RELATIVE IMPORTANCE OF MYSIDS AS A FOOD ITEM IN THE DIET OF TWO SMALL FISH SPECIES, *Galaxias maculates* and *Athrinidae* sp. IN THE KAKAMATUA STREAM, AUCKLAND REGION, NEW ZEALAND

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INTRODUCTION

Mysids occupy a wide variety of aquatic environments and can be a significant biological component both numericallyand in terms of biomass in these ecosystems. They are important in the consumption of suspended matter in the detritus-based estuarine food webs (Fockedy & Mees, 1999). Mysids are an important food sources for ecologically and commercially important fish. Thereby, they become an important link in estuarine food chains, and play a critical role in the cycling of energy within the system.

Mysids have been reported to be an important component of the diet of many juvenile fish such as young yellow-eyed mullet *Aldrichetta forsteri* and commoin bully *Gobiomorphus baslia* in the Avon-Heathcote Estuary New Zealand, the European perch *Perca fluviatilis*, in the Selwyn River, Canterbury, particularly during summer and yearling salmon *Oncorhynchus tshawytscha*, in bays along Akaroa Harbour in New Zealand. In order to determine the ecological importance of mysids, this study focuses on its relative importance as food item using stable isotopic study and the gut content analysis of fish.

More traditional method of gut content analysis has several draw backs. It reflects immediate feeding pattern only. Sometime it hinders identification, notably due to quick digestion of prey. Therefore, Stable Isotope Analysis (SIA) can provide a measure of feeding relationships of an organism, by visualizing all the possible trophic pathways leading to the organism (Peterson & Fry, 1987).This analysis is an effective tool integrating long-term assimilation of nutrients, and it may not reflect short term feeding patterns (Johannsson *et al*., 2001). In such cases, SIA can provide a useful alternative tool and give insights into the feeding relationships between the organisms within a given food web (Post, 2002).

METHODOLOGY

Fish species G*alaxias maculates* Jenyns, 1842 and *Athrinidae* sp. were collected from Kakamatua stream situated on the west coast of Auckland region. G*alaxias maculates* (whitebait) was very common andA*thrinidae* sp. was rarely found at this site where the mysid species *Tenagomysis* c*hiltoni* Tattersal, 1923 and *Tenagomysis novaezealandiae* Thomson, 1900 are highly dominated. These samples were collected for gut analysis in late January 2009 (summer) and the specimens were fixed in 5% formalin immediately.

Ten specimens from each fish species were dissected out and the stomach contents were mixed in a beaker with 10 ml water. After mixing the contents properly 1 ml of the sample was drawn and spread on a Sedgwick rafter. The gut content was examined under the microscope fitted with an eye piece micrometer. At each trial twenty squares were observed and there were three trials totaling to sixty squares per specimen. The number, volume and the frequency occurrence of different types of food materials were recorded. Percentage occurrence (F%), percentage volume (V%) percentage numbers (N%) and index of relative importance (IRI) were calculated as given by Hyslop (1980).

$$\text{Percentage occurrence (F\%)} = \frac{\text{The numberof stomachs in which a given food item is found}}{\text{Number of stomachs examined}} \times 100$$

$$\text{Percentage numbers (N\%)} = \frac{\text{The numberof stomachs in which a given food item is found}}{\text{Number of total food items in all specimens}} \times 100$$

$$\text{Percentage volume (V \%)} = \frac{\text{Volume of one food item found in all specimens}}{\text{The volume of all food items in all specimens}} \times 100$$

Index of Relative Importance (IRI) = F % × (N % + V %)

To study the feeding relationships using SIA, samples of fish species and mysid species were collected from the stream, Kakamatua, sealed in plastic bags, and stored in a freezer (−20°C) until processing. All the samples were oven-dried to constant weights at 40°C, then ground to obtain a homogeneous powder. Three replicates of each sample were prepared. The whole body of the mysid samples was considered. For the fish samples, only the muscle was used for the analysis. All animal samples of approximately 20 mg were processed by the Waikato Stable Isotope Unit, The University of Waikato, Hamilton, New Zealand. The carbon value ($\delta^{13}C$) was measured to a precision of ±0.1% and samples were referenced to a precalibratedC_4 sucrose standard that was cross-referenced to the Pee Dee belemnite standard (Craig, 1957). The nitrogen value $\delta^{15}N$ was measured to a precision of ±3%, and samples were referenced to an urea standard which was traceable to atmospheric nitrogen (Mariotti, 1983).The ratios of $^{13}C/\ ^{12}C$ and $^{15}N/^{14}N$ are expressed as relative difference using the following equation.

$$\delta^{13}C = \{(^{13}C/\ ^{12}C \text{ sample}/\ ^{13}C/\ ^{12}C\text{standard}) -1\} \times 10^3 \text{ and}$$
$$\delta\ ^{15}N = \{(^{15}N/^{14}N\text{sample}/\ ^{15}N/^{14}N\text{standard})-1\} \times 10^3$$

The stable isotope values of $\delta\ ^{15}N$ and $\delta^{13}C$ were used to visualize the trophic position of each collected food links of the Kakamatua Stream ecosystem.

RESULTS AND DISCUSSION

The gut content of *Athrinidae* sp. showed that they have fed on eight different food items. Among the *Athrinidae* sp. eight fish fed on diatoms, eight fed on rotifers and seven fed on filamentous algae. The other food items found in the guts were Ostracods, bivalves, copepods, Cladocerans and plant detritus (Table 1). The gut analysis of *Athrinidae* sp. revealed that the values of N% and V% are highest, for filamentous algae. The IRI value is highest in diatoms. Filamentous algae, diatoms and rotifers were the three most important food items respectively (Table 1 and Fig. 1).

The gut content of *G. maculates* indicated that they fed on 12 different food items. Among the 10 individuals analyzed six fed on mysids, five fed on cladocerans and four fed on amphipods. The other food items were ostracods, gastropods, bivalves, dipterans, coleopterans, rotifers, filamentous algae, diatoms and sand particles. The gut content analysis of *G. maculates* showed that F%, N%, V% and IRI values were highest in mysids and the second highest in amphipods (Table 2, Fig.2).

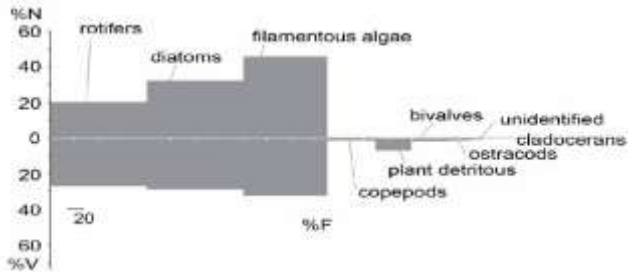

Figure 1: Diet of *Athrinidae* sp. from the Kakamatua stream expressed as percentage index of relative importance area chart (*n*=10), where %N is the percentage contribution by number, F% by occurrence and %V by volume

Table 1: Gut content analysis of *Athrinidae* sp. accordance with F%, N%, V% and IRI.

Food type	F%	N%	V%	IRI
Diatom	80	32.09	29.22	2369.69
Filamentous algae	70	45.01	32.88	2346.29
Rotifers	80	21.39	25.68	2075.87
Plant detritus	30	0.45	6.73	202.31
Bivalve	30	0.13	2.21	66.49
Copepod	40	0.40	1.61	64.66
Ostracods	20	0.36	1.37	27.83
Cladocerans	10	0.09	0.26	2.65
Unidentified	10	0.09	0.05	0.55

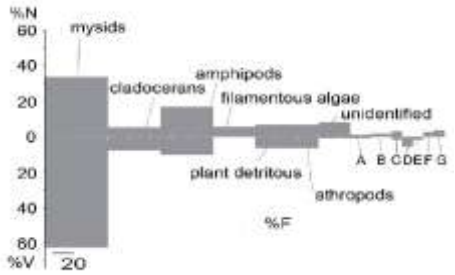

Figure 2: Diet of *G. maculates* from the Kakamatua stream expressed as percentage index of relative importance area chart (*n*=10), where %N is the percentage contribution by number, F% by occurrence and %V by volume. Legend: A, ostracods; B, rotifers; C, gastropods: D, diatoms, E, coleopterans F, diatoms, G, sand particles.

Table 2: Gut content analysis of *G. maculates* accordance with F%, N%, V% and IRI.

Food type	F%	N%	V%	IRI
Mysids	60	33.74	61.94	5740.7
Amphipods	50	17.07	9.83	1345.4
Cladocerans	50	5.28	7.30	629.2
Plant detritus	30	6.77	5.80	377.3
Unidentified animal parts	30	11.38	0.82	366.2
Unidentified matter	30	7.72	1.22	268.4
Filamentous algae	40	5.28	0.31	223.8
Dipterans	10	0.41	5.99	63.9
Gastropods	10	1.63	3.54	51.7
Rotifers	20	2.03	0.27	46.1
Ostracods	20	1.63	0.55	43.5
Sand particles	10	3.25	0.34	35.9
Diatom	10	3.25	0.09	33.4
Coleopterans	10	0.41	1.99	23.9

Stable Isotopic $\delta^{13}C$ values showed that *Athrinidae*sp had the highest $\delta^{13}C$ values (−19.5 to −19.43 ‰) and juvenile *T.chiltoni* had the lowest $\delta^{13}C$values (−23.09 to −23.2‰) than others respectively. The $\delta^{13}C$ values of:juvenile *G. maculates* −22.49 to −21.66‰; *G. maculates*−20.76 to −19.92‰; *T.novaezealandiae* −20.06 to −19.58‰ and adult *T. chiltoni*−21.48 to −20.49‰(Fig. 3).

The $\delta^{15}N$value of increasing order:*Athrinidae* sp.10.92 to 11.09‰;*T. novaezealandiae*10.9 to 12.3‰; ‰.juvenile *T. chiltoni*11.38 to 11.49‰; adult *T. chiltoni*10.61 to 12.5‰; juvenile *G. maculates*had 11.77 to 12.86‰; *G. maculates*12.9 to 13.6‰ (Fig. 3).

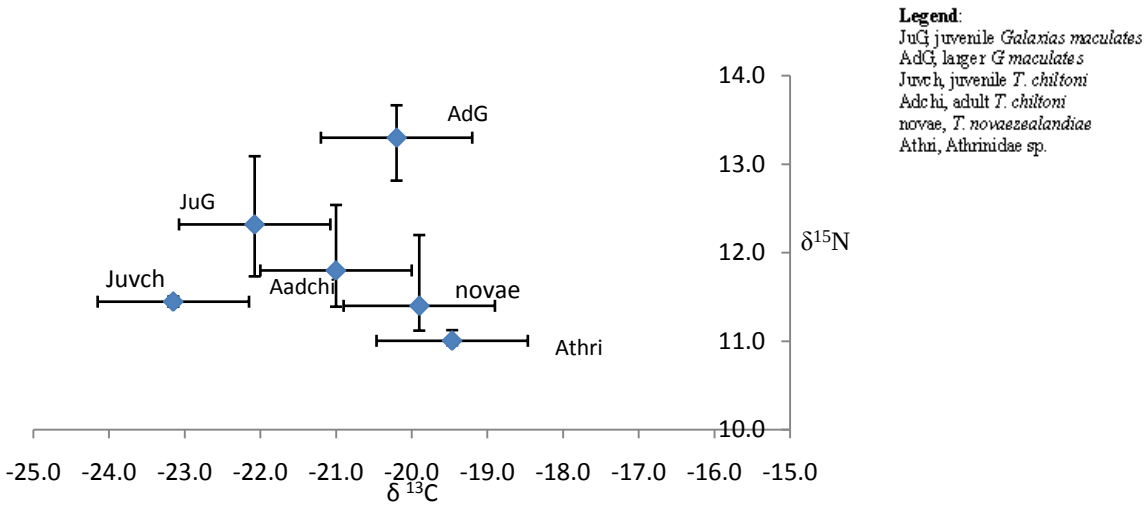

Figure 3: Mean (± SD) (*n* = 3) carbon and nitrogen stable isotopic composition of samples collected from Kakamatua Stream ecosystem.

Depending on the hypothesis of differences in $\delta^{15}N$ value between the consumers and the diet, a consumer is typically enriched by 3–4 ‰ relative to its diet (DeNiro& Epstein, 1981; Minagawa&Wada, 1984; Peterson & Fry, 1987), and depending on the above argument, the $\delta^{13}C$ value of the consumer is enriched up to 1 ‰ and it may be large as 3 ‰ relative to the food sources (DeNiro& Epstein, 1978), following conclusions were given by visual inspection (Fig. 3).

Based on the SIA result (Fig. 3), it is evident that $\delta^{13}C$ and $\delta^{15}N$ values of *T.chiltoni* ($\delta^{15}N$:10.61–12.5‰; $\delta^{13}C$−23.09 to −23.2 ‰) and *T.novaezealandiae*($\delta^{15}N$: 10.9–12.3‰; $\delta^{13}C$: −20.06 to −19.58‰), are closely linked with adult *G. maculates* ($\delta^{15}N$: 12.9–13.6‰; $\delta^{13}C$: −20.76 to −19.92‰) while juvenile *G. maculates* ($\delta^{15}N$: 11.77–12.86‰; δ13C:−22.49 to −21.66‰) link with juvenile *T.chiltoni*($\delta^{15}N$: 11.38–11.49 ‰; $\delta^{13}C$: −23.09 to −23.2 ‰). However, *Athrinidae* sp.($\delta^{15}N$: 10.92–11.09‰; $\delta^{13}C$−19.5 to −19.43 ‰) do not link with any mysid species collected from the ecosystem. It is appearent that juvenile *G. maculates* feed on juvenile *T.chiltoni* where as adult *G. maculates*feed on the adult *T.chiltoni*. This agrees with the Redon et al. (1994) that the juvenile spotted flounder contained a greater number of mysids in their stomachs whereas in the larger fish, decapods and fishes were the more abundant food items.

The gut content analysis of the present study revealed that *G. maculates* fed on 11different food items and based on IRI value mysids were the principal food item, secondly amphipods and thirdly cladocerans. This suggests that *G. maculates* prefers mysids but they act as opportunistic feeders. The gut content analysis of *Athrinidae* sp. suggests that they feed on eight different food items but mysids were not among them. Thus the stable isotopic values and the gut content analysis of fish have shown the same results that *G. maculates* fed on mysids whereas A*thrinidae* sp. did not.

The novel part of this study is the analysis of food materials using SIA which indicates resource partitioning among juvenile and adults a strategy of coexistence.

CONCLUSIONS

It is evident from both methods that *T.chiltoni* and *T. novaezealandiae* form a substantial component of the diet of commercially important *G. maculates*, at Kakamatua stream. Changes in the diet, during the ontogenetic development, in relation to body size have shown a significant enrichment of $\delta^{15}N$ values and $\delta^{13}C$ values of *T.chiltoni* and *G. maculates*.

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