

## SEED PRODUCTION TRIAL OF THE DEEP-SEA WHELK *BUCCINUM BAYANI* USING DEEP SEA WATER

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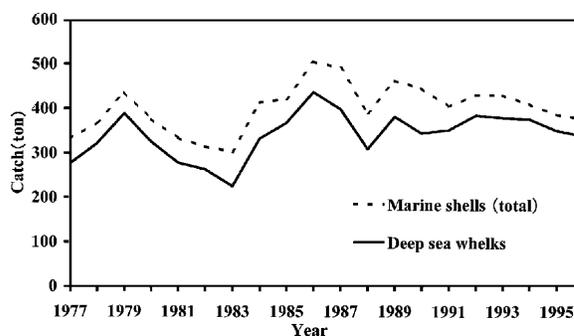
### ABSTRACT

The edible deep-sea whelk *Buccinum bayani* is distributed at depths from 200-800 m in the Sea of Japan, and especially Toyama Bay. It is one of the most important commercial shellfish in Toyama Prefecture. In order to establish seed production and to obtain ecological information necessary for the management and stock enhancement of this species, indoor tank culture of the whelk was carried out at the Toyama Prefectural Fisheries Research Institute using running, deep sea water at a temperature of about 3 C that was pumped from a depth of 321 m. For preparation as broodstock, the whelks were cultured on a diet of fish such as sardine or mackerel and after 1 yr of culture, as many as 80% of the whelks survived and some of the females laid eggs. Most of the younger whelks that were initially < 60 mm in shell height (SH) grew, while the presumed older ones (up to 120 mm SH) showed very little growth. Histological examination, low variation in the gonad index (GI), and the recorded mo during which eggs were layed all strongly suggest that *B. bayani* has no definite reproductive season. Spawned eggs were deposited as a mass of 80 to 250 egg capsules; each capsule containing 1500-3500 eggs. Whelks with larger SH produced many more egg capsules with about 10-30 individuals hatching from one egg capsule 6 mo after being spawned. By feeding whelks the fish as mentioned previously, juvenile whelks grew well and 50% of them survived after 1 yr in culture.

### INTRODUCTION

Toyama Prefectural Fisheries Research Institute has the capability to pump deep sea water (DSW) from Toyama Bay in the Sea of Japan at a depth of 321 m. The temperature of this DSW remains around 3 C year-round. The cold, clean, DSW is mainly used for stock enhancement or ecological studies on cold- and deepwater species such as Masu salmon *Onchorhynchus masou*, Pacific cod *Gadus macrocephalus*, red tanner crab *Chionocetes opilio elongatus* and Toyama shrimp *Pandalus hypsinotus*, as well as edible deep-sea whelks inhabiting the continental slope in the Sea of Japan. The whelks are among the most important commercial shellfish in Toyama Prefecture and are caught using chained basket traps. The catch of whelks in Toyama Bay (greater than 300 t) accounts for around 85% of the total catch of marine shells (Fig. 1). Because little biological information is available on the whelks,

indoor culture trials of *Buccinum bayani* were carried out to establish mass-culture techniques and to promote ecological studies for the management and stock-enhancement of this important shellfish species.



**Figure 1.** The total catches of marine shells and the catch of deep-sea whelks in Toyama Prefecture from 1977 to 1997. solid line indicates the catch of deep-sea whelks and broken line indicates the total catches of marine shells.

## MATERIALS AND METHODS

### Broodstock Culture

*B. bayani* of various sizes were collected for broodstock from Toyama Bay and cultured in 1-t tanks using running DSW under atmospheric pressure. Fish, such as sardine or mackerel, were given as food. Survival and growth, as determined by changes in shell height, were recorded over the course of 1 yr. When egg laying was observed, the mo of egg laying, SH of the egg-laying female and number of egg capsules were recorded.

### Culture of Juveniles

The culture of juveniles was carried out in two 5-L tanks stocked with 100 juveniles/tank. The tank bottoms were covered with mud collected from the sea bottom at a depth of 200 m. To validate the hypothesis that juvenile *B. bayani* feeds on organic matter in the mud, fish meat such as sardines were given to the juveniles in one tank, while no food was given to those in the other tank. After 1 yr of culture, the survival and growth of juveniles were assessed.

### Reproductive Cycle

*B. bayani*, more than 90 mm SH and presumed to be sexually mature, was sampled from Toyama Bay at 3 mo intervals. Fifteen to 20 shells were examined during each sampling and the gonad index (GI) was determined in the manner described by Takamaru and Fuji (1981); where GI is equal to gonad weight  $\times$  100/BW without the shell. The gonads were fixed in a formalin solution, dehydrated in alcohol, and embedded in paraffin wax in preparation for histological examination. Sections were cut at 8–12  $\mu$ m, stained with Mayer's hematoxylin and counterstained with eosin.

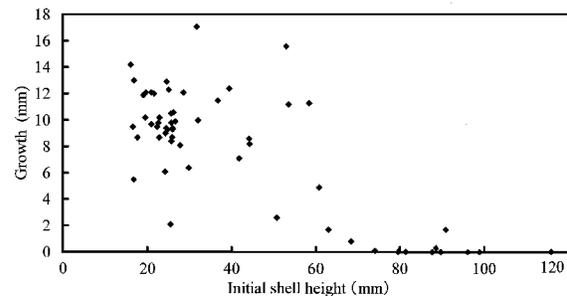
## RESULTS AND DISCUSSION

### Broodstock Culture

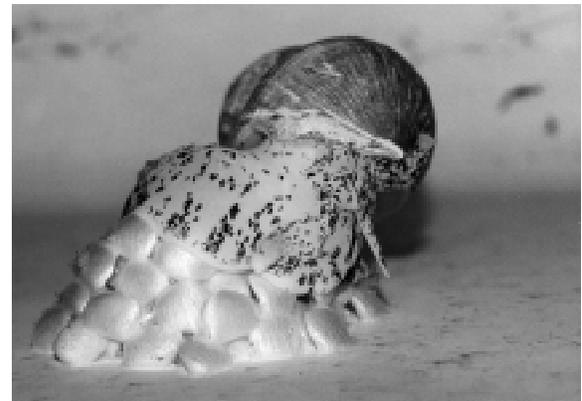
After 1 yr in culture, as many as 80% of the whelks survived. Most of the younger cultured whelks that were less than 60 mm SH grew, while the older ones (up to 120 mm SH) rarely grew (Fig. 2). The reason for this difference is unknown,

but perhaps a better food source must be investigated for older whelks to grow and mature.

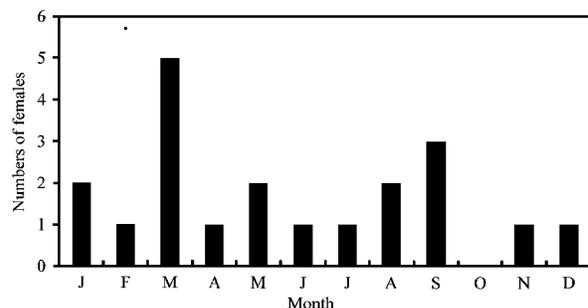
During the course of culture, some of the females laid eggs (Fig. 3). Since egg laying was observed throughout the year (Fig. 4), it is suggested that *B. bayani* have no definite egg-laying season. During the egg-laying process, female *B. bayani* formed an 'egg mass' by producing 80–250 egg capsules (each capsule containing 1500–3500 eggs). A female, 73.5 mm



**Figure 2.** Growth in shell height of *Buccinum bayani* after a year of culture. Growth = Shell height after a year of culture — Initial shell height.



**Figure 3.** Laying eggs of *Buccinum bayani*. Dome-shaped egg mass was comprised of egg capsules.



**Figure 4.** Number of female shells that laid eggs during indoor culture by months.

SH, was the smallest whelk to lay eggs, and it was noted that the larger whelks laid more egg capsules. At the given temperature (3 C), it took 6 mo before the eggs hatched. About 10-30 individuals hatched from one egg capsule, while the other eggs in the capsule appeared to serve as nurse eggs. The shell height just after hatching was about 2 mm. As the females did not lay eggs again for at least 2 yr after previously laying eggs, further investigation is necessary to determine the life span and egg-laying cycles of whelks. Tag-and-release experiments may bring further information on the growth and survival rates of *B. bayani*, particularly in their natural habitats.

### Culture of Juveniles

Juvenile *B. bayani* survived and grew on the mud substrate under both conditions; given fish meat and without any solid food (Table 1). Surviving and growing without any solid food for 1 yr strongly suggests that the juveniles could survive only on the organic matter in the mud. However, the growth of the whelks in the 'mud group' was inferior to that of the 'mud + fish group' where the weight of the 'mud group' was only one-sixth of the 'mud + fish group.' When given fish meat, the SH increased from 2.5 to 7.1 mm after 1 yr of culture and the survival was 51%. It appears that fish meat is a suitable food for juvenile as well as adult whelks.

### Reproductive Cycle

The maximum gonad index value of the female whelks was about 12, which is approximately twice of that observed for males (Fig. 5). In both the males and the females examined, however, whelks that revealed a GI greater than half of each maximum GI value were

reported in each mo throughout the yr. This was coincident with the above results that egg laying was observed year-round. Histological examination of testes and ovaries revealed the presence of mature spermatozoa and mature oocytes filled with large yolk granules (about 20  $\mu\text{m}$  in diameter) in more than 80% of the males and more than 50% of the females, respectively, every representative mo of the four sampling periods (Fig.6, 7). In addition, the year-round maturity in the males (>80%) suggests that there is no resting period in spermatogenesis. We are speculating that sperm is constantly produced in the testis and transported to the seminal vesicle.

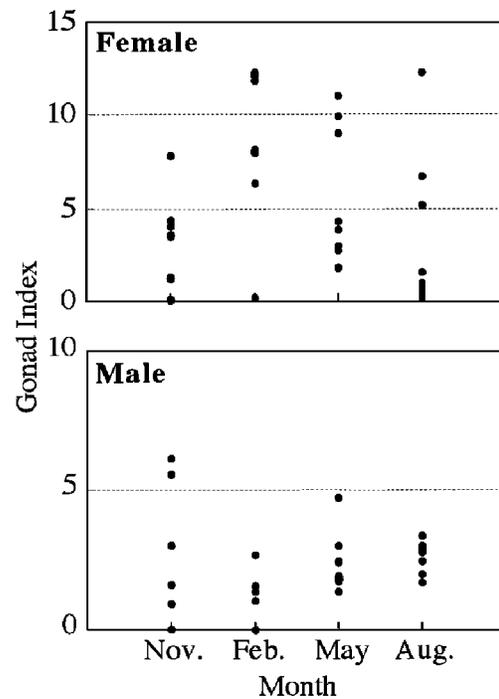


Figure 5. Gonad index of *Buccinum bayani*. Gonad Index = gonad weight X 100/body weight without shell

Table 1. Growth of juveniles of *Buccinum bayani* after a year of culture.

	Average survival rate (%)	Average shell height (mm)	Average weight (mg)
Mud+fish meat group	51.0	7.1	58.4
Mud group	31.0	3.5	10.0
*Initial juveniles			
Average shell height (mm) = 2.5			
Average weight (mg) = 3.2			

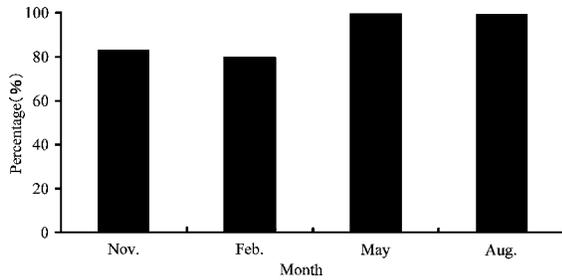


Figure 6. Percentage of males with mature testis.

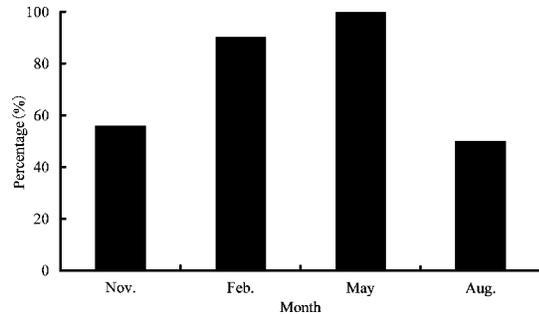


Figure 7. Percentage of females with mature oocytes.

In other studies on the reproductive cycle of subtidal neogastropods of the family Buccinidae, *Buccinum undatum* (Martel et al. 1986), *Nucella freycineti* (Kawai and Nakao 1993) and *Neptunea arthritica* (Takamaru and Fuji 1981; Fujinaga 1985), a clearly defined reproductive season was exhibited and seasonal changes of water temperature was considered to be an important factor in gonad development. The water temperature in the zone (200 to 800 m) where *B. bayani* lives was below 3 C throughout the year (Nakura and Nagata 1989). It is quite likely that there is no environmental cue to induce or arrest maturation of *B. bayani* in their deep-sea habitat.

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