampullariidae ในพื้นที่ชุ่มน้ำและแหล่งน้ำ จังหวัดสระบุรี โดยทำการเก็บตัวอย่างทั้งหมด 13 แห่ง 9 อำเภอ จากทั้งหมด 13 อำเภอในจังหวัดสระบุรี ซึ่งคัดเลือกเฉพาะพื้นที่มีการประกอบอาชีพทำนาข้าวเป็นหลัก จุดเก็บตัวอย่างทั้งหมดประกอบด้วย นาข้าว 10 แห่ง ลำคลอง 2 แห่ง และสระน้ำ 1 แห่ง ทำการเก็บข้อมูลปัจจัยทางกายภาพของพื้นที่และข้อมูลพิกัดจุดตามระบบ GIS วัดขนาดเปลือกและจำแนกชนิดของตัวอย่างหอยตระกูลAmpullariidae ที่พบในพื้นที่ศึกษาตามระบบการจำแนกทีปรับปรุงโดย Brandt, 1974 และ Burch and Keawjam, 1991

การศึกษานี้พบว่า ค่า richness value ไม่มีความสัมพันธ์กับค่าปัจจัยทางกายภาพ แต่มีความสัมพันธ์กับประเภทของพื้นที่ชุ่มน้ำ ไม่พบตัวอย่างหอยที่มีชีวิตในกลุ่ม *Pila* และพบเพียงเปลือกเก่าของ *Pila ampullacea* เท่านั้น หอยวงศ์ Ampullariidae ที่พบอยู่ในกลุ่ม *Pomacea* ทั้งหมด 3 ชนิดคือ *P. canaliculata* *Pomacea* sp. และ *P. insularus* พบ *P. canaliculata* เป็นหลักในทุกพื้นที่และมีจำนวนมากที่สุดในนาข้าว *Pomacea* sp. *เป็นชนิดที่มีมากที่สุดในลำคลอง*และมีขนาดใหญ่สุด หอยที่มีขนาดเล็กสุดที่พบคือ *P. insularus* โดยพบในนาข้าว ไม่มีความแตกต่างกันในจำนวนหอยวงศ์ Ampullariidae และแพไข่ที่พบในแต่ละแห่ง ดัชนีความเหมือนของชนิดที่พบระหว่างนาข้าวและคลองเป็น 100% ระหว่างสระและคลอง และนาข้าวมีค่าเท่ากันคือ 85.71%

การศึกษานี้พบว่าหอย *Pomacea* sp. พบทั่วไปในทุกพื้นที่ที่ศึกษาและมีการกระจายตัวแบบยูนิฟอร์ม ความรู้ดังกล่าวอาจนำไปสู่พื้นฐานความรู้ในการศึกษาการควบคุมการระบาดของหอยในนาข้าวและการจำกัดแหล่งอาหารของนกที่อพยพในอนาคตได้

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LIST OF ABBREVIATIONS

GIS	=	Global Information System
IRD	=	Institut de recherche pour le développement (Development Research French Institute)

CHAPTER I
INTRODUCTION

During the post several decades, the snail in genus *Pomacea* or apple snails have invaded South-East Asia such as Thailand (1989), Cambodia (1995), Hong Kong (1991), Southern China (1985), Korea (probably 1986), Malaysia (Sarawak and Peninsular Malaysia, 1987), Laos (1992), Vietnam (1988 or 1989), Singapore (1993), Guam (1992) Taiwan, Japan and the Philippines (1982) (Cowie H. R.,1997;). It was initially introduced from Argentina to Taiwan (Mochida. O., 1991; Cowie H. R., 1997) as a food resource and as a potential food export item (Teo Su Sin, 2001). However, the market was not economically viable and the snails escaped and were released to natural freshwater systems (Naylor, 1996, Teo Su Sin, 2006). The rapid proliferation of the golden apple snail can be attributed to their high reproductive capacity, fast growth and the ability to aestivate underground for more than 6 months during adverse conditions (Anon, 1998). It gradually become a serious pest of rice field in Asian countries (Yusa, 1999; Wada, 1999; Naylor, 1996; Halwart, 1994; Jambari et al., 1993; Rejesus et al., 1990; Hirai, 1988). In Philippines, golden apple snail has been considered as a major rice field pest causing a huge lost in economic. In addition, it was introduced to Hawaii in 1989 and became a major taro pest (ISSG, 2010).

Many countries have been long concerned on the invasion of *Pomacea* in both ecological and economic perspectives. The invasion of golden apple snail render to destruction of native aquatic plants and leading to serious competition problem of native species and habitat change (Horn K. *et al.*, 2008; Woods S. T., 2006; Henderson *et al.*, 2006; Courchamp *et al.*, 2003; Bruton, 1995; ISSG, 2010). *Pomacea* snails have been implicated in the decline of native species apple snail as *Pila* in south-east Asia. In the Philippines, there were reports on the decrease of the *Pila* due to the pesticide application that was aimed to against *Pomacea.* In Thailand, the native ampullariidae snail such *Pila* has been in rare. Furthermore, *Pomacea* has high potential to spread worldwide and affect the rice fields in India, USA and Australia.

Pomacea snail was originally introduced from Japan and the Philippines to Thailand as an aquarium decoration and new food cultivation. It was first found in natural wetlands in 1987. Because of the suitablity of climate and massive food sources such as rice field, *Pomacea* snail rapidly populated and invaded rice fields through 60 Province of Thailand in 2000, according to the report no. Kor. Sor. 1025/0627 Department of Agricultural Extension. However, the flooding disaster in 1990 and 1995 were excellent natural factor supporting apple snail distribution in Thailand.

Saraburi is one of the important paddy field areas which located in the central region of Thailand. It is one of famous areas in rice cultivation. The most famous quality rice race from Saraburi “Sao Hai” is named after the producing district as a geographical identity which represents a livelihood of Saraburi habitants. According to the Department of Agricultural Extension statistic in 2007, the total cultivating of Saraburi province in-season rice field (as “Na Pee” called in Thai) was 378,077 rai and the average product rate was 538 kg. / rai, as well as the total cultivating area for off-season rice field (as “Na Prang” called in Thai) was 177,278 rai and the average product rate was 661 kg. / rai. Saraburi was ranked in 23 of the provinces which provided the highest rice producing rate in 2007. In addition, the Chaipattana foundation established demonstration paddy fields at Nhong Khae District, Saraburi Province.

Utilizing GIS (Geographic Information System) which is a geographical computing information system which indicates and displays correlation between data and coordinating position such as where is the position on the earth surface or coordinate system of a rice field. The spatial data are presented in graphic and map relating to attribute data or database. The correlations between several spatial data are analyzed and interpreted by GIS in order to display the change of data related at a period of time, for example: epidemic dispersion, migration, invasion and land usage.

These studies aim to report the current situation of snail species in Family: Ampullariidae distributed in wetlands, Saraburi Province. The mapping data of this family snail population in the rice field and other wetlands in Saraburi Province, Thailand was also elaborated.

CHAPTER II
OBJECTIVES

The objectives of this study were:

1. to study the distribution of the ampullariids in various wetland types at Saraburi Province;

2. to compare the species distribution of the ampullariids in various wetlands types at Saraburi Province;

3. to report on the current situation of introduced and native species in study areas; and

4. to present the data collection and analysis by using Geographical Information System (GIS).

CHAPTER III
LITERATURE REVIEW

3.1 Snail species

3.1.1 *Pila polita* (Deshayes, 1830)

Pila polita (Figure 3-1), common name African apple snail, is classified as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus : *Pila*
Speices: *Pila polita* (Deshayes, 1830)

Shell: There are two forms exist: a large form (80-95 mm high, 70-80 mm wide) with a short spire and a smaller form (60-70 mm high, 45-55 mm wide) with a high spire. The shell opening is oval and the umbilicus is narrow and almost closed. The lip is thickened and the surface of the shell is smooth. The color of the shell varies from brown to bright olive green and sometimes with faint spiral bands.

Body: The color of the body varies from yellow, brown to nearly black, with yellow spots on the siphon. At rest condition, the tentacles are curled under the shell.

Operculum: The operculum is two times higher than wide and calcified.

Eggs: The calcareous, white eggs are deposited above the waterline.

Food: Various water pants.

Behavior: It is often found at stagnant water (swamps, flood-planes).

Habitat and Distribution: Asia: Thailand, Cambodia, India, South China.

3.1.2 *Pila ampullacea* (Linne)

Pila ampullacea (Figure 3-2), common name Asiatic apple snails is classified as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus : *Pila*
Speices: *Pila ampullacea* (Linne)

Shell: The shell of Asiatic apple snails varies from 90-100 mm high, 85-90 mm wide. They have a globose shell with an oval shell aperture. The spire is rather short and the umbilicus narrow to nearly closed. The surface of the shell is smooth. The color varies from bright green to orange-brown with reddish spiral bands. The internal part of the shell is yellowish with a tinge of purple and marked with strong spiral bands, lighter at the lip.

Body: The color of the body is grey-brown.

Operculum: The operculum is two times higher than wide and calcified in older snails.

Eggs: The calcareous, white eggs are deposited above the water line on banks and mudflats in shallow depressions.

Food: All kind of aquatic vegetation, algae.

Behavior: *Pila ampullacea* aestivates during the dry season. The snails bury themselves deep into the mud and can be found to depth of 1 m.

Habitat and Distribution: This apple snail species is abundant throughout South Asia such as Philippines, Singapore, Borneo, Sumatra, and etc.

3.1.3 *Pila pesmei* (Morelet, 1889)

Pila pesmei (Figure 3-1), is a very common mollusk species found in central and northern Thailand. It is rare or absent from the south. Its classification as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus : *Pila*
Speices: *Pila pesmei* (Morelet, 1889)

Shell: *Pila pesmei* is one of the smaller snails from this genus (29-33 mm high, 25-31 mm wide). The shell is globose and has an oval shell opening (aperture). The umbilicus is narrow and almost closed. The shell surface is smooth with a polished appearance. The colour varies from pale olive green to brown sometimes with faint spiral bands. The interior of the shell is yellowish with a tinge of purple and marked with dark purple spiral bands.

Operculum: 2 times higher than wide and calcified.

Eggs: The calcareous, white eggs are deposited above the waterline on the mud.

Food: Various water plants.

Behavior: *Pila pesmei* aestivates during the dry season. The snails bury themselves deep into the mud and can be found to depts of 1 m.

Habitat and Distribution: Asia: Cambodia, India.

3.1.4 *Pomacea canaliculata,* (Lamarck, 1819)

Pomacea canaliculata,(Figure 3-4) common name Golden apple snail or South American apple snail or Cherry snail (in Thailand) is a common mollusk species found in rice filed. It can be distinguished in two grops, which are yellow-brown shell and green-black-strip shell. Its classification as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus : *Pomacea* (Perry, 1811)
Speices: *Pomacea canaliculata*, (Lamarck, 1819)

Shell: The shell is globose form and heavy with 5 to 6 whorls. The aperture is large and oval to round. Male's aperture is rounder than one of female. The umbilicus is large and deep. The size of apple snail is various from 40 – 60 mm wide and 45-75 high. The color of the shell varies yellow and green to brown and with or without dark spiral stripe.

Body: The color of the body varies from yellow, brown to nearly black, with yellow spots on the siphon. At rest condition, the tentacles are curled under the shell.

Operculum: It is moderately tick and concentric with the nucleus near centre of the shell. It is two times higher than wide. The color varies from light in young snail to dark brown.

Reproduction: Golden apple snail becomes mature and fertile within 2-3 months. Sex are separated and there is no mating season. Within 1-2 days after mating, female golden apple snail lays a cluster of egg on substances above waterlines. The new egg clusters can be found in every few weeks.

Eggs: The calcareous, high carotenoid content pinkish eggs are loosely attached to each other on a substance above waterline. Egg size varies from 2.20 – 3.50 mm. and the cluster is various from 800 – 1,000 eggs or 2-3 inches long in average. These eggs will hatch within 7-12 days after lying.

Food: Golden apple snail is herbivore which able to eat various kinds of soft-texture aquatic plant such as morning glory, algae, water mimosa, duckweed, young rice tree

and debris. It frequently found golden apple snail eating 10-day-old rice tree. A golden apple snail can finish a whole rice tree within 1-2 minutes.

Behavior: The golden apple snail is an amphibious animal; submerged during the day, hidden in the vegetation near the border and the surface. It is more active during the night.

Habitat and Distribution: Apple snails inhabit a wide range of swamp, ditches and ponds and lake. It is widely distributed in lentic habitats throughout South America.

Longevity: Its longevity is up to 4 year.

Nutrient and advantage: The snail tissue is rich with protein contain 34-53 percentage and only lipid 1.66 percentage. It is can well used as a food for several animals such as duck, chicken and pig. Moreover, its shell is useful for soil pH adjustment. The whole including shell can be produced as a good soil fertilizer.

3.1.5 *Pomacea insularus* (Orbigny, 1839)

Pomacea insularus (Figure 3-5) is in apple snail or South American apple snail group. Its classification as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus: *Pomacea* (Perry, 1811)
Speices: *Pomacea insularus* (Orbigny, 1839)

Shell: The shell of this apple snail species is globose and relatively thick (especially in older snails) with a low spire. The 4 to 5 whorls are separated by a slightly indented suture. The shell opening or aperture is large and oval to round, sometimes slightly reflected. The umbilicus is large and deep. The size of this shell varies from 25 to 40 mm wide and 30 to 47 mm high depending on the conditions. The shell is yellow-brown to yellow-live in colour with a dark banding pattern.

Body: The body has a grey-brownish colour with dark pigment spots.

Operculum: The operculum is moderately thick and corneous. The structure is concentric with the nucleus near the centre of the shell. The operculum can be retracted in the aperture (shell opening).

Eggs: Pink eggs, deposited up to 1 m. above the water level.

Food: Eats almost all types of vegetation.

Habitat and Distribution: *Pomacea insularus* inhabits an area from the Islands of Parana, La Plata to Bolivia. And recently, *Pomacea insularus* has spread to Thailand.

3.1.6 *Pomacea* sp.

Pomacea sp.(Figure 3-6) is classified as follows:

Phylum: Mollusca
Class: Gastropoda
Subclass: Orthogastropoda
Order: Architaenioglossa
Family: Ampullariidae
Genus: *Pomacea* (Perry, 1811)
Speices: *Pomacea* sp.

Shell: The shell is large and ovate-conical or subglobose in shape with moderate high spire. Its shell is thin or moderately thick and wide. The size of fully-grown shells is 35-50 mm. wide and 45-60 mm high. There are 5 ¼ whorles. The shell is yellow-olive or brown-olive in colour and generally unbanded. Some are banded. The aperture is oval.

Body: Prostate gland cream colored; seminal vesicle small, round at proximal tip of prostate gland.

Operculum: The operculum is thin, with yellow brown nacre and distinct spiral lines in the inner surface.

Eggs: Pink eggs, deposited above the water level.

Food: Eats almost all types of vegetation.

Figure 3-1. Shell structure of *Pila polita* (Deshayes, 1830).

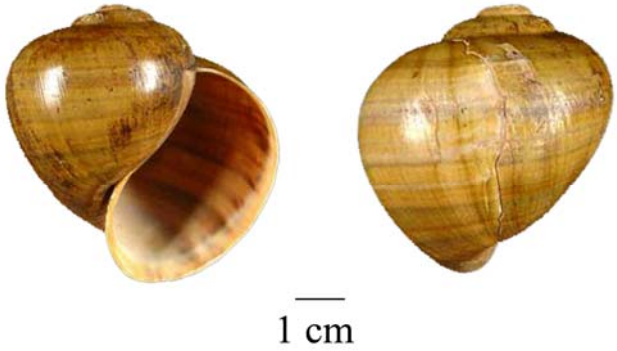


Figure 3-2. Shell structure of *Pila ampullaceal* (Linne).

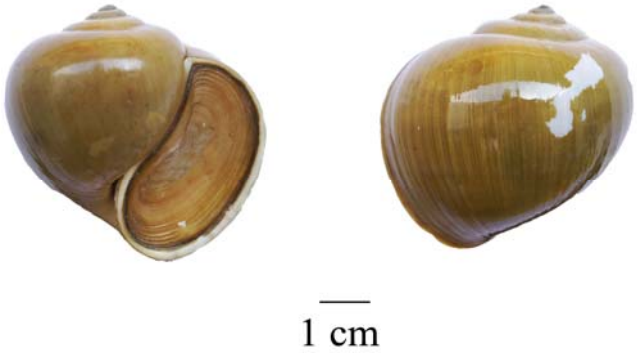


Figure 3-3. Shell structure of *Pila pesmei.*

Figure 3-4. Shell structure of *Pomacea canaliculata* (Lamarck, 1819).

Figure 3-5. Shell structure of *Pomacea insularus (*Orbigny,1839).

Figure 3-6. Shell structure of *Pomacea* sp.

3.2 Rice field in centre of Thailand

From year 1950 to 2003, there are only five agricultural censuses conducted by National Statistical Office. In year 2003, the total number of agriculture area of central region is 21,592,365 Rai (1 rai = 1,600 m^2), including 8,541,412 Rai of planted rice areas. At the central region of Thailand, there are many rice fields grown up in several provinces such as Prathum Thani, Nakhorn Sri Ayutthaya, Ang-Thong, Singburi, Uthai Thani, Nakornsawan, Pichit, Pitsanulok, Suphanburi and Prachinburi Provinces (Figure 3-9). However, the five highest amount of rice product by Provinces are Suphanburi, Chai Nat, Ayutthaya, Lopburi and Singburi Provinces (Figure 3-10). The level of water during September to November is around 1-3 metres. The rice field in these provinces called as “Kao Na Maung” which will be harvested around December to January (Figure 3-7).

The rice field in other provinces such as Nonthaburi, Nakhonprathom, Petchburi, Chainat, and Chachengsao called as “Kao Na Suan”. Its harvest season is from October to December (Figure 3-8) (Thai youth Encyclopedia year, 2007).

Figure 3-7. The rice harvest in Suphanburi Province (Credited to Mr Pornchai Thongsaksri).

Figure 3-8. The rice field in the Sao Hai district, Saraburi Province.

3.2.1 Rice field in Saraburi Province

Saraburi is a province at the center of Thailand, 107 km. far from Bangkok Metropolis in the North-East direction. It is surrounded by several provinces such as Lopburi, Nakhon Ratchasima, Nakhon Nayok, Pathum Tani and Ayuthaya Province. Saraburi Province contains of 3,576.486 square km. which accounts for 0.7 % of all Thailand area (http://www.saraburi.go.th).

Saraburi lands are categorized into three types of geography; flat areas, hill areas and highlands. Typically, Saraburi soil is mixture of clay and fine sand which is suitable for rice plantation because of poor quality in water draining. However, Saraburi has an acid soil problem in some areas due to the substance in soils. Some lands of Saraburi are clay area which suitable for fruit orchards. In addition, there is the stone at underground level at highland area which well support in raw material of cement and gypsum industries (http://www.saraburi.go.th).

According to Koppen's Climate Classification, Saraburi is classified as Tropical Savanna Climate or Tropical Wet and Dry Climate (AW) that there are a lot of rains during May to October by the influence of South-West monsoon period (Saraburi Province. 2009 : website). Saraburi ambient temperature is quite high because it is located in the far mainland. The temperature annual average is 28 - 29 °C. The average highest temperature is 33-34 °C and the lowest average temperature is 23 - 24 °C. The highest temperature is in April, and The lowest temperature is in January.

Rains at Saraburi Province are influenced by the South-West monsoon and low air pressure flow which covers the upper part of Thailand throughout the rainy season. The average number of raining is 70 - 90 days per year. Moreover, there are depression storms passing Saraburi or neighborhoods which render more rain water quantity (http://www.saraburi.go.th).

Saraburi Province is composed of 13 administrative Districts (Figure 3-9). There is 511,342 Rais of rice plantation areas in Saraburi Province. According to national statistical office 2003 (Table 3-1, Figure 3-10), the rice production of the province was 307,856,692 Tans in year 2003.

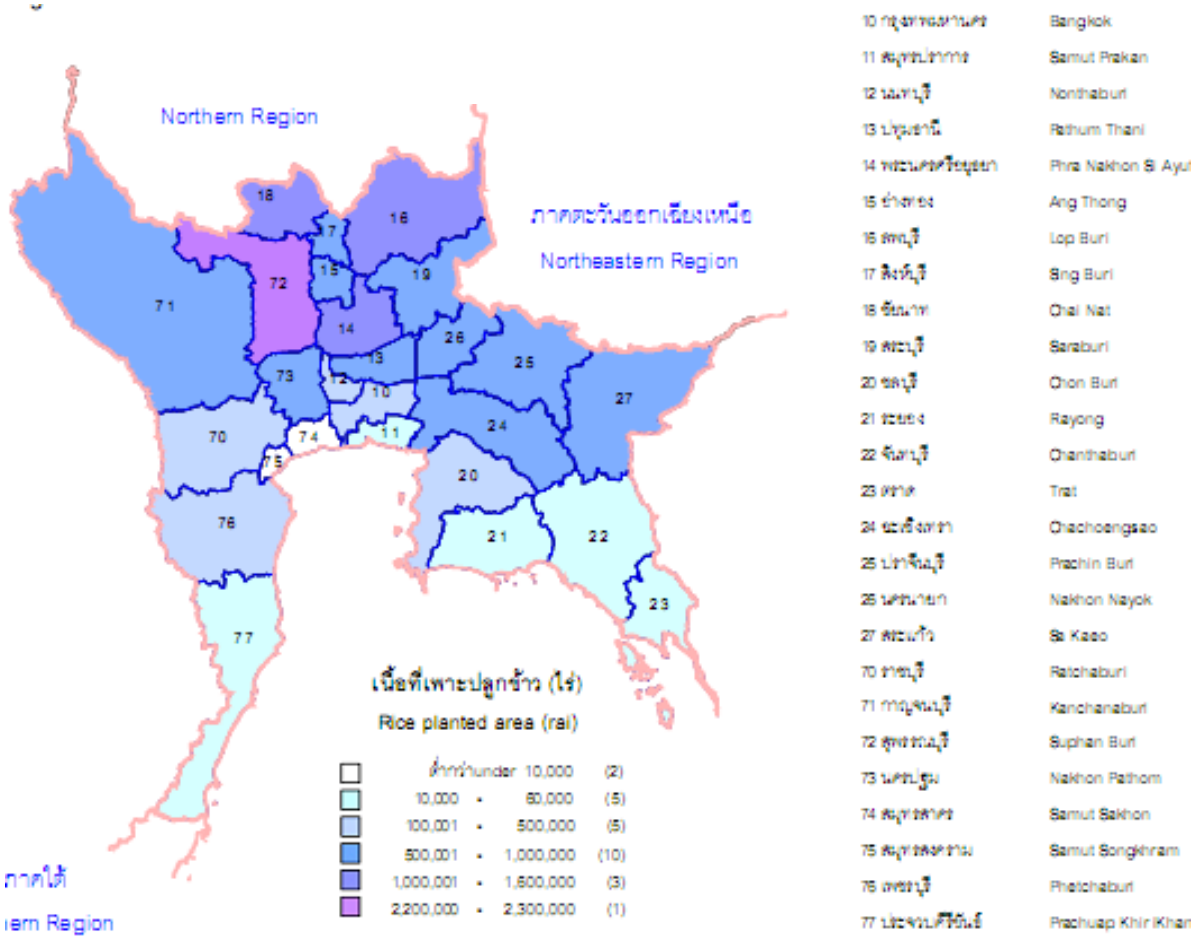


Figure 3-9. Rice planted area by province (National Statistical Office, 2003).

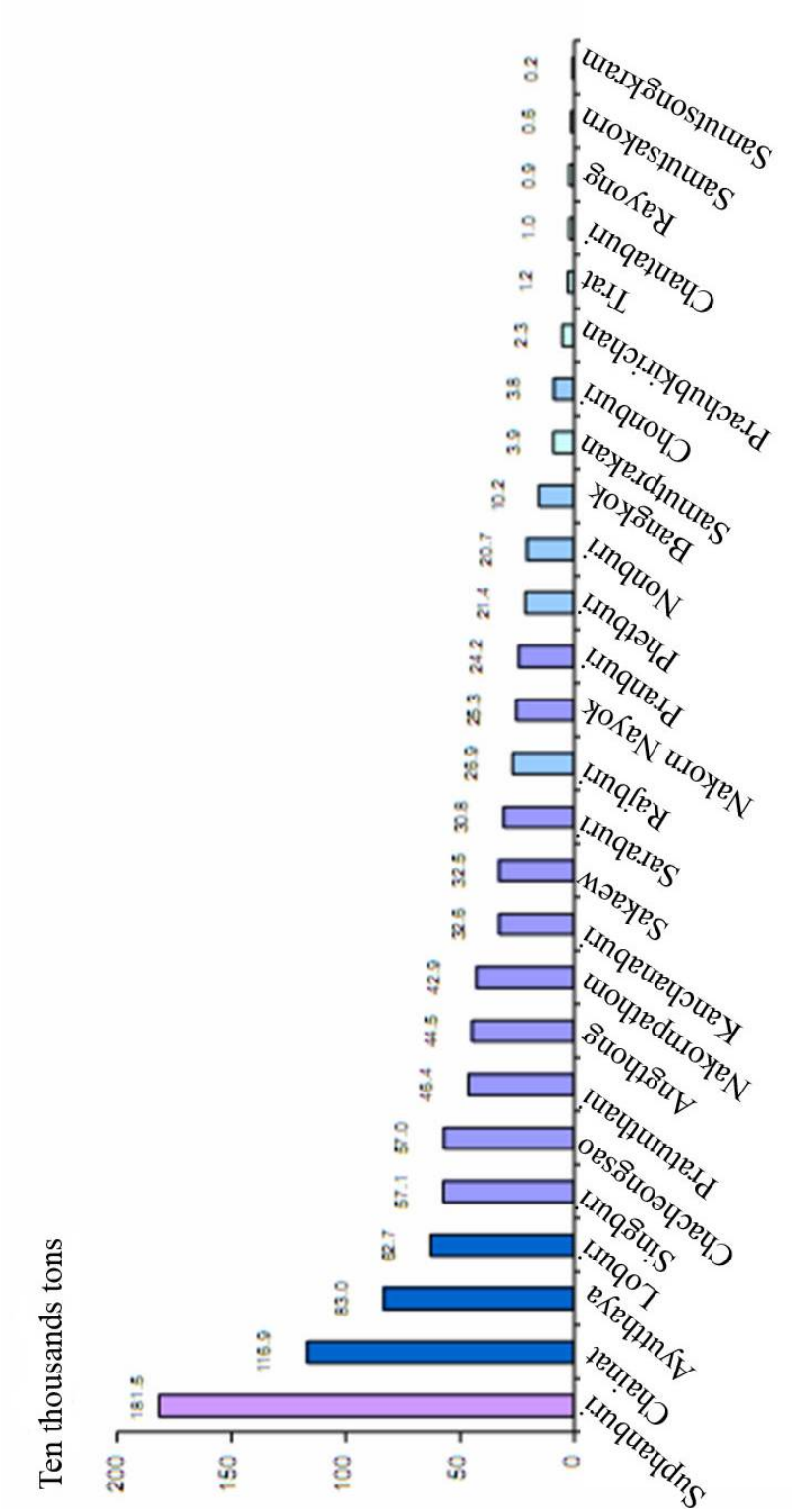


Figure 3-10. Rice product by province (National Statistical Office, 2003).

Table 3-1. Saraburi Province's agricultural censuses conducted by National Statistical Office, 2003.

District	Number of farmer	Rice plantation area (Rai)	Rice harvested area (Rai)	Rice production (Ton)
1. Maung Saraburi	1,124	30,285	29,860	16,524,745
2. Kan Koi	1,324	28,915	27,783	13,793,574
3. Nhong Khae	2,446	109,925	108,439	70,667,234
4. Wihan daeng	670	17,209	16,730	7,277,620
5. Nhong Sang	1,291	56,907	56,253	34,791,325
6. Ban Mo	1,652	94,967	92,909	62,739,075
7. Don Pud	658	34,518	33,858	18,223,250
8. Nhong Don	971	60,286	58,201	43,754,165
9. Praputthabat	743	18,679	17,694	8,464,575
10. Sao Hai	1,140	46,570	43,921	27,860,480
11. Muak Lek	4	40	40	20,500
12. Wang Muang	32	426	314	151,810
13. Chalerm Prakait	612	12,615	8,397	3,588,339
Total	12,667	511,342	494,399	307,856,692

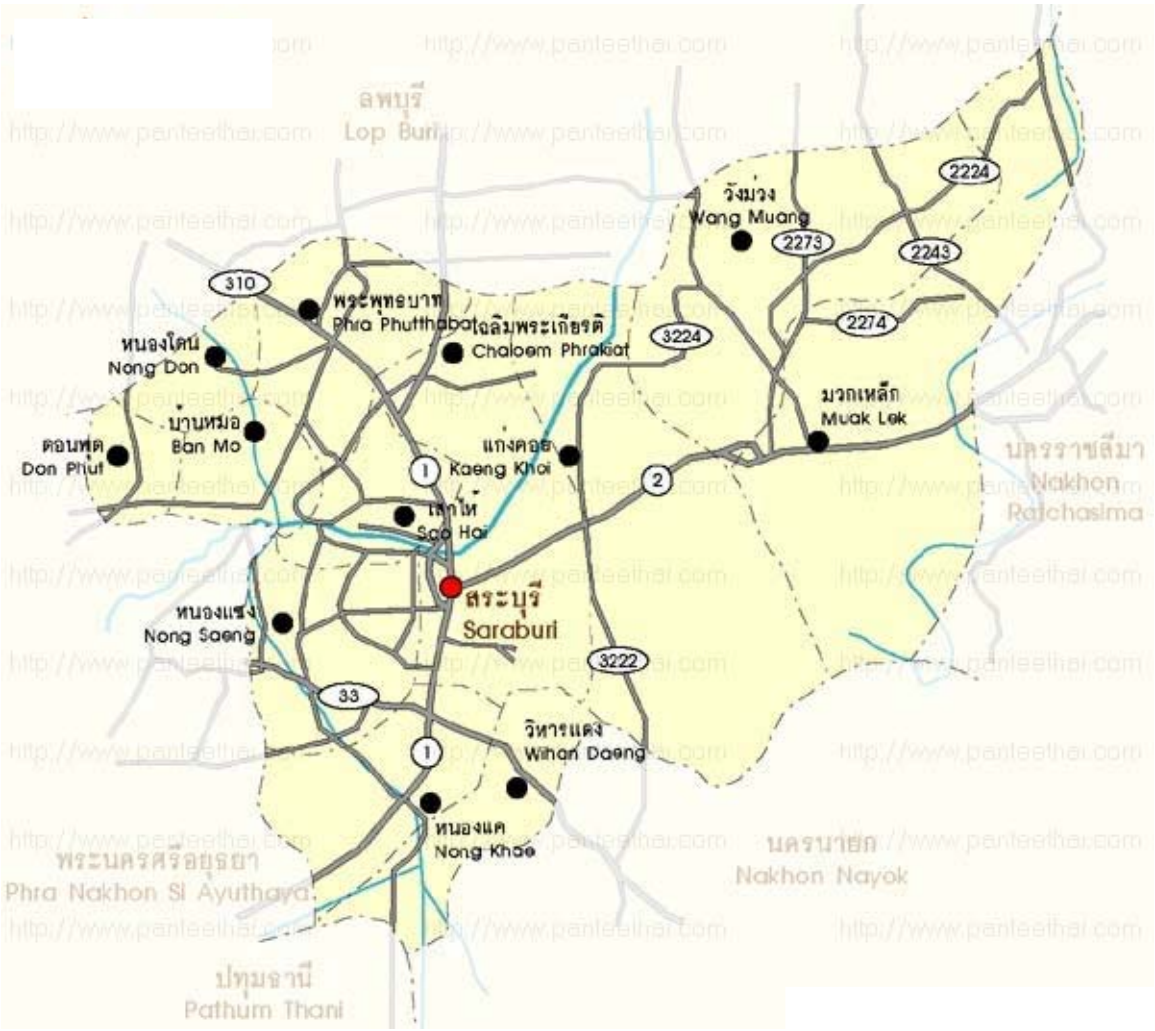


Figure 3-11. Map showing Saraburi administrative district (www.panteethai.com, 2010).

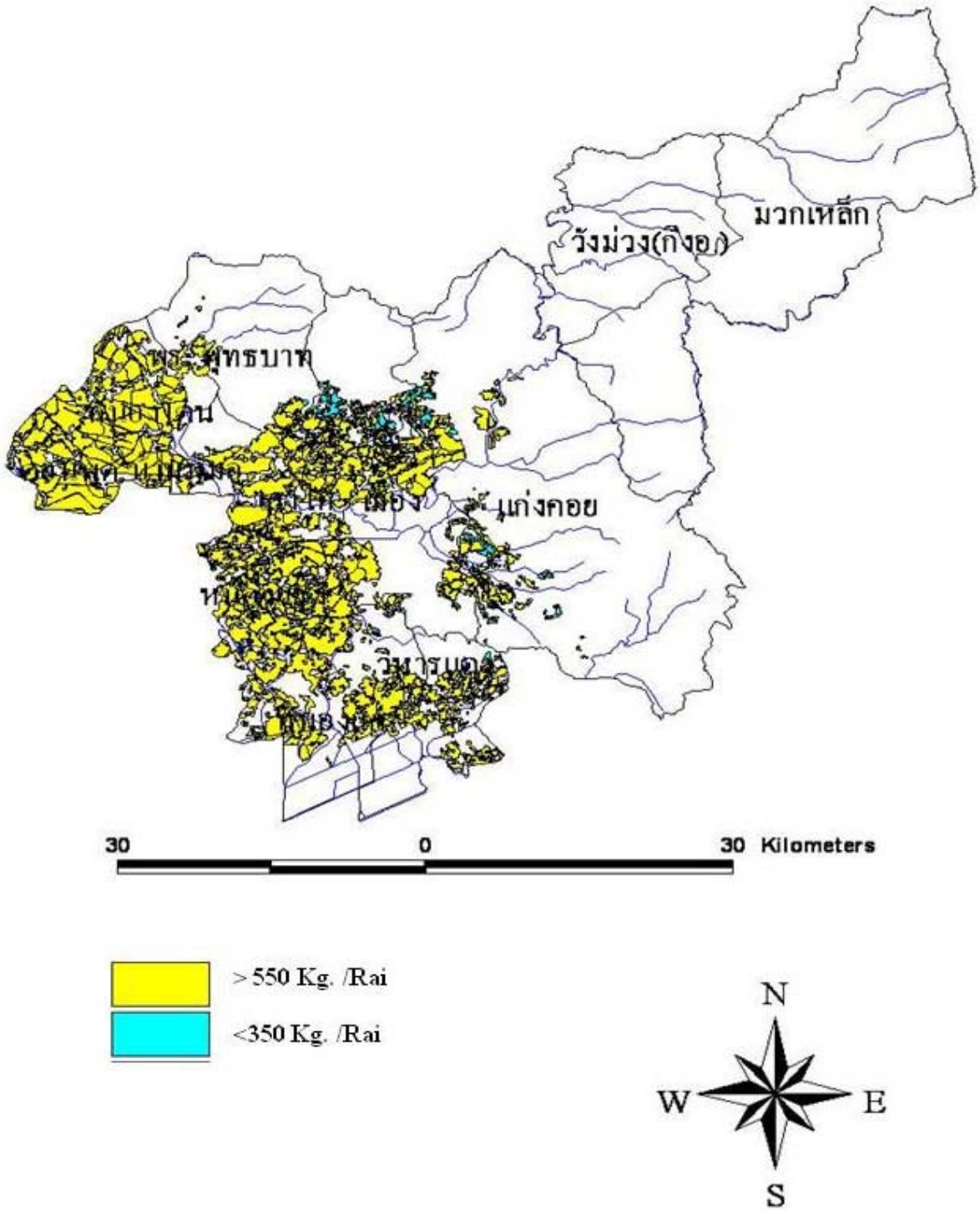


Figure 3-12. Map showing Saraburi rice plantation efficiency area (www.ricethailand.go.th).

The period of rice growing is 115 or 120 days depended on the species of rice. The harvest seasons are various in Saraburi Province. Saraburi farmers do both "Kao Na Pee" and "Kao Na Prung" methods. "Kao Na Pee" method, the rice are planted during May to December or July to December. Meanwhile, "Kao Na Prung" method the first plantation is occurred during November to April, and the second plantation is around March to July. (Saraburi's rice plantation surveys, Ministry of commerce Thailand, 2007).

3.3 GIS

This research field data were analyzed and evaluated by GIS System, free software trademark named "SaVGIS©" in order to present physical factor and diversity of snail in rice field. Developed in 1984 by the IRD (Development Research French Institute), SavGIS© is a GIS software including some remote sensing functionalities, which are able to provide specific needs of the IRD scientific teams and their counterparts (geographers, demographers, geologists, epidemiologists, entomologists, archaeologists). SaVGIS© was first implemented in Latin America; Quito (Ecuador), in the state of Veracruz (Mexico), in the region of Tijuana-San Diego (at the border between USA and Mexico), in the province of Limari (Chile), at Brasilia, and also in Africa, in Senegal, in some cities such as Bamako, Abidjan, Addis-Abeba, Tunis and in some refugees camps in Kenya. It was also used in New-Caledonia as well as in Thailand within the framework on the conditions and territories of vector-borne infectious disease emerging. In addition, this software is a freeware and also compatible with other commercial products such as ArcGIS, MS Access, and AutoCad (www.savgis.org).

CHAPTER IV
MATERIALS AND METHODS

4.1 Study Areas

The ecological survey will be conducted in Saraburi Province (14N31 100E55) (Figure 4-1). Only districts that contain rice fields were selected. Nine out of thirteen districts were selected. Total thirteen wetland sampling sites were conducted throughout Saraburi Province. The ecological survey of all sample sites were conducted by using GPS (Mangellan SporTrak Geographic Positioning System Receiver) in order to obtain the ground control points (GCPs) for image registration, classification, and post-classification process.

The snails were indentified to species and measured sizes in fields. However, the unidentified species were collected separately in a plastic bag with label for further taxonomy at Biology department, Faculty of Science, Mahidol University, Bangkok, Thailand.

4.2 Ecological Studies

The studies were conducted at rice field and wetland habitats in Saraburi Province, at the centre of Thailand from July to September 2009. (Figures 4-1 to 4-4).

Figure 4-1. Map showing ecological survey area provinces in the center of Thailand.

☆ = Showing field study areas

Figure 4-2. The rice field in Saraburi Province.

Figure 4-3. The wetland, pond area, in Saraburi Province.

Figure 4-4. The wetland, canal area, in Saraburi Province.

4.2.1 The rice field habitat

There were ten sampling areas per each rice field. The distance between each sampling areas is equal to total border line of rice field dividing by ten. Each sampling size was in a 1 x 1m^2 quadrate. The snail and eggs were observed at each sampling in the distance of one meter from the rice field border (Figure 4-5).

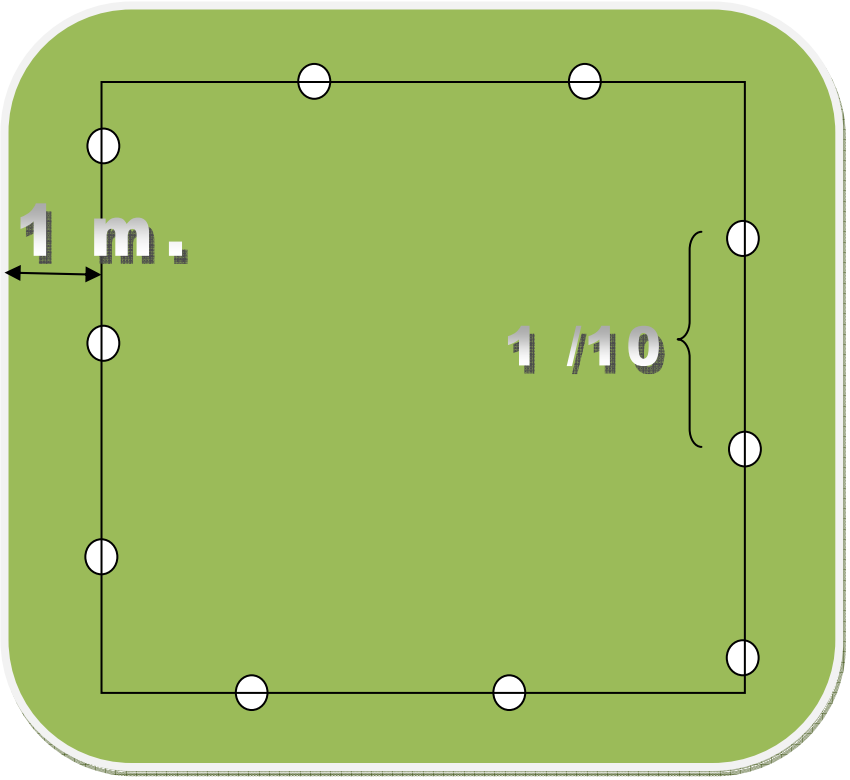


Figure 4-5. Diagram showing ten sampling areas at the rice field. Each is 1 x 1 m^2 quadrate, the length of total border line dividing by ten meters apart and one meter away from rice field border.

◯ = sampling area

.

4.2.2 The pond habitat

The snail distribution will be observed in 1 x 1m^2 quadrate. There are ten sampling areas. The distance between each sampling area is equal to total shore line dividing by ten. The snail and egg cluster were observed along the shore line (Figure 4-6).

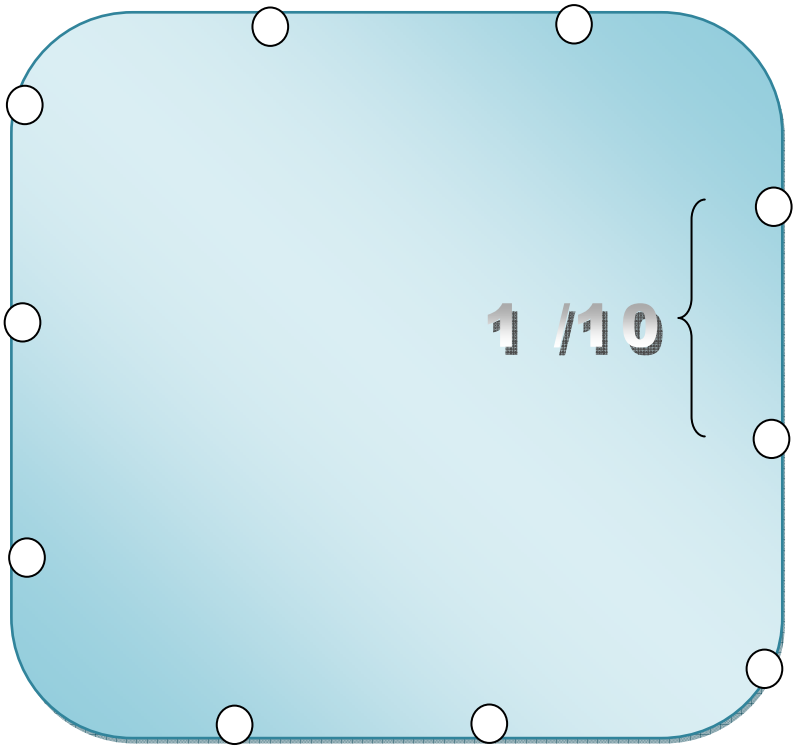


Figure 4-6. Diagram showing ten sampling areas at the pond. Each is 1 x 1 m^2 quadrate and the length of total border line dividing by ten meters apart along the pond.

○ sampling area

4.2.3 The canal habitat

Samplings were conduct at every twenty-five meters for the total length of 250 meters. Then, there were ten samplings at each field (Figure 4-7).

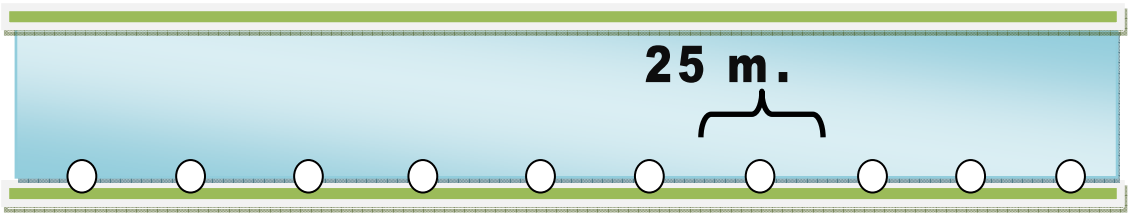


Figure 4-7. Diagram showing the sampling area at the canal.
Each is 1 x 1m^2 quadrate and twenty-five meters apart along the canal.
◯= sampling area

4.3 Data collection

The Ampullariidae species and their egg clusters were examined in egg cluster size, shell size (shell length, shell width), color and its number by a Vernier Caliper. Furthermore, the physical data such humidity, air temperature, soil and water pH and temperature, condition of weather, time, rice species and GPS latitude and longitude position were also recorded at each sampling plots (Figure 4-8).

Figure 4-8. Ecological survey and snail collecting method.

4.4 Maintenance of snail

The snails which could not be identified during field survey were collected in plastic bag with label in order to further taxonomy in laboratory. The snails were placed under laboratory condition with aerated fresh water and fed for the white part of Chinese cabbage or lettuce. The apple snails were fed twice a week and the water was changed at the day after feeding.

4.5 Ecological Data analysis

The Shannon-Wiener Index is one of the most common methods used to measure diversity in categorical data. It takes into account the number of species and the evenness of the species. Shanon-Weiner's Diversity Index for analyzing species diversity was obtained by the following index:

$$H' = -\sum P1 \ln P1$$

Where; H' = species diversity of Shannon-Weiner

P_1 = the proportion of individuals found in the 1st species

ln = the natural logarithm

The species richness values (Menkinick) was obtained by the following index:

$$R = \frac{s}{\sqrt{n}}$$

Where; R = the richness value

S = the total number of species

n = the number of individual

The evenness value was obtained by the following index:

$$E = \frac{H'}{lnS}$$

Where; E = the evenness value

H' = species diversity of Shannon-Weiner

S = the total number of species

ln = the number of individual

The similarity Index (Sorensen index) to analyze the similarity of species in two locations was obtained by the following formula;

$$C_S = \frac{2a}{2a + b + c}$$

Where; C_S = the similarity index

a = the number of species found in both sites

b = the number of species found in sites b, but not a

c = the number of species found in sites a, but not b

The density value of snail was calculated as following equation:

$$\textit{Total density of each site} = \frac{\textit{Total number of individuals in } m^2}{\textit{Total quadrats}}$$

$$\textit{Density of each site} = \frac{\textit{Number of individuals in each site}}{\textit{Number of quadrats in each site}}$$

$$\textit{\% Density of each species} = \frac{\textit{Average density of each species}}{\textit{Average density of all species}} \times 100$$

The distribution pattern (dispersion) of ampullariidae species in three provinces was calculated by proportion between the variance (s^2), and the mean ($\bar{x}$) shown in Table 4-1 and Figure 4-9.

Table 4-1. The distribution pattern (dispersion) of population.

$\frac{s^2}{\bar{x}}$	**Dispersion**
= 1	**Random**
< 1	**Uniform**
> 1	**Clumped**

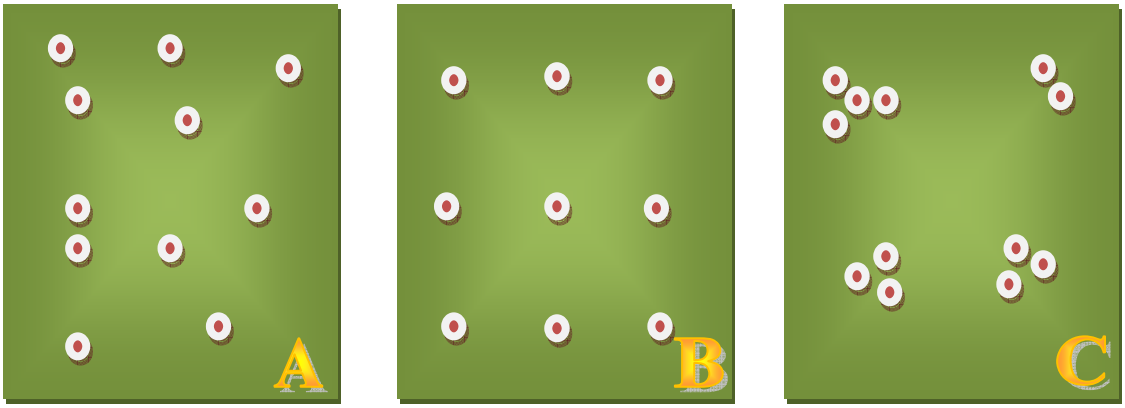


Figure 4-9. Population distribution patterns.

A = Random

B = Uniform

C = Clumped

4.6 Snail identification

Snail identification key followed Brandt, 1974, Keawjam S. R., 1990, and Burch *et al*., 1991.

4.7 Statistical analysis

The number of snail was calculated as number per square meter. Data will be checked for normality and homogeneity of variance prior to use in statistical tests. Data that did not meet parametric criteria were transformed. Data were determined using SPSS program version 11 for two-way analysis of various (two-way ANOVA and correlation (r).

4.8 GIS Analysis

Using SavGIS software to map out the species diversity following four steps using four modules.

4.8.1 The Savamer module : The SAVAMER module allows to geo-reference images (topographic maps, aerial photographs, satellite images, DEM) and to also rectify vector files (shapefile).

4.8.2 The Savedit module : The SAVEDIT module allows to digitize on screen with vector control quality and topology control. It also makes it possible to import GPS points and shapefile. It includes a semi-automated image vectorisation function too.

4.8.3 The Savateca module : The SAVATECA module is meant for managing the SavGIS© geodatabase. It allows adding or removing relations (layers) and attributes (fields).

4.8.4 The Savane module : SAVANE is the main module of SavGIS© system. It integrates a wide set of functionalities to analyze and to map out data encompassed in a SavGIS© geo-database.

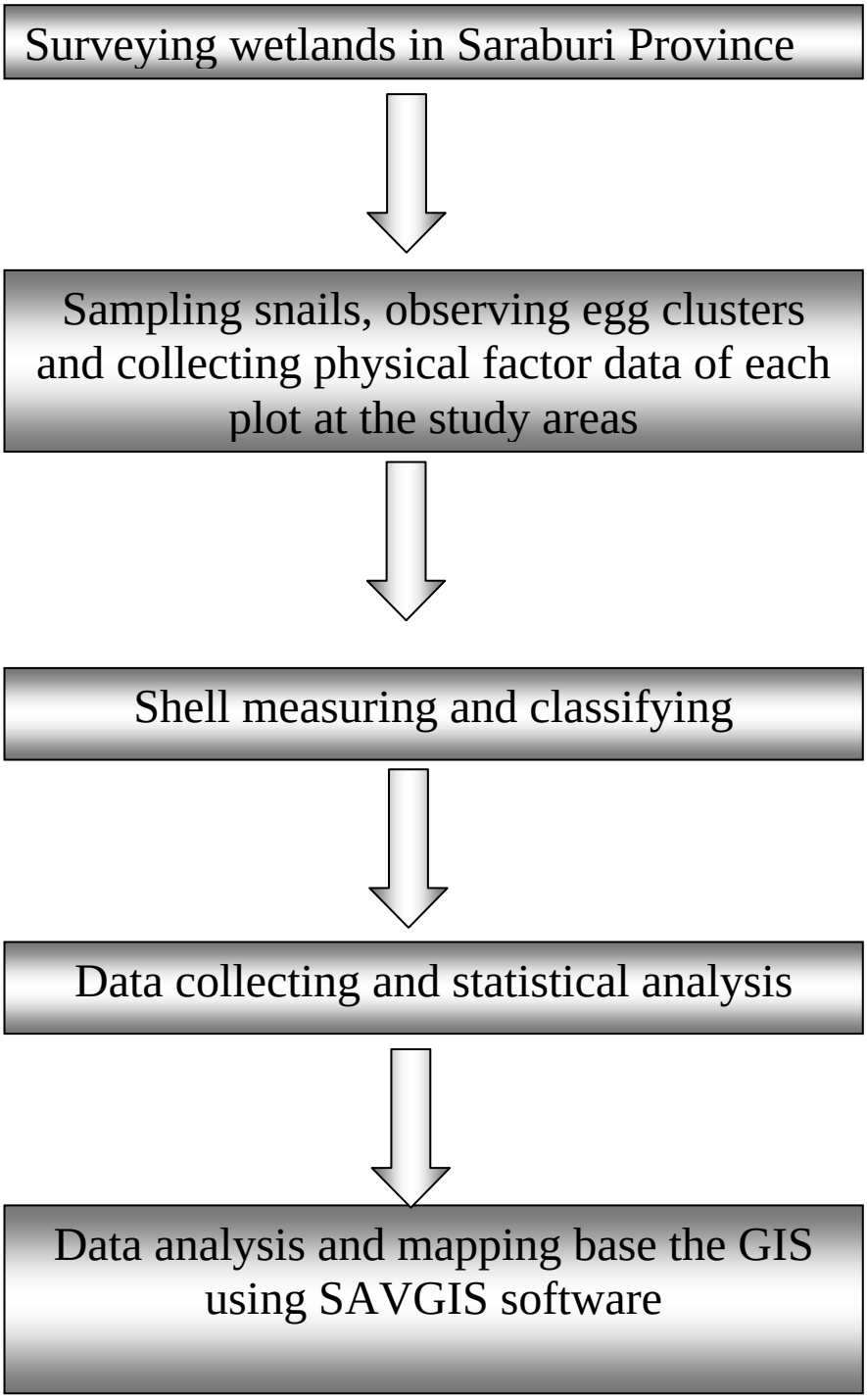


Figure 4-10. Diagram showing the study plan.

CHAPTER V
RESULTS

5.1 Study areas

A total of thirteen wetland sampling sites (ten rice fields with % total sampling area from 0.004 – 0.01, two canals, and one pond with % total sampling area of 0.016) of nine out of thirteen districts at Saraburi Province were shown in Figure 5-1, Table 5-1 and Appendix A.

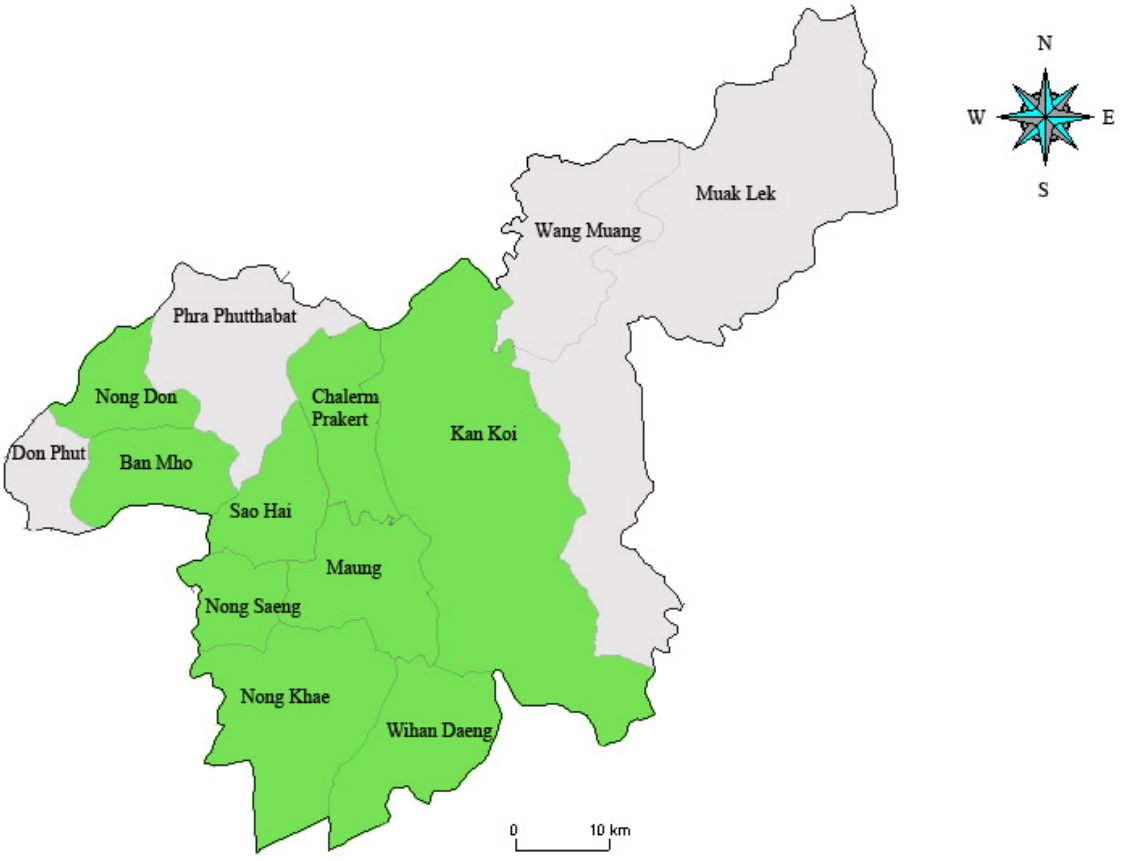


Figure 5-1. Map showing the nine districts where sampling were conducted.

Table 5-1. Location of all sampling sites which were conducted at wetlands in various district of Saraburi Province.

Site	Type of wetland	Sub-District	District	Lat/Long
1	Rice field	Ta Chang	Sao Hai	X701391 Y1612559
2	Rice field	Phraya Tod	Sao Hai	X702167 Y1610954
3	Rice field	Huai Bong	Chalerm Prakert	X704688 Y1612403
4	Rice field	Ban Yang	Sao Hai	X696170 Y1612727
5	Rice field	Nhong Sang	Nhong Sang	X693136 Y1606145
6	Rice field	Ban Mho	Ban Mho	X685722 Y1616239
7	Rice field	Nhong Don	Nhong Don	X685796 Y1622535
8	Rice field	Ban Bu Yai	Kan Koi	X714181 Y1601633
9	Rice field	Ban Lum	Wihan Daeng	X713122 Y1591479
10	Rice field	Bua Loi	Nhong Khae	X697210 Y1593549
11	Canal	Dao Rueang	Maung	X703665 Y1610144
12	Canal	Ban Mho	Ban Mho	X693757 Y1612560
13	Pond	Ban Lum	Wihan Daeng	X712131 Y1591471

5.2 Physical factors

The physical factor values of all wetland sampling areas were shown in Tables 5-2, 5-3 and Figures 5-2, 5-3.

The soil pH values were almost the same in each site, they were in the range of 6 - 7. However, they were different between types of wetland; the soil pH values of rice field were significantly less than those of canal and pond zones ($P<0.05$). The highest average pH value (6.92 ± 0.10) was found at the canal (site 12) and the lowest average pH value (6.01 ± 0.11) was found at the rice field (site 10). However, there was no soil pH data collected at site 12 because it was a concrete bank canal.

The water pH values were almost the same in each sampling area, they were in the range of 5.9 – 7.5. However, the water pH values of rice field were significantly less than those of the canal zones ($P<0.05$). The highest average water pH value (7.12 ± 0.29) was found at canal (site 12) and the lowest average value (6.01 ± 0.04) was found at the rice field (site 10).

The water temperature values were in the range of 27 – 32.5 °C. The water temperature values of the rice field were significantly different to those of canal zones ($P<0.05$). The highest water temperature (31.87 ± 0.46 °C) was found at the rice field (site 4) and the lowest average value (28.00 ± 0.23 °C) was found at the rice field (site 9).

The air temperature values were various in the range of 33 – 39 °C. It was significantly different in each sites ($P<0.05$). The highest water temperature (38.22 ± 0.25 °C) was found at the canal (site 11) and the lowest average value (30.71 ± 0.52 ° C) was found at the pond (site 13).

The percentages of humidity were various in the range of 44.40 – 80.50 %. There were significantly different between the humidity value of canal zones ($P<0.05$). The average percentage of humidity was the highest (79.11 ± 0.29 %) and the lowest (50.24 ± 0.26 %) at site 9 and 8, respectively.

Table 5-2. The average (mean ± SD) physical factor values at all thirteen sampling sites.

Site No.	Type of wetland	Soil pH	Water pH	Water temperature (°C)	Air temperature (°C)	Humidity (%)
1	rice field	6.40 ± 0.22	6.95 ± 0.13	31.05 ± 0.54	37.83 ± 0.77	54.61 ± 3.67
2	rice field	6.50 ± 0.22	6.85 ± 0.18	30.36 ± 0.62	36.94 ± 0.44	60.05 ± 0.34
3	rice field	6.55 ± 0.28	6.90 ± 0.13	28.52 ± 0.77	35.26 ± 0.52	64.61 ± 1.00
4	rice field	6.72 ± 0.20	6.94 ± 0.19	31.87 ± 0.46	37.48 ± 0.37	54.83 ± 0.44
5	rice field	6.63 ± 0.31	6.87 ± 0.17	28.61 ± 0.59	35.98 ± 0.58	54.91 ± 0.35
6	rice field	6.91 ± 0.11	6.95 ± 0.09	28.92 ± 0.25	37.16 ± 0.24	44.92 ± 0.43
7	rice field	6.80 ± 0.19	6.93 ± 0.12	27.76 ± 0.37	34.11 ± 0.41	71.33 ± 1.33
8	rice field	6.26 ± 0.33	6.28 ± 0.38	28.31 ± 0.35	36.27 ± 0.41	50.24 ± 0.26
9	rice field	6.03 ± 0.14	6.46 ± 0.39	28.00 ± 0.23	37.16 ± 0.24	79.11 ± 0.29
10	rice field	6.01 ± 0.11	6.01 ± 0.04	29.07 ± 0.30	37.67 ± 0.30	45.69 ± 0.25
11	canal	-	7.12 ± 0.29	30.84 ± 0.63	38.22 ± 0.25	51.63 ± 0.84
12	canal	6.92 ± 0.10	7.05 ± 0.85	30.36 ± 0.49	37.61 ± 0.53	54.77 ± 0.25
13	pond	6.76 ± 0.15	6.80 ± 0.13	29.11 ± 0.19	30.71 ± 0.52	64.82 ± 0.28

Table 5-3. The average (mean ± SD) physical factor values at all thirteen sampling sites. The different letters identified values which were significantly different at P < 0.05.

Type of wetland	Soil pH	Water pH	Water temperature (°C)	Air temperature (°C)	Humidity (%)
Rice field	6.49 ± 0.36 [a]	6.73 ± 0.37 [a]	29.28 ± 1.37 [a]	36.60 ± 1.23 [a]	58.15 ± 10.69 [a,b]
Canal	6.92 ± 0.10 [b]	7.09 ± 0.21 [b]	30.64 ± 0.58 [b]	37.93 ± 0.48 [b]	53.28 ± 1.62 [a]
Pond	6.76 ± 0.15 [b]	6.80 ± 0.13 [a,b]	29.11 ± 0.19 [a]	30.71 ± 0.52 [c]	64.82 ± 0.28 [b]

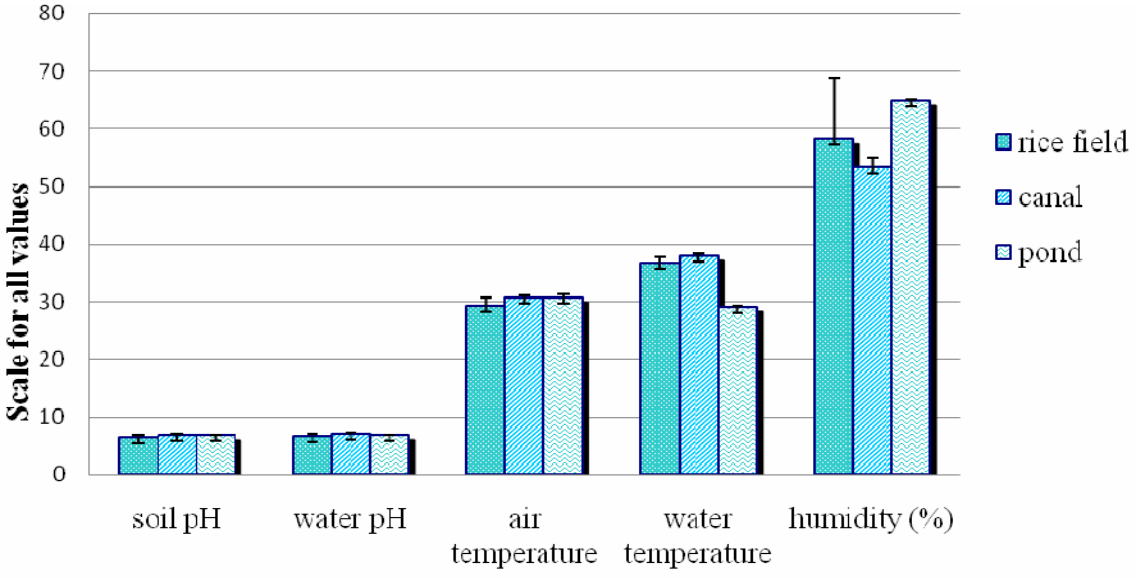


Figure 5-2. Average physical factor values in each type of wetland areas at Saraburi Province.

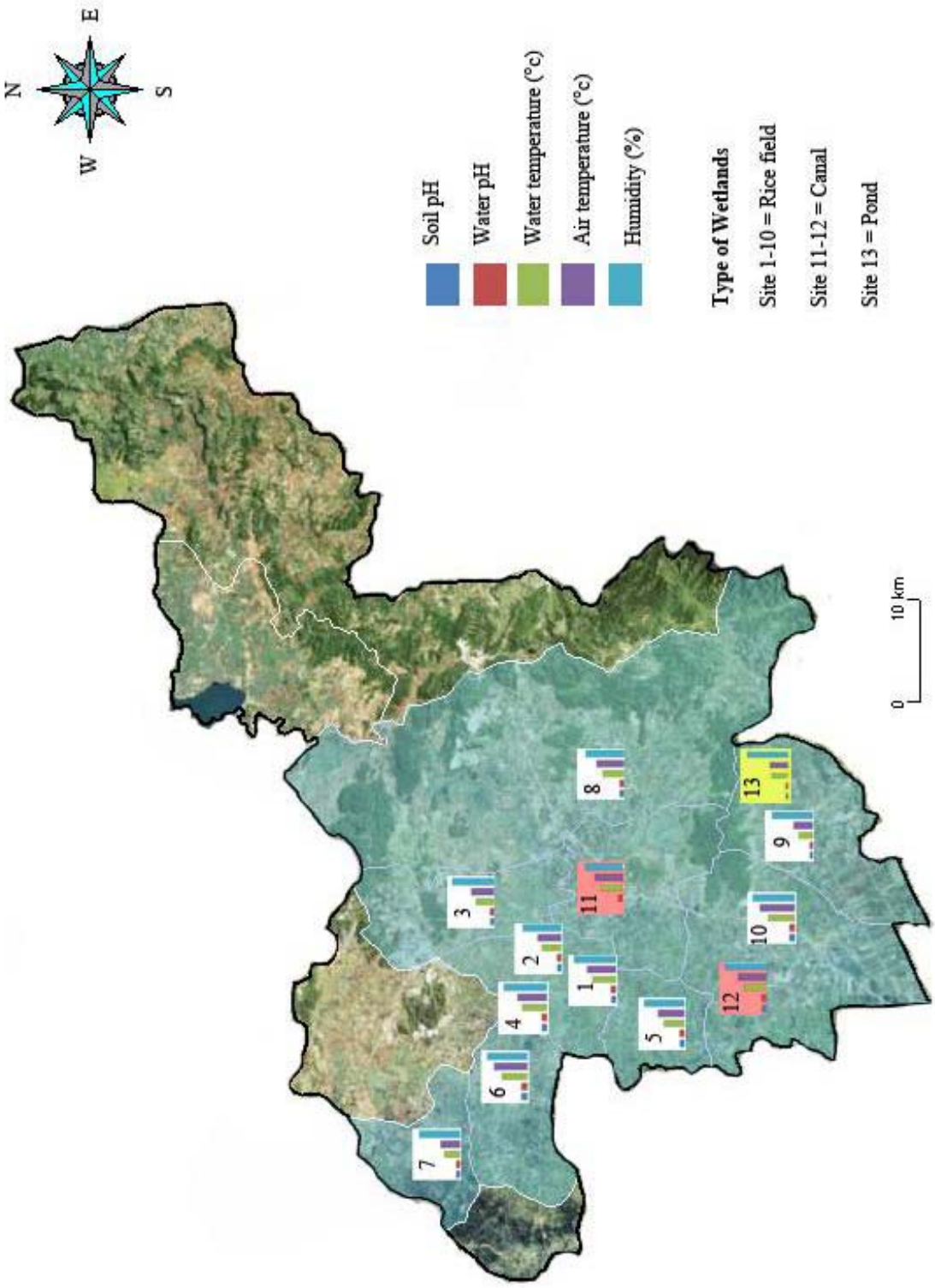


Figure 5-3. GIS Map showing average physical factor values in each type of wetland areas at Saraburi Province.

5.3 Ecological data

5.3.1 Number of species and species diversity

The total number of 180 ampullariid snails was found in all 130 sampling areas of all sampling sites. These snails were classified under genus *Pomacea*. There was no any snail of genus *Pila* found at any sampling sites. However, some very old death shells of *Pila ampullacea* were found at site 6 and 12. In almost all sampling sites, the highest found species were three. The number of individual (24) were the highest and lowest (three) at site 8 and nine, respectively. The highest richness value (1.15), diversity index (2.24) and evenness value (3.01) were found at site 8, 9, 5 and 8, respectively.

The highest number of individuals of *Pomacea* sp. were 17 at site 11, however there were no *Pomacea* sp. were found at sites 8, 10 and 13. The average of its number of individuals found in each site was 4.77 $\pm$ 5.10. Its highest percentage of diversity (83.33 %) was found at site 6 (Tables 5-4 to 5-16).

The highest number of individuals of *Pomacea canaliculata* were 13 at site 8, meanwhile its lowest number was one at site 6. The average of its number of individuals found in each site was 4.85 $\pm$ 3.23. Its highest percentage of diversity (66.66 %) was found at sites 7 and 9 (Tables 5-4 to 5-16).

The highest number of individuals of *Pomacea insularus* were 11 at site 8, however there were no *P. insularus* found at site 6 and 9. The average of its number of individuals found in each site was 4.23 $\pm$ 3.00. Its highest percentage of diversity (46.66 %) was found at site 5 (Tables 5-4 to 5-16).

There was no significant difference between the total number of individuals which were found in each sampling site ($P>0.05$). However, the number of individuals at site 1 was significantly different to those at sites 6 and 9 ($P<0.05$). The number of individuals at site 6 was significantly different to those at sites 1 and 8 ($P<0.05$). As well as, the number of individuals at site 9 were significantly different to those at sites 1, 8 and 11 ($P<0.05$) (Table 5-3).

The highest number of 18 egg clusters were found at site 12, however there were no egg clusters found at site 7 and 10. (Tables 5-4 to 5-16). The average of its number of individuals of egg clusters found in each site was 6.92 $\pm$ 5.17. There

was no significant different of the number of egg clusters found in each site, except the sites that an egg cluster was not found such site 7 and 10 ($P<0.05$) (Tables 5-3 to 5-16).

The similarity index of ampullariids between rice field and canal was 100%. Also, the similarity index of ampullariids 85.71% between canal and pond, and between rice field and pond was 85.71%.

There were no significantly different between site richness values of each wetland type ($P>0.05$). The site richness value was the highest at site 9 (1.1547) and lowest at site 8 (0.4082). There was no significant different of diversity Index between each type of wetland ($P>0.05$). Also there was no significantly different of diversity Index between each type of wetland ($P>0.05$). The diversity index was the highest at site 5 (2.24) and lowest at site 9 (1.10).

5.3.2 Density value and distribution pattern

There was no significant different of total value of diversity between each type of wetland ($P>0.05$). The total diversity was the highest at site eight ($2.4/m^2$) and lowest at site six ($0.6/m^2$).

Among ampullariids, *Pomacea* sp. was the most abundance (83.33%) at site six (Tables 5-4 to 5-16). In *Pomacea canaliculata*, the highest percentage diversity (66.66%) and the lowest percentage diversity (9.52%), were found at site seven and nine, and 11, respectively (Tables 5-4 to 5-16). In *Pomacea insularus*, the highest percent diversity (46.66%) was found at site five, and the lowest percent diversity (0%) were found at site five, and six, and nine, respectively (Tables 5-4 to 5-16).

At site 1: Ta Chang Sub-District, *Pomacea* sp. was the most abandant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 47.82, 26.08 and 26.08%, respectively.

At site 2: Phraya Tod Sub-District, *Pomacea* sp. was the most abandant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 52.94, 11.76 and 26.08%, respectively.

At site 3: Huai Bong Sub-District, *Pomacea* sp. and *Pomacea insularus* was about the same abundant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata*, *Pomacea insularus* were 40, 20 and 40%, respectively.

At site 4: Ban Yang Sub-District, the *Pomacea* sp. was the most abandant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 26.66, 33.33 and 33.33%, respectively.

At site 5: Nhong Sang Sub-District, *Pomacea insularus* was the most abandant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 20, 33.33 and 46.66%, respectively.

At site 6: Ban Mho Sub-District, *Pomacea* sp. was the most abundant species. The percentage diversity of *Pomacea sp.* and *Pomacea canaliculata* were 83.33 and 16.66%, respectively. However, *Pomacea insularus* was not found at this site.

At site 7: Nhong Don Sub-District, *Pomacea canaliculata* was the most abundant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 11.11, 66.66 and 22.22%, respectively.

At site 8: Ban Bu Yai Sub-District, *Pomacea canaliculata* was the most abundent species. The percentage diversity of *Pomacea canaliculata* and *Pomacea insularus* were 54.16 and 45.83%, respectively. However, *Pomacea* sp. was not found at this site.

At site 9: Ban Lum Sub-District, *Pomacea canaliculata* was the most abundant species. The percentage diversity of *Pomacea* sp. and *Pomacea canaliculata* were 33.33 and 66.66%, respectively. However, *Pomacea insularus* was not found at this site.

At site 10: Boi Loi Sub-District, *Pomacea canaliculata* was the most abundent species. The percentage diversity of *Pomacea canaliculata* and *Pomacea insularus* were 54.54 and 45.45%, respectively. However, *Pomacea* sp. was not found at this site.

At site 11: Nhong Don Sub-District, *Pomacea* sp. was the most abundant species. The percentage diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 80.95, 9.52 and 9.52%, respectively.

At site 12: Nhong Don Sub-District, *Pomacea* sp. was the most abundant species. The percent diversity of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 46.66, 33.33 and 20% respectively.

At site 13: Boi Lum Sub-District, the *Pomacea canaliculata* was the densest species. The percentage diversity of *Pomacea canaliculata* and *Pomacea insularus* were 63.63 and 36.36%, respectively. However, *Pomacea* sp. was not found at this site.

The distribution pattern of egg laying at thirteen sampling sites was mostly clumped or cluster pattern except at sites eight and nine which was random and uniform, respectively.

Without regarding to its species, the distribution pattern of ampullariids was mostly uniform, except at site eight which was clumped. The distribution pattern of *Pomacea* sp. was mostly uniform, except at site three which was clumped and six, seven and nine which was random. The distribution pattern of *P. canaliculata* was uniform at sites one, two, seven, 9 and 13. The distribution pattern of the rest was clumped, except at sites 4, 6 and 12 which was random. *P. insularus* mostly distributed in the pattern of uniform, except at sites four 4 and 10 which was random and site 13 which was clumped (Table 5-17).

GIS map showing density of ampullariid species in each type of wetland areas at Saraburi Province (Figure 5.4) and the graph of comparing of Shannon diversity index, evenness, and richness of ampullariids in thirteen sampling areas (Figure 5.5).

Table 5-4. Showing the number of individual and species diversity and number of ampullariids' egg clusters at all 13 sampling sites. The different letters identified values which were significantly different (P< 0.05).

- = no snail found

+ = the number of snails or egg clusters between 1-9

++ = the number of snails egg clusters between 10-15

+++ = the number of snails egg clusters more than 15

No. of sampling site	Type of site	No. of individual	*Pomacea* sp.	*Pomacea canaliculata*	*Pomacea insularus*	Ampullariid's egg clusters
1	Rice field	23 [a,b]	++	+	+	++
2	Rice field	17	+	+	+	+
3	Rice field	10	+	+	+	+
4	Rice field	15	+	+	+	+
5	Rice field	15	+	+	+	+
6	Rice field	6 [a,c]	+	+	-	+
7	Rice field	9	+	+	+	-
8	Rice field	24 [c,d]	-	++	++	+
9	Rice field	3 [b,d,e]	+	+	-	+
10	Rice field	11	-	+	+	-
11	Canal	21[e]	+++	+	+	++
12	Canal	15	+	+	+	+++
13	Pond	11	-	+	+	+

Table 5-5. Ecological data at sampling site 1.

Sampling site 1	
Total of Individuals	23
Total species	3
Site Richness	0.6255
Diversity Index	2.1858
Evenness	1.9896
Total Density of site	2.3000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	11	47.826	0.5444
P. canaliculata	6	26.0869	0.2666
P. insularus	6	26.0869	0.4888
No. egg cluster	11		

Table 5-6. Ecological data at sampling site 2.

Sampling site 2	
Total of Individuals	17
Total species	3
Site Richness	0.7276
Diversity Index	2.0377
Evenness	1.8548
Total Density of site	1.7000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	9	52.9411	0.5444
P. canaliculata	2	11.7647	0.1777
P. insularus	6	26.0869	0.2666
No. egg cluster	6		

Table 5-7. Ecological data at sampling site 3.

Sampling site 3	
Total of Individuals	10
Total species	3
Site Richness	0.9486
Diversity Index	2.0253
Evenness	1.8435
Total Density of site	1

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	4	40	0.4888
P. canaliculata	2	20	0.4000
P. insularus	4	40	0.2666
No. egg cluster	8		

Table 5-8. Ecological data at sampling site 4.

Sampling site 4	
Total of Individuals	15
Total species	3
Site Richness	0.7746
Diversity Index	2.0262
Evenness	1.8443
Total Density of site	1.5000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	4	26.6666	0.2666
P. canaliculata	5	33.3333	0.5000
P. insularus	5	33.3333	0.5000
No. egg cluster	8		

Table 5-9. Ecological data at sampling site 5.

Sampling site 5	
Total of Individuals	15
Total species	3
Site Richness	0.7746
Diversity Index	2.2459
Evenness	2.0443
Total Density of site	1.5000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	3	20	0.2333
P. canaliculata	5	33.3333	0.2777
P. insularus	7	46.6666	0.2333
No. egg cluster	8		

Table 5-10. Ecological data at sampling site 6.

Sampling site 6	
Total of Individuals	6
Total species	2
Site Richness	0.8164
Diversity Index	1.5607
Evenness	2.2516
Total Density of site	0.6000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	5	83.3333	0.5000
P. canaliculata	1	16.6666	0.1000
P. insularus	0	0	0
No. egg cluster	3		

Table 5-11. Ecological data at sampling site 7.

Sampling site 7	
Total of Individuals	9
Total species	3
Site Richness	1
Diversity Index	1.8891
Evenness	1.7195
Total Density of site	0.9000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	1	11.1111	0.1000
P. canaliculata	6	66.6666	0.4888
P. insularus	2	22.2222	0.1777
No. egg cluster	0		

Table 5-12. Ecological data at sampling site 8.

Sampling site 8	
Total of Individuals	24
Total species	2
Site Richness	0.4082
Diversity Index	2.0870
Evenness	3.0110
Total Density of site	2.4000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	0	0	0
P. canaliculata	13	54.1660	1.5666
P. insularus	11	45.8333	0.5444
No. egg cluster	5		

Table 5-13. Ecological data at sampling site 9.

Sampling site 9	
Total of Individuals	3
Total species	2
Site Richness	1.1547
Diversity Index	1.0986
Evenness	1.5849
Total Density of site	3

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	1	33.3333	0.1000
P. canaliculata	2	66.6666	0.1777
P. insularus	0	0	0
No. egg cluster	2		

Table 5-14. Ecological data at sampling site 10.

Sampling site 10	
Total of Individuals	11
Total species	2
Site Richness	0.6030
Diversity Index	2.0198
Evenness	2.9139
Total Density of site	1.1000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	0	0	0
P. canaliculata	7	54.5454	0.9000
P. insularus	5	45.4545	0.5000
No. egg cluster	0		

Table 5-15. Ecological data at sampling site 11.

Sampling site 11	
Total of Individuals	21
Total species	3
Site Richness	0.6546
Diversity Index	2.2436
Evenness	2.0422
Total Density of site	2.1000

Species	Total number of individuals	% Density	Variance(s)
Pomacea sp.	17	80.9523	0.6777
P. canaliculata	2	9.5238	0.4000
P. insularus	2	9.5238	0.1777
No. egg cluster	13		

Table 5-16. Ecological data at sampling site 12.

Sampling site 12	
Total of Individuals	15
Total species	3
Site Richness	0.7746
Diversity Index	2.2110
Evenness	2.0126
Total Density of site	1.5000

Species	Total number of individuals	% density	Variance(s)
Pomacea sp.	7	46.6666	0.6777
P. canaliculata	5	33.3333	0.5000
P. insularus	3	20	0.2333
No. egg cluster	18		

Table 5-17. Ecological data at sampling site 13.

Sampling site 13	
Total of Individuals	11
Total species	2
Site Richness	0.6030
Diversity Index	2.0198
Evenness	2.9139
Total Density of site	1.1000

Species	Total number of individuals	% density	Variance(s)
Pomacea sp.	0	0	0
P. canaliculata	7	63.6363	0.6777
P. insularus	4	36.3636	0.4888
No. egg cluster	8		

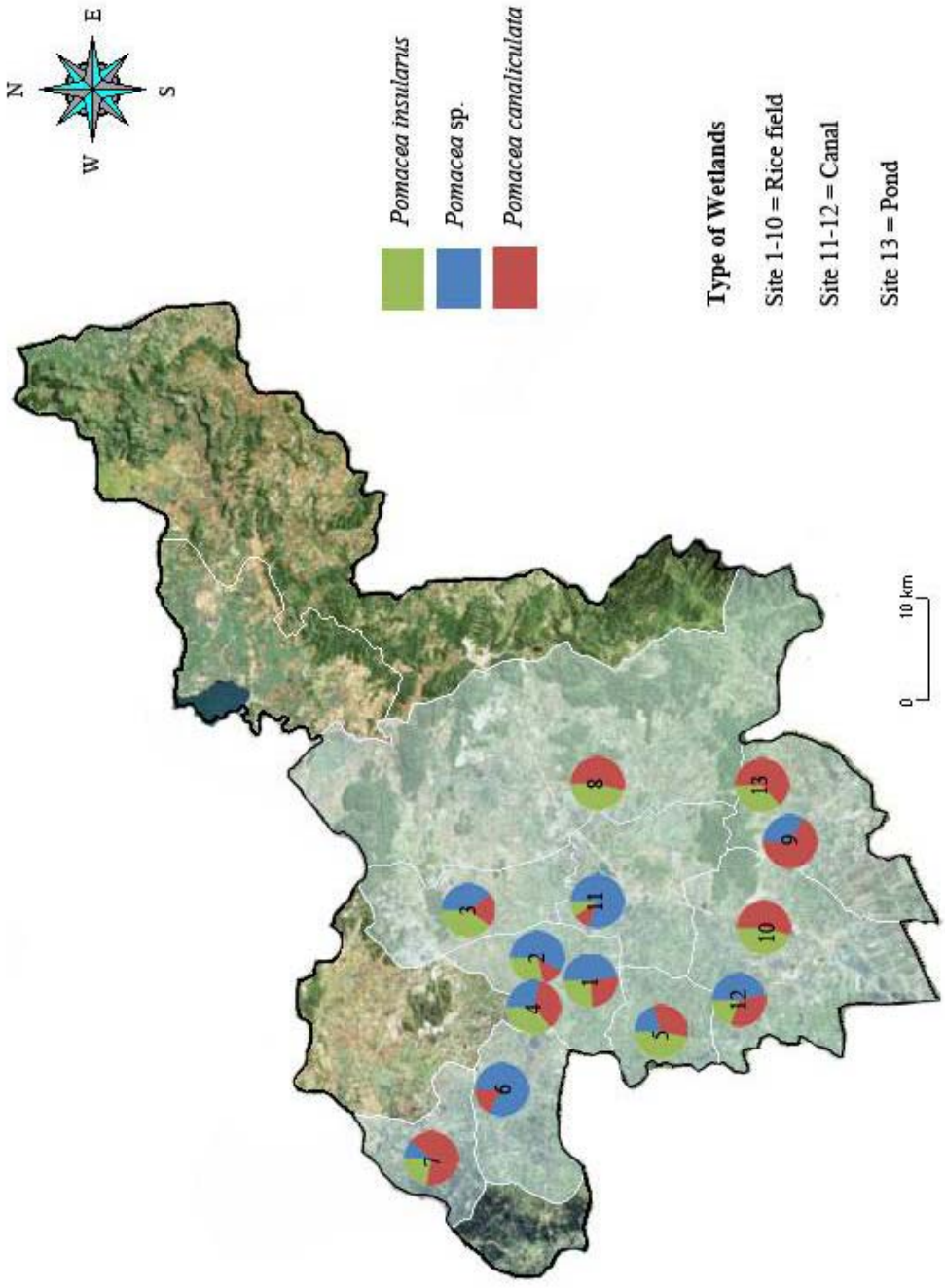


Figure 5-4. GIS map showing density of ampullariid species in each type of wetland areas at Saraburi Province.

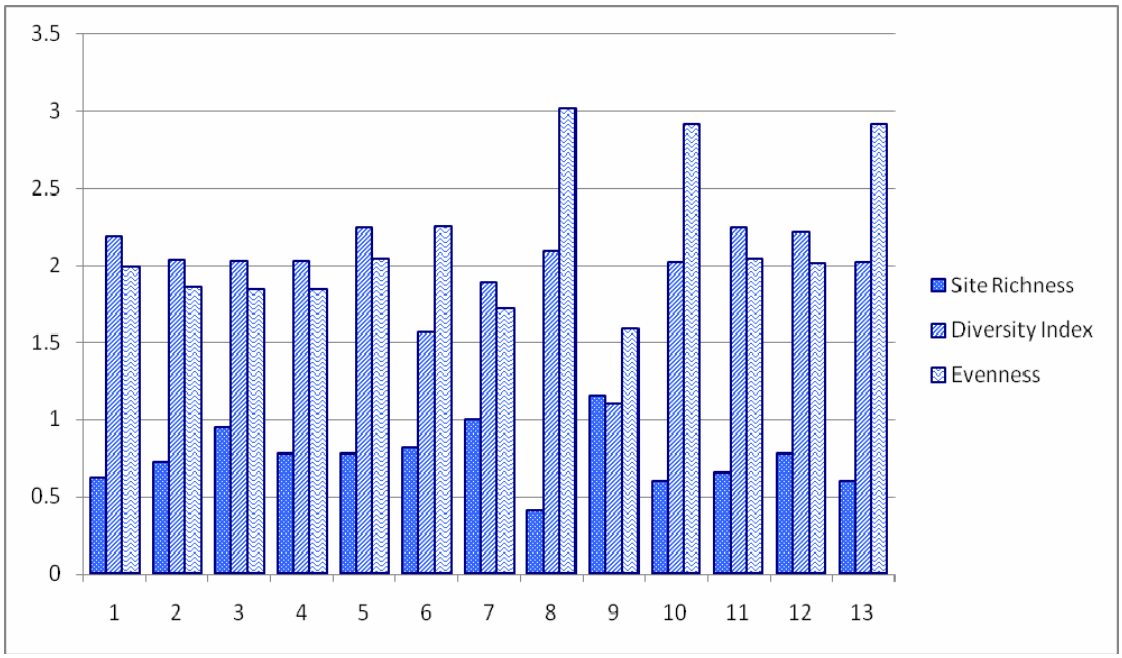


Figure 5-5. Comparing of Shannon diversity index, evenness, and richness of ampullariids in thirteen sampling areas.

5.3.3 Shell characteristics

The shell sizes of all found ampullariids were as follows:

Pomacea sp. : the average size was SL: 3.91 ± 1.51 cm, SW: 5.04 ± 1.86 cm;

P. canaliculata : the average size was SL: 5.27 ± 6.67 cm, SW: 3.47 ± 1.15 cm;

P. insularus : the average size were SL: 2.95 ± 0.85 cm, SW: 3.81 ± 1.18 cm.

The total number of 95 egg clusteres were found. The average size of egg cluster was 2.17 ± 0.97 cm in width and 3.09 ± 1.22 cm in length.

Table 5-18. Type of species distribution.

Site No.	Type of wetland	Over all of ampullariidae snails	*Pomacea* sp.	*P. canaliculata*	*P. insularus*
1	rice field	uniform	uniform	uniform	uniform
2	rice field	uniform	uniform	uniform	uniform
3	rice field	uniform	clumped	clumped	uniform
4	rice field	uniform	uniform	uniform	random
5	rice field	uniform	uniform	uniform	uniform
6	rice field	uniform	random	random	-
7	rice field	uniform	random	uniform	uniform
8	rice field	clumped	-	clumped	uniform
9	rice field	uniform	random	uniform	-
10	rice field	uniform	-	clumped	random
11	canal	uniform	uniform	clumped	uniform
12	canal	uniform	uniform	random	uniform
13	pond	uniform	-	uniform	clumped

CHAPTER VI
DISCUSSION

6.1 Study areas

All 130 wetland sampling areas were conducted in nine of thirteen districts of Saraburi. These wetland sites were selected according to the high quantity of rice. However, there were several obstacles influenced to area selection such as the period of rice field plantation, the flotation after raining night, unapproachable area and too small pond area.

Because of the variation in geography, Saraburi was not only famous in the rice production area but also as well known of several industries. The rice production is dominant in area of Sao Hai District, Maung District, Ban Mho District and Wihan Daeng District. Meanwhile, there are three cement industries TPI, SCCC (Siam City Cement Public co.ltd.) and the Siam Cement Group are located at Kan Koi District. Mouk Lhek District is well known as a agricultural industries, plantation town and tourist place. In addition, the provincial agricultural extension office also encourage the habitant to culture other kind of agricultural products such as mango, maize, taro and tapioca which take the lower budget.

The appropriate snail sampling time in rice field should be before harvesting. Some rice fields were not appropriate in snail sampling because of the heavy raining at the night. The heavy rain was influent by the monsoon period. Eventhrough, the rain was not strong enough to carry on the flooding disaster, but it rendered the high level of water in rice field which were obstacle to observe and sampling snails. The high level of water after the heavy rain made the sampling more difficult both in being approachable to the sampling sites and snail observation. The snail well sank themselves or well attached with water plant at the near-to-ground level. However, the high water level and flooding is a major way of snail to be distributed to other areas.

The period of rice field plantation and harvesting in Saraburi Province was varied depending on the rice field owner and the number of plantation per year. The plantation period at Muang, Nhong Sang, and Sao Hai Districts were in June and July. The harvesting period at Wihan Daeng, Kan Koi, and Nhong Khae Districts were either in August and September or November and December. Meanwhile, the harvesting period at Muang, Nhong Sang, and Sao Hai Districts was in November and December. Therefore, the most convenient time for snail sampling should be one to two months before harvesting.

Another main problem on snail sampling was inapproachability and insecurity, especially at canal site. The canal site normally was a high bank canal, strong floating, being fenced by electric line. However, the habitant also gave an advice to avoid the area which were abundant of leeches and high criminal risk areas.

6.2 Physical factors

The physical factor values of each sampling sites were probably influenced by the uncertain weather condition at periods of study. There were several monsoon storms occurred in South-East Asia during July to October (Thai Metrological department weather condition monthly summary reports, July to October, 2009). These storms directly affected to the rain frequency which rendered to the verity of temperature and humidity value in each day that the samplings were taken place. In addition, the water volumes which suddenly added to the rice field by overnight raining may affected to the values of soil and water pH. The study result also showed the correlation among some soil and water, pH and temperature, and air temperature and humidity ($P< 0.05$). However, the appropriate value of soil pH for rice cultivation is 6.0 - 6.5. (Boonjaras, 2008). According to Srinives (1999), he indicated in the golden apple snail control manual that the golden snail was able to live in the very poor quality of water and slightly being acid. However, the poor quality condition would render to slow growth rate and less egg lying. The appropriate water temperature condition for golden apple snail was around $30^{o}C$. The slightly difference physical factors were not a matter of snail distribution. There several report of many country all around the world, without regarding to the earth longitude position; from

Ireland to Australia, shown well distribution and growth of apple snails even there was some different in the value of physical factors from place to place. The different of species distribution in each place was various to the kind of apple species snails, which were introduce into each place. This study result also confirmed that there was no correlation between species richness value and physical factor.

6.3 Species diversity and distribution

The total of 180 ampullariids of three species and its 95 egg clusters were found in all sampling sites. These three ampullariid species belong to genus *Pomacea*; *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus*. These species was in accordance with an assuming of Brandt (1974), Keawjam and Upatham (1990), Srinives (1999), Upatham *et al.* (1995) and Department of disease control (1998). There was no any snail of genus *Pila* found at any sampling site. There was only one very old shell of *Pila ampullacea* found outside the sampling area of the study area. This fact was presented in several distribution reports showing that these introduced pomacea species responded to the lost of native ampullariid species such as some from genus *Pila* (Rawlings *et al*., 2007; Yusa and Wada, 1999; Halwart, 1994; Acosta and Pullin, 1989). The very old shells proved that *Pila* had lived around this area before it population was reduced and become a rare species to be found nowadays. Keawjam (1990) reported that *Pila ampullacea*, *Pila pesmei* and *Pila polita* were very common in central Thailand. The native species as *Pila* species were lost in competition with *Pomocea* species may because of the different number of laid eggs. Upatham *et al.* (1995) suggested that a female snail of genus *Pila* laid around 100 – 300 eggs per cluster while a female of genus *Pomocea* laid around 800 – 1,000 eggs per cluster which can increase large number in a short period of time. Even both species laid eggs above water line, *Pomocea* eggs were laid on water plant stalks. Meanwhile, *Pila* eggs were laid on mud or debris which contributed to the high exposure of pesticide than *Pomocea* eggs did. Eventhrough there was no publication of current situation of *Pila*, it is possible to believe that *Pila* snails are in danger but currently still not extinct off Thailand. There were unofficial photo reports via Internet forum by upcountry habitants that *Pila* snails and its egg clusters could be found but very rare in number and chance. In further studies, these *Pila* species should be found by a large

scale sampling survey. Moreover, there was some news report that there was a hybrid between *Pomacea* species and *Pila* species however, there was no study on its effect on rice field (MEAs intelligence Unit, 2009). The invasion of apple snail species destroyed the local ecological and biological system. The high number of golden apple snails was not only affected to the snail native species, but also influenced to bird migration to Thailand. Some Thai stakeholders were worry that the migrated bird would not seasonally move back to China and India because of the abundant food. As well as, Wood T.S. *et al*., 2007 suggested that the alien apple snail related to the lost of some bryozoans by heavy predation.

The total number of found individual of *Pomacea* sp., *Pomacea canaliculata* and *Pomacea insularus* were 62, 63, and 55, respectively. Its ratio was 1.13 : 1.14 : 1, respectively. *P. canaliculata* was the most common species because it was found in all 13 study sites.

Meanwhile, the *Pomacea* sp. is the dominate species, especially in canal area. However, in canal area at site 11, the number of *Pomacea* sp. was very high. This site was the cement bank canal with a massive of morning-glory plant growing along the canal. The snail of this site was very large in size and snails were mostly found mating, high growth rate, long life. This may be because they are not disturbed by human inhabit in an appropriate habitat, abundant of soft aquatic plant as its food, and good water quality. In addition, at the canal site 12, *Pomacea* sp. presented the same result as these of site 11. However, snails of this site were occasionally disturbed by sediment dredge. The snails that were brought up to the bank became bird preys or died by the high temperature during day time. Most of egg clusters were attached on the lotus stalks or cement water gate. The highest number of egg cluster and high mating in canal sites may assumed that the best sanctuary of apple snail species was the canal because food abundance, and less human disturbing. Even if there was significantly different in physical factor results, there was no correlation between the richness value and any physical factors. However there were correlation between the richness value and type of wetlands. This result could be interpreted that the major factor that supports the high number of snail should involve with the some character of canal that differ from the rice field and pond, such as water circulation, abundance of food, and no pesticide contamination.

It was very difficult to find an appropriate pond for using as study areas. There were several small ponds next to the rice field. Most ponds were too small to put 10 quadrates of 1x1 m^2 along their border lines. These ponds were built up in the propose of water supply to the rice field and the snails were usually found in this kind of pond, but most of them were killed by the pesticide, as the evidence of a huge number of snail shell and pesticide containers nearby.

The farmers concern ampullariid snails as pests, therefore their abundance may depend on not only the appropriate physical factors in each rice field but also the serious pest control, either biological field or chemical control methods of the farmer in each rice field (Appendix B). However, there also were some snail preventions that were plant products such as tea leave extract in Japan and *Colocasia esculenta* extract by Thai local wisdom. If the apple snail has not disturbed by these products, it was possible to have high or higher number of individual in rice field areas as those of canal areas.

However, some researcher stated that it was very difficult to get rid of apple snails. The best way to manage this problem is to control its number. In Japan, the farmers change their attitude toward snail and not treat it as a rice pest, but in environmental friendly way (Kenji 2003).

Pomacea canaliculata can be found in all sampling sites.

CHAPTER VII
CONCLUSION

All 130 samplings areas were conducted at thirteen wetland sampling sites in nine out of 13 Districts of Saraburi Province. They were randomly selected by considering at a large common rice field area and accessibility. 13 wetlands consisted of ten rice fields, two canals and one pond.

Each of the physical factors showed slightly significantly different between each area ($P< 0.05$). The average soil pH of rice field was slightly lower than ones of canal and pond ($P< 0.05$). As well as, the average water pH of rice field was also slightly lower than one of others type wetlands ($P< 0.05$). The average water temperature in canal was higher than one of other wetlands. Average air temperature of all three type of wetlands were slightly different to each other ($P< 0.05$). The degrees of air temperature from the highest to the lowest were in order as follows: canal, rice field, and pond. The average humidity of rice field was not significantly different to ones of canals and pond, however, there was a significantly different between canal and pond.

The totals of 180 ampullariid snails were found in this study. They were classified under the same genus *Pomacea*. There was no any life snail of genus *Pila* found at any sampling sites except the old shell of *Pila ampullacea*. There were three life species of *Pomacea*, *Pomacea*. sp., *P. canaliculata,* and *P. insularus*, The highest and lowest numbers of living individuals both found in rice field study areas. *Pomacea canaliculata* was common of this study because of its abundance in every study areas. *Pomacea* sp. was a dominate species of the canal area, meanwhile, *Pomacea canaliculata* was a dominate species of the rice field area. The largest shell size (6.9 cm. in width and 8.9 cm. in length) was *Pomacea* sp. found in canal and the smallest one (1.5 cm. in width and 1.7 cm. in length) was *P. insularus* found in rice field.

The highest richness, diversity index and the evenness values were found at the rice field area. There was no significantly different between the total number of individuals in each site (P>0.05). The highest number of egg clusters was found at the canal area. There was no significantly different of the number of egg cluster of each sampling site. The similarity index of ampullariid species between the rice field and canal was 100%, and it was 85.71% between the canal and pond, and also between rice field and pond. The site richness values of each wetland type were not significantly different between one another (P>0.05). The highest and lowest values were found in the rice field. There was no significantly different of diversity Index between each type of wetland (P>0.05). As well as, there was no significantly different of diversity Index between sites (P>0.05). The highest and lowest diversity index belonged to rice field. There was no significantly different of total value of diversity between each type of wetland (P>0.05), the highest and lowest total diversity was found in rice field.

Among ampullariid species, *Pomacea* sp. was the densest species with the highest percent diversity following by *Pomacea canaliculata.* However, the highest percent diversity of all species found at the rice field. The distribution patterns of ampullariid egg clusters at all sampling sites were mostly clumped or cluster except at sampling site which was random and uniform. Without regarding to its species, the distribution pattern of ampullariid was mostly uniform. Meanwhile, the distribution pattern of *Pomacea* sp. and *P. insularus* was mostly uniform and that of *P. canaliculata* was clumped. In the canal area, all ampullariid species was uniformly distributed except *Pomacea canaliculata*.

There was no correlation between physical factors and richness value (P > 0.05). But there were correlations between type of wetland and some physical factors such as soil, water pH and air temperature. Some physical factors, soil pH, water pH and air temperature of each sampling site are correlated (P < 0.05). In addition, there was a significantly correlation among humidity, water and air temperature, of wetland types and richness.

REFERENCES

Acosta B. O. and Pullin R. S. V. (1989). Environmental impact of the golden snail (*Pomacea* sp.) on rice farming System in The Philippines. Summary report on the workshop, Freshwater Aquaculture Center, The Philippines.

Anon. (1998). The ecology of the golden apple snail (*Pomacea canaliculata* lamarck). Annual research progress report. Department of agriculture, Sabah, Malaysia.

Basilio R. (1991). Problems of golden snail infestation in rice farming. In: Acostia. B. O. And Pullin, R. S. V. (Eds). Environmental impact of the golden snail (*Pomacea* sp.) on rice farming systems in the Philippines, International center for living aquatic resources management, Manila: 11-12.

Boonjaras Samart. (2008). Academic officer, Thai Green Agriculture Group (Information is available on: www.thaigreenagro.com).

Bruton M. N. (1995). Have fishes had their chips-the dilemma of threatened fishes. *Environmental Biology of Fish*, 43: 1-27.

Brandt, R.A.M. (1974). The Non-Marine Aquatic Mollusca of Thailand. *Archiv fur Molluskenkund*, 105: 1-423.

Bureau of General Communicable Disease, Department of disease control (1998). *Atlas of medical Helminthology.*

Courchamp F. J., L. Chapuis and M. Pascal. (2003). Mammal invaders on islands: impact, control and control impact. *Biological Reviews*, 78: 347-387.

Carvolho, G.R. and L. Hauser. (1994). Molecular genetics and the stock concept in fisheries. *Rev. Fish. Biol. Fisheries*, 4: 326-350.

Cowie R. H. (1997). Participation Report Submitted to USAID, Washington, DC. International workshop on Ecology and Management of the golden Apple snail in rice production in Asia, 16-19 June, Phitsanulok. Thailand.

Cowie R. H. (2002). Apple snails (Ampullariidae) as agricultural pests: Their Biology, Impacts, and Management. In: Barker, G. M. (Ed). *Molluscs as crop pests*, Cabi, New York, 145-192.

Duangswasdi, S. (1987). Freshwater abalone. *Journal Kasikorn,* 60 (3): 204-207.

Department of Agricultural Extension statistic. (2007). Thailand. (Information available on: http://www.aec.agr.ku.ac.th).

Department of Agricultural extension, Ministry of agriculture of Thailand, Report no. Kor. Sor. 1025/0627.

E.S. Upatham, M. Kruatrachue, Y. Chitramvong and S. Chantataemae. (1995). *Malacology*. 1st Edition, Bangkok, 517 pp.

Halwart, m. (1994). The golden apple snail *Pomacea canaliculata* in Asean rice farming systems: present impact and future threat. *International journal of pest management,* 40: 199 – 206.

Henderson S. T. P. Dawson and R.J. Whittaker. (2006). Progress in invasive plants research. *Progress in Physical Geography* 30: 25-46.

Hirai, Y. (1988). Apple snail in Japan: The present status and management. *J.A.R.Q*. 22(3): 161 – 165.

Horn K. C., Johnson S. D., Boles K. M., Moore A., Siemann E. and Gabler C. A. (2008) factors affecting hatching success of golden apple snail eggs: Effects of water immersion and cannibalism. *Wetlands*, Vol. 28, No. 2: 544–549.

Invasive Species Specialist Group (ISSG). (2008). Information is available on: http://www.issg.org.

Jambari. H.A., Ismail, A. Esa, Y. M., Wong S.W., Ibrahim. I. and Lat H. L. (1993). interception and control of golden apple snail (*Pomacea* sp.) In Malaysia. *The 3rd Congress of Medical and Applied Malacology*, Sydney, Australia.

Janyapeth, C. and Archawakom T. (1999). Biology of the alien apple snails. *Report on the Alien Apple Snail.* Thai Ministry of Agriculture and Cooperatives, ed. Conference Pailin Hotel, Phitsanulok, Thailand.

Keawjam, R.S. (1990). The Apple snail of Thailand: Molecular Genetics. *J. Med. Appl. Malacol*. 2: 1 - 44.

Keawjam, R.S. and E.S. Upatham. (1990). Shell morphology, reproductive anatomy and genetic patterns of three species of apple snails of the genus *Pomacea* in Thailand. J. Med. Appl. *Malacol*. 2: 45-57.

Kenji Ito. (2003). Expansion of the golden apple snail, *Pomacea canaliculata*, and features of its habitat. Department of Entomology and Nematology. National Agricultural Research Center Japan (information is available on http://www.agnet.org/library/eb/540/).

Kwong King-Lun, Wong Pak-Ki, Lau Sam S. S., and Qiu Jain-Wen. (2008). Determinants of the distribution of apple snails in Hong Kong two decades after their initial invasion. *Malacologia*, 50(1): 293-302.

Lauhachinda, N., S. Duangswasdi and S. Sidhi. (1988). South America golden apple snails (*Pomacea canaliculata*) the new pest of aquatic plants. *Kasetsart University Conference Report 26th*, Kasetsart University, Bangkok, 108-115.

Lauhachinda, N., C. Senawong., D. Phongsmas., V. Udomchoke., U. Homchan and N. Makatan. (1999). Crop Protection and Control from the Golden Apple Snail *Pomacea canaliculata* (Orbigny) by Physiological Means and Biocontrol. *Final Report Submitted to Kasetsart University Research and Development Institute*, Bangkok, 44 pp.

Ministry of commerce Thailand. (2007). Saraburi Province Rice Plantation Surveys.

Mochida O. 1991. Spread of freshwater *Pomacea* snails (Pilidae, Mollusca) from Argentina to Asia. *Micronesia supplement*, 3: 51-62.

National Statistical Office of Thailand. (2003). The 5th Agricultural Census.

Naylor R. 1996. Invasion in agriculture: assessing the cost of the golden apple snail in Asia. *Ambio* 25 (7): 443 – 448.

Oya, S., Hirai, Y. and Miyahara, Y. (1986). Injuring habits of the apple snail, *Ampullarius Insularus* d'orbigny, to the young rice seedlings. *Proceedings of the association of plant protection in Kyushu*, 32: 92-95.

Rawlings T. A., Hayes K. A., Cowie R. H. and Collins T. M. (2007). The identify, distribution, and impacts of non-native apple snails in the continental United States. BMC Evolutionary Biology, 97: 1-14.

Rejesus, B. M., Sayaboc, A.S., Joshi, R.C. (1990). The distribution and control of the introduced golden apple snail (*Pomacea* sp.) in the Philippines. In: introduction of germplasm and quarantine procedures. *Planti proc.* 4: 213 – 224.

Saraburi Provincial Administrative. (2009). Saraburi Province website. (Information is available on : http://www.saraburi.go.th).

SavGIS. (2009). Information is available on: http://www.savgis.org.

Srinives, S. (1999). Pomocea snails Control. Department of Agricultural extension, Ministry of agriculture of Thailand, 60 pp.

Teo Su Sin. (2001). Evaluation of different duck varieties for the control of the golden apple snail *Pomacea canaliculata* in transplanted and direct seeded rice. *Cropprotection,* 20: 599-604.

Teo Su Sin, (2006). Evaluation of different species of fish for biological control of golden apple snail *Pomacea canaliculata* (lamarck) in rice. *Cropprotection,* 25: 1004-1012.

The apple snail website. (1998). Information is available on: www.applesnail.net.

Thaewnon-ngiw, B. (2003). Species Diversity and Molecular Marker of Alien Apple Snails (*Pomacea* sp.) and Native Species (*Pila* sp.) in Thailand. Thesis for complete of Ph.D degree, Graduate School, Kasetsart University, Thailand. 226 pp.

Thai Junior Encyclopedia Project By Royal Command of H.M. the KingThai. 1977. Vol. 3. Thailand.

Thai Metrological department. (2009). *Weather condition monthly summary reports of July to October 2009,* Bangkok.

Timothy S. Wood, Anurakpongsatorn P., Chaichana R., Mahujchariyawong J. and Satapanajaru T. (2006). Heavy predation on freshwater bryozoans by the golden apple Snail, *Pomacea canaliculata* (Lamarck), 1822 (Ampullariidae) *The natural history journal of Chulalongkorn University* 6(1): 31-36.

Wada, T. (1997). Introduction of the apple snail *Pomacea canaliculata* and its impact on rice agriculture. In: Proceedings of the International Workshop on Biological Invasions of Ecosystems by Pests and Beneficial Organisms. *National Institute of Agro-Environmental Sciences*, 170-180.

Wada, T., Ichinose, K. and Higuchi, H. (1999). Effect of drainage on damage to direct-sown rice by the apple snail *Pomacea canaliculata* (Lamarck) (Gastropoda: Ampullariidae). *Appl. Entomol. Zool.* 34: 365-370.

Woods, s. T., Anurakpongsatorn, P., Chaichana, A., Mahujchariyawong J., Satapanajaru, T. (2006). Heavy predation on freshwater bryozoans by the golden pple snail, *Pomacea canaliculata* (Lamarck), 1822 (Ampullariidae). The natural history Journal of Chulalongkorn University 6 (1): 31-36.

Yamanaka, M., Fujiyoshi, N., and Yoshida, K. (1988). Injuring habits of the apple snail (*Pomacea canaliculata* Lamarck) to the rice plant. *Bulletin Fukuoka Agriculture research center*, 8: 29-32.

Yusa Y. and Wada, T. (1999). Impact of the introduction of apple snails and their control in Japan. Naga, *The ICLARM Quarterly* 22: 9-13.

APPENDICES

APPENDIX A

STUDY AREAS

Sampling site 1. Ta Chang Sub-District, Sao Hai District, Saraburi Province.

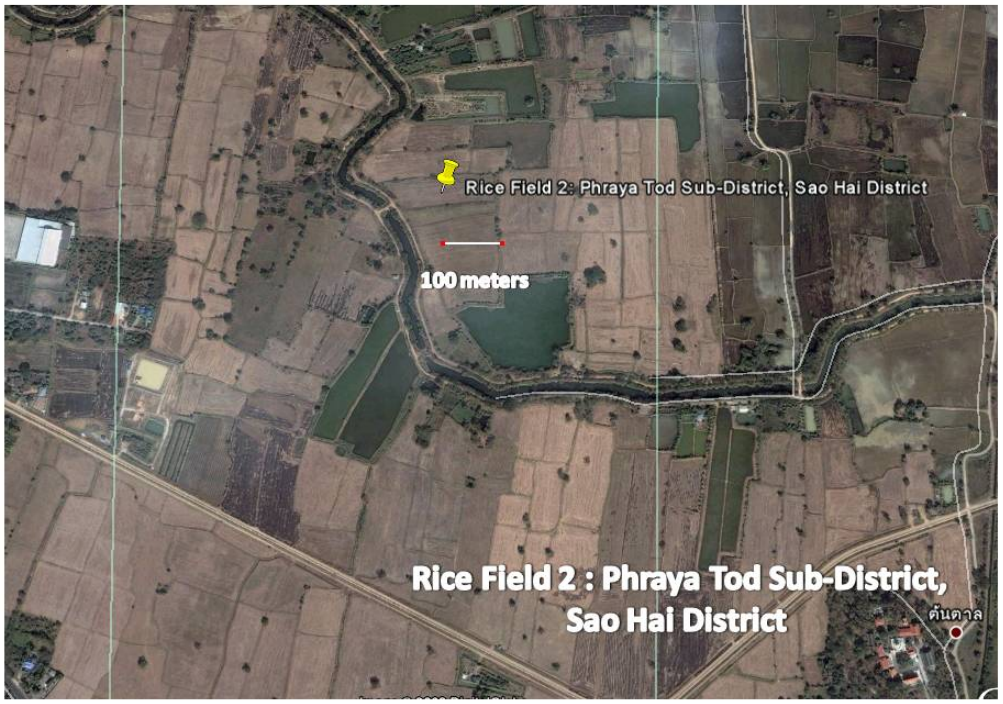
Rice field

***Pomacea* snail's egg clusters attached on rice trees and aquatic plants.**

Satellite image showing study area (Google earth, 2010).

Sampling site 2. Phraya Tod Sub-District, Sao Hai District, Saraburi Province.

***Pomacea* snail's egg cluster attaches on the rice trees.**

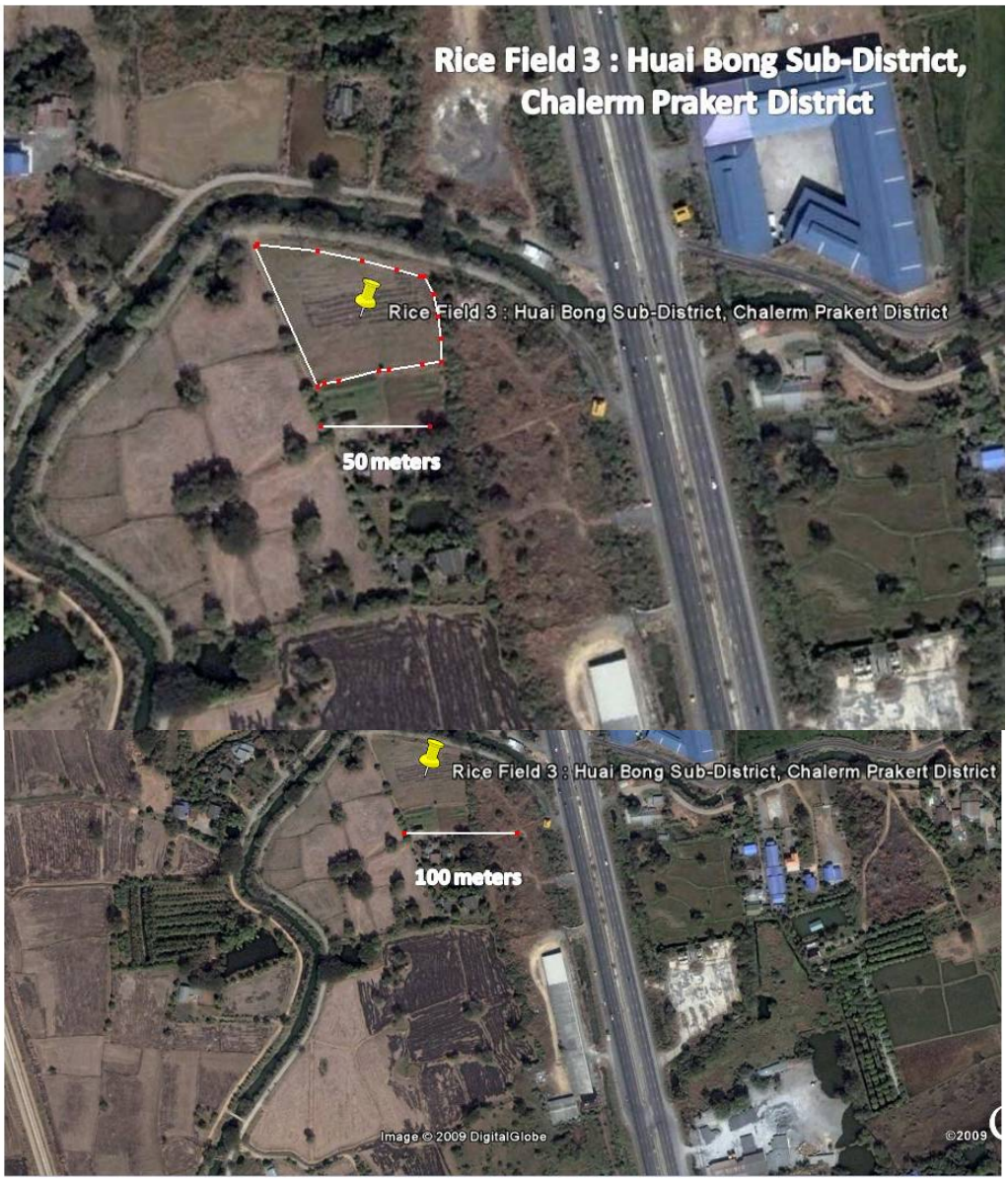


Satellite image showing study area (Google earth, 2010).

Sampling site 3. Huai Bong Sub-District, Chalerm Prakert District, Saraburi Province.

Rice field

***Pomacea* snail and ampullariid's egg cluster attaches on rice trees.**



Satellite image showing study area (Google earth, 2010).

Sampling site 4. Ban Yang Sub-District, Sao Hai District, Saraburi Province.

Rice field

***Pomacea* snail's egg cluster attaches on the rice trees.**

Satellite image showing study area (Google earth, 2010).

Sampling site 5. Nhong Sang Sub-District, Nhong Sang District, Saraburi Province.

Rice field

***Pomacea* snail's egg cluster attaches on the rice trees.**

Satellite image showing study area (Google earth, 2010).

Sampling site 6. Ban Mho Sub-District, Ban Mho District, Saraburi Province.

Rice field

Satellite image showing study area (Google earth, 2010).

Sampling site 7. Nhong Don Sub-District, Nhong Don District, Saraburi Province.

Rice field

Satellite image showing study area (Google earth, 2010).

Sampling site 8. Nhong Sang Sub-District, Nhong Sang District, Saraburi Province.

Rice field

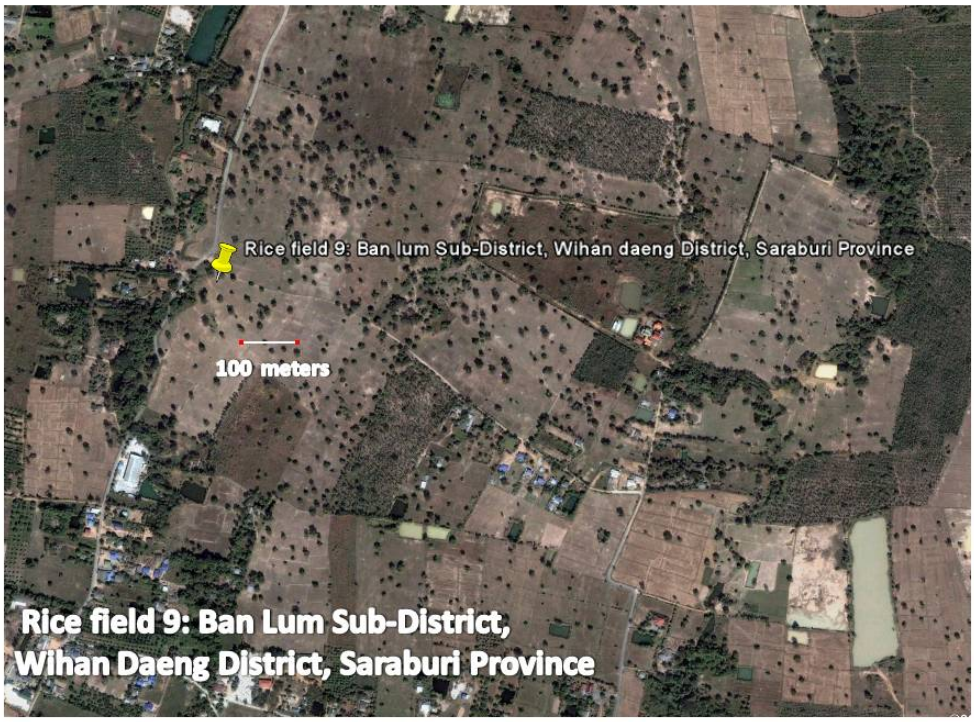
***Pomacea* snail and *Pomacea* snail's egg cluster attaches on the rice trees.**

Satellite image showing study area (Google earth, 2010).

Sampling site 9. Ban Lum Sang Sub-District, Wihan Daeng District, Saraburi Province.

Rice field

***Pomacea* snail's egg cluster attaches on the rice trees.**

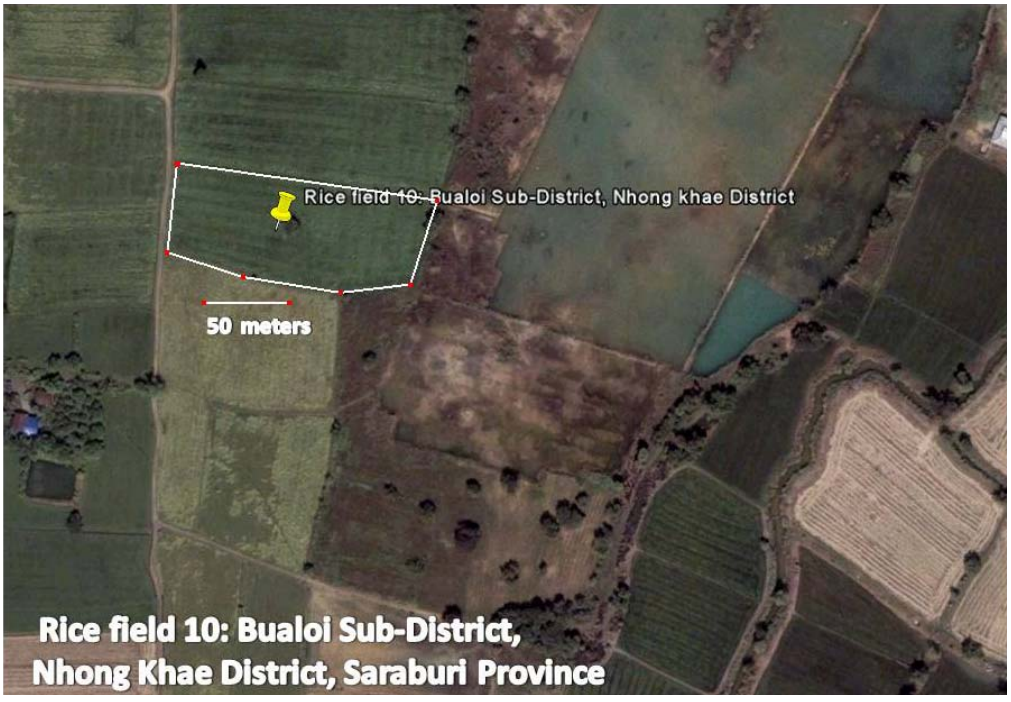


Satellite image showing study area (Google earth, 2010).

Sampling site 10. Bua Loi Sub-District, Nhong Khae District, Saraburi Province.

Rice field

***Pomacea* snail's egg cluster attaches on the rice trees.**



Satellite image showing study area (Google earth, 2010).

Sampling site 11. Dao Rueang Sub-District, Maung District, Saraburi Province.

Canal zone

***P.* sp. on the canal zone**

Satellite image showing study area (Google earth, 2010).

Sampling site 12. Ban Mho Sub-District, Ban Mho Sang District, Saraburi Province.

Canal zone

***Pomacea* snail and egg cluster attaches on aquatic plants.**

Satellite image showing study area (Google earth, 2010).

Sampling site 13. Ban Lum Sub-District, Wihan Daeng District, Saraburi Province.

Pond zone

***Pomacea* snail's egg cluster attaches on the aquatic plant.**

Satellite image showing study area (Google earth, 2010).

APPENDIX B

BIOLOGICAL PEST CONTROL IN RICE FIELD.

Numerous of open-bill stork feed on snail in rice field.

APPENDIX C

GIS DATABASE

Sampling site . 1

COORD_ X	COORD_ Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
701391	1612559	1	2	1	0	0	0	2	0	0	1	0.7071	2
701387	1612544	2	3	3	0	0	0	1	1	1	0	1.7320	3
701383	1612527	3	4	3	0	0	0	1	1	2	1	1.5	4
701373	1612539	4	2	2	0	0	0	1	1	0	1	1.4142	2
701408	1612521	5	3	2	0	0	0	2	1	0	3	1.1547	3
701424	1612521	6	4	3	0	0	0	2	1	1	1	1.5	4
701433	1612527	7	2	2	0	0	0	1	0	1	0	1.4142	2
701437	1612542	8	1	1	0	0	0	1	0	0	1	1	1
701428	1612549	9	1	1	0	0	0	0	0	1	0	1	1
701414	1612550	10	1	1	0	0	0	0	1	0	3	1	1
		total	23	3	0	0	0	11	6	6	11	0.6255	2.3
		% density	100					47.8260	26.0869	26.0869	47.8260		
		Average	2.3					1.1	0.6	0.6	1.1		
		Variance(s)	1.3444					0.5444	0.2666	0.4888	1.2111		
		Distribution	0.5845 Uniform					0.4949 Uniform	0.4444 Uniform	0.8148 Uniform	1.1010 Clumped		

Sampling site . 2

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
702167	1610954	1	2	2	0	0	0	1	0	1	2	1.4142	2
702211	1610955	2	1	1	0	0	0	1	0	0	0	1	1
702255	1610957	3	3	2	0	0	0	2	0	1	0	1.1547	3
702296	1610984	4	2	2	0	0	0	1	0	1	0	1.4142	2
702322	1611005	5	3	2	0	0	0	2	0	1	0	1.1547	3
702302	1611000	6	0	0	0	0	0	0	0	0	0		0
702259	161030	7	0	0	0	0	0	0	0	0	2		0
702212	1611024	8	2	2	0	0	0	1	1	0	0	1.4142	2
702170	1611020	9	2	2	0	0	0	1	0	1	0	1.4142	2
702142	1611005	10	2	2	0	0	0	0	1	1	2	1.4142	2
		total	17	3	0	0	0	9	2	6	6	0.7276	1.7
		% density	100					529411	11.7647	352941			
		Average	1.7					09	0.2	06	06		
		Variance(s)	1.1222					0.54444	0.1777	02666	09333		
		Distribution	0.6601 Uniform					0.6049 Uniform	0.8888 Uniform	0.4444 Uniform	1.5555 Clumped		

Sampling site . 3

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
704688	1612403	1	1	1	0	0	0	0	0	1	0	1.0000	1
704697	1612380	2	0	0	0	0	0	0	0	0	0		0
704705	1612358	3	1	1	0	0	0	0	0	1	0	1.0000	1
704721	1612343	4	1	1	0	0	0	0	0	1	1	1.0000	1
704747	1612346	5	1	1	0	0	0	0	0	1	0	1.0000	1
704771	1612348	6	2	2	0	0	0	0	2	0	0	1.4142	2
704772	1612371	7	1	1	0	0	0	1	0	0	4	1.0000	1
704762	1612393	8	1	1	0	0	0	1	0	0	1	1.0000	1
704738	1612398	9	0	0	0	0	0	0	0	0	0		0
704714	1612402	10	2	1	0	0	0	2	0	0	2	0.7071	2
		total	10	3	0	0	0	4	2	4	8	0.9487	1
		% density	100					40	20	40	0		
		Average	1					0.4	0.2	0.4	0.8		
		Variance(s)	0.4444					0.4889	0.4000	0.2667	1.7333		
		Distribution	0.4444 Uniform					1.2222 Clumped	2.0000 Clumped	0.6667 Uniform	2.1667 Clumped		

Sampling site . 4

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
696170	1612727	1	2	1	0	0	0	0	2	0	1	0.7071	2
696180	1612752	2	1	1	0	0	0	1	0	0	0	1.0000	1
696154	1612752	3	3	3	0	0	0	1	1	1	2	1.7321	3
696134	1612760	4	1	1	0	0	0	0	1	0	0	1.0000	1
696107	1612760	5	2	2	0	0	0	1	0	1	0	1.4142	2
696079	1612758	6	0	0	0	0	0	0	0	0	1		0
696083	1612735	7	2	2	0	0	0	0	1	1	0	1.4142	2
696108	1612738	8	2	1	0	0	0	0	0	2	3	0.7071	2
683564	1612634	9	0	0	0	0	0	0	0	0	1		0
696160	1612726	10	2	2	0	0	0	1	0	0	0	1.4142	2
		total	15	3	0	0	0	4	5	5	8	0.7746	1.5
		% density	100					26.6667	33.3333	33.3333	6.6667		
		Average	1.5					0.4	0.5	0.5	0.1		
		Variance(s)	0.9444					0.2667	0.5000	0.5000	0.1667		
		Distribution	0.6296 Uniform					0.6667 Uniform	1.0000 Random	1.0000 Random	1.6667 Clumped		

Sampling site . 5

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
693136	1606145	1	2	2	0	0	0	0	1	1	2	1.4142	2
693156	1606159	2	2	2	0	0	0	0	1	1	1	1.4142	2
693179	1606165	3	2	2	0	0	0	0	1	1	0	1.4142	2
693200	1606174	4	1	1	0	0	0	0	1	0	2	1	1
693192	1606197	5	1	1	0	0	0	0	0	1	0	1	1
693171	1606203	6	2	2	0	0	0	0	1	1	0	1.4142	2
693181	1606191	7	2	2	0	0	0	1	0	1	0	1.4142	2
693130	1606182	8	1	1	0	0	0	1	0	0	0	1	1
693112	1606173	9	1	1	0	0	0	0	0	1	3	1	1
693118	1606159	10	1	1	0	0	0	1	0	0	0	1	1
		total	15	3	0	0	0	3	5	7	8	0.7745	1.5
		% density	100					20	33.3333	46.6666	533333		
		Average	1.5					0.3	0.5	0.7	0.8		
		Variance(s)	0.2777					0.2333	0.2777	0.2333	1.2888		
		Distribution	0.1851 Uniform					0.7777 Uniform	0.5555 Uniform	0.3333 Uniform	1.6111 Clumped		

Sampling site . 6

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
685722	1616239	1	1	1	0	0	0	1	0	0	0	1	1
685724	1616265	2	1	1	0	0	0	1	0	0	0	1	1
685714	1616265	3	0	0	0	0	0	0	0	0	1		0
685701	1616292	4	0	0	0	0	0	0	0	0	0		0
685677	1616289	5	2	1	0	0	0	2	0	0	0	0.7071	2
685624	1616287	6	0	0	0	0	0	0	0	0	0		0
685642	1616268	7	0	0	0	0	0	0	0	0	2		0
685646	1616242	8	1	1	0	0	0	1	0	0	0	1	1
685669	1616239	9	0	0	0	0	0	0	0	0	0		0
685698	1616237	10	1	1	0	0	0	0	1	0	0	1	1
		total	6	2	0	0	0	5	1	0	3	0.8164	0.6
		% density	100					83.3333	16.6666	0	0		
		Average	0.6					05	0.1	0	0.3		
		Variance(s)	0.4888					05	0.1	0	0.4555		
		Distribution	0.8148 Uniform					1 Random	1 Random	0 0	1.5185 Clumped		

Sampling site . 7

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
685796	1622535	1	2	1	0	0	0	0	2	0	0	0.7071	2
685772	1622596	2	0	1	0	0	0	0	0	0	0		0
685747	1622656	3	0	0	0	0	0	0	0	0	0		0
685723	1622715	4	1	0	0	0	0	0	0	1	0	1	1
685659	1622690	5	1	1	0	0	0	0	1	0	0	1	1
685602	1622665	6	1	0	0	0	0	1	0	0	0	1	1
685618	1622605	7	0	0	0	0	0	0	0	0	0		0
685647	1622542	8	2	1	0	0	0	0	1	1	0	1.4142	2
685674	1622485	9	1	0	0	0	0	0	1	0	0	1	1
685733	1622510	10	1	1	0	0	0	0	1	0	0	1	1
		total	9	2	0	0	0	1	6	2	0	1	0.9
		% density	100					11.1111	66.6666	22.2222	0		
		Average	0.9					0.1	0.6	0.2	0		
		Variance(s)	0.5444					0.1	0.4888	0.1777	0		
		Distribution	0.6049 Uniform					1 Random	0.8148 Uniform	0.8888 Uniform	0 0		

Sampling site 8

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
714181	1601633	1	6	2	0	0	0	0	4	2	2	0.8164	6
714177	1601600	2	2	2	0	0	0	0	1	1	0	1.4142	2
714172	1601567	3	3	2	0	0	0	0	1	2	1	1.1547	3
714167	1601535	4	2	1	0	0	0	0	0	2	0	0.7071	2
714161	1601507	5	2	2	0	0	0	0	1	1	0	1.4142	2
714190	1601500	6	0	0	0	0	0	0	0	0	1		0
714208	160154	7	3	2	0	0	0	0	2	1	0	1.1547	3
714211	1601556	8	3	2	0	0	0	0	2	1	0	1.1547	3
714213	1601588	9	1	1	0	0	0	0	0	1	0	1	1
714202	1601617	10	2	1	0	0	0	0	2	0	1	0.7071	2
		total	24	3	0	0	0	0	13	11	5	0.4082	2.4
		% density	100					0	54.1666	45.8333	20.8333		
		Average	2.4					0	13	1.1	0.5		
		Variance(s)	2.4888					0	1.5666	0.5444	0.5		
		Distribution	1.0370 Clumped					0 0	1.2051 Clumped	0.4949 Uniform	1 Random		

Sampling site : 9

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
713122	1591479	1	0	0	0	0	0	0	0	0	0		0
713152	1591460	2	0	0	0	0	0	0	0	0	1		0
713183	1591449	3	1	1	0	0	0	1	0	0	0	1	1
713217	1591437	4	0	0	0	0	0	0	0	0	0		0
713251	1591428	5	1	1	0	0	0	0	1	0	0	1	1
713263	1591452	6	0	0	0	0	0	0	0	0	0		0
713241	1591467	7	0	0	0	0	0	0	0	0	0		0
713210	1597477	8	1	1	0	0	0	0	1	0	0	1	1
713177	1591485	9	0	0	0	0	0	0	0	0	1		0
713145	1591500	10	0	0	0	0	0	0	0	0	0		0
		total	3	2				1	2	0	2	1.1547	0.3
		%density	100					33.3333	66.6666	0			
		Average	0.3					0.1	0.2	0	0.2		
		Variance(s)	0.2333					0.1	0.1777	0	0.1777		
		Distribution	0.7777 Uniform					1 Random	0.8888 Uniform		0.8888 Uniform		

Sampling site. 10

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m²
697210	1593549	1	2	1	0	0	0	0	0	2	0	0.7071	2
697248	1593538	2	1	1	0	0	0	0	0	1	0	1	1
697288	1593526	3	0	0	0	0	0	0	0	0	0		0
696614	1594248	4	2	1	0	0	0	0	2	0	0	0.7071	2
697359	1593540	5	1	1	0	0	0	0	0	1	0	1	1
697371	1593578	6	1	1	0	0	0	0	0	1	0	1	1
697330	1593584	7	2	1	0	0	0	0	2	0	0	0.7071	2
697287	1593590	8	1	1	0	0	0	0	2	0	0	1	1
697249	1593587	9	0	0	0	0	0	0	0	0	0		0
697214	1593589	10	1	1	0	0	0	0	1	0	0	1	1
		total	11	2	0	0	0	0	7	5	0	0.6030	1.1
		%density	100					0	54.5454	45.4545	0		
		Average	1.1					0	0.7	0.5	0		
		Variance(s)	0.5444					0	0.9	0.5	0		
		Distribution	0.4949 Uniform						1.2857 Clumped	1 Random			

Sampling site . 11

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
703665	1610144	1	2	1	0	0	0	2	0	0	2	0.7071	2
703670	1610170	2	3	1	0	0	0	3	0	0	2	0.5773	3
703678	1610192	3	2	1	0	0	0	2	0	0	0	0.7071	2
703687	1610213	4	2	1	0	0	0	2	0	0	3	0.7071	2
703698	1610236	5	2	1	0	0	0	0	2	0	0	0.7071	2
703706	1610262	6	3	2	0	0	0	2	0	1	1	1.1547	3
703721	1610282	7	1	1	0	0	0	1	0	0	1	1	1
703735	1610304	8	1	1	0	0	0	1	0	0	0	1	1
703749	1610325	9	2	1	0	0	0	2	0	0	1	0.7071	2
703768	1610343	10	3	2	0	0	0	2	0	1	3	1.1547	3
		total	21	3	0	0	0	17	2	2	13	0.6546	2.1
		%density	100					80.9523	9.5238	9.5238			
		Average	2.1					1.7	0.2	0.2	1.3		
		Variance(s)	0.5444					0.6777	0.4	0.1777	1.3444		
		Distribution	0.2592 Uniform					0.3986 Uniform	2 Clumped	0.8888 Uniform	1.0341 Clumped		

Sampling site . 12

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
693757	1612560	1	2	1	0	0	0	2	0	0	4	0.7071	2
693732	1612555	2	1	1	0	0	0	1	0	0	3	1	1
6393711	1612549	3	2	1	0	0	0	2	0	0	0	0.7071	2
693685	16112542	4	1	1	0	0	0	0	0	1	0	1	1
693660	1612535	5	1	1	0	0	0	1	0	0	2	1	1
693637	1612529	6	1	1	0	0	0	0	1	0	0	1	1
693621	1612527	7	1	1	0	0	0	0	0	1	0	1	1
693589	1612511	8	1	1	0	0	0	0	1	0	0	1	1
693566	1612506	9	3	2	0	0	0	1	2	0	8	1.1547	3
693544	1612498	10	2	2	0	0	0	0	1	1	1	1.4142	2
		total	15	3	0	0	0	7	5	3	18	0.7745	1.5
		%density	100					46.6666	33.3333	20			
		Average	1.5					0.7	0.5	0.3	1.8		
		Variance(s)	0.5					0.6777	0.5	0.2333	6.8444		
		Distibution	0.3333 Uniform					0.9682 Uniform	1 Random	0.7777 Uniform	3.8024 Clumped		

Sampling site . 13

COORD_X	COORD_Y	Plot ID	Individuals	Species	*Pila polita*	*P. ampullacea*	*P. pesmei*	*Pomacea* sp.	*P. canaliculata*	*P. insularus*	No. egg batch	Richness	Density/m^2
713121	1591471	1	1	1	0	0	0	0	0	1	4	1	1
713123	1591465	2	1	1	0	0	0	0	0	1	2	1	1
713124	1591458	3	2	1	0	0	0	0	2	0	0	0.7071	2
713119	1591453	4	1	1	0	0	0	0	1	0	0	1	1
713113	1591453	5	1	1	0	0	0	0	1	0	0	1	1
713106	1591450	6	1	1	0	0	0	0	1	0	0	1	1
713099	1591452	7	0	1	0	0	0	0	0	0	2		0
713105	1591457	8	2	1	0	0	0	0	0	2	0	0.7071	2
713110	1591462	9	0	0	0	0	0	0	0	0	0		0
713113	1591469	10	2	1	0	0	0	0	2	0	0	0.7071	2
		total	11	2	0	0	0	0	7	4	8	0.6030	1.1
		%density	100					0	63.6363	36.3636			
		Average	1.1					0	0.7	0.4	0.8		
		Variance(s)	0.5444					0	0.6777	0.4888	1.9555		
		Distribution	0.4949 Uniform						0.9682 Uniform	1.2222 Clumped	2.4444 Clumped		

APPENDIX D

PHYSICAL FACTOR

Comparison between each site

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SMEAN(Soil_pH)	Between Groups	10.463	12	.872	20.760	.000
	Within Groups	4.914	117	.042		
	Total	15.377	129			
Water_pH	Between Groups	12.152	12	1.013	22.763	.000
	Within Groups	5.205	117	.044		
	Total	17.357	129			
Water_temp	Between Groups	202.526	12	16.877	73.151	.000
	Within Groups	26.994	117	.231		
	Total	229.520	129			
Air_temp	Between Groups	503.651	12	41.971	201.525	.000
	Within Groups	24.367	117	.208		
	Total	528.018	129			
Humidity	Between Groups	12189.177	12	1015.765	735.856	.000
	Within Groups	161.505	117	1.380		
	Total	12350.682	129			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
SMEAN(Soil_pH)	1.00	2.00	-.06000	.09165	1.000	-.3700	.2500
		3.00	-.08000	.09165	1.000	-.3900	.2300
		4.00	-.22000	.09165	.451	-.5300	.0900
		5.00	-.16000	.09165	.871	-.4700	.1500
		6.00	-.45000(*)	.09165	.000	-.7600	-.1400
		7.00	-.35000(*)	.09165	.013	-.6600	-.0400
		8.00	.15000	.09165	.914	-.1600	.4600
		9.00	.43000(*)	.09165	.001	.1200	.7400
		10.00	.47000(*)	.09165	.000	.1600	.7800
		11.00	-.08500	.09165	.999	-.3950	.2250
		12.00	-.46000(*)	.09165	.000	-.7700	-.1500
		13.00	-.29000	.09165	.091	-.6000	.0200
	2.00	1.00	.06000	.09165	1.000	-.2500	.3700
		3.00	-.02000	.09165	1.000	-.3300	.2900
		4.00	-.16000	.09165	.871	-.4700	.1500
		5.00	-.10000	.09165	.997	-.4100	.2100
		6.00	-.39000(*)	.09165	.003	-.7000	-.0800
		7.00	-.29000	.09165	.091	-.6000	.0200
		8.00	.21000	.09165	.528	-.1000	.5200
		9.00	.49000(*)	.09165	.000	.1800	.8000
		10.00	.53000(*)	.09165	.000	.2200	.8400
		11.00	-.02500	.09165	1.000	-.3350	.2850
		12.00	-.40000(*)	.09165	.002	-.7100	-.0900
		13.00	-.23000	.09165	.378	-.5400	.0800
	3.00	1.00	.08000	.09165	1.000	-.2300	.3900
		2.00	.02000	.09165	1.000	-.2900	.3300
		4.00	-.14000	.09165	.947	-.4500	.1700
		5.00	-.08000	.09165	1.000	-.3900	.2300
		6.00	-.37000(*)	.09165	.006	-.6800	-.0600
		7.00	-.27000	.09165	.156	-.5800	.0400
		8.00	.23000	.09165	.378	-.0800	.5400
		9.00	.51000(*)	.09165	.000	.2000	.8200
		10.00	.55000(*)	.09165	.000	.2400	.8600
		11.00	-.00500	.09165	1.000	-.3150	.3050
		12.00	-.38000(*)	.09165	.004	-.6900	-.0700
		13.00	-.21000	.09165	.528	-.5200	.1000
	4.00	1.00	.22000	.09165	.451	-.0900	.5300
		2.00	.16000	.09165	.871	-.1500	.4700

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3.00	.14000	.09165	.947	-.1700	.4500
		5.00	.06000	.09165	1.000	-.2500	.3700
		6.00	-.23000	.09165	.378	-.5400	.0800
		7.00	-.13000	.09165	.969	-.4400	.1800
		8.00	.37000(*)	.09165	.006	.0600	.6800
		9.00	.65000(*)	.09165	.000	.3400	.9600
		10.00	.69000(*)	.09165	.000	.3800	1.0000
		11.00	.13500	.09165	.959	-.1750	.4450
		12.00	-.24000	.09165	.311	-.5500	.0700
		13.00	-.07000	.09165	1.000	-.3800	.2400
	5.00	1.00	.16000	.09165	.871	-.1500	.4700
		2.00	.10000	.09165	.997	-.2100	.4100
		3.00	.08000	.09165	1.000	-.2300	.3900
		4.00	-.06000	.09165	1.000	-.3700	.2500
		6.00	-.29000	.09165	.091	-.6000	.0200
		7.00	-.19000	.09165	.682	-.5000	.1200
		8.00	.31000	.09165	.050	.0000	.6200
		9.00	.59000(*)	.09165	.000	.2800	.9000
		10.00	.63000(*)	.09165	.000	.3200	.9400
		11.00	.07500	.09165	1.000	-.2350	.3850
		12.00	-.30000	.09165	.068	-.6100	.0100
		13.00	-.13000	.09165	.969	-.4400	.1800
	6.00	1.00	.45000(*)	.09165	.000	.1400	.7600
		2.00	.39000(*)	.09165	.003	.0800	.7000
		3.00	.37000(*)	.09165	.006	.0600	.6800
		4.00	.23000	.09165	.378	-.0800	.5400
		5.00	.29000	.09165	.091	-.0200	.6000
		7.00	.10000	.09165	.997	-.2100	.4100
		8.00	.60000(*)	.09165	.000	.2900	.9100
		9.00	.88000(*)	.09165	.000	.5700	1.1900
		10.00	.92000(*)	.09165	.000	.6100	1.2300
		11.00	.36500(*)	.09165	.007	.0550	.6750
		12.00	-.01000	.09165	1.000	-.3200	.3000
		13.00	.16000	.09165	.871	-.1500	.4700
	7.00	1.00	.35000(*)	.09165	.013	.0400	.6600
		2.00	.29000	.09165	.091	-.0200	.6000
		3.00	.27000	.09165	.156	-.0400	.5800
		4.00	.13000	.09165	.969	-.1800	.4400
		5.00	.19000	.09165	.682	-.1200	.5000
		6.00	-.10000	.09165	.997	-.4100	.2100
		8.00	.50000(*)	.09165	.000	.1900	.8100
		9.00	.78000(*)	.09165	.000	.4700	1.0900
		10.00	.82000(*)	.09165	.000	.5100	1.1300
		11.00	.26500	.09165	.177	-.0450	.5750
		12.00	-.11000	.09165	.992	-.4200	.2000

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		13.00	.06000	.09165	1.000	-.2500	.3700
	8.00	1.00	-.15000	.09165	.914	-.4600	.1600
		2.00	-.21000	.09165	.528	-.5200	.1000
		3.00	-.23000	.09165	.378	-.5400	.0800
		4.00	-.37000(*)	.09165	.006	-.6800	-.0600
		5.00	-.31000	.09165	.050	-.6200	.0000
		6.00	-.60000(*)	.09165	.000	-.9100	-.2900
		7.00	-.50000(*)	.09165	.000	-.8100	-.1900
		9.00	.28000	.09165	.120	-.0300	.5900
		10.00	.32000(*)	.09165	.036	.0100	.6300
		11.00	-.23500	.09165	.344	-.5450	.0750
		12.00	-.61000(*)	.09165	.000	-.9200	-.3000
		13.00	-.44000(*)	.09165	.000	-.7500	-.1300
	9.00	1.00	-.43000(*)	.09165	.001	-.7400	-.1200
		2.00	-.49000(*)	.09165	.000	-.8000	-.1800
		3.00	-.51000(*)	.09165	.000	-.8200	-.2000
		4.00	-.65000(*)	.09165	.000	-.9600	-.3400
		5.00	-.59000(*)	.09165	.000	-.9000	-.2800
		6.00	-.88000(*)	.09165	.000	-1.1900	-.5700
		7.00	-.78000(*)	.09165	.000	-1.0900	-.4700
		8.00	-.28000	.09165	.120	-.5900	.0300
		10.00	.04000	.09165	1.000	-.2700	.3500
		11.00	-.51500(*)	.09165	.000	-.8250	-.2050
		12.00	-.89000(*)	.09165	.000	-1.2000	-.5800
		13.00	-.72000(*)	.09165	.000	-1.0300	-.4100
	10.00	1.00	-.47000(*)	.09165	.000	-.7800	-.1600
		2.00	-.53000(*)	.09165	.000	-.8400	-.2200
		3.00	-.55000(*)	.09165	.000	-.8600	-.2400
		4.00	-.69000(*)	.09165	.000	-1.0000	-.3800
		5.00	-.63000(*)	.09165	.000	-.9400	-.3200
		6.00	-.92000(*)	.09165	.000	-1.2300	-.6100
		7.00	-.82000(*)	.09165	.000	-1.1300	-.5100
		8.00	-.32000(*)	.09165	.036	-.6300	-.0100
		9.00	-.04000	.09165	1.000	-.3500	.2700
		11.00	-.55500(*)	.09165	.000	-.8650	-.2450
		12.00	-.93000(*)	.09165	.000	-1.2400	-.6200
		13.00	-.76000(*)	.09165	.000	-1.0700	-.4500
	11.00	1.00	.08500	.09165	.999	-.2250	.3950
		2.00	.02500	.09165	1.000	-.2850	.3350
		3.00	.00500	.09165	1.000	-.3050	.3150
		4.00	-.13500	.09165	.959	-.4450	.1750
		5.00	-.07500	.09165	1.000	-.3850	.2350
		6.00	-.36500(*)	.09165	.007	-.6750	-.0550
		7.00	-.26500	.09165	.177	-.5750	.0450
		8.00	.23500	.09165	.344	-.0750	.5450

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		9.00	.51500(*)	.09165	.000	.2050	.8250
		10.00	.55500(*)	.09165	.000	.2450	.8650
		12.00	-.37500(*)	.09165	.005	-.6850	-.0650
		13.00	-.20500	.09165	.567	-.5150	.1050
	12.00	1.00	.46000(*)	.09165	.000	.1500	.7700
		2.00	.40000(*)	.09165	.002	.0900	.7100
		3.00	.38000(*)	.09165	.004	.0700	.6900
		4.00	.24000	.09165	.311	-.0700	.5500
		5.00	.30000	.09165	.068	-.0100	.6100
		6.00	.01000	.09165	1.000	-.3000	.3200
		7.00	.11000	.09165	.992	-.2000	.4200
		8.00	.61000(*)	.09165	.000	.3000	.9200
		9.00	.89000(*)	.09165	.000	.5800	1.2000
		10.00	.93000(*)	.09165	.000	.6200	1.2400
		11.00	.37500(*)	.09165	.005	.0650	.6850
		13.00	.17000	.09165	.817	-.1400	.4800
	13.00	1.00	.29000	.09165	.091	-.0200	.6000
		2.00	.23000	.09165	.378	-.0800	.5400
		3.00	.21000	.09165	.528	-.1000	.5200
		4.00	.07000	.09165	1.000	-.2400	.3800
		5.00	.13000	.09165	.969	-.1800	.4400
		6.00	-.16000	.09165	.871	-.4700	.1500
		7.00	-.06000	.09165	1.000	-.3700	.2500
		8.00	.44000(*)	.09165	.000	.1300	.7500
		9.00	.72000(*)	.09165	.000	.4100	1.0300
		10.00	.76000(*)	.09165	.000	.4500	1.0700
		11.00	.20500	.09165	.567	-.1050	.5150
		12.00	-.17000	.09165	.817	-.4800	.1400
Water_pH	1.00	2.00	.09000	.09433	.999	-.2290	.4090
		3.00	.05000	.09433	1.000	-.2690	.3690
		4.00	.03000	.09433	1.000	-.2890	.3490
		5.00	.10000	.09433	.998	-.2190	.4190
		6.00	.00000	.09433	1.000	-.3190	.3190
		7.00	.02000	.09433	1.000	-.2990	.3390
		8.00	.62000(*)	.09433	.000	.3010	.9390
		9.00	.44000(*)	.09433	.001	.1210	.7590
		10.00	.96000(*)	.09433	.000	.6410	1.2790
		11.00	-.18000	.09433	.787	-.4990	.1390
		12.00	-.09000	.09433	.999	-.4090	.2290
		13.00	.17000	.09433	.845	-.1490	.4890
	2.00	1.00	-.09000	.09433	.999	-.4090	.2290
		3.00	-.04000	.09433	1.000	-.3590	.2790
		4.00	-.06000	.09433	1.000	-.3790	.2590
		5.00	.01000	.09433	1.000	-.3090	.3290
		6.00	-.09000	.09433	.999	-.4090	.2290

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		7.00	-.07000	.09433	1.000	-.3890	.2490
		8.00	.53000(*)	.09433	.000	.2110	.8490
		9.00	.35000(*)	.09433	.018	.0310	.6690
		10.00	.87000(*)	.09433	.000	.5510	1.1890
		11.00	-.27000	.09433	.189	-.5890	.0490
		12.00	-.18000	.09433	.787	-.4990	.1390
		13.00	.08000	.09433	1.000	-.2390	.3990
	3.00	1.00	-.05000	.09433	1.000	-.3690	.2690
		2.00	.04000	.09433	1.000	-.2790	.3590
		4.00	-.02000	.09433	1.000	-.3390	.2990
		5.00	.05000	.09433	1.000	-.2690	.3690
		6.00	-.05000	.09433	1.000	-.3690	.2690
		7.00	-.03000	.09433	1.000	-.3490	.2890
		8.00	.57000(*)	.09433	.000	.2510	.8890
		9.00	.39000(*)	.09433	.004	.0710	.7090
		10.00	.91000(*)	.09433	.000	.5910	1.2290
		11.00	-.23000	.09433	.425	-.5490	.0890
		12.00	-.14000	.09433	.957	-.4590	.1790
		13.00	.12000	.09433	.987	-.1990	.4390
	4.00	1.00	-.03000	.09433	1.000	-.3490	.2890
		2.00	.06000	.09433	1.000	-.2590	.3790
		3.00	.02000	.09433	1.000	-.2990	.3390
		5.00	.07000	.09433	1.000	-.2490	.3890
		6.00	-.03000	.09433	1.000	-.3490	.2890
		7.00	-.01000	.09433	1.000	-.3290	.3090
		8.00	.59000(*)	.09433	.000	.2710	.9090
		9.00	.41000(*)	.09433	.002	.0910	.7290
		10.00	.93000(*)	.09433	.000	.6110	1.2490
		11.00	-.21000	.09433	.574	-.5290	.1090
		12.00	-.12000	.09433	.987	-.4390	.1990
		13.00	.14000	.09433	.957	-.1790	.4590
	5.00	1.00	-.10000	.09433	.998	-.4190	.2190
		2.00	-.01000	.09433	1.000	-.3290	.3090
		3.00	-.05000	.09433	1.000	-.3690	.2690
		4.00	-.07000	.09433	1.000	-.3890	.2490
		6.00	-.10000	.09433	.998	-.4190	.2190
		7.00	-.08000	.09433	1.000	-.3990	.2390
		8.00	.52000(*)	.09433	.000	.2010	.8390
		9.00	.34000(*)	.09433	.026	.0210	.6590
		10.00	.86000(*)	.09433	.000	.5410	1.1790
		11.00	-.28000	.09433	.148	-.5990	.0390
		12.00	-.19000	.09433	.721	-.5090	.1290
		13.00	.07000	.09433	1.000	-.2490	.3890
	6.00	1.00	.00000	.09433	1.000	-.3190	.3190
		2.00	.09000	.09433	.999	-.2290	.4090

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3.00	.05000	.09433	1.000	-.2690	.3690
		4.00	.03000	.09433	1.000	-.2890	.3490
		5.00	.10000	.09433	.998	-.2190	.4190
		7.00	.02000	.09433	1.000	-.2990	.3390
		8.00	.62000(*)	.09433	.000	.3010	.9390
		9.00	.44000(*)	.09433	.001	.1210	.7590
		10.00	.96000(*)	.09433	.000	.6410	1.2790
		11.00	-.18000	.09433	.787	-.4990	.1390
		12.00	-.09000	.09433	.999	-.4090	.2290
		13.00	.17000	.09433	.845	-.1490	.4890
	7.00	1.00	-.02000	.09433	1.000	-.3390	.2990
		2.00	.07000	.09433	1.000	-.2490	.3890
		3.00	.03000	.09433	1.000	-.2890	.3490
		4.00	.01000	.09433	1.000	-.3090	.3290
		5.00	.08000	.09433	1.000	-.2390	.3990
		6.00	-.02000	.09433	1.000	-.3390	.2990
		8.00	.60000(*)	.09433	.000	.2810	.9190
		9.00	.42000(*)	.09433	.001	.1010	.7390
		10.00	.94000(*)	.09433	.000	.6210	1.2590
		11.00	-.20000	.09433	.650	-.5190	.1190
		12.00	-.11000	.09433	.994	-.4290	.2090
		13.00	.15000	.09433	.930	-.1690	.4690
	8.00	1.00	-.62000(*)	.09433	.000	-.9390	-.3010
		2.00	-.53000(*)	.09433	.000	-.8490	-.2110
		3.00	-.57000(*)	.09433	.000	-.8890	-.2510
		4.00	-.59000(*)	.09433	.000	-.9090	-.2710
		5.00	-.52000(*)	.09433	.000	-.8390	-.2010
		6.00	-.62000(*)	.09433	.000	-.9390	-.3010
		7.00	-.60000(*)	.09433	.000	-.9190	-.2810
		9.00	-.18000	.09433	.787	-.4990	.1390
		10.00	.34000(*)	.09433	.026	.0210	.6590
		11.00	-.80000(*)	.09433	.000	-1.1190	-.4810
		12.00	-.71000(*)	.09433	.000	-1.0290	-.3910
		13.00	-.45000(*)	.09433	.000	-.7690	-.1310
	9.00	1.00	-.44000(*)	.09433	.001	-.7590	-.1210
		2.00	-.35000(*)	.09433	.018	-.6690	-.0310
		3.00	-.39000(*)	.09433	.004	-.7090	-.0710
		4.00	-.41000(*)	.09433	.002	-.7290	-.0910
		5.00	-.34000(*)	.09433	.026	-.6590	-.0210
		6.00	-.44000(*)	.09433	.001	-.7590	-.1210
		7.00	-.42000(*)	.09433	.001	-.7390	-.1010
		8.00	.18000	.09433	.787	-.1390	.4990
		10.00	.52000(*)	.09433	.000	.2010	.8390
		11.00	-.62000(*)	.09433	.000	-.9390	-.3010
		12.00	-.53000(*)	.09433	.000	-.8490	-.2110

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		13.00	-.27000	.09433	.189	-.5890	.0490
	10.00	1.00	-.96000(*)	.09433	.000	-1.2790	-.6410
		2.00	-.87000(*)	.09433	.000	-1.1890	-.5510
		3.00	-.91000(*)	.09433	.000	-1.2290	-.5910
		4.00	-.93000(*)	.09433	.000	-1.2490	-.6110
		5.00	-.86000(*)	.09433	.000	-1.1790	-.5410
		6.00	-.96000(*)	.09433	.000	-1.2790	-.6410
		7.00	-.94000(*)	.09433	.000	-1.2590	-.6210
		8.00	-.34000(*)	.09433	.026	-.6590	-.0210
		9.00	-.52000(*)	.09433	.000	-.8390	-.2010
		11.00	-1.14000(*)	.09433	.000	-1.4590	-.8210
		12.00	-1.05000(*)	.09433	.000	-1.3690	-.7310
		13.00	-.79000(*)	.09433	.000	-1.1090	-.4710
	11.00	1.00	.18000	.09433	.787	-.1390	.4990
		2.00	.27000	.09433	.189	-.0490	.5890
		3.00	.23000	.09433	.425	-.0890	.5490
		4.00	.21000	.09433	.574	-.1090	.5290
		5.00	.28000	.09433	.148	-.0390	.5990
		6.00	.18000	.09433	.787	-.1390	.4990
		7.00	.20000	.09433	.650	-.1190	.5190
		8.00	.80000(*)	.09433	.000	.4810	1.1190
		9.00	.62000(*)	.09433	.000	.3010	.9390
		10.00	1.14000(*)	.09433	.000	.8210	1.4590
		12.00	.09000	.09433	.999	-.2290	.4090
		13.00	.35000(*)	.09433	.018	.0310	.6690
	12.00	1.00	.09000	.09433	.999	-.2290	.4090
		2.00	.18000	.09433	.787	-.1390	.4990
		3.00	.14000	.09433	.957	-.1790	.4590
		4.00	.12000	.09433	.987	-.1990	.4390
		5.00	.19000	.09433	.721	-.1290	.5090
		6.00	.09000	.09433	.999	-.2290	.4090
		7.00	.11000	.09433	.994	-.2090	.4290
		8.00	.71000(*)	.09433	.000	.3910	1.0290
		9.00	.53000(*)	.09433	.000	.2110	.8490
		10.00	1.05000(*)	.09433	.000	.7310	1.3690
		11.00	-.09000	.09433	.999	-.4090	.2290
		13.00	.26000	.09433	.237	-.0590	.5790
	13.00	1.00	-.17000	.09433	.845	-.4890	.1490
		2.00	-.08000	.09433	1.000	-.3990	.2390
		3.00	-.12000	.09433	.987	-.4390	.1990
		4.00	-.14000	.09433	.957	-.4590	.1790
		5.00	-.07000	.09433	1.000	-.3890	.2490
		6.00	-.17000	.09433	.845	-.4890	.1490
		7.00	-.15000	.09433	.930	-.4690	.1690
		8.00	.45000(*)	.09433	.000	.1310	.7690

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		9.00	.27000	.09433	.189	-.0490	.5890
		10.00	.79000(*)	.09433	.000	.4710	1.1090
		11.00	-.35000(*)	.09433	.018	-.6690	-.0310
		12.00	-.26000	.09433	.237	-.5790	.0590
Water_temp	1.00	2.00	.62000	.21481	.179	-.1066	1.3466
		3.00	2.41000(*)	.21481	.000	1.6834	3.1366
		4.00	-.84000(*)	.21481	.010	-1.5666	-.1134
		5.00	2.33000(*)	.21481	.000	1.6034	3.0566
		6.00	2.15000(*)	.21481	.000	1.4234	2.8766
		7.00	3.26000(*)	.21481	.000	2.5334	3.9866
		8.00	2.70000(*)	.21481	.000	1.9734	3.4266
		9.00	3.05000(*)	.21481	.000	2.3234	3.7766
		10.00	2.03000(*)	.21481	.000	1.3034	2.7566
		11.00	.19000	.21481	1.000	-.5366	.9166
		12.00	.62000	.21481	.179	-.1066	1.3466
		13.00	1.91000(*)	.21481	.000	1.1834	2.6366
	2.00	1.00	-.62000	.21481	.179	-1.3466	.1066
		3.00	1.79000(*)	.21481	.000	1.0634	2.5166
		4.00	-1.46000(*)	.21481	.000	-2.1866	-.7334
		5.00	1.71000(*)	.21481	.000	.9834	2.4366
		6.00	1.53000(*)	.21481	.000	.8034	2.2566
		7.00	2.64000(*)	.21481	.000	1.9134	3.3666
		8.00	2.08000(*)	.21481	.000	1.3534	2.8066
		9.00	2.43000(*)	.21481	.000	1.7034	3.1566
		10.00	1.41000(*)	.21481	.000	.6834	2.1366
		11.00	-.43000	.21481	.730	-1.1566	.2966
		12.00	.00000	.21481	1.000	-.7266	.7266
		13.00	1.29000(*)	.21481	.000	.5634	2.0166
	3.00	1.00	-2.41000(*)	.21481	.000	-3.1366	-1.6834
		2.00	-1.79000(*)	.21481	.000	-2.5166	-1.0634
		4.00	-3.25000(*)	.21481	.000	-3.9766	-2.5234
		5.00	-.08000	.21481	1.000	-.8066	.6466
		6.00	-.26000	.21481	.992	-.9866	.4666
		7.00	.85000(*)	.21481	.008	.1234	1.5766
		8.00	.29000	.21481	.979	-.4366	1.0166
		9.00	.64000	.21481	.144	-.0866	1.3666
		10.00	-.38000	.21481	.861	-1.1066	.3466
		11.00	-2.22000(*)	.21481	.000	-2.9466	-1.4934
		12.00	-1.79000(*)	.21481	.000	-2.5166	-1.0634
		13.00	-.50000	.21481	.502	-1.2266	.2266
	4.00	1.00	.84000(*)	.21481	.010	.1134	1.5666
		2.00	1.46000(*)	.21481	.000	.7334	2.1866
		3.00	3.25000(*)	.21481	.000	2.5234	3.9766
		5.00	3.17000(*)	.21481	.000	2.4434	3.8966
		6.00	2.99000(*)	.21481	.000	2.2634	3.7166

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		7.00	4.10000(*)	.21481	.000	3.3734	4.8266
		8.00	3.54000(*)	.21481	.000	2.8134	4.2666
		9.00	3.89000(*)	.21481	.000	3.1634	4.6166
		10.00	2.87000(*)	.21481	.000	2.1434	3.5966
		11.00	1.03000(*)	.21481	.000	.3034	1.7566
		12.00	1.46000(*)	.21481	.000	.7334	2.1866
		13.00	2.75000(*)	.21481	.000	2.0234	3.4766
	5.00	1.00	-2.33000(*)	.21481	.000	-3.0566	-1.6034
		2.00	-1.71000(*)	.21481	.000	-2.4366	-.9834
		3.00	.08000	.21481	1.000	-.6466	.8066
		4.00	-3.17000(*)	.21481	.000	-3.8966	-2.4434
		6.00	-.18000	.21481	1.000	-.9066	.5466
		7.00	.93000(*)	.21481	.002	.2034	1.6566
		8.00	.37000	.21481	.881	-.3566	1.0966
		9.00	.72000	.21481	.055	-.0066	1.4466
		10.00	-.30000	.21481	.973	-1.0266	.4266
		11.00	-2.14000(*)	.21481	.000	-2.8666	-1.4134
		12.00	-1.71000(*)	.21481	.000	-2.4366	-.9834
		13.00	-.42000	.21481	.759	-1.1466	.3066
	6.00	1.00	-2.15000(*)	.21481	.000	-2.8766	-1.4234
		2.00	-1.53000(*)	.21481	.000	-2.2566	-.8034
		3.00	.26000	.21481	.992	-.4666	.9866
		4.00	-2.99000(*)	.21481	.000	-3.7166	-2.2634
		5.00	.18000	.21481	1.000	-.5466	.9066
		7.00	1.11000(*)	.21481	.000	.3834	1.8366
		8.00	.55000	.21481	.346	-.1766	1.2766
		9.00	.90000(*)	.21481	.004	.1734	1.6266
		10.00	-.12000	.21481	1.000	-.8466	.6066
		11.00	-1.96000(*)	.21481	.000	-2.6866	-1.2334
		12.00	-1.53000(*)	.21481	.000	-2.2566	-.8034
		13.00	-.24000	.21481	.996	-.9666	.4866
	7.00	1.00	-3.26000(*)	.21481	.000	-3.9866	-2.5334
		2.00	-2.64000(*)	.21481	.000	-3.3666	-1.9134
		3.00	-.85000(*)	.21481	.008	-1.5766	-.1234
		4.00	-4.10000(*)	.21481	.000	-4.8266	-3.3734
		5.00	-.93000(*)	.21481	.002	-1.6566	-.2034
		6.00	-1.11000(*)	.21481	.000	-1.8366	-.3834
		8.00	-.56000	.21481	.318	-1.2866	.1666
		9.00	-.21000	.21481	.999	-.9366	.5166
		10.00	-1.23000(*)	.21481	.000	-1.9566	-.5034
		11.00	-3.07000(*)	.21481	.000	-3.7966	-2.3434
		12.00	-2.64000(*)	.21481	.000	-3.3666	-1.9134
		13.00	-1.35000(*)	.21481	.000	-2.0766	-.6234
	8.00	1.00	-2.70000(*)	.21481	.000	-3.4266	-1.9734
		2.00	-2.08000(*)	.21481	.000	-2.8066	-1.3534

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3.00	-.29000	.21481	.979	-1.0166	.4366
		4.00	-3.54000(*)	.21481	.000	-4.2666	-2.8134
		5.00	-.37000	.21481	.881	-1.0966	.3566
		6.00	-.55000	.21481	.346	-1.2766	.1766
		7.00	.56000	.21481	.318	-.1666	1.2866
		9.00	.35000	.21481	.917	-.3766	1.0766
		10.00	-.67000	.21481	.102	-1.3966	.0566
		11.00	-2.51000(*)	.21481	.000	-3.2366	-1.7834
		12.00	-2.08000(*)	.21481	.000	-2.8066	-1.3534
		13.00	-.79000(*)	.21481	.020	-1.5166	-.0634
	9.00	1.00	-3.05000(*)	.21481	.000	-3.7766	-2.3234
		2.00	-2.43000(*)	.21481	.000	-3.1566	-1.7034
		3.00	-.64000	.21481	.144	-1.3666	.0866
		4.00	-3.89000(*)	.21481	.000	-4.6166	-3.1634
		5.00	-.72000	.21481	.055	-1.4466	.0066
		6.00	-.90000(*)	.21481	.004	-1.6266	-.1734
		7.00	.21000	.21481	.999	-.5166	.9366
		8.00	-.35000	.21481	.917	-1.0766	.3766
		10.00	-1.02000(*)	.21481	.000	-1.7466	-.2934
		11.00	-2.86000(*)	.21481	.000	-3.5866	-2.1334
		12.00	-2.43000(*)	.21481	.000	-3.1566	-1.7034
		13.00	-1.14000(*)	.21481	.000	-1.8666	-.4134
	10.00	1.00	-2.03000(*)	.21481	.000	-2.7566	-1.3034
		2.00	-1.41000(*)	.21481	.000	-2.1366	-.6834
		3.00	.38000	.21481	.861	-.3466	1.1066
		4.00	-2.87000(*)	.21481	.000	-3.5966	-2.1434
		5.00	.30000	.21481	.973	-.4266	1.0266
		6.00	.12000	.21481	1.000	-.6066	.8466
		7.00	1.23000(*)	.21481	.000	.5034	1.9566
		8.00	.67000	.21481	.102	-.0566	1.3966
		9.00	1.02000(*)	.21481	.000	.2934	1.7466
		11.00	-1.84000(*)	.21481	.000	-2.5666	-1.1134
		12.00	-1.41000(*)	.21481	.000	-2.1366	-.6834
		13.00	-.12000	.21481	1.000	-.8466	.6066
	11.00	1.00	-.19000	.21481	1.000	-.9166	.5366
		2.00	.43000	.21481	.730	-.2966	1.1566
		3.00	2.22000(*)	.21481	.000	1.4934	2.9466
		4.00	-1.03000(*)	.21481	.000	-1.7566	-.3034
		5.00	2.14000(*)	.21481	.000	1.4134	2.8666
		6.00	1.96000(*)	.21481	.000	1.2334	2.6866
		7.00	3.07000(*)	.21481	.000	2.3434	3.7966
		8.00	2.51000(*)	.21481	.000	1.7834	3.2366
		9.00	2.86000(*)	.21481	.000	2.1334	3.5866
		10.00	1.84000(*)	.21481	.000	1.1134	2.5666
		12.00	.43000	.21481	.730	-.2966	1.1566

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		13.00	1.72000(*)	.21481	.000	.9934	2.4466
	12.00	1.00	-.62000	.21481	.179	-1.3466	.1066
		2.00	.00000	.21481	1.000	-.7266	.7266
		3.00	1.79000(*)	.21481	.000	1.0634	2.5166
		4.00	-1.46000(*)	.21481	.000	-2.1866	-.7334
		5.00	1.71000(*)	.21481	.000	.9834	2.4366
		6.00	1.53000(*)	.21481	.000	.8034	2.2566
		7.00	2.64000(*)	.21481	.000	1.9134	3.3666
		8.00	2.08000(*)	.21481	.000	1.3534	2.8066
		9.00	2.43000(*)	.21481	.000	1.7034	3.1566
		10.00	1.41000(*)	.21481	.000	.6834	2.1366
		11.00	-.43000	.21481	.730	-1.1566	.2966
		13.00	1.29000(*)	.21481	.000	.5634	2.0166
	13.00	1.00	-1.91000(*)	.21481	.000	-2.6366	-1.1834
		2.00	-1.29000(*)	.21481	.000	-2.0166	-.5634
		3.00	.50000	.21481	.502	-.2266	1.2266
		4.00	-2.75000(*)	.21481	.000	-3.4766	-2.0234
		5.00	.42000	.21481	.759	-.3066	1.1466
		6.00	.24000	.21481	.996	-.4866	.9666
		7.00	1.35000(*)	.21481	.000	.6234	2.0766
		8.00	.79000(*)	.21481	.020	.0634	1.5166
		9.00	1.14000(*)	.21481	.000	.4134	1.8666
		10.00	.12000	.21481	1.000	-.6066	.8466
		11.00	-1.72000(*)	.21481	.000	-2.4466	-.9934
		12.00	-1.29000(*)	.21481	.000	-2.0166	-.5634
Air_temp	1.00	2.00	.85000(*)	.20409	.004	.1597	1.5403
		3.00	2.76000(*)	.20409	.000	2.0697	3.4503
		4.00	.36000	.20409	.863	-.3303	1.0503
		5.00	1.81000(*)	.20409	.000	1.1197	2.5003
		6.00	.75000(*)	.20409	.021	.0597	1.4403
		7.00	3.90000(*)	.20409	.000	3.2097	4.5903
		8.00	1.55000(*)	.20409	.000	.8597	2.2403
		9.00	.75000(*)	.20409	.021	.0597	1.4403
		10.00	.24000	.20409	.994	-.4503	.9303
		11.00	-.31000	.20409	.949	-1.0003	.3803
		12.00	.25000	.20409	.991	-.4403	.9403
		13.00	7.10500(*)	.20409	.000	6.4147	7.7953
	2.00	1.00	-.85000(*)	.20409	.004	-1.5403	-.1597
		3.00	1.91000(*)	.20409	.000	1.2197	2.6003
		4.00	-.49000	.20409	.451	-1.1803	.2003
		5.00	.96000(*)	.20409	.000	.2697	1.6503
		6.00	-.10000	.20409	1.000	-.7903	.5903
		7.00	3.05000(*)	.20409	.000	2.3597	3.7403
		8.00	.70000(*)	.20409	.044	.0097	1.3903
		9.00	-.10000	.20409	1.000	-.7903	.5903

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		10.00	-.61000	.20409	.141	-1.3003	.0803
		11.00	-1.16000(*)	.20409	.000	-1.8503	-.4697
		12.00	-.60000	.20409	.159	-1.2903	.0903
		13.00	6.25500(*)	.20409	.000	5.5647	6.9453
	3.00	1.00	-2.76000(*)	.20409	.000	-3.4503	-2.0697
		2.00	-1.91000(*)	.20409	.000	-2.6003	-1.2197
		4.00	-2.40000(*)	.20409	.000	-3.0903	-1.7097
		5.00	-.95000(*)	.20409	.001	-1.6403	-.2597
		6.00	-2.01000(*)	.20409	.000	-2.7003	-1.3197
		7.00	1.14000(*)	.20409	.000	.4497	1.8303
		8.00	-1.21000(*)	.20409	.000	-1.9003	-.5197
		9.00	-2.01000(*)	.20409	.000	-2.7003	-1.3197
		10.00	-2.52000(*)	.20409	.000	-3.2103	-1.8297
		11.00	-3.07000(*)	.20409	.000	-3.7603	-2.3797
		12.00	-2.51000(*)	.20409	.000	-3.2003	-1.8197
		13.00	4.34500(*)	.20409	.000	3.6547	5.0353
	4.00	1.00	-.36000	.20409	.863	-1.0503	.3303
		2.00	.49000	.20409	.451	-.2003	1.1803
		3.00	2.40000(*)	.20409	.000	1.7097	3.0903
		5.00	1.45000(*)	.20409	.000	.7597	2.1403
		6.00	.39000	.20409	.786	-.3003	1.0803
		7.00	3.54000(*)	.20409	.000	2.8497	4.2303
		8.00	1.19000(*)	.20409	.000	.4997	1.8803
		9.00	.39000	.20409	.786	-.3003	1.0803
		10.00	-.12000	.20409	1.000	-.8103	.5703
		11.00	-.67000	.20409	.066	-1.3603	.0203
		12.00	-.11000	.20409	1.000	-.8003	.5803
		13.00	6.74500(*)	.20409	.000	6.0547	7.4353
	5.00	1.00	-1.81000(*)	.20409	.000	-2.5003	-1.1197
		2.00	-.96000(*)	.20409	.000	-1.6503	-.2697
		3.00	.95000(*)	.20409	.001	.2597	1.6403
		4.00	-1.45000(*)	.20409	.000	-2.1403	-.7597
		6.00	-1.06000(*)	.20409	.000	-1.7503	-.3697
		7.00	2.09000(*)	.20409	.000	1.3997	2.7803
		8.00	-.26000	.20409	.987	-.9503	.4303
		9.00	-1.06000(*)	.20409	.000	-1.7503	-.3697
		10.00	-1.57000(*)	.20409	.000	-2.2603	-.8797
		11.00	-2.12000(*)	.20409	.000	-2.8103	-1.4297
		12.00	-1.56000(*)	.20409	.000	-2.2503	-.8697
		13.00	5.29500(*)	.20409	.000	4.6047	5.9853
	6.00	1.00	-.75000(*)	.20409	.021	-1.4403	-.0597
		2.00	.10000	.20409	1.000	-.5903	.7903
		3.00	2.01000(*)	.20409	.000	1.3197	2.7003
		4.00	-.39000	.20409	.786	-1.0803	.3003
		5.00	1.06000(*)	.20409	.000	.3697	1.7503

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		7.00	3.15000(*)	.20409	.000	2.4597	3.8403
		8.00	.80000(*)	.20409	.009	.1097	1.4903
		9.00	.00000	.20409	1.000	-.6903	.6903
		10.00	-.51000	.20409	.385	-1.2003	.1803
		11.00	-1.06000(*)	.20409	.000	-1.7503	-.3697
		12.00	-.50000	.20409	.418	-1.1903	.1903
		13.00	6.35500(*)	.20409	.000	5.6647	7.0453
	7.00	1.00	-3.90000(*)	.20409	.000	-4.5903	-3.2097
		2.00	-3.05000(*)	.20409	.000	-3.7403	-2.3597
		3.00	-1.14000(*)	.20409	.000	-1.8303	-.4497
		4.00	-3.54000(*)	.20409	.000	-4.2303	-2.8497
		5.00	-2.09000(*)	.20409	.000	-2.7803	-1.3997
		6.00	-3.15000(*)	.20409	.000	-3.8403	-2.4597
		8.00	-2.35000(*)	.20409	.000	-3.0403	-1.6597
		9.00	-3.15000(*)	.20409	.000	-3.8403	-2.4597
		10.00	-3.66000(*)	.20409	.000	-4.3503	-2.9697
		11.00	-4.21000(*)	.20409	.000	-4.9003	-3.5197
		12.00	-3.65000(*)	.20409	.000	-4.3403	-2.9597
		13.00	3.20500(*)	.20409	.000	2.5147	3.8953
	8.00	1.00	-1.55000(*)	.20409	.000	-2.2403	-.8597
		2.00	-.70000(*)	.20409	.044	-1.3903	-.0097
		3.00	1.21000(*)	.20409	.000	.5197	1.9003
		4.00	-1.19000(*)	.20409	.000	-1.8803	-.4997
		5.00	.26000	.20409	.987	-.4303	.9503
		6.00	-.80000(*)	.20409	.009	-1.4903	-.1097
		7.00	2.35000(*)	.20409	.000	1.6597	3.0403
		9.00	-.80000(*)	.20409	.009	-1.4903	-.1097
		10.00	-1.31000(*)	.20409	.000	-2.0003	-.6197
		11.00	-1.86000(*)	.20409	.000	-2.5503	-1.1697
		12.00	-1.30000(*)	.20409	.000	-1.9903	-.6097
		13.00	5.55500(*)	.20409	.000	4.8647	6.2453
	9.00	1.00	-.75000(*)	.20409	.021	-1.4403	-.0597
		2.00	.10000	.20409	1.000	-.5903	.7903
		3.00	2.01000(*)	.20409	.000	1.3197	2.7003
		4.00	-.39000	.20409	.786	-1.0803	.3003
		5.00	1.06000(*)	.20409	.000	.3697	1.7503
		6.00	.00000	.20409	1.000	-.6903	.6903
		7.00	3.15000(*)	.20409	.000	2.4597	3.8403
		8.00	.80000(*)	.20409	.009	.1097	1.4903
		10.00	-.51000	.20409	.385	-1.2003	.1803
		11.00	-1.06000(*)	.20409	.000	-1.7503	-.3697
		12.00	-.50000	.20409	.418	-1.1903	.1903
		13.00	6.35500(*)	.20409	.000	5.6647	7.0453
	10.00	1.00	-.24000	.20409	.994	-.9303	.4503
		2.00	.61000	.20409	.141	-.0803	1.3003

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3.00	2.52000(*)	.20409	.000	1.8297	3.2103
		4.00	.12000	.20409	1.000	-.5703	.8103
		5.00	1.57000(*)	.20409	.000	.8797	2.2603
		6.00	.51000	.20409	.385	-.1803	1.2003
		7.00	3.66000(*)	.20409	.000	2.9697	4.3503
		8.00	1.31000(*)	.20409	.000	.6197	2.0003
		9.00	.51000	.20409	.385	-.1803	1.2003
		11.00	-.55000	.20409	.269	-1.2403	.1403
		12.00	.01000	.20409	1.000	-.6803	.7003
		13.00	6.86500(*)	.20409	.000	6.1747	7.5553
	11.00	1.00	.31000	.20409	.949	-.3803	1.0003
		2.00	1.16000(*)	.20409	.000	.4697	1.8503
		3.00	3.07000(*)	.20409	.000	2.3797	3.7603
		4.00	.67000	.20409	.066	-.0203	1.3603
		5.00	2.12000(*)	.20409	.000	1.4297	2.8103
		6.00	1.06000(*)	.20409	.000	.3697	1.7503
		7.00	4.21000(*)	.20409	.000	3.5197	4.9003
		8.00	1.86000(*)	.20409	.000	1.1697	2.5503
		9.00	1.06000(*)	.20409	.000	.3697	1.7503
		10.00	.55000	.20409	.269	-.1403	1.2403
		12.00	.56000	.20409	.244	-.1303	1.2503
		13.00	7.41500(*)	.20409	.000	6.7247	8.1053
	12.00	1.00	-.25000	.20409	.991	-.9403	.4403
		2.00	.60000	.20409	.159	-.0903	1.2903
		3.00	2.51000(*)	.20409	.000	1.8197	3.2003
		4.00	.11000	.20409	1.000	-.5803	.8003
		5.00	1.56000(*)	.20409	.000	.8697	2.2503
		6.00	.50000	.20409	.418	-.1903	1.1903
		7.00	3.65000(*)	.20409	.000	2.9597	4.3403
		8.00	1.30000(*)	.20409	.000	.6097	1.9903
		9.00	.50000	.20409	.418	-.1903	1.1903
		10.00	-.01000	.20409	1.000	-.7003	.6803
		11.00	-.56000	.20409	.244	-1.2503	.1303
		13.00	6.85500(*)	.20409	.000	6.1647	7.5453
	13.00	1.00	-7.10500(*)	.20409	.000	-7.7953	-6.4147
		2.00	-6.25500(*)	.20409	.000	-6.9453	-5.5647
		3.00	-4.34500(*)	.20409	.000	-5.0353	-3.6547
		4.00	-6.74500(*)	.20409	.000	-7.4353	-6.0547
		5.00	-5.29500(*)	.20409	.000	-5.9853	-4.6047
		6.00	-6.35500(*)	.20409	.000	-7.0453	-5.6647
		7.00	-3.20500(*)	.20409	.000	-3.8953	-2.5147
		8.00	-5.55500(*)	.20409	.000	-6.2453	-4.8647
		9.00	-6.35500(*)	.20409	.000	-7.0453	-5.6647
		10.00	-6.86500(*)	.20409	.000	-7.5553	-6.1747
		11.00	-7.41500(*)	.20409	.000	-8.1053	-6.7247

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		12.00	-6.85500(*)	.20409	.000	-7.5453	-6.1647
Humidity	1.00	2.00	-5.70000(*)	.52543	.000	-7.4772	-3.9228
		3.00	-10.20000(*)	.52543	.000	-11.9772	-8.4228
		4.00	-.50000	.52543	.999	-2.2772	1.2772
		5.00	-.47000	.52543	1.000	-2.2472	1.3072
		6.00	9.47000(*)	.52543	.000	7.6928	11.2472
		7.00	-17.05000(*)	.52543	.000	-18.8272	-15.2728
		8.00	4.17000(*)	.52543	.000	2.3928	5.9472
		9.00	-25.47000(*)	.52543	.000	-27.2472	-23.6928
		10.00	8.73000(*)	.52543	.000	6.9528	10.5072
		11.00	2.68000(*)	.52543	.000	.9028	4.4572
		12.00	-.35000	.52543	1.000	-2.1272	1.4272
		13.00	-10.41000(*)	.52543	.000	-12.1872	-8.6328
	2.00	1.00	5.70000(*)	.52543	.000	3.9228	7.4772
		3.00	-4.50000(*)	.52543	.000	-6.2772	-2.7228
		4.00	5.20000(*)	.52543	.000	3.4228	6.9772
		5.00	5.23000(*)	.52543	.000	3.4528	7.0072
		6.00	15.17000(*)	.52543	.000	13.3928	16.9472
		7.00	-11.35000(*)	.52543	.000	-13.1272	-9.5728
		8.00	9.87000(*)	.52543	.000	8.0928	11.6472
		9.00	-19.77000(*)	.52543	.000	-21.5472	-17.9928
		10.00	14.43000(*)	.52543	.000	12.6528	16.2072
		11.00	8.38000(*)	.52543	.000	6.6028	10.1572
		12.00	5.35000(*)	.52543	.000	3.5728	7.1272
		13.00	-4.71000(*)	.52543	.000	-6.4872	-2.9328
	3.00	1.00	10.20000(*)	.52543	.000	8.4228	11.9772
		2.00	4.50000(*)	.52543	.000	2.7228	6.2772
		4.00	9.70000(*)	.52543	.000	7.9228	11.4772
		5.00	9.73000(*)	.52543	.000	7.9528	11.5072
		6.00	19.67000(*)	.52543	.000	17.8928	21.4472
		7.00	-6.85000(*)	.52543	.000	-8.6272	-5.0728
		8.00	14.37000(*)	.52543	.000	12.5928	16.1472
		9.00	-15.27000(*)	.52543	.000	-17.0472	-13.4928
		10.00	18.93000(*)	.52543	.000	17.1528	20.7072
		11.00	12.88000(*)	.52543	.000	11.1028	14.6572
		12.00	9.85000(*)	.52543	.000	8.0728	11.6272
		13.00	-.21000	.52543	1.000	-1.9872	1.5672
	4.00	1.00	.50000	.52543	.999	-1.2772	2.2772
		2.00	-5.20000(*)	.52543	.000	-6.9772	-3.4228
		3.00	-9.70000(*)	.52543	.000	-11.4772	-7.9228

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		5.00	.03000	.52543	1.000	-1.7472	1.8072
		6.00	9.97000(*)	.52543	.000	8.1928	11.7472
		7.00	-16.55000(*)	.52543	.000	-18.3272	-14.7728
		8.00	4.67000(*)	.52543	.000	2.8928	6.4472
		9.00	-24.97000(*)	.52543	.000	-26.7472	-23.1928
		10.00	9.23000(*)	.52543	.000	7.4528	11.0072
		11.00	3.18000(*)	.52543	.000	1.4028	4.9572
		12.00	.15000	.52543	1.000	-1.6272	1.9272
		13.00	-9.91000(*)	.52543	.000	-11.6872	-8.1328
	5.00	1.00	.47000	.52543	1.000	-1.3072	2.2472
		2.00	-5.23000(*)	.52543	.000	-7.0072	-3.4528
		3.00	-9.73000(*)	.52543	.000	-11.5072	-7.9528
		4.00	-.03000	.52543	1.000	-1.8072	1.7472
		6.00	9.94000(*)	.52543	.000	8.1628	11.7172
		7.00	-16.58000(*)	.52543	.000	-18.3572	-14.8028
		8.00	4.64000(*)	.52543	.000	2.8628	6.4172
		9.00	-25.00000(*)	.52543	.000	-26.7772	-23.2228
		10.00	9.20000(*)	.52543	.000	7.4228	10.9772
		11.00	3.15000(*)	.52543	.000	1.3728	4.9272
		12.00	.12000	.52543	1.000	-1.6572	1.8972
		13.00	-9.94000(*)	.52543	.000	-11.7172	-8.1628
	6.00	1.00	-9.47000(*)	.52543	.000	-11.2472	-7.6928
		2.00	-15.17000(*)	.52543	.000	-16.9472	-13.3928
		3.00	-19.67000(*)	.52543	.000	-21.4472	-17.8928
		4.00	-9.97000(*)	.52543	.000	-11.7472	-8.1928
		5.00	-9.94000(*)	.52543	.000	-11.7172	-8.1628
		7.00	-26.52000(*)	.52543	.000	-28.2972	-24.7428
		8.00	-5.30000(*)	.52543	.000	-7.0772	-3.5228
		9.00	-34.94000(*)	.52543	.000	-36.7172	-33.1628
		10.00	-.74000	.52543	.971	-2.5172	1.0372
		11.00	-6.79000(*)	.52543	.000	-8.5672	-5.0128
		12.00	-9.82000(*)	.52543	.000	-11.5972	-8.0428
		13.00	-19.88000(*)	.52543	.000	-21.6572	-18.1028
	7.00	1.00	17.05000(*)	.52543	.000	15.2728	18.8272
		2.00	11.35000(*)	.52543	.000	9.5728	13.1272

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3.00	6.85000(*)	.52543	.000	5.0728	8.6272
		4.00	16.55000(*)	.52543	.000	14.7728	18.3272
		5.00	16.58000(*)	.52543	.000	14.8028	18.3572
		6.00	26.52000(*)	.52543	.000	24.7428	28.2972
		8.00	21.22000(*)	.52543	.000	19.4428	22.9972
		9.00	-8.42000(*)	.52543	.000	-10.1972	-6.6428
		10.00	25.78000(*)	.52543	.000	24.0028	27.5572
		11.00	19.73000(*)	.52543	.000	17.9528	21.5072
		12.00	16.70000(*)	.52543	.000	14.9228	18.4772
		13.00	6.64000(*)	.52543	.000	4.8628	8.4172
	8.00	1.00	-4.17000(*)	.52543	.000	-5.9472	-2.3928
		2.00	-9.87000(*)	.52543	.000	-11.6472	-8.0928
		3.00	-14.37000(*)	.52543	.000	-16.1472	-12.5928
		4.00	-4.67000(*)	.52543	.000	-6.4472	-2.8928
		5.00	-4.64000(*)	.52543	.000	-6.4172	-2.8628
		6.00	5.30000(*)	.52543	.000	3.5228	7.0772
		7.00	-21.22000(*)	.52543	.000	-22.9972	-19.4428
		9.00	-29.64000(*)	.52543	.000	-31.4172	-27.8628
		10.00	4.56000(*)	.52543	.000	2.7828	6.3372
		11.00	-1.49000	.52543	.200	-3.2672	.2872
		12.00	-4.52000(*)	.52543	.000	-6.2972	-2.7428
		13.00	-14.58000(*)	.52543	.000	-16.3572	-12.8028
	9.00	1.00	25.47000(*)	.52543	.000	23.6928	27.2472
		2.00	19.77000(*)	.52543	.000	17.9928	21.5472
		3.00	15.27000(*)	.52543	.000	13.4928	17.0472
		4.00	24.97000(*)	.52543	.000	23.1928	26.7472
		5.00	25.00000(*)	.52543	.000	23.2228	26.7772
		6.00	34.94000(*)	.52543	.000	33.1628	36.7172
		7.00	8.42000(*)	.52543	.000	6.6428	10.1972
		8.00	29.64000(*)	.52543	.000	27.8628	31.4172
		10.00	34.20000(*)	.52543	.000	32.4228	35.9772
		11.00	28.15000(*)	.52543	.000	26.3728	29.9272
		12.00	25.12000(*)	.52543	.000	23.3428	26.8972
		13.00	15.06000(*)	.52543	.000	13.2828	16.8372
	10.00	1.00	-8.73000(*)	.52543	.000	-10.5072	-6.9528
		2.00	-14.43000(*)	.52543	.000	-16.2072	-12.6528
		3.00	-18.93000(*)	.52543	.000	-20.7072	-17.1528
		4.00	-9.23000(*)	.52543	.000	-11.0072	-7.4528

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		5.00	-9.20000(*)	.52543	.000	-10.9772	-7.4228
		6.00	.74000	.52543	.971	-1.0372	2.5172
		7.00	-25.78000(*)	.52543	.000	-27.5572	-24.0028
		8.00	-4.56000(*)	.52543	.000	-6.3372	-2.7828
		9.00	-34.20000(*)	.52543	.000	-35.9772	-32.4228
		11.00	-6.05000(*)	.52543	.000	-7.8272	-4.2728
		12.00	-9.08000(*)	.52543	.000	-10.8572	-7.3028
		13.00	-19.14000(*)	.52543	.000	-20.9172	-17.3628
	11.00	1.00	-2.68000(*)	.52543	.000	-4.4572	-.9028
		2.00	-8.38000(*)	.52543	.000	-10.1572	-6.6028
		3.00	-12.88000(*)	.52543	.000	-14.6572	-11.1028
		4.00	-3.18000(*)	.52543	.000	-4.9572	-1.4028
		5.00	-3.15000(*)	.52543	.000	-4.9272	-1.3728
		6.00	6.79000(*)	.52543	.000	5.0128	8.5672
		7.00	-19.73000(*)	.52543	.000	-21.5072	-17.9528
		8.00	1.49000	.52543	.200	-.2872	3.2672
		9.00	-28.15000(*)	.52543	.000	-29.9272	-26.3728
		10.00	6.05000(*)	.52543	.000	4.2728	7.8272
		12.00	-3.03000(*)	.52543	.000	-4.8072	-1.2528
		13.00	-13.09000(*)	.52543	.000	-14.8672	-11.3128
	12.00	1.00	.35000	.52543	1.000	-1.4272	2.1272
		2.00	-5.35000(*)	.52543	.000	-7.1272	-3.5728
		3.00	-9.85000(*)	.52543	.000	-11.6272	-8.0728
		4.00	-.15000	.52543	1.000	-1.9272	1.6272
		5.00	-.12000	.52543	1.000	-1.8972	1.6572
		6.00	9.82000(*)	.52543	.000	8.0428	11.5972
		7.00	-16.70000(*)	.52543	.000	-18.4772	-14.9228
		8.00	4.52000(*)	.52543	.000	2.7428	6.2972
		9.00	-25.12000(*)	.52543	.000	-26.8972	-23.3428
		10.00	9.08000(*)	.52543	.000	7.3028	10.8572
		11.00	3.03000(*)	.52543	.000	1.2528	4.8072
		13.00	-10.06000(*)	.52543	.000	-11.8372	-8.2828
	13.00	1.00	10.41000(*)	.52543	.000	8.6328	12.1872
		2.00	4.71000(*)	.52543	.000	2.9328	6.4872
		3.00	.21000	.52543	1.000	-1.5672	1.9872
		4.00	9.91000(*)	.52543	.000	8.1328	11.6872

Dependent Variable	(I) Site_ number	(J) Site_ number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		5.00	9.94000(*)	.52543	.000	8.1628	11.7172
		6.00	19.88000(*)	.52543	.000	18.1028	21.6572
		7.00	-6.64000(*)	.52543	.000	-8.4172	-4.8628
		8.00	14.58000(*)	.52543	.000	12.8028	16.3572
		9.00	-15.06000(*)	.52543	.000	-16.8372	-13.2828
		10.00	19.14000(*)	.52543	.000	17.3628	20.9172
		11.00	13.09000(*)	.52543	.000	11.3128	14.8672
		12.00	10.06000(*)	.52543	.000	8.2828	11.8372

* The mean difference is significant at the .05 level.

Comparison between type of wetlands.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SMEAN(Soil_pH)	Between Groups	1.460	2	.730	6.661	.002
	Within Groups	13.917	127	.110		
	Total	15.377	129			
Water_pH	Between Groups	2.233	2	1.116	9.374	.000
	Within Groups	15.124	127	.119		
	Total	17.357	129			
Water_temp	Between Groups	32.340	2	16.170	10.415	.000
	Within Groups	197.179	127	1.553		
	Total	229.520	129			
Air_temp	Between Groups	364.895	2	182.448	142.045	.000
	Within Groups	163.123	127	1.284		
	Total	528.018	129			
Humidity	Between Groups	916.683	2	458.341	5.091	.007
	Within Groups	11433.999	127	90.031		
	Total	12350.682	129			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Type_wetland	(J) Type_ wetland	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
SMEAN(Soil_pH)	1.00	2.00	-.24550(*)	.08109	.008	-.4378	-.0532
		3.00	-.26300(*)	.10979	.047	-.5234	-.0026
	2.00	1.00	.24550(*)	.08109	.008	.0532	.4378
		3.00	-.01750	.12821	.990	-.3215	.2865
	3.00	1.00	.26300(*)	.10979	.047	.0026	.5234
		2.00	.01750	.12821	.990	-.2865	.3215
Water_pH	1.00	2.00	-.36600(*)	.08453	.000	-.5665	-.1655
		3.00	-.06100	.11445	.855	-.3324	.2104
	2.00	1.00	.36600(*)	.08453	.000	.1655	.5665
		3.00	.30500	.13365	.062	-.0120	.6220
	3.00	1.00	.06100	.11445	.855	-.2104	.3324
		2.00	-.30500	.13365	.062	-.6220	.0120
Water_temp	1.00	2.00	-1.36600(*)	.30521	.000	-2.0898	-.6422
		3.00	.13900	.41326	.940	-.8411	1.1191
	2.00	1.00	1.36600(*)	.30521	.000	.6422	2.0898
		3.00	1.50500(*)	.48259	.006	.3605	2.6495
	3.00	1.00	-.13900	.41326	.940	-1.1191	.8411
		2.00	-1.50500(*)	.48259	.006	-2.6495	-.3605
Air_temp	1.00	2.00	-1.32700(*)	.27761	.000	-1.9853	-.6687
		3.00	5.80800(*)	.37588	.000	4.9166	6.6994
	2.00	1.00	1.32700(*)	.27761	.000	.6687	1.9853
		3.00	7.13500(*)	.43894	.000	6.0941	8.1759
	3.00	1.00	-5.80800(*)	.37588	.000	-6.6994	-4.9166
		2.00	-7.13500(*)	.43894	.000	-8.1759	-6.0941
Humidity	1.00	2.00	4.86700	2.32420	.095	-.6449	10.3789
		3.00	-6.70800	3.14698	.088	-14.1711	.7551
	2.00	1.00	-4.86700	2.32420	.095	-10.3789	.6449
		3.00	-11.57500(*)	3.67488	.006	-20.2900	-2.8600
	3.00	1.00	6.70800	3.14698	.088	-.7551	14.1711
		2.00	11.57500(*)	3.67488	.006	2.8600	20.2900

* The mean difference is significant at the .05 level.

Comparing the number of individual in three species.

One-way ANOVA

Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Pomacea sp.	13	4.7692	5.10153	1.41491	1.6864	7.8521	.00	17.00
P. canaliculata	13	4.8462	3.23641	.89762	2.8904	6.8019	1.00	13.00
P. insularus	13	4.2308	3.00427	.83323	2.4153	6.0462	.00	11.00
Total	39	4.6154	3.80177	.60877	3.3830	5.8478	.00	17.00

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
1.806	2	36	.179

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.923	2	1.462	.096	.908
Within Groups	546.308	36	15.175		
Total	549.231	38			

Comparing the number of individual in 13 plots.

Two-way ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	54.923	38	1.445	3.902	.000
Intercept	83.077	1	83.077	224.308	.000
SITE	15.990	12	1.332	3.598	.000
SPECIES	.292	2	.146	.395	.674
SITE * SPECIES	38.641	24	1.610	4.347	.000
Error	130.000	351	.370		
Total	268.000	390			
Corrected Total	184.923	389			

a R Squared = .297 (Adjusted R Squared = .221)

Multiple Comparisons

Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITE	(J) SITE				Lower Bound	Upper Bound
1.00	2.00	.2000	.15713	.988	-.3242	.7242
	3.00	.4333	.15713	.227	-.0908	.9575
	4.00	.3000	.15713	.789	-.2242	.8242
	5.00	.2667	.15713	.895	-.2575	.7908
	6.00	.5667	.15713	.021	.0425	1.0908
	7.00	.4667	.15713	.138	-.0575	.9908
	8.00	-.0333	.15713	1.000	-.5575	.4908
	9.00	.6667	.15713	.002	.1425	1.1908
	10.00	.3667	.15713	.494	-.1575	.8908
	11.00	.0667	.15713	1.000	-.4575	.5908
	12.00	.2667	.15713	.895	-.2575	.7908
	13.00	.4000	.15713	.348	-.1242	.9242
2.00	1.00	-.2000	.15713	.988	-.7242	.3242
	3.00	.2333	.15713	.959	-.2908	.7575
	4.00	.1000	.15713	1.000	-.4242	.6242
	5.00	.0667	.15713	1.000	-.4575	.5908
	6.00	.3667	.15713	.494	-.1575	.8908
	7.00	.2667	.15713	.895	-.2575	.7908
	8.00	-.2333	.15713	.959	-.7575	.2908
	9.00	.4667	.15713	.138	-.0575	.9908
	10.00	.1667	.15713	.998	-.3575	.6908
	11.00	-.1333	.15713	1.000	-.6575	.3908
	12.00	.0667	.15713	1.000	-.4575	.5908
	13.00	.2000	.15713	.988	-.3242	.7242
3.00	1.00	-.4333	.15713	.227	-.9575	.0908
	2.00	-.2333	.15713	.959	-.7575	.2908
	4.00	-.1333	.15713	1.000	-.6575	.3908
	5.00	-.1667	.15713	.998	-.6908	.3575
	6.00	.1333	.15713	1.000	-.3908	.6575
	7.00	.0333	.15713	1.000	-.4908	.5575
	8.00	-.4667	.15713	.138	-.9908	.0575
	9.00	.2333	.15713	.959	-.2908	.7575
	10.00	-.0667	.15713	1.000	-.5908	.4575
	11.00	-.3667	.15713	.494	-.8908	.1575
	12.00	-.1667	.15713	.998	-.6908	.3575
	13.00	-.0333	.15713	1.000	-.5575	.4908
4.00	1.00	-.3000	.15713	.789	-.8242	.2242
	2.00	-.1000	.15713	1.000	-.6242	.4242
	3.00	.1333	.15713	1.000	-.3908	.6575
	5.00	-.0333	.15713	1.000	-.5575	.4908
	6.00	.2667	.15713	.895	-.2575	.7908
	7.00	.1667	.15713	.998	-.3575	.6908
	8.00	-.3333	.15713	.649	-.8575	.1908
	9.00	.3667	.15713	.494	-.1575	.8908
	10.00	.0667	.15713	1.000	-.4575	.5908
	11.00	-.2333	.15713	.959	-.7575	.2908
	12.00	-.0333	.15713	1.000	-.5575	.4908
	13.00	.1000	.15713	1.000	-.4242	.6242
5.00	1.00	-.2667	.15713	.895	-.7908	.2575

	2.00	-.0667	.15713	1.000	-.5908	.4575
	3.00	.1667	.15713	.998	-.3575	.6908
	4.00	.0333	.15713	1.000	-.4908	.5575
	6.00	.3000	.15713	.789	-.2242	.8242
	7.00	.2000	.15713	.988	-.3242	.7242
	8.00	-.3000	.15713	.789	-.8242	.2242
	9.00	.4000	.15713	.348	-.1242	.9242
	10.00	.1000	.15713	1.000	-.4242	.6242
	11.00	-.2000	.15713	.988	-.7242	.3242
	12.00	.0000	.15713	1.000	-.5242	.5242
	13.00	.1333	.15713	1.000	-.3908	.6575
6.00	1.00	-.5667	.15713	.021	-1.0908	-.0425
	2.00	-.3667	.15713	.494	-.8908	.1575
	3.00	-.1333	.15713	1.000	-.6575	.3908
	4.00	-.2667	.15713	.895	-.7908	.2575
	5.00	-.3000	.15713	.789	-.8242	.2242
	7.00	-.1000	.15713	1.000	-.6242	.4242
	8.00	-.6000	.15713	.010	-1.1242	-.0758
	9.00	.1000	.15713	1.000	-.4242	.6242
	10.00	-.2000	.15713	.988	-.7242	.3242
	11.00	-.5000	.15713	.078	-1.0242	.0242
	12.00	-.3000	.15713	.789	-.8242	.2242
	13.00	-.1667	.15713	.998	-.6908	.3575
7.00	1.00	-.4667	.15713	.138	-.9908	.0575
	2.00	-.2667	.15713	.895	-.7908	.2575
	3.00	-.0333	.15713	1.000	-.5575	.4908
	4.00	-.1667	.15713	.998	-.6908	.3575
	5.00	-.2000	.15713	.988	-.7242	.3242
	6.00	.1000	.15713	1.000	-.4242	.6242
	8.00	-.5000	.15713	.078	-1.0242	.0242
	9.00	.2000	.15713	.988	-.3242	.7242
	10.00	-.1000	.15713	1.000	-.6242	.4242
	11.00	-.4000	.15713	.348	-.9242	.1242
	12.00	-.2000	.15713	.988	-.7242	.3242
	13.00	-.0667	.15713	1.000	-.5908	.4575
8.00	1.00	.0333	.15713	1.000	-.4908	.5575
	2.00	.2333	.15713	.959	-.2908	.7575
	3.00	.4667	.15713	.138	-.0575	.9908
	4.00	.3333	.15713	.649	-.1908	.8575
	5.00	.3000	.15713	.789	-.2242	.8242
	6.00	.6000	.15713	.010	.0758	1.1242
	7.00	.5000	.15713	.078	-.0242	1.0242
	9.00	.7000	.15713	.001	.1758	1.2242
	10.00	.4000	.15713	.348	-.1242	.9242
	11.00	.1000	.15713	1.000	-.4242	.6242
	12.00	.3000	.15713	.789	-.2242	.8242
	13.00	.4333	.15713	.227	-.0908	.9575
9.00	1.00	-.6667	.15713	.002	-1.1908	-.1425
	2.00	-.4667	.15713	.138	-.9908	.0575
	3.00	-.2333	.15713	.959	-.7575	.2908
	4.00	-.3667	.15713	.494	-.8908	.1575
	5.00	-.4000	.15713	.348	-.9242	.1242
	6.00	-.1000	.15713	1.000	-.6242	.4242
	7.00	-.2000	.15713	.988	-.7242	.3242
	8.00	-.7000	.15713	.001	-1.2242	-.1758

	10.00	-.3000	.15713	.789	-.8242	.2242
	11.00	-.6000	.15713	.010	-1.1242	-.0758
	12.00	-.4000	.15713	.348	-.9242	.1242
	13.00	-.2667	.15713	.895	-.7908	.2575
10.00	1.00	-.3667	.15713	.494	-.8908	.1575
	2.00	-.1667	.15713	.998	-.6908	.3575
	3.00	.0667	.15713	1.000	-.4575	.5908
	4.00	-.0667	.15713	1.000	-.5908	.4575
	5.00	-.1000	.15713	1.000	-.6242	.4242
	6.00	.2000	.15713	.988	-.3242	.7242
	7.00	.1000	.15713	1.000	-.4242	.6242
	8.00	-.4000	.15713	.348	-.9242	.1242
	9.00	.3000	.15713	.789	-.2242	.8242
	11.00	-.3000	.15713	.789	-.8242	.2242
	12.00	-.1000	.15713	1.000	-.6242	.4242
	13.00	.0333	.15713	1.000	-.4908	.5575
11.00	1.00	-.0667	.15713	1.000	-.5908	.4575
	2.00	.1333	.15713	1.000	-.3908	.6575
	3.00	.3667	.15713	.494	-.1575	.8908
	4.00	.2333	.15713	.959	-.2908	.7575
	5.00	.2000	.15713	.988	-.3242	.7242
	6.00	.5000	.15713	.078	-.0242	1.0242
	7.00	.4000	.15713	.348	-.1242	.9242
	8.00	-.1000	.15713	1.000	-.6242	.4242
	9.00	.6000	.15713	.010	.0758	1.1242
	10.00	.3000	.15713	.789	-.2242	.8242
	12.00	.2000	.15713	.988	-.3242	.7242
	13.00	.3333	.15713	.649	-.1908	.8575
12.00	1.00	-.2667	.15713	.895	-.7908	.2575
	2.00	-.0667	.15713	1.000	-.5908	.4575
	3.00	.1667	.15713	.998	-.3575	.6908
	4.00	.0333	.15713	1.000	-.4908	.5575
	5.00	.0000	.15713	1.000	-.5242	.5242
	6.00	.3000	.15713	.789	-.2242	.8242
	7.00	.2000	.15713	.988	-.3242	.7242
	8.00	-.3000	.15713	.789	-.8242	.2242
	9.00	.4000	.15713	.348	-.1242	.9242
	10.00	.1000	.15713	1.000	-.4242	.6242
	11.00	-.2000	.15713	.988	-.7242	.3242
	13.00	.1333	.15713	1.000	-.3908	.6575
13.00	1.00	-.4000	.15713	.348	-.9242	.1242
	2.00	-.2000	.15713	.988	-.7242	.3242
	3.00	.0333	.15713	1.000	-.4908	.5575
	4.00	-.1000	.15713	1.000	-.6242	.4242
	5.00	-.1333	.15713	1.000	-.6575	.3908

	6.00	.1667	.15713	.998	-.3575	.6908
	7.00	.0667	.15713	1.000	-.4575	.5908
	8.00	-.4333	.15713	.227	-.9575	.0908
	9.00	.2667	.15713	.895	-.2575	.7908
	10.00	-.0333	.15713	1.000	-.5575	.4908
	11.00	-.3333	.15713	.649	-.8575	.1908
	12.00	-.1333	.15713	1.000	-.6575	.3908

Based on observed means.

* The mean difference is significant at the .05 level.

Comparing the number of egg batch in 13 sites.

One-way ANOVA

EGG

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	32.092	12	2.674	1.985	.031
Within Groups	157.600	117	1.347		
Total	189.692	129			

Multiple Comparisons

Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITE	(J) SITE				Lower Bound	Upper Bound
1.00	2.00	.5000	.51904	.999	-1.2556	2.2556
	3.00	.3000	.51904	1.000	-1.4556	2.0556
	4.00	.3000	.51904	1.000	-1.4556	2.0556
	5.00	.3000	.51904	1.000	-1.4556	2.0556
	6.00	.8000	.51904	.943	-.9556	2.5556
	7.00	1.1000	.51904	.650	-.6556	2.8556
	8.00	.6000	.51904	.994	-1.1556	2.3556
	9.00	.9000	.51904	.877	-.8556	2.6556
	10.00	1.1000	.51904	.650	-.6556	2.8556
	11.00	-.2000	.51904	1.000	-1.9556	1.5556
	12.00	-.7000	.51904	.979	-2.4556	1.0556
	13.00	.3000	.51904	1.000	-1.4556	2.0556
2.00	1.00	-.5000	.51904	.999	-2.2556	1.2556
	3.00	-.2000	.51904	1.000	-1.9556	1.5556
	4.00	-.2000	.51904	1.000	-1.9556	1.5556
	5.00	-.2000	.51904	1.000	-1.9556	1.5556
	6.00	.3000	.51904	1.000	-1.4556	2.0556
	7.00	.6000	.51904	.994	-1.1556	2.3556
	8.00	.1000	.51904	1.000	-1.6556	1.8556
	9.00	.4000	.51904	1.000	-1.3556	2.1556
	10.00	.6000	.51904	.994	-1.1556	2.3556
	11.00	-.7000	.51904	.979	-2.4556	1.0556
	12.00	-1.2000	.51904	.513	-2.9556	.5556
	13.00	-.2000	.51904	1.000	-1.9556	1.5556
3.00	1.00	-.3000	.51904	1.000	-2.0556	1.4556
	2.00	.2000	.51904	1.000	-1.5556	1.9556
	4.00	.0000	.51904	1.000	-1.7556	1.7556
	5.00	.0000	.51904	1.000	-1.7556	1.7556
	6.00	.5000	.51904	.999	-1.2556	2.2556
	7.00	.8000	.51904	.943	-.9556	2.5556
	8.00	.3000	.51904	1.000	-1.4556	2.0556
	9.00	.6000	.51904	.994	-1.1556	2.3556
	10.00	.8000	.51904	.943	-.9556	2.5556
	11.00	-.5000	.51904	.999	-2.2556	1.2556
	12.00	-1.0000	.51904	.776	-2.7556	.7556
	13.00	.0000	.51904	1.000	-1.7556	1.7556
4.00	1.00	-.3000	.51904	1.000	-2.0556	1.4556
	2.00	.2000	.51904	1.000	-1.5556	1.9556
	3.00	.0000	.51904	1.000	-1.7556	1.7556
	5.00	.0000	.51904	1.000	-1.7556	1.7556
	6.00	.5000	.51904	.999	-1.2556	2.2556
	7.00	.8000	.51904	.943	-.9556	2.5556
	8.00	.3000	.51904	1.000	-1.4556	2.0556
	9.00	.6000	.51904	.994	-1.1556	2.3556
	10.00	.8000	.51904	.943	-.9556	2.5556
	11.00	-.5000	.51904	.999	-2.2556	1.2556
	12.00	-1.0000	.51904	.776	-2.7556	.7556
	13.00	.0000	.51904	1.000	-1.7556	1.7556
5.00	1.00	-.3000	.51904	1.000	-2.0556	1.4556
	2.00	.2000	.51904	1.000	-1.5556	1.9556

	3.00	.0000	.51904	1.000	-1.7556	1.7556
	4.00	.0000	.51904	1.000	-1.7556	1.7556
	6.00	.5000	.51904	.999	-1.2556	2.2556
	7.00	.8000	.51904	.943	-.9556	2.5556
	8.00	.3000	.51904	1.000	-1.4556	2.0556
	9.00	.6000	.51904	.994	-1.1556	2.3556
	10.00	.8000	.51904	.943	-.9556	2.5556
	11.00	-.5000	.51904	.999	-2.2556	1.2556
	12.00	-1.0000	.51904	.776	-2.7556	.7556
	13.00	.0000	.51904	1.000	-1.7556	1.7556
6.00	1.00	-.8000	.51904	.943	-2.5556	.9556
	2.00	-.3000	.51904	1.000	-2.0556	1.4556
	3.00	-.5000	.51904	.999	-2.2556	1.2556
	4.00	-.5000	.51904	.999	-2.2556	1.2556
	5.00	-.5000	.51904	.999	-2.2556	1.2556
	7.00	.3000	.51904	1.000	-1.4556	2.0556
	8.00	-.2000	.51904	1.000	-1.9556	1.5556
	9.00	.1000	.51904	1.000	-1.6556	1.8556
	10.00	.3000	.51904	1.000	-1.4556	2.0556
	11.00	-1.0000	.51904	.776	-2.7556	.7556
	12.00	-1.5000	.51904	.178	-3.2556	.2556
	13.00	-.5000	.51904	.999	-2.2556	1.2556
7.00	1.00	-1.1000	.51904	.650	-2.8556	.6556
	2.00	-.6000	.51904	.994	-2.3556	1.1556
	3.00	-.8000	.51904	.943	-2.5556	.9556
	4.00	-.8000	.51904	.943	-2.5556	.9556
	5.00	-.8000	.51904	.943	-2.5556	.9556
	6.00	-.3000	.51904	1.000	-2.0556	1.4556
	8.00	-.5000	.51904	.999	-2.2556	1.2556
	9.00	-.2000	.51904	1.000	-1.9556	1.5556
	10.00	.0000	.51904	1.000	-1.7556	1.7556
	11.00	-1.3000	.51904	.381	-3.0556	.4556
	12.00	-1.8000	.51904	.039	-3.5556	-.0444
	13.00	-.8000	.51904	.943	-2.5556	.9556
8.00	1.00	-.6000	.51904	.994	-2.3556	1.1556
	2.00	-.1000	.51904	1.000	-1.8556	1.6556
	3.00	-.3000	.51904	1.000	-2.0556	1.4556
	4.00	-.3000	.51904	1.000	-2.0556	1.4556
	5.00	-.3000	.51904	1.000	-2.0556	1.4556
	6.00	.2000	.51904	1.000	-1.5556	1.9556
	7.00	.5000	.51904	.999	-1.2556	2.2556
	9.00	.3000	.51904	1.000	-1.4556	2.0556
	10.00	.5000	.51904	.999	-1.2556	2.2556
	11.00	-.8000	.51904	.943	-2.5556	.9556
	12.00	-1.3000	.51904	.381	-3.0556	.4556
	13.00	-.3000	.51904	1.000	-2.0556	1.4556
9.00	1.00	-.9000	.51904	.877	-2.6556	.8556
	2.00	-.4000	.51904	1.000	-2.1556	1.3556
	3.00	-.6000	.51904	.994	-2.3556	1.1556
	4.00	-.6000	.51904	.994	-2.3556	1.1556
	5.00	-.6000	.51904	.994	-2.3556	1.1556
	6.00	-.1000	.51904	1.000	-1.8556	1.6556
	7.00	.2000	.51904	1.000	-1.5556	1.9556
	8.00	-.3000	.51904	1.000	-2.0556	1.4556
	10.00	.2000	.51904	1.000	-1.5556	1.9556

	11.00	-1.1000	.51904	.650	-2.8556	.6556
	12.00	-1.6000	.51904	.112	-3.3556	.1556
	13.00	-.6000	.51904	.994	-2.3556	1.1556
10.00	1.00	-1.1000	.51904	.650	-2.8556	.6556
	2.00	-.6000	.51904	.994	-2.3556	1.1556
	3.00	-.8000	.51904	.943	-2.5556	.9556
	4.00	-.8000	.51904	.943	-2.5556	.9556
	5.00	-.8000	.51904	.943	-2.5556	.9556
	6.00	-.3000	.51904	1.000	-2.0556	1.4556
	7.00	.0000	.51904	1.000	-1.7556	1.7556
	8.00	-.5000	.51904	.999	-2.2556	1.2556
	9.00	-.2000	.51904	1.000	-1.9556	1.5556
	11.00	-1.3000	.51904	.381	-3.0556	.4556
	12.00	-1.8000	.51904	.039	-3.5556	-.0444
	13.00	-.8000	.51904	.943	-2.5556	.9556
11.00	1.00	.2000	.51904	1.000	-1.5556	1.9556
	2.00	.7000	.51904	.979	-1.0556	2.4556
	3.00	.5000	.51904	.999	-1.2556	2.2556
	4.00	.5000	.51904	.999	-1.2556	2.2556
	5.00	.5000	.51904	.999	-1.2556	2.2556
	6.00	1.0000	.51904	.776	-.7556	2.7556
	7.00	1.3000	.51904	.381	-.4556	3.0556
	8.00	.8000	.51904	.943	-.9556	2.5556
	9.00	1.1000	.51904	.650	-.6556	2.8556
	10.00	1.3000	.51904	.381	-.4556	3.0556
	12.00	-.5000	.51904	.999	-2.2556	1.2556
	13.00	.5000	.51904	.999	-1.2556	2.2556
12.00	1.00	.7000	.51904	.979	-1.0556	2.4556
	2.00	1.2000	.51904	.513	-.5556	2.9556
	3.00	1.0000	.51904	.776	-.7556	2.7556
	4.00	1.0000	.51904	.776	-.7556	2.7556
	5.00	1.0000	.51904	.776	-.7556	2.7556
	6.00	1.5000	.51904	.178	-.2556	3.2556
	7.00	1.8000	.51904	.039	.0444	3.5556
	8.00	1.3000	.51904	.381	-.4556	3.0556
	9.00	1.6000	.51904	.112	-.1556	3.3556
	10.00	1.8000	.51904	.039	.0444	3.5556
	11.00	.5000	.51904	.999	-1.2556	2.2556
	13.00	1.0000	.51904	.776	-.7556	2.7556
13.00	1.00	-.3000	.51904	1.000	-2.0556	1.4556
	2.00	.2000	.51904	1.000	-1.5556	1.9556
	3.00	.0000	.51904	1.000	-1.7556	1.7556
	4.00	.0000	.51904	1.000	-1.7556	1.7556
	5.00	.0000	.51904	1.000	-1.7556	1.7556
	6.00	.5000	.51904	.999	-1.2556	2.2556
	7.00	.8000	.51904	.943	-.9556	2.5556
	8.00	.3000	.51904	1.000	-1.4556	2.0556
	9.00	.6000	.51904	.994	-1.1556	2.3556
	10.00	.8000	.51904	.943	-.9556	2.5556
	11.00	-.5000	.51904	.999	-2.2556	1.2556
	12.00	-1.0000	.51904	.776	-2.7556	.7556

* The mean difference is significant at the .05 level.

Comparing the richness values in each type of wetland.

One-way ANOVA

Richness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.034	2	.017	.405	.677
Within Groups	.422	10	.042		
Total	.456	12			

Comparing the Diversity Index in each type of wetland.

Diversity Index

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.162	2	.081	.768	.490
Within Groups	1.056	10	.106		
Total	1.218	12			

Comparing the Evenness in each type of wetland.

Evenness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.633	2	.316	1.484	.273
Within Groups	2.132	10	.213		
Total	2.765	12			

Comparing the total density in each type of wetland.

Total density

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.329	2	.165	.305	.744
Within Groups	5.400	10	.540		
Total	5.729	12			

BIOGRAPHY

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