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Emmanuel C. Capinpin Jr.
Pangasinan State University, Binmaley Campus
Binmaley, Pangasinan
Philippines

Correspondence:
Emmanuel C. Capinpin Jr.
Pangasinan State University, Binmaley Campus
Binmaley, Pangasinan
Philippines
Email: manny_capinpin@yahoo.com

Growth and survival of sea urchin (*Tripneustes gratilla*) fed different brown algae in aquaria

Emmanuel C. Capinpin Jr.

Abstract

The study was conducted to determine the growth and survival of the sea urchin *Tripneustes gratilla* fed with three types of brown algae, *Sargassum* sp., *Padina australis*, and *Hormophysa cuneiformis* under static conditions in glass aquaria for 35 days. *Sargassum* sp. produced the fastest growth in terms of weight and length among the different algae tested which became evident at day 21, which continued until the end of the experiment. Survival rates were high and not significantly different in all treatments. The study show the feasibility of culturing sea urchin in aquaria under static conditions. The use of cultured sea urchin as decorative pets for the marine aquarium industry is viable and should be promoted in order to decrease pressure on wild stocks.

Keywords: Sea Urchin; *Tripneustes gratilla*; Brown Algae; Growth; Survival

1. Introduction

Tripneustes gratilla is the most commercially exploited sea urchin species in the Philippines [1]. It is a large urchin with test reaching 10 cm in diameter and 6 cm in height. The body surface is often purple black. The spines are short with sharp tips, and variable in color from white to copper brown or orange. Hence, it is a colorful species and interesting to keep as an aquarium species by marine aquarists.

After the collapse of the sea urchin fishery in Bolinao in 1992, the University of the Philippines – Marine Science Institute focused on the development of its culture [2]. This species grows fast as soon as it starts feeding on a brown alga, *Sargassum*. Beginning 1 cm in TD, sea urchins grow at an average rate of 17 mm/month in pens set in the sea or raceways with flow-through seawater. It is interesting to note, however, if this species will survive and grow in aquaria under static conditions. The use of hatchery-bred species as pets can boost the marine aquarium industry and hopes to discourage the collection of wild specimens.

The objective of the study was to assess growth and survival of sea urchin *T. gratilla* using different types of brown algae as feed under static conditions in aquaria.

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted using 10-L glass aquaria at the wet laboratory of the Pangasinan State University – Binmaley Campus.

2.2 Experimental Animal

Juveniles of *Tripneustes gratilla* measuring 1 cm in test diameter (TD) produced at the Integrated Mollusk and Echinoderm Hatchery of the Bolinao Marine Laboratory (BML) of the Marine Science Institute, University of the Philippines (UP-MSI) in Bolinao, Pangasinan were used in the study. The sea urchin juveniles were randomly distributed in different aquaria with 10 sea urchins per aquarium. Only healthy juveniles were selected and used in the culture trials.

2.3 Experimental Design and Treatments

The experimental method of research was employed in this study. There were 3 treatments and 2 replicates under a completely randomized design. Different types of brown algae (*Sargassum* sp., *Padina australis*, and *Hormophysa cuneiformis*) were offered as food for 35 d using natural seawater as the culture medium. Seawater (35 ppt) was collected from the inshore (littoral) zone at Binmaley beach in Binmaley Pangasinan.

2.4 Feeds and Feeding

The test animals were fed *ad libitum*. Feed was given in excess at weekly intervals by providing a weighed amount of seaweed based on established feeding rates. Fresh macroalga was drained for one hour using an improvised strainer to remove the excess water before weighing. The amount of food eaten was determined, which was used in calculating the daily feeding rate. An estimate of the daily feeding rate (DFR) in terms of wet weight of algae as a percentage of sea urchin body weight, was determined using the formula below:

DFR = (amount of feed consumed/biomass)/*n* X 100

where *n* is the number of days (usually 7). The calculation of feeding rate was done after every sampling, to gain a more meaningful estimate of the actual feeding rate as the sea urchin juveniles grow.

2.5 Sampling

2.5.1 Growth

Growth was monitored by measuring the sea urchin diameter in mm using a Vernier caliper and weight in g at weekly intervals using a triple beam balance. The growth rate in terms of diameter (mm/d) and weight (g/d) were determined as follows:

Diameter (mm/d) = (Final diameter – Initial diameter)/ Days of culture

Weight (g/d) = (Final weight – Initial weight)/ Days of culture

2.5.2 Survival

Survival rates were measured as the percentage of juveniles surviving from the first day until the last day of each experiment.

2.6 Maintenance of Aquaria

The aquaria were cleaned twice daily (9 am and 3 pm) with 10% partial change each time for a total of 20% daily water change. Cleaning involves siphoning of the bottom of the aquaria to remove feces and replacing with new seawater. Salinity and temperature were determined twice daily using a refractometer and thermometer, respectively. On the other hand, pH, total ammonia, and nitrite measurements were taken at weekly intervals during sampling. Ammonia (NH_4^+/NH_3) and nitrite (NO_2^-) values were determined using test kits (Sera) specifically for marine aquarium.

2.7 Statistical Treatment of Data

Data on growth were analyzed using one-way analysis of variance (ANOVA) to test for significant differences at the 5% level of significance per time interval followed by Duncan's Multiple Range Test (SPSS Version 10). Data on survival were arc sine transformed prior to analysis to homogenize the data.

3. Results

3.1 Test Diameter and Weight

Table 1 and Figure 1 shows the mean weight (g) of sea urchin juveniles fed with different types of brown algae, *P. australis*, *H. cuneiformis* and *Sargassum* sp. The data showed significant differences in mean weight of sea urchin fed *Sargassum* as compared to the two other treatments after day 21, which continued until the end of the culture trial.

Table 1: Mean weight (g) of sea urchin juveniles fed with different brown algae for 35 d.

Culture Period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
0	5.26	5.10	5.18^a	5.50	5.39	5.44^a	5.82	6.29	6.06^a
1-7	7.61	6.90	7.26^a	7.35	7.80	7.58^a	9.91	9.06	9.48^a
8-14	9.61	9.31	9.46^a	9.71	8.82	9.26^a	10.66	12.61	11.64^a
15-21	11.10	10.38	10.74^a	11.33	10.50	10.92^a	14.44	16.53	15.48^b
22-28	14.44	13.32	13.88^a	12.96	11.32	12.14^a	18.26	21.00	19.63^b
29-35	16.84	13.94	15.39^a	14.17	9.93	12.05^a	22.26	22.71	22.48^b

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

Means with same superscript are not significantly different (*P*>0.05)

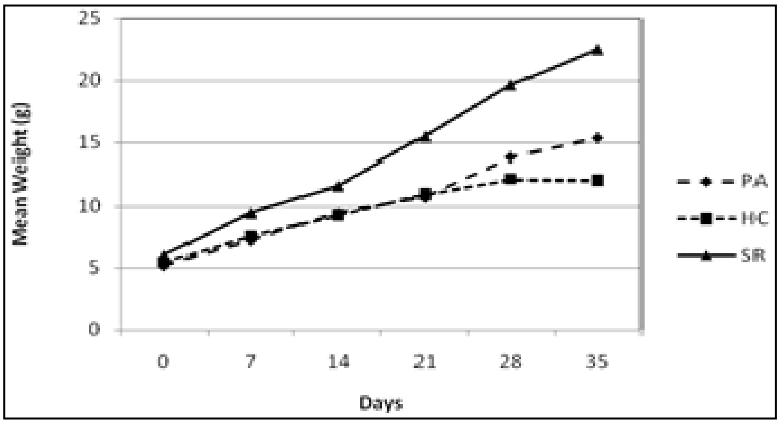

Fig 1: Mean weights (g) of sea urchin juveniles fed different types of brown algae for 35 d in aquaria.
PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

Table 2 and Figure 2 shows the mean diameter of sea urchin juveniles fed different types of brown algae. Sizes among sea urchins diverged on day 21, with those cultured on *Sargassum* showing significant difference (*P*<0.05) as compared to the other treatments which continued until the completion of the growth trial.

Table 2: Mean diameter (mm) of sea urchin juveniles fed different brown algae for 35 d.

Culture Period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
0	23.19	23.04	23.12[a]	23.61	23.08	23.34[a]	23.10	24.00	23.55[a]
1-7	25.56	24.26	24.91[a]	25.50	24.63	25.06[a]	26.21	27.65	26.93[a]
8-14	27.69	26.53	27.11[a]	26.77	27.33	27.05[a]	28.11	30.27	29.19[a]
15-21	30.59	29.66	30.12[a]	29.81	29.51	29.66[a]	33.32	35.31	34.32[b]
22-28	30.97	29.33	30.15[a]	27.76	27.91	27.84[a]	33.82	35.67	34.74[b]
29-35	32.70	30.22	31.46[a]	28.80	28.33	28.56[a]	36.12	37.85	36.98[b]

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.
Means with same superscript are not significantly different (*P*>0.05)

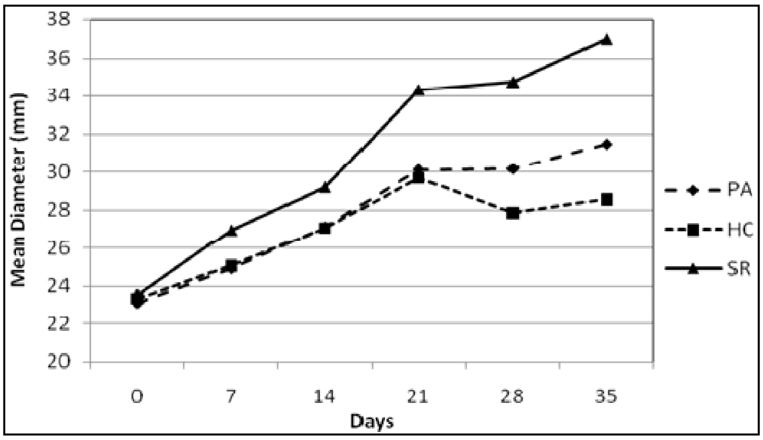

Fig 2: Mean test diameter (mm) of sea urchin fed different brown algae for 35 d in aquaria.
PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

3.2 Daily Growth Rate
3.2.1 Weight (g/d)
Table 3 shows the mean growth in terms of weight (g/d) of sea urchin fed different types of brown algae.

Table 3: Mean growth in terms of weight (g/d) of sea urchin fed different types of brown algae.

Culture period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
1-7	0.34	0.26	0.30	0.26	0.34	0.30	0.58	0.40	0.49
8-14	0.29	0.34	0.32	0.34	0.15	0.24	0.11	0.51	0.31
15-21	0.21	0.15	0.18	0.23	0.24	0.24	0.54	0.56	0.55
22-28	0.48	0.42	0.45	0.23	0.12	0.17	0.55	0.64	0.59
29-35	0.34	0.09	0.22	0.17	0.00	0.08	0.57	0.24	0.41
Overall			0.29	Overall		0.21	Overall		0.47

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

3.2.2 Length (mm/d)
Table 4 shows the mean growth in terms of test diameter (mm/d) of sea urchin fed different types of brown algae for 35 days in glass aquaria.

Table 4: Mean growth in terms of diameter (mm/d) of sea urchin fed different types of brown algae.

Culture period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
1-7	0.34	0.17	0.26	0.27	0.22	0.24	0.44	0.52	0.48
8-14	0.30	0.32	0.31	0.18	0.38	0.28	0.27	0.37	0.32
15-21	0.41	0.45	0.43	0.43	0.31	0.37	0.74	0.72	0.73
22-28	0.05	0.00	0.02	0.00	0.00	0.00	0.07	0.05	0.06
29-35	0.25	0.13	0.19	0.15	0.06	0.10	0.33	0.31	0.32
Overall			0.24	Overall		0.20	Overall		0.38

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

3.3 Feeding Rate
Table 5 shows the daily feeding rates as percentage of body weight. Generally, a decreasing trend in the amount of food eaten per day was observed.

Table 5: Daily feeding rate of sea urchins (%BW) fed different brown algae.

Culture period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
1-7	34.17	33.95	34.06	21.82	25.87	23.84	19.78	16.31	18.04
8-14	37.54	41.41	39.48	21.90	22.39	22.14	18.73	21.19	19.96
15-21	26.25	28.35	27.30	12.37	12.16	12.26	11.34	13.48	12.41
22-28	14.26	15.60	14.93	10.41	8.31	9.36	9.40	10.02	9.71
29-35	14.84	16.56	15.70	11.66	7.16	9.41	12.37	9.49	10.93

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.

3.4 Survival

Table 6 shows the survival rates of sea urchins.

Table 6: Survival rate of sea urchin.

Culture Period	Treatment 1 (PA)			Treatment 2 (HC)			Treatment 3 (SR)		
	R1	R2	Mean	R1	R2	Mean	R1	R2	Mean
0	100	100	100^a	100	100	100^a	100	100	100^a
1-7	100	100	100^a	100	90	95^a	100	100	100^a
8-14	100	90	95^a	100	90	95^a	100	90	95^a
15-21	100	90	95^a	100	90	95^a	90	90	90^a
22-28	100	90	95^a	100	90	95^a	90	90	90^a
29-35	100	90	95^a	100	90	95^a	90	80	85^a

PA – *Padina australis*, HC – *Hormophysa cuneiformis*, SR – *Sargassum* sp.
Means with same superscript are not significantly different ($P>0.05$)

3.5 Water Quality Parameters

Temperature ranged from 24-30 °C, salinity from 32-37 ppt, and pH from 7.9-8.2. Ammonia and nitrite levels were not detected. All parameters were within tolerable limits for sea urchin culture.

4. Discussion

4.1 Test Diameter and Weight

The sea urchins fed with *Sargassum* were larger and heavier than those fed with *Padina australis* and *Hormophysa cuneiformis* which became evident at day 21 and continued to the end of the 35-day feeding experiment (Tables 1 and 2; Figures 1 and 2). The study further showed that *Sargassum* is the most preferred of the different brown algae and that it translates into faster growth than *P. australis* and *H. cuneiformis*.

4.2 Daily Growth Rate

The mean growth rates as observed in the present study ranged from 0.21 to 0.47 g/d in terms of total weight and from 0.20 to 0.38 mm/d in terms of test diameter in aquaria (Table 3 and 4). Highest growth rate was observed using *Sargassum* sp. as feed. On the other hand, the reported average growth rate of *T. gratilla* in three field trials in Bolinao, Pangasinan was 17 mm/month [2]. This shows that growth rates in aquaria (0.38 mm/d or 11.4 mm/month using *Sargassum*) are much slower than in the field because of greater water movement and flushing of wastes in the sea. However, our data showed that sea urchins could grow well in aquaria with good water quality conditions and can be kept as aquarium pets.

The growth rate of fish and other cultured organisms is highly variable because it is dependent on a variety of interacting environmental factors such as water temperature, levels of dissolved oxygen and ammonia, salinity, and photoperiod. Such factors interact with each other to influence growth rates, and with other factors such as the degree of competition, the amount and quality of food ingested, and the age and state of maturity of the cultured organism.

Age and maturity are usually the best predictors of relative growth rates in fishes, although the absolute growth rates are strongly influenced by environmental factors. Thus fish typically grow very rapidly in length in the first few months or years of life, until maturation. Then increasing amounts of energy are diverted from growth of somatic tissues to growth of gonad tissues. As a consequence, growth rates of mature fish are much slower than those of immature fish. This phenomenon is also evident in other aquatic organisms.

In the present study, a slowing of growth rates was observed during the last week of the experiment. This could be explained by lower temperatures toward the end of the experiment. This resulted to lower amount of food ingested (see Table 5). *T. gratilla* attains sexual maturity at 60 mm [2]. The maximum size attained during the 35-day culture period was only about 37 mm, which is still at the juvenile stage and immature. Hence, the slowing of growth was not due to the onset of sexual maturity.

Food availability and quality also interact with other factors, particularly temperature, to affect the growth of aquatic organisms on a seasonal basis [3]. For example, marked seasonal differences in growth were observed in northern Indiana bluegill populations [4]. Their growth was accelerated during the warmer months of abundant food. This is typical of most other fishes and aquatic organisms. Regarding food quality, a complete diet with essential nutrients is required for high growth rates. High dietary protein content often stimulates increased growth. Dwarf gourami (*Colisa lalia*) and largemouth bass (*Micropterus salmoides*) are two species in which increased dietary protein (up to 45% and 37%, respectively) increased growth to maximal levels [5, 6].

4.3 Feeding Rate

Feeding rate depends on body size, type of food, season (temperature) and density of cultured animals. Body size is a major factor affecting feeding rates of cultured aquatic organisms [7]. Generally, feeding rates per unit biomass are higher in smaller and faster growing juveniles than larger individuals. Variations in feeding rates of echinoderms are not unusual as they are known to be erratic feeders, sensitive to a number of environmental and physiological influences.

4.4 Survival
High survival rates were attained in sea urchin fed the different types of brown seaweeds in this study. The results showed that sea urchins can be fed with other brown seaweeds if there is a shortage of the preferred *Sargassum* sp.

Echinoderms such as sea urchin are truly marine species and very sensitive to varying changes in salinity. It is important that salinity be checked regularly. Salinity also affects growth and survival rates. The euryhaline (broad salt tolerance) desert pupfish shows the maximum growth rate at 35 ppt compared with both higher and lower salinities [8]. Growth is altered and survival affected as other energy-demanding components (such as ion and osmoregulatory active transport systems) respond to environmental characteristics. These responses increase maintenance energy requirements, which will decrease growth and affect survival rate.

The study showed the feasibility of culturing sea urchin in aquaria under static conditions. The use of cultured sea urchin as decorative pets for the marine aquarium industry is viable and should be promoted rather than collecting wild specimens in order to ease pressure on wild stocks.

5. Acknowledgement
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