Death at a Distance

Exhibit message

Some predators disarm and capture prey without pouncing directly onto them. This exhibit displays hunting techniques of archer fish, snapping shrimp and veiled chameleon.

Quick fact

Snapping shrimp tend to live together in colonies. When they produce cavitation bubbles, they sound like popping corn or hundreds of marbles hitting glass.

During World War II, the sound made by snapping shrimp was so loud, it disrupted communication between warships.

Graphic panel text

Archer fish *(Toxotes chatareus)*

Archer fish knock insects into the river by spitting at them!

Archer fish shoot 'off-target' to allow for water distortion. They also calculate where the insect will fall into the water and grab it in one tenth of a second.

Veiled chameleon *(Chameleo calyptratus)*

Just before a chameleon's tongue hits prey, muscles pull the tip of the tongue into the shape of a suction cup.

Chameleon eyes move in different directions, so they can look for prey in front and behind at the same time!

Snapping shrimp *(Alpheus heterochaelis)*

Snapping shrimp shut their claw and shoot out a bubble at 100 km/h. This bubble collapses and releases a loud sound and a bright flash of light to paralyse prey.

Want to know more about archer fish, chameleons or snapping shrimp?

Archer fish

When they're looking for insects above the water, archer fish swim in an almost vertical position. Once they have spotted an insect up to 50 centimetres away, the archer fish spits water at the insect to try and knock it into the water.

Water distorts an archer fish's view of insects. This is because water bends light and makes objects appear larger and in a different position (just as a drinking straw in a glass of water appears bent and oddly shaped). Some scientists think that archer fish allow for this distortion by shooting at insects slightly 'off-target'.

The archer fish has a groove along the roof of their mouth and a ridge-shaped tongue. When they press their gills shut, they push their tongue against the groove to shoot out jets of water.

As soon as the insect starts to fall off its 'perch' and into the water, the archer fish turns and darts over to the spot where the insect will land. If the archer fish dawdles, other fish nearby will swoop in and gobble up the insect.

The archer fish seems to calculate where their lunch will land before the insect hits the water. Because archer fish shoot prey of different sizes which fall at different speeds, scientists think that their calculations of where prey will land are quite complex.

Snapping Shrimp

Snapping shrimp are small, but they pack a punch! They grow up to 5 centimetres long, but they can create shockwaves powerful enough to kill prey or even break glass!

The shockwaves are used by snapping shrimp to stun and kill small fish, crabs and shrimp to eat, or to fight other snapping shrimp over territory.

For a long time, scientists thought that the snapping shrimp made its rapid-fire sound by physically hitting each half of its claw together.

However, new research shows that the sound and a tiny flash of light are generated when the snapping shrimp produces a collapsing water vapour bubble or cavitation bubble.

These cavitation bubbles do not contain air like normal bubbles, but are areas of extreme pressure difference in the water.

When the shrimp snaps its claw shut at incredible rates of 30 000 rpm, it drives a plunger on the upper half of its claw into a socket on the lower claw.

The water between the claw halves is squeezed out and forms a water jet with a speed of 100 km/h. The speed of the water jet is so high that the water pressure drops below the vapour pressure of water. This creates a cavitation bubble which collapses to generate shockwaves.

Veiled chameleon

Most chameleon species live in trees. They can range in size from 3 centimetres to 60 centimetre bird-eating chameleons.

Chameleons change their colour to camouflage themselves. They also move slowly, allowing them to sit and wait for prey to come near, rather than chase and catch prey.

Being ambush predators, chameleons eat infrequently and capture relatively large prey. This means that their tongue:

1. must be able to stretch and reach prey that happens to pass by and
2. needs to be strong enough to hold on to prey as it is being pulled back into the chameleon's mouth.

Once the prey has approached the chameleon at close range, the chameleon shoots out its muscular, projectile tongue. Just before their tongue hits the prey, muscles at the tip of the chameleon's tongue contract. This forms a kind of suction cup on the tip of their tongue to adhere to the prey and pull the prey back into their mouth.

Extra for Experts

Archer fish

Humans track a falling ball (such as a cricket ball hit high by a batsman) by watching, calculating and moving to the spot where the ball is likely to land.

Unlike humans, archer fish cannot keep watching their target (the falling insect) until it lands. Instead, the archer fish seems to dislodge the insect, calculate the landing spot (using a few simple ballistic calculations within 100 milliseconds), then swims over to the landing spot in a direct, straight lined route.

Scientists tested this by sitting a dead fly (tethered by a string) over a tank containing an archer fish. They allowed the archer fish to spit at and dislodge the fly from its perch.

Just after the fly started falling, scientists pulled the fly up in mid-air and stopped the fly from landing in the water. Even though the fly stopped in mid-air, the archer fish continued to rush to the predicted landing spot.

Scientists also placed the fly on a glass plate above the tank and slid the fly horizontally over the tank. When the archer fish spat at and hit the fly, the fish still swam to the position where the fly should have landed if the fly was able to fall downwards into the water.

From this, scientists believed that the archer fish was calculating the fly's height and initial velocity rather than extrapolating where the fly would land.

Chameleon

The chameleon's tongue has special muscles that can contract and extend more than normal muscles.

These super-contracting muscles can extend the tongue six times the tongue's normal, resting length. For some chameleons, this makes their extended tongue almost twice their body length.

Muscles at the tip of the tongue also contract just before the tongue hits prey, so it can create a suction cup to hold on to large prey.

Chameleon jaws are very strong—they have one of the strongest bite forces of any lizard for their size.

Chameleons also have eyes that move independently. When prey comes near, they fix one eye on the prey and slowly move their head to watch the prey if it moves. Their second eye continues to swivel around and survey the scene above and behind the chameleon, so they can watch out for potential attackers.

Snapping shrimp

Powerful cavitation bubbles generated by snapping shrimp only grow to about one centimetre in size, but they can do a lot of damage!

Cavitation bubbles form when the water is squirted out at a very high velocity from the shrimp's claw (100 km/h) and the pressure drops dramatically due to the Bernoulli principle.

If water pressure drops below the vapour pressure of water, it will boil (or vapourise) at ambient temperatures. This creates a very low pressure inside the vapour bubble, while the surrounding water pressure remains high.

Cavitation bubbles collapse due to this surrounding pressure and temperatures inside the bubble can reach up to 5000 °C before collapsing.

As the bubble collapses, it releases a flash of light (called sonoluminescence), a sharp tapping sound and a shockwave.

Even propeller blades on ships can generate their own cavitation bubbles that corrode and damaged the blades. As ship propellers start to accelerate, they generate cavitation bubbles that erode the metal blades.

Further information

Special thankyou to:

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- Dr Stefan Schuster (archer fish)
  http://www.biologie.uni-freiburg.de/data/bio1/schuster/
- Dr Anthony Herrel (chameleon)
  http://www.uia.ac.be/u/aherrel/

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Archer fish

http://www.nationalzoo.si.edu/Animals/ThinkTank/Animals/ArcherFish/default.cfm

http://www.austmus.gov.au/fishes/fishfacts/fish/tchatar.htm

http://www.nature.com/nsu/020923/020923-15.html

http://jeb.biologists.org/cgi/reprint/205/21/2103/i.pdf

http://jeb.biologists.org/cgi/reprint/205/21/3321.pdf
(free access journal)

Chameleons

http://www.thetech.org/exhibits_events/traveling/robotzoo/about/chameleon.html

http://www.uia.ac.be/u/aherrel/lizards/Chameleonidae.html

http://jeb.biologists.org/cgi/reprint/205/15/2167.pdf
(free access journal)

http://jeb.biologists.org/cgi/reprint/204/21/3621.pdf
(free access journal)

http://jeb.biologists.org/cgi/reprint/203/21/3255.pdf
(free access journal)

High speed footage of salamanders feeding (salamanders are related to chameleons)
http://autodax.net/feedingmovieindex.html

Snapping Shrimp

High speed footage of snapping shrimp cavitation bubble (click on Research, then Shrimp)
http://www.tn.utwente.nl/pof

Noise made by snapping shrimp
http://www.sciencenews.org/20000923/snapping.au