International Journal of Environmental Science & Technology
Vol. 1, No. 2, pp. 89-95, Summer 2004

Dietary overlap between invasion ctenophora (*M . leidy*i) and anchovy (*C. engrauliformis*) in the southern parts of Caspian Sea

[1*]*F. Darvishi,* [2]*A. Esmaili Sari and* [1]*P. Farshchi*

[1]*Department of Environmental Science, Graduate School of the Environment, Science and Research Campus, Islamic Azad Uuniversity, Tehran, Iran*

[2]*School of Natural Resources and Marine Science, Tarbiat Modarres University, Noor, Iran*

Abstract

Mnemiopsis leidyi, native to America, Invaded the Caspian Sea in 1999. By the end of 2000, the entire sea was accupied with them. In parallel, a sharp decline in pelagic fish such accurrred.This survey was studied the relationship between the *M. leidyi* and this decline. Dietary analysis was conducted on anchovy sprat (Clupeonnela engrauliformis) and *M. leidyi* from August 2001 to October 2002 in the coastal water in the southern parts of Caspian Sea, in Iran. *M. leidyi* was caught by plankton net, (the mesh size ~5 mm), at three depth at 5, 10 and 15m . Sprat was caught by fisheries boat at Babolasar fishery harbor. Samples were not fixed in *M. leidyi* common fixative, 96% Ethanol were used. The Schoener index analysis reflected a similar diet composition of both species, with an critical level of overlap (>89 in Babolsar samples and >84 in Noushahar samples). This competition is one of the reasons for the decline of anchovy sprat. also, the results show *M. le*idyi is feeding on fish eggs, but effects of this factor on anchovy population is less than feeding competition. Controlling of *M. leidyi* population is reducing the pressure of its invasion and the effective approach is introduces a predator to the Caspian Sea.

Key words: *Anchovy sprat, Clupeonella engralifourmis, Ctenophore, dietary overlap, feeding competition, Menemiopsis leidyi, schoener index.*

**Corresponding Author, E-mail: darvishifariba@hotmail.com*

Introduction

Over the past years sprat (Clupeonella engralifourmis) population has decreased dramatically in the Caspian Sea (CaspNIRIKH, 2002; CEP, 2002). Overfishing depleted some anchovy sprat stocks, and environmental modifications, directly and indirectly had the same effects too (CaspNIRKH, 2002). However, the invasion of Mnemiopsis leidyi caused the sharpest decline according to the study of Shiganova (2001). Biological invasion by alien species is recognized as one of the major threats to native species and the region ecosystems. *M. leidyi*, a Ctenophore, is native to the west coast of America (Mayer, 1912; Kremer, 1994; Kremer, 2001; Purcell, et al., 2001). It moved across the Atlantic in the ballast water of cargo ships to the Black Sea in 1982 (GESAMP, 1997), and the Caspian Sea, in 1999 (Ivanov, et al., 2000; Esmaeili, et al., 2001; CEP, 2002).

M. leidyi is a predator on Zooplankton and fish eggs and larvae (Main, 1928). It competes with pelagic fish, which have a similar feeding (Kideys and Niermann, 1994; GESAMP, 1997; Harbison, 2001; Kremer, 2001; Shiganova, 2001). This survey was arranged during 2001-2002, in order to study the relationship between *M. leidyi* and pelagic sprat. The food of Anchovy and *M. leidyi* were evaluated at southern part of Caspian Sea in north of Iran to assess the degrees of dietary overlap.

Materials and Methods

The location of study was performed at two stations, in coastal water near Babolsar (52.38°E, 36.42°N) and Noushahar (51.33°E, 36.39°N) in the southern parts of Caspian Sea, in Iran. Some reports (Razavi, 1993; Esmaeili, *et al.,* 1999) described that biomass and densities of *C. engralifourmis* and *M. leidyi* in these regions are very high. *M. leidyi* was caught by plankton net (the mesh size ~5 mm), at three depth at 5, 10 and 15 meters. Sprat was caught by fisheries boat at Babolasar fishery harbor (Figure 1).

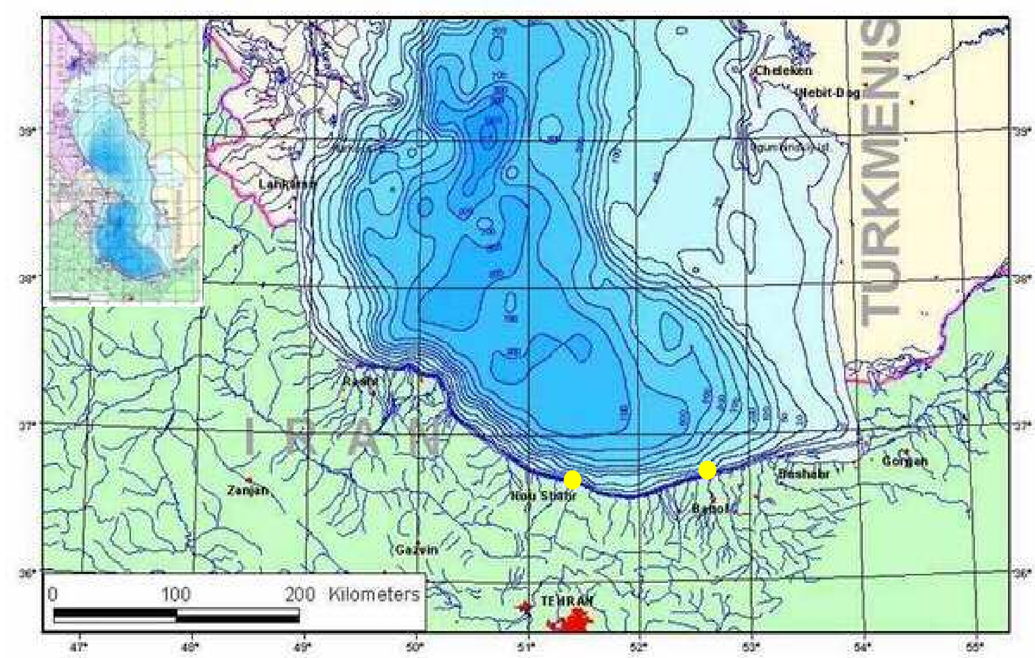

Figure 1: Sampling areas in the southern parts of the Caspian Sea

Sampling was conducted monthly from August 2001 to October 2002. Anchovy stomachs were removed immediately after catching. Individuals with the length more than 70mm were sampled for stomach contents. Stomachs were fixed in 4% buffered formaldehyde and labeled with date. A maximum of 100 stomachs of anchovy was sampled per month. They were then classified by time of sampling.

All caught *M. leidyi* were taken out of the net on boat and placed in plastic vases. They were placed one by one in the glass vials, in the shore. Samples were not fixed in *M. leidyi* common fixative (Esmaeili, *et al.,* 1999). 96% Ethanol was used and the vials were shaken for a few seconds in order to quicken the fixation. Each sample was then labeled with site number, depth and date. A maximum of 100 individuals of *M. leidyi* was sampled per month. Moreover, some alive samples were carried out to laboratory, in order to study of *M. leidyi* digestion system. The stomach contents of anchovy sprat and samples of *M. leidyi* were expanded on slides. Glycerol - Ethanol, at about 1 to 6 ratios were added to each slides. The slides were studied by Nikon 600 fluorescence microscope that was connected to a computer were designed specialliy for this experiment. Live samples of *M. leidyi* were studied directly. In many cases, the light was directly reflected on the sample and microscopic image was prepared in dark background.

Prey items were identified to the lowest taxonomic category (Minor, 1950). Prey items were separated into taxonomic groups and enumerated. Partially digested unidentifiable foods were counted as a group. Stomach contents of fish and gut contents of comb jellies collected in each month were pooled and analyzed on copeopoda numbers and in percent total numbers

Diet overlap was quantified using the Schoener index (Karchesky and Bennett, 1997; Chouniard and Bernatchez, 1998), and it is calculated as equation:

$$PSI_{xy} = 1 - 0.5(\sum \left|P_{xi} - P_{yi}\right|) \qquad (1)$$

Where:

PSI_{xy} = present similarity index

p_{xi} = proportion by number of food category (*i*) in the diet of the anchovy, and

p_{yi} = proportion by number of food category (*i*) in the diet of *M. leidyi.*

The result of index ranges from a value of 0.0 to 1.0 and is considered to be biologically significant when the index exceeds 0.60

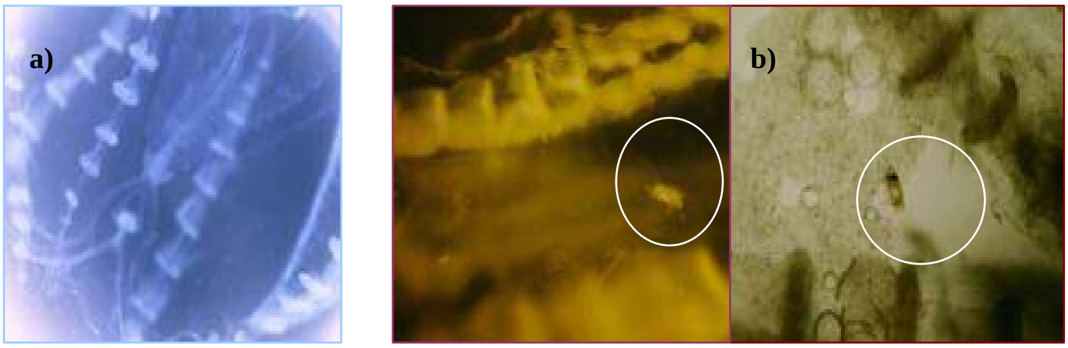

Figure 2: a) interior digestive channels, b) prey items

The percentages of fish eggs in the gut contents of *M. leidy*i per month, and prey items on the content of anchovy stomach in August 2001 were calculated using percentage composition by index number (N) in equation 2 (Chipps and Garvey, 2002):

$$N = \frac{N_i}{\sum_{i=1}^{Q} N_i} \qquad (2)$$

N = Index number
N_i = Number of food category *i*
Q = Number of food types

ANOVA test was performed on the diet overlap in three depths in each station to determine a significant difference between all three depths. Using the *Staticgraph Plus 2.1* program made this calculation.

Results

M. leidyi

Six thousands *M. leidyi* were studied at this experiment. Microscopic study (x100) shows *M. leidyi* has interior digestive channels such as jellyfishes (Figure 2-a). Many prey items were observed in this channel (Figure 2-b). In some cases, *M. leidyi* had vomited semi digested prey items that were wrapped in a kind of mucus (Figure 3).

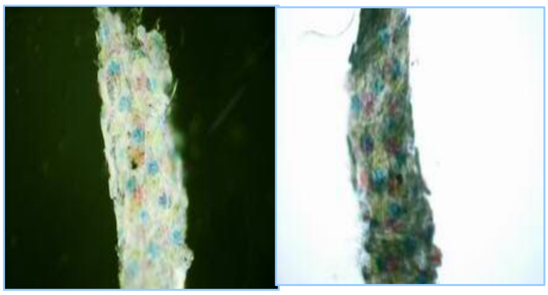

Figure 3: semi digested prey items were vomited by *M. leidyi*

Prey item in *M. leidyi* `s gut contents

The prey items were classified into 4 groups: phytoplankton, zooplankton, fish eggs and detritus (Figure 4).

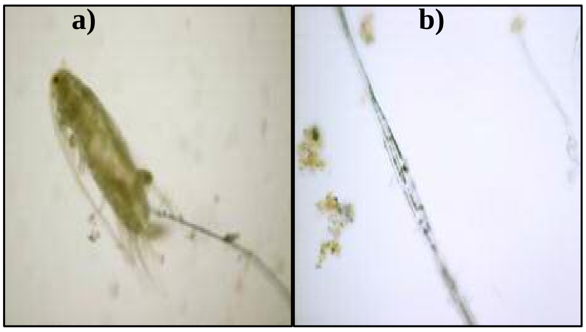

Figure 4: prey items in *M. leidyi* gut
(a: Copepod (*Eurytemora grimmi*) , b: Algae)

This study shows the most frequently occurring prey items in *M. leidyi* `s gut contents were copepoda (*Eurytemora grimmi*) and fish eggs made up a minor portion of the total diet (Table 1).

Table 1: Means of prey items in *M. leidyi* `s gut contents (Noushahr station) (%)

Prey items	Autumn	Spring	Summer
Zooplankton	54	61	60.6
Detritus	32	10.2	14.4
Phytoplankton	1.5	2.6	2.1
Fish eggs	1.2	1.5	1.5

The number of copepoda and fish eggs were enumerated in this study (Tables 2 and 3). Consumed copepoda was registered in summer, more than winter, probably, becauseof the growing bloom of this zooplankton in summer.

Table 2: The percentage of copepoda and fish eggs in *M.leidyi* `s gut in 2001-2002 (Noushahr station)

	Depth								
	5 m.			10 m.			15 m.		
Month	No. Sample	Fish eggs (%)	Copepoda (%)	No. Samples	Fish eggs (%)	Copepoda (%)	No. Samples	Fish eggs (%)	Copepoda (%)
August 2001	92	0.8	61.7	98	1.1	61.9	96	1.5	62.0
September	86	0.7	62.3	93	1.2	60.3	93	1.6	63.8
October	98	2.8	53.0	86	3.1	55.0	89	3.4	53.5
November	95	3.1	51.6	99	3.3	54.8	97	3.6	55.0
February 2002	98	0.1	50.3	98	0.2	51.3	93	0.9	51.2
April	93	0.6	54.9	96	1.1	57.4	95	1.9	56.0
May	98	2.2	56.2	95	2.6	61.8	83	2.8	58.3
June	99	1.9	61.8	94	3.2	63.6	96	4.2	64.0
August	98	0.8	62.7	89	1.2	62.2	99	1.4	62.8
September	96	1.1	61.0	96	1.3	60.8	94	1.6	59.8
October	95	0.1	56.8	93	0.4	56.2	97	0.5	53.7

Table 3: The percentages of copepoda and fish eggs in *M.leidyi* `s gut in 2001-2002 (Babolsar station)

Month	Depth								
	5 m.			10 m.			15m.		
	No. Samples	Fish eggs (%)	Copepoda (%)	No. Samples	Fish eggs (%)	Copepoda (%)	No. Samples	Fish eggs (%)	Copepoda (%)
August 2001	96	0.9	57.00	93	1.2	54.40	98	1.1	58.50
September	99	0.7	55.20	97	1.0	51.90	96	1.6	56.00
October	95	3.2	50.35	98	3.4	49.70	99	3.1	52.80
November	94	3.4	50.15	95	1.9	47.80	97	3.4	51.30
February 2002	100	0.2	45.20	97	2.0	43.60	98	0.6	48.00
April	87	0.5	49.20	95	1.6	45.10	93	0.9	43.20
May	95	2.7	52.50	97	3.4	48.00	97	1.8	49.80
June	99	2.9	55.00	96	2.9	52.70	98	2.5	56.50
August	98	0.8	56.70	99	1.6	52.25	98	1.4	55.35
September	98	1.1	55.50	95	0.6	51.50	95	1.5	53.00
October	96	0.0	52.20	94	0.4	50.70	99	0.3	54.80

The percentage of fish eggs in early of spring and end of autumn were also registered more than other seasons. These times are spawning times to many pelagic fishes in the southern parts of Caspian Sea. No significant differences, statistically, were found in percentage of Copepoda and fish eggs on those 3 depths (ANOVA test, F=0.05023 and 0.434939 in Babolsar and Noushahr stations, respectively). It might be the cause of vertical immigration of *M. leidyi* and the short distances between these depths, in attention to topography of the regions.

The prey items in anchovy digestion system

The prey items in anchovy digestion system were classified into 3 groups: phytoplankton, zooplankton, detritus and unidentified items (Table 4). Most abundant were Rotifera, Termatoda and Copepoda (*Eurytemora grimmi*), (Figure 5).

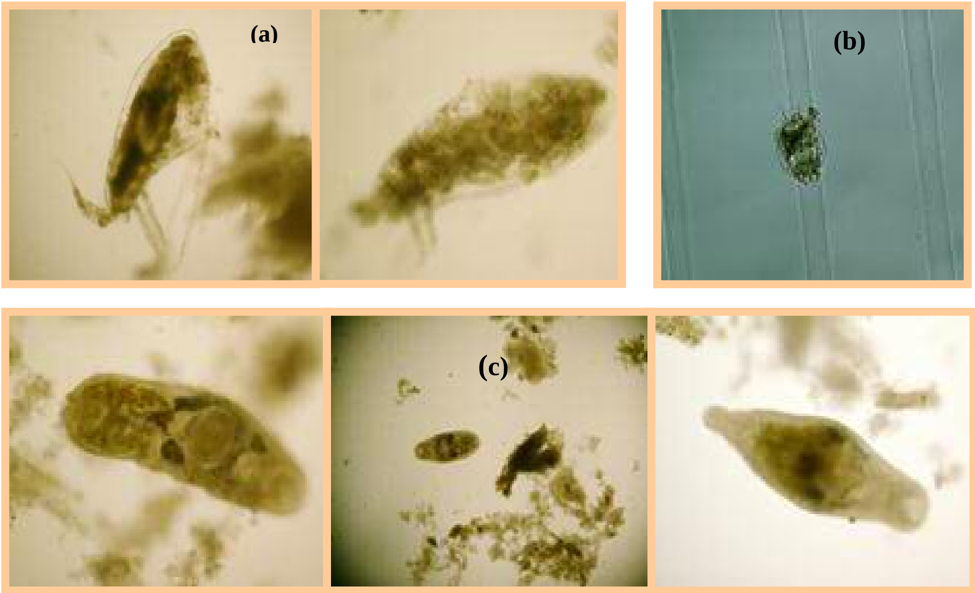

Figure 5: prey items in sprat anchovy `s stomach
(a: Copepoda b: Rotifera. c: Termatoda)

Table 4: Stomach contents of 92 anchovy in August 2001

Prey items	Number (%)
Zooplankton:	
Copepoda	35.25
Termatoda	47.1
Rotifera	0.8
Phytoplankton	1.60
Unidentified	15.25

The number of copepoda was enumerated monthly in Anchovy stomach and in *M. leidy*`s guts (Table 5). The percentage frequency of copepoda, consumed in summer was higher than in winter. Paralleling the blooms of these crustaceans. Schoener overlap indices varied monthly (Table 6) and diet overlap values on copepoda between Anchovy and *M. leidyi* exceeded the critical level of overlap (0.6) in every months (more than 0.8). No significant

differences, in dietary overlap were found at 3 depths (ANOVA test, F= 0.198465, 1.65394, Babolsar and Noushahar stations, respectively). The mean percent similarity indices (or diet overlap) were calculated. Values in Babolsar station were higher than in Noushahr (Table 7). This value at 15 meters depth was higher than other depths because the densities of *M. leidyi* and anchovy are higher than elsewhere.

Table 5: The Percentages of copepoda in Anchovy stomach in 2001-2002

Month	No. Samples	Copepoda (%)
August 2001	92	35.2
September	88	32
November	85	25.5
December	93	22
January 2002	84	17.3
February	89	18
April	81	22.5
June	90	32.6
August.	90	36.6
September	93	33.2
October	90	24.75

Table 6: The Percentages of Schoener overlap indices

Date	Babolsar			Noushahr		
	5 m.	10 m.	15 m.	5 m.	10 m.	15 m.
August 2001	88.35	89.10	90.40	86.65	86.60	86.75
September	88.00	88.40	90.05	85.88	84.10	84.85
October	86.35	87.57	87.90	85.25	86.00	86.25
November	85.35	85.93	87.10	83.60	83.50	85.20
February 2002	85.00	86.40	87.20	83.35	83.38	83.85
April	89.65	86.65	88.70	82.25	83.45	83.80
June	88.05	88.80	89.95	84.50	84.30	85.37
August	90.63	95.89	92.17	87.20	86.90	86.95
September	90.10	88.85	90.85	86.20	86.70	86.10
October	85.88	86.28	87.30	84.28	85.60	83.98

Table 7: The Mean percentages of dietary overlap indices (Babolsar and Noushahr stations)

Station \ Depth	5 m.	10 m.	15 m.
Noushahr	84.92	85.10	85.31
Babolsar	87.74	87.99	89.19

Discussion and Conclusion

The results of this study support the view of other researchers. There is feeding competition between *M. leidyi* and sprat anchovy. The maximum overlap (89.12) was at 15 meters depths at Babolsar and the minimum (84.92) at 5 m. depths at Noushahar. Same as the Black Sea, since the invasion of *Mnemiopsis leidyi* to the Caspian Sea a sharp decline in main stocks pelagic fish has been seen. After that, the main competitor of *M. leidyi* is phasing out and thereby, the population of *M. leidyi*, successfully, outspread in the Caspian Sea.

Interaction between these organisms and losses of main item food to anchovy sprat has caused changes in structures of its population. So, one of the reasons of decline in sprat's stocks, Probably, is competition between this fish and *M. leidyi*. Morover , the results show that *M. le*idyi is feeding on fish eggs, but effects of this factor on anchovy population is less than feeding competition. Even in spawning season, there were a few percentage of fish eggs in *M. leidyi*'s guts.

Also, size of *M. leidyi* in the Caspian Sea is smaller than its size in main habitat. Maximum frequency size of *M. leidyi* in the Caspian Sea is about 10 mm. So, it is not directly the main cause of the sharp decline in sprat anchovy stocks via feeding on fish eggs. Controlling of *M. leidyi* population for reducing the pressure of its invasion is necessary. The effective approach attention introduces a predator to the Caspian Sea. Introduction a new alien species to this ecosystem must be done with precaution and attention needs to environmental impact assessment projects, in the Caspian region. Ecosystem approach is necessary to environment management of the region and finally recovery of pelagic fishes and specially sprat stocks via sustainable fishery is so useful.

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