ENERGETIC COST OF EGG-CARRYING STRATEGY IN CALANOID COPEPOD *PSEUDOCALANUS ELONGATUS*

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Abstract
Respiration rates were measured in active and anesthetized females of *Pseudocalanus elongatus* with or without ovisacs in order to estimate the energy cost of egg-carrying strategy. Mass density of the body and eggs and sinking and swimming speed of female in different reproductive stages were measured to understand the effect of brood on body position maintaining in the water and predator avoidance of females.

Keywords: Copepoda, Black Sea, Zooplankton

Introduction
Widespread calanoid copepod *Pseudocalanus elongatus* spawn their eggs into ovisacs remaining attached to the female until the emergence of nauplii. The main advantage of such egg-carrying strategy is the decrease in egg mortality [1]. Therefore, egg sac attached to the body may increase energy losses for locomotion [2] and vulnerability of females to predation. Our aim was to evaluate extra energy expenditure due to egg carrying and study the effect of ovisacs on mean mass density, sinking speed and active swimming of females.

Material and methods
Respiration rate of *Pseudocalanus elongatus* was determined by a sealed chamber method using luminescent dissolved oxygen sensor HACH LDO 101. The cost of egg sac transport (R_{et}) in unfed individuals was calculated as: $R_{et} = R_{aOF} - R_{aNOF} - R_{egg}$; where R_{aOF} and R_{aNOF} are the respiration rates of active ovigerous and non-ovigerous females, respectively, and R_{egg} is the respiration rate of eggs in the ovisac which can be expressed as a difference between respiration rates of anesthetized ovigerous R_{anOF} and non-ovigerous R_{anNOF} females: $R_{egg} = R_{anOF} - R_{anNOF}$ [2]. Mass density and sinking speed of females and their eggs were determined according to Svetlichny and Hubareva (2014). Copepod swimming speed was measured using videoshooting by the Nikon 1 V1 camera at a rate of 1200 frames s^{-1}.

Results and Discussion
Respiration rate in females carrying ovisacs (9.8 ± 2.5 eggs per sac) was 1.27 times higher than that in females without ovisacs (0.0792 ± 0.013 µg O_2 ind^{-1} h^{-1}) due to extra energy expenditure on oxygen consumption of eggs and transport of egg sac (10 and 17 % of energy demands of females, respectively) (Fig.1). Mass densities of the body and eggs were similar (1.051 and 1.056 g cm^{-3}, respectively), sinking speed was 10 % higher in ovigerous females while speeds of routing and escape swimming were 40 and 9 % lower, respectively. Taking into account that clutch size in *P. elongatus* in high-productivity seas on average amounts to 20 and may reach 40 [4], one can suggest significantly higher energy expenditure and higher vulnerability to predation in those females in comparison with the individuals studied in our experiments.

Acknowledgements
The present study was partly supported by the Scientific and Technological Research Council of Turkey (114Y424) and the Research Fund of the Istanbul University (IRP-49165).

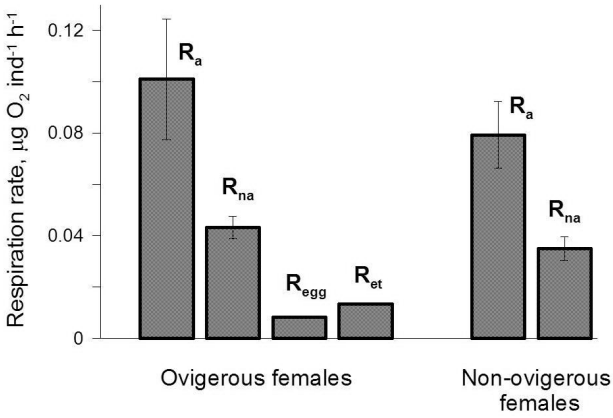

Fig. 1. Respiration rates of ovigerous and non-ovigerous active (R_a) and anesthetized (R_{an}) females, respiration rate of eggs (R_{egg}) and energy cost of egg sac transport (R_{et}).

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