Trophic ecology and length-weight relationship of *Hypoatherina temminckii* (Bleeker, 1854) in the seagrass ecosystem of Semak Daun Island, Kepulauan Seribu

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Abstract. Semak Daun Island is commonly used as a tourist destination site in the Kepulauan Seribu Marine National Park. Seagrass beds are found along the coast of this small island and have an essential role as shelter and feeding areas for various aquatic biotas, such as small-sized fishes of Samoan Silverside, *Hypoatherina temminckii*. Samoan silverside is usually used as bait in the tuna fishery. The present study aimed to determine growth pattern, diet composition, trophic level, guild, and feeding strategy of Samoan silverside in the seagrass ecosystem of the Semak Daun Island. Fish samples were captured using seine net monthly from February 2018 to March 2019. A total of 1,481 *H. temminckii* were collected, and all were juvenile. Results indicate that juveniles of Samoan silverside feed mainly on zooplankton and shows specialist predator as its feeding strategy. Moreover, this species occupies trophic levels ranging from 3.00-3.99 and exhibits a positive allometric growth pattern. Thus, the current study confirms that the seagrass ecosystem of the Semak Daun Island is the nursery and feeding grounds for the juvenile of Samoan silverside.

1. Introduction

Semak Daun Island is situated in the Kepulauan Seribu, Marine National Park, commonly used as a tourism spot. [1] stated that the waters of Kepulauan Seribu, including the Semak Daun Island, are vulnerable due to various pollution threats. The pollution from tourism activities like camping and snorkeling can directly affect the sustainability of the aquatic ecosystem of this island, including the seagrass ecosystem.

The seagrass ecosystem is a habitat for many marine organisms, both nursery habitat and feeding ground [2,3]. Seagrass ecosystem especially holds a vital role for juvenile fishes as nursery ground [4]. Not only for fishes, the seagrass ecosystem is also a habitat for various invertebrate biotas and algae. Moreover, [5] explained that macrozooobenthic biotas have a higher diversity in the habitat vegetated with seagrass than the other non-vegetated areas.

The seagrass ecosystem provides a habitat for juvenile fishes because this ecosystem can be used as a shelter and an area to find some food [6]. It has also been proven by [7] that many fish species enhanced their biomass in the seagrass ecosystem. Several organisms associated with seagrass can
become natural food resources for fishes, such as zooplankton and crustaceans [8], meiofauna like Copepods, Polychaetes, Foraminifera, Nematodes, Ostracods, Isopods, Mollusks, and Amphipods [9]. [10] states that zooplankton in the seagrass ecosystem has a high diversity in the open waters that can be consumed by fish juvenile.

One of the fish species found in the seagrass ecosystem of Semak Daun Island is Hypoatherina temminckii. However, there is no information about the functional role of Hypoatherina temminckii in the seagrass ecosystem of Semak Daun Island. Therefore, the present study intended to determine diet composition, trophic level, trophic guild, feeding strategies, and biological condition of H. temminckii in the Semak Daun Island, Kepulauan Seribu.

2. Materials and Methods

2.1 Sampling time and location

This research was conducted monthly from February 2018 to March 2019, represents rainy, dry, and transition seasons. The rainy season occurred from February to March 2018 and December to March 2019; the first transition season was from April to May 2018; the dry season was from June to September 2018, and the second transition season occurred from October to November 2018. Sampling was carried out in three zones of seagrass ecosystem in the Semak Daun Island, namely north, east, and south of the Semak Daun Island (Figure 1).

![Figure 1. Semak Daun Island, Kepulauan Seribu](image)

2.2 Fish sampling and seagrass identification

Hypoatherina temminckii was caught using a seine net with a mesh size of 3 mm, and its dimension is 10 m x 1 m. Two people operate the seine net using a swept area technique. The sampling area of the net was approximately 50 m² with a frequency of swept in each zone. The fish samples were preserved using formalin 10% for 3-4 hours and rinsed using clean water before sorting. The sorted fish were then immersed into a sample bottle containing 80% ethanol and analyzed at the Macro-biology Laboratory, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, IPB University. Seagrass species were identified directly on Semak Daun Island when the sampling process was held. Identification of seagrass and percentage of seagrass’s coverage refer to [11].

2.3 Sample analysis

Fish samples were identified to the lowest taxon based on [12]. Fish body weight and body length were measured. Then, each specimen's digestive tract was removed from the body cavity. The fish stage was determined by comparing the body length with the size when the fish reached gonad
maturity (Lm) [13]. The digestive tract of fish was preserved in 4% formalin. The food item was identified using book references [14,15].

2.4 Data analysis

2.4.1 The Relative Importance Index (IRI). The Relative Importance Index (IRI) is used to evaluate the relationship between different types of food found in the digestive tract of fish. This index is calculated using the equation [16] to determine the composition of certain types of food consumed by fish. The highest composition of a particular type of food indicates the primary food type of fish, which is then used to determine the fish's trophic guild.

\[ IRI = (N+V) \times F \]  

IRI = index of relative importance
N = numerical percentage
V = volumetric percentage
F = frequency of occurrence percentage

2.4.2 Trophic guild. [17] divide the trophic guild of fish communities into three groups: detritivores, herbivores, and carnivores. The herbivorous fish group is divided into phyto-planktivore (phytoplankton feeders) and algivore (macro-alga feeders). The carnivorous fish group is divided into zooplanktivore (zooplankton feeders), zoobenthivore (zoobenthos feeders), and piscivore (fish feeders).

2.4.3 Trophic level. The trophic level is used to determine the position of fish on the trophic level in the seagrass ecosystem of Semak Daun Island. This value was analyzed using the Trophlab software by inputting the IRI value data obtained for each type of food found in H. temminckii's stomach content.

2.4.4 Feeding strategy. Determination of fish feeding strategy through analysis of the specific abundance of food organisms in the modified Costello formula [18].

\[ P_i = \left( \frac{\sum S_i}{\sum S} \right) \times 100 \]  

Pi = Specific abundance of prey i
S = Stomach content of fish comprised of prey i
St = The total stomach in only those fish with prey i in their stomach
i = food organism, for example Copepod.

The value of the specific abundance of the food organism (y-axis) is related to the presentation of the frequency of occurrence of the food (x-axis) plotted on the graph as follows (Figure 2).
2.4.5 Fish length-weight relationship. The length-weight relationship of H. temminckii was calculated using the equation below.

\[ W = aL^b \]  

Where \( W \) is the weight of the fish (grams), \( L \) is the length of the fish (mm), and \( a \) is constant (intercept), and \( b \) is exponent or growth coefficient. The growth pattern of fish is known by comparing \( t_\text{arithm} \) and \( t_\text{tab} \), if \( t_\text{arithm} < t_\text{tab} \) is isometric with the addition if \( b < 3 \) indicates the growth pattern is negative allometric, and vice versa [19].

3. Results

3.1 Hypoatherina temminckii

H. temminckii (Figure 3) is taxonomically derived from the order Atheriniformes and the family Atherinidae. It has a silvery and elongated body, with a separated dorsal fin and a line extending from the pectoral fin to the caudal fin. It was caught in both schooling and solitary formations in the seagrass ecosystem of Semak Daun Island.

3.2 Trophic ecology of Hypoatherina temminckii

The trophic attributes of H. temminckii, including the occupancy status, length and weight range, trophic guild, trophic level, and feeding strategy, are shown in Table 1. Although the length and weight were adequately diverse, all the H. temminckii caught were juvenile.
Table 1. Trophic attributes of *Hypoatherina temminckii*

| Month-year | Season | N   | n   | L     | W       | Trophic Guild   | Trophic Level |
|------------|--------|-----|-----|-------|---------|-----------------|---------------|
| Feb 2018   | Rainy  | 201 | 64  | 9.47  | 0.018-1.27 | Zooplanktivore  | 3.2           |
| March      | Rainy  | 126 | 50  | 12.25 | 0.01-0.24  | Zooplanktivore  | 3.39          |
| April      | T-I    | 761 | 41  | 13.47 | 0.01-1.29  | Zooplanktivore  | 3.01          |
| May        | T-I    | 228 | 47  | 11.35 | 0.03-0.8   | Zooplanktivore  | 3.05          |
| July       | Dry    | 57  | 50  | 10.40 | 0.03-1.6   | Zooplanktivore  | 3.25          |
| August     | Dry    | 20  | 20  | 16.31 | 0.03-0.44  | Zooplanktivore  | 3.01          |
| September  | Dry    | 44  | 44  | 20.34 | 0.1-0.54   | Zooplanktivore  | 3             |
| November   | T-II*  | 0   | 0   | 0     | 0         | -               | -             |
| December   | Rainy  | 21  | 21  | 15.56 | 0.04-3.18  | Zooplanktivore  | 3.01          |
| Feb 2019   | Rainy  | 2   | 2   | 15.21 | 0.04-0.1   | Zooplanktivore  | 3             |
| March      | Rainy  | 23  | 22  | 17.26 | 0.1-0.22   | Zooplanktivore  | 3.07          |
| Total      |        | 1481| 360 | 9-56  | 0.01-3.2   |                 | 3.00 - 3.39   |

Information: T-I, T-II= Transitional season I, II; L= the range of total length (mm), W= the range of body weight (g), N= the number of fish caught, n= the number of fish observed for diet and trophic analysis.

*H. temminckii* belongs to the zooplanktivore with a trophic level ranging from 3.00 to 3.39 (Table 1). Zooplankton is the organism most eaten by Samoan silverside in all seasons (*Cymbaloporetta*, IRI=31.3-80.8%). The diet composition of *H. temminckii* is presented in Figure 4. The figure shows a difference in the diet composition for each season, but the main food was the same.

![Figure 4](image)

Figure 4. Diet composition of *Hypoatherina temminckii* in a different season

The types of food consumed by *H. temminckii* were grouped into seven groups: detritus, macroalgae, phytoplankton, zooplankton, zoobenthos, crustaceans, and mollusks. The group of macroalgae diet consists of seagrass leaves and algae, which were existed in the seagrass ecosystem of Semak Daun Island. The group of zooplankton food types consists of copepod zooplankton and planktonic foraminifera, which were abundant in the stomach content of *H. temminckii*. The group of zoobenthos diet consists of benthic crustaceans, benthic foraminifera, and insect larvae, while the mollusks group consists of gastropods.

The feeding strategy of *H. temminckii* was specialist to mixed (Figure 5). The majority of *H. temminckii* fed on certain food organisms, such as *Oncaea* sp. (x= 23.87%, y= 91.2%), algae (x= 17%, y= 72.34%), *Cymbaloporetta* sp. (x= 45.8%, y= 38.33%), and *Sapphirina* sp. (x= 22.5%, y= 53.98%)
in the rainy season, *Cymbaloporetta* sp. (x= 68.4%, y= 84.8%) in the dry season, whereas *Mysis* (x= 17.07%, y= 88.26%) and *Cymbaloporetta* sp. (x= 67%, y= 68.2%) in the first transitional season.

![Figure 5](image)

**Figure 5.** Feeding strategy of *Hypoatherina temminckii* in a different season

### 3.3 Length-weight relationship of *Hypoatherina temminckii*

The number of *H. temminckii* caught during the sampling period in the seagrass ecosystem of Semak Daun Island was 1,483 individuals. The number of fish caught each month was very varied, which the highest number in April 2018 (761 fishes) and the lowest was in February 2019 (2 fishes). *H. temminckii* was not caught in November 2018. The total length range was between 9-56 mm, and the range of weight body was 0.01-3.2 g. The length-weight comparison derived were \( W = 5E-06L^{3.3346} \) with \( R^2 = 0.9123 \) (Figure 6). Comparison of t-test and t-tabs resulted that the growth pattern of *H. temminckii* was positive allometric, with \( b > 3 \).

![Figure 6](image)

**Figure 6.** Length-weight relationship of *Hypoatherina temminckii*

### 4. Discussion

Seagrass in Semak Daun Island comprises *Thalassia hemprichii, Syringodium isoetifolium, Halodule uninervis, Enhalus acoroides*, and *Cymodocea serrulata* species. These types were also found in the research conducted by [20] on the same island and adjacent sampling times. The types of seagrass found by [20] were *Halophila ovalis, T. hemprichii, C. rotundata, S. isoetifolium*, and *H. uninervis*. The different types of seagrass found might occur due to differences in the checkpoint of seagrass sampling locations.

During the study, seagrass density on Semak Daun Island was moderate, only 27% to 43%. The condition of seagrass cover is very important for fish survival, considering that seagrass can provide shelter for invertebrates and fish juveniles from predators. The relationship between seagrass and the organisms in it is described by [21], where the denser the seagrass cover in the waters, the wider the attachment place for invertebrate animals, so that the biomass will be high. This statement shows that
seagrass supports the life of fish as the object of research and the life of various other animals that will also be useful for fish as food resources. 

*H. temminckii* is a common fish found in seagrass ecosystems, as in several studies conducted on Kema Beach, North Sulawesi [13, 22], on Karang Congkak Island, Kepulauan Seribu [23], as well as in Tanjung Tiram, Southeast Sulawesi [24]. The abundance of *H. temminckii* as a juvenile caught on Semak Daun Island reinforces the previous studies, which found that seagrass ecosystems play an important ecological role for the juvenile fish as a nursery ground [25, 26, 27].

According to fisher community leaders and traditional fishers on the southern coast of Sri Lanka, *H. temminckii* (local name: koralawa) was a non-target fish and the biological indicator [28]. This fish is a biological indicator because the appearance of schooling from this fish will be followed by the appearance of the target fish for catching, such as Bluestripe herring, *Herklotsichthys quadrimaculatus* (local name: ehalamurua). This fish was also used as bait and fodder for tuna fishery [12].

All of *H. temminckii* was in the juvenile stage during the study period. This finding indicates that this species is a temporary resident, as explained by [29]. Temporary resident fish utilize the seagrass ecosystem during the juvenile stage. [30] stated that not all fish in the seagrass ecosystem are permanent residents that live their all life cycle in the seagrass. Fish from the surrounding ecosystem visit this ecosystem to spawn or find food occasionally. The explanation above is strong evidence that the seagrass ecosystem is a feeding habitat and shelter for juveniles of *H. temminckii*.

The fish diet consists of plants, algae, plankton, fish, shrimp, worms, benthos, or other insects and larvae [31]. The main type of food used by *H. temminckii* is zooplankton, which mainly consists of Copepods and planktonic Foraminifera. The high level of consumption of zooplankton by this species indicates that zooplankton was abundant in the seagrass ecosystem of Semak Daun Island. Many Copepods such as Harpacticoid and Cyclopoid were found in the digestive tract of Samoan silverside. The volume of Foraminifera was higher due to its size. Therefore, the IRI value of Foraminifera was higher than the copepod. This finding is related with the feeding strategy. Mostly Copepod like *Oncaea sp.*, *Oithona sp.*, and Harpacticoid copepod are the most consumed by fish in the rainy season. 

The trophic guild is a group of species that use the same diet in the same environment [32]. [33] explained that trophic guilds are determined based on the level of utilization of food types by fish. The trophic guilds can explain the functional role of *H. temminckii* in the seagrass ecosystem of Semak Daun Island. The trophic level of *H. temminckii* is low because it was still below 4 (another group of Piscivore fishes), considering that it was still in the juvenile stage.

*H. temminckii* in dry seasons was a specialist predator, where the fish majority chose *Cymbaloporeta* sp. to consume. In the rainy and first transitional season, they preferred to consume more food, which found Nauplius of Copepoda, *Oithona* sp., *Oncaea* sp., *Saphirina* sp., *Mysis*, *Cymbaloporeta* sp., and even algae in their guts. There was a tendency that *H. temminckii* was a specialist zooplankton feeder. This species shows a mixed diet strategy by feeding various food items in the seagrass ecosystem by their mouth openings and size.

*H. temminckii* in the seagrass ecosystem of Semak Daun Island shows a positive allometric growth pattern, where its weight grows faster than its length. This finding indicates that the seagrass ecosystem of Semak Daun Island supplies enough food and suitable habitat for *H. temminckii* juveniles.

5. References
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