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THE BIOLOGICAL CHARACTERISTICS AND UTILIZATION OF *Urechis unicinctus*

Feng LIU[1], Xuening LI[1], Yuan JI[1], Chune LIU[1], Tao SUN[1], Yancui ZHAO[2], Carmen Georgeta NICOLAE[3], Lorena DEDIU[4]

[1]Yantai Research Institute, China Agricultural University, 2006 Binhai Zhong Road, Yantai, 264670, P.R. China
[2]Ludong University, School of Life Science, 186 Hongqi Middle Road, Yantai, 264025, P.R. China
[3]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd., District 1, 011464, Bucharest, Romania
[4]„Dunărea de Jos" University, 47 Domnească Street, 800008, Galaţi, Romania

Corresponding author email: lorena.dediu@ugal.ro

Abstract

The Urechis unicinctus is a rare treasure benthonic animal that most seen in China, Japan and Korean Peninsula. As the research moves along, people gradually realized that Urechis unicinctus possesses delicious meat with high economic value. High protein content and the presence of numerous essential amino acids in the body wall muscle are arguments for regular consumption to increase human health. This paper reviews and discusses available research results regarding biology, ecology and physiology of Urechis unicinctus emphasizing its potential to be valorized for different industries. Nevertheless, the paper provides references for further studies dealing with producing of Urechis unicinctus under controlled conditions.

Key words*: biology, characteristics, Urechis unicinctus, use.*

INTRODUCTION

Urechis unicinctus which is known as spoon worm or fat innkeeper worm belonging to the *Echiurioidea, Echiurida, Xenopneusta, Urchidae* and *Urechi*s (Ma et al., 2016; Zhang et al., 2016). Shandong peninsula is the main producing region, and the "Yantai sea worm" has become a protection product with a geographical indication. Spoon worm is considered a delicacy and, because of the high protein content and high number of essential amino acids, a sea food product with high nutritional value (Jo et al., 2008). *U. unicinctus* has potential medical value (Sung et al., 2008) due to anti-tumor and immune-improving effects of some extracts.

In order to provide reference for the further development of *U. unicinctus*, this paper summarizes the biological aspects of *U. unicinctus* such as structure, distribution, growth and reproduction as well as utilization.

Figure 1. Mature *U. unicinctus* (50 g wet weight)

Figure 2. Mature dark *U. unicinctus* (110 g wet weight)

MATERIALS AND METHODS

This paper presents a review of the relevant literature regarding the biological characteristics and utilization of *Urechis unicinctus*.

RESULTS AND DISCUSSIONS

BIOLOGICAL CHARACTERISTICS OF *U. unicinctus*

The body structure of *U. unicinctus*

U. unicinctus has a sausage-like body in purple (Figure 1). The length of the adult is ranging from 100 to 250 mm while the body width could vary from 15 to 30 mm (Li et al., 1998). The front part of the body is represented by a stocky snout, which has the function of ingesting and breathing. The base of the snout has a pair of neuroseta and the center is the mouth. The rear of the mouth has two pairs of nephridial pores which are connected to the nephridium and are full of germ cells during the breeding period (Ma et al., 2016). The back of the body is a transversely-shaped anus with 9 to 13 bristles around the anus (Li et al., 1998).

The body wall of *U. unicinctus* is a dermo-muscular sac that consists of outer muscularis, muscle layer, inner muscularis and inner oblique muscles (Li et al., 1995). The body wall contains well-developed glandular cells, which can secrete mucus to keep the body moist (Figure 2).

Glandular cells can withstand for 72 hours at 7°C and a relative humidity of 69.7% in the openair (Li et al., 1998). *U. unicinctus* has a developed body cavity which is filled with coelomic fluid without the vascular system (Li et al., 1995). Coelomic fluid contains round brown body cavity ball (containing red pigment) (Li et al., 1998). The digestive tract is long and circuitous composed of the mouth, pharynx, esophagus, hernia sac, gizzard, stomach, midgut, pneogaster, hindgut, and anus (Sung et al., 2008). The pneogaster is a special part of the gastrointestinal tract. The former of it is connected with the midgut, and the rear of it is connected with the rectum (Li et al., 1998).

Distribution and origin

U. unicinctus has the strong adaptability to the environment and is widely distributed in Russia, Korean Peninsula, Japan and China. It lodges in the sediment and its cave is the type of "U" (Kimura et al., 1983).

Whether Echiura belongs to Annelida has much controversy. Due to lack of segmentation, in the traditional classification system, scholars trend to classify Echiura as the independent phylum. However, with the deepening of morphological research and the development of molecular biology, more and more scholars trend to classify it as the member of annelids (Clark, 1969). Echiura and Annelida have many similar morphological characteristics, like the superstructure of the bristle and epidermis, the segmentation of the trochophore stage, and the developmental mechanism of the nervous system. The order of mitochondrial genes and the phylogenetic tree based on amino acid sequences all indicate that *U. unicinctus* may have originated from annelids, and its sister groups are oligochaetes from annelids (Wu et al., 2009).

Diet and growth

U. unicinctus is a filter feeder and slag eater. It has no selectivity to food particles and the ingestion is continuous (Li et al., 1995). Snout is the organ for ingestion. The surface of its body has many cilia that form many plicae. Adjacent plicae form the food groove (Li et al., 1995). The water flow caused by the cilia

beating drives the suspended *Chlamydomonas*, small zooplankton larvae and organic debris to enter the mouth along the food channel (Li et al., 1998). *U. unicinctus* has a low requirement for the type of bait but a high requirement for the bait specification. *U. unicinctus* grows pretty fast. The larva can be sold after half a year of artificial breeding (Li et al., 2012). The ratio of individual fresh weight to body wall fresh-spotting varies from season to season, with individual fresh weight ranging from 39% to 47% in winter and only from 17% to 27% in spring (Li et al., 1995).

Breeding and Development

U. unicinctus is dioecious. It has two breeding seasons: spring (from mid-late April to late May) and autumn (from mid-September to mid-October). When *U. unicinctus* has a body length of 4 cm, lower type gonad is emerging. Once the body length reaches 7 cm mature individuals will appear. The gonad maturity precedes with half a month the breeding period (Li et al., 2012). The spermatozoids of *U. unicinctus* have a flagellum shape, with the top-front of the head being a pacifier-shape acrosome. The nucleus is cup-shaped and inside contains nuclear vesicles. The midline is a circular mitochondrion and the tail axis is a "9+2"-structure (Gould et al., 1986).

Conditions of low temperature, moderate salinity, and weak base are better for the sperm. The ovary of *U. unicinctus* is elongated composed of connective tissue outside the posterior wall of the intestine and germ cells. Germ cells develop in the ovary first, and then enter the coelom to further develop until maturation. The mature oocytes are excreted by the nephridium, waiting for fertilization (Li et al., 2012). The mature eggs of *U. unicinctus* are oval-shaped in yellow. There are germinal vesicle and nucleolus in the eggs. The egg diameter is about 150 μm, one individual brood producing around 1.5×10^6 grains (Luykx, 1965). After sperm-egg binding, they begin to cleave and develop immediately. The process of development goes through fertile egg, cleavage, blastocysts, gastrulation, early trochophore, late trochophore, and worm-like larva and then develop into larva (Kimura et al., 1983).

Adaptability to the environment

Temperature and Dissolved Oxygen

U. unicinctus is a poikilothermal animal. The highest and lowest temperature tolerated by an adult is 32.5°C and -4°C, respectively. The water temperature compatible for surviving is from -2°C to 31°C, and the optimal temperature range between 8-26°C (Li et al., 1998). The larva's ability to withstand high temperature is slightly decreased comparing with adults. The water temperature exceeding 31.6°C is not compatible with larva survival. Even in the case of a short exposure to temperatures above upper tolerated limit, the adverse reactions induce high mortality, the survival rate not exceeding 10% even if the temperature is lowered (Li et al., 1995). *U. unicinctus* is a benthic organism who preferring low temperature which is consistent with its geographical and ecological distribution under natural conditions.

U. unicinctus has strong tolerance to low dissolved oxygen and can tolerate low dissolved oxygen from 0.34 to 0.45 mg/L for more than 46 hours (Wu et al., 2009). It lives normally in seawater with dissolved oxygen above 1.14 mg/L. However, when dissolved oxygen drops to 0.28-0.34 mg/L, it will die because of suffocation (Liyong et al., 2016).

Salinity and pH

U. unicinctus tolerate a wide range of salinity, and it can live normally at salinity from 15 to 36. The appropriate level of salinity is from 24.94 to 35.77 (Li et al., 1998). The larva prefers environments with salinity ranging from 20.8 to 35.2 (Zheng Yan et al., 2006). *U. unicinctus* has a higher adaptability to high salinity than lower salinity. When the level of salinity is lower than the survival range, *U. unicinctus* will absorb water, swell, show light pink color, and decrease the ability of drilling. When the salinity exceeds the tolerance interval, it will become dehydrated, turn henna and the body wall will contract quickly. The metabolism will be disordered, and it will lack the ability to drill sands (Zheng Yan et al., 2006).

Changes of the water pH will cause stress on *U. unicinctus*, affecting its growth and physiological conditions. *U. unicinctus* lives

better in weakly alkaline seawater with a pH from 7.5 to 8.5.

The pH-adaptation range of the adult is from 4.46 to 9.5 (Li et al., 1998), and the adaptive range of the larva is slightly larger (Zheng Yan et al., 2006). *U. unicinctus* has a certain pH adaptability and the adaptability to lower pH is better than higher pH. Outside the pH adaptive range, if water pH is changed within a short time (2 hours), *U. unicinctus* can also return to normal when pH is back to normal (Zheng Yan et al., 2006).

UTILIZATION OF *U. unicinctus*

Amino acids in the body wall

The edible part of *U. unicinctus* is the body wall, which accounts for about 32% of the body weight. The nutrients of the body wall muscle are mainly amino acids. Li Nuo (1998) found that there are 18 kinds of amino acids in the body wall muscles of *U. unicinctus* which accounts for 57.39% of the dry weight of the parietal muscle. Even more, it contains 8 kinds of essential amino acids (17.9%).

The content of delicious amino acids (glutamic acid, aspartic acid, arginine, alanine, and glycine) of the wall of *U. unicinctus* is high, accounting for approximately 56% of the total amount of amino acids. That is similar to the content of delicious amino acids (41.39%) in the body wall of *Sipunculus nudus* (Meyer et al., 2010). Glutamate plays an important role in the body's metabolism and it is the primary amino acid in the brain tissue's biochemical metabolism with a brain-stimulating effect (Jinap et al., 2010). Yang Guiwen (Yang Guiwen et al., 1999) measured, using the automatic amino acid analyzer, the content of glutamic acid in the body wall of *U. unicinctus* and found it in high concentration (12.39%). The composition of essential amino acid is close of what the human body required, so all essential amino acids can be fully utilized under the correct eating in terms of quantity (Li et al., 1995).

Active polysaccharide in the body wall

Polysaccharides, along with nucleic acids and proteins, play a critical role in the living system. But due to its complex structure and function, progress in polysaccharide research lags significantly behind that of proteins and nucleic acids (Seeberger et al., 2005). Due to marine life's special living conditions such as high salt, high pressure, low temperature, lack of oxygen, lack of light and less nutrition, marine polysaccharides have unique structure and biological activity in immune regulation, anti-tumor, anti-coagulation, etc. (Manivasagan and Oh, 2016). For example, *Axinelloside* A has obvious telomere inhibitory activity isolated from *Axinella infundibula* (Warabi et al., 2005). A steroid maltooligosyl glucoside isolated from sea stars with obvious cytotoxicity to bronchiolar lung cancer cells (De Marino et al., 1997). Yang (2011) extracted the body wall polysaccharides from *U. unicinctus* with 80°C hot water, and the yield was 6.1%. UWA1, UWA2, UWB2, UWB3, UWC1 were isolated and purified by ion exchange chromatography and gel exclusion chromatography. Zhu et al., in 2015, have extracted and separated polysaccharide components from the body wall of *U. unicinctus* by using enzymatic extraction and chromatographic separation technology and found that polysaccharide is mainly composed of high polydextran and complex glycosaminoglycans. Polysaccharide is rich in biological activity, and can effectively reduce the production of lipid peroxides, modulate the cardiovascular system and delay aging by scavenging free radicals (Veldez et al., 2017).

Utilization of plasmin in body fluids

With the improvement of people's living standard and the increasing aging population, thromboembolic disease is becoming more and more prevalent. Its high morbidity, high mortality and high disability rate have made the research of thrombolytic drugs the focus of medical research all over the world (Bi et al., 2013).

At present, the most common thrombolytic drugs are streptokinase (SK), urokinase (UK), tissue plasminogen activator (T-PA) and some thrombolytic enzymes from natural tissue (Liyong et al., 2016). Thrombolytic agent has developed for three generations but there are still many shortcomings in it such as short-acting, low-targeting, high antigenicity, etc. (Li et al., 2012; Niu et al., 2005). There are still some side effects in clinical medication

(Kandzari et al., 2004) so it is urgent to develop new antithrombotic drugs.

U. unicinctus relies on a large amount of protein from the coelomic fluid and a large respiratory intestine to adapt to the life in the seabed. The special metabolites have anti-tumor, thrombolytic, anti-inflammatory and antibacterial effects (Wen et al., 2015).

In the long-term evolution, the reason why *U. unicinctus* forms an anti-thrombotic function is because its unique mechanism of coelomic fluid plasmin. The study found that the plasmin extracted from *U. unicinctus* is a good thrombolytic drug. It is very stable to heat and pH, and as long as the temperature is below 50°C, the enzyme activity will remain almost constant. It is very stable at the pH range from 3.0 to 12.0 (Wang et al., 2007). Bi et al. (2013) purified a new serine protease called UFEIII from *U. unicinctus* and showed electrophoretic homogeneity using column chromatography.

Owing to its fibrin (ogen)-degrading activity and good safety, UFEIII may be a new source of fibrinolytic agents and potentially be utilized in thrombolytic therapy. In order to better exploit plasmin from *U. unicinctus*, enzyme genes are studied all over the world. Du Fang (2013) cloned high fibrinolytic active gene UFEIII to obtain recombinant plasmin. Plasmin is a small, non-acidic protein and it is the smallest thrombolytic agent currently known. UFE is expected to have fewer side effects than any other thrombolytic drugs in clinical use (Wang et al., 2007).

The nutrients from the obsolete viscera

The viscera of *U. unicinctus* accounts for about 68% of the whole weight (wet weight ratio) and 61% (dry weight ratio). The main part of utilization is the body wall, and the viscera is often waste (Wang et al., 2007). Yang Guiwen et al. (1999) measured the nutritional composition of obsolete viscera and found it was rich in protein, polyunsaturated fatty acids and trace elements. It has large potential value. The content of Ca (2.1%) in inorganic elements was the highest, followed by Mg (0.41%), Fe (0.32%), and Zn (0.03%). While Pb, As, Hg, Cd and other heavy metals were lower. Huang Mingfa (Mingfa et al., 2007) analysed the fatty acids contained and found that both EPA and DHA were relatively abundant, accounting for 21.61% and 3.67% of total fatty acids respectively. EPA had significant hypolipidemic capacity, antithrombotic capacity and platelet aggregation inhibition. It can also prevent arteriosclerosis and the deposition of cholesterol on the arterial wall. The content of DPA in the total fatty acids of obsolete viscera was the highest, accounting for 56.24%. DPA is a long-chain unsaturated fatty acid found in human colostrum and can improve human's immunity (Pedersen et al., 2010). We can see that the development and utilization of obsolete viscera of *Urechis unicinctus* have high economic value and large social benefits.

CONCLUSIONS

U. unicinctus is a unique marine invertebrate in Chinese coastal areas that is resilient to the environment. From a nutrition standpoint, the body wall and viscera are rich in nutrients and have great edible value.

From the perspective of medicinal use, polypeptides and enzymes extracted from the body have antineoplastic and thrombolytic properties. So it has great potential for drug development. It is necessary to carry out extensive and deep research on *U. unicinctus*.

In China, with the increasing demand for *U. unicinctus* as well as the increasing intensity on fishing, its natural resources are obviously insufficient.

At present, research on artificial cultivation of *U. unicinctus* has already begun. Investigating its medical value will not only provide new ideas and new resources for the development of new drugs from marine organisms, but also plays a positive role in promoting the development of marine economy. With the development of science, the comprehensive utilization of *U. unicinctus* is promising.

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