Kuroshio Science 18-1, 34-43, 2024

Research Paper

Diet composition of the fringescale sardinella (*Sardinella fimbriata*) found in Malampaya Sound, Palawan, Philippines: a preliminary study on their feeding habits

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Abstract

Food availability influences fish interaction and density. It is essential for movement, growth, development, and survival. Many studies have been done on feeding behavior and preference of fish and Clupeids. However, very little has been done for Fringescale sardinella, more so, for fishes caught from Malampaya Sound, Palawan. A total of 59 individuals, with sizes ranging between 11.1-14.2 cm were collected to determine the food and feeding habits of Fringescale sardinella, *Sardinella fimbriata* during the wet season. There were 30 food items identified with the following order of dominance: copepods > bivalve > fish larvae/egg > barnacles > decapods > others. *Temora* sp. was observed to be the most preferred food item in the gut with the calculated Index of Relative Importance and Selectivity Index of 4009 and 0.33, respectively. The average fullness index was computed as 0.63 which indicates moderate feeding intensity.

This study contributes to our knowledge of the feeding ecology of Fringescale sardinella and gives significant information for the management and conservation of fish populations in Malampaya Sound. Further research on the feeding behavior of this species, including seasonal variations, responses to environmental changes, and the long-term implications for fish population dynamics and ecosystem health, is essential. Such knowledge will enhance our understanding of its ecological role and ensure the sustainability of marine resources in the region.

Keywords: trophic ecology, fish diet, fish and food interaction, food web

INTRODUCTION

Food is essential for the movement, growth, development, and survival of organisms (Manoharan et al. 2012). It dictates species interactions within a population (Mequila and Campos 2007) and relies on the productivity of the marine ecosystem (Nyunja et al. 2002). Its availability in a particular habitat is also one of the factors that determine fish density (Robertson and Duke 1987). Studies have shown that fish at various stages of their development may prefer different foods (Saikia 2015). Information on feeding habits can be used to identify feeding competition (Bacheler et al. 2004, Crow et al. 2010, Leduc et al. 2015, Ševove and Kováč 2016), predator-prey interaction (Dörner and Wagner 2003, Hartvig and Andersen 2013, Nakazawa et al. 2013), prey selection (Isaac et al. 2012, Ranåker et al. 2014), territoriality (Bo et al. 2010), niche overlap and partitioning (Guzzo et al. 2013, Sa-Oliveira et al. 2014, Córdova-Tapia et al. 2015) and ecotypes coexistence (Hartvig and Andersen 2013). At the same time, it is also a useful tool in fish stock assessment and ecosystem modeling (Lopez-Peralta and Arcila 2002, Bachok et al. 2004). It can be an integral part of fishery management that is related to prey management, forage fish population manipulation, and fish production (Devries and Stein 1990,

Received 21 March 2024; Accepted 21 June 2024
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Kamler and Pope 2001, Pikitch et al. 2004).

Many studies have been done on feeding behavior and preference of fish and Clupeids (James 1988, Mummert and Drenner 1986, Pavlov and Kasumyan 2002, Whitehead 1985). However, very little has been done for Fringescale sardinella (*Sardinella fimbriata*), more so, for fishes caught from Malampaya Sound, Palawan. This species is one of the common sardines found in the Philippines (Willette et al. 2011). They are ray-finned fish belonging to the herring family (Whitehead 1985) that grows up to 19 cm in length (Dalzell and Ganaden 1987) with compressed deep bodies (Stern et al. 2016). The dorsal third of their body is light blue to dark grey, while the ventral two-thirds are a bright silvery hue. Their dorsal fin is slightly located anterior to the center of the standard length and has thin, serrated gill rakers. They are found in schools in coastal waters of the Indo-west Pacific, from Kuwait to southern India and the Bay of Bengal to the Philippines, in depths of up to 50 m (Whitehead 1985).

The fringescale sardinella, also known as "lapad," play a significant role in the fish caught in Malampaya Sound, accounting for 17% of the Philippines' total catch from commercial and marine municipal fisheries, of which, 9,504.24 mt came from Palawan province, in the western Philippines (PSA 2020). Not only are they used for food, but they also contribute to the production of fish meal and fish oil. While the fringescale sardinella population in the Philippines is currently healthy (Willete et al. 2011), high fishing pressure is causing depletion in major fishing grounds where sardines are caught. For instance, the Visayan Sea and Manila Bay which are crucial fishing grounds for this species, are already considered over-exploited and overfished (Guanco et al. 2009; Dicdiquin et al. 2017). Malampaya Sound is no different from them, the increasing demand for marine fish food did not spare the Sound from overexploitation. It is compounded by ecological stress brought about by degrading human activities that cause damage to corals and other marine life (McNeely et al. 1990; Deocadez and Aliño 2005). As a result, the area was closed for commercial fishing in 1973 due to overfishing and exploitation (Ronquillo and Llana 1987). In 1986, stricter conservation measures were put in place. Only municipal fishing boats weighing 3 GT or less are permitted to fish in the area, using only certain fishing methods. This helps to conserve the remaining marine resources, maintain species continuity and sustainability, replenish fish stocks, and increase biodiversity. In 2000, the area was declared a protected landscape and seascape to further promote conservation.

According to Robertson and Duke (1987), fish densities are determined by the productivity, food availability, and structural heterogeneity of a particular habitat. Hence, study aims to determine the food and feeding habits of Fringescale sardinella, *Sardinella fimbriata* from Malampaya Sound, Palawan. The information that was gathered can be used to better understand the biology of Fringescale sardinella in the area.

MATERIALS AND METHODS

Specimens of Fringescale sardinella found in the Sound were collected from Barangay Pancol, the major landing site in the area (Figure 1). Fish samples of varying sizes, caught from gill nets were bought directly from several fishermen and or from different fresh landings. The fish were selected by randomly picking from the catch, kept in a cooling box, and brought to the laboratory for measurements and dissection. A total of 59 individuals, with sizes ranging between 11.1-14.5 cm were collected. These constituted three batches spreading in three months covering the wet season. Wet months in Malampaya Sound occur from June to December (CHE-UPLB 2015).

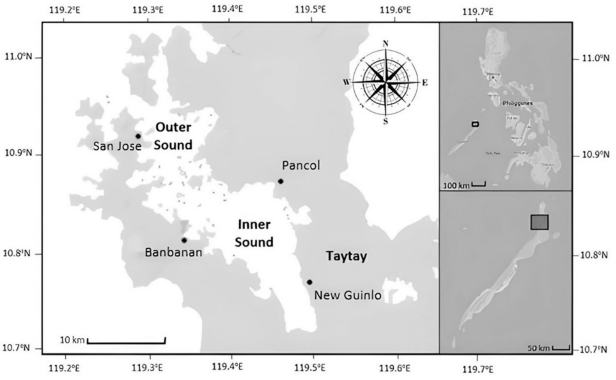

Fig. 1. The map of Malampaya Sound, Palawan.

Morphometrics, such as the length and weight of the fish samples were determined. Total length (TL) of each fish were measured from the tip of the snout to the posterior most edge of upper caudal fin to the nearest 0.1 cm using a ruler. The body weight (BW) was measured to the nearest 0.01 g using a scale. Fish samples were dissected, and digestive organs were carefully removed and measured to the nearest 0.01 g using a scale. They were placed in plastic vials and immediately fixed in 10% formalin. After 24 hours, they were removed from the fixative material and were transferred in 70% ethanol for storage and further analysis. The stomach was incised, and contents were identified to the lowest taxonomic group possible. In instances where only parts of the prey where seen, they were still counted and included in bigger food category groups. The following indices were computed:

$$\text{Percentage Frequency of Occurrence (PFO) (Chrisafi et al. 2007)} = \frac{N_{1i}}{N_p} \times 100$$

$$\text{Index of Relative Importance (IRI) (Abdel – Aziz and Gharib 2007)} = (\%N_{1i})(\%N)$$

$$\text{Selectivity Index (SI)(Berhaut 1973)} = \frac{n}{N_p}$$

$$\text{Fullness Index (FI)(Hureau 1969)} \quad \frac{W_f}{W_b} \times 100$$

where W_f is the weight of the stomach contents, W_b is the total body weight, N_{1i} is the number of stomachs in which food item was found, N_p is the number of non-empty stomachs, N is the total number of food items found in the stomach, n is the number of stomachs containing a particular food category and N_p is the total number of stomachs examined.

The food categories were subjected to diversity analysis using the Shannon-Diversity Index and Pielou Evenness with the following formulas:

$$\text{Shannon Diversity Index (H')(Shannon 1948)} = -\sum_{i=1}^{s} p_i \ln p_i$$

$$\text{Pielou Evenness (Eh')} \text{ (Pielou 1966)} = H' \ln S$$

where S is the number of species, and pi is the proportion of individuals of each species belonging to the ith species of the total number of individuals.

RESULTS

Prey Composition

A total of 59 stomachs were examined with sizes ranging from 11.1 to 14.0 cm (males) and 11.5 to 14.5 cm (females), of which three of them were found to be empty. A total of 30 genera/taxa were identified as food items of *Sardinella fimbriata*. Some of them were in Figure 2. The percentage frequency of occurrence (Figure 3) shows that *Temora* sp. and bivalve larvae are the most preferred food that is being preyed on by this species with a frequency of occurrence of 84.5% and 77. 6%, respectively. Prey is composed mainly of zooplankton; however, some guts were found to have few *Coscinodiscus* sp., a diatom.

The Index of relative importance (IRI) and selectivity index (SI) for various food items found in the gut are shown in Figures 4 and 5, respectively. Accordingly, the highest value of IRI (4009) and SI (0. 83) was observed for *Temora* sp. Bivalve larvae (IRI = 1782; SI = 0.76) were also found to be a prominent prey. The composite prey preference by group is as follows: copepods > bivalve > fish larvae/egg > barnacles > decapods > others.

Food preference of male and female fish was also identified. The food contents of the stomach between sexes were similar except that *Daphnia* sp., *Acrocalanus* sp., and *Coscinodiscus* sp. were only found amongst males. However, females have a more varied diet as evident in the number of food items (27) found in their stomachs. 13 food items were found only in females' stomachs such as *Nereis* sp., *Bestiolina* sp., *Oithona* sp., *Tisbintra* sp., *Corycaeus* sp., *Lucifer* sp., *Sagitta* sp., sea mites, shrimp larvae, isopods, ostracods, and gastropods. Despite this, both sexes have been found to have a highly diverse composition (Table 1) of the prey as exemplified by the diversity index of 0.91 and 1.05 for male and female fishes, respectively.

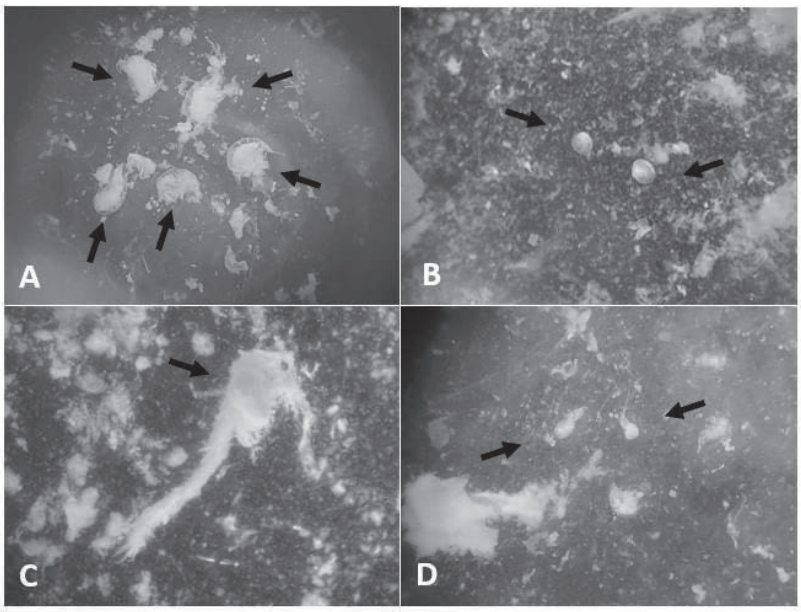

Fig. 2. Common food items in the gut of *Sardinella fimbriata*, A. *Temora* sp.; B. bivalve larvae; C. fish larvae; D. *Microsetella* sp.

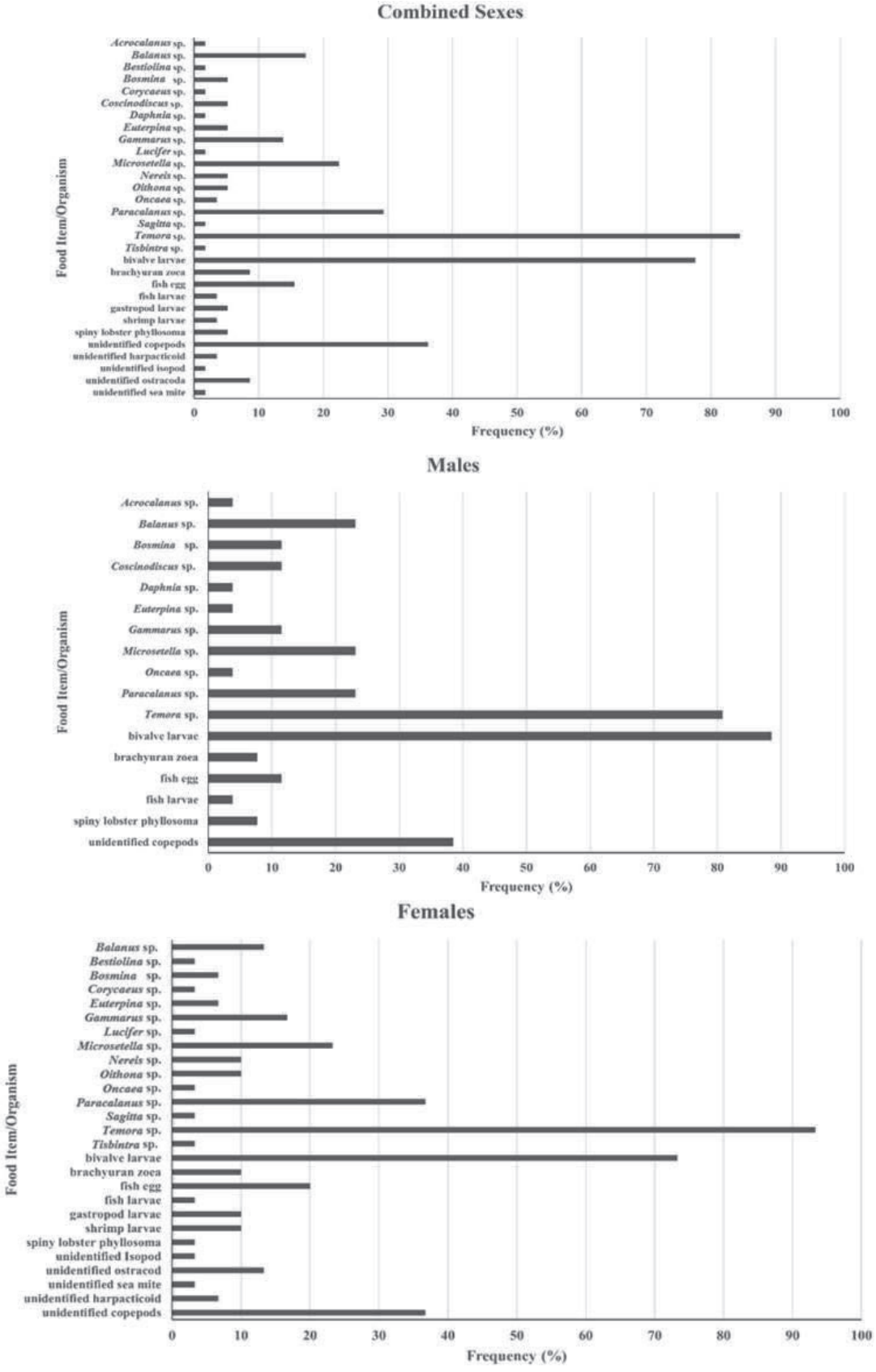

Fig. 3. Percentage frequency of occurrence (PFO) of food items in the gut of *Sardinella fimbriata.*

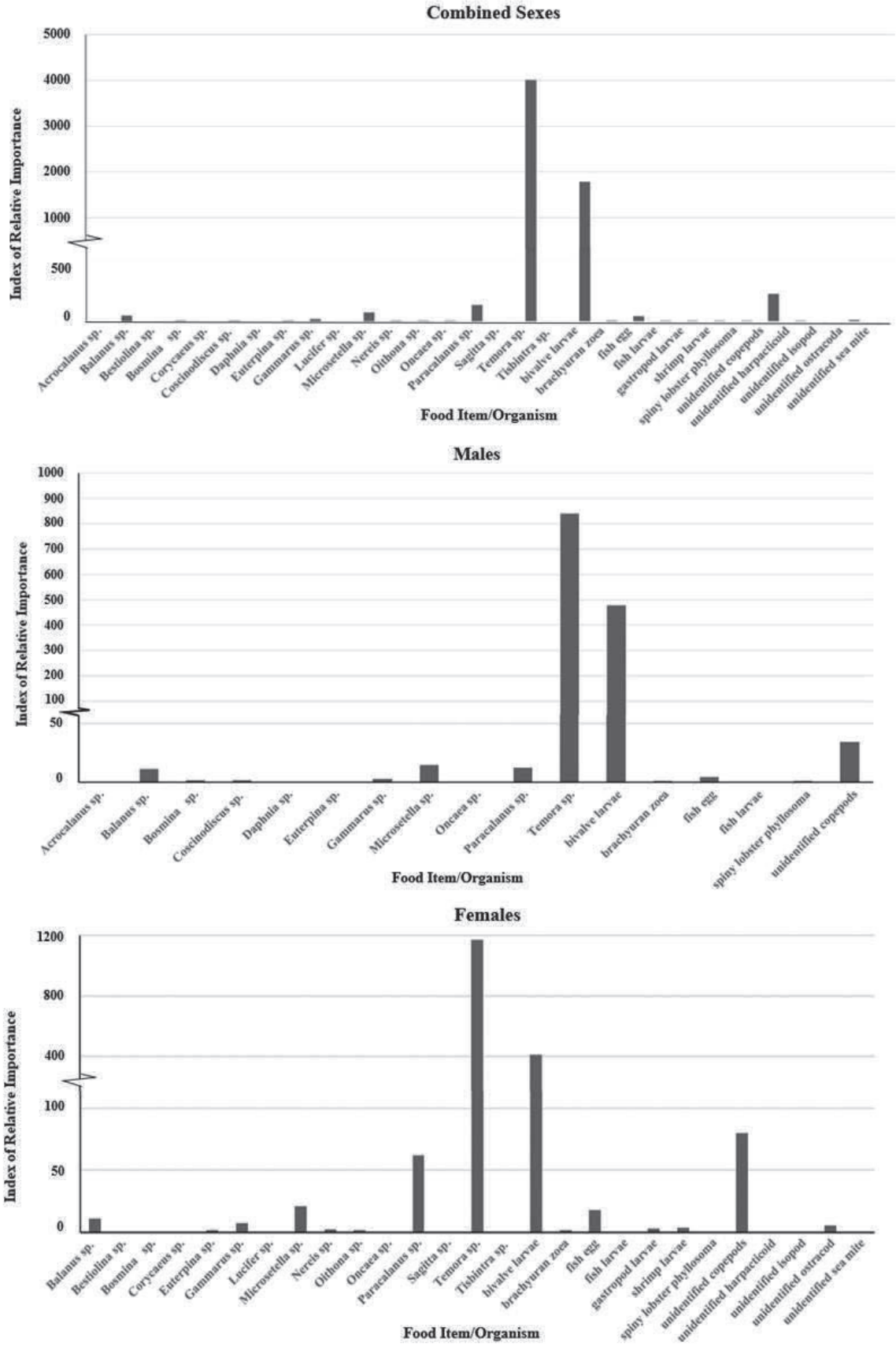

Fig. 4. Index of relative importance (IRI) of food items in the gut of *Sardinella fimbriata.*

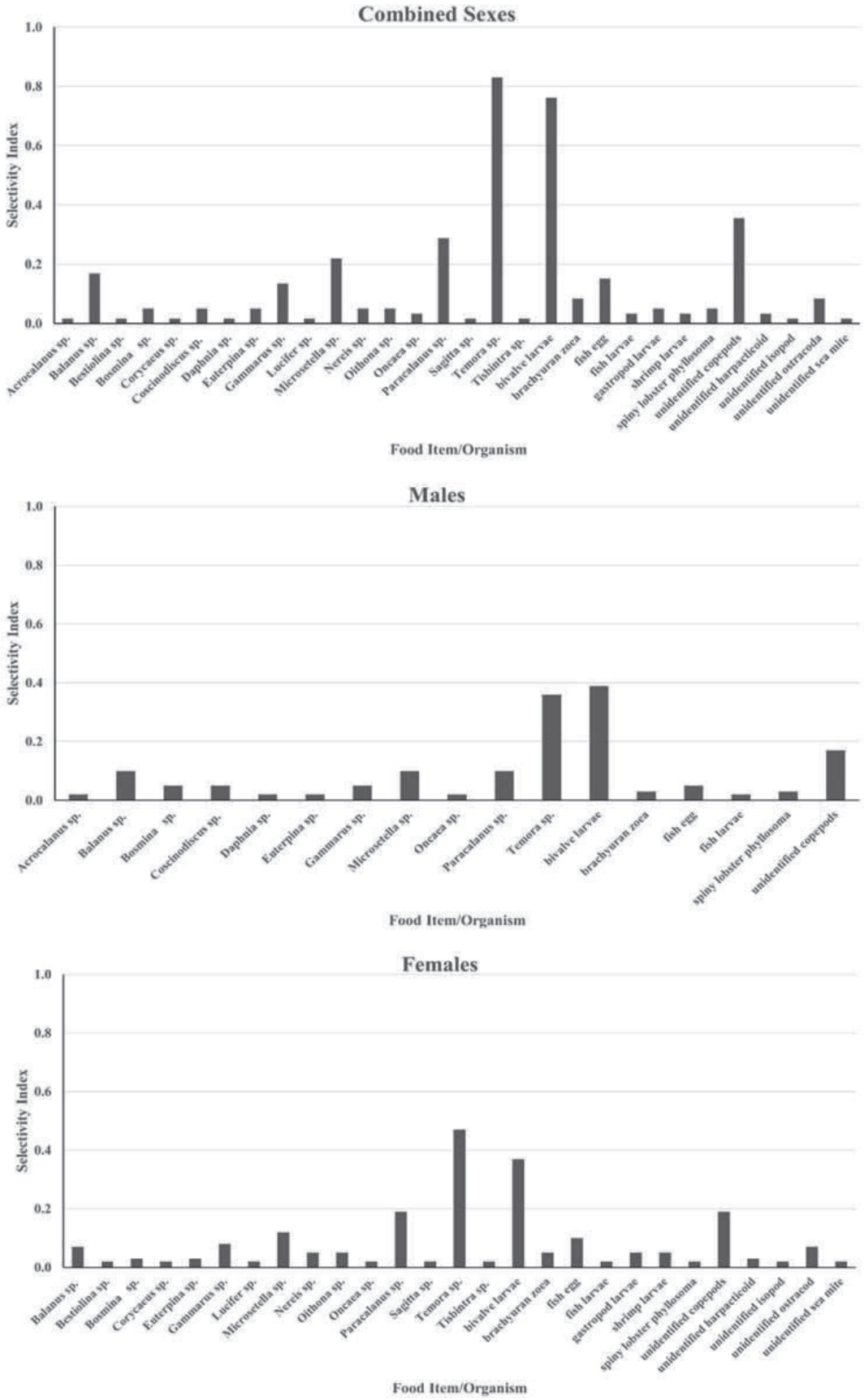

Fig. 5. Selectivity index (SI) of food items in the gut of *Sardinella fimbriata.*

Feeding Intensity

The feeding intensity of the fish can be described by the fullness index (FI) (Table 1). Dissection of the gut content revealed that the weight of the food consumed varies from 0 — 0.32g. The fulness index was computed between 0-2.02, with a mean calculated as 0.67.

DISCUSSION

Generally, sardines are known to be schooling pelagic planktivores (Willete et al. 2011, Schroeder 1980). They are opportunistic foragers (James 1988) that commonly feed on crustaceans, phytoplankton, and fish eggs (Nguyen et al. 2016). Like other sardines, the diet of Fringescale sardinella found in Malampaya Sound is comprised mainly of crustaceans, bivalves, fish eggs and larvae, and phytoplankton. The high percentage frequency of occurrence, and index of relative importance of *Temora* sp., a copepod and bivalve larvae means that these food items are abundant and readily available in its environment. This is anticipated as Malampaya Sound harbors a high concentration of zooplankton, six times greater than in the Visayan Sea and twice greater than in Bacuit Bay, northeastern Palawan (Estudillo et al. 1987). In their study, zooplankton assemblage is dominated by copepods, which are also the preferred food of Fringescale sardinella and other sardines. Consequently, the selectivity index scored high also for the said two food items, 0.83 and 0. 73 respectively. This implies that both are the preferred primary source of nutrition of *Sardinella fimbriata*. It actively seeks out, consumes, and favors these two food items when available. According to Huse et al. (2002), the selectivity index in fish is influenced by several factors such as availability of prey, prey size and morphology, prey behavior, nutritional value, habitat structure, and competition.

The results of this study verified the previous studies conducted by Bennet et al. (1992) which revealed that the food of *Sardinella fimbriata* is comprised mainly of zooplankton with small quantities of phytoplankton. This is also similar to a more detailed study conducted by Rao (1981) where he found out that bigger fish, with sizes more than 10 cm prefer bigger prey such as copepods and other zooplankton. Other food items identified in their gut include molluscan larvae, mysids, megalopa, alima larvae, amphipods, and prawn larvae.

Some reports reveal that *S. fimbriata* may swim close to the seabed and ingest detritus along with the other bottom-dwelling organisms. In this study, no detritus nor sand particles were found in the gut samples. However, the presence of amphipods, annelids, isopods, and ostracods can be an indication that they are also feeding near the substrate or on detritus. These animals are designated as zoobenthos (Froese and Pauly 2013) thus mainly bottom-dwelling (Lopez-Peralta and Arcila, 2002). This behavior is influenced by several ecological factors such as habitat availability, competition for resources, and environmental conditions (Soares et al. 2016). Though this is not common, detritivory in sardines has already been observed on *Sardinella aurita* and *Sardinella maderensis*, two species closely related to *Sardinella fimbriata* (Bazigos and Tsimenides 1984). They can also be carnivores or herbivores as evident in the fish larvae and the diatom that was found in their gut.

Fringescale sardinella, like other sardines exhibits opportunistic feeding because they can exploit a wide range of food resources depending on the availability and circumstances. They are mainly planktivorous, however, can consume small fish fry, fish eggs, larvae of other marine invertebrates, or even detritus if necessary. They use filter feeding and or particulate feeding depending on the availability of food and clarity of the water (Plounevez and Champalbert 2000, Garrido and van der Lingen 2014). This ability allows them to cope with the fluctuating prey abundance and distribution, as well as changing environmental conditions like temperature, currents, and nutrients (Pauly and Tsukayama 1987). Having a wide range diet allows them to maximize food efficiency and energy intake thereby increasing chances of survival and reproduction making the population more resilient. According to Lall and Tibbetts (2009), fish feeding behavior is also influenced by various biotic and abiotic factors such as light, temperature, water velocity, social factors, predators, and disturbance by humans. Moreover, food preference also depends on the size and stage

Table 1. Morphometric characteristics, Shannon Diversity Index (H'), Pielou Evenness (Eh'), Fullness Index of food items found in the gut of *S. fimbriata*.

Sex	N	Length Range	Mean Length	Mean Weight of Gut Contents	H'	Eh'	Fullness Index
Combined Sex	59	11.1-14.5	12.6	0.13	0.98	0.82	0.67
Male	28	11.1-14.0	12.5	0.13	0.91	0.81	0.72
Female	31	11.5-14.5	12.8	0.13	1.05	0.82	0.63

of the fish (Nguyen et al. 2016). The type and size of the food consumed by a fish also varies on its geographic and seasonal availability (Garrido and van de Lingen 2014).

The fullness index (FI) describes the relationships between fish and ecosystems as well as the impact of the environment on fish feeding patterns (Sajeevan & Kurup, 2013). The feeding intensity of 0.63 was found to be moderate. This result is an indication that the population of S. fimbriata in this area is actively foraging and consuming food resources at an optimum level. There is a balanced feeding pattern where fishes are meeting their nutritional needs without putting excessive pressure on the prey population. This is also an indication that there is a balance between natural foraging behaviors and potential disruptions from fishing activities.

CONCLUSION

Despite numerous studies on the feeding behavior of fish and clupeids, there is a scarcity of information regarding the feeding habits of Fringescale sardinella (*Sardinella fimbriata*), particularly in the context of the Malampaya Sound, Palawan. This study intended to address this gap. Through gut analysis of collected specimens, it was revealed that this species is mainly planktivorous. Their diet is composed primarily of copepods, bivalves, fish larvae/eggs, barnacles, decapods, and others. Specifically, *Temora* sp. and bivalve larvae were identified as preferred prey items, indicating their abundance in the environment. The presence of different food items in the gut of male and female fish implies a degree of dietary variation between sexes, possibly influenced by factors such as prey availability and nutritional requirements. Assessment of the fullness index which revealed moderate feeding activity implies a balanced foraging behavior that meets nutritional needs without excessive pressure on prey populations. While no detritus nor sand particles were found in the gut samples of the fish samples, the presence of zoobenthos such as amphipods, annelids, isopods, and ostracods imply potential feeding near substrate or on detritus. These findings highlight the importance of understanding the relationships between fish and ecosystems, as well as the potential impacts of environmental factors and human activities on feeding patterns.

In general, this study contributes to our knowledge of the feeding ecology of Fringescale sardinella and gives significant information for the management and conservation of fish populations in Malampaya Sound. The information on feeding behavior can be used as additional input to fishery management strategies, stock assessment, and ecosystem modeling, ultimately aiding in the sustainable utilization of marine resources.

Food is a necessity for survival, growth, and reproduction of an organism. The available food resources in a particular ecosystem significantly influence fish density and population dynamics. The dependance of Fringescale sardinella on copepods, bivalve larvae, and other planktonic organisms emphasize the importance of keeping a healthy population of zooplankton in the marine environment. Conservation managers should consider the availability of prey items and must ensure implementation of sustainable fishing practices. Regular monitoring of zooplankton population and water quality parameters is necessary to ensure overall health of the ecosystem.

Further research on the feeding behavior of this species, including seasonal variations, responses to environmental changes, and the long-term implications for fish population dynamics and ecosystem health, is essential. It is also important to examine a wider size range of fish specimens from various fishing gears to better understand ontogenetic dietary shifts. Additionally, noting the reproductive stage of specimens is essential, as it may impact their diets too. Further studies should be done on seasonal variations in diet, influence of environmental factors on feeding behaviour and impact of anthropogenic activities on sardine diet. Such knowledge will give us a deeper understanding of its ecological role and ensure the sustainability of marine resources in the region.

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