Innovation Wild robots: Five ways scientists are using robotics to study animal behavior

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background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Here are five animal-like, or biomimetic, robots that researchers are already using to study — and, in one case, to control — the social life of real-life animals.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 17pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Robobee is in the hive<span style="font-size:18.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">The famous “waggle dance” of honeybees — in which a worker returning to the hive signals the location of a food source by running in specific patterns near the entrance to the hive while vibrating its wings and body — has been known for more than 60 years. But researchers still don’t know exactly how the bee’s hive mates decode its message. “What are the signals here? What are the components of the dance that actually carry information, and which are just a by-product?” says Tim Landgraf, a roboticist at the Free University of Berlin. This, he thought, was a job for Robobee.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Landgraf built a life-size bee replica — just a vaguely bee-shaped plastic blob with a single wing — and attached it to a mechanical drive system that allowed him to vary where and how the replica moved and vibrated. After inserting the bee into the hive, Landgraf found he could indeed <span style="font-size:12.0pt;line-height:115%;font-family: " times="" new="" roman",serif;mso-fareast-font-family:"times="" roman";mso-bidi-language:="" ne"=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">direct real bees to a food source<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">, even one they’d never used before — solid proof of principle.</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">
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background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">
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 <div class="caption" style="font-family: proxima-nova, Arial, " helvetica="" neue",="" helvetica,="" sans-serif;="" font-size:="" 12px;"=""> Researchers can move Robobee (shown at center) and vibrate its plastic wing to simulate the “waggle dance” that honeybees use to tell their hive mates where to locate food sources. Robobee’s waggle dance is good enough to guide real bees to new food sources — sometimes. <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"> <p class="source" style="font-size: 12px; margin: 15px 0px 0px; line-height: 1.5; font-family: proxima-nova, Arial, " helvetica="" neue",="" helvetica,="" sans-serif;="" font-kerning:="" normal;="" color:="" rgb(155,="" 155,="" 155);"">CREDIT: COURTESY OF TIM LANDGRAF <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">But Robobee’s successes didn’t happen reliably. “Sometimes the bees would follow within seconds,” Landgraf says. “But sometimes it would take days, and we couldn’t say why.” That made him realize there was another facet to the dance communication that he had never considered: how bees decide which dancer to follow, and when. Are potential follower bees actively searching for information about food sources, he wondered, or does the dancer somehow have to persuade them to listen? Are only certain individual workers receptive to any particular signal, as a result of their prior experience?<span style="font-size:12.0pt;line-height:115%; font-family:" times="" new="" roman",serif;mso-fareast-font-family:"times="" roman";="" mso-bidi-language:ne""><o:p></o:p> <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">To answer these questions, Landgraf and his team are developing an upgraded Robobee with a more realistic odor and a more reliable wing-vibration mechanism to go in a hive full of individually marked bees whose experience they can track. After the inevitable Covid-related delays, they’ve finally begun testing the system, but he’s not ready to talk about results yet. However, he says, “I think there’s a good chance of finding something.”<span style="font-size:12.0pt;line-height:115%;font-family: " times="" new="" roman",serif;mso-fareast-font-family:"times="" roman";mso-bidi-language:="" ne""><o:p></o:p> <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 17pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Robotic falcon on the hunt<span style="font-size:18.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne""><o:p></o:p> <p class="MsoNormal" style="margin: 6pt 0in; text-align:

justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">When a falcon strikes, how does a flock of pigeons respond? The classic theory — often called the “selfish herd” hypothesis — assumes that every pigeon merely tries to get into the middle of the flock, so that the predator takes some other unfortunate bird. But that idea isn’t easy to test. Every falcon strike is different: Some start a little higher than others, or from a different angle, and all this variability can affect how the pigeons respond. So Daniel Sankey, a behavioral ecologist now at the University of Exeter in the UK, turned to a robot.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">“We thought of it as a very controlled way to conduct this study,” says Sankey. “You could make sure the falcon was always exactly 20 meters behind when the pigeons were released, which made it repeatable.” Plus, he notes, the robot was safer for the pigeons. “I know a trained falcon in the past has absolutely obliterated a flock of pigeons.”</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">With the help of a falcon enthusiast’s robotic falcon — lifelike in appearance, except for the propellers that drive it — Sankey repeatedly attacked a flock of homing pigeons, while tracking each bird’s position by GPS. Contrary to the selfish flock hypothesis, the pigeons were no more likely to move to the middle of the flock when under attack than when unmolested, he found.<span style="font-size:12.0pt;line-height: 115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:"times="" roman";="" mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Instead, Sankey’s analysis showed that the pigeons mostly tried to fly in the same direction as their flock mates, so that the flock dodged in unison, leaving no stragglers for the predator to pick off. “This suggests that by aligning with each other, you can escape the predator as a group, so no one gets eaten,” he says. While not conclusive proof, this suggests that the pigeon flock <span style="font-size:12.0pt; line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne"=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">may be cooperative, not selfish<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><b><span style="font-size: 17pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-

attachment: initial; background-origin: initial; background-clip: initial;">Robofish in school<span style="font-size: 18.0pt;line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne"="""><o:p></o:p> <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Which fish in a school are most likely to lead the group? Most studies have suggested that the larger fish tend to have the most influence over where the school swims — but there's a problem: Big fish are also older and more experienced, and they can act differently than their smaller schoolmates. Which of these differences has the strongest effect on who becomes the leader? That's hard to test with real fish. "How could you make a big fish behave like a small one? These are the kinds of things you could only test with robots," says Jens Krause, an animal behaviorist at Humboldt University of Berlin who coauthored an overview of <span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">robots in behavioral research<span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"> in the 2021 Annual Review of Control, Robotics, and Autonomous Systems.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p> <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">So Krause and his colleagues developed Robofish, a 3D-printed replica of a guppy mounted on a magnetic pedestal and driven by a motorized unit underneath the tank. Two video cameras coupled to computers let Robofish respond to its schoolmates' movements in real time. <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">
 <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><img src="https://knowablemagazine.org/docserver/fulltext/10.1146/knowable-110321-1/p-robofish.jpg" style="width: 813px;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">
 <div class="caption" style="font-family: proxima-nova, Arial, " helvetica="" neue",="" helvetica,="" sans-serif;="" font-size:="" 12px;"=""> Real guppies respond to Robofish — a 3D-printed plastic model with a vaguely realistic paint job — as if it were a real schoolmate. Researchers used different-sized Robofish to show that guppy schools tend to follow larger fish.   <p class="source" style="font-size: 12px; margin: 15px 0px 0px; line-height: 1.5; font-family: proxima-nova, Arial, " helvetica="" neue",="" helvetica,="" sans-serif;=""

font-kerning:="" normal;="" color:="" rgb(155,="" 155,="" 155);="">CREDIT: D. BIERBACH ET AL / FRONTIERS IN BIOENGINEERING AND BIOTECHNOLOGY 2020</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">As long as the model had eyes and a vaguely realistic color pattern, they found, the guppies behaved toward the model much as they did toward any other fish. This allowed the researchers to swap in larger or smaller versions of Robofish while keeping every other aspect of its behavior identical, to study the effect of size alone. Sure enough, real guppies were <span style="font-size:12.0pt;line-height:115%;font-family: " times="" new="" roman",serif;mso-fareast-font-family:"times="" roman";mso-bidi-language:="" ne""=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">more likely to follow larger Robofish leaders<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">, they found. The team has also used Robofish to study how individuals’ <span style="font-size: 12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne"=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">swimming speeds affect the behavior of the school<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">.</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">And Krause’s team learned another surprising thing about fishy leadership: Politeness helps. Early versions of their Robofish control program caused the robot to approach schoolmates too closely, causing the real fish to back off. “We had some robots that ended up chasing the fish,” Krause recalls. After the team tweaked the robot so it respected its schoolmates’ space, the new “socially competent” Robofish <span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">proved to be much better at attracting followers<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align:

justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 17pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Termite robots in a swarm<span style="font-size:18.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">The previous studies used robots to infiltrate real groups of animals and provoke a response. But there’s another way to use robots to understand animal behavior: Program a swarm of robots to act according to the rules you think real animals are following, and see if the result mimics how the animals act.<span style="font-size:12.0pt; line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">That’s the approach followed by Justin Werfel, a collective behavior researcher at Harvard. Werfel wanted to understand how termites build such intricate mounds, notable for the arrays of fluted chimneys at their entrances. He focused on a single step in the process: how termites carrying excavated soil from the mound choose where to dump it. This simple decision determines the complex shape of the mound entrance.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Werfel and his colleagues had some evidence to suggest that termites might drop their dirt at the point where the mound’s high internal humidity gives way to the drier air on the surface, a good marker for the boundary of their home. But they didn’t know if the termites’ dirt-dropping behavior depended on other factors, too.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">So they built a swarm of robotic termites. Since the robots didn’t have to interact with real insects, they didn’t have to appear lifelike. Instead, the robots were brick-sized carts that could carry and drop colored blocks on a flat surface. Each “termite” carried a humidity sensor and was programmed to carry the blocks when humidity was high and drop them when humidity fell. Meanwhile, a hamster tube dribbled water as each “termite” moved, ensuring that the humidity was higher in occupied areas.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial;

background-attachment: initial; background-origin: initial; background-clip: initial;">“We know the robot is only paying attention to humidity, because that’s what we told it to do,” says Werfel. And that proved to be enough: The robot swarm ended up dropping its blocks in a <span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne="""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">two-dimensional version of a real termite mound entrance<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">. The robots even sealed off the opening on breezy days, just like real termites do. The experiment doesn’t prove, of course, that termites actually use a humidity rule to build their mounds, Werfel notes — but such a rule is sufficient to accomplish the task.</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-family: Helvetica;" times="" new="" roman",="" serif;="" font-size:="" 12pt;"=""> </p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 17pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">The terror-fish is lurking<span style="font-size:18.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Biomimetic robots don’t just reveal animal behavior. They may soon be used to manipulate it in useful ways.<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Mosquitofish, native to the southern US, have become one of the top 100 invasive species worldwide. Giovanni Polverino, a behavioral ecologist at the University of Western Australia, decided to try an unusual form of bio-robotic control.<span style="font-size:12.0pt; line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne="""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Polverino and his colleagues built a robotic fish designed to look like a largemouth bass, a key predator of mosquitofish in their native waterways. By programming the robot to swim aggressively toward mosquitofish, they hoped to terrorize the invasive species while leaving native Australian species unaffected. (Many <span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne="""><span style="font-family: Helvetica; color: rgb(51, 102, 107);

background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">wild animals show lasting effects of fear<span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">.)<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne"=""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">And that’s exactly what they saw: As little as 15 minutes per week with the robotic predator <span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne""><span style="font-family: Helvetica; color: rgb(51, 102, 107); background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">caused the mosquitofish to lose body fat <span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">and allocate more energy to escape and less to reproduction. “The effect on the mosquitofish is huge, and the other species is not scared at all, because we copied a predator that in Australia does not exist,” says Polverino.</p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Polverino has a lot more work to do before he can deploy his artificial predator in the real world. “Our robot works well in the lab,” he says. “But it has a computer nearby, a webcam over the tank and a battery with a short lifetime.”<span style="font-size: 12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Even so, he’s in discussion now with a national park in Queensland where two endangered fish species live in small, clear pools that have recently been colonized by mosquitofish. Because the pools are so small, they might provide a good first test in the wild. “It’s not ready now,” says Polverino, “but it’s a clear possibility.”<span style="font-size:12.0pt;line-height:115%;font-family:" times="" new="" roman",serif;="" mso-fareast-font-family:"times="" roman";mso-bidi-language:ne""><o:p></o:p></p><p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Much can go wrong, of course, when researchers try to insinuate robots into animal social groups — and sometimes, the failures are for prosaic reasons. When Biro tried to build a robotic pigeon to study collective decision-making by groups of homing pigeons, for example, the robot proved unable to fly fast enough to keep up with the real flock. Still, the opportunity to test animal behavior in new ways has enough promise that she hopes to try again someday. “If we had got all of this to work, there would have been all sorts of interesting things to do,” she says. “It is

on my list of things that I hope to do.” <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Helvetica; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Photo Credit <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Photo by Jeremy Hynes on Unsplash <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">Republished from knowablemagazine <p class="MsoNormal" style="margin: 6pt 0in; text-align: justify; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;"><span style="font-size: 12pt; line-height: 115%; font-family: Georgia, serif; background-image: initial; background-position: initial; background-size: initial; background-repeat: initial; background-attachment: initial; background-origin: initial; background-clip: initial;">
<span style="font-size:12.0pt; line-height:115%;font-family:" times="" new="" roman",serif;mso-fareast-font-family:="" "times="" roman";mso-bidi-language:ne"=""><o:p></o:p> <o:p> </o:p>