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The effect of substrate grain size on burrowing ability and distribution characteristics of *Perinereis aibuhitensis*

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Abstract

Perinereis aibuhitensis (Grube, 1878) lives in marine sediments of estuary or shoal areas, where substrate has some crucial environmental factors affecting its burrowing and distribution. In order to provide basic data for the habitat selection and suitability evaluations of the artificial aquaculture of *P. aibuhitensis*, this paper conducted a quantified analysis of its burrowing ability and explored its behavioral preferences in different substrates, including mud (<75 μm), fine sand (125–250 μm), medium sand (250–500 μm), coarse sand (500–2 000 μm), gravel (2 000–4 000 μm) and ceramsite (4 000–8 000 μm). The research results revealed that substrate grain size significantly affected the burrowing time, burrowing rate, burrowing depth and distribution rate ($P<0.01$). Moreover, *P. aibuhitensis* demonstrated preferential selections relating to substrate grain sizes, had higher burrowing ability in ceramsite, mud and fine sand compared with other substrates. The strongest burrowing ability and the highest distribution rate were observed in ceramsite. The study indicated that *P. aibuhitensis* was sensitive to substrate grain size, which also had an impact on its burrowing process and population distribution. In the natural sea, substrates mainly composed of mud and fine sand are fit for aquaculture and stock enhancement. Based on behavioral preferences and ecological rehabilitation function of *P. aibuhitensis*, this paper proposes a symbiotic system of marine animals and halophytes, and constructs an ecosystem model of "Marine fish-Halophytes-*Perinereis aibuhitensis*" with *P. aibuhitensis* as the link.

Key words: *Perinereis aibuhitensis*, substrate, grain size, burrowing ability, distribution characteristics

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1 Introduction

Perinereis aibuhitensis, as called "sea centipede" or "sea leech", is a species of Annelida, Polychaeta, Nereidae and *Nereis* and inhabits marine sediments of the estuary or shoal areas in China, South Korea, the Philippines and India (Jørgensen et al., 2008; Jia et al., 2017). *Perinereis aibuhitensis* is recognized as a sentinel species for environmental monitoring, and also a dominant species for ecological rehabilitation (Tian et al., 2014; Koo and Seo, 2017). In addition, it is often referred to as "universal bait", as it provides good feed for fish. *Perinereis aibuhitensis* has a rather high nutritional and economic value, and is therefore, one of the important export earning varieties. However, in recent years, due to overfishing and pollution, the destruction of *P. aibuhitensis*'s natural resources has become quite serious. In order to protect its germplasm resource and meet the needs of the market, many places have begun to conduct research on technology focused on artificial production-increasing cultivation of *P. aibuhitensis* (Liu et al., 2012; Fang et al., 2016). The larvae of *P. aibuhitensis* goes through a planktonic life stage, and then burrows into the substrate after the ciliary ring disappears and at this moment, it has burrowing and motility features (Hong and Tan, 1982).

Burrowing is an important ecological strategy, which enables organisms to avoid predators and be carried away by the current for the zoobenthos. For them, movement lays the foundation for exploring the appropriate substrate environment, thereby forming differentiated and varying distribution characteristics of diverse substrates (Stevens, 2003; Schmidlin and Baur, 2007). The substrate is an important environmental factor affecting zoobenthos' burrowing and distribution. Furthermore, the uniformity and compactness of substrate distribution exert varying effects on zoobenthos' burrowing ability and distribution (Nel et al., 2001; Beisel et al., 1998; Bunn and Arthington, 2002). At present, there are some reports on the substrate preferences and distribution of other polychaeta species, for example, *Polyphysia crassa* and *Leitoscoloplos pugettensis* are more adaptable to soft substrates, so they prefer mud environment (Hunter and Elder, 1989; Francoeur and Dorgan, 2014), while *Naineris dendritica* and *Orbinia johnsoni* are more observed to distribute in hard substrate and prefer sandy environment (Francoeur and Dorgan, 2014). However, the researches related to *P. aibuhitensis*'s burrowing ability and distribution characteristics under diverse sub-

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strate conditions are rarely reported. Therefore, this experiment aims to systematically evaluate the burrowing ability of *P. aibuhitensis*, and explore its behavioral preferences using six types of substrate grain sizes (mud, fine sand, medium sand, coarse sand, gravel and ceramsite), in order to obtain the optimum conditions for its artificial aquaculture. This article provides a theoretical basis for the habitat selection and suitability evaluations of *P. aibuhitensis*'s artificial aquaculture, so as to promote the progress of breeding technology and the full realization of an ecological rehabilitation function in the coastal zone.

2 Materials and methods

2.1 *Materials*

Numerous *P. aibuhitensis* organisms were purchased from an aquaculture business in Dongying, Shandong Province, China, and were selected for vibrant health and a similar size for the experimental materials, with a mean length of (12.07±1.18) cm and mean mass of (1.21±0.12) g. The sand was collected from the Yantai sea area, and then was dried and sorted into four specific grades using sieves (ISO 3310–1:2016, Test sieves-Technical requirements and testing-Part 1: Test sieves of metal wire cloth) according to the Wentworth scale (Buchanan, 1984): fine sand, 125–250 μm; medium sand, 250–500 μm; coarse sand, 500–2 000 μm; and gravel, 2 000–4 000 μm. Mud (grain size<75 μm) was also collected from the pond culture area in Yantai, while ceramsite (4 000 μm<grain size<8 000 μm) (GB/T 17431.1–2010, Lightweight aggregates and its test methods-Part 1: Lightweight aggregates, China) was purchased from Nantong Dadi Ceramic Co., Ltd. All the substrates needed to be dehydrated and sterile prior to the experiment. The experimental water consisted of natural seawater with sufficient aeration and sedimentation.

2.2 *Methods*

2.2.1 *Temporary culture*

The *P. aibuhitensis* organisms were acclimated to PVC receptacles (100 cm×50 cm×25 cm) for one week, lying on a 15 cm thick native substrate, which was collected from the production area of *P. aibuhitensis,* and 5 cm seawater was pumped in with an average density of 200 m^{-2}. During the temporary culture period, the seawater temperature was (20±1)°C, pH was 7.5±0.5, salinity was 20, and continues oxygenating was provided. Moreover, a little microalgae (*Chlorella vulgaris* and *Mtzschia closterium*) was equally fed, but at several intervals, while the seawater was changed by means of a siphoning method each day. In order to avoid the impact of light intensity on its burrowing behavior, it was controlled under 50 lx, while avoiding direct sunlight and exposed nightlights, thereby allowing the *P. aibuhitensis* organisms to fully adapt to the low light environment. Furthermore, the seawater was oxygenated for an hour prior to the formal experimentation, so as to ensure a sufficient dissolving of oxygen. The environment excluded feeding, oxygenating and changing water during the formal experiment period, so as to avoid bait, bubbles or the suspended substrate having an effect on the empirical observation.

2.2.2 *The burrowing experiment of P. aibuhitensis with different substrate grain sizes*

(1) Burrowing time and burrowing rate experiments

The experiment was conducted in 30 PVC sinks (30 cm×25 cm×25 cm), and five repeats were set for each substrate grain size. Moreover, each sink was laid with a 15 cm thick substrate consisting of different sizes, and infused slowly into 5 cm seawater depth, after which it sat quietly for 2 h. We placed ten *P. aibuhitensis* organisms evenly in each sink, and noted the time immediately when they scattered naturally on the surface of the substrate. We then recorded the burrowing time and burrowing rate of *P. aibuhitensis* under diverse substrate matter. The preliminary experimental results revealed that more than 50% *P. aibuhitensis* could complete the burrowing process within 1 h.

The standard for evaluating *P. aibuhitensis*'s burrowing behavior was that its tail could not be observed from substrate surface (de la Huz et al., 2002; Nel et al., 2001), while the burrowing time was set between scattering naturally on the surface and the burrowing of 50% individual samples (Zhou et al., 2014; Shin et al., 2002).

The computational formula of the burrowing rate (*BR*) is as follows:

$$BR = \frac{M}{N} \times 100\%,$$

where M is the number that finished burrowing, and N is the number introduced at the outset of the experiment.

(2) Burrowing depth experiment

The experiment was conducted in multiple uncovered and bottomless hollow-PVC-cylinders (Fig. 1a), and six bottomed cylinders (Fig. 1b), with 7.5 cm in inside diameter and 2.5 cm in height. Each cylinder was named a unit. In the experiment, each unit was linked by packaging tape (Fig. 1c). The tape could be easily removed, while still maintaining immobility and closure property. During the experiment, no liquid was exuded from the junction of two units. From top to bottom, each unit was encoded with 1, 2, 3, 4, 5, 6,..., n (Fig. 1c). The number of units for each grain size was obtained by preliminary experiment. However, in the formal experiment, the number of units was set larger than that obtained in the preliminary experiment, thus ensuring that the substrate was deep enough for the burrowing of *P. aibuhitensis*. In the experiment, substrate with a certain size was added into the set of units (Fig. 1c) until it sunk to the bottom of Unit 2.

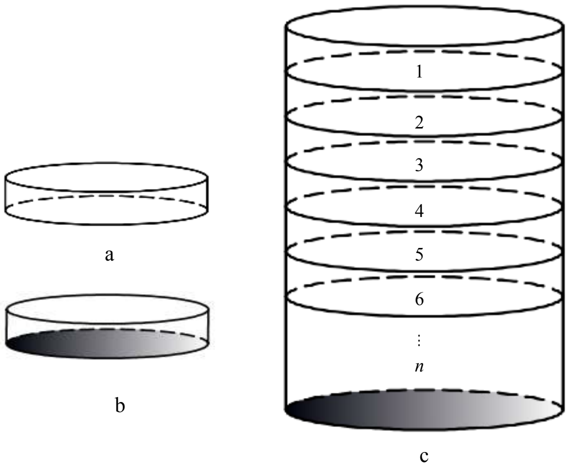

Fig. 1. The equipment had been used to study the burrowing depth of *P. aibuhitensis.* a. An uncovered and bottomless hollow-PVC-cylinder, with 7.5 cm in inside diameter and 2.5 cm in height, which was also called a unit. b. The shadow shows that the unit had bottom. c. A unit set consisting of small units connected by external tape.

Then seawater was slowly added to the depth of the bottom of Unit 1. Unit 1 was empty in order to prevent *P. aibuhitensis* from escaping. After that, the set of units was left quietly for 2 h. A total of ten *P. aibuhitensis* were put evenly into the set of units and then randomly scattered into the substrate surface. After 12 h, seawater was siphoned out, and the tape was torn carefully from the link of Units 2 and 3. Then each unit was separated slowly to avoid the disturbance of *P. aibuhitensis*. The authors recorded the coding number of the unit where the mouth of *P. aibuhitensis* was inside (Enderlein, 2004). Particularly, in Unit 2, *P. aibuhitensis* that did not burrow into the substrate was recorded as 2. Each substrate grain size was set as 5 repeats.

The computational formula of burrowing depth (*BD*) is deduced as:

$$BD = (U - 2) \times 2.5,$$

where U denotes the coding number of the units where the mouth of *P. aibuhitensis* was inside.

2.2.3 *The distribution experiment of P. aibuhitensis with different substrate grain sizes*

The experiment was conducted in a PVC cylindrical bucket with the diameter of 75 cm and the height of 25 cm, by choosing one substrate grain size out of six (Fig. 2). The bucket was divided into six equal spaces using six rigid plates (37.5 cm× 2 mm×25 cm). Then, each part and each type of substance were marked with a random number respectively. The number from 1 to 6 was generated from a random table, without repetition. The marking sequence was based on alphabetical order and grain size of substrate, and then the same numbers were combined together, with the data recorded. The clapboard was whipped out after a mark was made on the bucket where the clapboard was placed. Then 5 cm seawater depth was infused slowly (if the substrate surface was not flat, the corresponding substrate should increase or decrease), and left standing for 2 h. Twenty-five *P. aibuhitensis* were evenly put in a range of 15 cm away from the center of the substrate surface, and then 25 *P. aibuhitensis* again were added after 1 h, with a total of 100 *P. aibuhitensis* in four times. Seawater was siphoned out after 12 h, and then the clapboard was inserted into the substrate slowly according to the mark on the bucket. Then the substrate of each part was dug out carefully to gather the data for *P. aibuhitensis* in each part. The distribution experiment was repeated for five times.

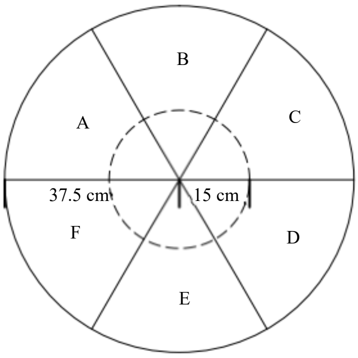

Fig. 2. The way of *P. aibuhitensis* selecting substrates. Different capital letters were used to represent the substrates with different grain sizes. In each repetition experiment, capital letter was randomly chosen to show a certain substrate. The areas with dotted lines were the delivery area of *P. aibuhitensis*.

The computational formula of distribution rate (*DR*) is as follows:

$$DR = \frac{X}{100 - Y} \times 100\%,$$

where X is the number that was in the substrate after 12 h and Y is the number without burrowing any substrate.

2.3 *Statistical analysis*

The experimental data were expressed as mean±SD. If multiple sets of variables were consistent with homogeneity of variance, one-way analysis of variance (ANOVA) was used to compare multi-group variables, followed by a Tukey's post hoc test; if not, Kruskal-Wallis test would be chosen, followed by a Nemenyi's post hoc test. The significant level was $P<0.05$. All statistical analyses were performed utilizing SPSS statistics 17.0 software (IBM, Armonk, USA).

3 Results

3.1 *The burrowing ability of P. aibuhitensis with different substrate grain sizes*

The burrowing time of *P. aibuhitensis* initially increased with the increasing substrate grain size and then decreased (Fig. 3), as opposed to the burrowing rate (Fig. 4) and burrowing depth (Fig. 5).

Upon Levene's test, the data of burrowing time, burrowing rate and burrowing depth was in accordance with homogeneity of variance (P value were 0.300, 0.250 and 0.149 respectively), which could be used for analysis of variance. The analysis of variance revealed that the substrate grain size had significantly affected the burrowing time [$F(5, 24) = 269.188$, $P<0.01$], the burrowing rate [$F(5, 24) = 13.760$, $P<0.01$] and the burrowing depth [$F(5, 294) = 225.776$, $P<0.01$] of *P. aibuhitensis*.

The longest burrowing time (423.60±22.25) s of *P. aibuhiten-*

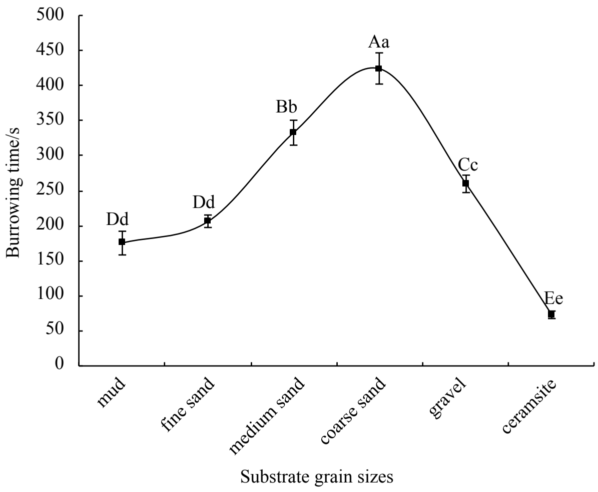

Fig. 3. The burrowing time of *P. aibuhitensis* with different substrate grain sizes. Means with different capital letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.01$); means with different minuscule letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.05$); means with the same letters are not significant different by one-way ANOVA, followed by a Tukey's post hoc test ($P>0.05$).

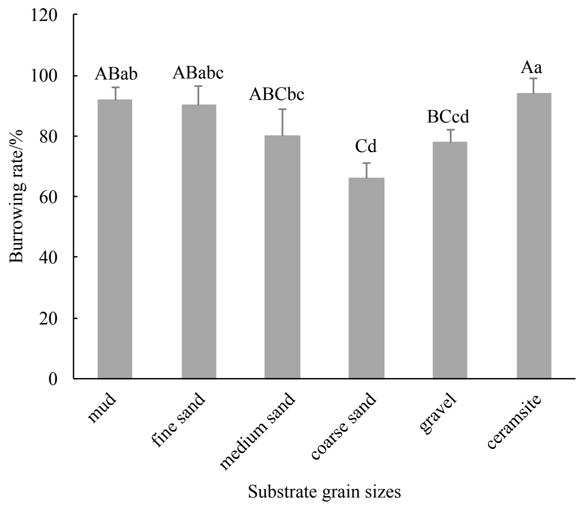

Fig. 4. The burrowing rate of *P. aibuhitensis* with different substrate grain sizes. Means with different capital letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.01$); means with different minuscule letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.05$); means with the same letters are not significant different by one-way ANOVA, followed by a Tukey's post hoc test ($P>0.05$).

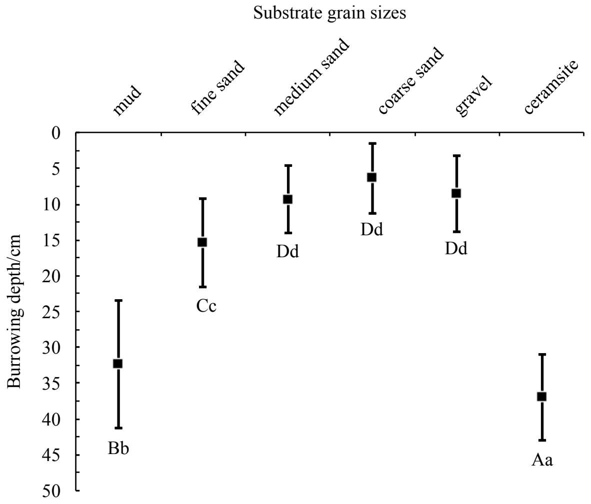

Fig. 5. The burrowing depth of *P. aibuhitensis* with different substrate grain sizes. Means with different capital letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.01$); means with different minuscule letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.05$); means with the same letters are not significant different by one-way ANOVA, followed by a Tukey's post hoc test ($P>0.05$).

sis was observed in coarse sand, which was significantly longer than other treatment groups ($P<0.01$), and the least time (73.00±4.56) s was observed in ceramsite, which was significantly less than other treatment groups ($P<0.01$). The burrowing time of *P. aibuhitensis* in mud and fine sand was shorter than other groups except that of ceramsite, where the value was (175.40±16.48) s and (206.20±9.37) s, but not significantly ($P>0.05$). The burrowing time in medium sand and gravel was significantly different ($P<0.01$), where the value was (333.40±17.96) s and (260.00±12.46) s.

The highest burrowing rate of *P. aibuhitensis* was obtained in ceramsite, which could go up to (94.00±4.90)%. The difference between mud and fine sand was not significant ($P>0.05$), reaching 90%. The burrowing rate of *P. aibuhitensis* in medium sand and coarse sand was not significantly different compared with the gravel group ($P>0.05$), with the value of (80.00±8.94)%, (66.00±4.90)%, and (78.00±4.00)%, respectively.

In ceramiste, *P. aibuhitensis* has the maximum burrowing depth, reaching (37.05±6.01) cm, which was significantly higher than that of other treatment groups ($P<0.01$). The burrowing depth of *P. aibuhitensis* in mud was significantly higher than that in sand ($P<0.01$). In mud, *P. aibuhitensis* could burrow as deep as (32.30±8.94) cm, while the maximum burrowing depth was only (15.40±6.19) cm in find sand. In medium sand, coarse sand and gravel, the burrowing depth was not significant ($P>0.05$), ranging from 6.35 cm to 9.30 cm.

3.2 *The distribution rate of P. aibuhitensis with different substrate grain sizes*

The mean distribution rate of *P. aibuhitensis* was (88.20±2.14)% after 12 h. The distribution rate decreased with the increase of substrate grain sizes and then increased (Fig. 6).

Upon Levene's test, the data of distribution rate was in accordance with homogeneity of variance, whose *P* value was 0.444, thus it could be used for analysis of variance. It was shown in the analysis of variance that the substrate grain size significantly affected the distribution rate of *P. aibuhitensis* [$F(5, 24) = 58.999$, $P<0.01$].

The total percentage of distribution rate in mud, fine sand and ceramsite was 65.56%, significantly higher than that of the other three groups ($P<0.01$). *Perinereis aibuhitensis* preferred to live in ceramsite, with the highest distribution rate, however, it was not significant compared with that of mud ($P>0.05$), with the value of (24.72±2.23)%. The lowest distribution rate of *P. aibu-*

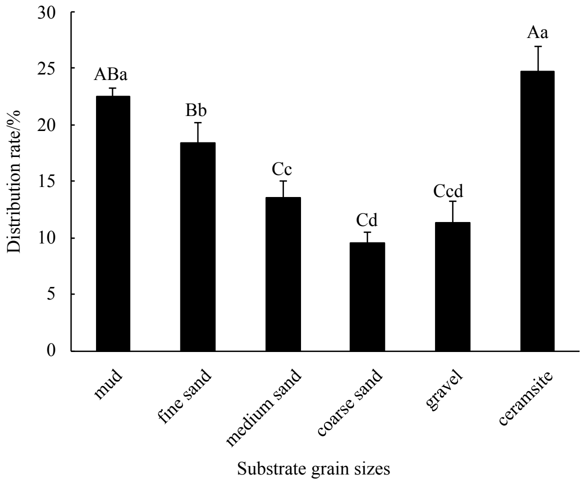

Fig. 6. The distribution rate of *P. aibuhitensis* with different substrate grain sizes. Means with different capital letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.01$); means with different minuscule letters are significantly different by one-way ANOVA, followed by a Tukey's post hoc test ($P<0.05$); means with the same letters are not significant different by one-way ANOVA, followed by a Tukey's post hoc test ($P>0.05$).

hitensis in coarse sand was significantly lower than that of medium sand (P<0.05), but not significant compared with that of gravel (P>0.05), the value was only (9.51±0.98)%. The distribution rate of *P. aibuhitensis* in medium sand and gravel also remained at more subdued levels, however, the difference was not significant (P>0.05), with the value of (13.59±1.40)% and (11.35±1.92)%, respectively.

4 Discussion

4.1 *The burrowing ability and distribution characteristics of P. aibuhitensis in various substrate grain sizes*

Substrate condition was one of the most important environmental factors for the growth, survival, behavioral responses and geographical distribution of zoobenthos (Nel et al., 2001; Beisel et al., 1998; Bunn and Arthington, 2002). The differences in substrate responses of individuals could be eliminated efficiently by burrowing time, burrowing rate, burrowing depth and distribution rate, thus substrate conditions are commonly used for measuring the burrowing ability of *P. aibuhitensis* and its adaptation of substrates (Nel et al., 2001; de la Huz et al., 2002; Alexander et al., 1993; Schmidlin and Baur, 2007; Enderlein, 2004). It was found out that the burrowing ability and distribution characteristics were different with shellfish with different grain sizes of substrates. For example, *Donaxserraand Donaxsordidus* had the fastest burrowing time in the medium sand, and showed an increasing trend in coarse sand (Nel et al., 2001); the burrowing rate of *Lampsilis radiate luteola* had a higher level in substrate grain size except mud (Huehner, 1987); the burrowing depth of *Ruditapes Philipponarum* in muddy sand was 0.7 times of its shell length, but in gravelly sand, the figure was up to 2.6 (Kondo, 1987); *Corbicula fluminea* preferred fine sand and the distribution rate was also the highest, while *Elliptio dilatatadid* did not show a distinguishing substrate preference (Schmidlin and Baur, 2007; Huehner, 1987).

This study found that the burrowing time was less in ceramsite, mud and fine sand, while the burrowing rate and burrowing depth were higher than others, indicating that *P. aibuhitensis* had a greater burrowing ability and a better adaptation in these three substrates. The shear strength of the substrate increased with the decreasing size of substrate grains (de la Huz et al., 2002). However, this study observed that the burrowing time became shorter with a decreased substrate grain size from coarse sand to mud, as opposed to the burrowing depth. This is due to the trunk of *P. aibuhitensis*, which can be divided into more than 100 successive metameres. Each metamere has a parapodia with several setae, which are surrounded by abundant capillaries, providing sufficient energy for setae movement. Meanwhile, there are many mucous glands on the head and trunk, whose function is to secrete mucus, so as to lubricate the body and the substrate (Song et al., 2010). Setae movement and mucus lubrication, therefore, allows *P. aibuhitensis* to have a significant burrowing ability, which was strong enough to overcome the shear strength of smaller size substrates. *Perinereis aibuhitensis* was more adaptable to mud environment than sand environment. The mud substrate has a small surface resistance, so *P. aibuhitensis* could easily burrow as deep as 32.30 cm, as compared to the burrowing depth of 15.40 cm in fine sand. With growing grain size, the substrates gradually increased in weight and its surface became rough. The parapodia's strength and mucus secretion were finite in *P. aibuhitensis*, and were not sufficient to move into large size substrate, therefore, its burrowing ability faded in medium sand and coarse sand, and it was hard for the whole body of *P. aibuhitensis* to enter these substrates. However, as the substrate grain size was continuously expanded, the spaces between substrate grains increased. Consequently, *P. aibuhitensis* could utilize its mucus to burrow into the substrate by taking advantage of the spaces. As a result, it had better burrowing ability in gravel in comparison with coarse sand. Hence, *P. aibuhitensis* could easily utilize its mucus to burrow into a ceramsite substrate through the largest space, and its burrowing ability in ceramsite was the strongest and could burrow a depth of 37.05 cm.

In distribution experiments, (88.20±2.14)% of *P. aibuhitensis* could complete the burrowing process and the distribution rate was significantly different in diverse substrates, indicating that *P. aibuhitensis* had an obvious substrate grain size choice behavior. The parapodia and setae acted as locomotive organisms for *P. aibuhitensis*, and the existence allowed *P. aibuhitensis* to have significant motility, thus it had the ability to select a suitable substrate. It was also found out that *P. aibuhitensis* exhibited specificity in the choice of substrate grain sizes. The results revealed that *P. aibuhitensis* preferred ceramsite, mud and fine sand, which is also consistent with the result of its significant burrowing ability in these three substrates. Among the substrates, the distribution rate was the highest in ceramsite. The analysis considered that *P. aibuhitensis* needed to get in and out of their cave when it finished burrowing. Additionally, the grain size of the mud and fine sand was smaller than others; thus, they selected a lower surface tension and could also be easily aggregated; because of this, the cave could not easily be closed. When the substrates comprised medium sand, coarse sand and gravel, the conditions were just the opposite. However, the space between the ceramsite was significantly larger than others, thus *P. aibuhitensis* could go through the substrate and obtain food effectively.

This study ascertained that the burrowing ability of *P. aibuhitensis* was obviously strengthened when the substrate grain size was relatively small and excessively large, and the distribution rate increased correspondingly. This demonstrated that *P. aibuhitensis* belonged to a substrate sensitive species, and that substrate grain size had an effect on the burrowing process and population distribution of *P. aibuhitensis* (Alexander et al., 1993).

4.2 *The ecosystem model of "Marine fish-Halophytes-Perinereis aibuhitensis" based on P. aibuhitensis*

With small holes in the inner part and surface, ceramsite is commonly used in freshwater fish and vegetable co-existing systems, and plays an important role in filtering out harmful material and culturing nitrobacteria (Chen et al., 2000; Moore et al., 2001). At present, soil salinization has become a common environmental and ecological problem worldwide, thus halophytes were widely cultivated, such as salt-tolerant rice (Takagi et al., 2015), *Salicornia bigelovii* (Glenn et al., 1992) and *Suaeda glauca* (Zhao et al., 2004). As deposit-feeding infaunal species, *P. aibuhitensis* has the ability to degrade and utilize organic pollutants. Mud, fine sand and other small grain sizes substrate could be ingested by *P. aibuhitensis* and egested with fecal pellets (Jia et al., 2017). In this way, *P. aibuhitensis* could meet its nutritional requirements by absorbing and utilizing organic compound small grain size substrates, thereby decreasing organics content in substrate. Accordingly, it could be used to relieve the accumulation of organic pollutants in substrate, thus improving and renovating the aquatic ecosystem (Tian et al., 2014; Pruell et al., 2000). *Perinereis aibuhitensis* is a zoobenthos, without struggling with upper-layer aquatic organisms for living space. In addition, with wide tolerance for salinity, it could survive in brackish water

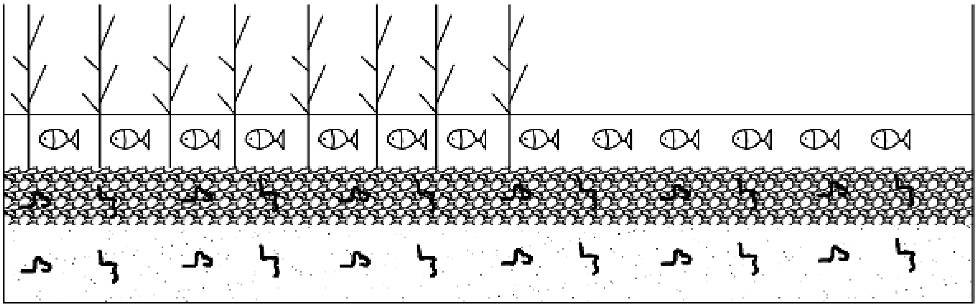

Fig. 7. “Marine fish-Halophytes-Perinereis aibuhitensis” ecosystem model.

and seawater (Neuhoff, 1979). Thus, in marine fish culture, “Marine fish-Halophytes-*Perinereis aibuhitensis*” ecosystem model (Fig. 7) could be established with suitable halophytes and *P. aibuhitensisin* in order to alleviate feed remnants, excrement and animal residues in the aquaculture system. Meanwhile, with feeding, burrowing and other activities of *P. aibuhitensis*, substrates would be loosened and large grains would be small, thus contributing to microorganism degradation. These activities also cause bioturbation and then accelerate the releasing of N, P and other nutritive elements from substrates into the water layer (Hansen and Kristensen, 1997) for promoting the growth of halophytes, which establishes a dynamic balance material circle system to achieve an ecological and efficient aquaculture. *Perinereis aibuhitensis* acted as a link in “Marine fish-Halophytes-*Perinereis aibuhitensis*” ecosystem model, which was similar to earthworms in freshwater fish and vegetable co-existing systems (Sandell, 2014).

Because of larger size and heavy weight of ceramsite, *P. aibuhitensis* cannot build independent caves though it can easily dive into ceramsite. Thus, ceramsite system cannot certainly bring about a safe and optimum living space for *P. aibuhitensis*. Based on the research findings and the analysis of *P. aibuhitensis*’ s natural distribution, a better habitat needs to be set up for the living of *P. aibuhitensis* with the substrate of mud and silver sand, and the nutrient substances in the upper water environment.

In the mud and fine sand substrate, high total organic carbon (TOC) and low oxygen is a general problem, especially in ageing aquaculture pool, and is harmful to most species (Kamal et al., 2018; Lange et al., 2014; Burone et al., 2003). However, the existence of *P. aibuhitensis* could accelerate materials turning over and recycling to improve this problem (Lopez and Levinton, 1987; Jia et al., 2017; Hansen and Kristensen, 1997). On the one hand, *P. aibuhitensis* could swallow a large number of small particles like mud and fine sand sediments, and the daily handling capacity is at least equivalent to the dry weight of its body (Lopez and Levinton, 1987). Through ingestion and digestion of *P. aibuhitensis*, there is a significant decrease in the content of organisms in sediment. That is why *P. aibuhitensis* is commonly used for ecological restoration in coastal intertidal zones and improvement of aging bottom quality in breeding-ponds (Jia et al., 2017). On the other hand, the role of bioturbation caused by *P. aibuhitensis* feeding and burrowing and other activities could reduce the accumulation of nutrient elements and increase oxygen content in substrate (Hansen and Kristensen, 1997). Meanwhile, the upper coasted ceramsite can also absorb and cultivate photosynthetic bacteria (Zhang et al., 2008), thus decontaminating water quality and increasing dissolved oxygen. In this context, the ecological system can work in a steady and continuous way.

This model is appropriate for small seawater aquarium system, and also valuable in aquaculture production. It is worth attention in the future.

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