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Diet Composition of Bullet Mackerel, *Auxis rochei* (Risso, 1810) in the Coastal Waters of Iloilo, Philippines

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ABSTRACT The diet composition of bullet mackerel, *Auxis rochei* was studied using 200 specimens collected from December 2013 to May 2014 in the coastal waters of Iloilo, Philippines. The size of *A. rochei* ranged from 11.1 to 31.2 cm in fork length (FL). *A. rochei* was epipelagic feeder that consumed mainly fishes. In addition, *A. rochei* consumed shrimps, copepods, crab larvae, amphipods and cephalopods. The diet also included small quantities of stomatopods, bivalves, and ostracods. Also, analysis of the prey-specific abundance against the frequency of occurrence shows that *A. rochei* have a narrow food niche, and are specialized feeder with fish as their dominant prey. Although fishes were the primary in food consumed by all size class. The fishes gradually increased with body size.

Key words : Diet composition, *Auxis rochei*, bullet mackerel, Iloilo, Philippines

INTRODUCTION

The bullet mackerel, *Auxis rochei* (Risso, 1810) (Perciformes; Scombridae), is a pelagic teleost widely distributed throughout the tropical and temperate waters, including the waters of Korea and the Philippines (Kim *et al*., 2005). *A. rochei* is a member of the Scombridae, which include approximately 49 species in 15 genera distributed throughout the world's oceans. The genus *Auxis* contains only two species, *A. rochei* and *A. thazard*. Knowledge of the diet composition of *A. rochei* is necessary for the systematic management and conservation of its stocks, as the species is an economically and ecologically valuable fishery resource in Korea and Southeast Asia, including the Philippines. Many ecological and biological studies of *A. rochei* have been conducted previously, including research into its age and growth on Turkish Mediterranean coasts (Kahraman *et al*., 2011), its seasonal distribution and spawning in the northwestern Mediterranean (Sabatés and Recasens, 2001), the behavior of *A. rochei* schools in nurseries and the catch functions of nursery grounds (Kim and Inoue, 1998), and the molecular identification and morphological development of *Auxis* larvae, including *A. rochei* (Ji *et al*., 2011). The stomach contents of *A. rochei* have been studied by Mostarda *et al*. (2007), Morote *et al*. (2008), Plandri *et al*. (2009), and Jasmine *et al*. (2013) in the southern Tyrrhenian Sea, Mediterranean Sea, Ligurian Sea, and Indian waters, respectively. However, these studies produced fragmentary information on the feeding habits of *A. rochei*. Therefore, this study aims to provide more detailed information on the dietary composition, size-related in diets and feeding strategy of *A. rochei* in the coastal waters of Iloilo, Philippines.

MATERIALS AND METHODS

A. rochei specimens of this study were collected monthly between December 2013 and May 2014 using a purse seine and hook and line in the coastal waters of Iloilo, Philippines (Fig. 1). Iloilo is a province of the Philippines located in the Western Visayas region. The coastal waters of IloIlo were depth about 22 m and annual average temperature was 28.5°C (WST, 2014). After collection, *A. rochei* specimens collected were fixed immediately in

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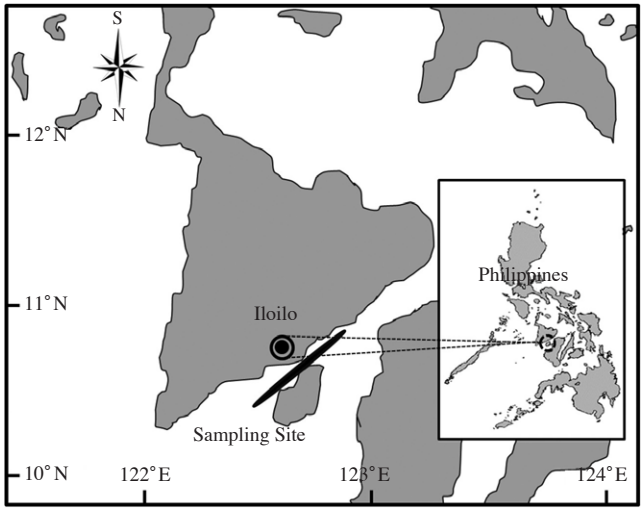

Fig. 1. Location of the sampling area in the coastal waters of Iloilo, Philippines.

10% formalin solution immediately after collection. Fish were brought to the University of the Phillippines Visayas (UPV) laboratory where fork length (FL) was measured to the nearest millimeter (mm). We analyzed 200 *A. rochei* specimens ranging from 11.1 to 31.2 cm (FL). Stomachs were removed and preserved in 10% formalin solution. For each specimen, prey items from the stomach were identified, and counted and weighted. Moisture was removed using dehumidification paper before weighing and then wet weight (the nearest 0.001 g) was measured using an electronic scale. Most prey items in the *A. rochei* stomachs were not fragmented. Some fragmented prey parts were collected and were considered to be parts of a single prey (the head part); prey counts included these considerations.

Diet was quantified by the frequency of occurrence (*%F*), numerical percentage (*%N*), and wet weight percentage (*%W*), which were calculated by the following equations:

$$\%F = A_i/N \times 100$$

$$\%N = N_i/N_{total} \times 100$$

$$\%W = W_i/W_{total} \times 100$$

where A_i is the number of fish preying on a prey species i, N is the total number of fish examined excluding individuals with empty stomachs, N_i (W_i) is the number (wet weight) of prey i, and N_{total} (W_{total}) is the total number (wet weight) of prey individuals.

The index of relative importance (*IRI*) (Pinkas *et al.* 1971) was calculated for each prey item as follows

$$IRI = (\%N + \%W) \times \%F$$

and expressed as a percentage (*%IRI*):

$$\%IRI = IRI_i / \sum_{i=1}^{n} IRI \times 100$$

where n is the total number of food items considered at a given taxonomic level.

To assess the feeding strategy of *A. rochei*, we used the graphical analysis described by Amundsen *et al.* (1996). In mathematical terms, the prey-specific abundance is calculated as

$$P_i = (\sum S_i / \sum S_{ti}) \times 100$$

where P_i is equal to the prey-specific abundance of prey i, S_i the weight of prey i in stomachs, and S_{ti} the total weight of prey in the stomachs of predators that contain prey i.

Size-related in diet were examined by dividing the *A. rochei* specimens into three size classes: small (< 20 cm), medium (20 ~ 25 cm), large (25 cm <).

RESULTS

Among the 200 *A. rochei* stomachs examined, 113 (56.5%) were completely empty and at least ten prey taxa were found in the remaining 87 stomachs (Table 1). The most important prey item of *A. rochei* was fishes, composing 49.4% of the diet by occurrence, 13.7% by number, 74.7% by wet weight, and 65.3% by *%IRI*. At least six fish taxa were identified. In the fish species consumed, *Amblygaster sirm* was the principal prey item. Also, *Lampanyctus* sp., unidentified fishes, *Stolephorus heterolobus*, *Leiognathus leuciscus*, and unidentified fish eggs constituted a portion of the diet. Shrimps were the second largest dietary component, making up 25.3% of the diet by occurrence, 21.3% by number, 8.0% by wet weight, and 11.1% by *%IRI*. Copepods (*%F*=26.4; *%N*=26.7; *%W*=0.6; *%IRI*=10.8) and crabs (*%F*=17.2; *%N*=26.3; *%W*=6.6; *%IRI*=8.5) were the next important prey items. A small portion of the prey items was amphipods, cephalopods, gastropods, stomatopods, bivalves, and ostracods which constituted less than 3.4% of the diet by *%IRI*.

The relative prey importance of *A. rochei* is graphically represented in Fig. 2, where prey-specific abundance (P_i) is plotted against the frequency of occurrence (F_i). Graphical analysis of the diet composition based on the weight showed that the P_i-F_i plot explains a mixed feeding strategy for *A. rochei*: a specialization for fishes and a generalization for other different prey items. Fishes are located in the upper center of the diagram suggesting a specialization by the *A. rochei* population and constituting the most important prey item composing of 88.4% by P_i and 49.4% by F_i of the stomach contents. However, crabs, copepods, shrimps, amphipods, cephalopods, gastropods, stomatopods, bivalves, and ostracods were rare

Table 1. Percentage frequency of occurrence (*%F*), number (*%N*), weight (*%W*) and index of relative importance (*IRI*) of prey species in the diets of *Auxis rochei*

Prey organism	*%F*	*%N*	*%W*	*IRI*	*%IRI*
Crustacean					
Copepoda	26.4	26.7	0.6	772.7	10.8
Ostracoda	1.2	0.1	+	0.1	+
Amphipoda	17.2	10.4	2.8	227.1	3.4
Stomatopoda	4.6	0.2	1.4	7.5	0.1
Macrura	25.3	21.3	8.0	739.7	11.1
Macrura larvae	21.8	20.9	5.3		
Unidentified Macrura	5.7	0.4	2.7		
Brachyura	17.2	26.3	6.6	567.9	8.5
Brachyura larvae	17.2	26.3	6.6		
Mollusca					
Gastropoda	11.5	0.9	0.2	12.8	0.2
Bivalvia	1.2	0.1	+	0.2	+
Cephalopoda	6.9	0.3	5.7	41.1	0.6
Loligo sp.	2.3	0.1	2.6		
Todarodes sp.	4.6	0.2	3.0		
Pisces	49.4	13.7	74.7	4367.7	65.3
Amblygaster sirm	9.2	0.4	26.2		
Lampanyctus sp.	4.6	0.2	18.7		
Leiognathus leuciscus	3.4	0.2	2.8		
Stolephorus heterolobus	1.1	+	12.7		
Unidentified eggs	3.4	11.2	0.1		
Unidentified Pisces	29.9	1.5	14.2		
Total		100.0	100.0	6687.7	100.0

+ : less than 0.1%

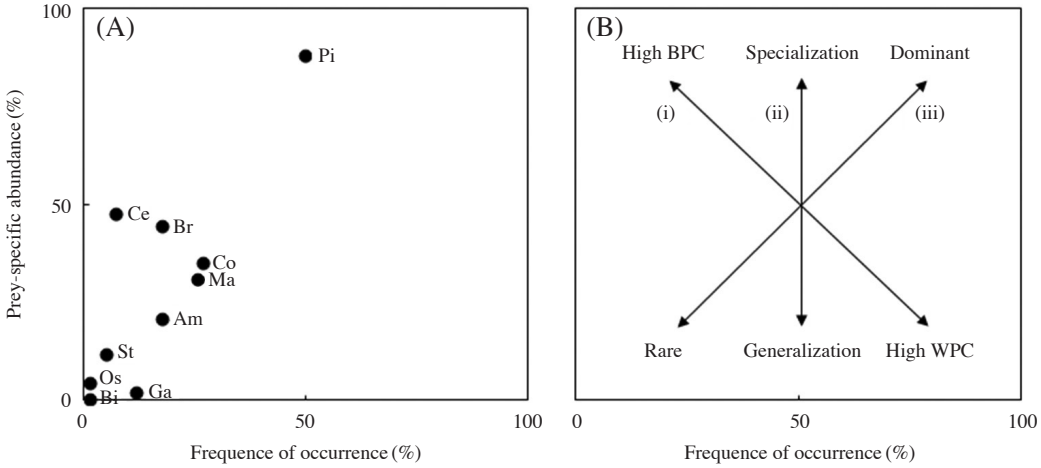

Fig. 2. (A) Graphical representation of feeding pattern of *Auxis rochei* in the coastal waters of Iloilo, Philippines (Pi, Fishes; Ce, Cephalopoda; Br, Brachyura; Co, Copepoda; Ma, Macrura; Am, Amphipoda; St, Stomatopoda; Os, Ostracoda; Ga, Gastropoda; Bi, Bivalvia). (B) Explanatory diagram for interpretation of niche width contribution (axis i, within phenotypic component (WPC) or between phenotypic component (BPC)) of the study population, feeding strategy (axis ii), and prey importance (axis iii).

or unimportant prey items, with low values of P_i (less than 47.9%) and F_i (less than 26.4%).

Fishes were the dominant prey item in all size classes, representing more than 64.3% of the diet by wet weight (Fig. 3). Shrimps contributed more to the diets of small size classes (32.4% of the diet by wet weight). The proportion of shrimps was decreased as body size increased, whereas the consumption of fishes increased gradually.

DISCUSSION

In this study, a high percentage (56.5%) of *A. rochei* stomachs was empty. High percentages of empty *A. rochei*

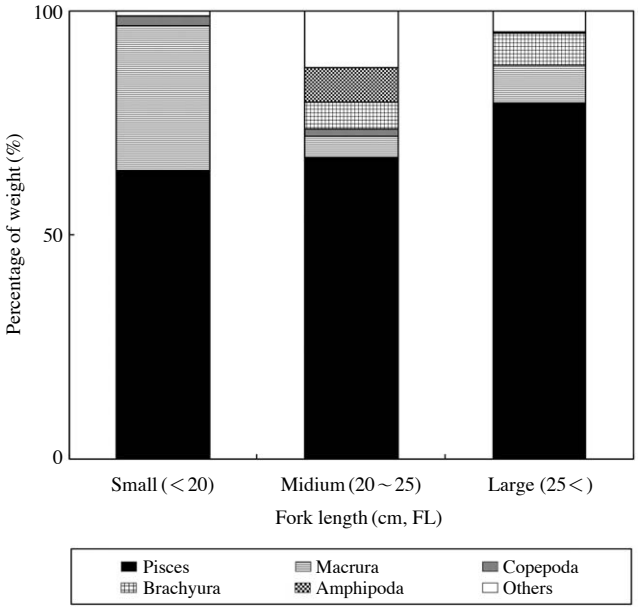

Fig. 3. Ontogenetic changes in the composition of *Auxis rochei* diets.

stomachs in other waters, such as the Ligurian Sea (43.4 %) and Indian waters (60.3%) were also reported by several researchers (Plandri *et al*., 2009; Jasmine *et al*., 2013). This indicates that the high percentage of empty *A. rochei* stomachs could be a characteristic of the species.

A. rochei is an epipelagic offshore carnivore, feeding on various prey items such as shrimps, copepods, crab larvae, amphipods, cephalopods, gastropods, stomatopods, bivalves, and ostracods, while depending primarily on small fish species. Mostarda *et al*. (2007) and Jasmine *et al*. (2013) reported that *A. rochei* foraged mainly on planktonic and small crustaceans in the southern Tyrrhenian Sea and Indian waters, respectively. However, the present study and the study of Plandri *et al*. (2009) from the Ligurian Sea showed different results with the former studies. The most important prey items of *A. rochei* differed between the former two studies (crustaceans) and this work (fishes). Therefore, *A. rochei* is considered an opportunistic carnivore, whose prey are selected on the basis of their availability and geographic abundance (Pihl, 1985; Gkenas *et al*., 2012).

An analysis of prey-specific abundance against the frequency of occurrence showed that *A. rochei* has a narrow food niche, and is a specialized feeder with fish as its dominant prey (Pianka, 1988) as also shown in several other studies of scombridae fishes, such as *Thunnus alalunga* in the central Mediterranean Sea and *A. rochei* in Indian waters (Consoli *et al*., 2008; Jasmine *et al*., 2013). Fishes, the dominant prey item, shows a high prey-specific abundance value (88.4%). Consoli *et al*. (2008) described that the feeding strategy of *A. rochei* could be related to the abundance of dominant prey items and its ability to take advantage of the most profitable food source at a particular time. The exact biomass of fish in the waters investigated in the present study is unknown. However, Mostarda *et al*. (2007) reported that *A. rochei* is an epipelagic offshore predator feeding on whatever abundant resources are available in the environment. Therefore, *A. rochei* in the present study area may feed mainly on fish, because small fish species are abundant in the tropical Philippines waters.

The ontogenetic changes in the diet of *A. rochei* were significant, as in many scombrid fishes (Tomoyuki *et al*., 2011; Shimose *et al*., 2013). Consumption of fishes increased in the large size class. Because larger individuals generally have large mouths, digestive ability improvement, and because they show faster darting and swimming behavior, they may be able to consume a large prey sizes (Hyndes *et al*., 1997; Yoon *et al*., 2008).

ACKNOWLEDGMENTS

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필리핀 일로일로 연안해역에 출현하는 몽치다래(*Auxis rochei*)의 위내용물 조성

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요 약 : 필리핀 일로일로 주변해역에 출현하는 몽치다래(*Auxis rochei*)의 위내용물 조성을 연구하기 위하여 2013년 12월에서 2014년 5월까지 매월 채집하였으며 채집된 몽치다래의 총 개체수는 200개체였다. 이들의 가랑이체장(FL)은 11.1～31.2 cm의 범위를 보였다. 위내용물을 분석한 결과 몽치다래는 어류(fishes)를 가장 선호하는 epipelagic feeder로 나타났다. 어류 다음으로 중요한 먹이생물은 새우류(shirmps), 요각류(copepods), 게유생(crab larvae), 단각류(amphipods), 두족류(cephalopods)로 나타났으며, 갯가재류(stomatopods), 이매패류(bivalves), 패충류(ostracods) 등도 섭식하였지만 그 양은 많지 않았다. 몽치다래의 섭식패턴에 대한 도해적방법의 결과는 몽치다래가 좁은 섭식폭을 가지며, 어류를 주로 섭식하는 specialized feeder임을 보였다. 모든 크기군에서 어류를 주로 섭식하였으며, 크기가 증가함에 따라 어류의 섭식비율이 증가하는 경향을 보였다.

찾아보기 낱말 : 위내용물 조성, *Auxis rochei,* 몽치다래, 일로일로, 필리핀