Video: Octopuses have unique way to control their 'odd' forms

April 16 2015

Octopus vulgaris. Image: Wikipedia.

The body plan of octopuses is nothing if not unique, with a sophisticated brain in a soft, bilaterally symmetrical body, encircled by eight radially symmetrical and incredibly flexible arms. Now, researchers reporting the first detailed kinematic analysis of octopus arm coordination in crawling show that the animals have a unique motor control strategy to match their "odd" form. The researchers report their findings in the Cell Press journal *Current Biology* on April 16.

"Octopuses use unique locomotion strategies that are different from those found in other animals," says Binyamin Hochner of The Hebrew University of Jerusalem. "This is most likely due to their soft molluscan body that led to the evolution of 'strange' morphology, enabling efficient

locomotion control without a rigid skeleton."

Earlier studies of octopus behavior by The Hebrew University of Jerusalem team have focused on goal-directed arm movements, like reaching to a target or fetching food to the mouth, Hochner explains. The new study is the first to tackle a larger question: how octopuses manage to coordinate their eight long, flexible arms during locomotion.

Octopuses most likely evolved from animals more similar to clams, with a protective outer shell and almost no movement to speak of. "During evolution, octopuses lost their heavy protective shells and became more maneuverable on the one hand, but also more vulnerable on the other hand," says study co-author Guy Levy. "Their locomotory abilities evolved to be much faster than those of typical molluscs, probably to compensate for the lack of shell."

The evolution of a typical snail's foot into long and slender arms gave octopuses extraordinary flexibility. Excellent vision, together with a highly developed and large brain and the ability to color camouflage, made cephalopods very successful hunters. But how do they control the movements of those remarkable bodies?

After poring over videos of octopuses in action, frame by frame, the researchers made several surprising discoveries, as reported in the new study. Despite its bilaterally symmetrical body, the octopus can crawl in any direction relative to its body orientation. The orientation of its body and crawling direction are independently controlled, and its crawling lacks any apparent rhythmical patterns in limb coordination.

Hochner, Levy, and their colleagues show that this uncommon maneuverability of octopuses is derived from the radial symmetry of their arms around the body and the simple mechanism by which the arms create the crawling thrust: pushing-by-elongation.

"These two together enable a mechanism whereby the central controller chooses in a moment-to-moment fashion which arms to recruit for pushing the body in an instantaneous direction," the researchers write. The animal needs only to choose which arms to activate in order to determine the direction of locomotion.

The findings lend support to what's known as the Embodied Organization concept. In the traditional view, motor-control strategies are devised to fit the body. But, the researchers say, under Embodied Organization, the control and the body evolve together in lockstep within the context of the environment with which those bodies interact.

"This concept, which is borrowed from robotics, argues that the optimal behavior of an autonomous robot or an animal is achieved as a result of the optimization of the reciprocal and dynamical interactions between the brain, body, and the constantly changing environment, thus leading to optimal adaptation of the system, as a whole, to its ecological niche," Levy says. "Another important virtue of this type of organization is that every level, including the physical properties and the morphology, contribute to the control of the emerging behavior—and not only the brain, as we tend to think."

Levy and Hochner say their next step is to uncover the neural circuits involved in the octopuses' coordinated crawling.

Provided by Cell Press