Parasitic worms have armies, and produce more soldiers when needed

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In parasitic trematode worm species, small members of the colony known as "soldiers" (left) are poised to attack any invading competing worms (right). In a new study, Resetarits and colleagues show that these worms can increase the number of soldiers in a colony in response to local invasion threat. Credit: Ryan Hechinger

In estuaries around the world, tiny trematode worms take over the bodies of aquatic snails. These parasitic flatworms invade the snail's body and use its systems to support their colony, sometimes for over a decade, "driving them around like cars," according to senior author Ryan Hechinger, professor of marine sciences at Scripps Institution of Oceanography at the University of California San Diego.

Like many other highly organized animal societies, including bees and ants, trematode colonies form castes to split the workload. Some trematodes, called "reproductives," are larger and do all the reproduction for the colony, while smaller worms with larger mouths known as "soldiers" protect against outside invasion from competing trematodes.

"People think of parasites doing the attacking, not getting attacked," said co-author Mark Torchin, a marine ecologist with the Smithsonian Tropical Research Institute (STRI). "But these parasites have to fight for their homes within their hosts, and deal with the risk of host invasion."

But, for any society with limited resources, this means a trade off—more soldiers means fewer reproductives.

"Animal societies, like trematodes, have to maintain a balance between reproduction and protection," said first author Emlyn Resetarits, a postdoctoral associate at University of Georgia and former Ph.D. student at the University of Texas at Austin and graduate fellow with STRI. "How many reproductive worms should exist in the colony, and how many soldiers? Are these numbers stable, or do they change in response to environmental pressure?"

In a new study published Feb. 26, 2020 in *Biology Letters*, the research team demonstrated for the first time that the number of soldiers in a trematode colony depends on the local invasion threat, showing that such societies produce greater standing armies in areas of greater threat. This

has big implications for understanding how animal societies determine their resource allocation.

"Each trematode colony is built of clones from a single invading worm," said Hechinger, who specializes in the study of ecology and evolution of parasites. "They don't want to share their snail with another trematode, so as their population takes over their host, they start producing soldiers to fight off any potential invaders."

But the real question was whether the trematodes produced more soldier worms when they lived in environments where they were more likely to encounter invaders.

To find out, the researchers collected snails at 38 different sites with varying levels of invasion threat from 12 estuaries along the North American Pacific coast, from Panama to Northern California, and brought them back to the lab for analysis.

There, they dissected over 150 individual snails to count the number of soldier worms in each one, and found that snails collected in locations where there was a high risk of being invaded by other parasites had larger numbers of soldier worms poised to attack any new threat.

This massive sampling effort, funded by graduate fellowships from the National Science Foundation and STRI, included counting trematode worms from six separate species. All but one showed the same pattern of more soldiers in response to higher risk, indicating that this trait is generalizable among trematode species, families, and even orders, providing support that this may be true for other animal societies.

According to Hechinger, parasitic trematodes make excellent animal models for these kinds of experiments. "It's difficult to study even one termite colony, because of its size," he said, "But with trematodes, you

can hold 50 colonies in your hand."

"Unlike a lot of organisms, these trematode societies within snails are very reproducible units—they all live in very similar environments, inside the same species of snail," said Resetarits. "You can really get a sense of how many soldiers there are in one colony versus another, and make direct comparisons between different colonies and across species."

Beyond their utility as a model system, understanding the ecology of these snailbound worms is important because they play a large role in the ecosystems where they're found, passing through the food web in snails, fish, and birds, with different species found in different marine animals.

"There are more tons of trematode flesh than bird flesh in these estuaries," said Hechinger. "These worms can be used as an ecological indicator. If you pick up a hundred snails and look at the diversity of trematode parasites inside them and how many are infected, it tells you something about the diversity and abundance of the birds in the area. Understanding these worms helps us understand how energy flows through these food webs."

"Our next steps will be to determine how these worms determine their resource allocation," said Resetarits. "Do individual colonies react and respond to information about the local invasion threat by producing more soldiers, or are the trematode species in high risk locations adapting their soldier allocation on a population level? This will show us how versatile these colonies are, and give us more information about how their societies adapt to external challenges."

"This discovery is not just an interesting research project," said Hechinger. "This serves as a clear demonstration of the utility of using this system as a model to tackle fundamental sociobiological questions."

More information: Social trematodes parasites increase standing army size in areas of greater invasion threat, *Biology Letters*, royalsocietypublishing.org/doi … .1098/rsbl.2019.0765

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