

Preliminary results of egg production and population structure of adult *Temora stylifera* from the Northeastern Mediterranean Sea

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Abstract- Egg production rates and population structure of adult *Temora stylifera* were studied at a shore station in NE Mediterranean Sea from June to September 2002. The effects of seawater temperature and chemical composition of seston on egg production rates of *T. stylifera* were examined. The seston was analyzed for carbon, nitrogen, protein, and chlorophyll concentrations. Adults were most abundant in June and early July. Egg production rates varied from 52.3 (in June) to 1.1 eggs female⁻¹ day⁻¹ (in August), and they showed nocturnal egg laying pattern characterized by a night maximum (between 01:00-05:00 h). Correlation analysis indicated that, the egg production rates of *T. stylifera* mostly depended on the temperature, phytoplankton concentration and nutritional status of females in NE Mediterranean.

Introduction

Studies of reproductive activity of planktonic copepods are fundamental for understanding mechanisms regulating their population dynamics and secondary production in sea. Egg production rates, clutch size and egg diameter are generally regarded as complex responses to both environmental and physiological conditions. Reproduction is affected by various environmental factors, basically by temperature and food availability (Kleppel, 1992; Saiz et al, 1999; Halsband-Lenk et al., 2001a, 2001b, 2002; Carotenuto et al., 2002). It is well known that the copepod egg production reflects the short-term feeding history, since most copepods produce eggs only from recently ingested food (Checkley, 1980; Bautista et al., 1994).

In our study, we focused on one of the most abundant Mediterranean coastal copepods *Temora stylifera*. This species was found throughout the year with the maximum abundance in May and June in NE Mediterranean (Uysal, 2000). The goals of this work were to extend knowledge on the biology of this species, temporal variability in population structure and egg production rate in oligotrophic north-eastern part of Mediterranean Sea, and specifically the effects of protein and chlorophyll-*a* concentrations, POC and PON content of seston, and C:N ratio of females on the reproductive activity of *T. stylifera* were examined.

odes (Actinopoda) Dans Les Eaux
ceanog., Paris, 64(1):65-78,

Plankton of Lebanese Coastal
3-222, (1989).
ntrations Along the Mediterranean
5-32, (1993).
Publ., Leiden.
n Japan. 1574 p., (1997).
ege. Univ. Faculty of Sci. Ser. B,

ton and Protozooplankton Species
11(42-43), 9-15, (1994) (in

ubl., London, 231 p., (1992).
planation de la mer. Zooplankton

Eastern Mediterranean: vertical,
Ser. 194: 269-282, (2000).
adillimanı Bight (Silifke-Içel), XI. Su
kish).
enne, Centre National de la Rescherche

Material and Methods

Sewater and copepod samples were collected at biweekly or monthly intervals from June to September 2002 from a shore station located in NE Mediterranean Sea (34°18'E 36°32'N). Water samples were collected from 2-3 m depth by using nansen bottles for the analysis of chlorophyll *a*, protein, and carbon and nitrogen contents of seston. The protein concentration of seston was determined by using modified Lowry method (Clayton et al., 1988), chlorophyll-*a* by fluorometric technique (Strickland et al., 1968), particulate organic carbon and nitrogen contents were determined using a Carlo Erba CHN analyser. Zooplankton was sampled with a 0.5 m diameter, 200 µm mesh net, hauled vertically through the entire water column (~60m). The individual females were incubated in 140 ml translucent HDPE bottles with 7-20 replicates for egg production measurements. Bottles were filled with 56 µm screened surface seawater, and then incubated under natural temperature and light regimes, and checked 3 times per day for egg production. Samples were preserved with 4 % buffered formaldehyde for abundance and stage identification, prosome length and egg diameter measurements.

Results

The abundance of adults of *T. stylifera* was high in June and in the first half of July. Body size of females and males varied throughout the study period, between 630 and 1023 µm for females, and between 577 and 963 µm for males. Males outnumbered females on July and late September (Table 1). The obtained results has shown that female:male ratio ranged between 0.5 and 1.2. Sea surface temperature varied from 25 to 30.5°C during the sampling periods (Table 1).

Table 1. Abundance, prosome length of copepods (mean±sd), Female:male ratio of *Temora stylifera* and seawater temperature during the sampling periods.

Date (2002)	Number of female (ind/m ³)	Female prosome length (µm)	Number of male (ind /m ³)	Male prosome length (µm)	Female:male ratio	Seawater Temp. (°C)
18.06	28.9	802.8±95.6	25.4	686.6±83.5	1.14	25.7
17.07	24.3	837.7±80.9	25.3	777.2±94.8	0.96	28
23.07	7.7	741.9±90.0	9.3	668.9±119.9	0.83	26.5
02.08	No data	838.4±43.7	No data	No data	No data	30.5
09.09	0.27	872.0±43.6	0.22	837.9±39.2	1.2	29.6
24.09	0.04	889.9±144.8	0.08	791.4±56.6	0.5	29.8

There were large range of protein, chlorophyll-*a* (chl-*a*), POC and PON concentrations in seston with the highest in June and the lowest in the first half of July and in August.

Egg production rate of females varied between 52 (in June) and 1 egg female⁻¹ day⁻¹ (in August). Carbon and nitrogen contents of females were in the range 6.3-10.3 µgC female⁻¹ and 1.2-2.1 µgN female⁻¹, respectively. Carbon to nitrogen ratio of females stayed relatively constant during the sampling periods with an overall mean (±SD) of 5.2 ± 0.4.

The relationship between egg production rate and surface temperature is shown in Fig. 1. There is a significant sharp decrease in egg production rate with increasing temperature (Spearman Rank Correlation, $r_s = -1.0$ $P < 0.003$).

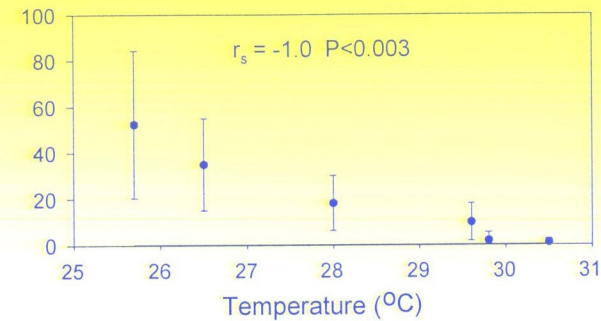


Fig. 1. Relationship between seawater temperature and egg production rate of *Temora stylifera*

Egg production rate showed positive significant relationship with chl-*a* and C:N ratio in females (Fig. 2). The POC:PON ratio has been used as indicator of nutrient status of food, and the significant relationships was not found between egg production and POC:PON ratio in seston. An unexpected result was observed in which the relationship was not significant between egg production and protein content of seston ($r_s = 0.49$ $P = 0.36$).

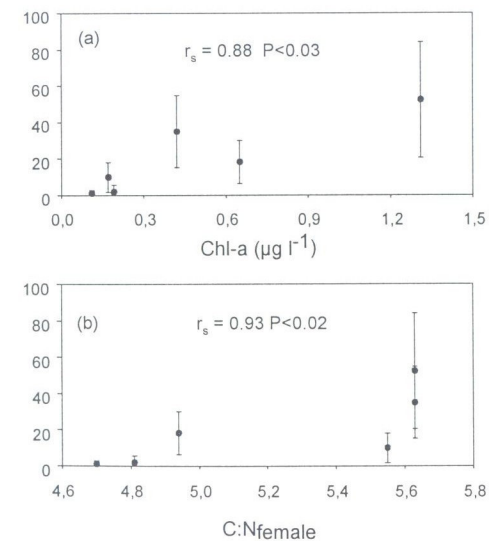


Fig. 2 Relationship between egg production rate and chlorophyll-*a* concentration (a) and C:N ratio of female (b).

The egg size of *T. stylifera* was not constant but varied between 66.15 and 80.5 μm diameter (average $71.1 \pm 2.4 \mu\text{m}$) with decreasing trend from June to early September. Egg diameter data were tested for correlation with seawater temperature, chl-*a*, protein, POC:PON ratio and C:N ratio in female, and a significant correlation was observed with seston protein ($r_s=1.0$, $P<0.003$).

Daily changes in egg production rates of *T. stylifera* were studied during 24 h time series experiment performed in June (Fig.3). Female produced up to 7-8 clutches per day. The egg-laying rhythm was characterized by a night maximum ($\sim 1-5$ h).

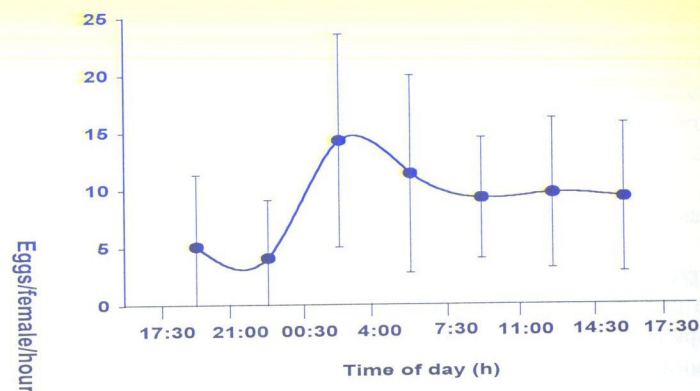


Fig. 3. Daily rhythm of egg production of *Temora stylifera*.

Discussion

The egg production rate of *Temora stylifera* observed in the present study lay within those recorded for the same species from the NW Mediterranean Sea. The maximal egg production rate of *T. stylifera* was 52 eggs female⁻¹ day⁻¹ in the present study, it was 33.3 eggs female⁻¹ day⁻¹ in the Ligurian Sea (Halsband-Lenk et al. 2001a, 2002), and 105 eggs female⁻¹ day⁻¹ in the Gulf of Naples (Ianora et al., 1993). Saiz et al. (1999) reported 12.5 eggs female⁻¹ day⁻¹ for *T. stylifera* in June in the Catalan Sea. We observed strong negative effect of temperature on egg production. Previous studies have shown that the optimum temperature for egg production of *T. stylifera* is 15-16°C (Halsband-Lenk et al., 2002). However, we observed high egg production at 25.7 and 26.5 °C, and rapid decrease with increasing temperature up to 30.5°C. The present study covered only warmer periods (June to September), therefore we cannot establish optimum temperature for egg production rate of *T. stylifera* in NE Mediterranean, however, at around 26°C we still observed high egg production rate. This fact permits to accept the new limits of temperature tolerance of reproduction and survival for copepod *Temora stylifera*.

Prososome length (PL) of female varied during the sampling period, but any significant correlation was not observed between temperature and PL. In our study, females were smaller than the females from NW Mediterranean with the mean

($\pm$ SD) was $815 \pm 91 \mu\text{m}$, while mean PL was $977 \pm 8.6 \mu\text{m}$ and $965.7 \pm 47.9 \mu\text{m}$ reported by Saiz et al. (1999) and Halsband-Lenk et al. (2001a) from NW Mediterranean, respectively. The carbon content of females was also lower with a mean of 7.5 μgC female⁻¹ in our study compared with previous results, mean carbon weight was 12.4 μgC female⁻¹ from NW Mediterranean (Halsband-Lenk et al. 2001a).

In the present study, the effects of temporal variability in chlorophyll-*a* concentration and chemical composition of seston (POC, PON, protein) and C, N content of female on egg production rates of *T. stylifera* were investigated. We found significant correlation between egg production rate and chl-*a* concentration (Spearman Rank Correlation, $r_s = 0.88$ $P<0.03$). But there is no significant correlation between egg production rate and POC. It may imply that contribution of phytoplankton to POC was very small, and phytoplanktonic cells controlled the egg production rate of *T. stylifera* during the study period. The POC:PON ratio has been used as indicator of the nutritional condition of food, and the egg production rate of *T. stylifera* did not related to *in situ* POC:PON ratio, but the C:N ratio of female was much more important in determining the observed egg production rates. It might be suggested that fecundity rates of *T. stylifera* are strongly related to nutritional status of the individual not daily nutritional status of food.

It has been reported in many previous laboratory and field studies, egg production rate of copepods increases with increasing concentration of chemical components (protein, lipids, carbohydrates) in their foods (Jonasdottir, 1994; Jonasdottir et al., 1995; Guisande et al., 1995; Kleppel et al., 2000; Burdloff et al., 2002). In our study, we have measured only protein concentration in seston and found not to influence egg production. This poor correlation is unexpected, since protein is extremely important for female nutrition. However, protein in seston was significantly correlated with egg diameter.

The egg production of copepod is a complex process affected by numerous factors including physical and nutritional environment and physiological condition of organism. This study has shown that the egg production of *T. stylifera* in NE Mediterranean seems to be influenced largely by temperature, phytoplankton cell concentration and nutritional status of female.

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References

- Bautista B., Harris R.P., Valeriano R., Francisco 1994. Temporal variability in copepod fecundity during two different spring bloom periods in coastal waters off Plymouth (SW England). *J. Plankton Res.*, V.16, N.10, pp.1367-1377.
- Burdloff D., Gasparini S., Villate F., Uriarte I., Cotano U., Sautour B., Etcheber H. 2002. Egg production of the copepod *Acartia biflosa* in two contrasting European estuaries in relation to seston composition. *J. Exp. Mar. Biol. Ecol.*, V.274, N.1., pp.1-17.
- Chekley D.M.J. 1980. The egg production of a marine planktonic copepod in relation to its food supply: laboratory studies. *Limnol. Oceanogr.*, V.25, N.3, pp.430-446.
- Carotenuto Y., Ianora A., Buttino I., Romano G., Miralto A. 2002. Is postembryonic development in the copepod *Temora stylifera* negatively affected by diatom diets? *J. Exp. Mar. Biol. Ecol.*, V.276, pp.49-66.
- Clayton J.R., Dortch Q., Thoresen S.S., Ahmed S.I. 1988. Evaluation of methods for the separation and analysis of proteins and free amino acids in phytoplankton samples. *J. Plank. Res.*, V.10, N.3, pp. 341-358.
- Guisande C., Harris R. 1995. Effect of total organic conyeny of eggs on hatching success and naupliar survival in the copepod *Calanus helgolandicus*. *Limnol. Oceanogr.*, V.40, N.3, pp. 476-482.
- Halsband-Lenk C., Nival S., Carlott F., Hirche H.-J. 2001a. Seasonal cycle of egg production of two planktonic copepods, *Centropages typicus* and *Temora stylifera*, in the north-western Mediterranean Sea. *J. Plankt. Res.*, V.23, N.6, pp. 597-609.
- Halsband-Lenk C., Hirche H.-J. 2001b. Reproductive cycles of dominant calanoid copepods in the North Sea. *Mar. Ecol. Prog. Ser.*, V.209, pp.219-229.
- Halsband-Lenk C., Hirche H.-J., Carlott F. 2002. Temperature impact on reproduction and development of congener copepod population. *J. Exp. Mar. Biol. Ecol.*, V.271, pp.121-153.
- Ianora A., Poulet S.A. 1993. Egg viability in the copepod *Temora stylifera*. *Limnol. Oceanogr.*, V.38, N.8, pp.1615-1626.
- Jonasdottir S.H. 1994. Effects of food quality on the reproductive success of *Acartia tonsa* and *Acartia hudsonica*: laboratory observations. *Mar. Biol.*, V.121, pp.67-81.
- Jonasdottir S.H., Fields D., Pantoja S. 1995. Copepod egg production in Long Island Sound, USA, as a function of the chemical composition of seston. *Mar. Ecol. Prog. Ser.*, V.119, pp.87-98.
- Kleppel G.S. 1992. Environmental regulation of feeding and egg production by *Acartia tonsa* off southern California. *Mar. Biol.*, V.112, pp.57-65.
- Kleppel G.S., Hazzard S.E. 2000. Diet and egg production of the copepod *Acartia tonsa* in Florida Bay. II. Role of the nutritional environment. *Mar. Biol.*, V.137, pp.111-121.
- Saiz E., Calbet A., Irigoien X., Alcaraz M. 1999. Copepod egg production in the western Mediterranean: response to food availability in oligotrophic environments. *Mar. Ecol. Prog. Ser.*, V.187, pp.179-189.
- Strickland J.D.H., Parsons T.R. 1968. Pigment analysis—a practical handbook of seawater analysis. *Bull. Fish. Res. Board. Can.*, V.167, pp.185-205.
- Uysal, Z. 2000. A time series study to determine anthropogenic influences on ecological cycles and long-term changes in the Northern Levantine Basin. Final Report. MAP-Med Poll Phase III. Supported by TUBİTAK & UNESCO - IOC. IMS-METU, Erdemli-Turkey. 48 p.

Distribution and a the western Irani

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Abstract- The alien the Black Sea into C ecosystem in this new of *M. leidyi* were stu (Lisar, Anzali and S (Guilan province) du biomass (166.1 g m ctenophore were mea station with 20 m bot m⁻²) was obtained at average biomass 67. biomass (34.1 g m⁻² contributed about 94 length was 51-55 mm

Keywords- Invasion

Introduction

The invasive ct coasts, after its grea 1994), has been dan al.2000) to this new through the Volga GESAMP 1997). S abundant small pe *Clupeonella spp*) h Mehdi 2003) and it sturgeon (*Huso hus significant threat in and spatial distrib information on the impact on the coast*