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Stomach contents and feeding ecology of estuarine fish assemblage from Songkhla Lake Basin, Southern of Thailand

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Abstract
In order to analyze trophic relationships occurring within an estuarine fish assemblage in Songkhla Lake Basin, stomach contents from 5 species of estuarine fishes were examined. Percent by weight (%W) was used to establish trophic organization applying Levins' dietary breadth (Bi) and Pianka's dietary overlap index to evaluate interspecific relationships in fish assemblage. The results showed that two herbivorous and 3 carnivorous species were defined with low dietary breadth; the former (*Scatophagus argus* and *Liza subviridis*) was species whose diet is based mainly on phytoplankton (diatoms and *Oscillatoria*). The latter (*Plotosus canius*, *Arius maculatus* and *Osteogeneiosus militaris*) was largely composed by predators of Phylum Mollusca (bivalve), Annelida (Polychaete) and Arthropoda (shrimps, Amphipods and Thanidacean). Results for feeding ecology presented that estuarine fish assemblage in Songkhla Lake Basins have low diet breath (Bi); Bi value was 0.00 for *P. canius*, *S. argus* and *L. subviridis*, whereas Bi value were 0.45 and 0.43 for *A. maculatus* and *O. militaris*, respectively. For diet overlap, this value was the highest value between *P. canius* and *A. maculata*, moderate value between *A. malulatus* and *O. militaris* and the lowest value between other fish species. These preliminary results suggest partitioning of food resources among five estuarine species, which may favor their coexistence in Songkhla Lake Basin. This may also contribution for resource management and preservation in further.

Keywords: Stomach analysis, feeding habit, Songkhla Lake Basin, resource partitioning, estuarine fish

1. Introduction
Songkhla Lake Basin is the largest natural lake in Thailand. It located on Malaysian peninsula at the southern part of Thailand (Fig.1). This basin covering an area of 1,040 km^2. Despite being called a lake, this water feature is actually a lagoon complex geologically. The basin is surrounded by mountain ranges along the northern to southern sides [1]. The lake is divided into three distinct parts; upper, middle and lower-Songkhla Lake Basin. The northernmost part is the upper-Songkhla Lake basin. The water in this area is freshwater through the year, except during dry period which salinity around 10 psu. Next, middle-Songkhla Lake Basin is second part of Songkhla Lake Basin. It represent a transition between freshwater and marine environments and are influenced by both aquatic ecosystems. Salinity levels are indicative of the position within the mixing zones of an estuary, around 0-20 psu. The southern part opens with a 380 m wide strait to the Gulf of Thailand in the city of Songkhla. Here it contains brackish water about half the salinity of seawater. Songkhla Lake Basin is various ecological ecosystems; freshwater, brackish water and marine ecosystems. In the past, there are more than 770 kinds of aquatic animals and plants observed from Songkhla Lake Basin. However, it number continuously decreasing. In 1999 [2], reported number of fresh water and estuarine fishes in Songkha Lake Basin is around 500 species. However, in 2009, Department of Marine and Coastal Resources Research Center reported that there are 465 species of fishes [3]. Biodiversity of Songkhla Lake Basin decreased as mentioned earlier, resulting from overfishing from last decade. Natural resources management and conservation are urgent requirement. To do that, diversity, biology and ecology of fish are importance for natural resource management. All of them, feeding ecology is quite an importance as well. Feeding habit and feeding ecology research are basic tool to understand role of fish in ecosystem since they indicate relationships based on feeding resources and indirectly indicate community

energy flux [4]. In addition, they also show understanding competition and predation effects on the community structure of organism in ecosystem [5]. Various researchers have worked on stomach content and feeding ecology of fish from Songkhla Lake Basin [6, 7]. However, nothing about feeding ecology of fishes assemblage in Songkhla Lake Basin. Therefore the objective of this study was to investigate stomach content and feeding ecology of fish assemblage in Songkhla Lake Basin. In addition, to suggest possible mechanisms for their coexistence. That will be impacted to resource management and conservation.

2. Materials and Methods

a. Sample site and fish collection

Fish samples were collected bimonthly from March – September 2019 at Nang Kham Island, middle Songkhla Lake Basin. The fish sample bought from local fishermen who operate local fisheries gear such as barrier nets. After collection the fishes were preserved immediately in ice box to preserve further digestion of food and to stop enzymatic activity of the gut content. Then, fish samples were transfer to the laboratory for further analysis [4].

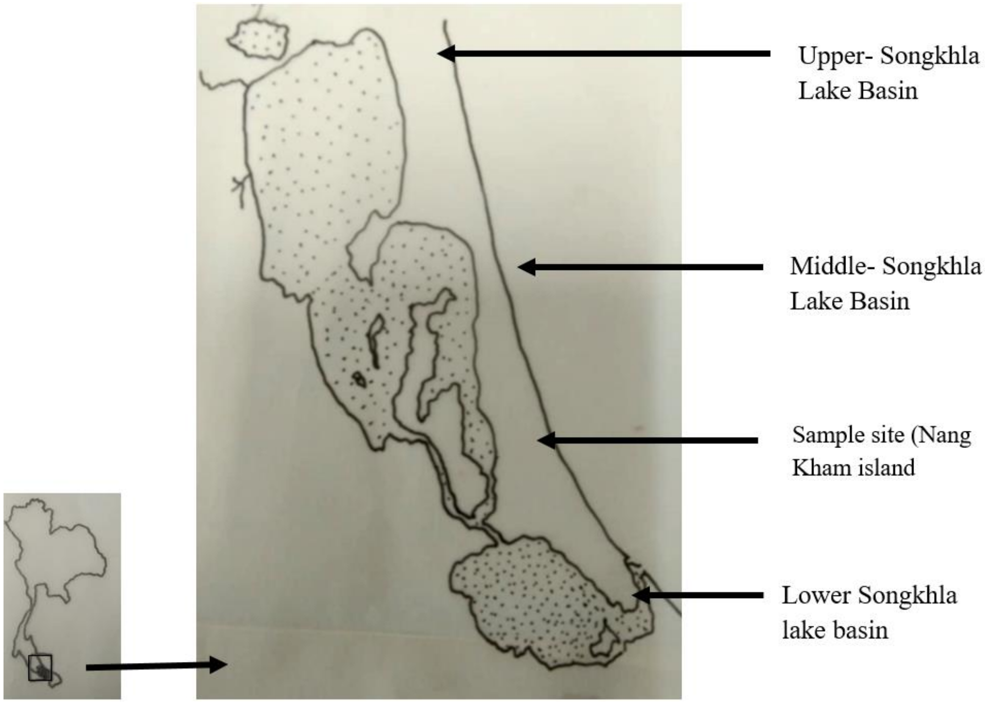

Fig 1: Songkhla lake basin map showing sample site

b. Laboratory analysis

In laboratory, fishes were identified to species level. Their stomachs were removed and preserved in 10% buffer formalin for 5 days, soaked in tap water overnight before transferred and stored in 70% ethanol. To analysis stomach, individual stomach was cut open in a petri dish with the aid of surgical scissors. The entire stomach was removed and stomach contents were examined under stereomicroscope. Each food items was identified and weighted [4, 8].

c. Data analysis

% composition Weight ratio of each food items (%) is the percentage of each food items to all food items in stomach and multiply with 100.

2.1 Diet breadth (Bi)

Diet breadth was calculated using Levin's standardized index [9]. The formula for this index is as follow;

$$\text{Bi} = \left(\frac{1}{n-1}\right)\left[\left[\frac{1}{\sum_{i,j=1}^{n} p_{ij}^{2}}\right] - 1\right]$$

Where Bi = ค่า Levin's standardized index for fish species "I"; P_{ij} = proportion of diet of fish 'I' that is made up of prey 'j'; N = number of prey categories.

2.2 Diet overlap

Diet overlap was the proportional dietary overlap between two fish species and was calculated by Morista-Horn index [10]. Definition of the rate of overlap was modified from Langton (1982); low overlap 0.00-0.29, moderate overlap 0.30-0.59 and high overlap 0.60-1.00. the formula for the Morista-Horn index was;

$$C_H = \frac{2(\sum p_{ij} p_{ik})}{\sum p_{ij}^2 + \sum p_{ik}^2}$$

Where C_H = Morisita-Horn index of overlap between species 'I' and 'k'; P_{ij} = proportion food 'I' of the total food used by species 'j'; P_{ik} = proportion of food 'I' of the total food used by species 'k'; n = number of total food items.

3. Results

3.1 Stomach contents

Stomach content of five fish species were showed in Table 1. The food items were grouped as phytoplankton (Diatoms and *Oscillatoria*), Mollusca (Bivalve), Annelida (Polychaete), and Arthropoda (shrimps, Amphipods and Thanidacean) (Fig. 2). Mollusca (bivalve) was the main item for fishes assemblage consist of 39.21% of stomach content. Phytoplankton, Diatoms and *Oscillatoria*, ranged second position (20% for each food items). Polychaete ranged third position (11.67%).

While Thanidacean, Amphipods, and shrimps were less than 10% (Fig.3).

For each fish species, *Scatophagus argus* and *Liza subviridis* were phytoplankton feeders. *Scatophagus arcus* preferred *Osscilatoria* while *Liza subviridis* feed on Diatoms. On the other hand, three other fish species are carnivorous, they feed on animal preys. Catfish, *Plotosus canius*, feed on bivalve. Stomach contents for *Arius maculatus* and *Osteogeneiosus militaris* were similar, feed on Mollusca (bivalve), Annelida (Polychaeta) and Arthropoda (shrimps, Amphipods and Thanidacean). However, main food items for *Arius maculatus* was bivalve (62.08%), followed by Polychaeta (28.72%). While *Osteogeneiosus militaris* preferred Bivalve (45.33%), Polychaeta (39.49%), and Thanidacean (31.44%).

Table 1: Stomach of fishes from Songkhla lake basin during March-September 2019.

Food items	groups	*Plotosus canius*	*Scatophagus argus*	*Arius maculatus*	*Osteogeneiosus militaris*	*Liza subviridis*
Phytoplankton	*Osillatoria*		100			
	Diatoms					100
Mollusca	Bivalve	100		62.06	45.33	
Annelida	Polychaeta			28.72	39.49	
Arthropoda	Shrimps				2.88	
	Amphipods			9.22		
	Thanidacean				31.44	

Fig 2: Food items in stomach content; (a) phytoplankton (diatoms), (b) phytoplankton (*Oscillatoria*), (c) Mollusca (bivalve), (d) Annelida (Polycahete, (e) Arthropoda (Amphipod and (f) Arthropoda (Thanidacean).

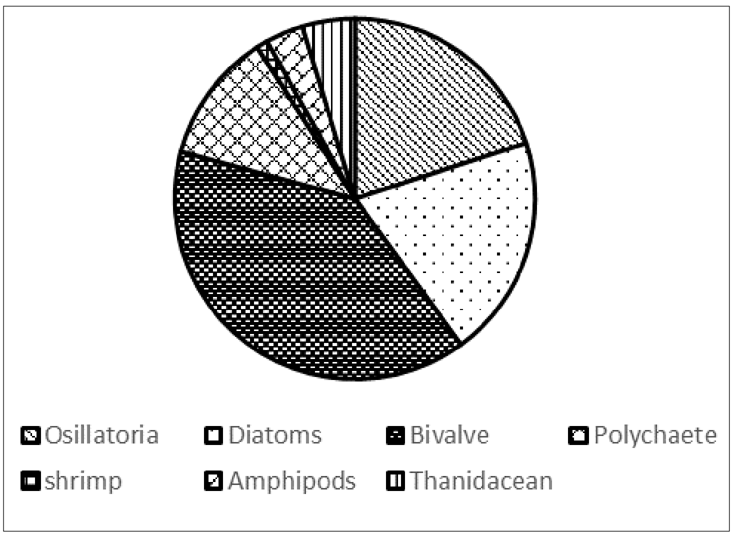

Fig 3: The proportion of food item in fish assemblage from Songkhla lake basin during study period.

3.2 Temporal variation in stomach content of estuarine fishes

Temporal changed in stomach content composition could not observed during the study period for *P. canius*, *S. argus* and *L. subviridis*. They feed on bivalve, *Oscillatoria* and Diatoms, respectively. On the other hand, some of them, *A. maculatus* and *O. militaris*, presented seasonal variation in stomach content composition (Fig. 4-7). For *A. maculatus*, bivalve was the main food item in stomach content during March-May. Its switch to Polychaete during July and change back to bivalve again in September. In contrast, *O.militaris* feed on Polychaete during March – May. Amphipods and Tanidacean were the main food item in July. Preferred food items in *O.militaris* in September was bivalve.

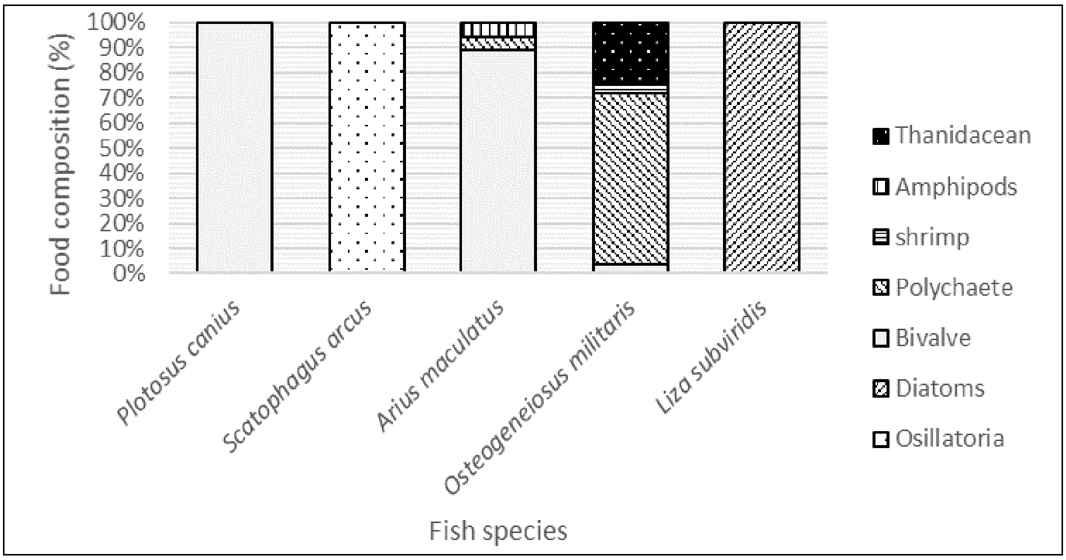

Fig 4: Stomach content composition (%) for estuarine fishes from Songkhla lake basin during March 2019.

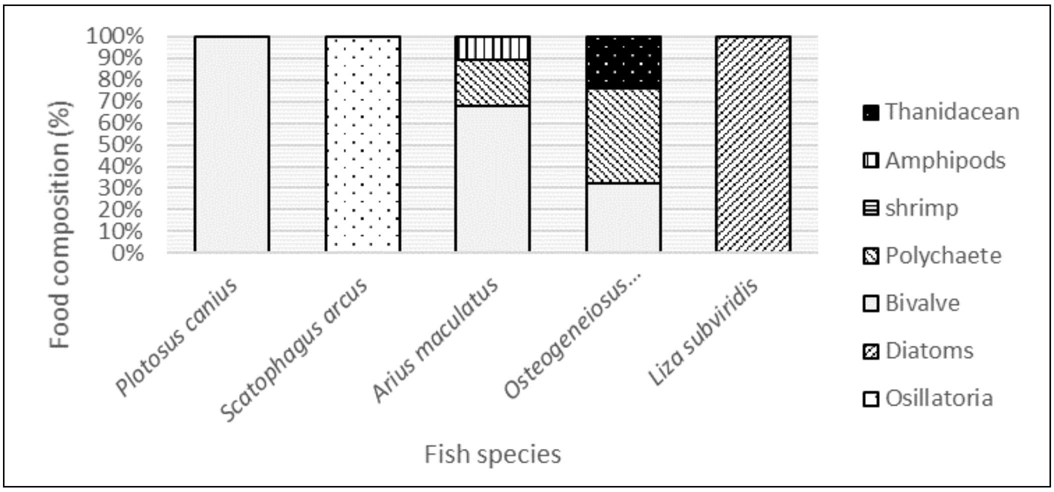

Fig 5: Stomach content composition (%) for estuarine fishes from Songkhla lake basin during May 2019.

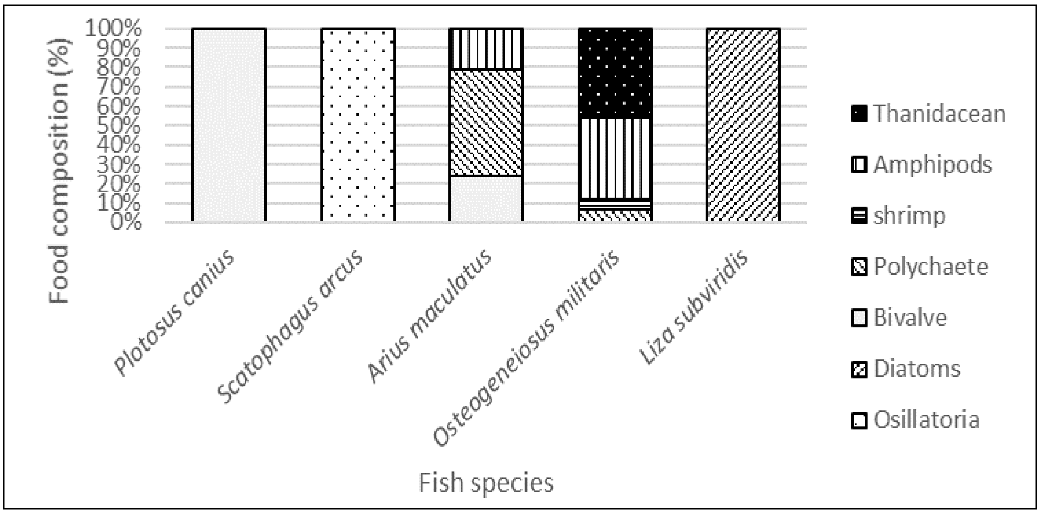

Fig 6: Stomach content composition (%) for estuarine fishes from Songkhla lake basin during July 2019.

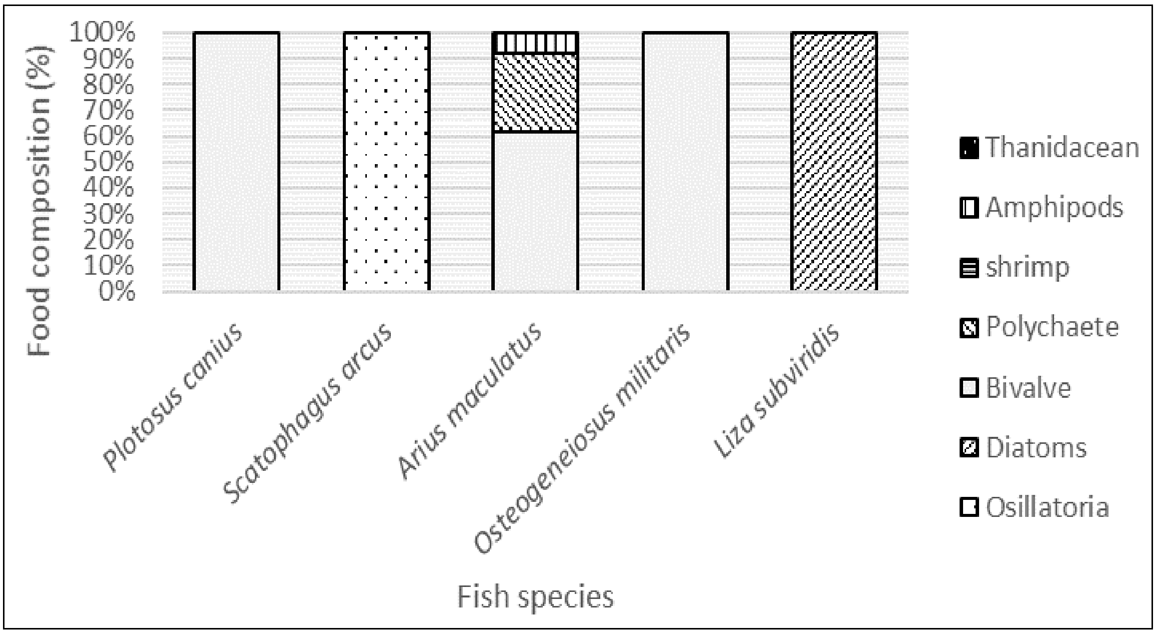

Fig.7: Stomach content composition (%) for estuarine fishes from Songkhla lake basin during September 2019.

3.3 feeding ecology

3.3.1 Diet breath and diet overlap

Both two species, *A. maculata* and *O. militaris*, had the broadcast diet breath (0.45 and 0.43), whereas *P. canius*, *S. argus* and *L.subviridis* presented the narrowest feeding spectrum (0.00) (Table 2). Table 3. show diet overlap for fish assemblage during study period. *P. canius* and *A. maculata* showed highest diet overlap (0.99). *A. maculate* and *O. militaris* had moderate diet overlap (0.55). On the other hand, other fish species were the lowest diet overlap (<0.29).

3.3.2 Feeding habits

From present study, *S. arcus* and *L. subviridis* were herbivorous. *L. subviridis* living in the midwater or surface water, since this fish species feed on Diatoms. While *S. argus* was mid-water column. Other three fish species were carnivorous fish, feed mainly on animal prey. *P. canius* feed mainly on benthic fauna, bivalve, that mean this fish species living on bottom sediment.

Table 2: Diet breath (Bi) for each species from Songkhla lake basin during study period.

Month	*Plotosus canius*	*Scatophaus argus*	*Arius maculatus*	*Osteogeneiosus militaris*	*Liza subviridis*
March	0.00	0.00	0.13	0.30	0.00
May	0.00	0.00	0.49	0.92	0.00
July	0.00	0.00	0.74	0.50	0.00
September	0.00	0.00	0.51	0.00	0.00
mean	0.00	0.00	0.45	0.43	0.00

Table 3: Diet overlap for fish assemblage from Songkhla lake basin during study period.

Liza subviridis	**0.00**	**0.00**	**0.00**
Osteogeneiosus militaris	0.27	0.00	0.55
Arius maculatus	0.99	0.00	
Scatophagus argus	0.00		
	Plotosus canius	*Scatophagus argus*	*Arius maculatus*

4. Discussion

Liza subviridis and *Scatophacus argus* were herbivorous feeder, they feed on phytoplanktons, Diatoms and *Oscillatoria*, respective. This result agree with previously works [11-13]. Both of them were stayed at the surface water, since they feed on phytoplankton. While other fish species were carnivorous, feed on animal preys such as bivalve, shrimp, Polychaete and Thanidacean. This result proposes that all of them are bottom feeders. *Plotosus canius, Arius maculatus* and *O. similaris* have been reported as bottom feeds in many aquatic ecosystems [6, 12, 7, 14, 15]. Our results showed that a potential for strong species interactions between estuarine and benthic fauna. Carnivorous predation could effects of population size of animal prey such as shrimp and bivalve. Benthic fauna community is the most important prey organism in Songkhla lake basin since they are very abundant in this area [16].

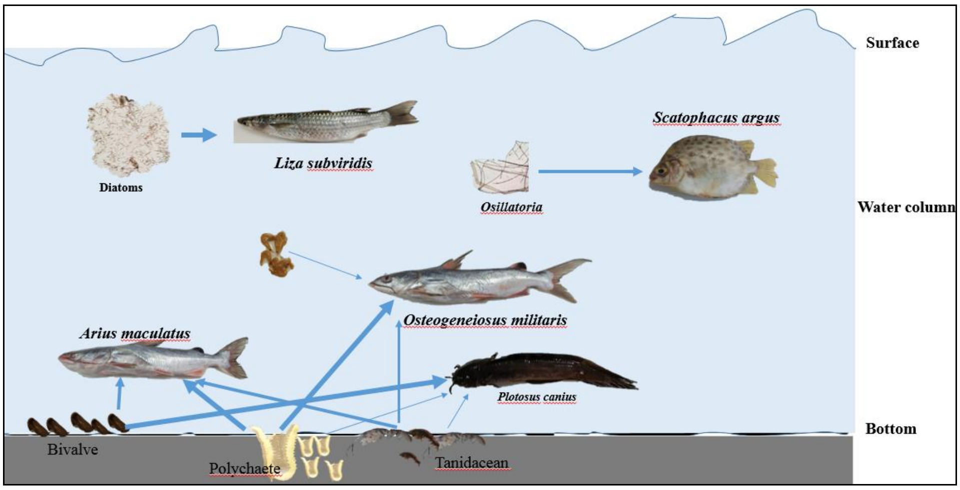

Fig 8: Feeding habit and its relation in ecosystem.

Our results showed that the diet of fishes, *P. canius, S. argus*, and *L. subviridis*, did not undergo pronounced seasonal changes. The lake of seasonal changes in diet may be attributable to relatively little seasonal fluctuations in food resource abundance at the study site, as also reported in other tropical coastal waters [17, 18]. This result suggesting that these fishes were specialist feeders.

From the present study, fish in estuarine ecosystem assemblage were feed in different food items. There is a potential for weak species interactions among the estuarine assemblage. This fish assemblage can coexist by reducing the degree of competition for food. Food partitioning is one of the several ways for reducing food competition. Small differences in preference for secondary prey items such as polychaete, amphipods, and shrimps may moderate intraguild competition in fish assemblage [19]. However, the overlap in diet composition in three fish species was recognized during the study period, although the main food items was somewhat different between species, suggesting that there is little or no composition between these fishes species in Songkhla Lake Basin. Several studies has demonstrated that diets among related cohabiting fishes greatly overlap where food sources are relative abundance, while lower food abundance results in greater trophic or habitat segregation through interspecific composition [20, 19]. The considerable diet and habitat overlap in Songkhla Lake Basin among carnivorous species at this lake may be due to the relative abundance of food resources.

Diet breadth values found were very low for most specie (0.00-0.45) that means most of fish species focused on only one food resource. One factor corresponding for low diet breath value is prey availability because when it is abundant, breadth trends to be very low [4]. Which is related to habitat structural complexity. Our low dietary breadth value in estuarine may be a species response to decreasing availability of food resources due to high fisheries efforts in estuarine. This reduction in dietary breadth would be a specialization mechanism toward the optimums resource of each species; thereby increasing coexistence possibilities [21].

This study showed the feed preference of estuarine fish assemblage and provides a better standing regarding their ecological roles in the Songkhla lake basin in Sothern of Thailand. This may also assist with their management and preservation.

5. Conclusion

In summary, phytoplanktons and benthic fauna were the most importance for five species from Songkhla Lake Basin. *Scatophagus argus* and *Liza subviridis* were herbivorous; feed on *Oscillatoria* and diatoms. Whereas, three other fish species were carnivorous, feed mainly on bivalve, Polychate and Thanidacean. Low diet breath value were observed for *Plotosus canius, S. argus* and *L. subviridis*, whereas it moderate for *Arius maculate* and Osteogeneiosus *militaris*. Besides, the diet overlap was only observed for *C. canius*, *A. maculatus* and *O. militaris*. Our results suggest that there are food partitioning in estuarine fish assemblage in Songkhla Lake Basin.

6. Acknowledgment

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