

Stealthy Predation by an Invasive Ctenophore, *Mnemiopsis leidyi*

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Colin S, Costello J, Hansson L, Titelman J, Dabiri J (2010). Stealth predation and the predatory success of the invasive ctenophore *Mnemiopsis leidyi*. *PNAS* 107: 17223-17227.

One of the most challenging goals of modern biology is to understand and manage the success of invasive species in foreign environments. These species are often able to effectively invade a habitat by filling an unoccupied, or sometimes novel, niche, where they are challenged by few predators and little competition. Among the most successful invasive species is the ctenophore *Mnemiopsis leidyi*. Although its home range extends along the Atlantic coastline of North and South America, this species has successfully invaded the Black Sea, the eastern Mediterranean, and the Caspian Sea among several other locations. In each of these areas, the arrival of *M. leidyi* has been marked by significant decreases in the abundance and diversity of zooplankton species including copepods and fish larvae.

The success of *M. leidyi* has been puzzling to many investigators. Unlike their primary competitors, copepods and fish, ctenophores do not generally use vision or any other remote mechanism for locating and encountering prey. Although the cilia lining their ctenes are able to act as weak mechanoreceptors, their primary function is in moving the ctenophore slowly through the water column and generating currents for suspension feeding. Given their method of feeding and limited sensory capabilities, it seems unlikely that *M. leidyi* would be able to efficiently forage on copepods and fish larvae. Copepods have adapted efficient escape behaviors using mechanoreceptors that are capable of detecting slight disturbances in the surrounding water. To forage successfully on these species, a predator must employ rapid movement or stealth, as some copepods are capable of moving at up to 800 body lengths per second with a reaction time of 2 milliseconds. Despite its slow movement, the apparent predatory success of *M. leidyi* seems to imply a high feeding and filtration rate. These observations suggest that the invasive success and abundance of this ctenophore may be due to a stealthy foraging strategy.

To examine this prospect, Colin et al. quantified how fluid interacts with the cilia of *M. leidyi* through 2D digital particle image velocimetry. This method allows the investigators to

visualize the shear deformation, velocity, and water flow that is produced across a swimming ctenophore body using a tracer molecule. To accomplish this, individual *M. leidyi* of various sizes were placed in filtered seawater aquaria that were seeded with 10- μm glass beads for the purpose of filming the distortion of surrounding fluids. The investigators then generated velocity vector fields from the film in order to determine flow rate across the ctene rows, which served as a measure of potential feeding rate. Additionally, Colin et al. tracked shear fluid deformation across the outer and inner oral lobes and ctene rows. These values were then compared to threshold values of strain for copepods. Above this value, copepods are able to detect an incoming object and respond with the appropriate escape reaction.

As predicted based on their success as invaders, it seems that *M. leidyi* are undetectable to their copepod prey. Fluid deformation rates resulting from ciliary movement were found to be very low across the oral lobes, at around 0.3 s^{-1} (Fig. 1). These rates were lower than the response threshold values of several copepod prey species of *M. leidyi*. The highest levels of shear were above the copepod threshold and found along the inner surface of the oral lobes at the mouth. This is not likely to alert potential prey, however, as this region is located internally to the ctene rows that generate the feeding current.

Further support for stealthy predation came from imaging the movement of food particles across the auricles of *M. leidyi*. Ctene rows were found to produce a laminar feeding current, wherein large amounts of food can be passed parallel to the body wall in a streamlined manner, resulting in low fluid deformation. While the cilia of each ctene row displaced water at only 2 mm s^{-1} , the laminar movement was efficient, with captured particles remaining associated with the cilia as they were transported toward the mouth ridge. Once at the mouth ridge, investigators found that fluids which pass outside the auricles begin to spiral in a corkscrew motion and flow directly across the tentacles which function in prey capture. This finding suggests a potential capture rate of 100% for prey that have been ensnared in the feeding current.

These results suggest that the invasion success of *M. leidyi* may come in part from its effective foraging strategy. Low fluid deformation from their feeding activity supports the claim that these ctenophores remain below the detection threshold of their copepod prey and are

stealth predators. Copepod prey are ensnared by the silent flow of the ciliary tract and then captured by tentacles. The efficiency of this stealth strategy seems likely to be a major contributor to the ecological success of *M. leidyi* in the diverse marine communities that it has invaded.

It is unclear why the success of *M. leidyi* is not been mirrored in its relatives, who forage in similar ways. Invasive ctenophores such as *Bolinopsis spp.* have not caused similar devastation to zooplankton communities as *M. leidyi* has in the Black Sea and eastern Mediterranean. What might be responsible for this vast difference? Might feeding apparatuses vary in structure and function? How could foraging behavior play a role? In order to resolve these questions, future studies will need to investigate not only that stealthy hunting is used in nature for capturing copepod prey, but also that it is present and effective in sister species to *M. leidyi*.

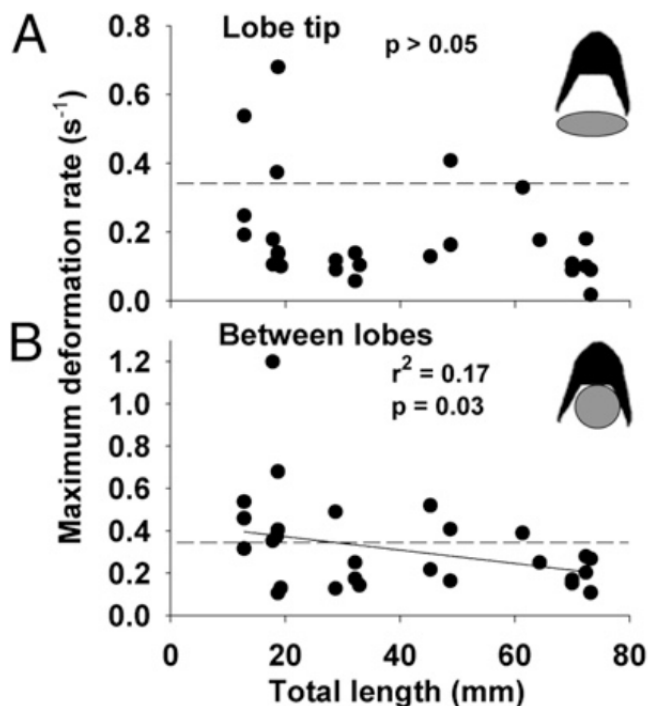


Figure 1. Maximum fluid deformation rate of water at the anterior lobe tips (A) and between the lobes (B) of *M. leidyi* at various body lengths. Dashed lines represent the lowest threshold value at which copepod prey can sense their predators. These results suggest that fluid deformation by *M. leidyi* generally falls beneath the copepod threshold. Adapted from Colin et al., 2010.