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The distribution of peanut-worm (*Sipunculus nudus)* in relation with geo-environmental characteristics

Nguyen Thi Thu Ha*, Mai Trong Nhuan, Nguyen Thi Ngoc, Huynh Tien Dung

College of Science, VNU

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Abstract. Quang Ninh Province, situated in Northeast coast of Vietnam, has about 250km of shoreline, many estuaries, and tidal flats and over 2000 islands. The diversified nature, natural landscapes and ecosystems grant the province a great potential for tourism and specially seafood products. Peanut-worms (*Sipunculus nudus*) are exploited and used as popular seafood in international and domestic markets as special food of high nutritional and pharmaceutical value.

According to the study results, peanut-worms live in unvegetative-cover sub-tidal flats, affected weakly by waves, wind and freshwater, submerged 10-18hours/day and environmental water is characterized by alkali - weak oxidized environment, high and stable salinity, low content of heavy metals. Beside, sedimentary environment is featured by high percentage of sand (more than 80%), alkali - weak oxidized environment, high nutrient and low heavy metals contents. Further more, the distribution of peanut-worms are strongly dependent on the following factors: sediment grain size, location and types of tidal flats, hydro-dynamic conditions, and environment parameters as pH, salinity and the dilution by freshwater.

The research result can provide scientific background for sustainable coastal planning, natural resources management and identification of suitable zones for peanut-worm conservation and farming in the near future.

Keywords: Peanut form; Geo-environment; Tidal flats; Heavy metals; Sediment.

1. Introduction

Peanut-worms are being exploited daily in many tidal flats along the coast of Quang Ninh Province as Vinh Thuc (Mong Cai District), Phu Hai, Quang Minh, Quang Dien (Hai Ha District), Chuong Ca, Hai Thoi (Tien Yen District), Quan Lan - Minh Chau, Chuong Xa (Van Don District) and Tong Man - Cai Rong (Ha Long City). The high reserves of peanut-worms in Quang Ninh have created a significant source of income for local residents and many poor people are dependent on this resource for their daily life.

Actually, those peanut-worm tidal flats are being over-exploited to satisfy the market demand. Beside that, those flats are threaten by human activities such as urbanization, pollution by solid and liquid wastes from adjacent areas, from aquaculture activities, and destructive fishing methods (using dynamite, toxic chemicals, and electric shock). The daily exploitation yield and the size of peanut-worms collected are

* Corresponding author. Tel.: 84-4-5587060.
E-mail: hantt_kdc@vnu.edu.vn

gradually decreased time by time. However the management of the exploitation of peanut-worms is hindered by the lack of scientific knowledge on their distribution in relation with living conditions.

The understanding of peanut-worms living conditions, especially geo-environmental factors, will provide a basic background for sustainable coastal planning and natural resources management in Quang Ninh Province in the long-term. Additionally, the study also contributes in identifying suitable zones for peanut-worm farming in the near-future.

2. Geo-environmental characteristics of peanut-worm tidal flats along the coast of Quang Ninh Province

2.1. Living location

Tidal flats, where peanut-worms live, are sub tidal-flats (or muddy flats) without cover vegetable (Fig. 1). The flats normally distribute along the coast or islands, estuarine sandy bars where tide is a dominant hydrological factor. Those flats are located outside the mangrove area with flat surface and submerged time from 10 to 18 hours/day, depending on tidal cycles. The flats are submerged absolutely from 5 to 7 days/month and can not be exploited during that time. Because peanut-worms are quite sensitive with the change of weather, salinity and hydro-dynamic conditions, so the flats, where peanut-worms live, are commonly surrounded by coastal island system and weakly affected by winds and waves and freshwater coming from rivers. That is the reason why peanut-worms can not be exploited during the bad weather or in the flats connected directly to freshwater flows.

2.2. Characteristics of sediment

Surface sediments of peanut-worm flats are composed 75-99% of sand. Surface sediment layer normally has grey to yellowish grey color, while deeper sediment layer has green grey to dark grey color due to sulfur enriched reducing environment. The sediment grain size is different from different flats. For example, Quan Lan - Minh Chau and Vinh Thuc are two exploited flats in offshore islands, affected weakly by land-based sources (sediment and pollutants), surface flat sediments content from 79 to 99% of sand of which 80-99% are quarts [1]. Chuong Ca, Hai Thoi, Long Vang are flats located in Tien Yen estuary and affected by

Fig. 1. Peanut-worm flat in Quang Minh Commune, Hai Ha District, Quang Ninh Province.

river source, that's why the surface sediment grain size is fine, the content of sand decreases to 75-78%. Other peanut-worm flats, weakly affected by river source, have 82% (Dong Xa) to 90% (Cai Rong, Phu Hai - see Fig. 2) of sand in surface sediment. The content of sand in sediment decreases with depth but not less than 80%.

2.3. Characterized environment parameters

As mentioned above, peanut-worm flats are sub-tidal flats, affected mainly by tide and surrounding sea water. In some flats as Chuong Ca, Hai Thoi, Phu Hai, the water environment is affected seasonally by river water (Tien Yen, Ha Coi), so pH and salinity of water is different from the water surrounding offshore islands (Table 1).

The pH value of water environment in peanut-worm flats is about 6.9 - 7.8. The salinity widely ranges from 20 - 31.5‰ with the lowest value in Chuong Ca - Hai Thoi flat in the rainy season (20‰) due to freshwater dilution effect of Tien Yen River. Flats in offshore islands as in Quan Lan - Minh Chau and Vinh Thuc areas, the salinity of water always reaches to 28-31.5‰ [1]. The content of DO in water depends on the condition of tide, wave and sea currents, so the content of DO in peanut - worm flats is quite high, ranging from 6.2 to 7.9 mgO_2/l.

The result of pH measurement shows that sediment in peanut-worm flats ranges from weak acid to alkaline environment with pH from 5.7 (in Chuong Ca - Hai Thoi) to 8.2 (in Minh Chau). The pH value of sediment also depends on location of flats (near or far from estuary).

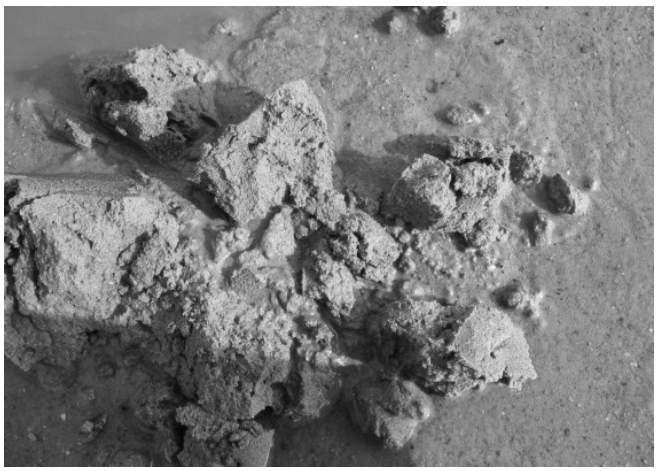

Fig. 2. Sediment of peanut-worm flat in Phu Hai Commune, Hai Ha District, Quang Ninh Province.

Table 1. Environment parameters in the water surrounding peanut-worm flats

Location	pH			Salinity (‰)	DO (mgO_2/l)
Quan Lan -Minh Chau	7.4	7.8	7.6	28.0 - 31.5	7.1
Cai Rong	7.2	7.7	7.5	26.3	6.1 - 7.0
Dong Xa	7.7	7.8	7.7	26.5	7.8
Chuong Ca - Hai Thoi	7.4	7.6	7.5	20.0 - 27.7	6.5
Phu Hai	6.9	7.3	7.0	23.0 - 28.0	7.9
Vinh Thuc	7.2	7.8	7.5	27.0 - 30.3	-
*TCVN-5943-1995**	*6.5*	*8.5*			*>5*

Based on data from survey in 2000 - 2005, SUMA; (*): Vietnam Environment quality Standards - 1995.

2.4. Content of some heavy metals in environment

The content of some heavy metals (except for Fe) in water is lower than standard levels in Vietnam Environment Quality Standards for coastal sea water and marine aquaculture (TCVN-5943-1995). Particularly, Copper (Cu) and Lead (Pb) range widely from 0.0011 to 0.0040mg/l (for Cu) and 0.0014mg/l to 0.0040mg/l (for Pb), much less than standard levels (Cu: 0.01mg/l), (Pb: 0.05mg/l). Other heavy metals also follow this trend as Zn (0.0031 - 0.0080mg/l), Cd (<0.0001 - 0.0021mg/l), As (0.0003 - 0.0011mg/l), Hg (0.00002 - 0.0007mg/l), V, Ni, Cr and less than criteria level (Zn: 0.01mg/l; Cd: 0.005mg/l; As: 0.01mg/l; Hg: 0.005mg/l). It means that, the sea water surrounding peanut-worm flats is not yet polluted by heavy metals.

Similarly, the content of heavy metals in sediments of peanut-worm flats (Table 3) shows that the content of most elements (as adsorbed ions) are less than Threshold effect level (TEL) according to Canadian Environment Quality Standards. So, the sediments in peanut-worm flats in Quang Ninh are still not yet polluted by heavy metals.

3. The distribution of peanut-worm in relationship with geo-environment factors

Peanut-worm (*Sipunculus nudus*) is a marine species which lives in sediments, and sediment environment characteristics and grain size are very important for the distribution of peanut-worms. Sediment grain size in environmental geochemistry study is one of the main factors to determine the behavior of elements, and in study of peanut-worm living conditions, it is also found as one of the main factors to determine the existence of peanut-worms in the

Table 2. Content of some heavy metals in the water surrounding peanut-worm flats (mg/l)

Location	Fe	Mn	Cu	Pb	Zn	Cd	As	Hg	Ni	V	Cr
Quan Lan - Minh Chau	-	-	0.0017	0.0018	0.0041	<0.0001	0.0011	0.00002	0.0004	0.0004	<0.001
Cai Rong	1.22	0.03	0.0013	0.0032	0.0074	0.0021	0.0004	0.0004	0.0019	0.0002	<0.01
Dong Xa	0.90	0.01	0.0011	0.0016	0.0036	0.0021	0.0003	0.0007	0.0012	0.0002	<0.01
Chuong Ca - Hai Thoi	0.26	0.1	0.0014	0.0021	0.0033	-	-	-	0.0019	<0.0002	<0.01
Phu Hai	-	-	0.0040	0.0040	0.0080	0.0001	0.0004	0.00003	-	-	-
Vinh Thuc	0.56	0.04	0.0015	0.0014	0.0031	-	-	-	0.0016	0.0002	<0.01
TCVN-1995-5943	*0.1*	*0.1*	*0.01*	*0.05*	*0.01*	*0.005*	*0.01*	*0.005*			*0.05*

Based on data from survey in 2000 - 2005, SUMA; (*): Vietnam Environment quality Standards - 1995; (-): below the detection limit.

Table 3. Content of some heavy metals in peanut-worm flat sediments (ppm)

Level	Zn	Cd	Pb	Cu	As	Hg	Ni	V	Cr	Fe	Mn
Max	9.1	0.09	4.3	26.0	3.5	0.15	6.1	3.8	4.0	26500	20
Min	0.6	0.01	0.1	0.1	0.3	0.04	0.3	0.2	0.5	1500	1
Average	2.4	0.02	1.5	3.1	0.7	0.07	1.4	1.2	1.7	10800	7
TEL		0.7	30.2	18.7	7.2	0.13			523		

Based on data from survey in 2000 - 2005, SUMA; (-): below the detection limit.

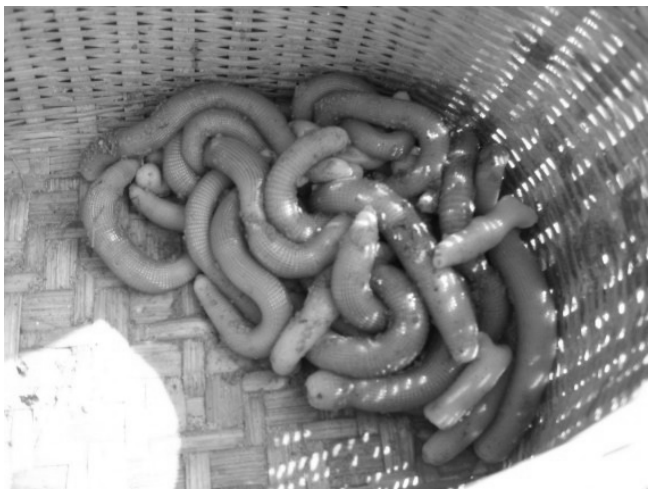

Fig. 3. Peanut-worms in Phu Hai Commune, Hai Ha District, Quang Ninh Province.

flats. Based on the results of sediment grain size analysis of samples collected from different sites, most peanut-worm flat sediments comprised of more than 80% of sand. Where the sand content in sediment is high, the more peanut-worms are found. Where the sand is mostly white and more than 80% in contents, the peanut-worms have big individual size, high density and quality (as in Quan Lan - Minh Chau, Vinh Thuc, Phu Hai). Where the content of sand is less than 80%, peanut-worms have low density and small individual size (Chuong Ca, Hai Thoi). Peanut-worms are found rarely in the flats with less than 60% of sand. Finally, it is impossible to find peanut-worms in flats with less than 60% of sand and more than 15% of clay (Dong Xa).

Another important factor for living conditions of peanut-worms is hydrological status in coastal areas. Peanut-worm sub-tidal flats are normally weakly affected by freshwater sources because peanut-worm are quite sensitive to salinity change, that's why, in some estuarine sub-tidal flats as Ba Lat, Tra Ly,... which are affected strongly by river, peanut-worms can not be found. In some sub-tidal flats, although having good conditions from the point of view of sediment grain size, but are influenced strongly by hydro-dynamic factors as wave, wind and sea currents, no peanut-worm exists.

As for environmental factor, coastal white sandy flats, characterized by weak reducing sediment environment in depth more than 10cm and stable salinity, are good living areas for peanut-worms.

The results of research on peanut-worm food show that peanut-worms are passive and unselective digestion [2]. According to Yan and Wang [3], peanut-worms adsorbs and accumulates elements from sediment through digestion with the accumulated coefficient for some elements as Cd: 6-30%, Cr: 0.5-8% and Zn: 5-15%; and the accumulated coefficient of elements in peanut-worms are not changed with polluted environment [4]. This means that if the content of heavy metals in sediment is high then their content in peanut-worm also will be high. As can be seen from Table 4, the content of elements in peanut-worm is much higher than in sediment from flats themselves. Based on this result, peanut-worms can be used as a species to adsorb the pollutants in sediments or we can adjust the quality of peanut-worm according to market demand through the improvement of sediment conditions.

Table 4. Analyzed content of some heavy metals in peanut-worms (ppm)

Location	Fe	Mn	Ni	Cr	V	Ti	Cu	Pb	Zn	Hg	Cd	As
Minh Chau	441.1	3.7	4.70	10.1	1.98	9.33	1.80	0.51	2.30	-	-	-
Phu Hai	-	-	-	10.4	-	-	-	8.4	32.77	0.046	0.24	0.327
Cai Rong	-	-	-	9.8	-	-	-	7.6	30.77	0.114	0.39	1.503
Average	*441.1*	*3.7*	*4.7*	*10.1*	*2.0*	*9.3*	*1.8*	*5.5*	*21.9*	*0.1*	*0.3*	*0.9*

Based on data from survey in 2000 - 2005, SUMA; (-): below the detection limit.

4. Conclusion

Peanut-worm flats are sub-tidal flats without vegetable cover, affected weakly by waves, wind and freshwater, submerged 10-18hours/day. Water surrounding peanut-worm flats is characterized by alkaline, weak oxidized environment, high and stable salinity, low content of heavy metals. Sediments in peanut-worm flats are characterized by the high content of sand (more than 80%), alkaline, weak oxidizing environment, high nutrients and low heavy metals contents.

Distribution of peanut-worms is closely related to geo-environmental factors such as: sediment grain size, location of flats, hydro-dynamic conditions, and environmental parameters as pH, salinity and the dilution by freshwater. The research results can provide a basic background for sustainable coastal planning and natural resources management in Quang Ninh Province in the long-term. Additionally, the study also contributes in identifying suitable zones for peanut-worm farming in the near-future.

Research on geo-environmental factors (content and color of sediments, content of elements in environment) of peanut-worm flats contribute to set up a scientific base for improvement of peanut-worm quality by adjusting the sedimentary conditions, especially for peanut-worm farming in the near future.

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