

**PIGMENTS OF APOLYMORPHIC SPECIES ,  
*LITTORARIA PALLESCENS*  
(PROSOBRANCHIA: LITTORINIDAE)**

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The littorinid snail *Littoraria pallescens* (Philippi, 1847) living on mangrove leaves presents three major shell colours: dark, yellow and pink. In the broad sense, body colour of organism is usually associated with such pigment. From the previous works of other authors, the shell colour variation of this species has mainly been related to an evolutionary response due to environmental pressure. There is no record available on the pigment content of this polymorphic species. Snails with the three major colours were collected from a mangrove forest near Manado and brought to laboratory for pigment analysis. Pigments in the shell as well as in the tissue were separately extracted, and analysed by means of a spectrophotometer and thin-layer chromatography. The pigments were similar in the three shell colours and recognised as melanin and carotenoid. The colour variation is probably related to a specific association between pigment and a certain amino acid, as recorded in the shell of lobster. Carotenoids recognised in the shell and tissue of *L. pallescens* are B-carotene. Carotenoid concentration was higher in the tissues than in the shell.

# **GENERAL FEATURES OF THE RESEARCH WORK AND HANDLING OF MOLLUSCAN RESOURCES IN VIETNAM AND THE ORIENTATION OF DEVELOPMENT**

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Molluscs constitute the 2nd largest phylum of marine animals. They are important for human life in Vietnam where people have used mollusc since ancient times. Yet, foreign scientists working in Vietnam did not initiate the first research on mollusc until the early 1900's. Serene (1937) proclaimed a nomenclature of 610 species available in Vietnamese seas. Subsequently, numerous investigators have supplemented the taxa and further completed the molluscan fauna of Vietnam. Recently, research has been carried out on biological characteristics of a certain number of species of economic value (for exploitation and culture purposes). Some species, such as cockles and clams have been cultured in large areas of northern and southern Vietnam with great economic results. Unplanned exploitation, however, has seriously exhausted the resources. Therefore, scientific research has become particularly pressing and should aim at maintaining and developing the molluscan resources in the long term.

**MORPHOLOGICAL CHARACTERISTICS AND GEOGRAPHICAL DISTRIBUTION OF THE COMMERCIAL BIVALVE SPECIES *TEGILLARCA GRANOSA* AND *T. NODIFERA* IN VIETNAM**

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The two species *Tegillarca granosa* and *T. nodifera* share the common name blood ark-shell given to them by fishermen because they have red-coloured blood and are remarkably similar in outer appearance. Distinguishing differences in shell morphology, ecology and geographical distribution are described in this paper, with a view to helping fishermen choose appropriate rearing grounds through recognition of these characteristics. It is also hoped that the study may stimulate search for new seed stock locations in coastal areas. Currently, the blood ark-shell culture industry in our country is focused on *T. granosa* being the more valuable of the two species. However, recently, farmers in Khanh Hoa and Ninh Thuan provinces started to culture *T. nodifera*.

**RESULTS OF YELLOW-LIPPED PEARL OYSTER *PINCTADA MAXIMA*  
ARTIFICIAL SEED BREEDING EXPERIMENTS IN VANNINH  
SEA WATERS, KHANH HOA PROVINCE, AND IN VUNG RO BAY,  
PHU YEN PROVINCE, VIETNAM**

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Yellow-lipped pearl oyster *P. maxima* is the largest species in the family Pteriidae. The pearl-planted culture is therefore remarkably focussed on this species. In Phu Quoc sea waters (Kien Giang province) some self-employed fishermen collect natural pearls from the yellow-lipped oyster and sell them for 800 to 1500 US\$ a piece. As the pearl oysters often live at 25 to 40 m water depth on bottoms with gravel substrata, culture in shallow water calls for rather complicated techniques. In this report, we present the results of yellow-lipped pearl oyster *Pinctada maxima* artificial seed breeding experiments in sea water of Van Ninh, Khanh Hoa province, and in Vung Ro Cove, Phu Yen province. From the artificial oyster seed stock produced at the Institute for aquatic products Research No III in 1997, it is noted that the survival rate was very low, but that after 20 months of breeding and culture the largest individuals reached 17 to 18 cm in length. From the out- come of the experiment, it's hoped that it's possible to increase the survival rate, producing an adult oyster stock from artificial seed, thus contributing to the *P. maxima* pearl-planted culture industry.

**DISTRIBUTION OF SOME ECONOMIC BIVALVE SPECIES IN  
INTERTIDAL AREAS IN NGHE AN, VIETNAM**

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The distribution of some economic bivalve species was investigated in relation to tide, salinity and substrate in intertidal areas of Nghean, Vietnam. Eighteen species of bivalves belonging to nine families have been recorded. Seven species are new records from the coast of Vietnam. Highly significant effects of sampling positions, tidal zone, and interactions with respect to sampling positions and tidal zones on density and biomass have been shown for *Tellina* sp., *Glaucanome cerea*, and *Anomalocardia producta*. Conversely, there were no interactions with respect to sampling positions and tidal zones, and low significant effect of sampling positions on the density for *Meretrix meretrix*. With respect to sampling positions and substrate on density, significant effects of sampling positions, substrate and interactions were found for *Tellina* sp., *Glaucanome cerea*, and *Anomalocardia producta*. There was a low significant effect of sampling positions for *Meretrix meretrix*. Two-way ANOVA was used to test all effects of those factors. A low significant effect of variation of salinity on density of bivalves was found in the range of 22-27 ‰, while no significant effect was found when salinity varied from 23-26 ‰ and 27-28 ‰ using one-way ANOVA.

**BIOLOGICAL SP AWNING CHARACTERISTICS OF BABYLON SNAIL  
(BABYLONIA AREOLATA)**

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Babylon snail is gonochoristic with internal fertilisation. Sex ratio of adult snails varied from 1:1.38 to 1:2.65. After 7 months of culture, the snails reached a shell length of 35-42 mm and spawned first time. Adult snails cultured in cement ponds deposited egg capsules year-round with 2 peaks of spawning in March and July. Vaseiform transparent egg capsules were laid during nighttime and attached to the sandy bottom or coarse substratum. Each breeder deposited from 18 to 75 (average 38) egg capsules. Egg capsules measured 30.6 x 9.9 mm in length on average and contained about 743 eggs in a jelly-like fluid. About 6 days after spawning, bilobed veliger larvae hatched out. Veliger larvae spent about 12 to 14 days in the free-swimming larval stage and metamorphosed to crawling juveniles after 26 to 18 days. Fertilisation and hatching rates were 83 and 90% on average respectively.

# EFFECT OF SALINITY ON HATCHING, LARVAL GROWTH, AND SURVIVAL IN BABYLONIAN SNAIL (*BABYLONIA AREOLATA*)

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The effects of salinity (15-40 ‰) on egg development, growth and survival of veliger stage to metamorphosis of *Babylonia areolata* were studied. Eggs were able to develop into veligers in 30 to 35 ‰ salinity. In 15 and 20 ‰, all the animals died within hours. In 25 ‰, eggs developed into trochophores but metamorphosis was incomplete; all the larvae developed into abnormal veligers. In 40 ‰, the eggs developed into trochophores but the complete larval development to metamorphosis was very low. The veliger larvae were able to survive to newly settled juveniles when cultured in salinities from 20 to 40 ‰. Optimum development of larvae to juvenile occurred in salinities between 30 and 35 ‰. In 20 and 25 ‰, first settling occurred on the 5th or 6th compared to 7th day for larvae cultured in 30, 35 and 40 ‰. The newly settled juveniles were capable of tolerating a wide range of salinities from 15 to 40 ‰. The optimum for both growth and survival were between 30 and 35 ‰. *B. areolata* juvenile (1 to 10 mm length) tolerated salinities from 17 to 47 ‰. The optimum salinities for both growth and survival were between 27 and 37 ‰. A lower limit of survival was observed at 15 and 49 ‰. Differences in growth rate and survival rate, as well as the activity of animals in different salinities, were noted.

# ENVIRONMENTAL PARAMETERS, BIOLOGY AND STOCKS OF *MERETRIX LYRATA* IN THE MEKONG DELTA, VIETNAM

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We have studied environmental factors influencing stocks of *Meritrix lyrata*, which is a commercially important bivalve in Vietnam. The species lives within the sediment where its habitat is influenced by the pH, temperature, salinity, dissolved oxygen, total suspended solid, chemical oxygen demand, biological oxygen demand, chlorophyll *a*, and bacteria. We have focused on the total number of *Vibrio*.

Hydrographic and meteorological factors were also noted: air temperature, velocity of the wind, total rain fall, and the tidal regime on clam grounds in the Mekong Delta: Thanh Phong village (Thanh Phu district), Thoi Thuan village (Binh Dai district) in Bentre province, Tan Thanh village (Go Cong Dong district) in Tien Giang province and some places at Thoi Thuan village (Binh Dai district), Bao Thuan village (Ba Tri district) in Ben Tre province, and Tan Thanh village (Go Cong Dong district) in Tien Giang province. Besides, some of the main biological characteristics of *Meritrix lyrata* were studied, viz. growth rate, quantity and quality of stomach contents, development of the gonads, and hermaphroditism in mature individuals. Emphasis has been on the variable yields and estimates of some of the main factors, which affect the quantity of clams. Statistics was used to estimate the market size yield of *Meritrix lyrata* per year in Tien Giang and Ben Tre province in the Mekong Delta. The present study forms a scientific base to propose ways to protect the natural breeding grounds and to provide juveniles raised to market size in the Mekong Delta.



# **SPECIES COMPOSITION AND DISTRIBUTION OF CEPHALOPODS IN VIETNAM**

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A total of 69 species of cephalopods in 23 genera, 13 families, and 3 orders were studied from 1977 to 1997. Data from other studies of Vietnamese cephalopods are included. The distributions of cephalopods according to area and depth are also presented.

**CEMENT POLE CULTURE OF OYSTER (**  
**CRASSOSTREABELCHERI )**  
**USING VARIOUS SIZES OF HATCHERY-PRODUCED SPAT.**

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Hatchery produced oyster spat were graded into three sizes: Large, medium and small spat on average  $5.0 \pm 0.2$ ,  $3.7 \pm 0.0$  and  $3.2 \pm 0.1$  cm in shell length, and  $4.4 \pm 0.5$ ,  $3.3 \pm 0.2$  and  $2.8 \pm 0.0$  cm in shell width respectively. Each size class was attached to 6 cement poles, 15 spat per pole. They were placed on a mud flat in Khoa Yoa Bay. Growth and survival of oyster and water quality parameters were determined monthly throughout the culture period. After 12 months of culture the size of the large, medium and small oysters were  $6.5 \pm 0.3$ ,  $6.5 \pm 0.1$  and  $6.3 \pm 0.3$  cm in length and  $5.8 \pm 0.4$ ,  $5.7 \pm 0.2$  and  $5.2 \pm 0.1$  cm in width respectively. The growth increments were 1.5, 2.7 and 3.0 cm in length and 1.4, 2.4 and 2.4 cm in width respectively. Survival rates were 35.8, 41.6 and 34.9 % respectively. It is concluded that small size hatchery-produced oyster spat can be cultured on cement pole with highest shell growth increment. Low survival was found in all size groups due to the detaching of the spat from the pole because they had too limited shell surface cemented to the pole. Environmental conditions in the culture area were temperature 26-34 °C, pH 7.1-8.2, Oxygen 3.2-8.2 mg/L, Turbidity 65-195 cm. Plankton of 52 species were found, the most abundant group was diatoms.

## BIODIVERSITY OF MOLLUSCS ON ARTIFICIAL REEFS IN PHE BA Y, EASTERN COAST OF THE GULF OF THAILAND

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Surveys of molluscs were conducted at two locations of abalone artificial reefs in Phe Bay, eastern coast of the Gulf of Thailand, using two types of concrete blocks. The blocks consisted of transplanted seaweed blocks and control blocks without seaweed. A total of 200 species of molluscs in 63 families, including 100 gastropod and 100 bivalve species (juvenile and adult), were identified on these blocks during the course of monitoring. Environmental conditions fluctuated little during one-year of monitoring at the location near Samet Island. There were 139 mollusc species, from 52 families (67 gastropods and 72 bivalves) found at this location. *Pyrene* sp. was the dominant gastropod in terms of its year-round occurrence and abundance in number of individuals, while *Chama* sp. and family Ostreidae were the dominant bivalves. The monthly index of diversity indicated no fluctuation in the number of species. The highest numbers of gastropods were found in January, while that of bivalves occurred in May. At the location near Ban Phe beach, environmental conditions fluctuated considerably, and 142 species in 53 families of molluscs (68 gastropod and 74 bivalve species) were recorded. The monthly diversity index also showed a significant fluctuation during the one-year of monitoring. *Thais rufotincta* was found to be the dominant gastropod species while *Anomia* sp. and Ostreidae were the dominant bivalves. The highest abundance of gastropods and bivalves were found in February and May respectively. In addition, the blocks with transplanted seaweed recorded a higher number of species, total abundance, and species richness, than those of control blocks. Overall, the results showed that biodiversity of molluscs on abalone artificial reef was dependent on fluctuations of environmental conditions, the presence of transplanted seaweed on the reef surface and interference by humans.

# **GROWTH RATE OF *TROCHUS NILOTICUS* L. WITH EMPHASIS ON MACRO-ALGAL FOOD ITEMS**

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A study on the growth rate of *T. niloticus* was conducted at the Marine Science Hatchery, University of Hasanuddin, Barang Lompo Island, and South Sulawesi. In nature, the food items of top shell *T. niloticus* are genera of macroalgae, such as *Gracilaria*, *Euclima*, microalgae, and other small organisms. In the hatchery, the growth rates were measured in terms of shell length and shell width when *T. niloticus* was fed with a mixture of dry + fresh algae, and dry algae alone. The algae were *Caulerpa*, *Padina*, *Gracilaria* and *Euclima*. The green macroalgae *Caulerpa* resulted in the best growth rate of shells of *Trochus*. The brown and the red macroalgae also resulted in growth of the shell, but not as well as the green macroalgae.

# MALACOLOGICAL RESULTS OF THE RUMPHIUS BIOHISTORICAL EXPEDITION TO AMBON (1990)

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In 1990 a marine biological expedition was carried out at Ambon Island (Moluccas, Indonesia). The primary objective of the expedition was to collect and study marine invertebrates from the localities mentioned by Rumphius in his book „d'Amboinsche Rariteitkamer“ (1705). During six weeks a considerable collection of marine molluscs was gathered in about 40 localities. Some preliminary results concerning the malacofauna of Ambon are: Rumphius was a good observer and his locality data are accurate. This became clear when several species could only be found in the localities indicated by Rumphius. This was the case for *Dentalium elephantinum* (L.), *Chicoreus ramosus* (L.), *Phalium glaucum* (L.) and several other species. The mollusc fauna of Ambon is remarkably rich. Part of the expedition material (already studied or currently under study) yielded the following numbers of species: Muricidae 58 species, Pectinidae 17 species, Nassariidae 47 species, Naticidae 27 species, Mitridae and Costellariidae 96 species, Rissoiinae 45 species, Terebridae 25 species and Polyplacophora 27 species. Unfortunately numerous mollusc groups remain unstudied by the lack of qualified specialist. Several new species were found and many species appeared to have a much wider geographic distribution than was known. *Callistochiton generos* (Iredale & Hull, 1925) was thought to be an endemic species from Queensland, Australia. *Nassarius maccauslandi* Cernohorsky, 1984 was only known from Fiji. *Cryptoplax planus* Ang, 1967 and *Morula parva* (Reeve, 1846) were only known from the type material from the Philippines. *Tetrastoma (Costastoma) serana* (P.J. Fischer, 1927) was only known from fossil (Pliocene) material, but many living specimens were found during the expedition.

## THE COMMERCIAL ASPECTS OF HARVESTING *SOLENGRANDIS* IN THE COASTAL WATERS OF EAST SURABAYA, INDONESIA.

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The bivalve *Solen grandis* has a high economic value. Villagers in Madura Strait, Kenjeran coast, South Madura coast and Pasuruan coast collect them. In the harvest season (July-August, December-January each year) each person can catch 40-60 kg (@ Rp. 4,000/kg) and in the poor season from April to May each person can catch 2-3 kg (@ Rp. 5-6,000/kg). The market price of dried *S. grandis* was Rp 70,000 to 80,000/kg. The condition index (ratio of dry weight/wet weight x 100%) was  $22,5 \pm 4,7\%$  in the best area and from  $16,1 \pm 2,7\%$  to  $15,7 \pm 1,9\%$  in poor areas. This study aims at giving the first information on the relationship between environmental conditions and the distribution of *S. grandis*. We recommend the following steps to be taken for more detailed knowledge in order to increase economic growth of the coastal people: 1. The habitat of *S. grandis*; 2. The water quality; 3. The life cycle of *S. grandis*; 4. Collecting methods; 5. Drying method and packing; and 6. Product preparation and distribution methods.

# MOLLUSCAN SPECIES IDENTIFICATION USING ARTIFICIAL NEURAL NETWORKS

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Conventional identification methods in biology involve either the use of diagnostic keys or the comparison method. Diagnostic keys work on the principle of exclusion. The number of taxa being considered is gradually decreased until the specimen is "keyed out", using one rule at a time. This method has inherent limitations that can lead to errors in identification. Besides the existence of poorly constructed keys, perhaps the most common problem is that the user fails to recognise particular character(s) used in the key and makes a mistake along the way. Often this can be detected as one progresses further along the key but sometimes it may lead to incorrect identification. Lack of qualitative characters amongst the taxa considered may also hamper key construction and use. The comparison method, in contrast, is a polythetic method. The specimen in question is matched with illustrations so that characters are compared and used together all at once. Rapid and accurate identification can be accomplished, provided good illustrations and detailed diagnoses are at hand. However, when these are not available, as is often the case for molluscs in Southeast Asia, matching of specimen to illustration becomes increasingly unreliable and highly subjective. New species, and taxa with inherent intraspecific variation, are particularly problematic. In view of these shortcomings, we made an attempt to see if artificial neural computing methods can provide useful solutions. Neural networks differ from keys in that they explore many competing hypotheses simultaneously. In this paper we present preliminary results of using commercially available artificial neural network software to use information inherent in gastropod shell morphometric data for species identification. Linear shell dimensions of several species of mangrove Littorinidae were used to train and subsequently test the effectiveness of a neural network on a desktop computer. Tests consisted of "asking" the computer to identify a series of *Littoraria* individuals based entirely on shell measurements. Although there are limitations, our results suggest that artificial neural networks are a promising, robust alternative to existing methods of species identification.

## FEASIBILITY STUDY ON CULTURE OF COCKLE *ANADARA TROSCHELIDUNKER*

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*Anadara troscheli* is one of the most common cockles in Thailand. It is distributed along the Andaman coastline and some areas in the Gulf of Thailand. In order to establish and improve culture of the species, basic information concerning movement behaviour and growth rate are essential. Movement behaviour of the cockles is the main obstacle for transplanted brood-stock to new culture areas. Movement experiments of two cockle species, *A. troscheli* and *A. nodifera*, were carried out in tanks and recorded by VDO equipment. *A. troscheli* did not move and they just buried in the sediment, while *A. nodifera* moved forward around the tank. Growth rate was estimated monthly in *A. troscheli* from Sapam Bay, Phuket Island, sampled during January-November, 1997. Average shell increment was 0.47 mm/month and the weight increased 1.49 g/month. In conclusion, *A. troscheli* is feasible for culture since it will not move out from culture area in contrast to *A. nodifera*. It is a big species and the weight increment is higher than for other cockles cultured for the same period of time.



**SIZE AND AGE AT SEXUAL MATURITY AND ANNUAL GAMETOGENIC CYCLE IN OCEAN QUAHOG, *ARCTICA ISLANDICA* (LINNAEUS, 1767), OFF NORTH-WEST ICELAND**

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Ocean quahogs, *Arctica islandica*, were collected from near shore populations off north-west Iceland for study of their sexual maturation and gametogenic cycle. In February 1994, two hundred and six quahogs 24-119 mm in length were sampled for determination of developmental stages relative to size, age and sex. Sexual differentiation was evident in 200 individuals, 17 were in the intermediate stage and 183 fully mature. On the basis of annual internal growth banding in the shells of the specimens the age ranged between 7-32 years in the intermediate stage and the individuals were from 24-68 mm in shell length. The smallest and youngest individuals that could be sexed were males. The smallest fully mature male was 36 mm in length but the youngest aged individual was 10 years old (49 mm length). The youngest fully mature female was 44 mm and 13 years old. Age and size at maturity showed a wide range and may be dependent on growth rate and environmental conditions. Sex ratio between males and females were examined relative to size in 200 quahogs. The male to female (M:F) ratio varied between size classes, with males dominating in the smallest size classes, which may be related to their earlier development of germinal cells. At a length of 40 mm or more the females dominated in all size classes except 65-69 mm (1.4:1) and 70-74 mm (1:1). A total of 350 adult quahogs were sampled at regular intervals over a year (1998) to determine the gametogenic cycle. Morphologically ripe specimens, as inferred from histological examination, were present all the year around but predominated from April to July. A prolonged spawning period is indicated, spawning being most intense from June through August. Partially spawned individuals were found all the year around but most of the population was in this condition from August through January when the abundance of early active and late active specimens rose sharply.