The Mind of Cephalopod

Vasiliki Tziouveli tests the ability of octopi to learn.

Cephalopods show an amazing diversity of form and function, from the deep water nautilus’ beautiful chambered shell, the cuttlefish’s fantastic disco light show and the enormous size of deep sea squid to the “master of escape”, the octopus.

As molluscs, octopi may be related to common garden snails, slugs, scallops and mussels, but they are undoubtedly more intriguing than their relatives. So much about them is fascinating, whether it is their many tickling arms, each with a “mind” of its own; the ink-cloud designed to confuse enemies; or their capacity to wear their heart on their sleeves by changing colour depending on mood. This is just a tiny sample of the wide range of displays they possess.

Yet we still don’t know much about some basic cephalopod biology and ecology. For example, while giant squid (Architeuthis dux) measuring more than 15 metres in length occasionally wash up on beaches, circular scars on sperm whales left by the suckers of these deep water calamari indicate that there are some truly massive squid swimming in the abyss. It has been hypothesised that the eye of A. dux can reach the size of a volleyball.

Cephalopods are still an area of active research, with octopi in particular hitting the headlines in recent years. Who would have thought of octopi with individual personalities and temperament, amusing themselves with play, wearing a cockle shell as a tin hat, or reinventing the wheel by using their arms to roll along the seabed? Yet the majority of Australians do not think of octopus in playful terms; they are either a pizza topping or a blue-ringed beach hazard.

Although the blue-ringed octopus is indeed the most dangerous, all octopi have toxic saliva, as I found out while working with the northern European species Eledone cirrhosa. I had become used to handling my favourite animal but one day, while trying to detach yet another stubborn arm, she gave me a friendly nip with her parrot-like beak. Within a few minutes my hand had swollen like an inflated rubber glove. Luckily for me, though, she was a juvenile.

I decided to work with octopi after reading an article suggesting that they had the ability to watch and learn like primates do, an indication of higher intelligence. Evidence of their ability to learn tasks dates back more than 100 years. Octopi have been taught to distinguish big from small, rough from smooth, and square from rectangular. They can find their way in a maze, and they can use cues to navigate back to rich hunting grounds. Octopi have even been caught opening glass jars to grab the cookie-crab, or drilling through a clam shell shut with steel wire to get to the meat inside. A general principle behind much of their behaviour seems to be: “Do whatever it takes to get your meal”.

Previous work on animal intelligence in birds and rodents has used food rewards, so what better place to start my investigation than with a tasty prawn and a group of octopi?

However, before I could start work I had to convince my eight-armed friends to stay put from one day to the next. Alcatraz prisoners could learn a useful thing or two from octopi, with the most persistent of the gang nicknamed Harry, after Houdini for obvious reasons. Essentially our octopi could squeeze through any space larger than the only rigid part of their body, the parrot-like beak. And since this is less than 10 mm for a 300 mm octopus, there were a lot of breakouts before the aquaria were finally escape-proofed.

For the experiment itself I used a
An angry Eledone cirrhosa outside its den in its experimental tank.

The curled octopus, Eledone cirrhosa, attempting to startle the predatory photographer by flattening out to appear larger and darkening the eye area.

transparent plastic box containing a live prawn with a single entry point facing away from the octopus, and recorded how long it took either juveniles or adults to find the entrance and catch the food. Over a series of trials you might expect them to get quicker with experience.

Instead what I found was that juvenile octopi get very excited in the presence of the box with the prawn, their first reaction being to try and capture the prey in a web formed by their outstretched arms, which is similar to how they behave in nature. Unfortunately for them, though, the prawn was protected by the container, and while they were fast to attack they were very slow at working out how to get into the box, preferring instead to follow the prawn from the outside. However, all juvenile octopi persisted, and a few eventually succeeded, even though success came after a lot of attempts.

I then continued to examine how adult octopi would deal with the same problem. However, bigger animals required a bigger box and bigger reward so this time I used Norway lobsters: quite an incentive!

The results differed in this set of trials. In general, adults were much more able to solve problems, working out how to overcome the box separating them from their delicious food. Interestingly, though, even the responses of the adults differed somewhat, with some particularly smart octopi entering the container very quickly from the very first trial. Others needed a bit more time to work out the problem, but once they did their entry time improved with each trial, an implication for memory capacity as well.

Curiously, those that needed more time tended to be the larger, older animals, perhaps indicating that it is harder to teach an old octopus new tricks.

It appears then that octopi are intelligent creatures that get better at problem-solving as they grow. Practise makes perfect, they say, and octopi are no exception. However, motivation is not to be underestimated.

It seems that octopi are a lot like people. Kids are enthusiastic but inexperienced; teenagers know how to get what they want and work fast; while older folk prefer to sit at home with a good book and their eight feet up. And just like humans, a variation in individual responses makes life a bit more interesting.

Why has intelligence evolved in such a short-lived solitary animal? Scientists form two camps on this question. Some argue that you need a big brain just to control the sophisticated eyes, the millions of chromatophore cells responsible for colour changes, and all those arms and suckers with which they basically do everything, from handling food, grasping surfaces, swimming and crawling on the bottom to mating.

Others hypothesise that intelligence serves to cope with a variable environment, since octopi are found throughout the world’s seas. In order to be the predator and not the prey, and make more babies, you need to be able to adjust quickly and use whatever resources are available efficiently. This is exactly what octopi do.

As someone said: “They don’t have claws, teeth, shells or spikes to protect them. All they have is their smarts.” Believe what you will. But maybe next time you are staring at baby octopi on your local supermarket you will see these little suckers in a new light: as the invertebrate intellects of the sea.

Vasiiki Taloull was the winner of Science at the Cutting Edge, a science writing competition for James Cook University postgraduate students that is co-sponsored by Australasian Science.