‘How do they do that?’

Team uncovering strengths of Antarctica’s toughest resident

By Steven Profaizer
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Photos courtesy of Robert Lee / Special to *The Antarctic Sun*

Above, two specimens of Belgica antarctica *mate during their brief lifespan as adults. The species is the most southerly distributed insect in the world and has the ability to withstand a wide spectrum of environmental stressors.*

Left, Rick Lee is the principal investigator for the project studying the coping capabilities of the Antarctic midge.

Very few creatures can claim to be as tough as Antarctica’s largest year-round land animal. It can survive extreme dehydration, freezing and weeks without oxygen.

So, which beast can withstand such a bruising and be the reigning king of Antarctica?

Belgica antarctica – a flightless fly.

This 7- to 8-millimeter-long midge lives on the Antarctica Peninsula and lays claim to the title of the insect distributed farthest south in the world.

“Why can it survive here where we don’t find other insects? How can you be tolerant to so many stresses all at once and still be able to undergo normal feeding and growth?” said Rick Lee, principal investigator of a science project studying this incredible survivor. “We’re here looking at an animal that’s absolutely living on the edge at a place where other insects cannot survive.”

This is Lee’s second stint on a project studying the midge’s coping capabilities. He first came to Antarctica as a post-doctoral fellow in 1981 and documented the midge’s tolerance to various environmental stressors.

“The plan for our new project, some 25 years later, is to come back and take a look at these adaptations with new molecular tools and more sophisticated physiological techniques to address, ‘how do they do that?’” he said.

Lee is collaborating with Dave Denlinger from The Ohio State University for his current project. Their research focuses on the midges’ resistance to extreme temperatures and dehydration – both observations with roots in the 1981 project in which he was involved.

“You could dry a midge out to 35 percent of it normal body mass,” he said. “It shriveled up like a little raisin, but yet when you added water to it, it plumped back up, wiggled away and was doing just fine.”

The project is in its third year, and new molecular techniques have allowed researchers to identify the year-round presence of stress proteins.

Such proteins are only activated in most organisms when cells are under stress. When this response occurs, cells normally shut down all their routine forms of protein production, but the midge appears to be producing these stress proteins while its cells continue to function normally.

“It tends to be you’re either in a stress mode and trying to survive or it’s business as usual,” Lee said. “It was remarkable to find that these stress proteins were being produced at the same time that normal growth, feeding and developing were occurring.”

Only a few animals demonstrate this ability, and Lee said all of them, including a fish and a protozoan, live in the Antarctic. Lee said he wants to try to discover why that is the case – is living in the Antarctic so constantly hard on the system that some animals require these proteins all of the time, or is it that they are exposed to intermittent periods of extreme conditions and so they have to be prepared?

It takes two years of growing and feeding for the midges to complete their metamorphosis to adulthood. They have a spotty distribution on the Antarctic Peninsula and can be located in a variety of microhabitats. Lee’s group has found them in conjunction with algae, penguin guano and an Antarctic grass.

“They really get into a lot of different habitats,” Lee said. “It suggests that maybe generalists do better in really rigorous, living-at-the-edge environments.”

After the midges make it to adulthood, the payoff is short-lived, as they only have seven to 10 days to mate and lay eggs before they die.

Belgica antarctica is part of the *Chironomidae* family, a group of insects well known for its stamina. *Polypedilum vanderplanki*, another member of this family, is found in African deserts and can lose 99 percent of it body mass to dehydration and live to tell the tale.

Unlike many other chironomids, which fly briefly during their life cycle, the Antarctic midge remains wingless.

Wings are certainly an important trait of flies, but Lee said the rest of a midge’s anatomy keeps it firmly in the fly category. And since its relatives have wings, the Antarctic midge probably had them at some point and lost them secondarily.

“It’s very expensive to support flight muscles and wings, and without them they can use that energy for growth and reproduction instead,” Lee said. “If you take a look at many insects that live on islands, mountaintops or places where it’s very windy, there’s strong natural selection against flight. We often see a reduction in flight muscles and a shortening of wings – a tendency toward flightlessness. In this case, it went as far as to completely do away with the wings.”

Lee said he hopes that the unassuming midge may allow us to learn more about how it can be so tough, specifically when it comes to the freezing of its tissue. There are only a few animals that can withstand freezing without sustaining damage, and most of them have that ability to a much lesser degree than the midge.

“If we study freeze-tolerant models,” Lee said, “they may give us some clues … as to how we might cryopreserve human tissues and organs.”

NSF-funded research in this story: Rick Lee, Miami University, www.units.muohio.edu/cryolab/education/antarctic.htm.