Jurnal Iktiologi Indonesia 19(3): 449-462 DOI: https://doi.org/10.32491/jii.v19i3.505

Trophic ecology of fish community at Nimbai Stream: Competition and predation interaction to Arfak rainbowfish, *Melanotaenia arfakensis* Allen, 1990

[Ekologi trofik komunitas ikan di Sungai Nimbai: Interaksi kompetisi dan pemangsaan terhadap ikan pelangi arfak, *Melanotaenia arfakensis* Allen, 1990]

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Received: 25 July 2019; Accepted: 8 October 2019

Abstract

Information on trophic ecology can provide an understanding of the functional role of fish in an ecosystem, including endemic and native fish groups, as well as alien fish that are introduced through anthropogenic activities. The research on the trophic ecology of the fish community in the Nimbai Stream, Prafi River system, is intended to describe the interaction of competition and predation, especially towards endemic fish, *Melanotaenia arfakensis*. Fish samples were collected monthly from four habitat types, i.e., slow littoral, medium littoral, pool, and run from May 2016 to April 2017. A combination of an electric shocker and a hand net was used to collect fish samples. A total of 16 fish species were collected, consists of one endemic species, namely *M. arfakensis*, nine species of native fish, and six species of alien fish. The Arfak rainbowfish and three native fish species were categorized as insectivorous, four native fish species as herbivorous, and two other fishes as carnivorous. Three alien fish species also belong to insectivorous, two alien fish species as carnivorous, and one species as herbivorous. The niche breadth of fish communities ranges from 0.071 to 0.857. The trophic niche overlap between the Arfak rainbowfish and three native fish species and three alien fish species was recorded. The results of this study indicate a potential competition and predation interactions between Arfak rainbowfish and native fish as well as with alien fish species. Therefore, introducing alien fish into Prafi River system will disrupt Arfak rainbowfish population.

Keywords: alien fish, competition, endemic fish, food niche, native fish, predation

Abstrak

Informasi mengenai ekologi trofik dapat memberikan pemahaman tentang peran fungsional ikan dalam suatu ekosistem, termasuk pada kelompok ikan endemik, ikan asli, maupun ikan asing yang dimasukkan melalui aktivitas antropogenik. Penelitian mengenai ekologi trofik komunitas ikan di Sungai Nimbai, sistem Sungai Prafi, bertujuan untuk mendeskripsikan interaksi kompetisi dan pemangsaan, khususnya terhadap ikan endemik, *Melanotaenia arfakensis*. Contoh ikan dikumpulkan setiap bulan dari Mei 2016-April 2017 di empat tipe habitat yakni tepi aliran lambat, tepi aliran sedang, lubuk, dan aliran deras. Kombinasi alat *electric shocker* dan *hand net* digunakan untuk mengumpulkan contoh ikan. Sebanyak 16 spesies ikan berhasil dikumpulkan yang terdiri atas satu jenis ikan endemik (*M. arfakensis*), sembilan jenis ikan asli, dan enam jenis ikan asing. Ikan pelangi arfak dan tiga jenis ikan asli termasuk insektivora, empat jenis ikan asli adalah ikan herbivora, dan dua jenis ikan asli lainnya termasuk ikan karnivora. Tiga spesies ikan asing juga termasuk ikan insektivora, dua jenis ikan asing adalah ikan karnivora, dan satu spesies ikan asing lainnya adalah ikan herbivora. Luas relung komunitas ikan berkisar di antara 0,071-0,857. Tumpang tindih relung makanan ditemukan antara ikan pelangi arfak dengan tiga spesies ikan asli serta tiga spesies ikan asing. Hasil penelitian ini menunjukkan adanya potensi interaksi kompetisi dan pemangsaan antara ikan pelangi arfak dan ikan asli serta dengan ikan asing. Introduksi ikan asing ke dalam sistem Sungai Prafi ditengarai akan mengganggu populasi ikan pelangi arfak.

Kata penting: ikan asing, ikan asli, ikan endemik, kompetisi, pemangsaan, relung makanan

Introduction

Information on trophic ecology provides an understanding of the functional role of fishes in their ecosystem (Blaber 1997, Cruz-Escalona *et al*. 2000) which is also related to population dynamics (e.g., growth, reproduction, and abundance). In addition, this information contributes to understanding resource partitioning (Grossman 1986, Ross 1986, Guedes & Araújo 2008), habitat preferences (Wetherbee & Cortés 2004), prey selection (Motta & Wilga 2001), competition (Stergiou & Karpouzi 2002, Svanbäck & Bolnick 2007), predation (Frid & Marliave 2010), and energy transfer within and between ecosystems (Nakano & Murakami 2001, Baxter *et al*. 2004, 2005). Therefore, this ecological information becomes important in protection of species and ecosystem, and also in the development of conservation strategies (Simpfendorfer *et al*. 2011).

The Nimbai Stream is part of the Prafi River system that located in West Papua. Based on previous information (Manangkalangi *et al*. 2014), one of endemic fish species, namely *Melanotaenia arfakensis* and 10 species of native fish are occurred. However, it is unfortunate that in this stream six alien species have also been found (Manangkalangi *et al*. 2014) which are likely to originate from aquaculture and mosquito control activities. Information on alien fish trophic and its potential impact on endemic Arfak rainbowfish is still relatively rare (*ie* Manangkalangi & Kaliele 2011). It is necessary, therefore, to conduct a research on trophic ecology of fish community in Nimbai Stream with purpose to describe competition and predation interactions between Arfak rainbowfish and other fish species in community. It is hoped that this information may useful as basis data for this endemic fish conservation strategy.

Materials and methods

Study area

This research was conducted in the Nimbai Stream, Prafi River system, West Papua Province (Figure 1). The stations were choosen related to previous information (Manangkalangi *et al*. 2019) that at these locations have a high frequency of occurrence and abundance of Arfak rainbowfish and a variety of alien species was found. At this location, four habitat types were determined for fish sampling, namely slow littoral, medium littoral, pool, and run (Copp 1992, Hawkins *et al*. 1993). Analysis of fish samples was conducted at the Fisheries Laboratory, Faculty of Fisheries and Marine Sciences, University of Papua.

Collection, identification, and handling of fish samples

Fish sampling was carried out monthly from May 2016 to April 2017. Fish samples collection in each habitat type was carried out using a combination of electric shocker and hand net (1 mm mesh size). Fish samples obtained were subsequently identified based on morphological characters referring to Allen (1990, 1991), Kottelat *et al*. (1993), Rainboth (1996), Roberts (1989), Allen *et al*. (2000), Pusey *et al*. (2004), Kadarusman *et al*. (2010), and Keith *et al*. (2011, 2012, 2017).

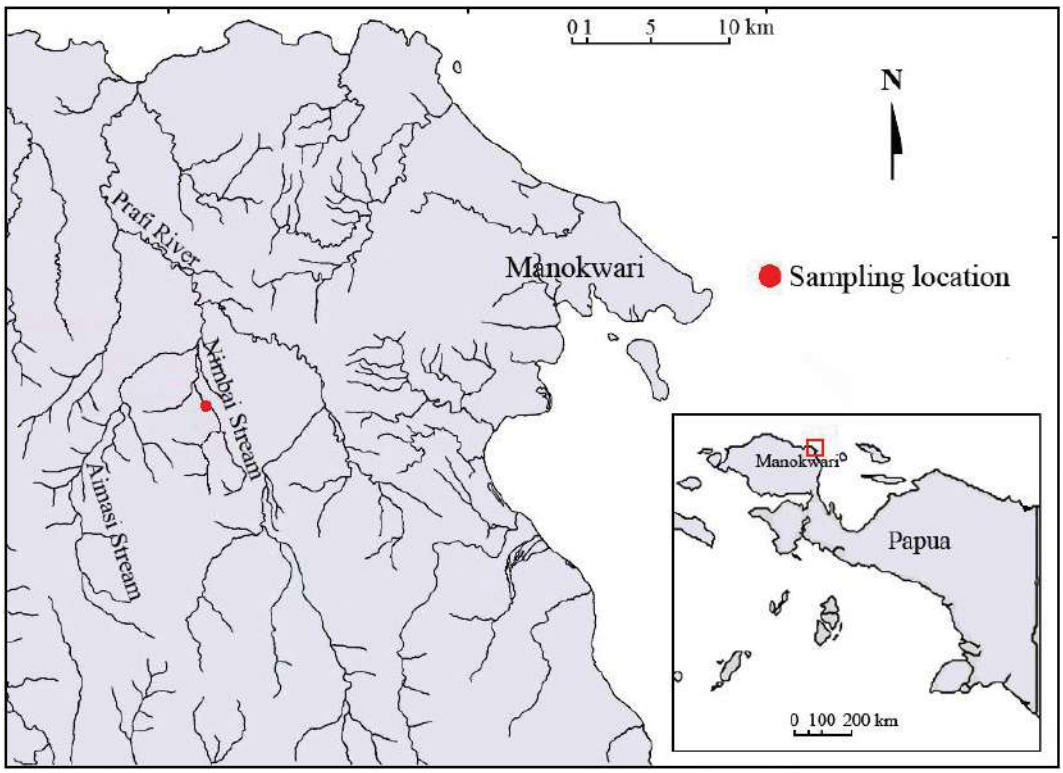

Figure 1 Map of sampling location at the Nimbai Streams, Prafi River system

Each sample of fish was measured in standard length using calipers with the nearest 0.01 mm. Fish samples were dissected and the digestive tract was removed. Diet in the digestive tract was further identified and counted individually. Food identification was carried out to the nearest taxa level with reference to Needham & Needham (1963), McCafferty (1983), Finlay *et al*. (1988), Carver *et al*. (1996), Colless & McAlpine (1996), Lawrence & Britton (1996), Naumann (1996), Neboiss (1996), Peters & Campbell (1996), Watson & O'Farrell (1996), Bouchard (2004), Pescador *et al*. (2004), Pescador & Richard (2004), and Bellinger & Sigee (2015).

Data analysis

Diet analysis of all fish species was carried out by calculating the index of preponderance, niche breadth and niche overlap. Only the stomach containing food was used for all of these analyses.

Preponderance index (I_i) of food is calculated based on the formula Natarajan & Jhingran (1961) which has been modified by combining the frequency of occurrence and the amount, namely:

$$I_i = \frac{n_i \times o_i}{\Sigma n_i \times o_i} \times 100$$

where, I_i as the index of the preponderance of the food group i; n_i is a percentage of the number of individuals in each food group i; o_i as a percentage of the frequency occurrence of the food group i; $\sum n_i.o_i$ as a multiplication of the percentage of the number and frequency of occurrences of all food groups in the digestive tract.

The size of niche breadth is calculated according to Levins (1968), which is based on the even distribution of individual food by the formula:

$$B = \frac{1}{\sum p_j^2}$$

where B as Levins' measure of niche breadth, p_j as the proportion of individuals found in or using resource state j (calculated by N_j/Y), N_j as the number of individuals found in or using resource state j, $Y = \Sigma N_j$ = total number of individuals examined contained food.

For the standardization of niche breadth on a scale from 0 to 1, a formula based on Hurlbert (1978) is used:

$$B_A = \frac{B-1}{n-1}$$

where B_A is Levins' standardized niche breadth, B is Levins' measure of niche breadth, and n is the number of possible food used. Niche breadth are classified into small (<0.4), moderate (0.4-0.6), and large (> 0.6) categories (modified from Grossman 1986).

To find the overlapping food niches, a simplified Morisita index (Horn 1966) is used with the formula:

$$C_H = \frac{2 \sum p_{ij} p_{ik}}{\sum p^2_{ij} + \sum p^2_{ik}}$$

where C_H as simplified Morisita index of overlap between species j and species k, p_{ij} as proportion of prey i of the total prey utilized by species j, and p_{ik} as proportion of prey i of the total prey utilized by species k.

This index value ranges between 0 and 1; if close to 0 indicates no similarity between food types and close to 1 indicates the use of the same food. This index is classified into several categories, namely small (<0.4), moderate (0.4-0.6), and large (>0.6) (Modified from Grossman 1986). This index assumes that all food is available equally to all predators (Reinthal 1990).

Results

Composition of species and number of fish samples

In this study, as many as 16 species were obtained, consisting of one endemic species, nine native fish species, and six alien fish species (Table 1). In addition to the Arfak rainbowfish, individuals from two species of native fish (*Sicyopterus cynocephalus*, *Stiphodon semoni*), and three species of alien fish (*Barbodes binotatus*, *Gambusia affinis*, *Aplocheilus panchax*) were also found in large numbers.

The composition and the largest portion of food

Food composition in the fish community in the Nimbai Stream is shown in Table 2. Food composition consists of groups of plants, more varied animals, and associated materials in the form of sand particles. Among the food groups in the form of animals, members of the insect group were mainly found to dominate the stomach contents of the fish community in this stream.

The composition and index of the preponderance (I_i) of food in the endemic fish group and native fish are shown in Table 3. In Arfak rainbowfish, the composition of the food varies but was dominated by the insect groups, especially Diptera and Ephemeroptera with I_i values > 16.58. Three species of native fish (*E. fusca*, *S. cynocephalus*, and *A. grammepomus*) also consume prey items that were relatively same as Arfak rainbowfish, which was mainly dominated by insect groups from orders Diptera and Ephemeroptera. The other four species of native fish mainly consumed benthic algae group (ie, *S. semoni*, *Schimatogobius* sp., *C. melanoptera*, and *R. guilberti*) as main food. Two other species of native fish (*A. marmorata*, *B. segura*), mainly eat groups of animals, specifically from Oligochaeta and Crustaceans.

Table 1 Composition of species, number of individuals, and size of sample fish collected in the Nimbai Stream

No.	Category and Species		Number of individu		Standard length (mm)
	Name	Code	Range of each sampling	Total	
	Endemic				
1.	*Melanotaenia arfakensis*	Mar	3-37	184	22.12-110.21
	Native				
2.	*Anguilla marmorata*	Ama	1	3	294.13-372.59
3.	*Eleotris fusca*	Efu	1-3	9	45.98-67.63
4.	*Belabranchus segura*	Bse	1-6	19	60.29-73.84
5.	*Stiphodon semoni*	Sse	1-17	47	26.75-35.83
6.	*Sicyopterus cynocephalus*	Scy	1-13	59	27.49-60.74
7.	*Schismatogobius* sp.	Sch	1	2	53.28-57.86
8.	*Awaous grammepomus*	Agr	1-3	6	65.53-77.81
9.	*Cheilon melinopterus*	Cme	1	1	98.46
10.	*Rhyacichthys guilberti*	Rgu	1	3	69.15-108.13
	Alien				
11.	*Aplocheilus panchax*	Apa	2-13	55	23.70-45.68
12.	*Oreochromis niloticus*	Oni	1-8	21	28.16-77.57
13.	*Clarias batrachus*	Cba	1	1	78.66
14.	*Barbodes binotatus*	Bbi	1-41	185	20.28-84.96
15.	*Gambusia affinis*	Gaf	11-52	87	26.63-40.93
16.	*Monopterus albus*	Mal	1	2	374.27-486.82
	Total			684	

The diet composition of six alien species also varies (Table 4). *Aplocheilus panchax*, *G. affinis*, and *B. binotatus* mainly eat insect groups, namely Ephemeroptera, Hemiptera, Diptera, and Trichoptera. *Clarias batrachus* and *Monopterus albus* mainly eat Oligochaeta (I_i value of 20.00-42.86). In contrast to *Orechromis niloticus,* this species mainly feeds on Bacillariophyta and Chlorophyta groups.

The niche breadth

Niche breadth of the fish community in Nimbai Stream varies, ranging from 0.071 to 0.857 and in the small to large categories (Table 5). Arfak rainbowfish have a niche breadth in the medium category, while the niche breadth of native fish and alien fish groups were categorized as small to large.

Trophic niche overlaps

Based on the results of the simplified Morisita's index analysis showed that niche trophic overlap between Arfak rainbowfish and native fish groups was vary in the range of 0.000 to 0.925 (Table 6). Overlap in the larger category which was mostly found between Arfak rainbowfish with *E. fusca*, *S. cynocephalus*, and *A. grammepomus*. Overlapping variations were also found between Arfak rainbowfish and alien fish (Table 7). The greatest overlap was found between this endemic fish with *G. affinis* (0.894-0.946), *A. panchax* (0.290-0.961), and *B. binotatus* (0.358-0.889).

Table 2 Food composition of fish communities in the Nimbai Stream

Group of organism		Taxa	Remarks
Plant (algae and macro-phyte)	1. Bacillariophyta	*Diatoma*, *Melosira*, *Navicula*, *Nitzschia*, *Rhizosolenia*, *Thalassiothrix*	-
	2. Chlorophyta	*Actinastrum, Closterium, Cosmarium, Docidium, Draparnaldia, Microspora, Mougeotia, Pleurotaenium, Spirogyra*	-
	3. Cyanophyta	*Anabaena*	-
	4. Macrophyta fraction	Unidentified	Leave fraction
Animal	5. Protozoa	*Difflugia*	-
	6. Rotifera	*Keratella*	-
	7. Cladocera	*Daphnia*	-
	8. Ephemeroptera	*Baetis*, *Caenis*, Leptophlebia, Habrophlebia, Tricorythidae	Aquatic insect, larva phase
	9. Coleoptera	Elmidae, Hydrophilidae, unidentified	Aquatic insect, larva phase
	10. Odonata	Libellulidae, Corduliidae, Calopterygidae	Aquatic insect, larva phase
	11. Diptera	Ceratopogonidae, Dixidae, Ephydridae, Simuliidae	Aquatic insect, larva phase
	12. Trichoptera	Glossosomatidae, *Hydropsyche* sp., *Stactobiella* sp., Leptoceridae, Hydroptilidae, *Ryacophila* sp.	Aquatic insect, larva phase
	13. Lepidoptera	-	Aquatic insect, larva phase
	14. Hemiptera	*Rheumatobates* sp., *Husseyella* sp., Naucoridae	Aquatic insect, adult phase
	15. Araneae	-	Semi terrestrial insect
	16. Hymenoptera	Formicidae	Terestrial insect, adult phase
	17. Collembola	Isotomidae	Semi terrestrial insect
	18. Insect fraction	-	Fraction
	19. Oligochaeta	-	-
	20. Gastropoda	*Lymnaea*	-
	21. Crustacea	Atyidae (shrimp)	-
	22. Fishes	Unidentified	Muscle fraction, scale
Other material	23. Sand particles	-	-

Note: - unidentified to species, genus, or family

Table 3 Food composition and indeks of preponderance (I_i) for Arfak rainbowfish and native fishes at the Nimbai Stream

No.	Prey item	Endemic and Native fishes									
		Mar	Ama	Efu	Bse	Sse	Scy	Sch	Agr	Cme	Rgu
1.	Bacillariophyta	0.30-9.52	-	-	-	39.22-77.38	4.17-22.50	50.00-75.00	4.07-9.68	27.03	60.34-77.78
2.	Chlorophyta	0.15-3.26	-	-	-	7.14-29.70	0.78-14.29	25.00-37.50	0.81-4.71	62.16	11.11-12.07
3.	Cyanophyta	0.33	-	-	-	5.31-50.00	1.39-14.12	-	3.23	2.70	20.69
4.	Macrophyta fraction	-	-	-	-	-	-	-	-	-	-
5.	Protozoa	0.05-0.10	-	-	-	0.17-6.67	-	-	-	-	-
6.	Rotifera	0.06-0.99	-	-	-	-	-	-	-	-	-
7.	Cladocera	0.03-4.76	-	-	-	-	-	-	-	-	-
8.	Ephemeroptera	16.58-44.43	-	20.00-55.56	-	-	21.57-55.65	-	70.97-87.06	-	1.72
9.	Hemiptera	0.11-2.12	-	5.26-16.67	-	-	-	-	-	-	-
10.	Odonata	-	0.00-50.00	5.56-20.00	3.13-33.33	-	0.40-14.81	-	-	-	-
11.	Coleoptera	0.03-6.47	-	5.26-5.56	3.13-8.33	-	0.39-14.29	-	0.41	-	-
12.	Diptera	38.10-75.60	-	5.26-40.00	-	5.88-33.33	7.26-38.89	12.50	7.06-14.63	-	-
13.	Hymenoptera	0.05-2.93	-	5.56	6.25-25.00	-	-	-	-	-	-
14.	Trichoptera	0.17-6.33	-	11.11-16.67	-	0.17-1.19	3.23-19.35	-	-	-	3.45-11.11
15.	Lepidoptera	0.05-0.77	-	-	-	-	0.16-0.40	-	-	-	-
16.	Collembola	-	-	-	-	-	-	-	-	-	-
17.	Araneae	0.05-0.21	-	-	-	-	-	-	-	-	-
18.	Insects fraction	0.06-2.61	-	5.26-33.33	-	-	1.61-14.29	-	0.81-3.23	-	1.72
19.	Oligochaeta	0.03-1.59	-	5.26-5.56	4.55-50.00	-	-	-	-	-	-
20.	Gastropoda (*Lymnaea*)	-	-	5.26-5.56	-	-	-	-	-	-	-
21.	Crustasea (shrimp)	-	50.00-100.00	5.56-33.33	12.50-75.00	-	-	-	-	-	-
22.	Fishes fraction (muscle, scale)	-	0.00-50.00	5.26-16.67	8.33-62.50	-	-	-	-	-	-
23.	Sand particles	-	-	-	-	-	-	-	-	8.11	-
Proportion of plant material		0.00-9.52	0.00	0.00	0.00	66.67-100.00	11.11-32.16	87.50-100.00	4.71-16.13	91.89	88.89-93.10
Proportion of insect material		84.13-100.00	0.00-50.00	50.00-94.44	0.00-27.27	0.00-33.33	67.84-88.89	0.00-12.50	83.87-95.29	0.00	6.90-11.11
Proportion of animal material		89.06-100.00	100	100	100	0.00-33.33	67.84-88.89	0.00-12.50	83.87-95.29	0.00	6.90-11.11
Categories		Carnivorous, (insectivorous)	Carnivorous	Carnivorous (insectivorous)	Carnivorous	Herbivorous	Carnivorous (insectivorous)	Herbivorous	Carnivorous (insectivorous)	Herbivorous	Herbivorous
Total observation		11	3	5	6	7	10	2	3	1	2

Table 4 Diet composition and index of preponderance (I_i) for alien fishes at the Nimbai Stream

No.	Prey item	Alien fishes					
		Apa	Oni	Cba	Bbi	Gaf	Mal
1.	Bacillariophyta	-	38.90-81.84	-	1.34-7.82	-	-
2.	Chlorophyta	0.47-0.90	23.27-37.83	-	0.07-1.41	-	-
3.	Cyanophyta	-	0.18-1.11	-	0.07-8.33	-	-
4.	Macrophyta fraction	-	0.71	-	0.58-19.05	-	-
5.	Protozoa	-	0.06	-	-	-	-
6.	Rotifera	-	0.16-6.39	-	-	-	-
7.	Cladocera	0.24	0.79-4.15	-	0.03-0.18	0.35-1.96	-
8.	Ephemeroptera	12.12-41.95	3.73-7.54	-	4.76-49.07	26.96-40.78	-
9.	Hemiptera	0.94-36.36	1.26-1.42	-	0.33-2.48	4.57-11.86	-
10.	Odonata	0.12-12.12	0.71	28.57	0.06-1.09	0.25-0.90	20.00
11.	Coleoptera	0.12-0.94	0.04-0.18	-	0.06-0.99	0.31-1.37	-
12.	Diptera	6.67-60.71	1.70-3.91	-	4.17-62.89	38.28-55.15	-
13.	Hymenoptera	0.94-18.18	0.06	-	0.71-4.76	0.25-2.39	-
14.	Trichoptera	0.47-40.00	0.18-2.01	-	0.93-53.47	1.96-6.59	-
15.	Lepidoptera	0.56-5.66	0.06-0.18	-	0.06-1.07	0.99-4.23	20.00
16.	Collembola	-	-	-	0.03-0.18	0.01	-
17.	Araneae	-	-	-	0.03-0.27	-	-
18.	Insects fraction	0.12-26.67	0.04-0.50	-	4.03-33.33	0.11-2.21	20.00
19.	Oligochaeta	-	-	42.86	0.53-4.81	0.05	20.00-40.00
20.	Gastropoda (Lymnaea)	-	-	-	-	-	20.00
21.	Crustasea (shrimp)	-	-	28.57	0.06-4.76	0.01-0.05	20.00
22.	Fishes fraction (muscle, scale)	0.12-5.26	-	-	-	0.05-0.25	20.00
23.	Sand particles	-	0.04-0.53	-	0.04-9.52	-	-
	Proportion of plant material	0.00-0.47	77.62-90.86	0.00	3.75-19.05	0.00	0.00
	Proportion of insect material	94.74-100.00	8.15-13.20	22.22	61.90-93.75	97.79-99.44	20.00-40.00
	Proportion of animal material	99.10-100.00	9.10-19.36	100.00	71.43-96.25	100.00	100.00
	Categories	Carnivorous (insectivorous)	Herbivorous	Carnivorous	Carnivorous (insectivorous)	Carnivorous (insectivorous)	Carnivorous
	Total observation	9	3	1	11	3	2

Table 5 Niche breadth of fish community at the Nimbai Stream

No.	Species	Niche breadth		n	Categories after standarized
		B	B_A		
	Endemic fish				
1.	*M. arfakensis*	2.828-5.043	0.181-0.512	7-14	Small-medium
	Native fish				
2.	*A. marmorata*	1.600-2.667	0.600-0.833	2-3	Large
3.	*E. fusca*	3.267-6.259	0.624-0.756	4-9	Large
4.	*B. segura*	1.800-4.840	0.667-0.833	2-6	Large
5.	*S. semoni*	1.471-3.771	0.421-0.786	2-6	Medium-large
6.	*S. cynocephalus*	3.769-6.896	0.399-0.737	5-10	Small-large
7.	*Schismatogobius* sp.	1.600-2.462	0.600-0.731	2-3	Large
8.	*A. grammepomus*	1.452-1.903	0.144-0.181	4-6	Small
9.	*C. melinopterus*	2.142	0.381	4	Small
10.	*R. guilberti*	1.588-2.362	0.272-0.294	3-6	Small
	Alien fish				
11.	*A. panchax*	2.814-6.119	0.203-0.852	4-12	Small-larger
12.	*O. niloticus*	1.854-3.743	0.071-0.196	11-15	Small
13.	*C. batrachus*	2.455	0.727	3	Large
14.	*B. binotatus*	4.596-8.559	0.281-0.845	6-19	Small-large
15.	*G. affinis*	4.477-5.488	0.290-0.408	11-13	Small-medium
16.	*M. albus*	3.571-3.769	0.692-0.857	4-5	Large

Note: B = Levins' niche breadth, BA = standardized Levins' niche breadth, n = number of food group

Discussion

Niche breadth

The niche breadth is being influenced by the number of food groups and by the even distribution of individual food. Krebs (1989) suggests that organisms that utilize more diverse types of food and/or proportions of each type of food that are relatively the same have wider niche breadth and vice versa. Therefore, a high predation rate when food is abundant at a certain location will cause the predator's food niche to be narrower (Crowder & Cooper 1982). Although a fish species utilizes more than one type of food, the dominance of a type of food is likely to indicate its abundance in waters. Moreover, the dominance of a type of food indicates the possibility of active food selection. The results of previous study (Manangkalangi *et al*. 2010) showed that Arfak rainbowfish tend to choose prey item. This explains why niche breadth of this endemic fish is small to medium, even though food diversity is relatively higher (7-14 food groups).

Niche trophic overlap

High overlapping values indicate the similarity of foods that are categorized as high (Grossman 1996). Values that exceed 0.6 indicate a very important biologically overlap in the use of resources (Wallace 1981), which is likely to have implications for competition in food sources if their availability is limited in nature.

Table 6 Niche overlap between Arfak rainbowfish and native fishes at the Nimbai Stream

Month	Native fish								
	Ama	Efu	Bse	Sse	Scy	Sch	Agr	Cme	Rgu
Mei	-	-	-	-	-	-	-	-	-
June	0.010	-	0.058	-	0.886	0.178	-	-	-
July	-	-	-	0.580	-	-	-	-	-
August	-	0.848	0.037	-	0.726	-	-	-	0.215
September	0.000	0.530	-	0.103	0.692	-	-	0.078	-
October	-	-	-	-	-	-	-	-	-
November	-	0.566	-	-	0.437	-	0.533	-	-
December	0.000	0.414	-	-	0.925	-	-	-	-
January	-	-	0.000	0.320	0.834	0.070	-	-	-
February	-	-	-	0.218	0.786	-	0.636	-	-
March	-	0.070	0.025	0.354	0.780	-	-	-	0.117
April	-	-	0.009	0.399	0.921	-	-	-	
Range	0.000-0.010	0.070-0.848	0.000-0.058	0.103-0.580	0.437-0.925	0.070-0.178	0.533-0.636	0.078	0.117-0.215
Category of niche overlap	small	small-large	small	small-medium	medium-large	small	medium-large	small	small

Table 7 Niche trophic overlap between Arfak rainbowfish and alien fishes at the Nimbai Stream

Month	Alien fish					
	Apa	Oni	Cba	Bbi	Gaf	Mal
Mei	0.881	-	-	0.893	-	-
June	0.959	-	-	0.769	-	-
July	-	0.125	-	0.437	-	-
August	-	-	-	0.358	-	-
September	0.948	-	-	0.658	-	-
October	-	-	-	-	-	-
November	0.939	0.210	-	0.690	-	-
December	0.961		-	0.738	-	-
January	0.952		-	0.766	0.946	-
February	0.816	0.158	-	0.637	0.894	0.035
March	0.554	0.256	-	0.758	-	0.063
April	0.290	0.257	0.024	0.789	0.942	-
Range	0.290-0.961	0.125-0.257	0.024	0.358-0.893	0.894-0.946	0.035-0.063
Category of niche overlap	small-large	small	small	small-large	large	small

Interaction of competition and predation on Arfak rainbowfish

The results showed that there is a potential for competition and predation interactions between the Arfak rainbowfish and some native fish in the Nimbai Stream. Although predation interaction cannot yet be proven directly, based on the results of identification of food composition and index of preponderance, the largest part shows that some species belong to the carnivorous group; in particular, there is a fish muscle fraction. Also, the introduced of alien fish adds pressure on the presence of Arfak rainbowfish and native fish populations concerning predation and the level of competition for food resources, especially the aquatic insect groups. Some studies indicate that some of alien fish species found in this study area have an impact on declining fish population and native biota through predation mechanism and food competition, for example, *Gambusia affinis* (Leyse *et al*. 2003, Laha & Mattingly 2007, Segev *et al*. 2008) and *Oreochromis niloticus* (Morgan *et al*. 2004).

Conclusions

The results of the present study show that there are two types of interaction between Arfak rainbowfish with other fishes in Nimbai Stream, namely competition and predation. Arfak rainbowfish competes with others native fish (such as *Eleotris fusca*, *Sicyopterus cynocephalus*, *Awaous grammepomus*) and alien fish species (i.e, *Aplocheilus panchax*, *Gambusia affinis*, *Barbodes binotatus*) in terms of feeding preferences. There is a possibility that Arfak rainbowfish becomes prey for carnivorous fishes like *Anguilla marmorata*, *Belobranchus segura* and *Monopterus albus*. Accordingly, introduction of alien fish species into Nimbai Stream will disrupt the Arfak rainbowfish population.

Acknowledgement

The authors thanks Luky Sembel, Abraham W. Manumpil, Frengky N. Krey, Adries Latul, Williwar Aronggear, Habema VY Monim, Nomensen Rumbewas (†), Dodi J. Sawaki, Yunus Baab, Dakar Prasetyo, Bernadus Duwit, Daud Orisu, Satriano N. Yoku, Philipus Musyeri, Hendry Amunau, Artasastra Arki H. M. Awairaro, Moses Peday, Riky Kaiway, Marten Sawaki, Bram Ondy, Adi I. Throvyan, Irman Rumengan, Dandy Saleky, who helped the collection and handling of samples in the field and laboratory. To Simon P. O. Leatemia as Head of the Fisheries and Marine Sciences Faculty of Fisheries Laboratory, the University of Papua who provided facilities in this research. The first author also thanks to the Ministry of Research, Technology, and Higher Education for the support of the 2014 Domestic Postgraduate Education Scholarship (BPPDN) and the Doctoral Research Grant 2017 with number of contract: 089/SP2H/LT/DRPM/IV/2017. Also to the Research Center for Fish Resource Recovery (BRPSDI) which has provided funding support for publication in the Indonesian Journal of Ichthyology

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