Unique gene regulation gives chilly bugs survival advantage at bottom of the world

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The larvae of Antarctic midges never stop producing special proteins that minimize environmental stress, allowing them to withstand a range of intense environmental conditions in one of the world's harshest environments.

Scientists found that adult midges (Belgica antarctica) lose their ability to continually express these protective heat-shock proteins. Instead, like most animals, adult midges produce these proteins only when they are stressed. The discovery currently appears in the online edition of the *Proceedings of the National Academy of Sciences*.

The proteins help defend the larval midges against environmental stresses including temperature changes as well as changes in water, oxygen and pH levels, said David Denlinger, the study's lead author and a professor of entomology at Ohio State University.

"They've somehow figured out a way to maintain a level of these heat-shock, or stress, proteins and still make proteins that are vital for growth and development," he said.

This mechanism seems to offer the larvae protection during their two-year life span, most of which is spent encased in ice.

All animals, including humans, make heat shock proteins, but normally they only do so during times of extreme physical stress. Curiously, adult midges don't express these proteins all the time – only during periods of

extreme environmental stress. Yet when most insects express stress proteins, it temporarily compromises the production of other proteins, Denlinger said.

"The production of stress proteins usually brings development to a halt," he said. "But in this case, the larvae merrily go about their business of feeding and growing while producing their stress proteins."

The Antarctic midge is barely bigger than a grain of rice, but it's still the largest free-roaming terrestrial animal to inhabit Antarctica. The larvae resemble tiny black worms.

"It's the largest species that has adapted to living on the continent year-round," said Denlinger, adding that other native animals, such as seals and penguins, spend much of their time in the water. The midge is also the only insect known to inhabit Antarctica.

He and his colleagues collected adult and larval midges during field study tours to Antarctica in early 2005 and 2006. They gathered insects from penguin colonies, where the midges feed on algae and waste material.

Penguins live along the Antarctic coast, where the average summertime temperature is around 36°F (2°C). In laboratory experiments, the researchers exposed the larvae and adults to 39.2°F (4°C) and to 68°F (20°C). They wanted to see if the larval and adult midges showed any resilience against the higher temperature.

Adult Antarctic midges usually live only a week or two in the field and, in the laboratory, the adults lived for five to six days at the lower temperature. But adult midges exposed to the higher temperature died in less than a day.

However, the larval midges lived up to four days at the higher temperature – four times longer than the adults.

"The adults were considerably less heat-tolerant than the larvae," Denlinger said. "The larval midges continuously express heat-shock proteins and are therefore prepared to respond to the normal kinds of challenges that they face in the harsh Antarctic environment. But the adults produce these proteins only when directly confronted with an environmental challenge.

"Clearly there is some kind of developmental switch that happens between the larval stage and adulthood," he added. "We're just not sure what that is."

He said that the next step is to study larval midges during the long Antarctic winter. While temperature may not play a large role during this time, as the larvae are encased in ice for months, many insects respond to seasonal changes in day length, which regulate their development. Understanding what happens to larvae during this time may give researchers more insight into the nature and role of heat-shock proteins.

Source: Ohio State University