Captive Breeding for the Gastropod Conch (*Strombus* spp.)

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ABSTRACT

A captive breeding program for three non-restricted Caribbean *Strombus* conch species: *S. raninus*, *S. alatus*, and *S. costatus*, as well as the commercially threatened *S. gigas* was established at Harbor Branch Oceanographic Institution in June 2000. A total of 24 adult conch were collected from the Florida Keys: five *S. costatus* (3 female, 2 male), seven *S. raninus* (5 females, 2 males), eight *S. alatus* (4 females, 4 males) and four *S. gigas* (1 female, 3 males). They were placed in a circular tank (4.5 m dia) that was divided into four equal quadrants (4.1 m^2). Egg masses from the breeding tank were measured for size, number of eggs, and egg capsule and strand diameter. In 40 weeks, 426 egg masses were collected. A total of 341 egg masses were collected from the five *S. raninus* females. The four *S. alatus* females laid 58 egg masses, the three *S. costatus* females laid a total of 23 egg masses, and the single *S. gigas* female laid 4 egg masses in mid-February. The viability of several eggs from all four species was confirmed by successfully hatching and culturing the larvae to the juvenile stage. The breeding success of these species holds promise for the establishment of a commercial captive breeding program, and may provide alternative conch species for the food markets and the aquarium trade.

KEY WORDS: Conch, spawning, *Strombus*

INTRODUCTION

For years conch belonging to the Family Strombidae have been harvested as a food source, building material, and decoration. There are seven *Strombus* species in the Caribbean and Florida region: *Strombus gigas*, *S. costatus*, *S. raninus*, *S. alatus*, *S. pugilis*, *S. gallus*, and *S. goliath* (Abbott 1974). Of these species, *S. gigas*, the queen conch, holds the highest commercial value as a subsistence and commercial fisheries product (Brownell 1977, Berg 1976). Beginning in the 1970s, the *S. gigas* fishery became impacted by overfishing, which eventually led to the enactment of several regulations (Appledoorn 1994). However, management strategies alone cannot keep up with the fishing pressures of today. Captive breeding and larval rearing are now promising means of raising juvenile *S. gigas* for the market and for restocking efforts (Davis 2000).

Today, scientists still rely upon wild adult populations of *S. gigas* for egg masses. Often it can be difficult to find egg masses in the wild due to limited spawning aggregations, low copulation frequency, and seasonal breeding. Establishing a captive breeding program would alleviate the need to collect egg masses from the wild and possibly extend the breeding season. Prior to this experiment, there have been no commercial captive breeding programs. However, spawning and egg-laying in captivity has been observed for *S. costatus*, *S. pugilis*, a close relative to *S. alatus*, and *S. raninus*, but only on a small, research scale (Bradshaw-Hawkins 1982, Davis et al. 1993, Reed 1995a, Reed 1995b).

The purpose of this experiment was to document the breeding activities for four *Strombus* species: *S. raninus, S. alatus, S. costatus*, and *S. gigas*. The number of egg masses laid per female on a weekly and daily basis was recorded, the size and number of eggs per mass was determined, and the viability of the eggs laid in captivity was assessed through larval and juvenile rearing. The results from this study will assist in developing a permanent captive breeding program at Harbor Branch Oceanographic Institution in Fort Pierce, Florida USA.

MATERIALS AND METHODS

The captive breeding study was conducted at Harbor Branch Oceanographic Institution (HBOI), Ft. Pierce, Florida from June 15, 2000 – March 22, 2001. Four Florida and Caribbean *Strombus* species: *S. raninus*, *S. alatus*, *S. costatus*, and *S. gigas*, were used in the study. A total of 24 adult conch were collected from the Florida Keys: five *S. costatus* (3 female, 2 male), seven *S. raninus* (5 females, 2 males), eight *S. alatus* (4 females, 4 males) and four *S. gigas* (1 female, 3 males). The *S. gigas* adults were hatchery-reared conch from the Florida Fish and Wildlife Conservation Commission (Glazer, unpubl. data). The sex of each conch was determined, by examining the external sex organs. The males and females were then numbered with fluorescent enamel paint (Shawl and Davis, in prep). The adult conch were covered with towels moistened with seawater and transported to HBOI in coolers.

Based on the availability of broodstock, the conch were stocked at varying densities and sex ratios: *S. gigas* were held at 0.98 conch/10 m^2 and a 1:3 female:male ratio, *S. raninus* conch were held at 1.7 conch/10 m^2 and a 3:1 ratio, *S. alatus* were stocked at 2 conch/10 m^2 and a 1:1 ratio, and *S. costatus* were held at 1.2 conch/10 m^2 and a 1:1 ratio. The broodstock were fed a total of 550-650 g of koi chow and *Ulva* gel diet daily (Shawl and Davis, in prep). Approximately 21 g were fed per day to each *S. raninus*, 19 g fed per day per *S. alatus*, and 50-70 g fed per day to each *S. costatus* and *S. gigas* conch.

The 4.5 m dia (0.9 m high) breeding tank at HBOI is on a recirculating system (Figure 1, 2). The initial and replenishment water (30 L/hr) for the system is pretreated water from a shallow salt water well. For this experiment, the breeding tank was divided into four equal areas (4.1 m^2) using 30 cm high polypropylene mesh (2.5 cm openings) (Figure 2). The breeding tank is designed to be a subgravel filter (Figure 1). Approximately 10 cm of sand is supported 15 cm above the bottom of the tank. The Bahamian aragonite sand (1 - 3 mm dia) is the substrate for the broodstock and also acts as the biofilter for the system. The water depth above the sand substrate is 45 cm. The recirculating water enters the tank both through angled spray bars and under the substrate (Figure 1). The water filters through the sand and returns to the pump from the bottom of the tank. The water goes through a sand filter prior to being pumped into the breeding tank. This filter is backwashed every two weeks.

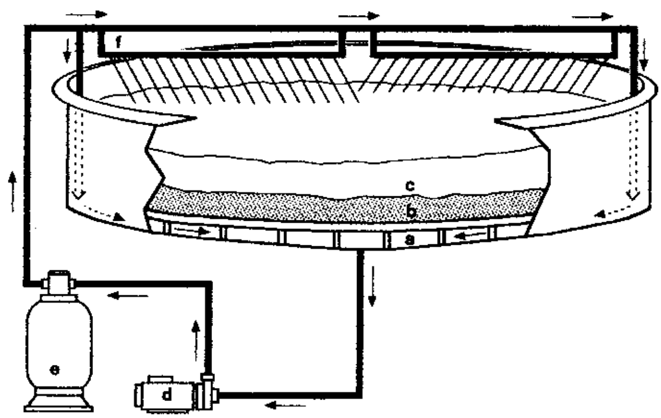

Figure 1. The Strombidae broodstock tank at HBOI: a) undergravel support, b) sand substrate, c) water column, d) pump, e) sand filter, and f) spray bars (drawing by Jackie Arosan).

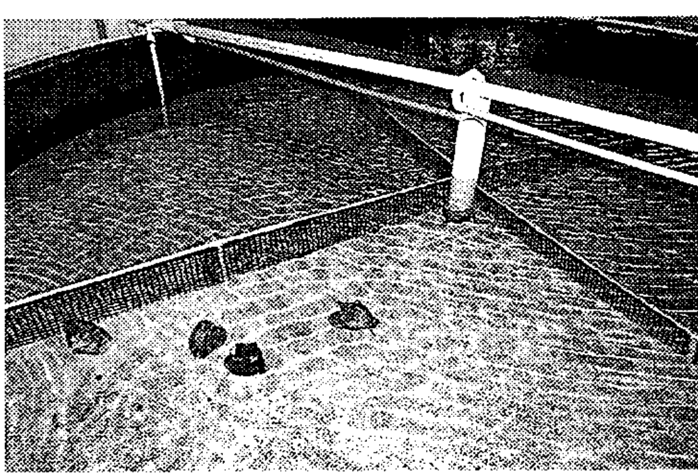

Figure 2. Strombidae broodstock tank at HBOI shows sand substrate and four breeding areas for *S. gigas*, *S. costatus*, *S. raninus*, and *S. alatus*.

Temperature, salinity, and pH were recorded daily and ammonia was determined weekly. Water temperature in the warmer months was 27.5 - 28.5°C, average salinity was 32 ‰, average pH was 8.0, and ammonia was 0.06 - 0.10 mg/L (Table 1). The breeding tank is inside a shaded greenhouse. Along with natural light, a small amount (250 watts) of artificial lighting is used above the tank for a 12 hour cycle (8am – 8pm). The tank water was heated during the winter months using a 4000 watt heater, to increase the ambient temperature to 24 - 27°C.

When an egg mass was found, it was removed with either a net or by hand and placed onto a wet table for measurements (length, width and height). Several egg masses were stretched to determine total length of the egg strand and the number off eggs per mass (n =13 for *S. raninus*, n =10 for *S. alatus*, and n =10 for *S. costatus*). Strand length was not determined for *S. gigas* masses because the eggs were used for culture. The strand diameter (μm), egg capsule diameter (μm), the number of eggs per mm of strand length, and newly hatched veliger size (μm) were also recorded using a compound microscope (40 X) equipped with a 1 mm micrometer. In order to determine whether or not the eggs were fertilized, several batches of each specie was hatched and cultured through juvenile stage using techniques described by Davis (1994, 2000) and Davis and Shawl (in review).

Table 1. Water quality records for the broodstock tank (June 2000 - March 2001) and the replenishment water (June 2000). The number in parentheses represents the number of samples.

	Tank Water	Replenishment Water
Temp (°C)	27.4 ± 2.11 (277)	28.3
Salinity (‰)	33.5 ± 1.25 (255)	33
Ammonia (mg/L)	0.1 ± 0.02 (39)	0.08
pH	8.1 ± 0.28 (242)	7.7
Nitrite	0.009 ± 0.006 (6)	NA
Ca+ ion Concentration	429 ± 12.7 (2)	403
Dissolved Oxygen	6.2 (1)	4.09
ORP	203.1 (1)	195

RESULTS

From June 15, 2000 – March 22, 2001 (282 days), a total of 426 egg masses were collected. The *S. raninus* females spawned persistently through November and again in March, and laid 341 egg masses. The four *S. alatus* females laid 58 egg masses, the three *S. costatus* females laid a total of 23 egg masses, and the single *S. gigas* female laid 4 egg masses beginning in February. During the first 22 weeks, each *S. raninus* female laid approximately 2.8 egg masses per week. They ceased egg production for 15 weeks (November – February), and then began to lay again during weeks 38 and 39 at 0.42 egg masses per female per week. The *S. alatus* females laid egg masses on a regular basis for the first 15 weeks, with each individual female laying roughly 0.48 eggs masses per week. The *S. alatus* females then underwent a period of quiescence from week 16 (October) until week 30 (January), and then began to spawn again, during weeks 31 thru 40, at a frequency of 0.44 egg masses per female per week. Each *S. costatus* female laid approximately 0.3 egg masses per week during the first 10 weeks. After this date, the *S. costatus* females did not lay eggs again until weeks 30 (January) thru 40 (March) at a frequency of 0.25 egg masses per female per week. The *S. gigas* female laid four egg masses from weeks 35 thru 40. Temperature records show an increase in temperature in January (week 31) and again in February (week 37) which corresponded to the start of egg-laying for *S. gigas* and initiated egg-laying activity for *S. raninus*, *S. alatus*, and *S. costatus* again (Figure 3).

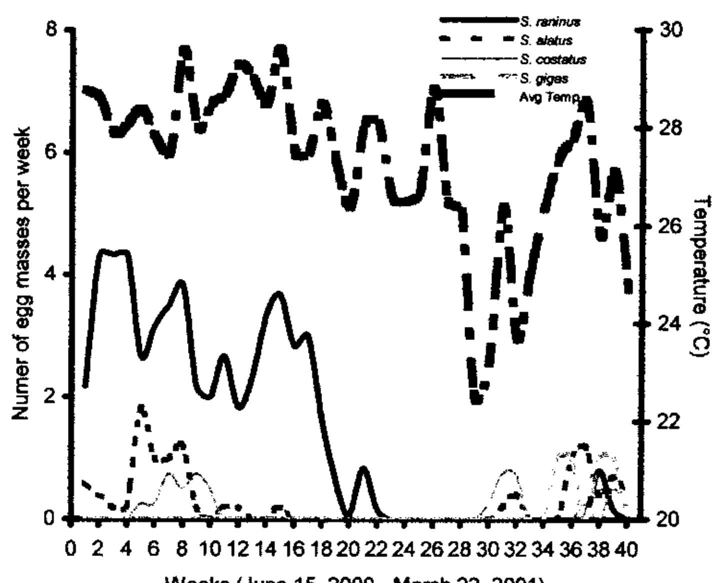

Figure 3. Average number of egg masses collected from each female conch on a weekly basis in comparison with weekly average temperatures for the duration of the breeding experiment at HBOI (June 15, 2000 – March 22, 2001).

The egg strand measurements obtained in this experiment were compared to published literature (Table 2). All four species laid viable eggs in captivity, and the veligers were successfully raised through metamorphosis to the juvenile stage. The larvae were cultured according to Davis (1994, 2000), and metamorphosis was induced using the hydrogen peroxide procedure (Boettcher et al. 1997). Once the post larval conch reached 3 – 4 mm shell length (SL), they were placed on sand trays in a recirculating system at a density of 3200 conch/m^2 (Davis and Shawl, in review) (Figure 4).

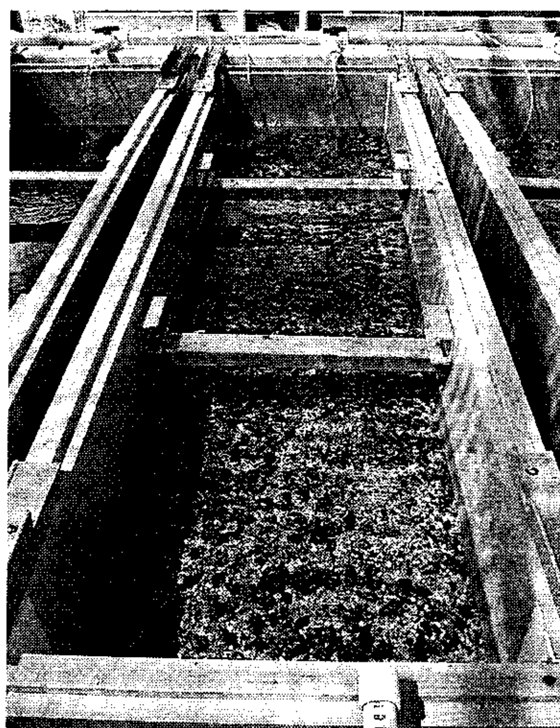

Figure 4. Sand tray for juvenile conch (3 – 40 mm SL).

Table 2. Summary of egg mass and veliger data from this experiment (bolded numbers) shown in comparison to published data. The numbers in parentheses indicate the number of samples.

Variables	*S. raninus*	*S. alatus*	*S. costatus*	*S. gigas*
Length of egg mass (cm)	**3.5 - 15.5 (315)** *4 - 7 (4)*[c]	**4.5 - 9 (30)**	**9.5 - 30 (10)** *6 - 10 (2)*[c]	**9 (1)** *8 - 15 (9)*[c]
Diameter of egg strand (µm)	**351 ± 24 (40)*** *321 ± 20 (10)*[c]	**509 ± 41 (20)*** *600*[b]	**825 ± 56 (9)*** *761 ± 18 (10)*[c]	**798 ± 18 (2)** *785 ± 44 (10)*[c]
Length of uncoiled strand (m)	**7.0 ± 2.0 (13)** *20*[a]	**10.8 ± 21.4 (10)** *10.7*[b]	**19 ± 9.7 (9)**	**N/A** *22.6*[a]
No. eggs/mass	**91,000-250,000 (13)** *206,000 - 245,000 (2)*[c] *400,000 - 460,000*[a]	**76,000-182,00 (10)** *92,000 (2)*[b]	**87,000-440,000 (9)** *185,000 - 210,000*[a]	**N/A** *313,000 - 485,000*[d]
No. egg capsules per mm	**15 - 34 (40)** *21 - 25 (15)*[c], *20 - 23*[a]	**11 - 15 (20)** *8.6*[b]	**10 - 13 (9)** *12 - 14 (10)c*	**12 - 15 (3)** *14 - 16 (10*[c]
Egg capsule diameter (µm)	**123 ± 10 (40)** *140 ± 4 (30)*[a]	**181 ± 11 (20)** *170*[b]	**250 ± 9 (9)** *262 ± 6 (20)*[c]	**233 ± 11 (2)** *225 ± 17 (20)*[c]
Newly hatched veliger SL (µm)	**205 ± 10.5 (10)** 197 ± 8 (20)[c]	**298 ± 14.2 (10)**	**370 ± 10.5 (10)** 388 ± 14 (20)[c]	**198 ± 14 (2)** *354 ± 15 (20)*[c]

[a] Robertson (1959) [b] D'Asaro (1986) [c] Davis et al. (1993) [d] Randall (1964)

DISCUSSION

The Florida and Caribbean *S. gigas* fishery stocks are threatened today and alternative conch species for the queen conch market need to be identified. Although there have been efforts to cultivate *S. gigas* as well as replenish their populations in the wild, only one commercial queen conch farm exists, and large-scale restocking efforts have not been attempted. This experiment examined the feasibility of a captive breeding program for S. *gigas* as well as for alternative, non-threatened *Strombus* species. All four species reproduced and spawned viable eggs in captivity. A total of 426 egg masses were collected in 40 weeks. There are two possible explanations for this success. First, the male and female conch were aggregated, as they tend to do in the wild (Berg 1975, Robertson 1959), which increases the likelihood that reproduction would occur. Secondly, the conch were provided with a stable breeding site that was devoid of predators, had optimal water quality conditions, had a consistent supply of food, and a sand substrate. In early January, the water temperature in the breeding tank spiked (from 23°C to 28°C) due to a warm front and *S. alatus* and *S. costatus* females laid egg masses again after two months of quiescence. Similarly, the *S. gigas* female spawned on February 12, 2001, which is not typical of this seasonal summer breeder. This supports the studies that show temperature and photoperiod control reproductive activity (Stoner et al. 1992).

This experiment was successful in demonstrating that spawning and egg-laying for four *Strombus* species can be achieved reliably in captivity. The breeding tank at HBOI is now being used to commercially produce *S. alatus* egg masses for production of juveniles for the aquarium trade. Future captive breeding studies for *S. alatus* and *S. gigas* at HBOI will include diet, temperature, photoperiod, and sex ratio manipulations. Determining these parameters will enhance the productivity of a captive breeding program and will alleviate the need to collect egg masses from the wild. Production of *S. gigas* and alternative *Strombus* species will take the pressure off the fisheries and provide juveniles for food and aquarium markets, as well as stock enhancement programs.

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