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Note on feeding relationships of three species of cyprinid fish larvae in Al-Huwaiza marsh, Southern Iraq

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Abstract - Food composition of three cyprinid larvae (*Cyprinus carpio, Carassius auratus* and *Alburnus mosulensis*) in Al-Huwaiza marsh has been studied during March and April 2006. The diet of these cyprinid larvae were consist mainly of zooplankton dominated by copepods both adult and larval stages followed by Cladocera Rotifera, aquatic insects and Ostracoda. The food of plant origin also exists and consists of diatoms and filamentous algae. Costello graphical plot showed that these larvae are generalist feeders. This strategy result in lower competition and allow these three species to co-occur in relatively high density in this marsh area. The food similarity between *C. carpio* and *C. auratus* was 0.60, between C. *carpio* and *A. mosulensis* was 0.44, while it was 0.72 between *C. auratus* and *A. mosulensis*. The food overlap analysis showed that *C. carpio*; *C.auratus* and *A.mosulensis* larvae share a wide range of prey types. Competition for food is possible However, direct competition seemed to be avoided to some extent as a result of great food availability in Al-Huwaiza marsh which makes it as a suitable nursery and feeding site for many cyprinid fish.

Introduction

Diet analysis of fishes allows us to understand their feeding strategy, their intra-or interspecific potential interaction (competition and predation) and indirectly indicate community energy flow (Ramirez-Luna *et al.*, 2008). However, studying trophic interaction between species is an important mechanism tool in determining the distribution of aquatic communities and improves aquatic management (Oscoz *et al.*, 2006). Food limiting at the time of first feeding was suggested as an important factor regulating recruitment success (Voss, 2009). Several studies assumed that a biotic environmental parameters have a significant effect on larval feeding success and survival (Nakata *et al.*, 1994; Dower *et al.*, 2002) either directly through larval mortality or indirectly through its impact on plankton production (Solow, 2002). Marsh area of Iraq often provides zones of high food availability for fish larvae owing to high primary and secondary productivity (IMRP, 2006). Therefore, the southern marshes of Iraq ecologically referred as nursery and feeding grounds for many fish species (Hussain *et al.*, 2008).

The food and feeding relationships of adult cyprinid fish in southern marshes of Iraq have been investigated extensively (Al-Mukhtar, 1982; Barak and Mohamed, 1982; Dawood, 1986; Hussein and Al-Kannaani, 1991; Hussain *et al.*, 2008; Hussain *et al.*, 2009), however, no such study on the diet of larval stage of cyprinid fish was done. Therefore, the aim of this study is to analyze diet composition and dietary overlap, in three species of cyprinid larvae (*Cyprinus carpio; Carassius auratus* and *Alburnus molunensis*) in Al-Huwaiza Marsh during April and March 2006 which will contributing to the knowledge of the feeding ecology of cyprinid fish.

Materials and methods

Larval fish were collected during March and April 2006 from Um al-Naaj at Al- Huwaiza Marsh, southern Iraq (Fig. 1), by using plankton net (500µ mesh size) lowered by boat. Sampling area was characterized by dense aquatic plants, the depth of water was ranged between 4-5 m, water temperature was ranged between 17-21 ºC and water salinity was ranged between 0.9-1.2 ‰. Plankton samples were preserved in 5 % formalin.

According to Fuiman *et al.* (1982), identification of cyprinid larvae was done using dissecting microscope. 41 preserved larval *A mosulensis* (TL= 13 – 22 mm), 64 *C. auratus* (TL= 6.4 – 19 mm) and 42 *C. carpio* (TL = 11 – 17 mm) were identified. Gut content analysis of the larvae was performed by first removing the entire digestive tract. The entire gut was examined. Content were identified to the lower practical taxon. Stomach fullness was estimated on a 0-20 points scale (Hyslop, 1982). Thus 0, 5, 10, 15 and 20 points were allotted to: empty, ¼ full, ½ full, ¾ full and fully stomach respectively. The presence of each food item was presented by a percentage by weighted points (P %), calculated from the sum of points given for each food item divided by the total number of points. Estimation of the occurrence of the different food organisms in each specimen was presented by the percentage occurrence (O %) calculated from the number of guts which contain the organism in question out of the total number of larvae examined (Hyslop, 1980) this index represents population's wide food habits. Diet for each class was analyzed as an index of relative importance (IRI). The index was calculated according to the formula of Stergion (1988) as follow:

$$IRI\ \% = P\ \% \times O\ \%$$

P %: percentage of total points for each food item.
O %: percentage of occurrence for each food item.

Feeding activity was calculated as a percentage of fish with food in its gut. Feeding intensity was calculated as the percentage of total weighted points divided by the total number of fed larvae (Hyslop, 1980). To determine feeding strategy and the importance of prey items, Costello graphical method (Costello, 1990) was used (Fig. 2). This plot combine percentage of prey occurrence (O %) and the percentage of weighted point of the prey item (W %). Information about prey importance and feeding strategy can be obtained by examining the distribution of points along the diagonals and the axes of the diagram as follows: The prey importance is represented in the diagonal from lower left (rare prey) to upper right (dominant prey). The feeding strategy is represented in the vertical axis from bottom (generalization) to top (specialization).

Figure 1. Map of the marshes of southern Iraq showing Al-Huwaiza Marsh and sampling area

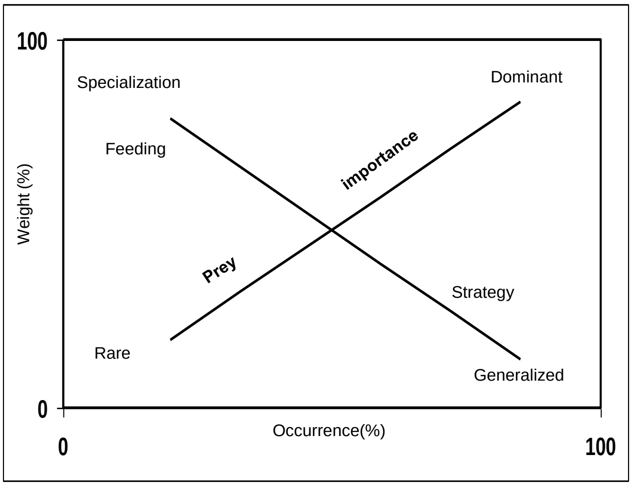

Figure 2. The Costello (1990) graphical plot showing axes and important diagonals positioning.

To calculate food niche breadth in each species, the Shannon-weaver Index (H) was used (Shannon and Weaver, 1949).
Food similarity was calculated according to Bray-Curtis (1957):

$$S_c\ \% = 2\ X_{jk} / X_j + X_k$$

S_c: Similarity index
X_{jk}: number of food items found in species j and k.

Diet overlaps between fish larvae were calculated according to Schoener's index (Schoener, 1968):

$$\text{Diet overlap}\ \% = 100\ \{1\text{-}0.5\sum (Xi - Yi)\}$$

Xi and Yi = the proportion of each food category in the gut of species X and Y.

Results

Food composition:

From the total number of fish larvae examined, six prey items were found in the gut of *C. auratus*, 4 items in *C. carpio* and 5 items in *A. mosulensis*. The diet of larvae studied consists mainly of zooplankton. Copepod (including adult and larval stages) was the main prey item found in all 3 species of cyprinid larvae (Table 1), followed by Cladocera (*Daphia spp*.). Aquatic insects represented mostly by chironomid and dragonfly larvae) were consumed by *C. auratus* (O=15.3 %) and *C. carpio* (66.6%). Diatom found in the gut of *A. mosulensis* (O=44.4 %) and *C. auratus* (O=46.0 %). While detritus was found in the gut of *C. auratus* (O=54 %) and *A. mosulensis* (O=44.4 %). Filamentous algae was consumed by *A. mosulensis* larvae only (O=44.4 %). Ostracoda (O=15.3 %) was found the gut of *C. auratus* larvae only. Rotifera was consumed by *C. carpio* larvae only (O=50 %).

Feeding activity was high for *C. carpio* (100 %) and *C.auratus* (100 %) while it was low for *A. mosulensis* (64 %) (Table 1), this reflected feeding intensity which was high for *C. auratus* and *C. carpio* comparing with *A. mosulensis*

Figure (3) shows the trophic diversity, as A. *mosulensis* have the greatest trophic diversity (H=1.561), followed by *C. carpio* (H=1.352), then *C. auratus* (H=0.967).

According to the Index of Relative Importance (IRI), the diet of *C. auratus* larvae consisted mainly of copepod (43.77 %), diatoms (4.32 %), Cladocera (2.09 %), Ostracoda (0.46 %) and aquatic insects (1.14 %). Detritus was also found with IRI=11.77% (Fig. 4). The diet of *C. carpio* larvae consist mainly of Copepoda (both adult and larval stages) (IRI=19.44 %) and aquatic insects (mostly chironomid larvae) (IRI=19.44 %) followed by Clodocera (mostly *Daphnia spp*) with IRI=13.85% then Rotifers with IRI=10.4 % (Fig. 4). The diet of *A. mosulensis* larvae is consist mainly of Cladocera (IRI=8.3 %), copepods (IRI=11.8 %), Diatoms (pinnate diatom) (IRI=6.39 %), filamentous algae (IRI=12.52 %) and detritus (IRI=6.08 %) (Fig. 4).

Table 1. Diet composition of *C. carpio* , *C.auratus* and *A. mosulensis* larvae from al Huwaiza marsh. Data are present as percentage of Occurrence (O %), percentage of weighted points (P %), Trophic diversity (H′), feeding activity (%) and feeding intensity.

	C. carpio n=42, TL: 11-17mm		*C. auratus* n=64, TL: 6.4-19mm		*A. mosulensis,* n=41, TL:13-22mm	
Food item	P %	O %	P %	O %	P %	O %
Copepoda	29.2	66.6	51.5	85.0	25.0	44.4
Aquatic Insect	29.2	66.6	7.5	15.3	-	-
Cladocera	20.8	66.6	6.8	30.8	18.7	44.4
Rotifera	20.8	50.0	-	-	-	-
Diatom	-	-	9.4	46.0	14.4	44.4
Detritus	-	-	21.8	54.0	13.7	44.4
Ostracoda	-	-	3.0	15.3	-	-
Filamentous algae	-	-	-	-	28.2	44.4
H´	1.352		0.967		1.561	
Feeding activity %	100		100		64	
Feeding Intensity	20.0		20.46		17.7	

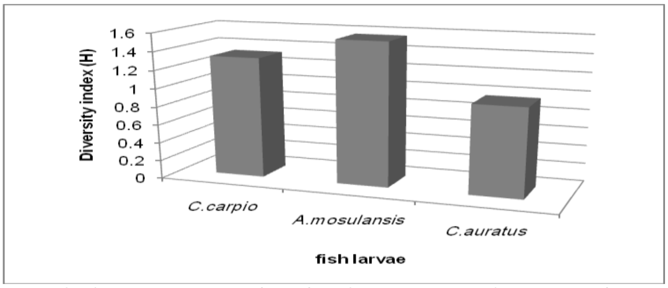

Figure 3. Food diversity (H) for food items in the gut of *C. carpio, C. auratus* and *A. mosulensis* larvae from Al-Huwaiza marsh.

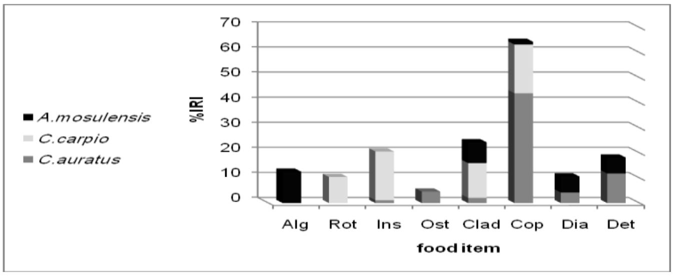

Figure 4. Index of relative Importance (IRI %) of food items in the gut of *C. carpio*, *C. auratus* and *A. mosulensis* larvae from Al-Huwaiza marsh.

According to Castillo plot displayed for *C. carpio* the diet was dominated by copepods and aquatic insects (mostly chironomid larvae) and Cladocera. Rotifers were also eaten (Fig 5). *C.auratus* larvae consumed copepods (adult and larvae) extensively, followed by diatoms, detritus and Cladocera. While Ostracoda and aquatic insects were shown to be rare and occasional (Fig. 6). *C. auratus* larvae being a generalist feeder also. *A. mosulensis* larvae consume a variety of food items (both animal and plant origin) mostly copepods and filamentous algae with adequate quantity of diatoms, Cladocera and detritus (Fig. 7).The larvae of *A. mosulensis* being a generalist feeder.

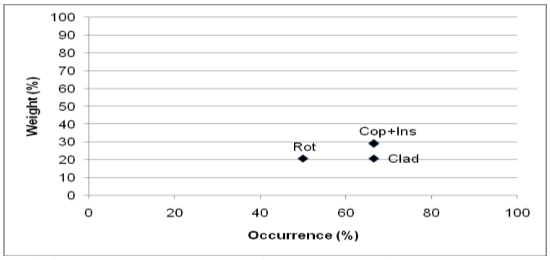

Figure 5. Diet and feeding strategy of *C. carpio* larvae in Al-Huwaiza marsh. (Rot=Rotifera; Cop:copepod; Ins: Aquatic insects; Clad=Cladocera.).

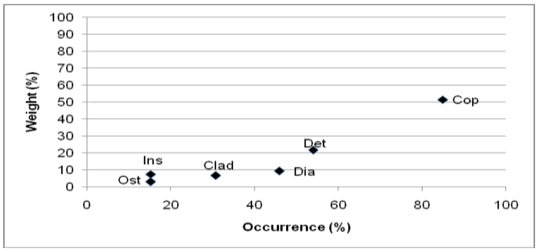

Figure 6. Diet and feeding strategy of *C. auratus* larvae in Al-Huwaiza marsh. (Ost: Ostracoda; Ins: Aquatic insects; Clad: Cladocera; Dia: Diatom; Det: Detritus).

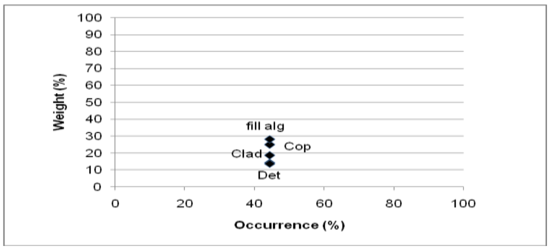

Figure 7. Diet and feeding strategy *of A.mosulensis* in Al-Huwaiza marsh. (Fill alg: filamentous algae; cop: Copepoda; clad: Cladocera; Det: Detritus).

Food similarity:

Food similarity among cyprinid larvae was high between *C. auratus* and *A. mosulensis* (0.72) and between *C. carpio* and *C. auratus* (0.60) while it was low between *C. carpio* and *A. mosulensis* (0.44). Table (2) shows the diet overlap between cyprinid larvae. The highest diet overlap was recorded for copepods between *C.carpio* and *C.auratus* (24.33 %) and between *C.carpio* and *A.mosulensis* (15.98) being the most consumed item in all cyprinid larvae studied. Diet overlap was recorded for Cladocera (11.76) between *C.carpio* and *C.auratus*.

Table 2. Food overlap between *C. carpio*, *C. auratus* and *A. mosulensis* larvae in Al-Huwaiza marsh.

Fish species	Food item	Food overlap	
		C. auratus	*A. mosulansis*
C. carpio	Copepod	24.33	3.82
	Cladocera	11.76	2.77
	Aqu. Insect	9.68	
C. auratus	Copepoda		15.98
	Diatom		1.08
	Cladocera		3.1
	Detritus		0.93

Discussion

First feeding is considered a critical period in the early life of fishes (Kalmar, 2002), thus the survival of larvae is depend on the quantity of food supply and availability of adequate food (Makrakis *et al.*, 2005; Voss *et al.*, 2009). The low number of larvae with empty guts which recorded in this study reflects feeding success, which depend both on the size of the larvae and the availability of suitable prey (Young, 2008; Nobriga, 2002). According to Costello (1990) plot which describe the feeding strategy, this plot shows that all 3 cyprinid larvae had similar generalized feeding strategies. Most of the prey points are located at the lower part of the plot corresponding to an important number of rare preys, whilst copepods (adult and larvae) were the prey most frequently consumed by 3 larval species. In this study, *C. carpio* larvae are active generalist feeders, with wide niche breadth. As adult, *C .carpio* in Al-Huwaiza marsh is considered as omnivorous generalist feeder, consume insect, Crustacea, mollusk, aquatic plant, algae and detritus (Hussain *et al.*, 2008; 2009). This species show high food similarity with *C. auratus* comparing with *A. mosulensis*.

Concerning *C. auratus* larvae, it is an active generalist feeder; with moderate niche breadth. These larvae show high food similarity with *A. mosulensis* larvae. As adult, *C. auratus* (in Al-Huwaiza marsh) is an herbivorous fish with some extent of specialization; eat mainly filamentous algae (Hussain *et al.*, 2008; 2009). The larvae of *A. mosulensis* also being generalist feeder (less active feeder) with highest niche breadth. It shows high food similarity with *C. auratus*. As adult in Al-Huwaiza marsh it is herbivorous fish consume the same food as *C. auratus* (Hussain *et al.*, 2008; 2009).

In general, cyprinid fish larvae consume planktonic copepods almost extensively, where large quantity of copepods are available in marsh area of southern Iraq (Sodani *et al.*, 2007; IMRP, 2007) which has a high nutritive value (60% protein) and good digestibility comparing with plant source food (Kamjunke *et al.*, 2002; Contente *et al.*, 2009). However, increased food diversity in gut content resulted in increase total energy or nutritive value (Tomec *et al.*, 2003; Oscoz *et al.*, 2006). However, Cowx (1989) reported that the growth rate of fish was reduced due to reduction in feeding diversity.

While planktonic copepods and Cladocera being comprised the majority of the diet of cyprinid larvae, however, diatoms and filamentous alga (plant source) was less important, although of its high density in the marsh area (IMRP, 2006).

This study showed that the larvae of *C. carpio* and *C. auratus* usually having higher feeding activity comparing with *A. mosulensis*. Akpan *et al.* (2005) referred that more active fish larvae have higher feeding activity.

The cyprinid fish larvae studied, fed mostly upon a variety of prey, mostly are generalized feeders, without strong feeding specialization. This feeding strategy resulted in a wide trophic niche width (Marshal and Elliot, 1997), which has been shown from high diversity index of food items. However, generalized feeding may considered as important adaptation to irregular climate regimes and water flow and availability of food (Blanco-Garrido *et al.*, 2003; Ramirez-Luna *et al.*, 2008). However Encina *et al.* (2004) referred that feeding plasticity allow fish to live and succeed in its environment.

Although the three cyprinid larval species had similar diet, there is no significant overlap among them. Since the highest value of diet overlap recorded was 24 % (Pedersen, 1999). Although the diet was similar, they did not necessarily compete for resources due to the availability of food in the marsh area, which is seen from high primary productivity (Richardson *et al.*, 2005). Besides, species with wide food spectrum have the ability to avoid the threat of competition (Persson, 1987). However, the similarity between species is expected from their similarity in habitat (Satoh *et al.*, 2004).

The similarity in the diet of larval cyprinid varies. Similarity was high among *C.auratus* and *A. mosulensis*, and diet overlapping was concentrate on copepod. Diet overlap Average between 25 % and 75 % was considered moderate while values exceeding 74 % indicating substantial overlap (Pedersen, 1999). Many cyprinid larvae form mixed species shoals in the littoral zone after hatching (Garner, 1996) and dietary overlap can be high. However, synchronous overlap does not necessarily imply competition since the food sources is unlimited in availability in the area studied (Richardson *et al.*, 2005). The same result was recorded by Nunn *et al.* (2007) for freshwater fish in Lowland rivers. However, Makrakis *et al.* (2005) referred that similarity in the use of food resources probably is a reflection of similarities in mouth size. However, overlap may have little significance, unless it will affect growth, survival or reproduction (Diana, 2004).

Dietary overlap is generally greatest among ecologically similar species (Adamek *et al.*, 2005; Hussain *et al.*, 2009), and that competition often causes a narrowing of niche width of the competing species (Nunn *et al.*, 2007). However, the greatest availability of zooplankton in Al-Huwaiza marsh (Sodani *et al.*, 2007) provides suitable prey for a wide range of fish species and may reduce the potential for competition and enhance recruitment success. The same result was recorded by Voss *et al.* (2009) for sprat and sardine larvae in North Sea, as these larvae share a wide range of prey types, but with no direct competition.

The food similarity between *C.auratus* and *C. carpio* concentrate on copepod. Some other food organisms appear also in both species (Cladocera, aquatic insect) but their contribution to the diet overlapping was rather occasional.

The food similarity between *C. carpio* and A. *mosulensis* was relatively low and diet overlap was concentrated on copepod and cladocera. *C. carpio* was the only larvae consume rotifers, while filamentous algae were consumed only by *A. mosulensis* with relatively high relative importance.

We conclude that the study of the trophic relationship of Cyprinid fish larvae represent a solid basis for the management of marsh area system in which these species co-occur. In addition it will be useful in ecological modeling for the better representation of tropic flow associated with adult fish.

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ملاحظات حول العلاقات الغذائية لثلاث أنواع من يرقات أسماك الشبوطيات في هور الحويزة / جنوب العراق

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المستخلص - تم دراسة مكونات الغذاء في القناة الهضمية لثلاث أنواع من يرقات الاسماك تعود لعائلة الشبوطيات (*Cyprinus carpio*; *Carassius auratus*; *Alburnus mosulensis*) Cyprinidae: في هور الحويزة خلال شهري آذار ونيسان. لوحظ ان غذاء هذه اليرقات يتكون أساسا من الهائمات الحيوانية ، حيث سادت مجذافية الأقدام بمراحلها اليرقية والبالغة, يتبعها براغيث الماء والدولابيات والحشرات المائية والدرعيات. أما الغذاء ذو الأصل النباتي فقد شمل الدياتومات والطحالب الخيطية. تم دراسة إستراتيجية التغذية باستخدام مخطط Costello وأظهر هذا المخطط بأن هذه الأنواع من اليرقات غير متخصصة في تغذيتها. وهذا النوع من إستراتيجية التغذية ينتج عنه تنافس اقل على موارد الغذاء ويسمح لهذه الأنواع الثلاثة من اليرقات للتواجد مع بعضها وبكثافة عالية في البيئة. سجل أعلى قيمة للتشابه الغذائي بين يرقات الكارب الذهبي والسمنان الطويل (0.72), بينما سجل أقل تشابه غذائي بين يرقات الكارب العادي والسمنان الطويل (0.44). بينت دراسة التداخل الغذائي بأن هذه اليرقات تشترك باستغلالها مدى واسع من أنواع الغذاء. وسجلت اعلى قيمة للتداخل الغذائي (24.33) لمجذافية الاقدام ما بين يرقات الكارب الذهبي والكارب العادي. أن التنافس الغذائي ممكن الحدوث, مع إمكانية تجنب التنافس المباشر نتيجة وفرة مصادر الغذاء في هور الحويزة والذي جعل منه بيئة مناسبة للتغذية والحضانة للعديد من يرقات أسماك الشبوطيات.