Cavitation and impact forces by the Peacock mantis shrimp
(Stomatopoda: *Odontodactylus scyllarus*)

This is a brief presentation about the morphology, impact forces and cavitation phenomena of the mantis shrimp’s raptorial strike. Most pages contain an image and reference to a video clip (in turquoise text) that is also uploaded to the biomechanics site.

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Odontodactylus scyllarus (Peacock mantis shrimp) uses its raptorial appendages (second thoracic appendages) to hammer hard-shelled prey.
The raptorial appendage is built of the typical crustacean appendage segments.

For complete CT scan images showing videos of internal and external anatomy, check out Digimorph’s website: [http://digimorph.org/specimens/Odontodactylus_scyllarus/whole/](http://digimorph.org/specimens/Odontodactylus_scyllarus/whole/)
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Lateral view of the peacock mantis shrimp’s raptorial appendage

carpus

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The raptorial appendage can be used for smashing (with the dactyl heel) or stabbing with the tip of the dactyl.
Here a peacock mantis shrimp strikes a snail wired to a stick. This video was filmed at 5000 frames per second and is played back at 15 fps. Even slowed down >300x, the movement is extremely rapid; the dactyl heel can reach speeds of over 20 m/s.

Note the formation of a bright bubble between the dactyl heel and snail shell.

Here is a closer look at the formation of bubbles between the snail and dactyl heel. This video was filmed at 20,000 frames per second (played back at 15 fps).

These bubbles are known as “cavitation”. Cavitation bubbles are formed because of extremely low pressure in the water between the snail and dactyl heel such that the water vaporizes (like boiling water, but without the application of heat).

The collapse of the cavitation bubbles is like a small explosion, and causes the emission of heat, light and sound. This is an extremely destructive phenomenon – it can destroy rapidly rotating metal boat propellers.
The forces generated by the limb’s impact and the collapse of cavitation bubbles were measured using a force sensor (a waterproof piezoelectronic load cell).

This is a video of a mantis shrimp striking the force sensor, filmed at 5000 frames per second, played back at ~15 fps.
Note the cavitation bubble forming between the dactyl heel and force sensor.
Because these processes occurred over such short time scales, it was necessary to film the strike with extremely high speed video - 100,000 frames per second (10 μs per frame), played back here at ~15 fps.
By synchronously recording force and video, one can see that mantis shrimp generate two force peaks with every strike – the first force peak is due to the impact of the limb on the sensor and then the second is caused by the collapse of cavitation bubbles. Thus, peacock mantis shrimp use two forms of force generation – one due to the limb’s direct impact, and the other due to the potent cavitation processes caused by the extreme speeds of the strike. This video shows synchronously recorded force sensor output and high speed images (100,000 frames per second; played here at 10 frames per second).


