Quantitative differences in escape responses to hydrodynamic stimuli by calanoid copepods

Daniel Burdick, Daniel K. Hartline, and Petra H. Lenz

Békésy Laboratory of Neurobiology, Pacific Biomedical Research Center,
University of Hawaii at Manoa, Honolulu, HI 96822

In the pelagic environment predation risk is typically high and as a result, many organisms have developed fast and effective escape responses. For example, in fishes peak swim velocities produced during fast-start escape responses increase as a two-thirds power function of length. Interestingly, the escape performances of many aquatic organisms, using a variety of locomotory methods (*e.g.*, lobster, water flea, pteropod, squid, damselfly, tadpole, etc.), fall close to the fish curve. Copepod maximum velocities are substantially higher, and an escaping copepod can keep ahead of a pursuing fish that is 30 times longer[1]. The ecological success of calanoid copepods can in part be ascribed to this high neuromotor performance. However, less is known about species-specific differences in the escape response of marine copepods.

Using high-speed video, we compared escape reactions to hydrodynamic stimuli in four planktonic calanoids, *Acartia hudsonica, Centropages hamatus, Tortanus discaudatus* and *Temora longicornis.* Responses to a flow field created by a suction tube involved reorientation away from the source of suction and multiple power strokes propelling the animals away. Responses to brief, sudden computer-controlled hydrodynamic stimuli had short latencies (2 to 4 milliseconds) and consisted of a reorientation followed by just a few pereiopod power strokes. Species-specific patterns in escape behavior included quantitative differences in performance to each stimulus type. *A. hudsonica* and *T. discaudatus* responded vigorously to the brief, sudden stimulus, achieving velocities of 400 to 500 mm s^{-1}. These two species responded with escape velocities of only 300 and 350 mm s^{-1} to the flow field stimulus. In contrast, escape velocities of *C. hamatus* and *T. longicornis* were similar to both stimuli (< 400 mm s^{-1}), but the distances jumped were greater to the flow field stimulus (10 mm vs. 3 to 5 mm, respectively).

Copepods modulated their escape response by either increasing the force produced during the pereiopod power strokes (*A. hudsonica* and *T. discaudatus*), or increasing the number of power strokes (*C. hamatus* and *T. longicornis*). Their neuromotor systems have evolved different reactions to predatory threat, apparently dependent on their ecological situation. While common predators in the bay include fishes, chaetognaths, shrimp, ctenophores, jellyfish and barnacles, which ones specialize on which copepod species is unknown. Our results suggest that escape responses of *A. hudsonica* and *T. discaudatus* would be particularly effective in evading a lunging predator with a short attack range. *C. hamatus* and *T. longicornis* may have a more effective escape to a predator producing a feeding current. In Frenchman Bay, these four species have overlapping distributions, although abundances vary greatly with season. Differences in the escape response suggest niche separation among these species includes differences in predation risk

This work is supported by: NSF OCE99-06223 and REU supplement to PHL, Hawaii BRIN summer research award to DB.

1. Lenz, P.H., A.E. Hower, and D.K. Hartline. Force production during pereiopod power strokes in *Calanus finmarchicus. J. Mar. Systems*, in press, 2004.