CALANUS FINMARCHICUS: ESCAPE BEHAVIOR

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The interface between physiology and ecology becomes particularly important as changes in the environment alter entire ecosystems. In the open ocean, pelagic communities are characterized by the combination of many predator-prey interactions from bacteria and phytoplankton to the largest predators. In the North Atlantic, a central group of organisms in this food web are the calanoid copepods, often dominated by one or more species of *Calanus* (Hays, G.C., Warner, A.J. and Tranter P., J. Sea Res. 38: 85-92, 1997). Although there is great interest in these calanoids among biological oceanographers, less attention has focused on their behavior and physiology. In general, calanoids are known for their spectacular escape behavior. These small animals (1 to 3 mm length) live in a highly viscous environment, yet within a few milliseconds, they propel themselves through the water at 200 to 500 body lengths per second to tens of centimeters away from a potential threat. We studied the kinematics of this behavior in *Calanus finmarchicus.*

We quantified behavioral responses in individual copepods tethered to a force transducer, as described in Lenz and Hartline (Mar. Biol. 133: 249-258, 1999). Escapes were elicited by small hydrodynamic disturbances produced by a vertically moving sphere. Escape jumps consisted of a series of one to many propulsive kicks from the pereiopods given at rates of 50 per second or more (Fig. 1). Kick frequency was lower at 5 to 8 °C (*ca.* 40 Hz). Different response patterns were observed for sub-adults, females and males. Escape responses in males tended to be short (Fig. 1B), typically consisting of 1 to 3 kicks. The sub-adults (stage CV) and the adult females responded with multiple kicks, often consisting of long series of 10 to more than 50 kicks (Fig. 1A). The strength of the response was graded with stimulus intensity. In the adult males a larger response consisted a short series of kicks (2-3), followed by another set of kicks 50 to 100 ms later. The CVs and the adult females responded with a long series of kicks for 300 ms and longer to a single short stimulus. Escape jumps tended to be longer at the higher temperatures. Force produced by the power strokes varied among individuals, with the smaller animals producing less force (ca. 30 dynes) than the larger ones (90 to 100 dynes) (Fig. 2). These animals vary widely in their size and lipid stores even within a specific age group and population. Thus, the correlation between size and kick strength may be important in considering susceptibility to predators. Latencies were short. At low temperatures (5 to 8 °C), animals responded to the mechanical stimulus in 3 to 4 ms. Above 10 °C, reaction times were approximately 1 ms shorter. The shortest reaction times measured were 1.9 to 2 ms.

Predator-prey interactions may change as a function of environmental factors. In particular, temperature will affect physiological performance as well as change the viscosity of the water. This in turn will have an effect on the kinematics of the escape response. *C. finmarchicus* experiences a wide range in temperature (4 to 18 °C). Changes in temperature can be both short term, due to vertical migration, or long term, due to seasonal warming. Our behavioral studies suggest that *C. finmarchicus* has a repertoire of effective and fast escapes response even at low temperatures, with some evidence for temperature compensation.

Figure 1

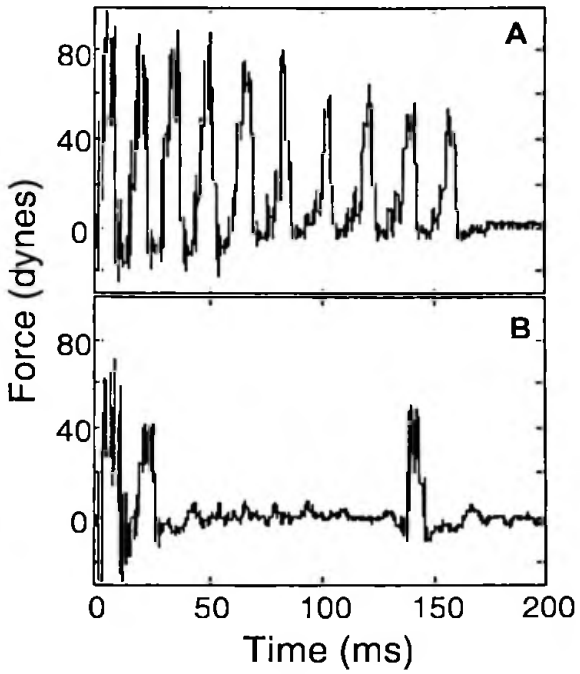

Figure 2

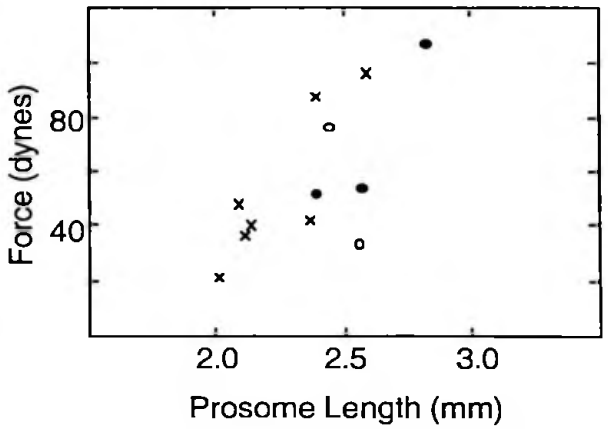

Figure 1. Force records of behavioral responses of *Calanus finmarchicus* to a brief stimulus given at time 0. A. Sub-adult CV, prosome length 2.39 mm. B. Adult male, prosome length 2.57 mm. Stimulus: 1.5 cycle of at 700 Hz, 10 dB above threshold. Temperature: 10 °C.

Figure 2. Prosome length (mm) versus force (dynes) for *Calanus finmarchicus* adult females (open circles), adult males (filled circles) and sub-adults CV (crosses).

Supported by NSF grant OCE 99-06223 and Mount Desert Island Biological Laboratory New Investigator Award.