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A Preliminary Seed Production of Green Snail (*Turbo marmoratus*) in Tonga

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Introduction

Green snail, *Turbo marmoratus*, is a very important marine resource in the South Pacific Island countries. Although there are suitable habitats in Tonga, this species does not occur naturally. Thus, the introduction of green snail was carried out after a series of surveys. Twenty-one green snails were released at Vaini beach, Tongatapu Is. and 195 were released off the coast of Tongatapu, at 'Euaiki Island. Seventy individuals were kept as spawners in a raceway tank at the Sopu hatchery (Naita *et al.*, 1995).

French Polynesia introduced 42 green snails from the New Hebrides (now Vanuatu) in the 1950s, however it took about 20 years to establish the resource (Yen, 1990). From the experience of French Polynesia, it is possible that the introduced individuals in Tonga are not enough to establish it as a resource within a decade. One of the methods to accelerate establishment of its resources is a seed release project. As the seed production of green snail had never been tried before in Tonga, a trial seed production was conducted.

Spawners

The rearing of 75 green snails for spawners (73 hatchery produced individuals and two individuals from the wild), introduced from Japan, was commenced in September 1994. The spawners were

reared in a plastic cage with 2.5 cm mesh made to fit inside a concrete raceway tank (three tonne capacity), with a strong aeration system for circulating water. The cage bottom was elevated 15 cm from the raceway tank bottom to prevent deterioration of the water quality in the cage. Sufficient amounts of *Gracilaria* sp. were used as the main feed and *Eucheuma* sp. as sub-feed for the spawners. The spawners were identified male and female by the dimorphic characteristics of the papillae of the right kidney opening (Kikutani *et al.*, 1994). Sixty-nine spawners are surviving and all are growing well. Six individuals died within three months of introduction from Japan. All dead individuals showed no shell growth. Twenty four of them, (spawned in August 1992), have been measured monthly since September 1994. The average growth in shell length of these individuals during the first 14 months is shown in Fig. 1. The average shell length was 49 mm in September 1994, 79.4 mm after one year and 81.7 mm after fourteen months. The growth of all individuals was stable and all reached a mature size. The survival rate was 100% after the initial three months. The snails will be kept for one year and then transplanted to 'Euaiki Island.

Spawning Induction

Spawning induction was conducted three times in 1994. The first trial was carried out on October 24, 1994 but no spawners stimulated at this time. The second trial was on November 8, 1994. One male released sperm, but other individuals were not stimulated by spawning induction. The stimulated male was 67.5 mm in shell length. The third trial was conducted on December 14, 1994. Six males and two females released gametes.

The procedures of the third trial spawning event are as follows. Thirty two individuals were used for spawning induction. The spawners' shell surfaces were cleaned before the non-circulated stimulation. They were taken into a 30 litre tub and filled with just enough sea water (one micron filtered) to cover the spawners

and were kept for 25 hours with strong aeration and no exchange of water (non-circulated stimulation). Then, the spawners were transferred to the spawning tank and filled with sea water (one micron filtered) which had been passed through the ultraviolet irradiation (UV) system (UV irradiation stimulation). The flow rate of the UV irradiated sea water was three litres/min.

The first male released sperm after 41 minutes and the first female released eggs one hour and 35 minutes from the start of stimulation. A total of two females and six males released gametes giving a stimulation rate of 28.1%. After spawning, the spawners were removed immediately from the spawning tank and held in separate male and female tanks.

When the females finished releasing eggs, they were removed from the female tank and minimal sperm was added via a beaker to the female tank. They were mixed gently and left together for about 15 minutes. After 15 minutes, the fertilised eggs were put into the 71 micron net and excess sperm was rinsed off using sea water (one micron filtered). They were then transferred to a 20 litre round plastic tank. The green snail ova is a demersal egg and it settled to the bottom of the tank. Excess sperm was removed by two decantations. After decantation, the fertility rate of the fertilised eggs was determined and the eggs were counted and transferred into the larval incubation tank.

Larval Incubation

An artemia incubation tank was used as the larval rearing tank. This tank is a 100 litre polycarbonate tank with a 71 micron mesh screen which is set above the bottom of the tank. The water inlet is placed in the centre of the tank, 30 cm above the surface.

The running sea water flows downward through the tank, through the 71 micron mesh, and exits from the standpipe. 105,500 spawned eggs, with a 96.8% fertilisation rate, were

accommodated and cultured using one micron filtered sea water at 0.3 litres/min flow rate. The fertilised eggs were kept in the larval incubation tank until they reached the creeping stage. 57,000 creeping stage larvae were produced by the sixth day after fertilisation. Table 2 shows spawning induction results on December 14, 1995 and Table 3 shows the early stages of larvae development.

Culture of Diatom for Juvenile Food

Before conducting spawning induction, diatoms were cultured in a three tonne raceway tank for larval settlement. The diatoms used for the settlement tank were produced by the pure culture system. Two litres of sea water (one micron filtered) was passed through the UV irradiation system and one litre of fertiliser (Norimax) added for the diatom pure culture. After two weeks the pure cultured diatoms were transferred to the three tonne larval settlement tank. Eight sets of corrugated plastic panels (130 cm x 30 cm, two plates each set) were placed in the three tonne raceway tank for use as substrates for the green snail juveniles. The procedure for the diatom culture was as follows:

1) Settlement tank was cleaned with fresh water and dried.
2) Eight sets of corrugated plastic panels were placed as substrate for green snail larvae in the raceway tank.
3) Raceway tank was filled with sea water filtered through a one micron filter bag.
4) Two bottles (500 cc bottle) of Norimax and two litres of pure culture diatom (*Navicula* spp.) sea water were added to the three tonne raceway tank.
5) Tanks were covered with 80% blockout sun shade to reduce light intensity.
6) The diatom in the 0.5 FRP round tank were also cultured using the same method as for the three tonne concrete raceway tank.

Rearing Juveniles

Hatchery juveniles are from the creeping larvae stage to three mm in diameter juveniles. 57,000 creeping stage larvae were collected the sixth day after fertilisation. The larvae were divided into a lot of 15, 000 and one of 42,000. Fifteen thousand larvae were transferred to a one tonne FRP tank where trochus larvae were being reared and 42,000 were transferred to a three tonne concrete raceway tank. The diatom in the three tonne concrete raceway tank were separated from those in the one tonne tank as the seven day diatom cultivation term was too short to complete sufficient diatom growth. The complete diatom cultivation requires at least two weeks. The rearing process was as follows :

1) The running sea water of two tanks was stopped and the larvae were transferred from the larval incubation tank to the juvenile settlement tank. Aeration was reduced to a gentle level.
2) After two days, no more veligers were floating in the water and the flow of one micron filtered sea water was recommenced.
3) Aeration was increased after two days.
4) After one month, the mesh size of the filter bag was changed from one micron to 25 microns. Some three month old juveniles were transferred from the juvenile rearing tanks to the giant clam juvenile tanks and kept for one month. Thereafter green snail juveniles were transferred to an intermediate tank.

Rearing the Intermediate Juvenile Phase

The four month old juveniles, more than three mm in diameter, were counted and transferred from the giant clam juvenile tank, the green snail juvenile tank and the drain to a 15 litre round plastic tank. A total of 111 juveniles were collected, 38 from the giant clam juvenile tank, 41 from the green snail juvenile tank and

32 from the drain. Twenty-five litres of filtered sea water was run into the rearing tank. For the first one month, *Hypnea* sp. and *Gracilaria* sp. were used to feed the juveniles. After one month, *Gracilaria* sp. was given as the main feed and *Eucheuma* sp. for sub-feed. The juveniles were kept in this tank for two months and then transferred to a four mm mesh plastic cage (50 cm x 30 cm x 30 cm).

The cage was hung on the green snail spawning tank. They were given *Gracilaria* sp. and *Eucheuma* sp. continuously. A total of 90 juveniles (nine months old) were transferred from the four mm mesh plastic cage to a one cm mesh plastic cage with a lid (50 cm x 33 cm x 25 cm).

A total of 86 individuals (11 months old) were being reared as of November 1995. The survival rate was very low at 0.15 %. The shell height of the snails was measured monthly from when they reached six months old (Fig. 2 and Table 4). The average shell height of a six month old juvenile was 6.2 mm and an 11 month old juvenile was 26.9 mm.

Conclusion

The rearing method of broodstock and over three mm diameter juveniles are being established. The results of the broodstock measurement are as follows. The broodstock shell height (SH) was 49 mm when first measured. One year later, the average shell height was 79.4 mm, an increase of 30.4 mm. Similar size green snail, in Okinawa Prefectual Fisheries Experimental Station, Yaeyama Branch (OPFES, YB), averaging 47.2 mm SH, grew to an average of 70.0 mm SH after one year. This was an increase of 22.8 mm SH (Tamaki 1993). Comparing the results, the shell height growth in Tonga was greater than in Okinawa by an average of 7.6 mm. Juveniles, 11 months old, had an average of 26.9 mm SH in Tonga, whereas one year old juveniles in OPFES, YB, averaged 25 mm SH. This shows the juvenile growth rate in Tonga was

also faster than in Okinawa. These growth rate results are promising and it is believed that better results could be obtained by using a sufficient supply of Gracilaria for the juveniles and brood stock green snail feed.

The very low survival rate (0.15%) may be due to the lack of food diatom and not enough equipment for all the processes of seed production for green snail.

Future Direction

Goals for the green snail culture project are :

- Establishment of a mass seed production system.
- Establishment of releasing techniques (releasing of creeping stage juvenile and young adults).
- Establishment of an economical seed production system.
- Development of the Gracilaria cultivation system.
- Development of a green snail food algae other than the Gracilaria.

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Table 1. *Turbo marmoratus* **monthly growth (Shell Length)**

	Sep 94	Oct 94	Nov-94	Dec-94	Jan-95	Feb-95	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95
Max (mm)	53.2	54.5	57.9			69.2	72.9	78.7	82.7	84.2	85.1		85.1	87.2	87.4
Ave (mm)	49.2	50.3	53.3			63.8	66.5	72.3	75.1	77.1	78.9		79.4	80.5	81.7
Min (mm)	42.8	44.2	47.5			57.7	59.9	66.6	68.2	70.4	71.3		72.2	72.4	73.8

Figure 1. *Turbo marmoratus* **monthly growth (Shell Length)**

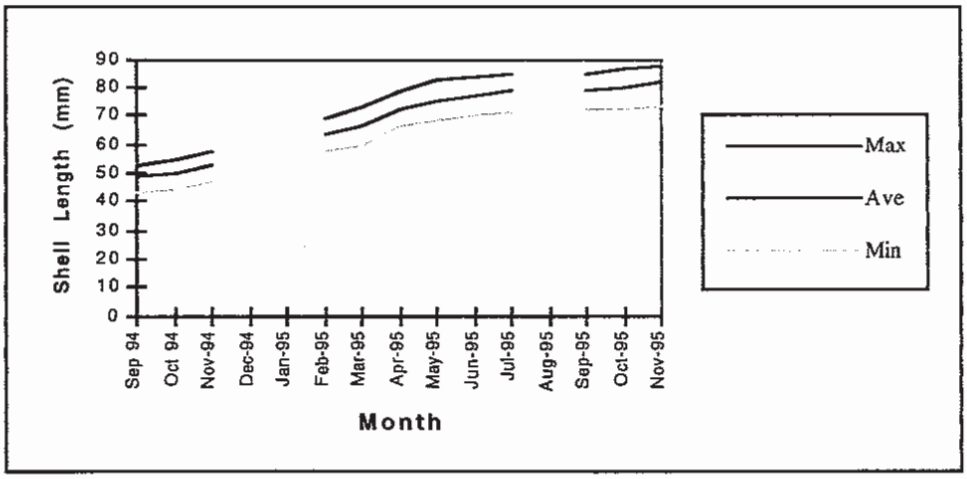

Table 2. Spawning Induction Results

Date spawned: 14 Dec 94

Number of spawners: 32

Stimulation	Time In	Water Temp °C	Time Out	Water Temp °C	Number of Stimulated Spawners	Stimulation Rate	Stimulation Time M	Stimulation Time F	Fert. Time	Water Temp °C	Fert. Rate	Number of Eggs
Non Circulated	14/12 18:00	27.5	14/12 19:00	28.0	M 6 F 2	28.1%	19:41 19:45 19:51	20:35	21:15 20:45	28.0	96.8%	105 500
U.V.	14/12 19:00	28.0	14/12 21:00	28.0			19:52 19:54 20:45					

Table 3. Early Development Stage of Green Snail

Date	Time	Water Temp °C	Early Development Stage
14-Dec-94	21:15	28	Fertilised eggs
	22:50	28	4-cell stage
15-Dec-94	10:00	26	Trochophore stage
	12:00	26.5	Early veliger stage
16-Dec-94	9:30	26.2	Larvae in veliger stage after torsion
	16:30	27	Larvae in veliger stage after torsion
17-Dec-94	9:30	26.2	Veliger larvae in late swimming stage
	18:00	29.5	Veliger larvae in early benthis stage
18-Dec-94	9:20	26	Veliger in benthis stage
	16:.40	27.5	A few creeping larvae were seen
19-Dec-94	9:00	25.7	A few creeping larvae were seen
	16:30	28	A few creeping larvae were seen
20-Dec-94	10:00	26.3	Many creeping larvae were seen

Table 4. Monthly shell height measurement of *Turbo marmoratus* juveniles

Age (months)	6	7	8	9	10	11
Max (mm)	10.2	13.2	18.5	21.7	25.9	31.4
Avg (mm)	6.2	9.6	15	18.1	21.5	26.9
Min (mm)	2.1	5.1	9	11.2	11.7	19.6

Figure 2. Monthly shell height measurement of *Turbo marmoratus* juveniles