Feeding behaviour of bubble-tip anemones Entacmaea quadricolor (Leuckart, 1828)

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Abstract. Bubble-tip (Entacmaea quadricolor) is an anemone that can be associated with many species of clownfish. This facts makes E. quadricolor more interesting as a marine aquarium ornamental fish, however information about biological aspects of E. quadricolor is not widely available. The purpose of this study was to determine the feeding behaviour, digestion rate, and feeding absorption efficiency to support the maintenance of E. quadricolor. Anemones were divided into two groups, a groups fed with shrimp and a groups fed with grouper. The result shows feeding behaviour such as shortening of the tentacles and folding of the oral disc during the feeding response phase and the absence of pre-feeding response phase. Digestion rate obtained by E. quadricolor has produced egesta (indigestible residue) as early as 22--25 hours after feeding and ended in the course of 46--48 after feeding. Feeding absorption efficiency fed by shrimps and groupers of E. quadricolor was 40.60% and 39.87% respectively. Analysis with t-test showed no significant difference in feeding absorption efficiency between E. quadricolor fed with shrimps and fed with groupers.

1. Introduction
Sea anemones are invertebrates that belong to the Class Anthozoa, as one of the species that lives in the coral reef ecosystem [1]. Sea anemones are benthic sessile animal that depend on water current and prey movement to deliver their food to the capture surface area. Sebens [2] explains that there are 3 different methods for an anemone to capture its prey. First, the prey that is suspended on the water column like zooplankton. Second, prey got carried by water current or an animal that is searching for food in the anemone area. Third, animals like sea urchin, crabs and reef fish that is moving accidentally captured by anemone’s tentacles.

Sea anemone’s feeding behavior can be showed in 2 phases, which is preparatory activity (pre-feeding response) that is triggered by chemical reaction and feeding response which needs mechanical response as the addition to chemical response [3]. Preparatory activity phase can be shown as the respond to the solute in the water that causes expansion of the oral disc followed by extension and twitching of body column. These sea anemone movement is done to increase the chance of contact between the tentacles and nearest food source. Feeding response phase can be shown as mechanical response on the tentacle, so the tentacle can sting the prey [4].

Bubble-tip anemone or Entacmaea quadricolor is one of the sea anemones with high demand in the market sold as salt water ornamental fish in south east Asia and the pacific [4, 5]. E. quadricolor is one of the anemone that can be the host for a lot of clown-fish, like Amphirion melanopus, A. akindynos, A. bicintus, A. clarkii, Premnas biaculeatus, Periclimenes tosaensis, and Dascyllus trimaculatus [6, 7, 8, 9, 10]. The number of clown-fish that can be associated makes E. quadricolor more interesting and
attractive than the other sea anemones species. This has an impact on increasing the potential for massive captures of *E. quadricolor*. WWF [11] analysis data elucidates all ornamental species that are traded, 95% come from the wild and only 5% from the cultures. Few steps have been done to prevent over-collecting such as asexual culture by fragmentation method as well as sexual culture [12, 13]. But those methods were not supported by the availabilities of basic information about *E. quadricolor* to bolster the maintenance or cultures. Viability and care become the most important things in maintaining anemones cultures [14]. Lack of information about biological aspects of *E. quadricolor* being a purpose of this research regarding to its feeding behavior. This study aiming to determine the feeding behavior, digestion rate, and absorption efficiency of food to support the care of *E. quadricolor*.

2. Material and Methods

2.1. Collection and Maintenance Anemones
Eight Bubble-tip anemones with 5-9 cm diameter obtained from local ornamental fish market in Pramuka Island, Kepuluan Seribu. Therefore, samples being acclimatizationed in controlled environment for 1 week. The purpose of acclimatization is to prevent anemone samples from being stress of environmental condition changes. Wet weight of post-acclimatization anemones being measured by digital scale.

2.2. Feeding Behaviour Experiment
Two series of experiment were conducted. The first experiment is used to measured digestion rate and feeding behavior of *E. quadricolor*. The second is to determine absorption efficiency of the 2 food types (groupers and shrimps) for *E. quadricolor* feeding on each. The observation of feeding behavior begun when the food was inserted to aquarium and placed on top of anemones for 1 minute before the food being put near down the oral disc. The observed behavior was preparatory activity (pre-feeding response) and feeding response. The observation was recorded qualitatively by describing the movement of the anemones while being fed.

2.2.1. Feeding Treatment
Feeding behaviour was observed after the anemones was acclimatized a week inside the aquarium. Food was given after the anemones was starved for two whole days to empty the gastrovascular tract. Anemones samples were divided into two groups, the first one being the anemones that are being fed fish (grouper) and the second group are being fed shrimp. The amount of food given is 0.5% of the anemones wet weight. The anemones will be starved again for two days prior to the following feeding session. In the course of two days while being starved anemones activity of egesta secretion is observed. Tweezers was used to directly feed the anemones. During the observation the duration between feeding until egesta secretion was recorded to obtain the digestion rate. Egesta was collected using pipette and was cleaned from salt using filter paper. Feeding will be done again after anemones gastrovascular was emptied.

2.2.2. Feeding Absorption Efficiency
Feeding absorption efficiency was measured using the dry weight of the food given and dry weight of the egesta. Calculation of feeding absorption efficiency was done using equation by Zamer [15] as follows:

\[
A_g = \frac{\text{dry weight food given (g)} \text{– egesta dry weight (g)}}{\text{dry weight food given (g)}} \times 100\%
\]  

(1)

Dry weight of the food given was obtain by drying the food in the oven at 40 °C for one hour until it reaches a constant weight. After the drying procedure the food then weighted using an analytic digitale scale. Food samples dry weight was used to predict the dry weight from the wet weight using simple regression linier test.
2.3. Data Analysis
Preparation, organization and data analysis of *E. quadricolor* feeding behaviour was done descriptively using T test to see the average difference of food absorption between the two types of food used (grouper and shrimp).

3. Results and Discussion

3.1. Results

3.1.1. Feeding Behavior
Feeding behaviour of *E. quadricolor* shows no preparatory activity (pre-feeding response) after stimulation by putting the food near the oral disc. Feeding response behaviour was observed when the food falls on the oral disc, food will then be attached to the tentacles and stimulate the tentacles. The shortened tentacles will then bring in the food closer to the anemone’s mouth. The movement of food to the mouth is not only helped by the tentacles, but also by the folding of the oral disc. The presence of the food will stimulate the anemone by making the mouth expands and move the food closer as seen on Fig. 1.

![Figure 1](image_url)

**Figure 1.** The stage of the anemone’s mouth expands and approaches its food, (A) anemones’s mouth, (B) food.

3.1.2. Digestion Rate
Result shows that *E. quadricolor* digestion rate varies within 3-22 minutes after direct feeding. Observation of the digestion rate shows that *E. quadricolor* secrete egesta two times gradually. The time range for the first egesta secretion is 22-25 hours and the following egesta secretion is 46-48 hours after feeding.

| Anemone Feeding Group | Feeding Time (Minutes) | First Egesta Secretion Time (Hours) | The Following Egesta Secretion Time (Hours) |
|-----------------------|------------------------|-------------------------------------|---------------------------------------------|
| Shrimp                | 3-19                   | 22-25                               | 46-48                                       |
| Grouper               | 4-22                   | 22-24                               | 46-48                                       |

3.1.3. Feeding Absorption Efficiency
*E. quadricolor* feeding absorption efficiency using shrimp shows a result of 40.60%, and a lower result of 39.88% from using grouper. The average feeding absorption of *E. quadricolor* is 40.24%. T test analysis is used to see the difference of feeding absorption efficiency on shrimp and grouper. The result
is 1.7958 which is -0.4847 lower than the 0.05 confidence table. The T test conclude that feeding absorption efficiency between shrimp and grouper shows no distinct differences.

### Table 2. Feeding absorption efficiency of *Entacmaea quadricolor*.

| No. | Anemones Weight (g) | Food Weight Dry (g) | Egesta Weight Dry (g) | Feeding Absorption Efficiency | Feeding Absorption Efficiency Percentage (%) |
|-----|----------------------|---------------------|-----------------------|-------------------------------|---------------------------------------------|
| 1   | Shrimp               | 32                  | 0.0378                | 0.0228                        | 0.3951                                       | 39.51%                                      |
| 2   |                      | 50                  | 0.0590                | 0.0342                        | 0.4196                                       | 41.96%                                      |
| 3   |                      | 125                 | 0.1475                | 0.0876                        | 0.4059                                       | 40.59%                                      |
| 4   |                      | 47                  | 0.0554                | 0.0331                        | 0.4036                                       | 40.36%                                      |
|     | **Average**         |                     | **0.0406**            |                               | **40.60%**                                   |                                            |
| 5   | Grouper              | 123                 | 0.1436                | 0.0858                        | 0.4026                                       | 40.26%                                      |
| 6   |                      | 50                  | 0.0584                | 0.0323                        | 0.4460                                       | 44.60%                                      |
| 7   |                      | 40                  | 0.0467                | 0.0308                        | 0.3403                                       | 34.03%                                      |
| 8   |                      | 84                  | 0.0981                | 0.0582                        | 0.4061                                       | 40.61%                                      |
|     | **Average**         |                     | **0.3987**            |                               | **39.87%**                                   |                                            |
|     | **Total Average**   |                     | **0.4024**            |                               | **40.24%**                                   |                                            |

### 3.2. Discussion

#### 3.2.1. Feeding Behavior

Feeding behaviour on anemones can be categorized into two phase, preparatory activity (pre-feeding response) and feeding response. *E. quadricolor* preparatory activity was not seen may be due to the difference of feeding response in all anemone, and not all anemone shows an evident response on food [3]. Anemones that is given food on a regular basis is also known to cause lack of response to food compared to starved individuals [4].

McFarlane [3] experiment (1970) and Boothby and McFarlane [16] shows preparatory activity on Telia felina and Urticina eques with three main response the expanding of the surface of oral disc that may be due to sphincter muscle relaxation on top of the column and radial on oral disc, lowers the oral disc and the opening of mouth also faring that protrude due to muscle contraction that transverse mesenterium. This is to increase food catching area on anemone. Preparatory activity response on anemone is helped by chemoreceptors that is located on the tentacles, oral discs, peristome and actinofaryng [4].

The storage time in the coelenteron cavity varies within anemone species depends on size and digestion ability. Anemone will secrete digestion residue a couple hours after feeding. Digestion residue will be secreted gradually [15, 4]. Observation on *E. quadricolor* shows that food can be digested 22-25 hours after feeding and finished 46-48 hours after secreting the last digestion residue. *Anthopleura elegantissima* was shown able to secrete digestive residue after 3.5-7 hours after feeding [15], *Metridium senile* shown to secrete its digestive residue after 4 hours [17], and shrimp given to *Cerianthus lloydii* can secrete digestive residue after 12 hours after feeding [18]. Van-Praët (1981) based on [4] discovered that food is still detected in *Actinia equina phagocyte* even after 48 hours after feeding. Riemann-Zürneck (1969) based on [4] discovered that *Sagartia troglodytes* secrete digestive residue gradually for 12-30 hours after feeding.
3.2.2. Feeding Absorption Efficiency
Feeding absorption efficiency shrimp and grouper on E. quadricolor does not have a significant value difference. Feeding absorption efficiency on E. quadricolor resulted an average of 40.24%. The result may be caused by a low ratio of prey acquired by wild anemones that absorption efficiency in the field can reach up to 90%. This happens because a small amount of prey frequently swallowed.

Food digestion potency is also one of the factors that contributes to feeding absorption efficiency on anemones [4]. E. quadricolor that was given shrimp have a slightly higher feeding absorption efficiency valued 40.60% compared to feeding absorption of grouper valued 39.88%. Shrimp and grouper have a high protein content that does not have a significant difference, the composition of 100 g shrimps are 78.45 g water; 20.1 g protein; 0.51 g fat; 214 mg phosphate; and 85 kkal energy, compared to 100 g grouper that consist of 79.22 g water; 19.38 g protein; 1.02 g fat; 162 mg phosphate; and 92 kkal energy [19]. The higher feeding absorption efficiency may be due to the higher protein and mineral composition of shrimp and higher water consistency. Other nutritional component such as phosphate and nitrogen that is needed for anemone [4]. Higher phosphate consistency in shrimp may cause the higher feeding absorption efficiency for shrimp rather than grouper.

4. Conclusion
Preparatory activity (pre-feeding response) on E. quadricolor feeding behaviour have not yet been seen. Feeding phase response on E. quadricolor similar to other anemones, consist of rhythmic tentacles movement, and folding of oral disc to move the food into the mouth, followed by the opening of the mouth aimed at the food. Digestion rate occur for 46-48 hours with the first egesta secretion on 22-25 hours after feeding. Entacmaea quadricolor swallowing duration happens for 3-22 minutes after feeding. Feeding absorption efficiency of E. quadricolor for shrimp valued 40.60% was higher than for grouper that valued 39.88%.

Acknowledgments
Thanks to Dr. rer. nat. Mufti Petala Patria, M.Sc. and Dra. Titi Soedjiarti, S.U. for your guidance during the research as a counsellor, as well as to all my friends in laboratory of marine biology.

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