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EVALUATION OF ECOLOGICAL IMPORTANCE OF MYSIDS AS A FOOD ITEM IN THE DIET OF FISH, NEW ZEALAND

N.N. Punchihewa
Department of Zoology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka
Corresponding author: neetha_punchihewa@yahoo.co.nz

Abstract

The main objective of this study is to determine the ecological importance of mysids as a food item of selected fish species using C and N isotopes (stable isotopic study) and gut content analysis of fish. Fish samples (*Galaxias maculates* and *Athrinidae* sp.) and mysid samples (*Tenagomysis chiltoni* and *T. novaezealandiae*) were collected from Kakamatua Stream situated on the west coast of Auckland region in late January 2009 (summer). All the collected samples were oven-dried, and then ground to obtain a homogeneous powder. Three replicates of each sample were prepared. Samples were processed by the Waikato Stable Isotope Unit (Scientific/20). For gut content analysis, ten specimens of each fish species, *G. maculates* and *Athrinidae* sp. were collected and were fixed in 5% formalin immediately. These fish specimens were dissected out and the stomach contents were mixed in a beaker with 10 ml water. After mixing, the contents were examined under the light microscope fitted with an eye piece micrometer. It is evident from both methods that two mysid species *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*.

Key words: Mysids, Fish, Stable isotope study, Gut analysis, C and N isotopes

Introduction

Mysids occupy a wide variety of aquatic environments and can be a significant biological component both numerically and in terms of biomass in these ecosystems (Drake et al., 2002). 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 (Mauchline 1980; Fulton 1982a, 1982b). Thereby, they become an important link in estuarine food chains, and play a critical role in the cycling of energy within the system (Webb, 1973; Grossnickle, 1982; Vilas et al., 2008).

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 (Webb, 1973), the European perch *Perca fluviatilis*, in the Selwyn River, Canterbury (Griffiths, 1976), particularly during summer and yearling salmon *Oncorhynchus tshawytscha*, in bays along Akaroa Harbour in New Zealand (James & Unwin, 1996). The three New Zealand mysid species were recorded as important food items of fish: *Tenagomysis novaezealandiae* recorded as a food item of *Perca fluviatilis* (Griffiths, 1976), *T. macropsis* dominated in the diet of *Oncorhynchus tshawytscha* (James & Unwin, 1996) and *T. chiltoni* was the prey for *Gobiomorphus cotidianus*, *Retropinna retropinna*, *Gambusia affinis*, and *Anguilla australis* (Hayes & Rutledge, 1991). Therefore, 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. In such cases, stable isotope study (SIA) can provide a useful alternative tool and give insights into the feeding relationships between the organisms within a given food web (Minagawa & Wada, 1984; Post, 2002). 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).

The main objective of this study is to evaluate the ecological importance of mysids as a food item of selected fish species (G*alaxias maculates* and A*thrinidae* sp.) using C and N isotopes (stable isotopic study) and gut content analysis of fish.

Methodology

Fish and mysid samples were collected from Kakamatua Stream (37°00′S 174°35′E) situated on the west coast of Auckland region, bordering with mature and dense riparian vegetation and reed beds. The mysid species *Tenagomysis chiltoni* Tattersal, 1923 and *Tenagomysis novaezealandiae* Thomson, 1900 are highly dominated at this site. The most common fish

population at this site was Inanga- whitebait (*Galaxias maculates* Jenyns, 1842) where *Athrinidae* sp. (hardy heads) was rarely found.

Gut content analysis

The stomach contents of dissected fish specimens 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 cell and was examined under the microscope fitted with an eye piece micrometer. At each trial twenty squares (randomly selected) 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).

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

$$\text{Percentage numbers (N\%)} = \frac{\text{The number of food items of a given type that were found in all specimens}}{\text{Number of total food items in all specimens}} \times 100$$

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

$$\text{Index of relative importance (IRI)} = F\% \times (N\% + V\%)$$

Stable Isotope Analysis (SIA)

The similar samples of fish species used for gut content analysis (*G. maculates* and *Athrinidae* sp.) and mysids *T. chiltoni* and *T. novaezealandiae* were employed in the SIA (using C and N isotopes) procedure. These samples were collected from the Kakamatua stream, sealed in plastic bags, and stored in a freezer (−20°C) until processing. The whole body of the mysid samples was considered where as for the fishes only the muscle part was used for the analysis. Samples were oven-dried to constant weights at 40°C, then ground to obtain a homogeneous powder. Three replicates of each sample (approximately 20 mg) were prepared and were processed by the Waikato Stable Isotope Unit on a fully automated Europa Scientific/20 isotope analyser, 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 precalibrated C_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 sample.

Results and discussion

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 (Fig. 1).

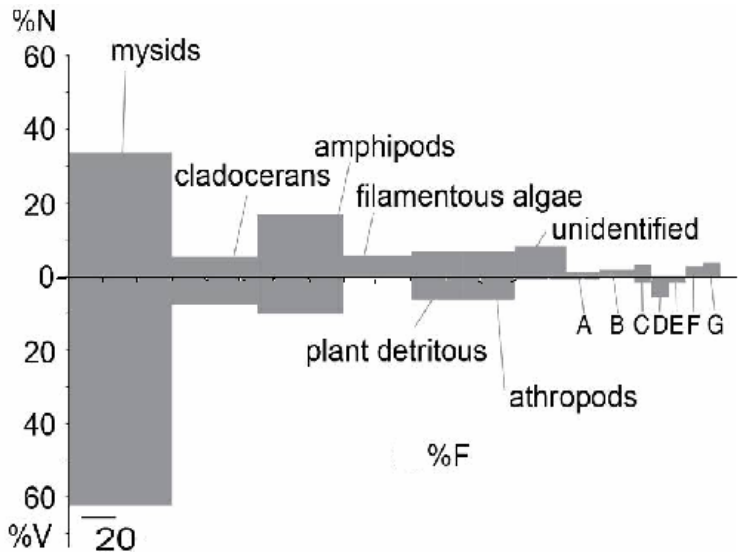

Figure 1: Diet of *G. maculates* from the Kakamatua stream expressed as percentage index of relative importance area chart (*n*=10), where N % is the percentage contribution by number, F% by occurrence and %V by volume.

Legend: A, ostracods; B, rotifers; C, gastropods: D, diatoms, E, coleopterans F, diatoms, G, sand particles.

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 (Fig. 2).

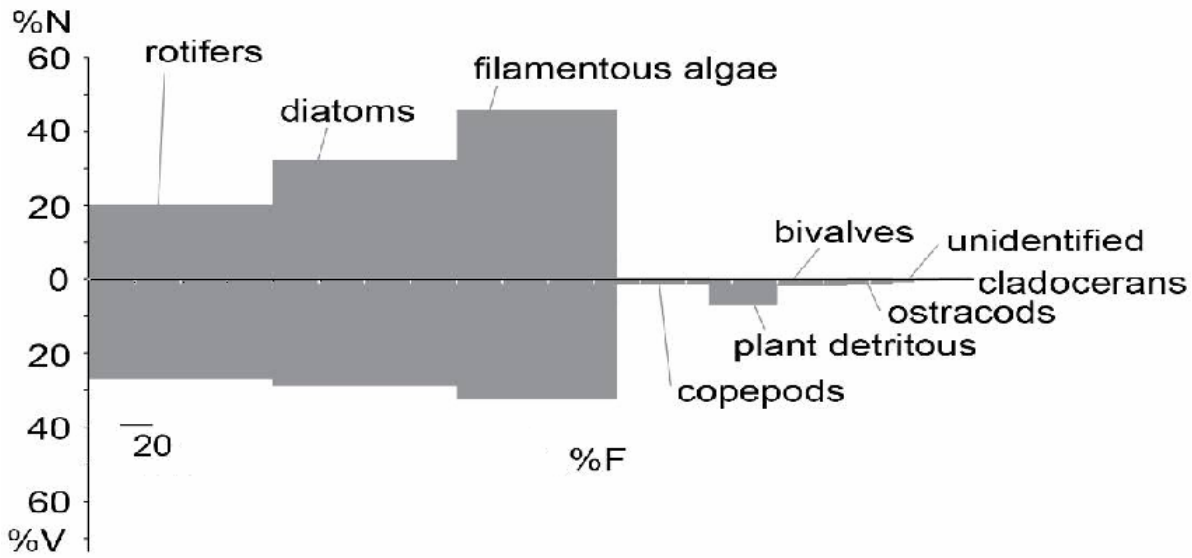

Figure 2: Diet of *Athrinidae* sp. from the Kakamatua stream expressed as percentage index of relative importance area chart (*n*=10), where %N is the percentage contribution by number, F% by occurrence and %V by volume.

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. 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).

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 upto 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* (δ^{15}N: 11.38–11.49 ‰; δ^{13}C: −23.09 to −23.2 ‰). However, *Athrinidae* sp. (δ^{15}N: 10.92–11.09 ‰; δ^{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.

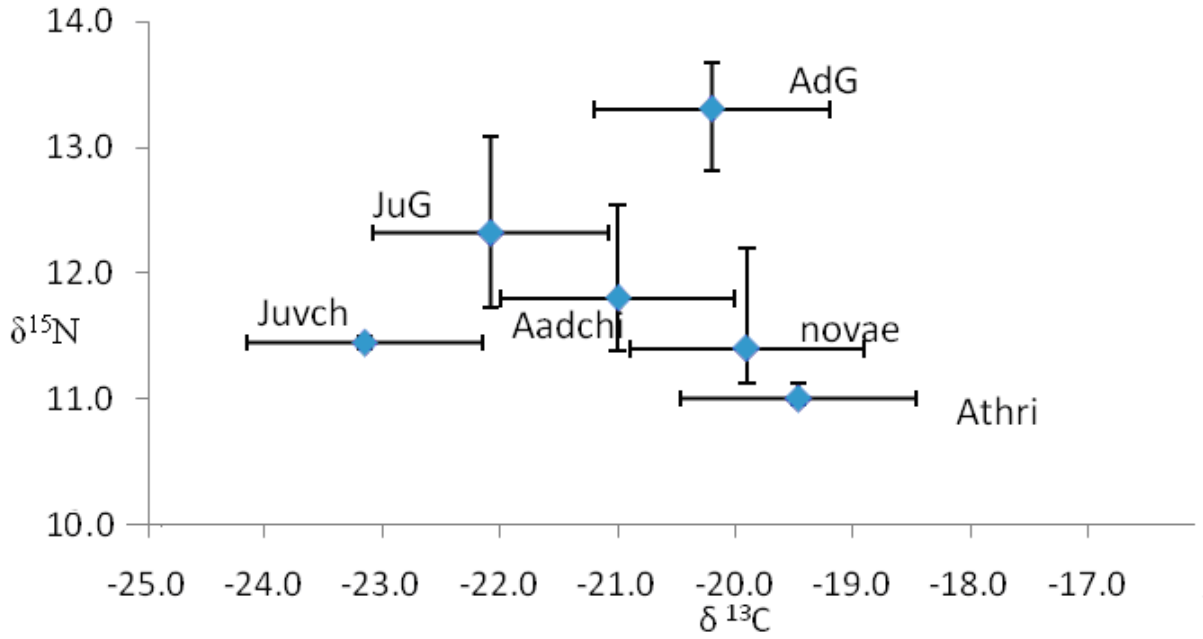

Figure 3: Mean (± SD) (*n* = 3) carbon and nitrogen stable isotopic composition of samples collected from Kakamatua Stream ecosystem.

Legend: **AdG**, larger *G. maculates* (7–8 mm); **JuG,** juvenile *Galaxias maculates* (4–5 mm)*;* **Juvch**, juvenile *T. chiltoni*; **Adchi**, adult *T. chiltoni*; **novae**, *T. novaezealandiae*; **Athri**, juvenile *Athrinidae* sp.

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.

Conclusion

It is evident from both methods that two mysid species *T. chiltoni* and *T. novaezealandiae* form a substantial component of the diet of commercially important *G. maculates*, at Kakamatua stream. During the ontogenetic development in relation to body size of *T. chiltoni*

and *G. maculates* it was shown a significant enrichment of $\delta^{15}N$ values and $\delta^{13}C$ values in their diet.

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