# Trophic ecology of twoblotch ponyfish Nuchequula blochii in Kendari Bay, Southeast Sulawesi, Indonesia

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# Trophic ecology of twoblotch ponyfish *Nuchequula blochii* in Kendari Bay, Southeast Sulawesi, Indonesia

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**Abstract**. Trophic ecology can be used to determine feeding strategy and indirect energy flux within a fish community, and also explains the trophic interaction between different fish species in a food web. This research was aimed to study the trophic ecology of twobloch ponyfish *Nuchequula blochii* in Kendari Bay, Southeast Sulawesi. The samples were collected monthly during October 2016 to May 2017 using bottom gillnets with mesh size ¾, 1, 1¼, 1½, and 2 inches. Food composition was analysed using Preponderance Index whereas feeding strategy was determined using Costello method modified by Admunsen. There were 247 fish with the total length and weight ranged from 45.0-119.0 mm and 5.0-31.4 g, respectively. The fish were categorized into 3 groups based on the length and weight sizes. The length sizes were classified into small size (45.0-69.7 mm), medium size (69.8-94.3 mm) and large size (94.4-119.0 mm). Twenty three species of organisms were found in the digestive system of the twoblotch ponyfish dominated by the phytoplankton genus *Thallasiothrix*. There was a significant difference in the food composition of the fish based on the size groups. Small size fish fed on 9 food organisms dominated by the phytoplankton group. Medium size fish utilized 19 organisms, and large size fish consumed 21 organisms. The twoblotch ponyfish developed mix feeding strategies; specialist and generalist. The specialist strategy was used by the small fish feeding on *Thallassiothrix*, whereas generalist strategy was employed by the medium and large size fish feeding on the other 22 prey species.

**Key Words**: feeding strategy, generalist, ponyfish, specialist, *Thallasiothrix*.

**Introduction**. Twoblotch ponyfish, *Nuchequula blochii* (Valenciennes, 1835) known locally as peperek is one of important wild fish sought after by fishermen in Indonesia. In Kendari Bay, Southeast Sulawesi, the fish is abundant and has been one of the target species by small-scale fishermen (Asriyana et al 2009; Asriyana et al 2011). The abundance of the fish in the bay can be attributed to the high productivity of the area. Coastal areas including bays, provide a suitable habitat for the early stages of many marine fishes including twoblotch ponyfish (Beck et al 2001; Jin et al 2007; Nanjo et al 2014; Edworthy & Strydom 2016). Specifically, bays that have a shallow profile, with soft substrates (muddy), and mangrove vegetation are preferred by twoblotch ponyfish (Kimura et al 2008). In addition, type of habitat is an important factor affecting fish feeding strategy. Fish has to choose between a habitat that provides abundant and diverse food sources but difficult to access or a habitat that has less food but easy to access (Crowder & Cooper 1982).

The tropical coastal ecosystems in the Southeast Asia are important habitat for fish communities (Chou 1996; Blaber 1997) and in general, the ecology of most fish in these areas have been well studied. For example, there were studies on Leiognathidae family such as biological and reproductive aspects of *Leiognathus dussumieri* (James & Badrudeen 1981; Seah et al 2009), *L. bindus* (Balan 1963; Murty 1983), *L. equulus* (Lee et al 2005); length-weight relationship of Leiognathidae family (Mazlan & Seah 2006), *L. brevirostris* (Batcha & Badrudeen 1992), *L. splendens* and *Gazza minuta* (Jayabalan & Bhat 1997), *Secutor insidiator* (Jayabalan 1988; Muddula et al 2015); population dynamics of *L. jonesi* (Karthikeyan et al 1989), *L. bindus* (Murty 1986; Nagarajan 2000; Abraham et al 2011); phylogeny and morphology (Ikejima et al 2004; Chakrabarty et al 2008; Kimura et al 2008; Chakrabarty et al 2010a; Chakrabarty et al 2010b; Seah et al 2012); food and feeding habits of Leiognathidae family (Seah et al 2009), *L. equulus* (Lankadhikara & Wijeyaratne 2014). In contrast, there are limited information about the trophic ecology of twoblotch ponyfish (Chong et al 1990; Chou 1996; Hajisamae et al 1999; Hajisamae et al 2003; Bachok et al 2004; Asriyana et al 2009; Asriyana et al 2011; Zahid et al 2011; Suyatna et al 2016). Therefore, this research can be considered as the first one to study trophic ecology of twoblotch ponyfish *Nuchequula blochii* (Valenciennes, 1835).

Kendari Bay in the Southeast Sulawesi is one of the areas that need special attention due to the increasing ecological pressure that affects the condition of water quality, community structure of phytoplankton, zooplankton, and benthic organisms which eventually affect fish population as occurred in other areas (Orpin et al 2004; Karakassis et al 2005; Jaureguizar & Milessi 2008). Research on trophic ecology of twoblotch ponyfish in this unique ecosystem will improve our understanding of the fish ecology. Trophic ecology is generally used to understand the ecosystem intricacy as a whole. In fish population, trophic ecology can be used to determine the fish's feeding strategy, indirect energy flux in the population, and also explain the trophic interaction between different species in a food web (Yáñez-Arancibia & Nugent 1977; Hajisamae et al 1999; Arceo-Carranza & Chiappa-Carrara 2015). Food web itself is the main characteristic of an organized basic ecology process. Different approaches have been developed to understand food webs. Direct analysis of the stomach of an individual species leading to the determination of food types at the population level is one of the approaches (Pasquaud et al 2010). Considering the importance of the information on the trophic ecology of twoblotch ponyfish, a study on twoblotch ponyfish in Kendari Bay was needed. Therefore, the aim of this study was to study trophic ecology of twoblotch ponyfish in Kendari Bay.

## Material and Method

***Research site***. The research was conducted in Kendari Bay, Southeast Sulawesi, Indonesia from October 2016 to May 2017. The bay is located between latitudes of 3°57'59,37"3°59'32,39" 'S and longitudes of 122°31'38,07"122°35'55,93" 'E (Figure 1). Sampling stations were determined horizontally from upstream to downstream of the Kendari Bay. The station I was located in upstream which receives freshwater input, organic materials and sediment from four big rivers (Mandonga, Kadia, Wanggu, and Kambu). Organic materials originated from villages, fish ponds, agricultural activity alongside the rivers whereas sediment was released from sand mining alongside the Wanggu and Kambu rivers. The water depth of this station was 5 m on average. Station II was located in the center of the bay with the water depth ranging from 5 to 10 m. Station III was located downstream, near the mouth of the bay, and thus influenced by seawater from outside Kendari Bay with the water depth ranged between 5 and 8 m.

***Fish collection and trophic analysis***. Fish samples were collected using bottom gillnets made from nylon monofilament, each has a mesh size of ¾, 1, 1¼, 1½, and 2 inches. The length of each gill net was 30 m. Sampling was carried out every month in the three stations. Samples were kept in a cool box for further analysis in a laboratory. In the laboratory, fish samples were measured for total length and weight. The digestive system was removed from the fish body cavity and preserved in distilled water mixed with 5% formalin for feeding analysis. The volume of the digestive system was determined using volume displacement technique.

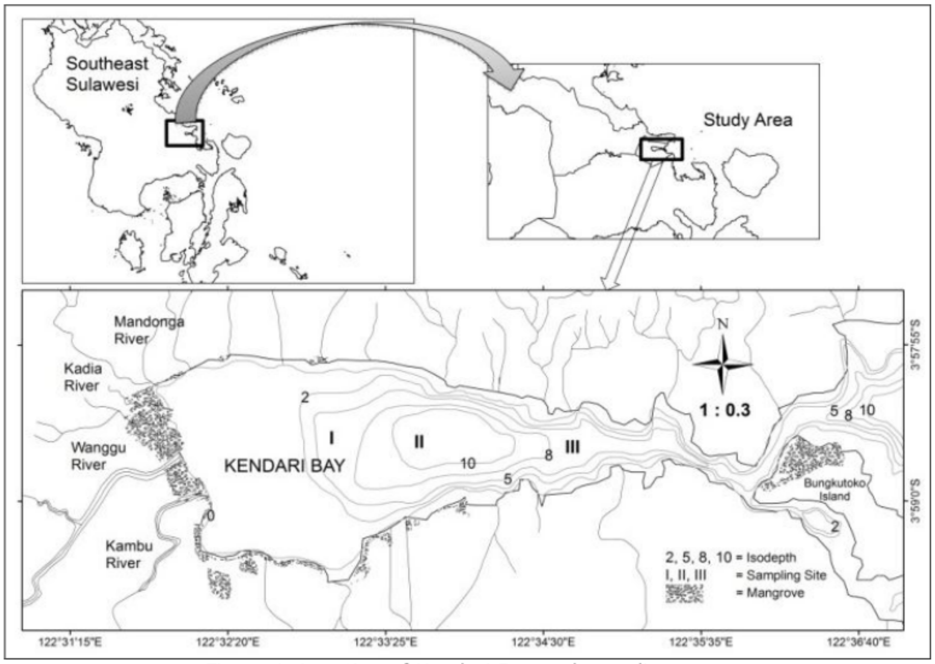

Figure 1. Location of Kendari Bay and sampling area.

***Data analysis***. For feeding analysis, the content of the digestive system was collected from the digestive tract and placed in a Petri dish. The types of the food were examined under a microscope and identified up to the lowest taxonomic group (Gosner 1971; Yamaji 1979; Higgins & Thiel 1988; Tomas 1997). Stomach fullness was determined based on the ratio of the stomach content volume and the stomach volume (Cunha et al 2005). Feeding habits were determined using the Preponderance Index method (Natarajan & Jhingran 1961). The preponderance index of prey items in the diet of these species was evaluated using two indices: percentage occurrence (O%) and percentage volume (V%). The mathematical expression for the preponderance index is expressed as follows:

$$I_i = \frac{V_i \ x \ O_i}{\sum V_i \ x \ O_i} \ x \ 100$$

where *Ii* is the Preponderance index, *Vi* is percentage volume of the specific prey, and *Oi* is percentage occurrence of the specific prey.

The percentage occurrence refers to the occurrence of a specific prey item in the non-empty stomachs. Percentage volume was calculated as the contribution of a prey species to the total volume of all prey species in the stomach. Stomach contents were then examined under a microscope (40x) and identified according to the categories ranging from broad taxonomic groups (i.e. class) to narrowest possible identification (genera or species). The Kruskal-Wallis test was employed to determine if there were significant differences in the fish's food habits based on the fish group sizes and sampling times (Sokal & Rohlf 1995).

Feeding strategy was determined using an approach modified from Costello's method (Amundsen et al 1996). The prey-specific abundance, defined as the percentage of a prey taxon fed by all predators, was plotted against the frequency of occurrence, providing a two-dimensional graph (Amundsen et al 1996). In mathematical terms, the prey-specific abundance is expressed as follows:

$$Pi = \frac{\sum S_i}{\sum S_{ti}} x \ 100$$

where $P_i$ is the prey-specific abundance of prey $i$, $S_i$ is the stomach content comprised of prey $i$, and $S_{ti}$ is the total stomach content in only those fish with prey i in their stomachs.

The resulted plot provides information on the prey importance, feeding strategy, and niche width contribution inferred through the position of prey categories in the diagram. The diagonal axis running from the lower left to the upper right of the diagram represents a measure of prey importance, with dominant prey at the upper end and rare or less important prey at the lower end. The axis running from the upper left to the lower right indicates the contribution of between- and within-phenotype (or individual) components to the niche width, with a high between-phenotype component at the upper end and a high within-phenotype component at the lower end. Finally, the vertical axis represents the specialization feeding strategy of the predator (upper part of the diagram) or generalization (lower part) (La Mesa et al 2008).

## Results

***Diet composition***. There were 247 fishes caught during the study with the total lengths and weight sizes ranging from 45.0–119.0 mm and 5.0–31.4 g, respectively. The fish were categorized into 3 size groups; small size (45.0-69.7 mm); medium size (69.8-94.3 mm); and large size (94.4-119.0 mm) (Table 1). Medium size fishes had the highest frequency (82.59%).

Table 1

The length size distribution of the fish

| *Size groups* | *Length range (mm)* | *Numbers* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Oct '16* | *Nov '16* | *Dec '16* | *Jan '17* | *Feb '17* | *Mar '17* | *Apr '17* | *May '17* |
| Small | 45.0-69.7 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| Medium | 69.8-94.3 | 56 | 20 | 12 | 42 | 28 | 35 | 9 | 2 |
| Large | 94.4-119.0 | 6 | 12 | 2 | 0 | 11 | 4 | 1 | 0 |
| Total numbers | 45.0-119.0 | 65 | 32 | 15 | 42 | 40 | 39 | 11 | 3 |

Food contents were found in all 247 stomachs with the stomach fullness was above 90% (Figure 2). Based on the stomach content analysis, 23 food types were found. The food types were divided into 4 groups; phytoplankton (14 genera), zooplankton (7 genera), benthic macroinvertebrate (1 genus) and detritus (Table 2).

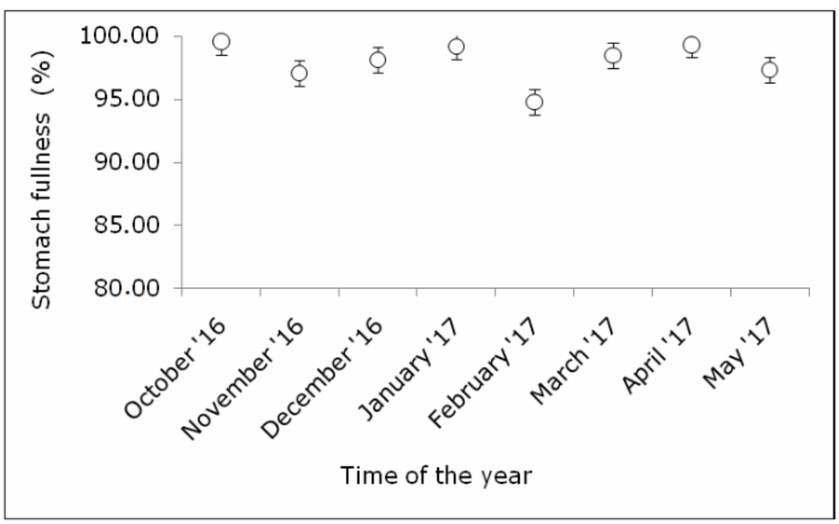


Figure 2. Monthly percentage of stomach fullness (%) of the twoblotch ponyfish.

Table 2

Main prey category of twoblotch ponyfish

| *Prey category* | *Organisms* |
|---|---|
| Phytoplankton | *Thalassiothrix, Guinardia, Coscinodiscus, Rhizosolenia, Isthmia, Leptocylindrus, Ankistrodesmus, Spirulina, Nitzschia, Raphidinium, Euglena,Trichodesmium, Peridinium, Ceratium* |
| Zooplankton | *Acartia, Calanus, Microsetella*, Nauplius, *Lucifer, Creseis*, Zoea |
| Macro-invertebrate benthic | *Balanus* |
| Detritus | Detritus |

The results of the food analysis are presented in Table 3. The phytoplankton genera *Thalassiothrix* and *Leptocylindrus* had the highest preponderance index of 40.24 and 17.85, respectively indicating that the two genera were the preferred food of the fish. The other food types contained in the fish stomachs had low preponderance index ranging from 0.16 to 10.00.

Table 3

Preponderance index of the main prey items in the diet of twoblotch ponyfish

| *No.* | *Category* | *Organisms* | *Ii** |
|---|---|---|---|
| 1 | Phytoplankton | *Thalassiothrix* | 40.24 |
| 2 | | *Guinardia* | 1.54 |
| 3 | | *Coscinodiscus* | 10.00 |
| 4 | | *Rhizosolenia* | 4.09 |
| 5 | | *Isthmia* | 1.57 |
| 6 | | *Leptocylindrus* | 17.85 |
| 7 | | *Ankistrodesmus* | 1.14 |
| 8 | | *Spirulina* | 0.40 |
| 9 | | *Nitzschia* | 0.16 |
| 10 | | *Raphidinium* | 3.90 |
| 11 | | *Euglena* | 1.59 |
| 12 | | *Trichodesmium* | 0.22 |
| 13 | | *Peridinium* | 0.19 |
| 14 | | *Ceratium* | 0.16 |
| 15 | Zooplankton | *Acartia* | 0.63 |
| 16 | | *Calanus* | 4.38 |
| 17 | | *Microsetella* | 0.34 |
| 18 | | Nauplius | 0.18 |
| 19 | | *Lucifer* | 0.56 |
| 20 | | *Creseis* | 0.94 |
| 21 | | Zoea | 0.20 |
| 22 | Macro-invertebrate benthic | *Balanus* | 0.20 |
| 23 | Detritus | | 9.51 |
| | Total numbers | | 100.00 |

*Ii = Preponderance index.

There was a significant difference in the food composition of the fish based on the size group (Kruskal-Wallis test, [$p < 0.05$; $\alpha = 5\%$, db = n-1]). Small size fish (45.0-69.7 mm) fed on 9 food organisms dominated by the phytoplankton group. Medium size fish (69.8-94.3 mm) utilized 19 organisms, and large size fish (94.4-119.0 mm) consumed 21 organisms. Regardless of the fish size, phytoplankton was the most dominant food.

The small size fish had the highest percentage of preponderance index (Ii) compared to the other size groups (Table 4).

Table 4

Natural food analysis of twoblotch ponyfish based on the size group

| *Category* | *Food organisms* | *Preponderance Index / size group (mm)* | | |
|---|---|---|---|---|
| | | *45.0-69.7* | *69.8-94.3* | *94.4-119.0* |
| Phytoplankton | *Thalassiothrix* | 52.1 | 41.39 | 37.15 |
| | *Guinardia* | 3.38 | 1.32 | 1.56 |
| | *Coscinodiscus* | 11.09 | 12.34 | 6.91 |
| | *Ankistrodesmus* | | 0.42 | 2.2 |
| | *Euglena* | | 0.94 | 2.62 |
| | *Rhizosolenia* | 5.07 | 3.92 | 4.17 |
| | *Isthmia* | 2.9 | 1.19 | 1.87 |
| | *Leptocylindrus* | 7.53 | 19.4 | 17.35 |
| | *Spirulina* | | | 0.96 |
| | *Nitzschia* | | | 0.38 |
| | *Trichodesmium* | | 0.2 | 0.29 |
| | *Ceratium* | | 0.13 | 0.21 |
| | *Peridinium* | | 0.36 | |
| | *Raphidinium* | 5.51 | 4.56 | 2.86 |
| | | **87.58** | **86.17** | **78.53** |
| Zooplankton | *Calanus* | 4.23 | 3.27 | 5.78 |
| | *Acartia* | | 0.21 | 1.24 |
| | *Microsetella* | | 0.51 | 0.17 |
| | Nauplius | | | 0.43 |
| | *Lucifer* | | 0.88 | 0.25 |
| | *Creseis* | | 0.57 | 1.54 |
| | Zoea | | 0.38 | |
| | | **4.23** | **5.82** | **9.41** |
| Macro-invertebrates benthic | *Balanus* | | | **0.48** |
| Detritus | | **8.19** | **8.01** | **11.58** |
| | | **100.00** | **100.00** | **100.00** |
| Kruskal-Wallis = p < 0.05 (α = 5%, db = n-1) | | | | |

Significant difference was observed in the food compositions of the twoblotch ponyfish in relation to sampling periods (Kruskal-Wallis test, [$p < 0.05$; $\alpha = 5\%$, db = n-1]) (Table 5). *Thallassiothrix, Coscinodiscus*, and *Leptocylindrus* were consistently found in all fish stomachs. *Thallassiothrix* had the highest average of Preponderance Index (IP 25) during most of the sampling times, except the sampling times in February, March, and April. Other types of food were varied in proportion and sampling time.

***Feeding strategy***. The distribution of the frequency of occurrence (%) and the prey-specific abundance (%) within the plot depicted the feeding strategy developed by twoblotch ponyfish. Regardless of the sizes and sampling times, the plotted frequency of occurrence and the prey-specific abundance were mostly distributed at the bottom of the graph. *Thalassiothrix, Coscinodiscus, Leptocylindrus*, and detritus dominated these distributions with the abundance was below 50% and the frequency of occurrence was above 50%. This condition showed that the fish developed a generalist strategy in acquiring food (Figure 3).

Table 5

Natural food analysis of twoblotch ponyfish from October 2016 to May 2017

| *Category* | *Food organisms* | *Preponderance Index (Ii) / time* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Oct '16* | *Nov '16* | *Dec '16* | *Jan '17* | *Feb '17* | *Mar '17* | *Apr '17* | *May '17* |
| Phytoplankton | *Thalassiothrix* | 57.12 | 26.66 | 38.35 | 35.27 | 18.38 | 18.09 | 19.41 | 25.80 |
| | *Guinardia* | | 11.79 | | 5.56 | 2.65 | 3.17 | | |
| | *Coscinodiscus* | 8.26 | 5.43 | 11.44 | 10.63 | 13.51 | 14.68 | 22.39 | 21.86 |
| | *Ankistrodesmus* | | | | | 7.03 | | | |
| | *Euglena* | | | | | 8.47 | | | |
| | *Rhizosolenia* | | | | | 8.26 | 8.01 | 7.92 | 29.47 |
| | *Isthmia* | 0.95 | | 3.93 | 0.50 | 8.48 | | | |
| | *Leptocylindrus* | 13.78 | 15.27 | 16.87 | 16.59 | 8.53 | 5.93 | 10.83 | 22.87 |
| | *Spirulina* | | 7.43 | | | | | | |
| | *Nitzschia* | | 4.01 | | | | | | |
| | *Trichodesmium* | 1.95 | | | 1.04 | | | | |
| | *Ceratium* | | | 0.86 | | | | | |
| | *Peridinium* | | | 2.20 | | | | | |
| | *Raphidinium* | 2.31 | | 5.85 | 5.22 | 10.98 | 4.96 | 2.34 | |
| | | **84.36** | **70.58** | **79.51** | **74.81** | **86.29** | **54.85** | **62.90** | **100.00** |
| Zooplankton | *Calanus* | | 10.11 | | 10.63 | 10.30 | 16.70 | 23.23 | |
| | *Acartia* | 4.28 | 8.90 | | | | 5.68 | | |
| | *Microsetella* | | | | | | 11.41 | 9.15 | |
| | Nauplius | | | | | 1.01 | | | |
| | *Lucifer* | | | 6.16 | | | | | |
| | *Creses* | 6.36 | | | 8.91 | | | | |
| | Zoea | | | | | | 5.67 | | |
| | | **10.64** | **19.01** | **6.16** | **19.54** | **11.31** | **39.47** | **32.38** | **0.00** |
| Macro-invertebrates benthic | *Balanus* | | | **8.47** | | | **5.68** | | |
| Detritus | | **5.00** | **10.41** | **5.87** | **5.65** | **2.39** | | **4.72** | |
| **Total** | | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |
| Kruskal-Wallis = $p < 0.05$ ($\alpha = 0.05$, db = n-1) | | | | | | | | | |

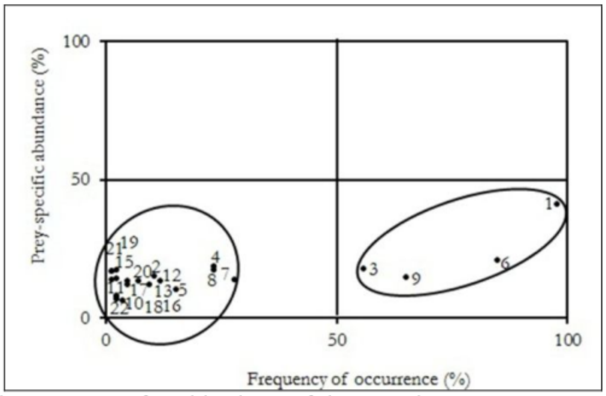


Figure 3. The feeding strategy of twoblotch ponyfish in Kendari Bay. Prey items: 1. *Thalassiotrix*, 2. *Guinardia*, 3. *Coscinodiscus*, 4. *Rhizosolenia*, 5. *Isthmia*, 6. *Leptocylindrus*, 7. *Raphidinium*, 8. *Calanus*, 9. Detritus, 10. *Acartia*, 11. *Balanus*, 12. *Ankistrodesmus*, 13. *Euglena*, 14. *Microsetella*, 15. Nauplius, 16. *Lucifer*, 17. *Ceratium*, 18. *Spirulina*, 19. *Nitzschia*, 20. *Creseis*, 21. *Trichodesmium*, 22. *Peridinium*, 23. Zoea.

Based on the fish length, plot dispersion showed gradual changes (Figure 4). The small fish (45.0-69.7 mm) developed a mixed strategy of specialist and generalist (specialist to *Thalassiothrix* and generalist to the other 8 prey items). *Thalassiothrix* was the dominant prey for the small fish with the abundance was more than 50% and the frequency of occurrence up to 100%. Other preys had the abundance and the frequency of occurrence less than 50%. The medium and large size fish developed a generalist strategy to all preys in which *Thalassiothrix, Leptocylindrus,* and detritus were the dominant food of both fish groups with the frequency of occurrence was above 50%.

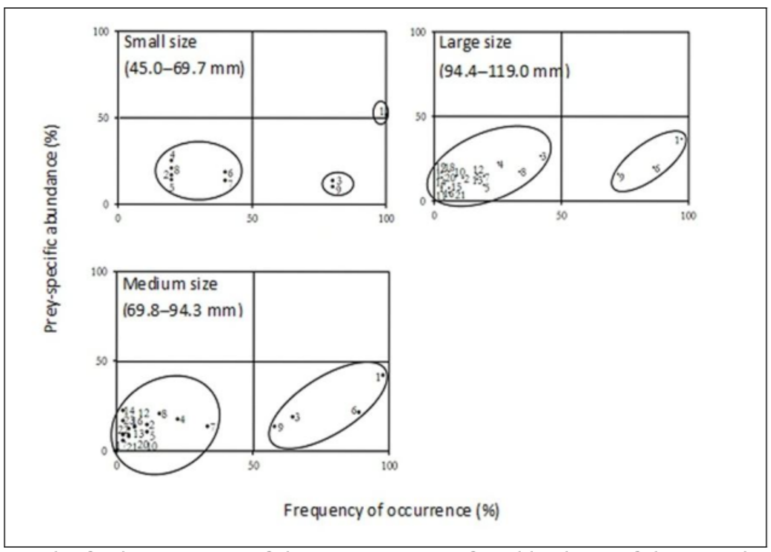


Figure 4. The feeding strategy of three size groups of twoblotch ponyfish in Kendari Bay, Prey items: 1. *Thalassiotrix*, 2. *Guinardia*, 3. *Coscinodiscus*, 4. *Rhizosolenia*, 5. *Isthmia*, 6. *Leptocylindrus*, 7. *Raphidinium*, 8. *Calanus*, 9. Detritus, 10. *Acartia*, 11. *Balanus*, 12. *Ankistrodesmus*, 13. *Euglena*, 14. *Microsetella*, 15. Nauplius, 16. *Lucifer*, 17. *Ceratium*, 18. *Spirulina*, 19. *Nitzschia*, 20. *Creseis*, 21. *Trichodesmium*, 22. *Peridinium*, 23. Zoea.

Based on the sampling time, twoblotch ponyfish developed a mix feeding strategy namely specialist and generalist (Figure 5). From October to December 2016, the fish developed specialist feeding strategy. During this period, *Thalassiotrhrix* became the dominant food with the specific density of more than 50% and the frequency of occurrence in the stomach up to 100%. Contrastingly, the fish shifted to the generalist feeding strategy during the period of January to May 2017. The genera *Thalassiothrix* and *Leptocylindris* were found in each sampling time which indicates their important contribution to the feeding behavior of the fish, whereas the abundance and occurrence of other preys varied every month with different proportions.

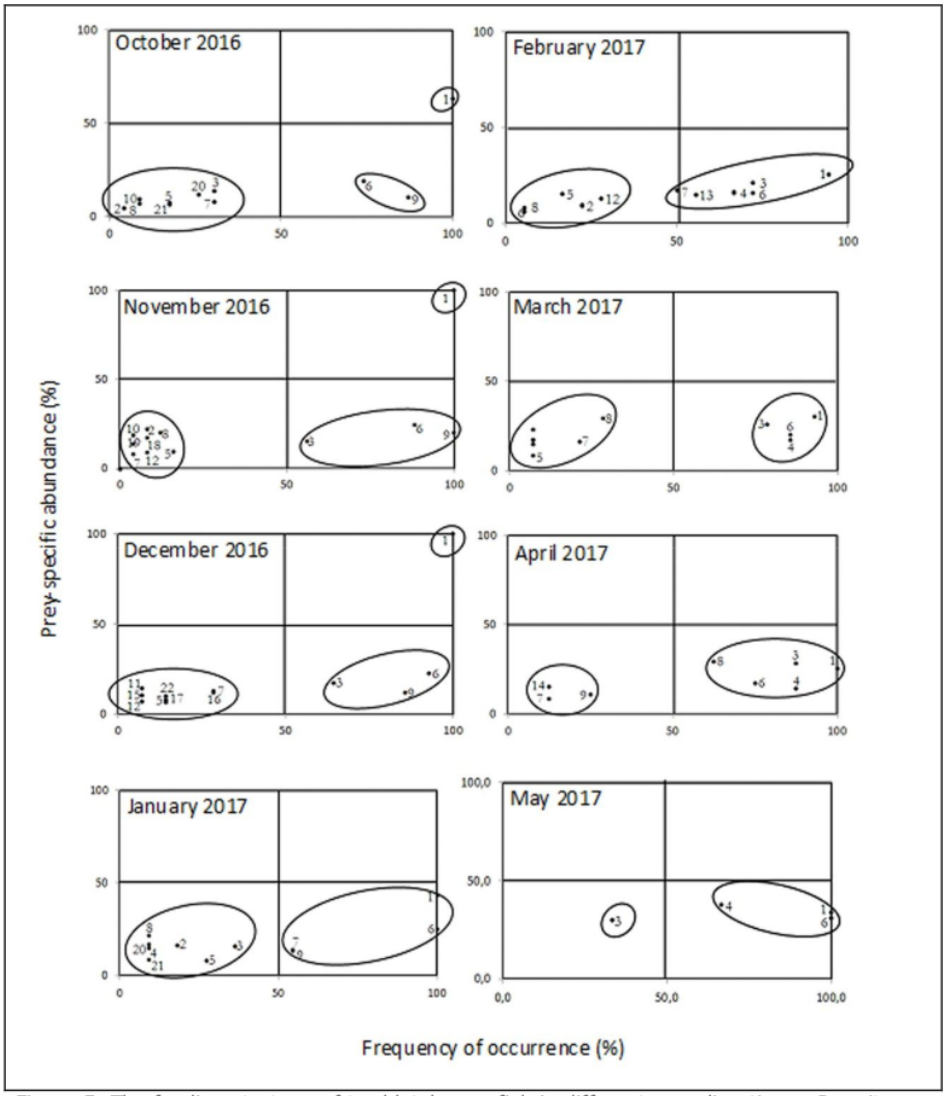


Figure 5. The feeding strategy of twoblotch ponyfish in different sampling times. Prey items: 1. *Thalassiotrix*, 2. *Guinardia*, 3. *Coscinodiscus*, 4. *Rhizosolenia*, 5. *Isthmia*, 6. *Leptocylindrus*, 7. *Raphidinium*, 8. *Calanus*, 9. Detritus, 10. *Acartia*, 11. *Balanus*, 12. *Ankistrodesmus*, 13. *Euglena*, 14. *Microsetella*, 15. Nauplius, 16. *Lucifer*, 17. *Ceratium*, 18. *Spirulina*, 19. *Nitzschia*, 20. *Creseis*, 21. *Trichodesmium*, 22. *Peridinium*, 23. Zoea.

**Discussion**. The twoblotch ponyfish collected were grouped in small, medium and large sizes, of which the medium size fish dominated the fish population indicating that the fish species use the Kendari Bay as nursery and feeding grounds (Asriyana et al 2009; Asriyana et al 2011; Asriyana & Syafei 2012). Sufficient food availability and mangrove vegetation around the station 1 are likely the reasons why the medium size fish dominated the Kendari Bay waters. Mangrove vegetation provides protection for the medium size fish from potential predators. In addition, detritus originated from decomposed mangroves litter is known as a food source for organisms that use mangrove area as nursery and feeding grounds (Beck et al 2001; Jin et al 2007; Green et al 2009; Wang et al 2009; Asriyana et al 2011; Nanjo et al 2014; Edworthy & Strydom 2016). The estimated population of twoblotch ponyfish caught in Kendari Bay was relatively small compared to Leiognathidae family in other coastal waters (Lee et al 2005; Muddula et al 2015; Acharya & Naik 2016). This is probably due to high turbidity (0.42-10.25 NTU), total suspended solid (255-418 mg $L^{-1}$), and sedimentation rate in the Kendari Bay (Asriyana & Syafei 2012; Irawati et al 2013). High turbidity affects the ability of the fish to find food which results in more energy being spent in acquiring food (Blaber & Blaber 1980; Kneib 1987; Barrett et al 1992; Blaber et al 1995; De Robertis et al 2003; Meager & Batty 2007; Carter et al 2010; Asriyana & Syafei 2012). In addition, turbidity and sedimentation also reduce the spawning success rate (Henley et al 2000; Bunt et al 2004; Asriyana & Syafei 2012). As a result, these conditions have suppressed the population of twoblotch ponyfish in Kendari Bay.

***Diet composition***. Most of the studies on feeding habits of fish are related to the food composition (Asriyana et al 2004; Olivera et al 2004; Rahardjo et al 2006; Vögler et al 2009; Asriyana et al 2010; Hedianto et al 2010) without really looking into the role of prey and how the fish develop strategy in acquiring food. This study discusses not only the food composition related to the fish size and time but also the role of the prey and the feeding strategies developed by the fish in acquiring food. The results showed that the genus *Thalassiothrix* had the highest preponderance index followed by *Leptocylindrus* and *Coscinodiscus* indicating that these organisms were the main food of the fish. The stomach fullness of the fish above 80% also confirmed that the three phytoplankton genera were the most important food ingredients of twoblotch ponyfish. The fact that there were no empty stomachs observed indicated that the fish had gut clearance rates proportional to the amount of ingested food, or that they were always feeding. This feeding habit was similar to what was observed in the fish populations of *Sardinops sagax* (Van der Lingen 1998), *Sardina pilchardus* (Cunha et al 2005), and *Sympterygia bonapartii* (Estalles et al 2016). Detritus was also an important food for the fish. The presence of the mangrove vegetation along the bay contributed to the abundance of detritus as the food source of twoblotch ponyfish.

The high percentage of phytoplankton from Bacillariophyceae family consumed by the small fish could be attributed to the availability and digestibility of the phytoplankton (Lannan et al 1983; Asriyana et al 2004; Asriyana et al 2010; Asriyana & Syafei 2012). Phytoplankton domination in the food composition of the small fish was also found in other fish such as *Sardinella fimbriata* (Asriyana et al 2004), *S. pilchardus* (Cunha et al 2005), *Dussumieria acuta* (Asriyana et al 2010), *Nemipterus hexodon* (Asriyana & Syafei 2012). However, twoblocth ponyfish also consumed zooplankton and benthic macroinvertebrates which were similarly observed on *L. splendens* in Ratnagiri water, India (Acharya & Naik 2016). *L. splendens* also consumed both food types with zooplankton being the dominant food. The variations of food consumed by the fish increased as the fish grew indicated that increase in the fish size was correlated with the wider food niche. This was due to the need of more nutrition and the increase in the fish ability to catch preys (Nyegaard et al 2004; Garcia et al 2005). Ontogenetic changes are correlated with predation rate, increased in body and mouth size, energy requirement, visual ability, ability to find preys and food availability (Scharf et al 2000; Asriyana et al 2004; Cruz-Escalona et al 2005; Bacha & Amara 2009; Asriyana et al 2010; Carpentieri et al 2010; Hammerschlag et al 2010; Asriyana & Syafei 2012). There was a significant difference in the food composition in relation to the fish size (Kruskal Wallis test, $p <$

0.05). These ontogenetic changes of prey items were also found in the *Citharichthys spilopterus* (Castillo-Rivera et al 2000), *Serrasalmus brandtii* (Olivera et al 2004), and *N. hexodon* (Asriyana & Syafei 2012).

There was a significant difference in the natural food of the fish in relation to the sampling time (Kruskal Wallis, P<0.05). *Thallasiothrix, Coscinodiscus*, and *Leptocylindrus* were consistently found in the fish stomachs, whereas the other food items were varied with different proportions. The presence of the three phytoplankton genera indicated that they had important roles in the growth of the fish and were abundant in Kendari Bay (Irawati & Asriyana 2007; Asriyana et al 2010; Asriyana & Syafei 2012). The abundance of the food resources in the waters gives the indication that the availability of natural food of twoblotch ponyfish is also high. A similar condition was also observed in the availability of natural food for *Creagrutus bolivari, Knodus deuterodonoid, Knodus* sp., and *Poecilia reticulata* in North Venezuela Water (Ortaz 2001); *Pseudorhombus pentophthalmus* in the southeastern coast of Korea (Park & Huh 2017). This is inline with Wootton (1998) who argued that the food availability in waters was strongly related to the environmental conditions. He continued that the accessibility of food resources affected the quantity and quality of food as well as feeding habit of the fish (Wootton 1998).

***Feeding strategy***. The feeding strategy developed by twoblocth ponyfish was a mixed feeding strategy of specialist and generalist. Different feeding strategies were observed through changes in consumed prey items which was parallel with the increased body sizes and sampling times. The small size fish developed the specialist feeding strategy to prey on *Thallasiothri*x due to the faster growth rate and thus higher food demand. High nutritional needs but with limited cruising range have forced the small size fish to feed on preys that are easy to access and abundant in the waters, yet still nutritious. The abundance and characteristic of the preys are the main factors determining the food choice of fish (Weatherley & Gill 1987; Johnson et al 2007; Sanchez-Hernandez et al 2011). Fish will select prey items that could give the maximum energy benefit (Gill 2003). This condition showed that the small fish had a narrow niche which resulted in an intense intraspecies food competition. Fish developed specialist feeding strategy due to specific morphological and behavioral adaptations to find their food effectively (Stevens et al 2006). Regardless of the fish size, twoblotch ponyfish developed specialist strategy in October to December due to the abundance of the phytoplankton *Thalassiothrix* in the waters (Asriyana et al 2010; Asriyana & Syafei 2012). When predators utilize the abundant prey, the niche of the predators becomes narrow and specialized to that prey. The abundance of the preys in waters would be the main factor contributed to the narrow niche (Hajisamae et al 2003; La Mesa et al 2008). However, this was not the case with *Sphyraena barracuda, Haemulon sciurus*, and *Archosargus rhomboidalis* where they maintained wider niches despite the abudance of their main foods (Hammerschlag et al 2010).

Twoblocth ponyfish also developed generalist strategy in acquiring food. The middle and large size fish were generalist to 19 and 21 prey species, respectively. The presence of the *Thallassiothrix, Coscinodiscus, Leptocylindrus*, and detritus in the lower right of the graph (Figure 4) showed that these preys would have been eaten by most individuals. This finding suggested that all fish sizes had a relatively wider niche and similar food. The fish developed the generalist strategy because the food was scarcely available during January-May. Several species, such as *Platichthys flesus, Solea solea, Clupea harengus,* and *Dicentrarchus labrax* in the estuarine near the Dutch-Belgian had a wider niche when the resources are less or when the fish population density is high. In addition, the generalist strategy is developed when the preferred prey is not available (Stevens et al 2006). Generalist feeding can reduce potential competition within a fish population and increase the fish population density (Stevens et al 2006) which arguably observed in the twoblocth ponyfish population in this study.

The fish *Synodus foetens* in Mexico Bay also developed a mixed feeding strategy which was specialist to *Engyophrys senta* and *Loligo paeli*, and generalist to other 7 food types (Cruz-Escalona et al 2005). Specialization of the fish was related to the availability of the two preys which were abundant in the bay. The combination of generalist and specialist strategy was also observed in the fish *Syngnathus folletti* (Garcia et al 2005) in Laguna Patos, Brazil; the fish goby *Aphia minuta* in Adriatic Sea (La Mesa et al 2008) and demersal Elasmobranchia in the Balearic Sea (Valls et al 2011).

Understanding the trophic ecology of the twoblotch ponyfish could give an indication of interaction between different trophic levels. Twoblotch ponyfish relies on phytoplankton at the lowest trophic level in the food web. The phytoplankton is also used by zooplankton and macroinvertebrate benthic which were also the food of the twoblotch ponyfish. This study would increase our understanding on the fish ecology as well as provide basic information on the twoblocth ponyfish resources management in Kendari Bay.

**Conclusions**. Twoblotch ponyfish feed on various foods ranging from phytoplankton to detritus. Phytoplankton genus *Thalassiothrix* was the dominant food found in all fish groups. The food composition changed significantly with the increase in fish size and different periods of time. The fish developed mix feeding strategy in acquiring food, specialist to *Thalassiothrix* genus and generalist to other 22 organisms.

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