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GRAZING ACTIVITY OF THE SEA URCHIN *TRIPNEUSTES GRATILLA* IN TROPICAL SEAGRASS BEDS OF BUTON ISLAND, SOUTHEAST SULAWESI, INDONESIA

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ABSTRACT

The research on grazing activity of a sea urchin (Tripneustes gratilla) in tropical seagrass beds was conducted in Buton Island. The objectives of the research were to study the grazing activity such as food preference, grazing rate and grazing times of T. gratilla in tropical seagrass community. The results of the research showed that Thalassia hemprichii and Enhalus acoroides are primary food items of T. gratilla and contained on average of 55 % and 31 % of the gut contents, respectively. The grazing rate of an individual ranged from 9.6 - 14.1 g wet weight in 24 hours. The grazing times of T. gratilla were between 01.00 - 11.00 a.m. and 15.00 - 21.00 p.m.

Key words : Grazing, *Tripneustes gratilla*, seagrass, gut contents

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INTRODUCTION

Seagrass beds play an important role in tropical marine coastal ecosystems and its high productivity contributes to lives of many organisms (den Hartog 1970). Seagrasses serve as habitats for epiphyte and epifauna, and also for macrobenthic organisms such as the sea urchin *Tripneustes gratilla* as feeding ground, shelters, nursery ground, and/or spawning ground (Mukai and Nojima, 1985; Mukai, *et al*., 1987, Vaitilingon, 2003).

T. gratilla is a macrobenthic animal using seagrass beds as grazing area. *T. gratilla* in seagrass beds grazes on seagrass leaves (Eklöfa, 2008, Vaitilingon, 2003, Aziz 1994, Mukai and Nojima, 1985; *Mukai et al.,* 1987). Herring (1972) reported the analysis of gut contents of the sea urchin in Zanzibar. He showed that seagrass leaf was a main food of the sea urchin. In the seagrass *Thalassodendron ciliatum* meadows of Mombasa Lagoon (Kenya), 39 % of the seagrass cover was heavily grazed by *T. gratilla* and more than 70 % of seagrass was found as dead shoots (Alcoverro and Mariani, 2002). *T. gratilla* was heavily grazing on seagrass *Halophila stipulacea* in Sinai seagrass beds, northern Red Sea and the Jordanian coast of the Gulf Aqaba (Lipkin 1979; Bouchon 1980; Hulings and Kirkman, 1982; Jafari and Mahasneh 1984). In Bolinao seagrass beds, Philippines, however, *T. gratilla* chose the seagrass leaves as alternative foods among many food items (Klumpp *et al*., 1993). Others that also live and graze on the seagrass beds are *Lytechinus variegatus* (Moore and McPherson 1965; Camp *et al*., 1973; Greenway 1976; Bach 1979; Vadas *et al.,* 1982; Keller 1983; Greenway 1995), *Astropyga magnifiga* (Bak and Nojima 1980), *Paracentrotus lividus* (Kirkman and Young 1981), *Diadema antillarum* (Zieman *et al*., 1984), *Temnopleuris michaelsenii* (Cambridge *et al*., 1986), *Tripneustes ventricosus* (Keller 1983; Tertschnig 1989), *Salmacis sphaeroides* (Klumpp *et al*., 1993), and *Heliocidaris erythrogramma* (Larkum and West 1990).

T. gratilla in some areas has been known as an alternative food for human and this has been exploited by local community. That is a reason for more and more reducing of the sea urchin population. Mukai *et al.* (1987) reported that local people in Loloata Island, Papua New Guinea, collected the sea urchin and other benthic animal occasionally, but the effect of this exploitation may not be substantial. In Lombok and Sumbawa Island, Indonesia, the local people collect the sea urchins that served as food alternatively (Darsono and Sukarno 1993). If the population density of *T. gratilla* at a certain seagrass habitat becomes extremely high, it would block the balance of seagrass communities (Bak and Nojima, 1980). Lawrence (1975) reported when *Tripneustes ventricosus* reaches high population in a seagrass bed, the grazing activity left many bare ground areas. The grazing activity by sea urchin is important in determining the impact of herbivores invertebrates on seagrass assemblages in many coastal ecosystems.

The present study was undertaken to investigate the grazing activity of *T. gratilla* including its main food, food preference, grazing ability, and grazing times.

MATERIALS AND METHODS

Study sites

The field research was conducted in the tropical seagrass beds of Buton Island (5^o 28’ N; 122^o 37’ E), southeast Sulawesi, Indonesia (**Fig. 1**). Further analysis of food items of seaurchin was held in the of biology laboratory Haluoleo University, Kendari.

The seagrass bed of study site was dominated by *Enhalus acoroides* and *Thalassia hemprichii*, and *T. gratilla* was usually found on the bottom of the seagrass meadows or sometimes climbing on the *E. acoroides* leaves. Most of sea floor was covered by fine sand and little piece of dead corals. The range of salinity and temperature was 30 – 31 $^o/_{oo}$ and 26 – 30 ^{o}C, respectively. The current speed was between 2.6 – 3.4 cm s^{-1}, and tidal range was 171 cm in average (Kasim, 1999).

Food preference

To determine food items, which were dominant in gut contents of *T. gratilla*, 20 sea urchins were collected from seagrass beds. The various sizes of sea urchin were separated on the two different samples. < 40 mm was categorized in to small size sea urchin, and > 40 mm was categorized in to large sized of sea urchin. The size range of sea uchin was measured in diameter size with calipers.

A dissection for the specimens was carried out very carefully, the gut contents of *T. gratilla* were taken out and preserved in 70 % alcohol. The gut contents were observed by using a stereomicroscope. Each food type was separated to measure its volume and wet weight. Food items in the gut contents were identified comparing with leaf and thallus tissues of all seagrass and sea weed species found in the field (Kasim, 1999). For analyzing gut contents, an index of preponderance (IP) (Natarajan and Jhingran,

1961) and an Ivlev's electivity index (IE) (Ivlev, 1961) were used.

$$IP = \frac{V_i \times O_i}{\sum (V_i \times O_i)} \times 100$$

Where V_i is composition ratio of *i*-th food type in volume, O_i is occurrence frequency of *i*-th food type. IE is ;

$$IE = \frac{r_i - p_i}{r_i + p_i}$$

Where r_i is expressed the volume percentage of *i*-th food type in gut contents, p_i is relative percentage of *i*-th food type in volume in the field (seagrass bed). The IE value can vary between –1 and +1. The positive IE means bigger proportion in the gut contents than in the field, which shows a preference on that type of food.

Grazing rates

In order to measure the grazing rate, each individual of *T. gratilla* was put in the cage that made from the metal and net (1 mm mesh size) with size 60 x 60 x 50 cm (length, width and height). Eight sea urchins and eight cages were prepared for the experiment. Eight cages were securely put on the bare sand bottom near the original seagrass bed. Eight individuals of *T. gratilla* were collected from seagrass beds. In order to determine the grazing rates related to the seaurchin sizes, eight samples were divided into two groups. Four seaurchin were categorizing in small size (< 2.5 cm diameter) and four sea urchin in large size (> 5.5 cm diameter).

A handful of fresh seagrass leaves (including three species, *E. acoroides* ,*Th. hemprichii* and *C. serrulata*) were weighed in wet weight at start point (W_o). Just before weighing, the selected seagrass leaves (complete and young leaves) were cleaned from the periphyton and macroalga which attach on the leaves. A young complete leaf was selected to avoid some physical factor that possibility to washing or damage some small parts of leaves. These methods to decrease any error data (weight) after 24 hours. Then, the seagrass leaves were put in a cage with stones as sinker to serve as food for *T. gratilla*. Then it was put into cages, one for each cage. After 24 hours, seagrass leaves were collected and weighed to know the final seagrass weight (W_{24}). The supplying and weighing of seagrass leaves were carried out every 24 hours intensively for 10 days to gain the grazing rates of *T. gratilla*. The formulation of the grazing rates, G, is :

$$G = W_o - W_{24}$$

(g seagrass (WW) ind $^{-1}$ day^{-1})

As preliminary research in November 1998, the weight of some groups of seagrass leaves without *T. gratilla* in a cage were have no significant different after 24 hours (Kasim, 1999). Its means, no other factors were decrease the weigh of seagrass leaves aside the grazing of *T. gratilla* after 24 hours.

Diurnal Grazing Activity

Diurnal grazing activity of *T. gratilla* was investigates by two cages, 100 x 100 x 50 cm (no net at bottom) and were put onto dense seagrass meadows. Twenty four individuals of *T. gratilla* (30 – 50 mm) were gathered from the seagrass bed and kept in the cages (each cage contained 12 individuals).

After 24 hours, every two hours, two *T. gratilla* were picked up from cages (each cage 1 individual), and materials in the gut were taken out by cutting the gut and stored in bottles (preserved by 70 % alcohol). The volume of gut contents was measured with cylinder glass (50 ml).

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Measurement of water conditions

The water temperature on the bottom at the experimental sites was measured with a mercury thermometer, and salinity with salinometer. Current velocity was measured at two points directly near the cages, just above the substratum surface using a kite sink drift modification (Kasim, 1999).

Statistical analysis

The grazing rates of sea urchin between diameter in size (small size and large size) were analyzed by one-way analysis of variance (ANOVA). Standard correlation analysis was addressed to statistically evaluate the correlation between tidal level and volume of gut, with Spearman correlation coefficients ($P \leq 0.05$) (Oliveira, *et al*., 1997).

RESULTS AND DISCUSSION

RESULTS

Food habits

Thalassia hemprichii had the largest IP value about 55 % and *Enhalus acoroides* was the second, about 32 % (**Fig. 2**). This showed that *T. hemprichii* was a main food, which was followed by *E. acoroides*. As a whole, seagrasses including *Halodule uninervis* and *Cymodocea serrulata* predominated in the gut contents.

Food preference

Some other foods were not seagrasses, such as algae and small animals. *T. hemprichii* had relative high index of electivity (IE), about 0.65. If it is compared to others species occurred in gut contents of *T. gratilla,* it can be considered that *T. hemprichii* leaf was preferred by *T. gratilla* (**Table 1**).

Grazing rate

The grazing rates of *T. gratilla* varied, but tended to increase with size of *T. gratilla*. Small-sized sea urchins (n = 4), 22.8 – 24.3 mm (m±sd : 23.6 ±0.1 mm) (A) and 21.9 – 23.6 mm (22.8 ± 0.1 mm) (B) in diameter, had average grazing rates of 9.8±1.6 and 9.93±1.8 g WW ind^{-1} day^{-1}, respectively. The large sized sea urchins (n = 4), 51.9 – 53.8 mm (52.9 ± 0.1mm) (C) and 54.8 – 56.2 mm (55.5 ± 0.1 mm) (D) in diameter, had grazing rates of 13.8±2.7 and 14.3±2.4 g WW ind^{-1} day^{-1}, respectively (**Fig. 3**).

The daily grazing rates of the sea urchins are not different in both similar diameter sizes. The small-sized and the large-sized *T. gratilla* had grazing rates between 10.8 ± 0.8 (A), 10.5 ± 0.9 (B), 15.4 ± 0.9 (C), and 15.5 ± 1.0 (D) g WW ind^{-1} day^{-1} (**Fig. 4**).

Analysis of variances of feeding rates on seagrasses showed no significant different between same diameter in size (ANOVA, AB, F=0.42, P=0.533, CD, F=0.12, P=0.739; Tab.3). But for different diameter in size between small and large, there were significant different (ANOVA, AC, F=88.46, P<0.001, BD, F=85.68, P<0.001; **Tabel 2**).

Grazing time

Fig. 5 shows a diurnal fluctuation in volume of gut contents of *T. gratilla*. The fluctuation suggests that the grazing activity of *T. gratilla* had a tidal rythm which corresponded to fluctuation of tidal level. The gut contents of *T. gratilla* decreased at high tides (11.00 a.m. – 13.00 a.m. and 23.00 to p.m.– 01.00 a.m). The speed of stream tended to increase or rise that made *T. gratilla* seen not eaten and heading on the under of dense seagrass leaves for preventing it from the strong stream. While at 01.00 a.m. – 09.00 a.m. and 15 p.m. – 21.00 p.m., the seawater surface started falling and also the speed of stream tended to decrease so this chance was used by *T. gratilla* more active to grazing at noon and evening,

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particularly at 09.00 a.m.– 12 .00 a.m. and between 18.00 p.m. – 21.00 p.m.

To find out the correlation between tidal level and volume of gut content of *T. gratilla*, standard correlation analysis was performed on these data. From these analysis, the tendency shows negative correlation between tidal level and volume of gut sea urchin (correlation = -0.716), suggesting that the feeding activity of *T. gratilla* is negatively affected by the tidal level.

DISCUSSION

The sea urchin, T *gratilla*, showed a strong preference for seagrass leaves *Th. hemprichii* and *E. acoroides* than other macrophytes as indicated by the food habit and food preference of this sea urchin in tropical seagrass beds in Buton Island, Indonesia. *Th. hemprichii, E. acoroides*, *H. uninervis* and *C. serrulata*, were dominant seagrass species in this site. *T. gratilla* was the most common sea urchin in seagrass bed in Buton Island, and accounted for 80 % of the total number of sea urchins. The remaining 20 % addressed to *Diadema setosum*, *Echinometra mathei*, *Echinotrix diadema* and *salmacis* sp. (Kasim, 1999).

T. gratilla shows a strong preference for *Th. hemprichii* over *E. acoroides* or other seagrass such as *H. uninervis* and *C. serrulata,* as indicated by grazing activity on seagrass habitat. *T. gratilla* consistently consumes more *Th. hemprichii* throughout the 20 individuals experiment. Several studies have been reported to clarify the preferential foods of *T. gratilla*. The research carried out in Papua New Guinean seagrass beds by Hattori, *et al*., (1985), was clarified that *T. gratilla* is an important element in tropical seagrass beds. It lives with grazing on seagrass leaves directly (Mukai, e*t al.,* 1987). In Mombasa lagoon, 90 % of the total number species of sea urchin is *T. gratilla* that direct grazing on seagrass shoot and has a significant impact to the highest number of seagrass dead shoot (Alcoverro and Mariani, 2002).

Lawrance (1975) reported that food preference pattern of the sea urchin was not clear but there was a tendency to favorite seagrasses, genus *Thalassia* and *Syringodium* in Atlantic seagrass beds. Mukai and Nojima (1985) reported that *Th. hemprichii* was a main food of *T. gratilla* in seagrass beds of Loloata Island, Papua New Guinea. From the field research in Zanzibar, Herring (1972) found about 82.5 % seagrass leaves in gut contents of sea urchin. Darsono and Sukarno (1993) reported that gut contents of *T. gratilla* in seagraas beds of Nusa Dua (Bali) were dominated by crushed and cut seagrass leaves, particularly *Th. hemprichii* and *E. acoroides.* They found a few algae and remain of *Ulva* sp. These foods preferential in seagrasses have been attribute to both food habit and food preference of *T. gratilla* in Buton Island seagrass beds. The occurrence and abundance of *Th. hemprichii* and *E. acoroides* in seagrass beds around the sea urchin has been forced to choose the kind of seagrass leaves as food source of *T. gratilla*.

The occurrence of some kind of foods in gut contents of sea urchin may indicate both, physical texture and chemical component in the seagrass leaves. Tertschnig (1989), explain that the preference for some type of seagrass was caused from some factors such as low tannin content (Chiroric acid). The high tannin content forced sea urchin *Tripneustes ventricosus* to decrease grazing seagrass leaves. Short and smooth texture leaves of *Th. hemprichii* were most common reasons for *T. gratilla* to select these kinds of leaves to graze (Kasim, 1999).

According to experiment by Mukai and Nojima (1985) grazing rates of *T. gratilla* in Papua New Guinean seagrass beds ranged from 2.0 to 5.7 g WW ind^{-1} day^{-1} (mean 3.6 g WW ind^{-1} day^{-1}) in single-animal experiment and 0.4 to 10.8 g WW ind^{-1} day^{-1} (mean 4.3 g WW ind^{-1} day^{-1}) in two-animal experiment, *T. gratilla* in Buton Island seagrass beds has biggest grazing rates around two times. In

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Bolinao seagrass beds, Philippines, by field and laboratory measurement of *T. gratilla* and *Salmacis sphaeroides* consumption of seagrass, both sea urchins grazed more than 60 % of seagrasses, and total consumption was estimated 240 to 400 g DW m^2 day^{-1} (Klumpp, *et al*., 1993). Other research about grazing rates of sea urchin on seagrasses briefly were shown in **Table 3**.

Grazing activity of sea urchin on seagrasses has been a unique phenomenon correspondent directly with the biological and physical parameter. Food preference of sea urchin is caused by the availability of some kind of food which dominantly occurs around them. In *Thalassodendron ciliatum* meadows, Mombasa lagoon, *T. gratilla* has increased a high number of *T. ciliatum* dead shoot (Alcoverro and Mariani, 2002). In Buton Island seagrass beds, *Th. hemprichii* and *E. acoroides* are potential food sources of *T. gratilla*. All the seagrasses that put inside the cage from the grazing rate experiment were grazed by *T. gratilla*. In fact, immediately upon placing the seagrasses leaves on the substrat in the cages, *T. gratilla* began climbing the shoots and direct graze the leaves. The grazing rates on the seagrass leaves was related to different sized in diameter. During our experiment, the biggest sea urchins were grazing more seagrass leaves than the small sea urchins. Moor and McPherson (1965) reported that grazing rates of sea urchin is influenced by water current velocity, other condition such as food species (Vadas, 1968; Fuji 1967; Lowe 1974), Temperature (Agatsuma, *et al*., 2000), season (Parcy, 1971; Moor and McPherson 1965), light intensity (Fuji, 1967), body size (Fuji, 1967; Leighton, 1968; Himmelman, 1969), and density (Greenway, 1976). The grazing time of *T. gratill*a is also influenced by the fluctuation of tidal range. The sea urchin hide under shoots of seagrasses during high tides when the current speed was high. It is considered that the most active graze of sea urchin is correlated to the low rate of flow. The flow rate also affects to grazing rates of sea urchin.

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