

## Khảo sát chu kỳ sinh sản và theo dõi một số chỉ số thành thực của sò mía (*Tapes dorsatus*) ở vùng đầm Thị Nại, tỉnh Bình Định

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### TÓM TẮT

Sò mía (*Tapes dorsatus*) được thu từ tự nhiên ở khu vực ven bờ đầm Thị Nại, tỉnh Bình Định nhằm khảo sát chu kỳ sinh sản và bố trí thí nghiệm nuôi vỗ thành thực. Kết quả khảo sát chu kỳ sinh sản tự nhiên cho thấy sò mía đạt đỉnh cao về thể trạng và thành thực sinh dục vào tháng 10 đến tháng 2 trong năm. Thực nghiệm theo dõi một số chỉ tiêu thành thực sinh dục sò mía được thực hiện trong 7 đợt, với các loại hình thức nuôi khác nhau: nuôi vỗ trong các rổ nhựa không có cát đáy, nuôi trực tiếp trên nền đáy cát ở bãi triều tự nhiên, có lưới bao quanh; nuôi vỗ trong các rổ nhựa có đáy cát dày 10 - 15 cm. Kết quả thực nghiệm cho thấy, sò được nuôi vỗ trong các rổ nhựa có đáy cát dày 10 - 15 cm cho sinh trưởng khối lượng, chiều dài và tỷ lệ sống cao nhất (các giá trị này đạt lần lượt 51,6g, 49,2 mm và 96,5% sau 60 ngày nuôi). Tương tự như vậy, các chỉ số thành thực CI và GI cũng đạt giá trị cao nhất khi sò được nuôi ở nghiệm thức này. Sức sinh sản của sò đạt cao nhất, với  $3.537 \pm 1.102$  trứng/g thịt tươi và  $28.339 \pm 10.556$  trứng/khối lượng tổng khi sò được nuôi trong các rổ nhựa có đáy cát 10 - 15 cm.

**Từ khóa:** *Tapes dorsatus*, sò, sinh sản, nuôi vỗ thành thực, tỷ lệ sống.

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# Investigating the reproductive cycle and some maturation indexes of clams (*Tapes dorsatus*) collected from Thi Nai lagoon, Binh Dinh province

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## ABSTRACT

Clams *Tapes dorsatus* were collected from the coastal areas of Thi Nai lagoon to examine some reproductive parameters and conduct the maturation culture experiment. The results of examining the reproductive cycle showed that clams get the highest value of condition index and gonad index from October to February of years. The gonado index GI the trial test of maturing mangrove clam was carried out in 7 periods with different treatments: the clams reared in the plastic baskets without sandy bottom; the clams directly reared on the sandy bottom of sandbank covered by net; the clams reared in the plastic baskets with sandy bottom of 10 - 15 cm. The results of the experiment indicated that clams reared in the plastic baskets with sandy bottom of 10 - 15 cm obtained the highest weight, length and survival rate (these values were 51.6g, 49.2mm and 96,5% respectively after 60 days of rearing). Similarly, CI and GI were also highest for clams cultured in this treatment. The fecundity of the clams was highest, with  $3,537 \pm 1,102$  eggs/g fresh muscle and number of eggs/g total weight of clams  $28,339 \pm 10,556$  when they were reared in the plastic baskets with sandy bottom of 10 - 15 cm.

**Keywords:** *Tapes dorsatus*, clam, reproduction, maturation culture, survival rate.

## 1. INTRODUCTION

Binh Dinh has a coastline of 134 km, a water surface area of more than 7,600 hectares, 33 large and small islands, 3 coastal lagoons. The coastal area has many typical ecosystems, such as estuaries and rivers lagoons, mangroves, coral reefs, seagrass beds. Considering such favorable natural conditions, it is very suitable to develop aquaculture and seafood.<sup>1,2</sup> However, for many years, outside of the planned shrimp farming area, other aquatic and seafood products have not been paid enough attention, especially with molluscs in mangrove areas, coastal areas such as oysters, snails, abalone, clam. Especially,

mangrove clam is a new farming species being collected and sold. At present, some households are doing experiments for commercial farming (with seeds imported from Nha Trang City, Khanh Hoa Province) which is bringing very high economic benefits.

Clam (*Tapes dorsatus*) is also known as two-headed clam, two-pronged clams, sweet clams, sweet silk scallops.<sup>3</sup> The clam is a bivalve mollusk. This filter-eating species is widely distributed, but there are very few studies on mangrove clam in the world as well as in Vietnam. The scientific studies on this species are too small, and do not meet the development of the

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mangrove clam rearing industry. Moreover, due to the lack of strict management of resources in the localities, fishermen have over-exploited this resource, making the exploitation yield decreases and the seed source is gradually scarce.<sup>2</sup>

Currently, at some tidal areas in the coastal area of Binh Dinh province, some households have recruited seed produced in Nha Trang for rearing testing. Initially, some rearing households said that the seed breed rearing in the trial condition had a fast growth rate and high survival rate. The product is sold with a high price ranging from 90 to 150 thousand VND per kilogram. Moreover, the market is more stable in comparison with some local aquaculture species.

Facing to those challenges, however, there are not many studies on clam's biological characteristics and reproduction. The mangrove clam seed used as a brood clam to produce breeding stock is now mainly applied similar to the production process of oysters, clams, and clams. Therefore, in this study, we conducted a survey on the reproductive cycle within 24 months, and then we tested the maturation of mangrove clam collected from experimental location in the coastal tidal area of Binh Dinh province within 2 months. The initial results of successful examining the reproductive cycle and some maturation indexes of clams will

contribute to the expansion of the commercial mangrove clam rearing model to many mangrove clam rearing households in Binh Dinh province with the different conditions of type sandy bottom. Furthermore, the goal of this study may contribute to improving the efficiency of using water surface area, diversifying cultured objects, transferring scientific and technical advances in rearing process, timely responding to current production requirements.<sup>3-8</sup>

## 2. OBJECT AND METHODS

### 2.1. Object and study sites

The object of this study was clam individuals *Tapes dorsatus* collected from the wild along the coastal areas of Thi Nai lagoon to examine some reproductive parameters and conduct the maturation culture experiment.

The sites to do the experiment were the Thi Nai's tidal zone (Cua Bien: *Seagate in Hoi Son village, Nhon Hoi commune, Quy Nhon city*) and mangrove intertidal zone (Diem Van village, *Phuoc Thuan commune, Tuy Phuoc district, Binh Dinh province: 1528928.000; 605218.000 (Vietnam coordinates, 2000)*) Binh Dinh province in Thi Nai lagoon. These areas are from a half to three kilometers far from the seagate, that have high daily tidal fluctuation of 0.8 - 1.5 m. The salinity in this area is in range of 25‰.



**Figure 1.** The wild clams collecting sites and the experiment conducting sites in Thi Nai lagoon (Diem Van village, *Phuoc Thuan commune, Tuy Phuoc district, Binh Dinh province: 1528928.000; 605218.000 (Vietnam coordinates, 2000)*) and Cua Bien: *Seagate in Hoi Son village, Nhon Hoi commune, Quy Nhon city*).

## 2.2. Research methods

### 2.2.1. Sample collection

A total of 700 clam individuals of *Tapes dorsatus* (100 individuals for every 4 months) were randomly collected from the coastal areas of Thi Nai lagoon to examine some reproductive parameters as gender, condition index (CI) and gonad index (GI). In addition, a total 2100 healthy individuals were selected to conduct the maturation culture experiment.

### 2.2.2. The experiment of maturation culture

The experiment included 3 treatments, with 100 individuals for each treatment. The experiment was carried out in 7 periods as 7 replicates, with 2 months/period. There were 3 plastic baskets with size of 60 x 80cm used to rear clams for each period in Treatment 1 and Treatment 3.



**NT1:** The clams reared in the plastic baskets without sandy bottom



**NT2:** The clams was irectly on sandy bed



**NT3:** The clams reared in the plastic baskets with sandy bottom

**Figure 2.** The illustration of the experimental treatments

### 2.2.3. Determination of the biological and environmental parameters

The environmental parameters as salinity, temperature, pH were measured twice a day (at 7:30 and 14:00) by handness environment meter Horiba U-52, while  $\text{NO}_2^-$  and  $\text{KH}$  ( $\text{mg CaCO}_3$ ) were tested every 7 days by Sera test kit – Germany.<sup>1,6,7</sup>

The biological parameters of length, width, total weight, muscle weight, gonad index (GI), condition index (CI) and survival rate of clam were determined at the beginning and end of the experiment.

- The biological parameters of length and width were determined by length ruler, precision 1mm.

Therefore, there were a total of 2100 clam individuals used for this experiment. The details of the experimental treatments were described as the followings:

- Treatment 1 (NT1): The clams were reared in the plastic baskets without sandy bottom, that were suspended in the wild water;
- Treatment 2 (NT2): The clams were directly reared on the sandy bottom of sandbank covered by net;
- Treatment 3 (NT3): The clams were reared in the plastic baskets with sandy bottom of 10-15 cm, that were suspended in the wild water

The clams were reared in natural environment so they only used natural food.

- The biological parameters of total weight and muscle weight were determined by digital scale, 0.01 accuracy.

- The gonad indix (GI) is an indicator to assess the maturity of the gonads in clams. The GI genital index was determined as per the method of Walker RL, Heffernar PB.<sup>8</sup> The GI varies from 0 to 4 (with 0: Resting phase; 1: Early development phase; 2: Complete development phase; 3: Maturity phase; 4: Spawn phase).<sup>3,9-12</sup>

- Condition index (CI) is determined as:

$$\text{CI (mg/g)} = (\text{W}_m / \text{W}_t) * 1000$$

Where:  $\text{W}_m$ : Weight of fresh muscle of clam (g);  $\text{W}_t$ : Total weight of clam (g).

- Survival rate (SR) of clam was determined as:



$SR = (Ne/Ns) \times 100$

Where: Ns - number of clam individual at the beginning of the experiment; Ne - number of clam individual at the end of the experiment.

At the end of the experiment, we selected 100 matured clam individuals to determine their fecundity. The fecundity was presented as number of eggs/g fresh muscle of clams and number of eggs/g total weight of clams.

To examine the reproductive biology of the wild clams, we dissected these individuals to get the gonads, then observed the gonads to determine gender of clams as well as CI and GI.

2.2.4. Data analysis

The data were presented as mean plus/minus standard deviation (MEAN ± SD) based on Microsoft Office Excel 2010. One-way ANOVA was used to test the difference of mean values between treatments using SPSS 17.0. Evaluation

of the difference of mean values was conducted after analysis of variance (Post Hoc Test) by Duncan test method. The difference between the values was determined at the significance level of  $p < 0.05$ .

3. RESULTS AND DISCUSSION

3.1. Experimental results

3.1.1. Environmental parameters in the experiment

The environmental factors in the treatments are shown in Table 1. It can be seen that the NO<sub>2</sub><sup>-</sup> content was from 1.0 to 2.0 mg/L of NT1, NT2 and NT3. The alkalinity (mg CaCO<sub>3</sub>) of water in the treatments ranged from 89.5 to 107.4 mg/L, of NT1, NT2 and NT3. The other parameters such as temperature, pH and salinity did not largely differ between treatments.

In general, the water environmental parameters are within the suitable range for the growth and development of the clams.

Table 1. Variation of environmental factors, hydration during rearing in conditions

Parameter		NT1	NT2	NT3
NO <sub>2</sub> <sup>-</sup> (mg/L)		1.0 – 2.0	1.0 – 2.0	1.0 – 2.0
kH (mg CaCO <sub>3</sub> )		89.5 – 107.4	89.5 – 107.4	89.5 – 107.4
Salinity (‰)	Morning	25.6±3.4	25.4±3.5	25.4±3.4
	Afternoon	26.3±3.3	25.5±3.6	26.6±3.3
Temperature (°C)	Morning	27.5±2.7	27.5±2.6	27.9±2.5
	Afternoon	28.9±2.3	28.8±2.2	28.6±2.5
pH	Morning	7.9±0.3	7.9±0.2	7.9±0.3
	Afternoon	7.8±0.2	7.8±0.2	7.8±0.3

3.1.2. Size, weight and survival rate of the clams

The growth parameters and survival rate of the clams in the treatments are presented in Table 2. Generally, growth values such as weight,

length and width of the clams increased after 60 days of raising. The survival rate of the clams decreased but still reached the high values, from 86.7 - 96.5%.

Table 2. Size, weight and survival rate of the clam in the different treatments

Parameter		Total weight (g)	Muscle weight (g)	Length (mm)	Width (mm)	Survival rate (%)
NT 1	Initial	43.6±2.3	6.7±1.21	42.2±0.3	33.8±0.2	100.0
	Finish	44.6±4.2 <sup>c</sup>	6.8±1.16 <sup>c</sup>	46.8±0.7 <sup>c</sup>	37.8±0.3 <sup>a</sup>	86.7±1.5 <sup>c</sup>
NT 2	Initial	43.6±2.3	6.7±1.21	42.2±0.3	33.8±0.2	100.0
	Finish	49.6±5.5 <sup>b</sup>	7.6±1.23 <sup>b</sup>	47.9±0.5 <sup>b</sup>	36.8±0.4 <sup>b</sup>	90.4±1.2 <sup>b</sup>
NT3	Initial	43.6±2.3	6.7±1.21	42.2±0.3	33.8±0.2	100.0
	Finish	51.6±4.3 <sup>a</sup>	9.3±1.26 <sup>a</sup>	49.2±1.1 <sup>a</sup>	37.8±0.4 <sup>a</sup>	96.5±1.8 <sup>a</sup>

Remark: For each parameter, the different letters indicate the significant difference ( $p < 0.05$ )

In comparison, it was found that clams reared in NT3 (reared in plastic baskets with bottom sand of 10 - 15 cm) had the highest values of weight and length while clams raised in NT1 (reared in plastic baskets without bottom sand) obtained the lowest values. Specifically, after 60 days of rearing, clams raised in treatment NT3 had the weight of 51.6 g and the length of 49.2 mm while these values in NT1 were 44.6g and 46.8 mm, respectively. The width of clams in treatment NT1 and NT3 was not different and higher than this in NT2. The survival rate of clams in NT3 was highest (96.5%) while this value in NT1 was lowest (86.7%). NT2 has the survival rate of clams reaching 90.4%.

It can be said that *Tapes dorsatus* is species that usually bury themselves in the sand, so rearing them in the suspended baskets without bottom sand affects the natural behaviors of this species. This make them obtain the lowest values of size, weight and survival rate. In contrast, reared in the baskets with bottom sand (NT3) with the water circulation, the growth and survival rate of clams are higher because such condition is suitable for both the biological behaviors of the species and creates a good environment for them. In treatment NT2, although clams were raised in the natural bottom, the water circulation was worse than in NT3. Consequently, the growth and survival values of clams in NT2 were lower than these in NT3. Therefore, in fact, such raising method in NT3 is currently the popular commercializing rearing

method in Khanh Hoa, Phu Yen, Ben Tre, Hai Phong, Quang Ninh.<sup>1-7,13-15</sup>

3.1.3. Condition index (CI) and gonad index (GI) of the wild clams

The results of examining the condition index (CI) and gonad index (GI) of clams after 60 days of rearing are shown in Table 3.

Table 3. Condition index and gonad index in the different treatments

Parameter		CI (mg/g)	GI
NT 1	Initial	156.2±17.7	2.6±0.5
	Finish	154.2±4.1 <sup>c</sup>	2.7±0.6 <sup>b</sup>
NT 2	Initial	156.2±17.7	2.6±0.5
	Finish	156.3±5.2 <sup>b</sup>	2.7±1.2 <sup>b</sup>
NT3	Initial	156.2±17.7	2.6±0.5
	Finish	183.7±4.9 <sup>a</sup>	3.2±0.5 <sup>a</sup>

Remark: For each parameter, the different letters indicate the significant difference ( $p < 0.05$ )

The initial condition index of the clams was 156.2±17.7 mg/g. After 60 days of raising, this index in NT1 decreased to 154.2 mg/g while this index in NT2 did not almost change (156.3 ± 5.2 mg/g). In contrast, the CI in NT3 increased. In comparison, it can be seen that the CI in NT3 was highest (183.7±4.9 mg/g), and the lowest value was in NT1 (154.2±4.1). This indicates that the raising condition in Treatment NT3 was suitable. Hua Thai Nhan *et al.*<sup>5</sup> did study on

Ben Tre clams *M. lyrata* and suggested that the condition index of clams is related to maturity and changes in water salinity during the rearing process.<sup>5</sup>

The gonad index (GI) at the beginning of the experiment was  $2.6 \pm 0.5$ . After 60 days of rearing, this index in NT3 obtained the higher value (3.2) than this value in NT1 and NT2 (2.7) ( $p < 0.05$ ). Chu Chi Thiet and Martin S Kumar<sup>15</sup> found that when food was scarce (0.25 mg organic matter/g fresh weight/day), the gonads of *Ruditapes decussates* developed very slowly (taking about 70 days for females to reach the stage 4 of gonad). The CI and GI reaching the highest value in NT3 implicate the suitable rearing condition for the clams.<sup>16</sup>

Table 4. Percentage of female mangrove clam spawning and actual fecundity in rearing conditions

Parameter	NT1 (n=100)	NT2 (n=100)	NT3 (n=100)
Number of eggs/g total weight	$2,256 \pm 1,573^b$	$2,221 \pm 1,012^b$	$3,537 \pm 1,102^a$
Number of eggs/g fresh muscle	$20,221 \pm 12,34^c$	$21,378 \pm 12,981^b$	$28,339 \pm 10,556^a$

Remark: In the same row, the different letters indicate the significant difference ( $p < 0.05$ )

3.2. The results of examining the reproductive cycle of the wild clams

3.2.1. Biological parameters of the clams

It can be seen that number of female is always higher than that of male in most of the studied month, excepting February 2021 (Table 5).

Table 5. Biological parameters of the wild clams

Month	Number of individuals	Length (mm)	Width (mm)	Total weight (g)	Muscle weight (g)	Gender (%)		
						Male	Female	Hermaphrodite
06/2019	100	$52.1 \pm 0.3$	$45.2 \pm 0.2$	$57.3 \pm 1.28$	$4.9 \pm 1.26$	32	65	3
10/2019	100	$51.2 \pm 0.4$	$44.3 \pm 0.3$	$59.4 \pm 1.34$	$4.6 \pm 1.22$	38	53	9
02/2020	100	$56.1 \pm 0.3$	$47.2 \pm 0.3$	$59.2 \pm 1.50$	$5.1 \pm 1.31$	56	44	0
06/2020	100	$52.4 \pm 0.4$	$44.3 \pm 0.5$	$55.1 \pm 1.16$	$4.6 \pm 1.24$	44	49	7
10/2020	100	$59.6 \pm 0.5$	$48.4 \pm 0.4$	$59.3 \pm 1.28$	$6.5 \pm 1.32$	36	59	5
02/2021	100	$53.8 \pm 0.2$	$42.2 \pm 0.3$	$55.3 \pm 1.28$	$6.6 \pm 1.27$	29	67	4
06/2021	100	$54.4 \pm 0.2$	$43.3 \pm 0.4$	$55.3 \pm 1.28$	$4.2 \pm 1.21$	39	55	6
Average	700	$54.4 \pm 0.3$	$45.3 \pm 0.3$	$57.3 \pm 1.3$	$5.2 \pm 1.30$	39	56	5

Remark, L: lenght; R: width; H: height; W-total: meat total, W-meat: meat. There are 3 sexes of sugarcane scallops: male, female and hermaphrodite.

3.1.4. The fecundity of clams in the experiment

After 60 days of rearing, 100 matured clam individuals in each treatment were selected to determine the fecundity. The results showed that the number of eggs/g fresh muscle of clams were highest in NT3 ( $28,339 \pm 10,556$ ) followed by NT2 ( $21,378 \pm 12,981$ ) and lowest in NT1 ( $20,221 \pm 12,34$ ) ( $p < 0,05$ ). The number of eggs/g total weight in NT3 ( $3,537 \pm 1,102$ ) was higher than this in NT1 ( $2,256 \pm 1,573$ ) and NT2 ( $2,221 \pm 1,012$ ) but there was no difference of this between NT1 and NT2 ( $p > 0,05$ ). The fecundity of the clams in this study was different from *M. lyrata* with ( $19,322 \pm 1,884$ ) eggs/g total weight and ( $91,743 \pm 7,769$ ) eggs/g fresh muscle (Chu Chi Thiet and Martin S Kumar).<sup>15</sup>

The percentage of female clams varied from 67%, males 29%, and 5% are non-sexual (hermaphrodite). The average percentage of females to 56% with an average value of 39%. This indicates that female clams are predominant in the wild population of this species in Thi Nai lagoon.

The results in Table 5 showed that in the same year (2020), the clams obtained the highest length and width, total weight, muscle weight with the values of 59.6 mm, 48.4 mm, 59.3 g, 6.5 g, respectively in October 2020, and the clams collected in February also obtained the high values of these parameters while these were lowest in June. The pooled data of 700 clam individuals showed that average length, width, total weight, muscle weight were 54.4 mm, 45.3 mm, 57.3 g and 5.2 g respectively.

3.2.2. Spawning season identification of the wild clam

The spawning season identification of the clams is based on GI and CI. The results of the study showed that GI was from 2.1 to 3.7. The clams in Stages 3 and 4 (genital and reproductive stages) fluctuated from 2.9 to 3.7 mg/g.

**Table 6.** Gonad index (GI) and condition index (CI) of the wild clams

Month	CI (mg/g)	GI
06/2019	68.9	2.1
10/2019	76.4	2.8
02/2020	80.3	2.9
06/2020	98.4	2.8
10/2020	110.4	3.7
02/2021	120.7	3.5
06/2021	70.4	2.7
Average	89.4	2.9

This percentage reached the highest value from October to February yearly (highest peak in October at 3.7 mg/g), the lowest in June is only 2.1 – 2.7 - 2.8 mg/g.

Similarly, CI of the wild clams also varied from 68.9 – 120.7 mg/g in the same tendency with GI (Table 6), that reached the high values in October and February of the year compared to June. Based on such variation of GI and CI of the clams, it can be identified that the spawning season of clams in Thi Nai lagoon - Binh Dinh is from October to February.

Therefore, to preserve the resource of this species, it is necessary to avoid exploiting wild clams in this period of year.

4. CONCLUSIONS

- The environmental parameters in the experiment are suitable for growth and development of the clams *Tapes dorsatus*.
- The clams reared in the plastic baskets with sandy bottom of 10 - 15 cm obtain the highest weight, length, survival rate, CI, GI and fecundity.
- The spawning season of the wild clams is from October to February of years.

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REFERENCES

1. Phung Bay. *Experimental study on hatchery production and commercial oyster farming in the estuary area of Binh Dinh province, Final Report*, 2012.

2. Phung Bay and Nguyen Thi Xuan Thu. *Cultivation of molluscs in Vietnam: History of formation, current status and development orientations for the future*, Collection of proceedings at the 3<sup>rd</sup> International Conference on Oysters, Taipei, Taiwan, 2009.

3. Nguyen Chinh. *Some species of bivalve mollusc (Bivalve Mollusc) have economic value in the sea of Vietnam*, Science and Technology Publisher, Hanoi, 1996.

4. Pham Viet Nam. *Experimental study on hatchery production and commercial oyster culture in the coastal estuary area of Tien Giang province*, final report, 2016.

5. Hua Thai Nhan, Ngo Thi Thu Thao, Huynh Han Chau and Tran Ngoc Hai. *Trial of maturation of clams Meretrix lyrata in blue water-tilapia system*. Collection of scientific reports of the



- 5<sup>th</sup> national molluscs conference-Nha Trang, September 17-18, 2007, Agricultural publisher, 2008, 375-383.
6. Summary report of the central agricultural extension project: Breeding of bivalves and molluscs, under the national agricultural extension program, Project implementation organization - Aquaculture Research Institute III, 2011 - 2013.
  7. Phung Bay. *Production trial of the Sydney oyster, Saccostrea glomerata (Gould, 1850)*, Collection of scientific proceedings of the 5<sup>th</sup> national molluscs conference – Nha Trang, September 17-18, 2007, Agricultural publisher, 2008, 357-365.
  8. K. E. Carpenter & V. H. Niem (Eds). *The living marine resources of the Western Central Pacific*, Rome: FAO Species Identification Guide for Fishery Purposes, 1998.
  9. R. L. Walker, P. B. Heffernan. *Temporal and spatial effects of intertidal exposure on the gametogenetic cycle of the northern quahog, Mercenaria mercenaria (Linnaeus, 1758)*, in coastal Georgia, J. Shellfish Res 13, 1994, 479-486.
  10. R. D. Braley. *Reproductive condition and season of the giant clams Tridacna gigas and T. derasa utilising a gonad biopsy technique*, In Giant Clams in Asia and the Pacific, Australian Centre For International Agricultural Research, 1988, 98-103.
  11. Francis x. O'beirn, Peter B. Heffernan, Randal I., Walker, Michelle L. Jansen. Young-of-the-Year Oyster, Crassostrea Reproduction in Coastal Georgia, *Estuaries*, **1996**, 19(3), 651-658.
  12. D. B. Quayle & G. F. Newkirk. *Farming bivalve molluscs methods for study and development advances in World Aquaculture*, Canada, The World Aquaculture Society in association with the International Development Research Center, 1989.
  13. Ngo Anh Tuan, Chau Van Thanh and Vu Trong Dai. *Some reproductive characteristics of oysters (Crassostrea belcheri Sowerby, 1871) in Cha River and Ba Ria - Vung Tau province*, Collection of scientific proceedings of the 4<sup>th</sup> national conference on molluscs - Nha Trang (September 2005), Agricultural publisher, 2007, 263-273.
  14. Ngo Thi Thu Thao and Truong Trong Nghia. *Effect of different salt concentrations on feed filtration rate, growth, survival rate and stress tolerance of Anadara granosa blood clam*, Collection of scientific proceedings of the 2<sup>nd</sup> national conference on mollusks – Nha Trang, August 2001, Agriculture Publishing House, 2001, 137-142.
  15. Chu Chi Thiet and Martin S Kumar. *Document on production techniques of Ben Tre clams Meretrix lyrata Sowerby, 1851*, Aquaculture Research Sub-Institute of North Central Vietnam (ARSINC), 2008.
  16. Truong Quoc Phu. *Research on some biological, biochemical and technical characteristics of clam Meretrix lyrata (Sowerby) with high yield*. Thesis of Doctorate in Agriculture, Nha Trang University of Fisheries, 1999.