HUE UNIVERSITY
COLLEGE OF EDUCATION

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STUDY ON ECOLOGICAL CHARACTERISTICS OF THE PEANUT WORM (SIPUNCULA) IN LOWER VALLEY OF THE GIANH RIVER, QUANG BINH PROVINCE

THESIS SUMMARY

Hue, 2017

This work was completed at
THE COLLEGE OF EDUCATION- HUE UNIVERSITY

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The thesis will be defended at the Council of thesis assessment of the Hue University level: .....

At ..... On ....., 2017

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INTRODUCTION

The sipunculans are a small phylum belong to group of unsegmented vermiform, coelomates. Most of which live in shallow, tidal or marine. This group is closely related to the annelids and mollusks. At present, the number of species can be up to 250 species or even 350 species.

Peanut worm also called sipunculan (some locals called it Sau đat, Bong thua…). *Siphonosoma australe australe* (Keferstein, 1865) is a subspecies of *Siphonosoma australe* (Keferstein, 1865) of the Siphonosoma genus; *Sipunculus nudus* Linnaeus, 1766 belong to Sipunculus family, both belong to familly Sipunculidae, order Sipunculiformes , phylum Sipuncula.

Situation of research on sipunculans in Vietnam is still limited. The research is concentrated in Can Gio (Ho Chi Minh City), Ben Tre, Quang Ninh and Khanh Hoa Province. Particularly in Quang Binh, no work has not been found related.

Peanut worms is one of the animals with high nutrition value. They are of economic value and are an important compose of the mangrove ecosystems due to the ability of soil disintegration and the consumption of organic humus. The potential of large coastal mangrove forests has created a favorable environment for Peanut worms to live and develop. Organic humus decomposites from carcasses of animals, plants and other aquatic plants provide a rich source of food for Peanut worms. On the other hand, with favorable climatic conditions, there is abundant food source and a habitats and shelters for the animals.

Peanut worms is easy to exploit due to the ability to move slowly. Since 2005, when the value of Peanut worm was determined, the consume for these species increased, especially the purchase from traders (from 1.2 to 1.5 tons/day) the exploitation Peanut worm becomes more mass. The indiscriminate exploitation not only engenders the Peanut worms populations severely degraded but also results in the destruction of mangroves and coastal protective forests.

Many peanut worm are regularly harvested in large quantities for use as food and medicine. Quang Binh as well as many other provinces in the central of our country have estuaries and mangroves, where favorable conditions for the habitat to live and develop can not avoid the situation mentioned above. Illegal exploitation is threatening the resources and habitats of the Peanut worm, causing significant impacts on ecological balance, biodiversity conservation

and mangrove ecosystems. So far, there is no study on the density and distribution of Peanut worm in the mangrove forest, Gianh river, Quang Binh province. Therefore, research on population density and other characteristics of Peanut worm is necessary to contribute to the protection and sustainable development of this species in particular and other animals in general.

In Vietnam, mangroves are distributed in the transition zone between the terrestrial and the marine region. Commonly found at estuaries, tidal marshes and along coastlines, which are often submerged in salt water and brackish water, where tides rise and fall daily. Semi-diurnal tides are more likely to be mangrove and Peanut worm than in the diurnal tide because it provides more nutrients and gas exchange. Mangroves are also habitat to many animal and plant species, including Peanut worm.

Quang Binh, as well as many of our central provinces, are located along the coast, with river mouths and mangroves. In Quang Binh, mangroves can be found in Quang Trach and Quang Ninh districts. According to a preliminary survey by the population and the operators in the above areas, we initially recognized that there are species of Peanut worm and there has been exploitation in these areas.

1. Reason of study

The first step is to study the research on Phylum Sipuncula in general and species of peanut worm in particular in the world and in Vietnam as well as the situation of conservation, exploitation and use of Peanut worm, we have chosen to study the subject for the following reasons:

- There are many studied of Sipunculan species in the world, but the number of research focusing on Peanut worm of Siphonosoma and Sipunculus is very limited, especially in Vietnam.

- Peanut worm not only scientifically but also valuable in terms of medicinal and food (price of dried peanut worm from 4-5 million/ kg). However, in order to truly appreciate the value of functional foods, commodities or pharmaceuticals, further research is needed for the published documents.

- The increase in indiscriminate exploitation of animals, including Peanut worm leads to the decrease of biodiversity, devastating coastal mangrove ecosystems of our country. To limit this, research is needed to conserve and develop species of peanut worm.

- Study on living conditions as well as characteristics of Sipuncula species in the Central region, including Quang Binh, where mangrove forests are not really considered. Therefore, research is needed to assess their current situation, contributing to the development of local economic and scientific potention.

2. Objectives of the study

1. Identification species of peanut worm in the lower valley of the Gianh river, Quang Binh Province.

2. Identification of ecological characteristics affecting individual density, burrow density and biomass of peanut worm.

3. Learn about the use Peanut worm and propose directions for research, exploitation, use, conservation and development in the future.

3. Research content

1. Description of morphological characteristics used in classification to identify the composition of the current Peanut worm in Quang Binh Province.

2. Identification of the distribution by habitat, water depth, soil depth, and natural conditions.

3. Study the number of individuals, individual density, burrow density and seasonal variation of densities and their distribution.

4. Analysis of nutrient composition and nutrient value in meat of Peanut worm.

5. Exploring the situation of exploitation and use of Peanut worm in research area.

6. Proposed solutions for conservation and sustainable development species of Peanut worm in Quang Binh.

4. Contribution of the thesis

- List the species composition, morphological characteristics, composition and distribution species of Peanut worm present in the lower valley of the Gianh river, Quang Binh Province.
- Natural conditions related to the natural conditions and habitat of Peanut worm.
- Data on ecology of population (number and density, fluctuation in quantity and density) of Peanut worm.
- Identification nutrient content in meat and diet of two species of Peanut worm.
- Propose some measures to preserve and develop sustainably.
- Proposed processing of breeding Peanut worm as commodity.

5. Thesis layout

In addition to the appendix, the thesis is presented in 125 pages, which includes the following sections:

Introduction

Content: Includes three chapters

Chapter 1: Document overview

Chapter 2: Object, Schedule, Location, Materials and Methods

Chapter 3: Results and Discussion

Conclusions and recommendations

References

Appendix

Chapter 1: OVERVIEW

The literature has shown that the study of the Phylum Sipuncula in general and Peanut worm in particular in the world first focused on identifying Sipunculan as an independent phylum that separates from the Phylum Annelida and Phylum Mollusca. Subsequent studies delineated molecular characteristics such as the sequence of genes and identification of relationships in phylogenesis, embryonic development studies, and other morphological characteristics to identify closed relationships between annelids and mollusks. However, so far this issue has not been clarifie.

When studying the classification, the authors describe the morphological characteristics used in the classification, building the classification key for species in the two classes. The publication of species composition does not include all regions of the world.

In addition to the above-mentioned studies, some authors investigated the habitat of the Sipunculans, particularly with regard to the reproductive and individual development of some species in the Sipunculans. Some recent work has focused on the characteristics of the sinus, musculature, and some environmental factors that affect the living function of the animal.

However, there is still little research material to assess biomass and density. There is no adequate research on the living conditions and ingredients of the Peanut worm. The less ecologically and ecologically-important research material is available in the Peanut worm in Vietnam.

In Vietnam, there are studies on the composition of Peanut worm but very few, only in some mangroves in Ben Tre, Can Gio (Ho Chi Minh City), Nha Trang (Khanh Hoa) and Quang Ninh. Other regions have almost no official announcements. Research on ecological characteristics is very limited and focused only on some

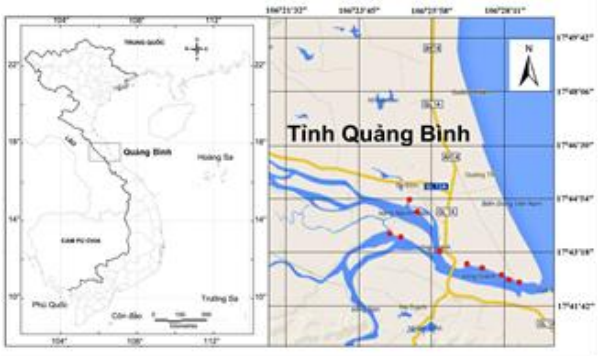
subjects. Breeding and grow-out studies have been conducted, but breeding for genetic conservation and research for conservation and sustainable development are of little interest.

Chapter 2: OBJECTS, SCHEDULE, LOCATION, MATERIALS AND METHODOLOGY OF STUDY

2.1. Object and schedule of study

Specimens of Sipuncula collected in the lower valley of the Gianh river, Quang Binh Province, was conducted from May 2014 to April 2017.

2.2. Location of study



(Ratio: 1: 10.000)

Figure 2.1. Site sampling map (Red sampling points)

The study was conducted on 10 different sites lower valley and mangroves in the Gianh river, Quang Binh Province; Geographic coordinates are 17°42'30 " - 17°44'59"N latitude and 106°24'38 " - 106°29'19" longitude East (Figure 2.1).

2.3. Materials of study

- This study was based on the results of analysis of 568 specimens of Peanut worm. Of which: the number of classified analysis specimens 62; Number of morphological analysis specimens 268; Meat analysis specimens 178; Some 60 diet specimens. The analyzed specimens is stored at the Laboratory of Zoology, University of Education - Hue University.

- Instruments and equipments for sampling, morphological analysis including: cloth bag, label paper, ruler, digital camera (Canon SX20IS), electronic scale (accuracy 0.01g) Weight-balanced body weight OHAUS PA 213 (OHAUS Corporation, USA), error of 0.01 g; GPS Garmin Colorado 400t (Garmin Corporation, Taiwan),

Olympus Imaging SZX7 (Olympus Imaging Corp., Japan), optical microscope with x40 objective, Surgical kits, multi-size containers, petri dishes, etc.

Instruments and equipments for analysis: Olymsus BX51 microscope (magnification x 100, x 400 and x 1000 times), 20 μm diameter sieve, conventional thermometer, APEL salinity meter, PH ATC PH-98108, pH meter, glass beaker, 50 mL, 1000 mL, glass rod...

2.4. Methods of study

2.4.1. Field research methods

During the study, we went to field once a month, at low tide. Interview the people in the study area and make questionnaires to the people who directly exploit the Peanut worm.

- Specimens were collected by direct excavation along with the operators in the study sites. Random sampling was used to represent the Peanut worm populations during the study period. Information regarding specimen collection such as time, location, means of excavation, etc. are recorded in the research diary. Specimens were treated immediately when fresh by soaking in 70 °C or 4% formol solution.

- Investigation of the exploitation situation using the questionnaire survey through people living in the riverine areas and exploiters from other areas.

2.4.2. Research methods in the laboratory

- Classification the specimens according to Cutler (1994); Morozov & Adrianov (2007) and Cutler, (2001) at the Center of Soil Animals, Hanoi Pedagogical University.

- After collecting and preserving specimens, Peanut worm is characterized by morphological characteristics, body weight (g), body length (mm) (measured from the anal to the end of the body), lenghth of introvert (mm) when maximum introvert reach, body diameter (mm), number of tentacles, number of hooks, number of longitudinal muscle, description of shape and color of Peanut worm.

- *Method of density and quantity research:*

Determine the coordinates and area of the study site by GPS. Identify and count the number of specimens collected and the number of burrow per unit area of each sampling. Then calculate individual density and density of burrow on the area of 1 m^2.

Density method using the formula:

$$M = N / n$$

(M is the average density (individuals/m^2), N is the total number individuals collected in sampling sites, n is the total area of sampling sites).

Method of calculating biomass: Biomass is calculated by the formula:

$$a = M / n$$

(a is the average biomass (g/m^2); M is the mass in the sampling sites, n is the total area of sampling sites).

- *Method of analysis of diet composition*: The analysis of diet composition was conducted at the Center for Coastal Management and Development Studies of College of Science-Hue University. Collect specimens in the field, operate immediately, take the intestines and stomach in alcohol 70^o. Number of specimens sent for analysis of diet including: 60; Each specimen surveyed three models. Specimens of food ingredients must be fixed with alcohol immediately so that food are not digested properly. Analytical specimens were taken so as to ensure representativeness between sampling points.

- *Nutritional value analysis method:* Take and preserve live specimens by adding Peanut worm to the cotton swab sample container. Then specimens immediately are put to the laboratory for analysis at the Center of Analytical Services and Experimentation HCMC and Central Laboratory of College of Agriculture and Forestry-Hue University. Total Protein analysis by AOAC Method, 2002 and Amino acid analysis by HPLC (High Performance Liquid Chromatography).

- *Soil sampling method:* Use digging soil to collect soil samples at depths of 20 cm, 40 cm and 60 cm at the place where there are occurrences of Peanut worm at 10 sampling points. These are the depths of the soil that Peanut worm live in the burrow. At each site, soil samples were collected at three different depths.

- *Soil analysis criteria*: Soil samples were analyzed by mechanical sedimentation and soil properties analysis by Soil and Fertilizer Laboratory (Faculty of Agronomy, College of Agriculture and Forestry - Hue University).

- *Water sampling method*: The water is taken at 10 sampling points where Peanut wowrm live, sampling the water put into the test tube and delivering it to the laboratory for analysis. Conduct the analysis of temperature, pH and salinity. Measurement of water temperature by conventional thermometer and direct measurement at

each sampling site, measuring salinity by APEL, pH measurement with ATC PH-98108.

- *Data processing method*: The data were tested for significance difference by specialized statistical software such as MINITAB and SPSS, with mean $P < 0.05$ was considered as significant difference. Data on individual density, population density, biomass and biomass concentrations between sites and seasons were tested using an ANOVA. ANCOVA analysis was used to examine the effects of environmental factors such as water temperature, pH and salinity (‰) on individual density, population density and biomass. Use Microsoft Excel and Stagraphic Plus 3.0 software to process and evaluate collected data.

Chapter 3: RESULTS AND DISCUSSION RESULTS

3.1. Composition of species and morphological characteristics

3.1.1. Species composition and classification

Based on the results of the investigation, collection and analysis of the specimens we recorded in the lower valley of the Gianh river, Quang Binh province, there are two species of ***Siphonosoma australe australe*** **(Keferstein, 1865) and** ***Sipunculus nudus*** **Linnaeus, 1766.**

3.1.2. Morphological, structural characteristics

3.1.2.1. *Siphonosoma australe australe* (Keferstein, 1865)

Figure 3.1. External structure of Siphonosoma australe australe

- Description: Peanut worm is vermiform and unsegmented, the front of the inconvert can be in or out very quickly. The body is light yellow and has two body regions, the body and the inconvert (Figure 3.1). Thanks to the inconvert that Peanut worm can move or

burrow in the soil easily. The Peanut worm can be drawn into the colemic sac from 1/5 to 1/3 of the body length, making the body shorter than before hitting the introvert. The mid region of the body has many longitudinal muscle. One end of the body is narrowed down to the tip of the mouth, with many tiny tentacles, pearl in color and not branch around the mouth. There is no nuchal organ, no anal shield and anus in the front of the body, about 1/3 of the length of the body from the end of introvert. Based on the position of the anal hole, it is possible to identify the back, abdominal, right and left sides, thus identifying the symmetrical plane on the ground.

There is no caudal shield and caudal appendage. The body wall forms the incomplete horizontal stripes, while the body becomes pink when the body is white. On the body wall there are layers of longitudinal muscles visible to the naked eye. The longitudinal muscle of *Siphonosoma australe australe* at the study sites ranged from 15 to 17 long muscles forming the grooves. The papillae has a hook shape with a pointed tip with a bend of less than 45°. Contractile vessel swollen into tuberous form.

The coelomic sacs is filled with fluid, in which the tentacle colelum and coelum. Coelum on the lower body, much larger than the tentacle colelum and main coelum of the body. These two coelum are separated by a septum. The tentacle coelum has two small, thick, sinuous tubules running along the coelum with shrinkage and inner cilia. Coelum are very broad, they contain most of the internal organs. Two contraction tubules of the tentacled coelum run directly into the body cavity. The dorsal retractor muscle of introvert consist of two pairs, white extending from the oral disc to the anus and attached to the body wall. The two ventral retractor muscles of the are longer than the dorsal retractor muscles. When observe by microscope, the section between introvert retractor muscle and the body wall, the muscles connected to the longitudinal muscle bands. The rectum is light yellow. There are two kidneys.

Throughout the study, we found that the number of hook rings ranged from 37 to 76, with an average of 53.25 ± 11.7. The number of tentacles is the largest variation of *Siphonosoma australe australe* (Keferstein, 1865) in Quang Binh, from 58 to 135, on average 107.35 ± 18.1. The number of longitudinal muscle bands is less variable with a number of 16.4 ± 1.

- The correlation between size and body weight

When analyzing the size and mass of 266 *Siphonosoma australe australe* specimens, we divided these specimens into three size groups based on the length of the largest and smallest Peanut worm, 210 - 300 mm (small group); 301 - 399 mm (medium group); 400 - 509 mm (large group). The results showed that body length varied from 210 to 509 mm, mean 335.2 mm; mass from 17.7 to 58.8 g; average 33.4 g (Figure 3.2).

Thus, the most commonly encountered size groups are medium sized (301-399 mm), followed by the smallest size group and the large group size.

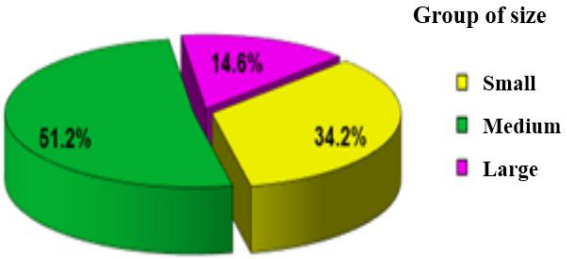


Figure 3.2. Percentage (%) of Siphonosoma australe australe in each size group

In 20 analyzed specimens representing groups of size, the average body length was 213.8 ± 55.4 mm. Most individuals in this group have trunk lengths greater than 130 mm (ranging from 133.6 to 317.5 mm). The average body weight was 33.4 ± 13.4 g (ranging from 16.49 g to 56.74 g); The body length is proportional to body weight; the more body length increases, the more body weight increases and vice versa; The ratio of introvert length and body length varies from 25% to 47%, with an average of 36% (introvert length is less than half of body length).

Peanut worm in the lower valley of the Gianh River showed significant correlation between body weight and body length (R = 0.845; F1.19 = 45.237; P <0.0001), body weight and diameter Body (R = 0,741; F1,19 = 21,976; P = 0.0002), between body diameter and body length (R = 0.497; F1,19 = 5,891; P = 0.026) between body mass and body length (R = 0.844; F1.19 = 44.652; P <0.0001).

Compared to Cutler's description (1994), the analyzed specimens had a greater body length (331.3 mm vs. 200 mm) (Fig. 3.3); While the number of longitudinal muscle bands (LMBs) is less (15 -17 vs. 15-20). This difference is within the allowable range

when identifying the species and subspecies belonging to the Siphonosoma. When describing the morphology of the *Siphonosoma australe australe* in Nha Trang Bay, Asia-Pacific Network for Global Change (APN) (2011) report showed that they have a body length of 150 mm. The description of Adrianov and Maiorova (2012) also has a body length of 150 mm, shorter body length than introvert length, 50 rows and 15 to 16 longitudinal muscle bands. These are in the minimum and maximum values we have shown above.

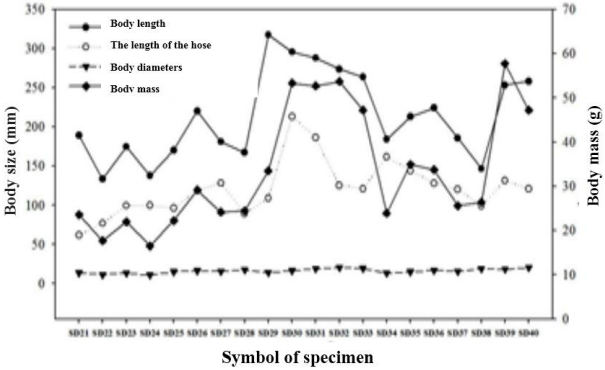


Figure 3.3. Size and body mass of Siphonosoma australe australe

3.1.2.2. Peanut worm Sipunculus nudus Linnaeus, 1766

Due to the number of individuals of this species are rare and can not collect more specimens to analyze statistics. Analysis specimens had body lengths of 119.69 mm and 148.29 mm; itrovert length 44.54 mm and 36.08 mm; body diameter 10.56 mm and 9.72 mm; The living body is grayish-pink, with white to opaque and has two main regions is the body and the introvert. The body is vermiform and unsegmented with the front of the introvert that can bend or stretch very quickly.

Figure 3.4. Morphology of the Sipunculus nudus

It can be observed that the middle region of the body has more long muscle bands. The end of the body is narrowed down to the end of the mouth, with branching tentacles. No anal sheld and anus are in front of the body. No caudal shield and caudal appendage. The body wall forms incomplete horizontal bands. A fluid filled coelomic sac. Dorsal retractor muscle include two pairs. There are two kidneys from the anus and about 30 - 40% long from the end of the body. The number of LMBs 27, 30 and 30. According to Cutler (1994), is usually 28 to 32 and begins to split in the gland region. Anus open out with a small hole, located in front of the body. According to the description in Nha Trang Bay, the report of APN (2007) and the results of Adrianov and Maiorova (2012) suggest that they have a body length of 120-140 mm; the introvert length is shorter than the body length and has 27-34 LMBs. These results are consistent with the results of our study above.

Table 3.3. Comparison of morphological characteristics of *Siphonosoma australe australe* and *Sipunculus nudus*

NO	FEATURES	*Siphonosoma australe australe*	*Sipunculus nudus*
1	Anus location	Located at the front of the body	Located at the front of the body
2	Caudal shield	None	None
3	Caudal appendage (Caudal)	None	None
4	Longitudial muscle bands	Into strips divided	Into strips divided
5	Coelum	Sac type	Sac type
6	Inside wall of body	Form the incomplete horizontal bands	Form the incomplete horizontal bands
7	Number of wing muscle (connecting digestal tract to body wall)	4	4
8	Papillae	Yes	No
9	Hook shape	Clear streak	
10	Angle of hook	Less than 45^0	
11	The number of hook rings	53,2±11,7	
12	The length of the introvert (from the anus to the tip) (mm)	121,5±35,4	44,54 mm and 36,08 mm

13	Trunk length (mm)	213,8±55,4 (>130)	119,69 and 148,29
14	Body length (mm)	335,2±45,4	164,2
15	Body shape	Slender cylinder/ spindle shaped	Short shape
16	Body diameters (width of the body at the trough)	16,0±2,8	10,56 và 9,72
17	Introvert length vs. body length (from anus to caudal end)	36%	30%
18	Number of longitudinal muscle bands (LMBs)	16,4 ± 1	27 and 30
19	Kidney	Two kidneys	Two kidneys
20	Size and shape of papillae	Hook shape	No
21	Retractor muscle		
	- Number (doubles)	Two pairs	Two pairs
	- Attached position	Of the anus	Of the anus
22	Tentacle position	Around the mouth	Around the mouth
23	Tentacle		
	- Number of tentacles	107,35±18,1	Not divided into fibers
	- Color	Pearl	Light yellow
	- Branching	Unbranching	Branching
24	Habitat	Sandy-muddy or muddy-sandy	muddy-sandy
25	Depth	<10 m	<10 m
26	Body weight (g)	33,4±13,4	8,6

For the purpose of distinguishing two species discovered together in the study area, we have compared the two species (Table 3.3). Differences between these two species can be seen with or without papillae, size and body weight. Body size of *Sipunculus nudus* smaller and shorter than that of *Siphonosoma australe australe* expressed in length of introvert; *Siphonosoma australe australe* has a introvert length of 121.5 ± 35.4 mm and a shorter introvert length of 44.54 mm and 36.08 mm for *Sipunculus nudus*; The body length of the *Siphonosoma australe australe* was 213.8 ± 55.4 mm, while in the *Sipunculus nudus* the body length was 119.69 and 148.29 mm. The body diameter, body mass of the *Siphonosoma australe australe* is also larger than that of the *Sipunculus nudus*.

The number of LMBs of *Sipunculus nudus* was higher than that of *Siphonosoma australe australe* (27 and 30 vs. 16.4), and finally a very clear difference in the shape and color of the tentacles. In the *Siphonosoma australe australe*, tentacles are filaments with the number 107.35 ± 18.1, whereas the tentacles of *Sipunculus nudus* are not split into filaments but branching plates; the color of the tentacles in the two species is also different, the species *Siphonosoma australe australe* is pearl, while the tentacles *Sipunculus nudus* is Light yellow. Whether or not the papilla is also character of the difference between the two species; the species *Siphonosoma australe australe* has papillae, while the species *Sipunculus nudus* has no papillae.

3.2. LIVING ENVIRONMENT, DISTRIBUTION AND HABITAT

3.2.1. Habitat characteristics

3.2.1.1. Water environment

Based on the results of the survey at ten study sites, we find that Peanut worm live in lower valleys or submerged mangrove forests with the depth of 0.5 - 1.8 m. These species live in sandy or muddy sand burows. They dig burrows in the ground to create a habitat. They can last for a period of 4-6 days after discharge and also found in brackish water (for example in the estuary). Results of water environment analysis show that the water temperature ranges from 24 - 26 ^{o}C; water pH ranges from 7.3 to 8.51 and salinity ranges from 13.9 to 19.9‰.

3.2.1.2. Soil environment.

From the results of the analysis, Peanut worm is found in sandy - muddy or muddy - sandy soils. In which the sandy-muddy occupies mainly, while Bui Quang Nghi et al. (2009) studied Ben Tre and APN (2007) in Nha Trang showed that this spcies distributed in the clay-muddy background.

When analyzing some indicators in the soil environment, the results show that both Peanut worm live in acidic soils, the composition of organic matter is classified as poor and medium; Index of N total poverty ranking and average; Both P and K indicators are generally poor. Research results of Nguyen Thi Thu Ha et al. (2007) on the *Sipunculus nudus* at the coast of Quang Ninh, this species lives in the low tidal zone, with mild waves and winds, weak alkalis, high salinity and stability with low heavy metals and sand in sediment 80%.

3.2.1.3. Organisms.

The habitat in the study area is very diversity, with complete flora and fauna. Some research sites have protective forest plantations including large trees and seedlings. The species are planted along the river such as mangrove, cucumber, parrot ... the rest is the intertidal area. In these places there are many animals such as oysters, snails, cocks, zooplankton ... There are also many species of plants such as algae, seaweed, ... appear on the soil surface where Peanut worm live.

3.2.2. Distribution

3.2.2.1. Distribution of Siphonosoma australe australe

The results show that *Siphonosoma australe australe* is distributed in the river tidal areas or mangroves, where the water depth is from 0.7 to 1.8 m. At depths of < 0.7 m we did not find their burows. The species *Siphonosoma australe australe* does not live in high tide, they live in middle tide and low tide. This species lives in the mud or sandy depths encountered 0.5 - 0.9 m, where the soil temperature ranges from 24.7 to 25.8 ^{o}C, salinity 13.9 - 19.9‰ and pH of water from 7.3 to 8.5. Specimens were collected in all 10 study sites, sandbanks and perennial mangroves. However, according to Zhou and Li (1996), this species lives in the muddy tidal habitat up to a depth of 600 m and is found in burow up to 50 m deep. This suggests further research is needed to deepen areas.

3.2.2.2. Distribution of Sipunculus nudus

Research results show that *Sipunculus nudus* distributed in the lower valley of the Gianh river, Quang Binh Province, found in the tidal area of 1.3 to 1.8 m depth. This species lives in burow with muddy sand with a depth of 0.4 - 0.6 m, where the soil temperature is 25.2 - 25.7 ^{o}C, salinity 16.3 - 17.9‰ and degree of water PH is 7.6 - 8.0. Specimens were collected at three study sites (XL2, CG and QM) in total of 10 study sites but the number of individuals was very rare. Although encountered in small numbers, we find that compared to the *Siphonosoma australe australe*, the *Sipunculus nudus* are only distributed at lower tide (low tide) habitats, where *Sipunculus nudus* is a sandy-muddy soils.

Siphonosoma australe australe live in both muddy and sandy soils, and *Sipunculus nudus* occurs only in muddy soils. This indicates that *Siphonosoma australe australe* is more widely distributed than *Sipunculus nudus* in the lower Gianh River, Quang Binh province.

3.2.3. Shelter and burow structure

The shelter of of Peanut worm is in the soil, they dig the soil to form the burow. Thay live in the burow with sandy soil and mud dug in the tide of the river or mangroves. Through research, we find that: Peanut worm's burrow is only distributed in areas with tidal range ranging from 0.7 to 1.8 m.

The burrow of *Siphonosoma australe australe* consists of three parts: burrow mouth, burrow cone and burrow. The mouth of the burrow is the place where Peanut worm's body sneaks up on its food-seeking activities, and when it comes out of the burrow mouth, the Peanut worm will feed on its mouth and tentacles. The mouth diameter measured from the study sites varies from 2.9 to 3.6 mm; diameter of burrow cone have ranging from 5.3 to 6.7 cm; The body of the burrow is underground and plays a very important role in the life of the Peanut worm, which is where the Peanut worm live during the tide.

3.3. QUANTITY, INDIVIDUAL, BURROW DENSITY AND BIOMASS

3.3.1. Individual density and burrow density

Compilation of statistical results from the ten monthly survey sites, the distribution and density of *Siphonosoma australe australe* in the Gianh River showed that the density and average of individual density of the species in the study area is quite low (individual density: 0.68 ± 0.036 ind./m^2, density of burrow: 1.96 ± 0.058 burrow/ m2). Individual density in the top ten study sites in Tan My (0.98 ± 0.192 in m^2) and lowest in Ba Don (0.51 ± 0.054 ind./m^2). However, the difference in individual density between sites was not statistically significant ($F_{9.99} = 1.77$; $P = 0.085$). In contrast, the average individual densitie in the study area were significantly different ($F_{9.99} = 3.43$, $P = 0.001$).

Regarding density of burrow, the results showed that the highest in Tan My (2.54 burrow/m^2) and the lowest in Quang Van (1.43 burrow/m^2). When survey in the field and specimens found that only one individual live. We find that the number of burrow is higher than the number of individuals, which does not mean that the density of individuals is higher because the burrrow is identified and confirmed whether the burrow is alive or not is a problem to continue research. This result is much lower than the result of Peanut worm study in Thanh Phu mangrove ecosystem, Ben Tre Province and Can Gio (Ho Chi Minh city). This density can reach from 9 to 18 ind./m^2.(Vu Ngoc Hung, Le Huy Ba, 2010).

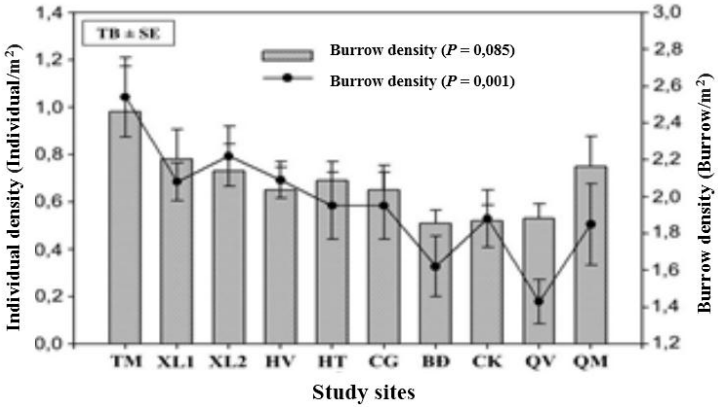


Figure 3.5. Individual density and density of burrow (TB ± SE) in the lower valley of the Gianh river

However, if the correlation between individual density and burrow density between points is observed, respectively, the density of burrow is higher. (Figure 3.5).

Table 3.2. Average (TB ± SE) of individual density, burrow density, number of individuals and biomass of Peanut worm in the lower valley of the Gianh river

Study site	Individual density (Individual/m^2)	Density of cave (Number of burrow/m^2)	Number of individuals (Individual on the study area)	Biomass (g/m^2)
TM	0,98 ± 0,192 (0,25-1,78)	2,54 ± 0,216 (1,62-3,75)	76,50 ± 9,853 (43-121)	20,27 ± 0,263 (18,96-21,45)
XL1	0,78 ± 0,127 (0,27-1,36)	2,08 ± 0,102 (1,65-2,65)	72,30 ± 10,456 (32-126)	22,03 ± 0,706 (19,21-25,2)
XL2	0,73 ± 0,116 (0,23-1,25)	2,22 ± 0,162 (1,54-3,16)	80,30 ± 10,441 (32-121)	28,07 ± 0,423 (25,68-29,31)
HV	0,65 ± 0,096 (0,35-1,15)	2,09 ± 0,100 (1,65-2,65)	64,60 ± 8,090 (31-98)	30,35 ± 0,868 (24,31-33,31)
HT	0,69 ± 0,079 (0,35-1,06)	1,95 ± 0,181 (1,15-2,85)	59,10 ± 9,253 (25-102)	33,60 ± 0,532 (30,68-36,27)
CG	0,65 ± 0,103 (0,15-1,06)	1,95 ± 0,181 (1,15-2,85)	48,40 ± 7,529 (16-86)	40,39 ± 0,535 (37,85-43,18)
BĐ	0,51 ± 0,054 (0,16-0,78)	1,62 ± 0,164 (0,87-2,35)	45,00 ± 7,537 (12-73)	38,95 ± 0,590 (35,56-41,16)
CK	0,52 ± 0,066 (0,21-0,87)	1,88 ± 0,156 (1,05-2,53)	45,00 ± 7,537 (12-73)	41,09 ± 0,417 (39-43,25)
QV	0,53 ± 0,061 (0,27-0,85)	1,43 ± 0,120 (0,66-1,87)	50,70 ± 8,842 (17-93)	39,78 ± 0,540 (36,23-41,93)
QM	0,75 ± 0,128 (0,22-1,85)	1,85 ± 0,221 (0,95-2,86)	70,00 ± 11,746 (25-131)	51,16 ± 0,345 (49,26-52,42)
F	1,77	3,43	2,11	303,85
P	0,085	0,001	0,037	<,0001

3.3.2. Number of individuals and biomass

The average number of individuals in the study area was 61.19 ± 3.063 individuals/100 m^2. The highest number of individuals was detected at Xuan Loc 2 (80.30 ± 10,441 individuals); the lowest sites are Ba Don market (45.00 ± 7,537) and Con Ket - Quang Thuan (45.00 ± 7,537 individuals). The difference in number of individuals between sites is statistically significant (F9.99 = 2.11, P = 0.037, (Table 3.2 and Figure 3.3). Individual density studies in Svalbard (Norway) of Kddra and Wiodarska-Kowalczuk (2008) showed that 80.0 and 96.7 individuals/m2. However, Maiorova & Adrianov's research on Japanese seafloor, with many species of Sipunculan has a large number of individuals, about 700 individuals/m2, even up to 8,000 individuals/m^2.

On biomass, this study showed that the average weight was 34.57 ± 0.925 g / m^2, the lowest in Tan My (20.27 ± 0.263 g / m^2) and the highest in Quang Minh (51.16 ± 0.345 g/m^2). Biomass of Peanut worm between sites of significant difference (F9.99 = 303.85; P <0.0001). Compared to the results of Kddra and Wiodarska-Kowalczuk (2008), the biomass of Peanut worm in Svaldard is greater (67.5 g/m^2 to 437.8 g/m^2). It may be a strictly protected area, without frequent exploitation such as in the lower valley of the Gianh river.

3.3.3. Affecting Factors

Investigated possible effects of environmental factors such as water temperature, pH value and salinity on individual density, burrow density, number of individuals and biomass of Peanut worm. using a ANCOVA factor. Results showed that water temperature had a significant effect on individual density (F199 = 16.93; P < 0.0001), burow density (F199 = 16.17, P < 0,0001) and the number of individuals (F199=11.45;P = 0.001). However, the water temperature had no significant effect on the biomass of Peanut worm (F199 = 2.21; P = 0.141).

The pH value has a significant effect on individual density (F199 = 63.57; P < 0.0001), burrow density (F1.99 = 51.84; P <0.0001), number of individual (F1.99 = 47.81; P < 0.0001) and biomass of Peanut worm (F1.99 = 14.75; P < 0.0001).

Similar to the pH value, salinity effects on individual density (F199 = 101.65; P < 0.0001), burrow density (F1.99 = 105.91; P < and number of individuals (F1.99 = 91.25; P < 0.0001). However, water temperature don't effect on biomass (F1.99 = 19.31; P < 0.0001). Salinity is a major factor affecting the body weight of the

Peanut worm, the results showed that from the first site Tan My to the final site Quang Minh, salinity concentration decreased from 19.9 ‰ down to 14.3 ‰, Body weight salinity increased from 20.27 g to 51.16 g respectively. This means that the concentration of decreases, the body weight increases at the same time of study. Individual density and burrow density were influenced by salinity. Individual and burrow density of densities is high from Tan My to Cau Gianh with salinity of 16.3-19.9 ‰. It can be said that this is the appropriate salinity to *Siphonosoma australe australe*.

On the other hand, the results of soil analysis show that the relationship between body mass and soil environment is closely. Peanut worm live in a soil rich in organic matter that has a higher body mass than it living in poor organic matter.

3.3.4. Fluctuation of individual, burrow density, number of individuals and biomass after seasons

Quang Binh, as well as the central provinces of Vietnam, can be divided into two seasons, dry season (from January to July) and rainy season (from August to December). The results show that the individual density, burrow density, number of individuals and biomass of Peanut worm in the lower valley of the Gianh river, Quang Binh Province fluctuate in two seasons. The biomass of during dry season was not significantly smaller than in rainy season (P = 0.294).

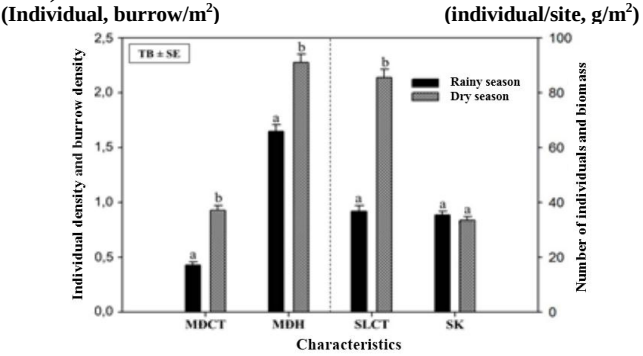


Figure 3.6. Individual density, burrow density, number of individuals and biomass in seasons in lower valley of the Gianh river

Results of the analysis using an ANOVA showed that the individual density, burrow density and number of individuals were statistically significantly different (P < 0.05) between the two

seasons. In the dry season, the density was 0.93 individuals/m^2, higher than the rainy season, density was 0.43 individuals/m^2; The density of burrow in dry season is 2.28 burrow/m^2 and in rainy season the cumulative density is 1.65 burrow/m^2 and the number of individuals collected in dry season is higher than that in rainy season. However, the biomass of the two seasons was not significantly different (F1 = 1.11, P = 0.294, Figure 3.6).

3.4. DIET

The diet composition of Peanut worm in the Gianh River in Quang Binh Province is rich and varied, comprising 52 items representing three different aquatic systems: algae, invertebrates and organic humus; of which, the major diet is Bacillariophyta (94.2%); The Cyanophyta, the Miozoa has low rate of 1.92%. Silic algae include 49 species belonging to 20 different families. In these, the largest species of Naviculaceae family with 7 species, followed by Coscinodiscaceae and Pleurosigmataceae with number of species is 5-6 species.

3.5. EXPLANATION, CONSERVATION AND DEVELOPMENT PEANUT WORM

3.5.1. The situation of exploitation and use Peanut worm

3.5.1.1. Exploitation situation

According to survey results from local people and some fishery staffs in Quang Phuc, Quang Thuan, Quang Van, Quang Minh and Ba Don (Quang Binh), in the past, local people have been digging ponds for shrimp farming and found the Peanut worm to be rich in moist and cool soil. The people here say that people from Thanh Hoa on collecting and digging are estimated at 70-100 kg per person per day.

Throughout the trip with the Quang Nam group, March to October 2015, the harvested yield is calculated on average of one harvesting 8.2 kg/point/day. The largest yield of Peanut worm in Quang Minh (14.2 kg), to Xuan Loc 2 and the lowest In Xuan Loc 1 (6.1 kg). Statistics on exploiting days in 2015 of Quang Nam group is 135 days and the total exploited output is 6,642 kg Peanut worm; the highest yield of Peanut worm of the group was August (836.4 kg) and lowest was December (295.2 kg).

Through the synthesis of 29 questionnaires on the situation of exploiting Peanut worm in Gianh river in 2015, the results of the total exploitation output of the four groups in the year. The total output of Peanut worm harvested in 2015 is 27,094 kg, the largest catcher group comes from Binh Dinh (8,892 kg/year), followed by Quang Nam, the lowest is the group of people coming from Quang

Ninh (5,435 kg/year). Based on the total production of Peanut worm in 2015 with the amount of 27,094 kg at the price of 80,000 VND/kg, the total income of the year from Peanut worm is 2,167,520,000 VND (more than 2 billion VND/year) .

3.5.1.2. The nutritional value of Peanut worm meat

Results of nutrient composition analysis of two Peanut worm collected in Gianh river showed that the average total protein content of *Siphonosoma australe australe* was 11% and that of *Sipunculus nudus* was 9.79% (compared to fresh weight of meat). Peanut worm and this content is quite high. In particular, there are 19 types of amino acids, including nine types of amino acids are not needed for human body such as Methionine, Valine, Lisine, Leucine, Isoleusine, Histidine, Phenylalanine, Threonine and Tryptophan with high content. Results of analysis of nutritional value in meat of Peanut worm living in Gianh river compared with that of Quang Ninh have more than one amino acid is non-substitute, it is Histidine amino acid and Peanut worm in Quang Ninh is not available. This amino acid is more than two amino acids, including one amino acid substitute and one non-substituted amino acid (Tryptophan) compared to the Peanut worm living in Can Gio (Ho Chi Minh City).

The levels of amino acids in each species vary. The total amino acid content of *Siphonosoma australe australe* was 88,651 mg/g higher than that of *Sipunculus nudus* 66,249 mg/g. Considering each amino acid alone, *Siphonosoma australe australe* also produces higher results. Of these, Glutamic acid accounts for the highest in the *Siphonosoma australe australe* of 17.6 mg/g while in the *Sipunculus nudus* it is 13.9 mg/g, an important amino acid. Metabolizes neurons and brain and simultaneously detoxifies the debris generated by brain activity.

The total protein content of the *Siphonosoma australe australe* is 20% higher than the 13.86% *Sipunculus nudus.* When analyzing the total dry matter index, *Siphonosoma australe australe* was 80.73%, and *Sipunculus nudus* was 79.94%. This result also shows that the protein content in the soil is very high.

3.5.1.3. Using Condition

Price of fresh Peanut worm is 80,000 - 100,000 VND/1 kg , can be processed into different dishes such as fried sweet and sour soup, cooking porridge ... But for long-term preservation and export to Chinese traders and some other areas must be dried and then sold for sale; The price of 1 kg dry Peanut worm is much more expensive than fresh one, costing VND 4-5 million/kg.

3.5.2. The problem of conservation and development

Apart from the management and protection zoning, it is necessary to have projects for the conservation, exploitation and development of these resources.

CONCLUSION AND RECOMMENDATIONS

1. CONCLUSION

***1. Morphological and structural characteristics*:** Two species of *Siphonosoma australe australe* and *Sipunculus nudus* are found in the lower valley of the Gianh river, Quang Binh Province. Morphological characteristics of the Peanut worm is vermiform and unsegmented. *Siphonosoma australe australe* has an average body length of 335.2 ± 45.4 mm; the average weight was 33.4 ± 13.4 g. *Sipunculus nudus* has a body length of 164.2 mm; the average weight is 8.6 g. The body consists of two regions, the introvert and the body; The ratio of introvert length to average body length is 36% in *Siphonosoma australe australe* and 33% in *Sipunculus nudus*. These two species differ mainly in size and body weight (*Siphonosoma australe australe* is larger in size and weight than *Sipunculus nudus*), the number of longitudinal muscle bands, the shape, structure and color of the tentacles.

2. Distribution characteristics: Siphonosoma australe australe is distributed in all ten study sites with a tidal range of 0.7 - 1.8 m; They live in muddy-sandy or sandy- muddy soils, with a depth of 0.5 - 0.9 m; Salinity ranges from 13.9 to 19.9‰; Water temperature is from 24.7 - 25.8 oC and the pH is from 7.3 to 8.5. Sipunculus nudus live in muddy with depth of 0.4 - 0.6 m; Tide level of 1.3 - 1.8 m; Salinity 16.3 - 17.9‰; Water temperature from 25.2 to 25.7 oC; pH from 7.6 to 8.0.

3. Density, number of individuals and effected factors: Average individual density of *Siphonosoma australe australe* in the study sites was 0.68 individuals/m^2, average burrow density was appropriate 1.96 burrow/1m^2. The average number of individuals is about 62 individuals/study site, average biomass is 34.57 g/m^2.

The pH, salinity and water temperature are factors that influence individual density, burrow density, number of individuals and biomass of Peanut worm. Average population density, burrow density and number of individuals in the dry season are greater than those in the rainy season.

4. Diet composition: Diet of Peanut worm are mainly species of Silic algae (94.2%), Cyanophyta (1.92%) and Miozoa (1,92%).

5. Habitat: Peanut worm lives in burrow that dig in the tidal areas along rivers or mangroves. Mechanical composition of the burrow is muddy-sand or sand- muddy soil. In a soil environment of 6 sandy soil: 4 mud soil, Peanut worm has higher number of individuals and higher biomass. Living environment for Peanut worm is evaluated for the acid soils, the total N, P, K content in soils classified as poor or medium.

6. Nutritional value: The nutrient content of two Peanut worm collected in the Gianh river had an average total protein content of 11% in *Siphonosoma australe australe* and 9.79% in *Sipunculus nudus* (fresh weight of Peanut worm) and this content is quite high. In particular, there are 19 types of amino acids, including nine types of amino acids are non-substitute for human body such as Methionine, Valine, Lisine, Leucine, Isoleusine, Histidine, Phenylalanine, Threonine and Tryptophan. Nutritional value of meat in geese living in the Gianh River - Quang Binh compared with the Peanut worm of Quang Ninh has more than one amino acid is non-substitute, it is Histidine amino acid; And there are more than two amino acids, including one amino acid substitute and one non-substitute amino acid (Tryptophan) compared to the Peanut worm living in Can Gio (Ho Chi Minh City).

7. Exploitation output and utilization: Annually, the Peanut worm is exploited by laborers from other provinces with large output. The total exploited output in 2015 is 27,094 kg corresponding to the total income. Over 2 billion VND/year.

2. RECOMMENDATIONS

1. Continue to study the biological characteristics of the existing Peanut worm in Quang Binh to serve the pilot culture model.

2. There should be specific provisions on the exploitation of Peanut worm. It is necessary to set up a regular patrol team to check the status of exploitation of Peanut worm in the Gianh river. Strengthening the management of capture fisheries, protection of fisheries resources, protection of mangrove forests, biodiversity conservation and environmental protection.

3. There should be pilot models of this species such as piloting at different salinity, stocking this species together with other species such as shrimp, seaweed, rabbit fish, ...

4. It is necessary to have a plan for rational exploitation, avoid exploitation at the time of laying of the soil, in order to create conditions for population regeneration and protection of soil worm resources in the area.

LIST OF PUBLISHED SCIENTIFIC WORKS

1. Nguyen Thi My Huong, Tran Van Giang, Ngo Dac Chung, Do Van Nhuong and Le Huy Ba (2016). Morphological characteristics and distribution of the Peanut worm *Siphonosoma australe australe* (Sipuncula: Sipunculidea: Sipunculiformes: Sipunculidae)in the lower reaches of the Gianh river, Quang Binh province. Journal of Science, Hue University, 119, 57-65.
2. Nguyen Thi My Huong, Ngo Dac Chung, Le Huy Ba (2017). Population Density of the Peanut *Siphonosoma australe australe* (Keferstein, 1865) (SIPUNCULUS) in the Mangrove Forest of Gianh River, Quang Binh Province. Journal of Biology, DOI: 10.15625/ 0866-7160 / v39n1.8511.
3. Nguyen Thi My Huong, Le Huy Ba, Ngo Dac Chung, (2017). Habitat and Shelter of the Peanut worm *Siphonosoma australe australe* (Keferstein, 1865) (Phylum Sipuncula) in Lower Valley of the Gianh River, Quang Binh Province. National Seventh National Conference on Ecology and Biological Resources, 1656-1662.
