Laboratory experiments with *Beroe and Mnemiopsis* in Iran.

Ahmet E. Kideys[1], Galina A. Finenko[2], Boris E. Anninsky[2], Tamara Shiganova[3], Abdolghasem Roohi[4], Mojgan Rowshan Tabari[4], M. Youseffyan[4], Mohammad T. Rostamiya[4]

[1]Institute of Marine Sciences, Erdemli, Turkey (kideys@ims.metu.edu.tr)
[2]Institute of Biology of Southern Seas, Sevastopol, Ukraine (shulman@iuf.net)
[3]P.P.Shirshov Institute of Oceanology RAS, Moscow, Russia
(shiganov@chip.sio.rssi.tr)
[4]Mazandaran Fisheries Research Center, Sari, Iran (roohi_ark@yahoo.com)

The alien ctenophore *Mnemiopsis*, native to the eastern coasts of America had caused great damage and therefore concern in the Black Sea after the late 1980s. This ctenophore was then transported to the Caspian Sea via Volga-Don Canal in late 1990s (Ivanov et al. 2000). The impact of the ctenophore in this new environment already seems very significant: by October 2000, abundance and biomass of fodder zooplankton was reported to decrease 5-6 fold (Shiganova et al. 2001) and by the late summer of 2001, the important pelagic fishery of Iran declined sharply (Kideys et al. 2001). To deal with the problem, Kideys et al (2001) suggested several immediate actions. Among these were laboratory studies with the predator ctenophore *Beroe* to combat Caspian *Mnemiopsis* and

performing laboratory experiments with Caspian *Mnemiopsis* to quantify and evaluate its impact on Caspian ecosystem. .

In order to understand the feasibility of *Beroe* introduction, as an effective predator on *Mnemiopsis*, into the Caspian Sea, *Beroe* has been transported from the Black Sea and Bosporus to the Khazerabad laboratory (Mazandaran) on the Caspian coasts of Iran where several experiments on survival of *Beroe* and on miscellaneous physiological characteristics (feeding, respiration, reproduction and growth) of both species were performed.

Acclimation of *Beroe* to low salinity

Beroe generally made up of small individuals (10-40 mm) was transported into Caspian coast of Iran in two batches: For the first batch, thirty *Beroe* sampled from Sinop, Turkey (southern Black Sea;salinity is about 18 ppt) were transported to the laboratory in Khazerabad (Mazandaran, Iran) in a10 lt jar. The total journey time was about 48 hours for this batch of *Beroe*. In the second batch about 60 Beroe were collected from Bosporus (salinity around 22 ppt). Journey time was around 24 hours for the second batch.

7 individuals from the first batch were kept individually at 26 ^{o}C in conditions of original salinity 18 ppt in 5-1 containers during the first day, next day they were removed to the container with lower salinity water about 16 ppt and than transferred into the container filled totally the Caspian water (12-13 ppt).

A total of 42 individuals sampled from Bosporus (salinity approx. 22 ppt) was acclimatised by lowering salinity gradually in 4 days. During the acclimation, animals fed actively with *Mnemiopsis*. Our main observations were recorded on the video.

Feeding, respiration and growth rates of *Beroe* on Caspian *Mnemiopsis*

A series of feeding experiments was undertaken to measure not only the feeding rate of *Beroe* on *Mnemiopsis* but also its digestion time, digestion rate, size preference. Additional experiments were performed in order to clarify whether *Beroe* would eat other zooplankton.

Under conditions of possible selection (4 different size groups of *M. leidyi* were offered to *B. ovata* in the same number simultaneously) *Beroe* mainly preferred the prey of mean size. Small sized *Mnemiopsis* comprised insignificant part of daily ration.In the absence of selection (these groups were offered separately in the same biomass) *Beroe* consumed all sized *Mnemiopsis* with the same rate. This is important as the main part of *Mnemiopsis* population in the Caspian Sea is comprised by small ctenophores.

The relationship between specific daily ration (SDR,g/g/day) and *Beroe* wet weight at 2 food concentrations (I- 1.6; II- 1.0 g/l) could be described with 2 power functions (Fig.1):

$$I - SDR = 3.184\ W^{-0.841}\ r^2 = 0.852$$
$$II - SDR = 0.842\ W^{-0.904}\ r^2 = 0.701$$

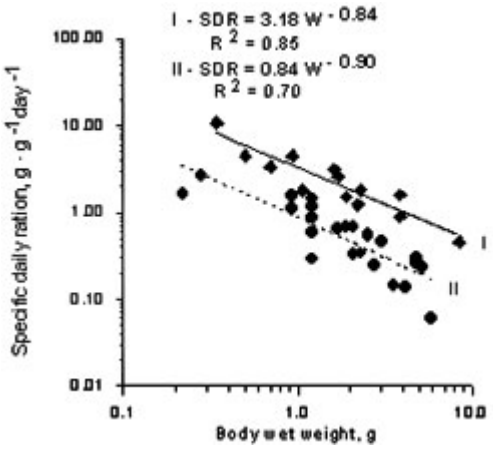

Fig.1. *Effect of body weight on specific ration in Beroe ovata at 1.66 g/l (I) and 1.00 g/l (II) food concentration.*

The difference between specific daily rations at tested food concentrations showed that food conditions is an important factor in *Beroe* feeding.

In long-term experiments mean ration of *Beroe* was 26-43% per body weight on Caspian *Mnemiopsis*.

Digestion time of *B. ovata* feeding on *M. leidyi* at 21± 1^0C varied from 30 to 450 min in the studied weight range of both ctenophores (13-38 mm in *Beroe* and 3-27 mm in *Mnemiopsis*). Interval between two following engulfs usually ranged from 95 to 720 min. Every size of *Beroe* consumed both small and large *M. leidyi*; but the ratio between prey and predator weight in these experiments had an insignificant effect on digestion time (Fig.2.) *Beroe* did not eat *Artemia salina* or *Acartia clausi* offered in abundance.

The relationship between oxygen consumption rate (Q, ml O_2 /ind/h) and wet weight of *B. ovata* (g*)* at 21-23^0 C is expressed by the equation (Fig.3):

$$Q = 0.0052\ W^{1.02}\ r^2 = 0.87$$

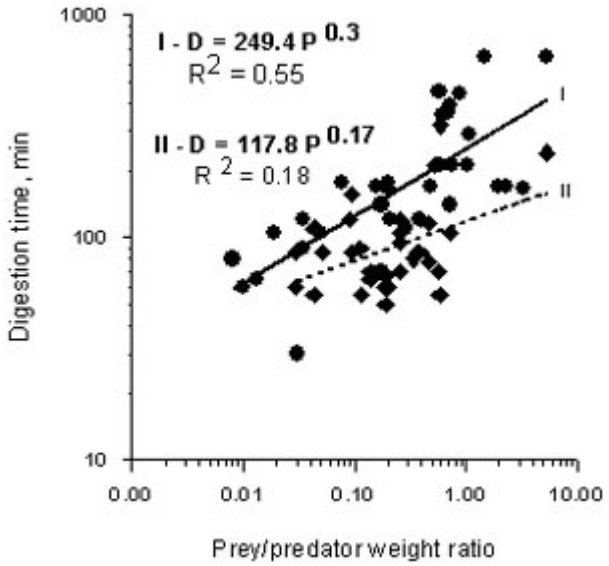

Fig. 2. *Effect of prey/predator weight ratio (P) on digestion time (D) in Beroe ovata in Caspian water at 21^{0}C (I) and 26^{0}C (II).*

Value of 1.02 indicates that the weight – specific respiration rate is independent of weight over the measured weight range (0.23-3.87 g).

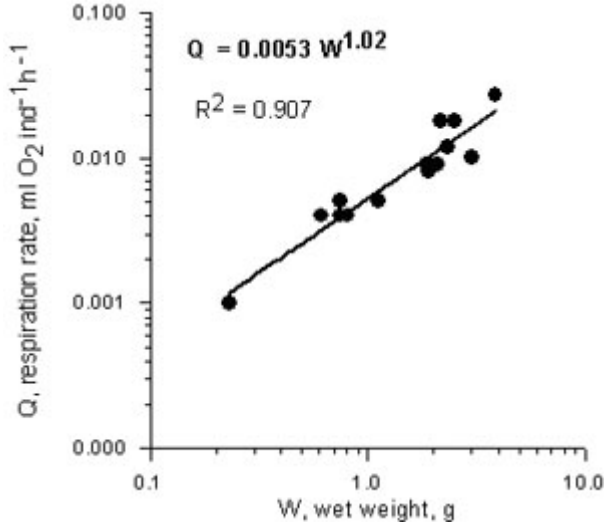

Fig.3. *Relationship between respiration rate (ml O_2 ind^{-1}h^{-1}) and wet weight (g) in Beroe ovata in the Caspian Sea water.*

Analyses of *Beroe* respiration rate in the Caspian Sea water has shown that *Beroe* respiration rate is lower of that in the Black Sea (Finenko et al., 2001).

In long-term experiment (12-14 days) average weight for 3 *Beroe* of the similar initial weight (3.17 g or 30 mm length) increased during the experiment and growth could be expressed with exponential function (Fig. 4):

$W = 2.615\ e^{0.101\ t}$ $r^2 = 0.964$, where W is wet weight, g, t- time, days.

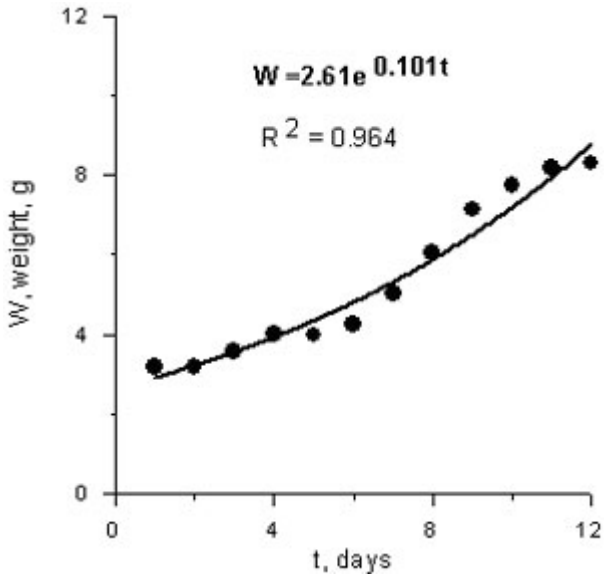

Fig.4. *Weight growth of the Beroe ovata in the Caspian Sea water.*

The daily specific growth rate of animals according to this equation makes up 0.1 (10%) of body weight. This high value was obtained in conditions of plenty of food and demonstrates high growth potential of these ctenophores. Exponential growth of animals supposes the same specific growth rate in animals of different size (it does not depend on ctenophore weight); so the population of *Beroe* in favorable food conditions could be doubled its biomass during 10 days.

The energy budget of *B. ovata* was calculated (Table 1).

Table 1. Daily energy budget (cal/ind/day) of *Beroe ovata* in the long- term experiment.

Initial weight,g	C	R	G	A	a	K_1	K_2
3.17	18.06	4.73	11.27	16	0.88	0.62	0.7
3.17	10.73	2.89	4.1	6.99	0.65	0.38	0.59
3.17	17.11	3.57	7.7	11.27	0.65	0.45	0.68
Average					0.72±0.13	0.48±0.12	0.66±0.06

Where C is daily ration, R is respiration rate, G- growth, A – assimilated food in cal/ind/day; a is assimilation efficiency, K_1 and K_2 – coefficients. Energy content in *.M. leidyi* is 6.8 cal/g wet weight*, B. ovata* is 17 cal/ g wet weight.

Mean assimilation efficiency in animals with initial weight 3.17 g was found to be rather high (0.72±0.1) as well as average K_1 coefficient (relation between growth and respiration rate) (0.48±0.12) and K_2 (relation between growth and assimilated rate) (0.66±0.06). All these values show the high use of consumption and assimilation food for ctenophore growth in conditions of food abundant.

We were able to reproduce *Beroe* in the laboratory. Thus during experiments 128 eggs of *Beroe* were obtained and 7 of these were hatched into larvae.

So based on physiological data we could suggest that in the Caspian Sea *Beroe* is able to ingest *Mnemiopsis* intensively and decrease its abundance sharply as it happened in the Black Sea

Although we were able to reproduce *Beroe* into eggs and on a few occasions into larvae, larval development experiments were not successful in the laboratory. However it is still possible that successful development may take place in field conditions

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Experiments with *Mnemiopsis leidyi.*

We also quantified different physiological characteristics (feeding, repiration rates and fecundity) of *Mnemiopsis leidyi*

Clearance rate (volume that *Mnemiopsis* have to sweep to consume some number of preys) for different weight of *Mnemiopsis* at 21 ^{0} C increased with increasing of wet weight (Fig.5). The relationship between clearance rate (Cl, ml/ind /h) and wet weight (g) was as following:

$Cl= 161.4W^{0.565}$ $r^2= 0.641$

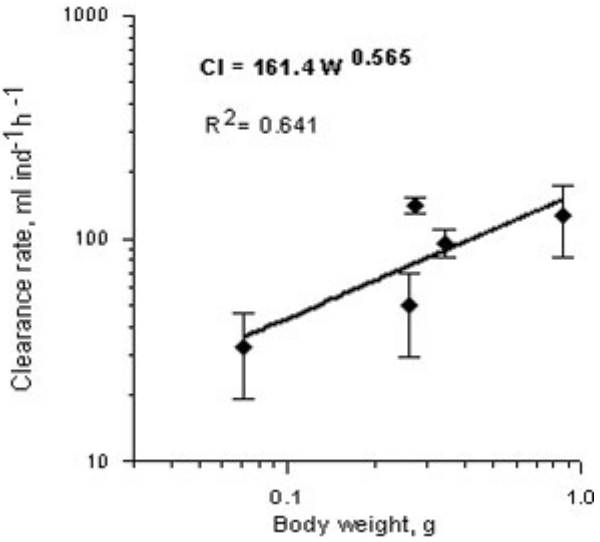

Fig.5. *Relationship between clearance rate and body wet weight in Mnemiopsis leidyi in the Caspian Sea.*

This clearance rate is higher by a factor of about 2 as compared with this in the Black Sea *Mnemiopsis* (Finenko & Romanova, 2000*).*

The relationship between oxygen consumption rate (Q, ml O_2 /ind/h and wet weight of *M. leidyi* (g*)* at 24^0 C is expressed by the next equation (Fig.6):

$Q= 0.0042W^{0.774}$ $r^2= 0.952$

In well adapted *Mnemiopsis* from the Caspian Sea the respiration rate at ambient temperature (24^0 C) is 1.5 times as high as this in the Black Sea at the same temperature The difference between oxygen consumption of the Caspian and the Black Sea *M. leidyi* probably is a result of different food concentration (biomass of zooplankton).

Average fecundity of *Mnemiopsis* in the Caspian Sea was 1174 eggs/day with maximal 2824 eggs/day for specimens 30-39 mm length and about weight 2.0-2.7 g.

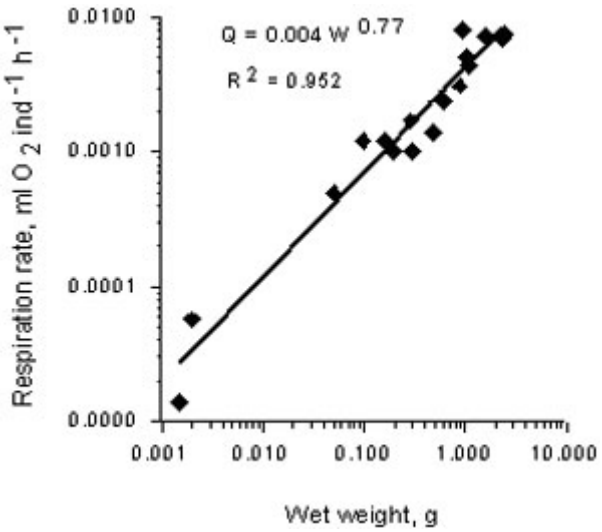

Fig.6. *Respiration rate in Mnemiopsis leidyi at 24^{0}C in the Caspian Sea*

These data will be evaluated with respect to ongoing monitoring studies to evaluate the impact of *Mnemiopsis* on the pelagic ecosystem of the Caspian Sea in near future.

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