# Growth rate of *Trochus niloticus* (L., 1767) fed different food types

*Do Huu Hoang[1,2], Hua Thai Tuyen[1], Hoang Duc Lu[1]*

## Abstract

To better understand the growth rate of the top shell *Trochus niloticus* in captivity, a feeding experiment was conducted using F1 top shells measuring 11 mm. Trochus were fed on six different diets, including algae attached to rocks, algae in a coral tank, cultured algae *Navicula* sp., *Nitzschia* sp., dried algae (*Spirulina*), and equal proportions of *Navicula* and *Nitzschia*. Results showed that while all the trochus grew well when fed on all these diets, trochus that fed on algae living on rocks and in coral tanks showed the highest growth rate. Another experiment was conducted using top shells sized 27–28 mm and four types of feeds: dried algae + N1, dried algae + soya bean powder, dried algae + N1 + soya bean powder, and dried algae + N1 + soya bean + detritus. Result showed that trochus fed a mixture of dried algae + N1 + soya bean + detritus showed the highest growth rates, and trochus fed dried algae + N1 + soya bean grew the slowest.

## Introduction

The trochus or top shell (*Trochus niloticus*) is a gastropod grazer found in the coral reefs of the Indo-Pacific region. It is a favourite seafood in the Asian and Pacific regions (Shokita et al. 1991).

The biology and ecology of trochus have been investigated in locations including Indonesia, Thailand, Japan, Micronesia and Australia, yielding data that are useful for applied studies (Bour 1988; Dobson and Lee 1996; Shokita et al. 1991). However, studies of trochus began only recently in Vietnam. Food items found in the stomach of trochus include 42 taxa belonging to Chrysophyta, Chlorophyta, Rhodophyta, Cyanophyta, Foraminifera, and suspended materials mixed with sand and detritus (Soekendarsi et al. 1998). Under laboratory conditions, trochus fed *Isochrysis galbana* grew faster than did three other groups fed *Tetraselmis* sp., *Chaetoceros gracilis* and *Nannochloropsis* sp. (Latama 1999). In the experiments by Soekendarsi et al. (1999) using individuals between 30 and 39.9 mm in size, a diet of *Ulva reticulata* produced the highest recorded growth rate, while groups fed *Caulerpa sertularioides, Ulva reticulata, Padina australis, Gracilaria salicornia* and *Eucheuma denticulatum* exhibited a much lower growth rate.

The shell is the most valuable part of the trochus. It is used for many purposes, but most commonly to make souvenirs and buttons. The shell is also used in cosmetics and paint (King 2001; Bouchet and Bour 1980; Nash 1993). The main producing countries are Indonesia, the Philippines and Thailand, while Japan, Hong Kong and Europe are the most important consumers. In Vietnam, *T. niloticus* has been exploited for human consumption, and shells are marketed as souvenirs (the current market price is about VND 40,000–70,000 per shell (USD 2.4–4.2 per shell) or VND 150,000 per kg (USD 9.03 per kg). Overexploitation of trochus due to high market demand has resulted in depletion of the resource in Vietnamese waters and *T. niloticus* is now listed as a protected species in Vietnam (Vietnam Red Data Book). Therefore, rehabilitation and enhancement of trochus stocks are necessary both locally and internationally. One of the solutions available is to replenish trochus resources through artificial breeding and release of larvae or juveniles in the wild (Ponia 2000; Amos 1992; Lee 2000). The aim of this experiment was to examine appropriate feeds for supporting mass seed production in hatcheries and for natural stock enhancement.

## Materials and methods

Twenty broodstock top shells (*T. niloticus*) were collected from Khanh Hoa waters and cultured in a 6 $m^3$ tank in a hatchery at the Institute of Oceanography, Nha Trang, Viet Nam. The broodstock was induced to spawn as follows. They were first removed from the water and exposed to ambient air for approximately 30 minutes. They were then put in a tank with water that flowed through an 11 W ultraviolet light system with a flow rate of 7–8 litres per minute to stimulate spawning. The first spawning occurred within an hour.

1. Institute of Oceanography, Nha Trang, 01 Cau Da, Nha Trang, Vietnam
2. Correspondence address: Huu Hoang Do, Institute of Oceanography, 01 Cau Da Nha Trang, Vietnam. Email: dohuuhoang2002@yahoo.com

### *Experiment 1*

When the basal shell diameter of the F1 generation had reached approximately 11.98 ± 0.08 mm (± S.E.) in size, their subsequent growth rate under six different diets was compared. The diets consisted of live algae found on natural rock, natural algae found on coral, *Navicula* sp, *Nitzschia* sp., an equal mixture of *Navicula* sp. and *Nitzschia* sp., and dried cells of *Spirulina* sp. The food supply was checked daily for abundance and replenished when required. The stocking density of the F1 was 20 individuals per 60 L tank and three replicate tanks were used for each treatment. The experiment lasted for 12 weeks.

### *Experiment 2*

Another experiment was conducted using top shells with an initial diameter of 27–28 mm. This experiment was conducted for 10 weeks. Feeds used included dried algae + N1, dried algae + soya bean powder, dried algae + N1 + soya bean powder, and dried algae + N1 + soya bean + detritus (about 25% each). Dried algae refers to dried cells of *Spirulina* sp.; N1, a Japanese industrial feed for the prawn market (described as "mixed feed for *P. monodon*"), is used to feed postlarvae 15 or later stages; and detritus corresponds to organic matter on rocks collected from the wild. The density in the experimental tanks (n = 3 replicates) was 10 top shells per 60 L tank.

### *Husbandry, environmental checks and data collection*

During the two experiments described above, the husbandry was similar. Monitoring, cleaning and other activities were undertaken daily. A continuous flow of sea water was used, corresponding to a volume replacement of 80% per day. Average daily temperatures varied between 26.5 and 31.5°C. The pH of the sea water was between 7.24 and 8.38 and the salinity was about 34. Basal shell diameter in millimetres and total weight in grams were measured every two weeks.

### *Data analysis*

Data were tested for normality and analyses of variance were performed using SPSS (Version 10.0). Where data were not normally distributed, they were transformed to logarithms before analysis.

## Results

### *I. Feeding experiment using top shells with an initial size of about 12 mm*

Results showed that the weight (0.35 ± 0.05 g) and basal diameter (11.98 ± 0.07 mm) of the top shells used at the beginning of the experiment were not significantly different among the treatments (ANOVA, $F = 1.035$, $p = 0.40$).

During the first two weeks of the experiment, trochus sizes in most treatments showed little change (Figs 1 and 2), except for top shells fed live algae in coral tanks, which showed a slight gain in both weight and shell size. After the first two weeks, weights and shell sizes in all treatments increased dramatically and showed significant differences (ANOVA, $F = 54.146$, $p < 0.001$) between treatments. By the end of the experiment the top shells had developed into two size groups.

The first group consisted of top shells fed natural algae on rocks and on coral. The top shells in these two treatments grew significantly faster than in the remaining treatments, and in these two treatments trochus fed algae on rock showed a significantly higher growth rate than those fed algae in the coral tank (ANOVA, $p < 0.02$).

The second group, which had a slower growth rate than the first group, consisted of trochus fed *Navicula* sp., *Nitzschia* sp., dried algae, and a mix of *Navicula* sp. and *Nitzschia* sp. In this group, the trochus fed *Navicula* showed significantly higher growth rates than those fed on *Nitzschia* and *Navicula* + *Nitzschia* sp. (ANOVA, $p < 0.04$). In addition, both treatments fed *Nitzschia* sp. and a mix of *Navicula* sp. + *Nitzschia* sp. showed a significantly slower growth rate when compared to other groups (ANOVA, $p < 0.001$). However, there were no significant differences between these two treatments (*Nitzschia* sp. vs a mix of *Navicula* sp. + *Nitzschia* sp.) (ANOVA, $p < 0.01$).

### *II. Feeding experiment on top shells with an initial size of 27–28 mm*

In this experiment, the initial size of the top shells was larger (27–28 mm) than in experiment 1 (12 mm) (Fig. 3). There was no significant difference in initial size between the treatments at the beginning of the experiment (ANOVA, $p > 0.12$).

In general, all the treatments showed good growth rates and by the end of the experiment, all the trochus had reached >33 mm in shell diameter. The trochus fed a mix of dry algae + N1 + soya bean + detritus reached the largest size in comparison to specimens in the other treatments (ANOVA, $p < 0.02$). The specimens fed on a mix of dry algae + N1 + soya bean showed the slowest growth rate (ANOVA, $p < 0.001$). Top shells fed a mix of dry algae + soya bean and a mix of dry algae + N1 exhibited intermediate growth rates without significant differences between each other (ANOVA, $p > 0.10$). However, both of these conditions showed

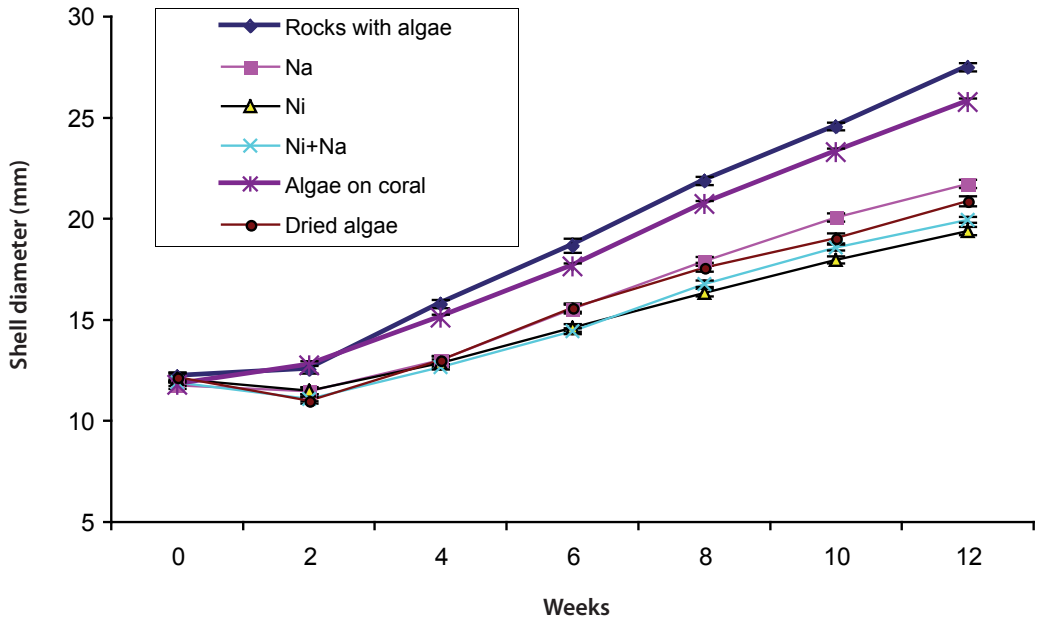


**Figure 1.** Mean shell basal diameter of *Trochus niloticus* fed on six different diets. Na: *Navicula* sp., Ni: *Nitzschia* sp., Ni + Na: 50% mix *Nitzschia* sp. and *Navicula*, dried algae: *Spirulina* sp.

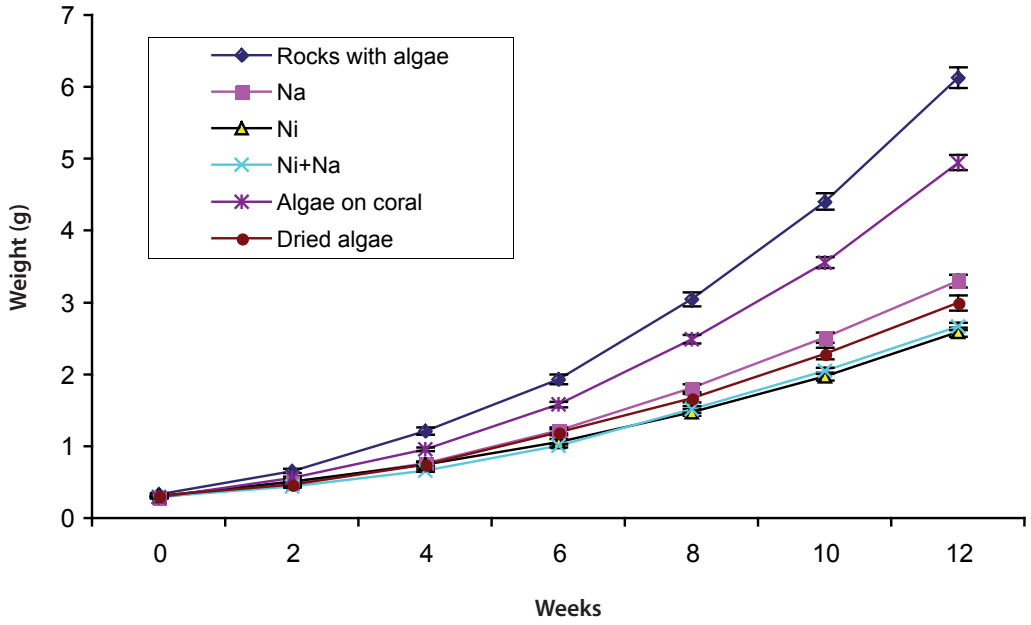


**Figure 2.** Mean weights of *Trochus niloticus* fed on six different diets. Na: *Navicula* sp., Ni: *Nitzschia* sp., Ni + Na: 50% mix *Nitzschia* sp. and *Navicula*, and dried algae: *Spirulina* sp.

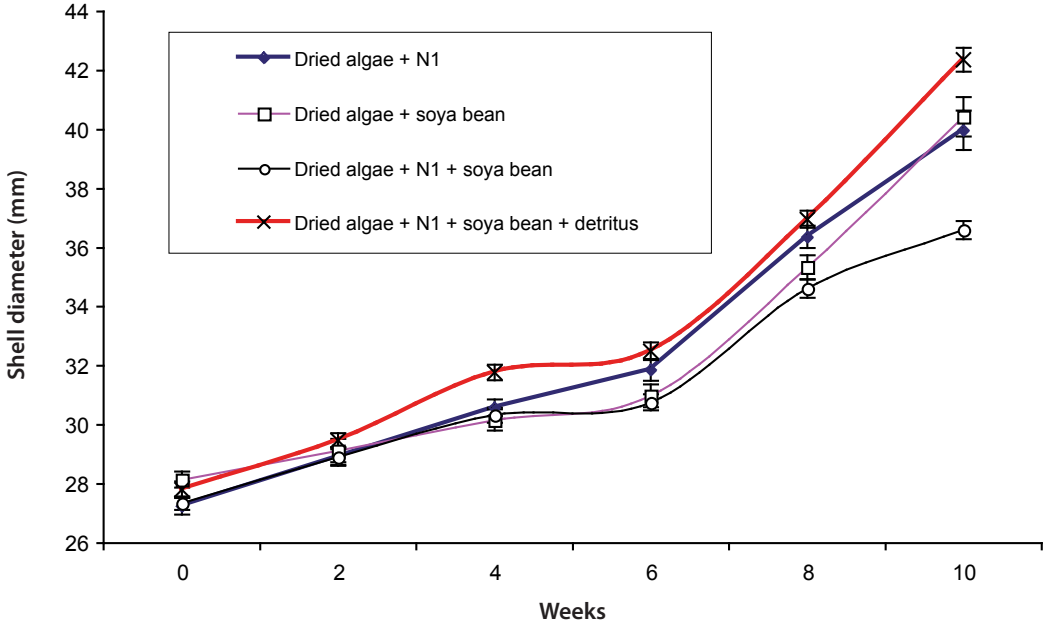


**Figure 3.** Growth of shell diameter (in mm) of top shells fed dry algae + N1; a mix of dry algae + soya bean; dry algae + N1 + soya bean; and mix of dry algae + N1 + soya bean + detritus.

significant differences in comparison to the mix of dry algae + N1 + soya bean + detritus (ANOVA, $p < 0.001$) (Fig. 3).

## Discussion

According to Shokita et al. (1991), *T. niloticus* is a grazing mollusc and its natural diet consists of filamentous algae attached to rocks or detritus and sediments found on various substrata. However, this diet may change depending on the stage of development. The author also states that trochus juveniles feed on small-size seaweeds attached to the substratum, while adults eat small seaweeds and microalgae. Observations in captivity showed that both juveniles and adults ate microalgae, but adults also ate some seaweeds such as *Gracilaria*.

In both experiments, trochus fed on algae living on rocks and the walls of coral tanks showed better growth rates compared with other treatments. It is possible that the composition of food obtained from coral bases on rocks was similar to the usual diet of trochus in nature, which resulted in a shorter acclimation time and faster growth rate than in trochus fed other diets. For example, in experiment 1, during the first two weeks, trochus fed algae growing on the walls of coral tanks seemed to grow faster and did not show any delay in growth initially, while trochus in the other treatments grew more slowly – possibly while adapting to new food items. Another possibility is that the presence of detritus and sediment in the diet might be beneficial for trochus growth.

The trochus used in the experiments were initially cultured in tanks that had algae attached to their walls. These conditions were therefore similar to those in the experimental coral tanks. As a result, these trochus acclimated faster and had reasonable access to food, as shown by the good growth rates obtained.

The algae species composition on the natural rock included Rhodophyceae (*Ceramium mazatlanense, Centroceras clavulatum, Chondria repens*), Chlorophyceae (*Enteromorpha clathrata, Cladophora laetevirens, Chaetomorpha javanica*), Diatomophyceae (*Nitzschia* spp., *Navicula* spp., *Diploneis* cf. *bombus, Paralia sulcata, Achnanthes brevipes, Pleurosigma naviculaceum, Bacillaria paradoxa, Cylindrotheca closterium, Coscinodiscus* spp., *Oscillatoria* sp.), detritus, sand, and others (Final topshell report, 2005). This diet is close to the natural diet of trochus in the wild (Soekendarsi et al. 1998) and hence it yielded the best growth rate in captivity. The same results were found in a previous experiment conducted on *T. maculatus* bred in captivity. The result in that experiment, also performed in our laboratories, showed that trochus fed on algae on natural rocks exhibited the highest growth rate compared with those fed other diets (Do et al. 2003).

Despite the fact that the different types of feed used in the experiments resulted in different growth rates of trochus, all the diets could be selectively used to feed trochus in captivity, depending on practical conditions. In addition, although the results of

the experiments showed that some diets produced higher growth rates in trochus in captivity, it is essential to conduct more experiments on numerous other diets, particularly using the industrial mixtures produced for other aquatic animals such as prawn.

There are some difficulties involved in trochus culture. Firstly, according to Nash (1993) trochus grow slowly, reaching a commercial size at 2–3 years of age. They are thus costly to culture in captivity. Algae attached to rock promote faster growth of trochus, but there are difficulties in collecting such rocks for mass production of trochus. For this reason, trochus should be cultured in natural conditions using methods such as sea ranching, or released into marine protected areas. Therefore, replacement feeds should be used only in the juvenile stages, until culturing them in the wild becomes possible.

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