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Short contribution

Food habit of chiton *Acanthopleura japonica* from Jogashima, Miura peninsula, Kanagawa prefecture, Japan

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Abstract: We examined the food habits and ontogenetic trophic shifts of the Japanese common chiton, *Acanthopleura japonica*. Specimens were collected from the intertidal zone of Jogashima, Miura Peninsula, Kanagawa Prefecture, Japan. Based on gut content analysis of 18 specimens, red algae were found to be the most abundant food item (37.0%), followed by green and brown algae (5.6% each), bivalves (5.0%), mites (2.6%), and abundant abiogenic minerals (stone or rock debris) as non-food items. This gut content composition was inconsistent with that of another population from Amakusa, Kyushu, Japan; hence, the food habits of *A. japonica* would vary depending on habitat environments, suggesting they are non-selective omnivorous feeders. Individual variations of the gut contents did not correlate with the body length, indicating *A. japonica* has no ontogenetic trophic shift. Overall, we concluded that *A. japonica* is omnivorous without an ontogenetic trophic shift.

Keywords : *Polyplacophora, diet, rocky shore, ontogeny*

1. Introduction

Chitons are a class of mollusks with eight longitudinal rows of dorsal shell plates on their backs (NISHIMURA, 1992). Most intertidal chitons are known to prey on epiphytic algae and other organisms (BARNES and HARRISON, 1994), and some authors have stated that they are herbivorous (BOOLOOTIAN, 1964; CONNOR, 1975; ROBB, 1975). However, FULTON (1975) reported that four chiton species of the genus *Mopalia* had considerable amounts of animal debris in their gut contents. LATYSHEV *et al.* (2004) found debris of coralline algae in addition to diatoms in the gut contents of *Ischnochiton hakodadensis*, *Tonicella granulate*, and *Mopalia retifera*, whereas *Lepidozona albrechti* mainly contains nematodes, shellfish, and foraminifers.

Acanthopleura japonica is the most common chiton species found on the rocky coastal intertidal shores from southern Hokkaido to Yaku Island, Japan (NISHIMURA, 1992). Although *A. ja-*

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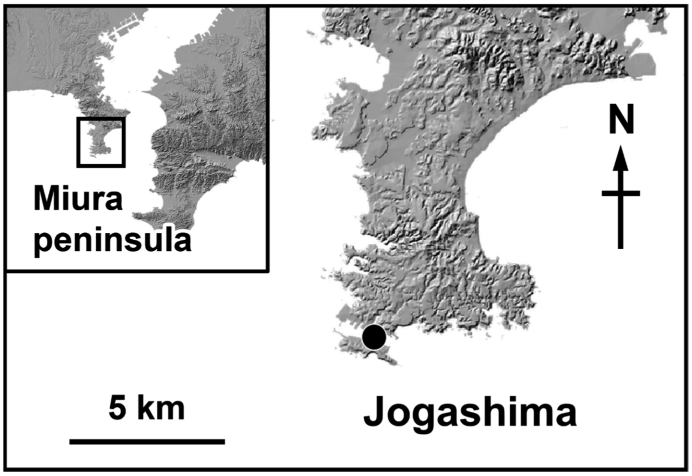

Fig. 1 Map of the intertidal rocky shore in Jogashima, Miura peninsula, Kanagawa prefecture, Japan, showing sampling station as black circle.

ponica has been widely recognized as a grazer (HUTCHINSON and WILLAMS, 2003), NISHIHAMA *et al.* (1986) reported that they mainly prey on animals such as barnacles; hence, their detailed food habits and food preferences remain unclear.

Furthermore, ontogenetic trophic shifts have not been addressed in *A. japonica*. CAMUS *et al.* (2012) reported that another *Acanthopleura* species (*A. echinata*) increased their algal diets with increase in their body size. However, this dietary shift was attributed to the variation of the niche breadth and algal richness at a local scale. The ontogenetic trophic shifts remain unclear, and this could give rise to the two different views on food habits of *A. japonica*.

Therefore, we investigated the gut contents of *A. japonica*, to evaluate the detailed food habits and the ontogenetic trophic shift.

2. Materials and methods

Sample collection

Sample collection was conducted in April 2022 at the intertidal rocky shore (35° 13.7° 'N, 139° 62.2' ° E) in Jogashima, Miura Peninsula, Kanagawa Prefecture, Central Japan (Fig. 1). The substratum in the area is composed of volcaniclastic rocks (YAMAMOTO *et al.*, 2000). We scraped *A. japonica* from the rock surface during daytime low tides using an ointment spatula, and 18 individuals were collected. Collected individuals were identified by SAITO (2017) and immediately anesthetized for several hours in a 1:1 solution of 3.2% NaCl and 7.5% MgCl following the method described by SPEISER *et al.* (2011). After anesthetization, the specimens were fixed in 70% ethanol, and their body lengths were measured with electric calipers to an accuracy of one-tenth of a millimeter.

Gut contents analysis

After body length measurements, foot muscles were cut open with postmortem scissors, and gut contents were removed and squashed on a Sedgewick-Raffer cell (1 mm × 1 mm grid slide) to a uniform depth of 1 mm. Each item was photographed with a single-lens reflex camera attached to the microscope. The area of each item was measured using ImageJ software (SCHNEID-

Table. 1 Mean percentage of specimen units consuming each food item by volume (%V, N = 18), with the ranges given within parentheses.

Category	Food item	Mean %V (Min – Max)
Minerals	Stone or rock fragments	42.0 (0.0 – 94.5)
Algae	Green algae	5.6 (0.0 – 100.0)
	Brown algae	5.6 (0.0 – 100.0)
	Red algae	37.0 (0.0 – 100.0)
Animals	Bivalves	5.0 (0.0 – 60.5)
	Mites	2.6 (0.0 – 42.2)
Others	Unknown taxa	0.3 (0.0 – 5.6)

ER *et al.*, 2012) with an accuracy of 0.001 mm^2. The measured area was divided by the total area of the gut contents to calculate the percentage volume (%V) of that item (NAKANE *et al.*, 2011). Food resource use was expressed as the mean percentage composition of each item by volume, which was calculated by dividing the sum of the individual volumetric percentage for the item by the number of specimens (NANJO *et al.*, 2008). Items in the gut contents were identified as the lowest possible taxa based on their color and shape by SEGAWA and YAMADA (1977), NISHIMURA (1992, 1995), KUBO and MATSUKUMA (2007).

Statistical analysis

To evaluate whether *A. japonica* is carnivorous or herbivorous, the percentage volumes of animal and algal fragments were compared using the Wilcoxon signed-rank test. To evaluate the ontogenetic shift in food habits, single linear regression analyses were performed for body length as an explanatory variable and two food categories (algae and animals) as response variables. All statistical analyses were performed using R v4.2.2 (R CORE TEAM, 2022).

3. Results

A wide variety of food items were consumed by *A. japonica* (Table 1). No individual was observed with an empty gut (0.028 – 3.494 mm^2 volume, N = 18). According to the mean percentage volume of each food item, red algae were the most abundant biogenic gut content (37.0%), followed by green and brown algae (green algae, 5.6%; brown algae, 5.6%), bivalves (5.0%), and mites (2.6%). Macroalgal fragments had not been digested well and retained their color and shape. Bivalves, such as Lasaeidae retained their shape and were identified, but other shells were fragmented. The mites were not decomposed and retained their shapes. On the other hand, minerals, abiogenic stones, or rock debris, were the most abundant item (42.0%). The Wilcoxon signed-rank test revealed that the algal diet (50.4% in total) was significantly greater than the animal diet (7.3% in total) ($p < 0.01$).

The collected individuals (n = 18) showed a wide size range, with a minimum body length of 16.7 mm and a maximum of 54.3 mm. However, the body length and percentage volume of algae and animals did not show any significant regression (Fig. 2).

4. Discussion

Our study demonstrated that *A. japonica* from Jogashima, Kanagawa, central Japan, mainly fed on epiphytic algae, particularly red algal species

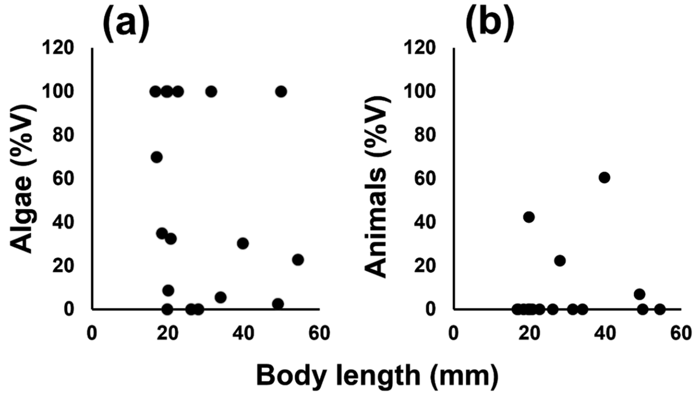

Fig. 2 Correlation diagrams between body length of *A. japonica* and minerals (a), algae (b), animals. A single linear regression analysis did not show any significant regression.

(Table 1). This result was consistent with general perceptions (HUTCHINSON and WILLAMS, 2003); however, NISHIHAMA *et al.* (1986) reported that barnacles (*Chthamalus challengeri*) were frequently found in the gut contents of *A. japonica*, in a local population of Amakusa, Kyushu, western Japan. This contradiction might be caused by the non-selective feeding of chitons. ROBB (1975) indicated that another chiton species, *Cyanoplax hartwegii*, varied its food utilization according to *in situ* food resource conditions. As a result, *A. japonica* may exhibit a variety of feeding habits depending on its habitat environment, with no specific food preferences. Another possible cause of the feeding variation could be a seasonal change in the availability of prey. The present study was conducted in April. At this time of the year, in general, macroalgae are abundant, whereas barnacles (*C. challengeri*) are present in lower density owing to the early stages of settlement (MORI, 1990). NISHIHAMA *et al.* (1986) examined the gut contents of *A. japonica* in July. At that time of the year, macroalgal biomass is typically scarce and barnacle density could have been higher owing to the late stages of settlement (MORI, 1990). Accordingly, such seasonal occurrences may have led to the feeding variation observed in *A. japonica.*

Our results also revealed that minerals such as stones and rock debris were the most abundant in the *A. japonica* gut (Table 1). Chitons, including *A. japonica*, possess robust radulae coated mainly with magnetite (LOWENSTAM, 1967) and thus feed on epiphytic organisms by scraping off the rock surface (NISHIHAMA, 1993). Such destructive feeding could have a powerful effect on removing surrounding sessile organisms (i.e., the bulldozing effect).

Body length was not correlated with either algal or animal food categories (Fig. 2), indicating that *A. japonica* has no ontogenetic trophic shift, unlike *Acanthopleura echinata* (CAMUS *et al.*, 2012). This suggests that size distribution (an ontogenetic difference) would not cause differences in food habits between the Jogashima and Amakusa populations.

Overall, the present study revealed that *A. japonica* is omnivorous without an ontogenetic trophic shift. Diet utilization can vary depending on the food environment, suggesting a non-selective feeder. Together with destructive feeding, *A. japonica* would have a substantial grazing effect on intertidal rocky shore habitats.

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