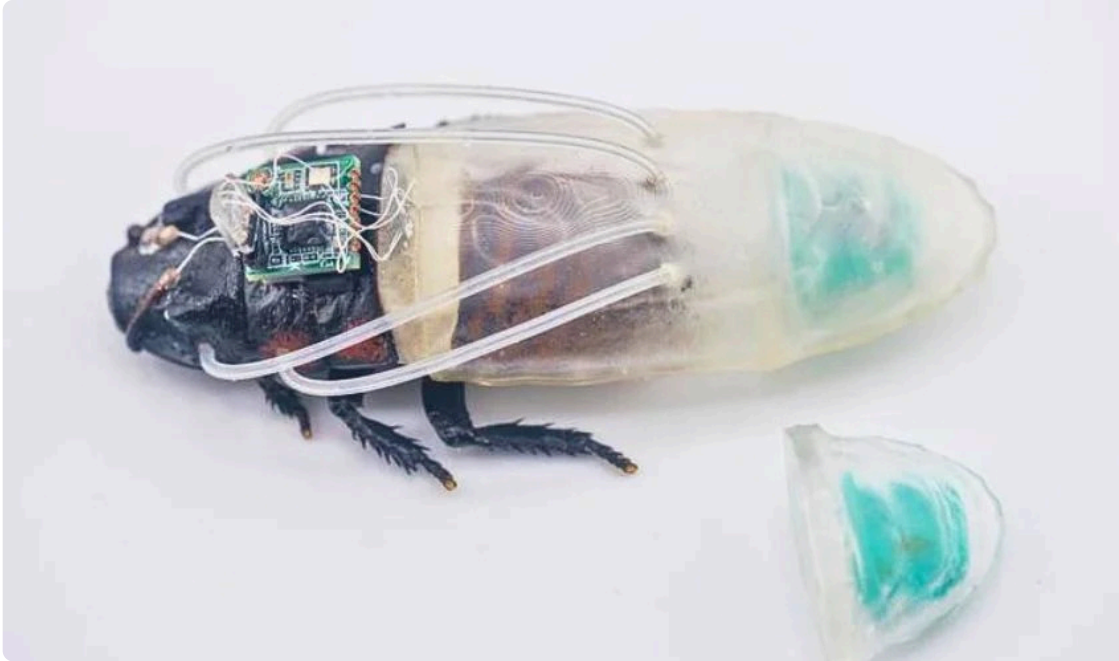


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A 3D-printed suit allows cyborg cockroaches to move underwater.

Posted on August 10, 2026 by **Lucía C.**



Cockroaches are certainly not the kind of creatures you'd want to encounter. Yet researchers at *Nanyang Technological University* and *Waseda University* have turned them into potential rescue tools, outfitting live insects with 3D-printed underwater suits that allow them to navigate even flooded environments.

It may sound like the plot of a science fiction movie, but it's the starting point of a study published in *Nature Communications*. Researchers have developed radio-controlled cyborg insects capable of moving both on land and underwater and remaining active for hours, even in cramped spaces and extreme conditions, where humans and conventional robots face greater operational challenges.

Instead of building a **robot** capable of mimicking a cockroach, the researchers used the live insect, integrating it with electronic components. This is the principle behind cyborg insects: hybrid systems that exploit the animal's natural abilities, rather than attempting to reproduce them artificially.

Using hissing cockroaches from Madagascar, the team combined the insects' natural abilities with an existing electronic control backpack and a novel 3D-printed respiratory system, enabling them to operate both on land and underwater.

Why a cockroach?

The choice is no accident. Cockroaches can squeeze through cracks just a few millimeters wide, climb over debris and uneven surfaces, quickly recover when knocked over, and continue moving for hours with minimal energy consumption.

Engineers have been working for years to reproduce even some of these capabilities in small robots.

On land, cockroaches' resistance allows them to remain active for long periods. Underwater, however, the situation changes rapidly. These insects breathe through small lateral openings called spiracles. Once submerged, the spiracles can no longer perform their function, and the insect cannot absorb oxygen.

This is precisely the problem that researchers have been trying to solve.

A 3D-printed diving suit

The solution developed by the team is a miniature diving rig: a flexible 3D-printed shell that wraps around the insect's abdomen and operates separately from the electronic backpack used to control its movements.

Thanks to this system, the insects remained active underwater for up to three hours. Without the suit, their autonomy would have been about two minutes.

Adapting the device to the body of a living insect was more complex than it might seem. The structure had to be lightweight, waterproof, and precisely shaped so as not to interfere with the cockroach's natural movements. These three requirements were difficult to meet simultaneously without resorting to 3D printing.

Photo credits: Nature Communications

Each component was designed based on the individual insect's build. The central element of the system is an oxygen tank 3D printed with a transparent PMMA resin , a material chemically similar to acrylic.

Inside is a sponge coated with manganese dioxide, which, when combined with a small amount of hydrogen peroxide, generates oxygen. This oxygen is then conveyed through thin silicone tubes directly to the insect's respiratory orifices.

The shell enclosing the tank is made of flexible resin, so it can follow the cockroach's movements without hindering them. The connectors connecting the shell to the spiracles were also custom-molded. The two pairs of breathing openings have different shapes and require specific fittings to ensure a proper seal.

Can cyborg cockroaches become rescue tools?

This isn't just a theoretical hypothesis. The cyborg insects developed by Hirotaka Sato's team have already been used in real search and rescue operations, including Operation Lionheart, launched after the 7.7 magnitude earthquake that struck Myanmar in March 2025.

The research group is now working on further developments of the technology, with a particular focus on applications for infrastructure inspection.

"Our new insect diving suit works like the oxygen tank used by scuba divers. It generates oxygen and delivers it directly to the insect's breathing holes, allowing the cyborg cockroach to survive and move in submerged or oxygen-poor environments ," explained Hirotaka Sato, a professor at NTU Singapore's School of Mechanical and Aerospace Engineering .

According to the researchers, the system could also be applied to other species. Locusts and beetles use a similar respiratory system, based on spiracles. In theory, an adapted version of the suit could therefore be developed for these insects as well.