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Research Article

Food Preference of Shortfin Scad (*Decapterus macrosoma*) at the Southern Waters of Gunungkidul Yogyakarta, Indonesia

Preferensi pakan ikan layang deles (*Decapterus macrosoma*) di Pantai Selatan Gunungkidul Yogyakarta

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Abstract

The food habit is one of the important information used in the fisheries resource management. This study aimed to determine food preferences, index of preponderance, and trophic level of shortfin scad (*D. macrosoma*) captured from the southern waters of Gunungkidul Yogyakarta, Indonesia. A total of 325 fish samples were collected from March to September 2018. Each fish sample was measured in total length, body weight, determined its sex, and then dissected. The digestive tract was measured in total length then the gut contents were preserved in 5% formaldehyde to observe the type of food composition. The results showed that shortfin scad was carnivorous fish (relative gut length = 0.47) with the diet composing of fish (84.15%), phytoplankton (8.91%), zooplankton (4.47%), and snipping shrimp (3.19%). The molecular identification showed that the main fish species eaten by shortfin scad was *Cololabis saira* (*Scomberesocoidae*).

Abstrak

Kebiasaan pakan ikan merupakan salah satu informasi penting yang digunakan dalam manajemen sumberdaya perikanan. Penelitian ini bertujuan untuk mengetahui preferensi pakan, indeks bagian terbesar dan tingkat trofik ikan layang deles (*D. macrosoma*) yang ditangkap dari Perairan Gunungkidul. Total 325 sampel ikan layang deles dikumpulkan selama bulan Maret sampai dengan September 2018. Setiap sampel ikan diukur panjang total, berat tubuh, ditentukan jenis kelaminnya kemudian dilakukan pembedahan. Saluran pencernaan diukur panjangnya, kemudian isi lambung ikan diawetkan dalam formalin 5% untuk diamati komposisi jenis makanannya. Analisis data meliputi panjang usus relatif, frekuensi kejadian, indeks bagian terbesar, dan tingkat trofik ikan layang deles. Hasil penelitian menunjukkan bahwa ikan layang deles bersifat karnivora (panjang usus relatif = 0,47) dengan komposisi jenis makanan utama adalah ikan (84,15%). Makanan pelengkap layang deles adalah fitoplankton (8,91%), sedangkan zooplankton (4,47%) dan potongan udang (3,19%) merupakan makanan tambahan. Berdasarkan identifikasi molekuler, spesies ikan yang menjadi makanan utama ikan layang deles adalah *Cololabis saira* (*Scomberesocoidae*).

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1. Introduction

The *Carangidae* family, known as jacks, trevallies, amberjacks, pompanos, scads, kingfish, pilotfish, rainbow runners (Honebrink, 2000), is the important economical fish group representing approximately 5% of the global capture fisheries. *Decapterus* spp. as a member of the *Carangidae*, is one of the fish that has been used as a commodity of trade and economic resources (Ditty *et al*., 2004; Kimura *et al*., 2013). Shortfin scad (*D. macrosoma*) is an important small pelagic fishery resource in the Java Sea waters (Wahju *et al*., 2011). Shortfin scads live in schooling, with a wide distribution ranging from the Indian Ocean, the Western, and Eastern Pacific Oceans (Kimura *et al*., 2013), at a depth of 30-70 m above the water surface (Alatorre-Ramirez *et al*., 2013).

Food availability in the term of sufficient in amount and good quality is one of the important factors in ensuring population life, growth, and condition of fish (Astuti *et al*., 2005). Food preferences can be known, among others, through the composition of stomach contents and relative gut length. Analysis of food composition and food habits aim to determine the position of fish in the food chain (Behzadi *et al*., 2016) because information regarding fish food types is highly important in the management and utilization of fisheries resources. An understanding of the type of food contained in the fish stomach aims to show the integration of important ecological components such as behavior, conditions, habitat adaptation and specific interactions between species (Nath *et al*., 2015). Fish feeding habit is an information relating to predator-prey interactions in the food chain to determine ecosystem-based fisheries management (Hanson *et al*., 2002). Food habits include the composition of types of organisms from food sources that have been digested by fish (Mata-Sotres *et al*., 2016). Food resources are available in waters such as sediments, benthic organisms, plankton, or fish larvae (Jo *et al*., 2013). Research on the composition and food preferences of *Decapterus* spp. has been carried out among others on the Northwest Coast of India (Jaiswar *et al*., 1993), Malabar Beach (Manojkumar, 2007) and Mangaluru Beach (Ashwini *et al*., 2016). Even from the same group or species, a fish population may have different types of food in accordance to the availability of food from nature and their trophic level. This study aimed to determine the composition, food preferences and trophic level of shortfin scads (*D. macrosoma*) in the southern waters of Gunungkidul Yogyakarta, Indonesia.

2. Materials and Methods

2.1 Fish sample

A total of 325 shortfin scads as samples were obtained from fishermen along the southern coast of Gunungkidul landed in Fish port of Sadeng (Figure 1) within March to September 2018. The fishing gear used by fishermen is a gillnet and a fishing line (longline).

2.2 Method

Each fish sample was measured for total length, body weight, sex, and then a dissection was performed to measure gut length and obtain sample of the type of food digested. The contents of the fish gut are preserved in 5% formaldehyde before the observation process. The volume of the gut contents is measured by volumetric method of water displacement techniques (Biswas, 1993). Each fish feed sample was taken 3-5 drops and poured into the Sedgwick Rafter Counting Cell, then observed using a 4 × 10 magnification binocular microscope. Each type of food contained in the fish gut is identified and grouped to determine its proportion. Specifically, for feed in the form of fish or pieces of fish, molecular analysis is carried out with the direct sequencing method to determine the species of prey.

2.3 Data analysis

Data analysis included relative intestine length, frequency of occurrence, index of the largest part, and trophic level of shortfin scads.

$$\text{Relative Intestine Length} = \frac{PU}{PT}$$

Where,

PU = Intestine Length (cm)

PT = Body Length (cm)

Relative Intestine Length formula (Nikolsky, 1993);

$$FK = \frac{Ni}{I} \times 100\%$$

Where,

FK = Occurrence frequency

Ni = Organism total quantity

I = total gut contents

Occurrence Frequency (Effendie, 1979);

$$IP(\%) = \frac{Vi \times Oi}{\sum_{i=1}^{n}(Vi \times Oi)} \times 100$$

Where,

Vi = percentage of i-type fish food volume

Oi = percentage of frequency occurrence of type i food

n = number of fish food organisms (i = 1, 2, 3, ..., n)

IP = index of propenderence (%)

Index of preponderance formula (Biswas, 1993);

$$Tt = 1 + \sum\left(\frac{Ttp \times Ip}{100}\right)$$

Where,

Tp = fish trophic level

Ttp = trophic level of the p-food group

Ip = index of the largest share for the p-food group

Trophic level formula (Caddy and Sharp, 1986);

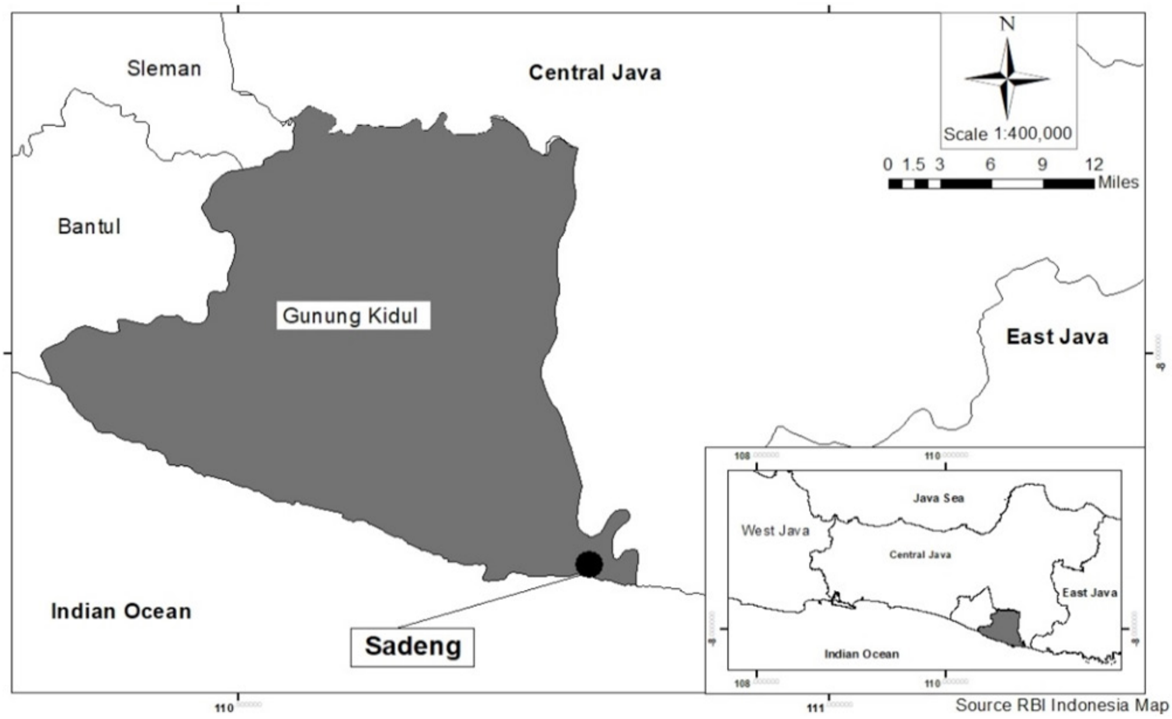

Figure 1. Location of Sadeng Beach, Gunungkidul waters, D.I Yogyakarta indicating sampling site of shortfin scad (*Decapterus macrosoma*).

3. Results and Discussion

3.1 Result

There are 325 shortfin scads gathered from Gunungkidul waters, of those had length between 20.7 – 37.6 cm and weight between 83 – 383 g. The sample that had feed within its gut was 273 (84%), most of them had a length between 25.1 – 27 cm (34.2%) and few were measured more than 31 cm (2.2%). Their weights were measured at 161 – 190 g (25.2 %) and 4.9% were less than 100 g of weight (Table 1).

Table 1. The distribution of length and weight of shortfin scad based on sex

Sex	Quantity (N)	Average Length (min-max) (cm)	Average weight (min-max) (gr)
Male	176	25,6 (20,7–37,6) cm	158,1 (83–383) g
Female	149	26,4 (21,8–31,6) cm	176,1 (97–308) g

The relative intestine length of shortfin scads was between 0.31 – 0.57 and averaging at 0.41 – 0.52 (Table 2). Hence, it classifies shortfin scads as a carnivore. The total intestine lengths of shortfin scads were between 6.4 – 18.2 cm and averaging in 9.2 – 17.3 cm. The longer total intestine length makes the relative length value high as well (Figure 2).

Fish can be found in all of the shortfin scads gut, either in male or female (Occurrence frequency 100%). Other type of food had less than 50% occurrence are as follows; zooplankton (male 36.3%; female 42.2%), phytoplankton (male 24.4%; female 24.2%), prawn (male 21.8%; female 18.9%) and debris (male 2.1%; female 6.6%) (Figure 3).

The food type of shortfin scads consists of 5 groups; fish classified as main food (IBT 84.15%), phytoplankton as supplemental feed (IBT 8.91%), zooplankton and prawn as additional food (each had IBT value of 4.47% and 3.19% respectively), while debris was observed on a negligible level (IBT 0.16%) (Figure 4). Fish as the main food dominates the entire class size of shortfin scads. Phytoplankton such as *Gymnodium* sp., *Leptocylindrus* sp. and *Triceratium* sp. were not found in sizes > 31.1 cm, but can be found in sizes 27.1 – 29.0 cm. *Rhizosolenia* sp. is phytoplankton that has the highest IBT value of 16.71%. Foods such as shrimp and zooplankton were not found in the <23.0 cm size class. Zooplankton types such as copepods show IBT values ranging from 0.235 to 3.173% while crustacean larvae range from 0.001 to 0.115%. Debris was found in fish sizes ranging from 23.1 to 29.0 cm. Younger shortfin scads and more mature shortfin scads experience a change in diet.

Shortfin scads are a type of carnivorous fish in the food chain at Gunungkidul waters (2.75-3.0). The trophic level of shortfin scads based on size class is presented in Table 4. Further identification with molecular methods shows that the main food of Shortfin scads from Gunungkidul waters is *C. saira*. The phylogenetic tree of the *Cololabis saira* species is presented in Figure 5.

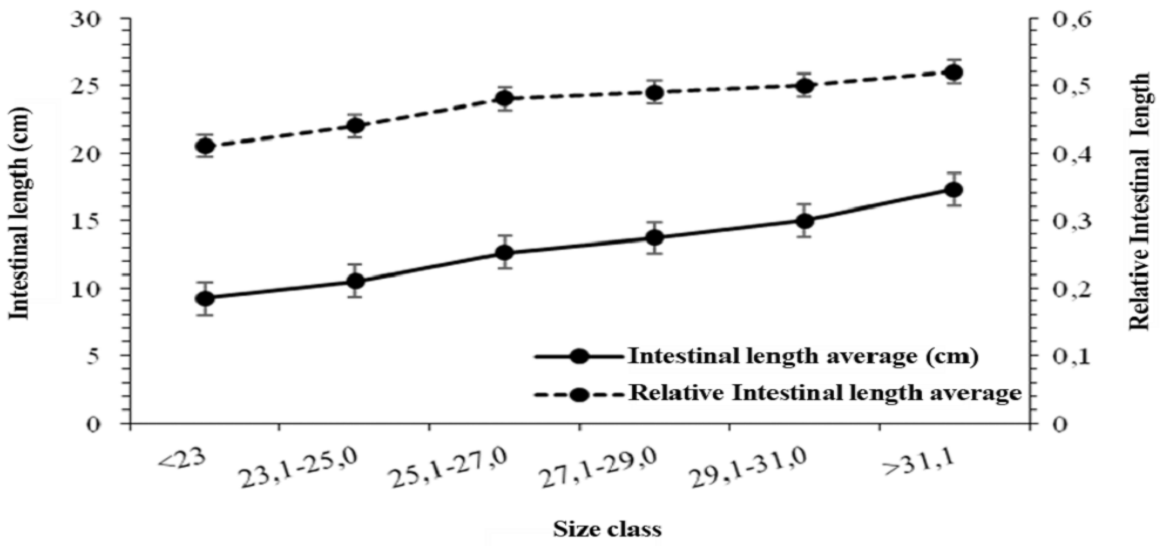

Figure 2. The average of gut length and relative gut length of shortfin scad

Table 2. The distribution of relative gut length of shortfin scad based on size class

Class Size (cm)	Quantity (N)	Intestine Length (cm)	Intestine Relative Length	Notes (Nikolsky, 1963)
<23	20	6,4–12,0	0,31–0,54	Carnivores
23,1–25,0	78	7,8–13,6	0,33–0,57	Carnivores
25,1–27,0	91	9,2–15,5	0,35–0,56	Carnivores
27,1–29,0	57	11,1–15,9	0,40–0,56	Carnivores
29,1–31,0	22	14,3–16,3	0,43–0,56	Carnivores
>31,1	6	16,7–18,2	0,48–0,53	Carnivores

Note: The relative intestine length of fish is divided into three, namely carnivores (<1), omnivira (1-3) and herbivores (> 3).

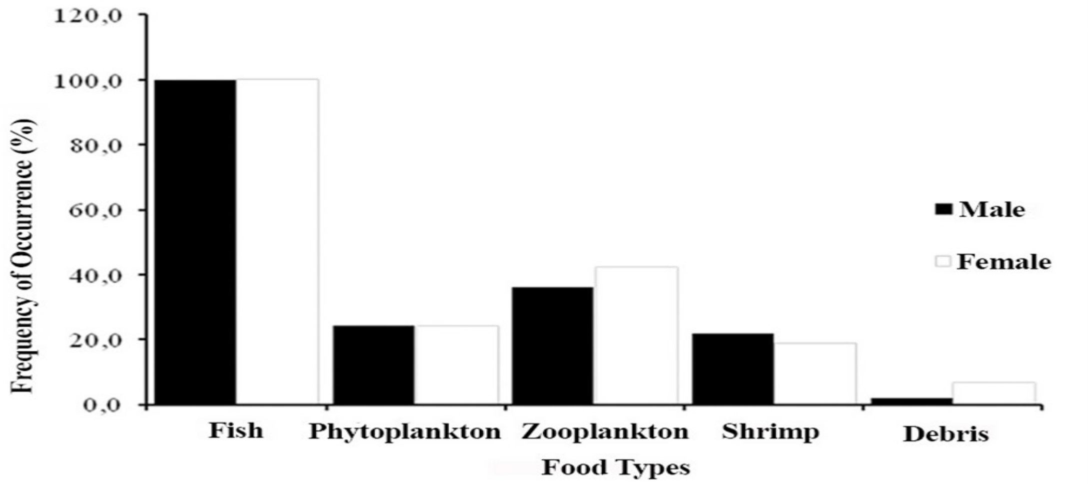

Figure3. The ccurence frequency of shortfin scad

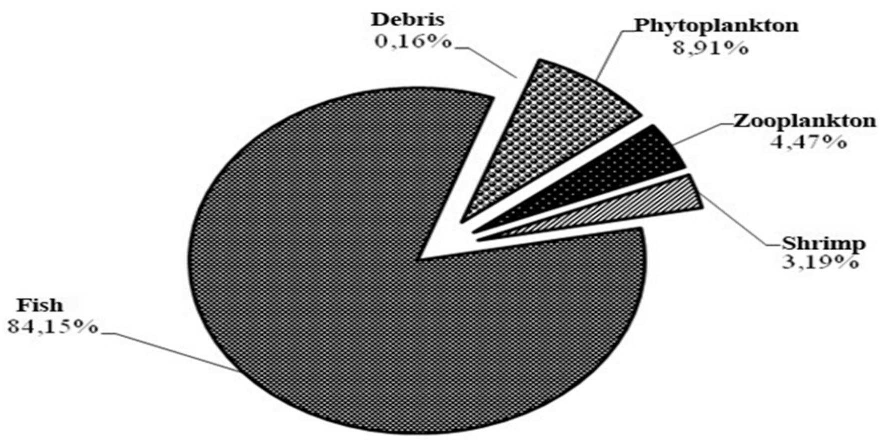

Figure 4. Index of propenderence of shortfin scad

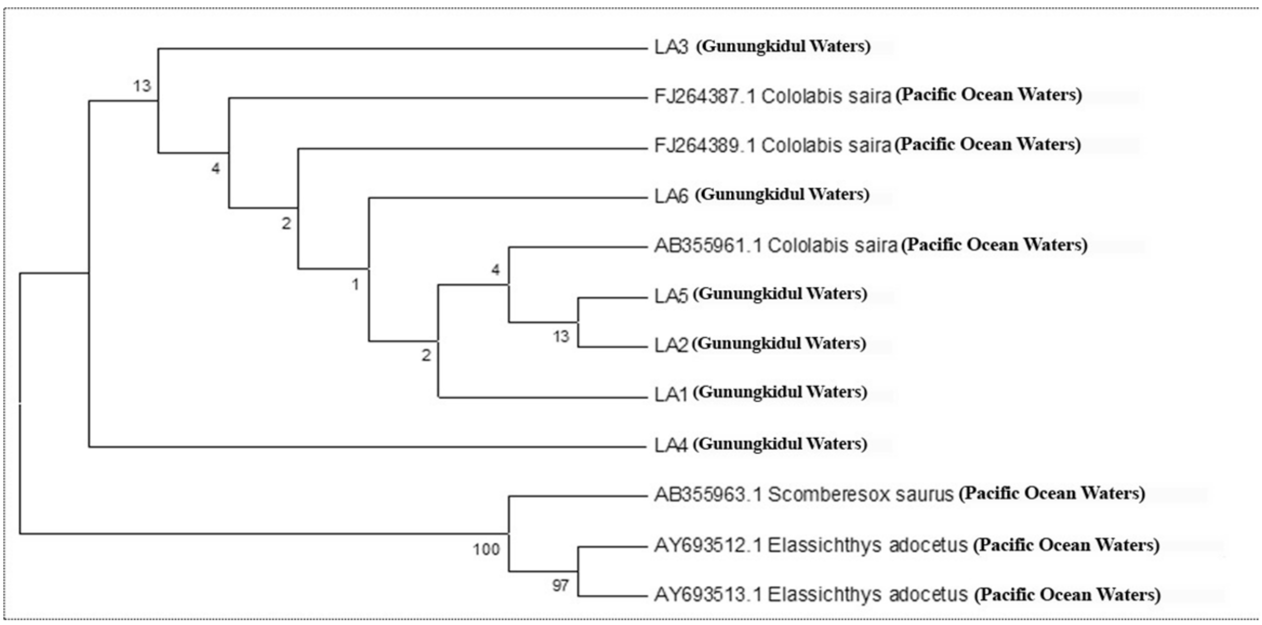

Figure 5. Phylogenetic tree of *Cololabis saira* species consumed by shortfin scad as its main food

Table 3. Index of propenderence of shortfin scad based on size class

Food Type	IBT (%)					
	<23,0	**23,1–25,0**	**25,1–27,0**	**27,1–29,0**	**29,1–31,0**	**>31,1**
Phytoplankton						
Amphisolenia sp.	0,006	0,014	0,281	0,018	0,002	0,075
Chrysonephos sp.	0,000	0,004	0,000	0,033	0,058	0,075
Creseis sp.	0,013	0,011	0,005	0,002	0,008	0,000
Diatoma sp.	0,762	0,629	0,242	0,079	0,290	0,281
Eutintinnus sp.	0,028	0,03	0,009	0,019	0,007	0,014
Frustalia sp.	1,815	0,854	0,990	1,094	1,810	2,159
Gymnodium sp.	0,001	0,000	0,001	0,001	0,004	0,000
Leptocylindrus sp.	0,002	0,012	0,003	0,003	0,004	0,000
Nostochopsis sp.	0,003	0,003	0,016	0,076	0,620	3,680
Oscillatoria sp.	0,003	0,025	0,013	0,004	0,002	0,006
Podolampas sp.	0,008	0,044	0,006	0,002	0,003	0,000
Prorocentrum sp.	0,001	0,009	0,006	0,004	0,000	0,007
Rhizosolenia sp.	12,29	16,71	9,609	4,438	0,778	9,474
Synedra sp.	0,566	2,054	0,147	0,384	0,357	0,580
Thalassiosira sp.	9,258	5,302	2,591	3,266	6,506	9,961
Triceratium sp.	0,000	0,002	0,001	0,001	0,000	0,000
Zooplankton						
Copepod	0,000	0,235	0,219	2,149	1,564	3,173
Crustacean larvae	0,000	0,001	0,012	0,115	0,081	0,035
Prawn	0,000	0,004	0,002	0,109	0,138	0,155
Fish	75,23	75,04	92,11	93,21	90,52	78,72
Debris	0,000	0,002	0,000	0,003	0,000	0,000

Table 4. Trophic level of shortfin scad based on size class

Class Size (cm)	Trophic level	Notes (Cardy & Sharp, 1986)
<23	2,75	Omnivore-Carnivore
23,1–25,0	2,76	Omnivore-Carnivore
25,1–27,0	3,0	Carnivore
27,1–29,0	3,0	Carnivore
29,1–31,0	2,95	Omnivore-Carnivore
>31,1	2,76	Omnivore-Carnivore

Noted: The trophic level of fish can be divided into four categories namely 2.00-2.49 (herbivores), 2.5-2.74 (omnivores), 2.75-2.99 (omnivores-carnivores) and ≥3 (carnivores)

3.2 Discussion

The shortfin scads (*D. macrosoma*) obtained in the waters of Gunungkidul had varying lengths and weights, ranging in length from 20.7 to 37.6 cm and weighs around 83-383 g. Research conducted by Sangadji (2016) in Central Maluku showed that male shortfin scads size ranged from 12.5 to 32.1 cm, while female fish size ranged from 14.5 to 32 cm. Whereas the average length of *Decapterus* spp. in Eastern China waters have a larger size, ranging from 28.6 to 37.1 cm. Biological parameters (length and weight) are highly important to show the growth of fish populations in order to evaluate sustainable fisheries (Jin *et al*., 2015). Factors that influence fish growth include the amount and size of food available, water temperature, dissolved oxygen, fish age, size, and gonad maturity (Nikolsky, 1963). Male and female fish have different growth rates and different migration patterns to meet the needs of food and energy sources (Dhurmeea, 2016).

According to Honebrink (2000), *Decapterus* spp. is a plankton feeder as a prey for small fish and crustaceans. Shortfin scads (*D. macrosoma*) at Gunungkidul waters indicate that both young and adult fish consume small fish and are carnivores with a relatively long intestine length range of 0.31-0.57 cm (<1). Crustacean larvae are found in the class size of 27.1–29.0 cm. Zooplankton, such as copepod and shrimp, are found in the scads gut in all sizes except in the < 23.0 cm size class. According to Ginderdeuren (2014), various types of copepods are found to be the prey for small pelagic fish. Phytoplankton is also found in all size classes, although in small amounts. In fish, specifically an omnivorous- carnivorous adult, the presence of plankton may be an incidental food that is carried into the digestive tract of fish. Nevertheless, the movement of phytoplankton in waters can control and determine trophic level biomass in the structure of marine ecosystems through food webs (Frank *et al*., 2007). The zooplankton community may also function as primary productivity in the food chain because it has a trophic ecosystem function (Richardson, 2008).

The largest part index (IBT) can describe food habits and find out various types of scads' favorite food (Effendie, 1997). The highest feed preference showed that fish (IBT = 84.15%) as the main food shortfin scads in the waters of Gunungkidul. The research of Kulbicki *et al*., (2005) stated that more than 70% of Carangidae fish groups in New Caledonia waters consume fish as the main food. Phytoplankton is consumed as supplement food (IBT = 8.91%) while zooplankton (IBT = 4.47%) and shrimp (IBT = 3.19%) are consumed as complemental food. It allows shortfin scads to eat phytoplankton and zooplankton because, at that time, smaller fish preys on several types of plankton. According to Ory *et al*., (2017), *Decapterus* spp. originating from the South Pacific waters, capture zooplankton in a type of copepod (20%) transparent and blue. Meanwhile, flying fish caught in the waters of Southeast Sulawesi consume 94% zooplankton (Bubun *et al*., 2014). *Decapterus* spp. experience changes in food preferences caused by several factors, including the length, age of fish, availability, and abundance of fish food sources that tend to fluctuate (Pauly & Watson, 2005). The effectiveness of fish in finding prey is also influenced by light intensity, temperature, avoidance behavior of the enemy, the width of mouth opening, food density, and types of food that can be digested by fish (Gerking, 1994). Based on the value of frequency of occurrence, debris eaten by shortfin scads in Gunungkidul waters is 2.1% (male) and 6.6% (female). Debris found in the content of scads gut is fine sand, pieces of ropes, and polymer plastic. The presence of sand in fish gut proves that fish have consumed on benthic organisms (Alatorre-Ramirez *et al*., 2013). Similar results were also found in shortfin scads at Makassar waters, which also found anthropogenic debris (29%) in the form of styrofoam and plastic pieces (Rochman *et al*., 2015). Pelagic fish usually prey based on color, size, and shape to select anthropogenic plastic flakes (Collard *et al*., 2015). The presence of plastic debris that floats on the surface and water column is considered as prey so that predation errors will occur. Choy & Drazen (2013) also added that plastic flakes are ingested in pelagic fish found near the water surface when fish are in the process of being transported onto fishing vessels.

Food composition can be used to estimate the trophic level of fish in an aquatic ecosystem (Hart & Reynolds, 2002). Trophic levels indicate the presence or status of fish and other organisms in food webs (Stergiou *et al*., 2007). Trophic level describes the order of the level of food and energy utilization of primary producers, primary consumers, secondary, tertiary, and top predators (Almohdar & Souisa, 2017). The trophic level of shortfin scads in Gunungkidul waters is 3.01, which shows that shortfin scads are categorized as a carnivore in food webs. Similar results were also found in fly fish in Mangaluru Beach, carnivorous fish that consume shrimp and cuttlefish as main food (Aswini *et al*., 2016). Based on the results of the trophic level analysis, shortfin scads in Gunungkidul waters are included in level IV, while those below are level I: phytoplankton, level II: zooplankton, and level III: small shrimp or small fish. Menard *et al*., (2006) states that in marine ecosystems, large fish are predators of smaller fish so that it suffices nutrient necessity. Therefore, the main prey of fish plays an important key role in food webs (Potie, 2011). In general, small pelagic fish have close links with lower and upper trophic levels in the marine ecosystem; therefore, they become a supporting factor for fisheries (Tiphaine *et al*., 2015).

Fish samples in the gut are analyzed molecularly to determine the type of fish as its main food. The results of the molecular analysis of the fish samples were recognized as *C. saira* (99%; 343/345 bp). Baitaliuk *et al*., (2013) state that *C. saira* are generally of medium size and are often eaten by carnivore fish. Tseng *et al*., (2014) also mentioned that this fish is epipelagic nekton and has a high migration rate to find the food and fulfil their nutrient necessity. The *C. saira* likely became the target of *D. macrosoma* as prey when they migrate through the same route. It is confirmed by Huang (2007) that the Pacific saury (*C. saira*) is found in the high seas and appears the outside the waters of Japan's exclusive economic zone.

The composition of shortfin scads food can be used to learn more about the population, habitat from interactions between prey and predators. The interaction is significantly not only influenced by environmental factors but also intra and inter-species competition in obtaining nutrients. Furthermore, the results are expected to be the basis of environmental management in terms of biological aspects.

4. Conclusion

The composition of shortfin scads food consists of five groups namely fish, phytoplankton, zooplankton, shrimp, and debris. Shortfin scads have different food preferences between juvenile and adult fish. Shortfin scads are carnivorous fish, which consume mostly *C. saira*.

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Authors' Contributions

FL collected the data, drafted the manuscript and designed the figures. RIA and ES devised the main conceptual ideas and critical revision of the article. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare that they have no competing interests

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