Grasshoppers change coats to beat the heat

Many people head to southern California in search of a laid-back, sun-and-surf lifestyle. For insects, however, the living appears far from easy. To cope with the region's hot, dry conditions, grasshoppers in southern California develop special adaptations, biologists report in the Aug. 15 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

By studying one such trait – the ability to resist desiccation (drying) – the researchers have determined that populations of the lesser migratory grasshopper, *Melanoplus sanguinipes,* in different parts of California evolved varying abilities to withstand their local climates. "It tells us there's a lot of variation for a very important physiological trait previously thought to be fixed within a species," says study coauthor Timothy A. Mousseau, an evolutionary biologist at the University of South Carolina in Columbia.

With their relatively small size and large surface area, insects could dry out quite rapidly in hot, arid climates. But a thin, invisible, waxy coat over their hard outer skeleton protects against water loss – at least until the insect gets so warm that the lipids in the coating melt, says physiologist Allen Gibbs of the University of California, Davis, who directed the study.

He and his colleagues describe two types of adaptations by which *M. sanguinipes* can maintain its waterproofing even in harsh weather. In the short run, an individual grasshopper can acclimatize somewhat to its environment. In the long run, entire populations evolve to become better suited for their local conditions. This "implies they have genetic diversity so they could evolve fairly quickly," says Mousseau.

"It's evidence of evolutionary change that can occur within a species," comments George N. Somero, an environmental physiologist at the University of California, San Diego. "That's novel."

Both he and Gibbs' team speculate that such fine-scale tuning of the genetic makeup of populations within a single species may occur more often than scientists realize.

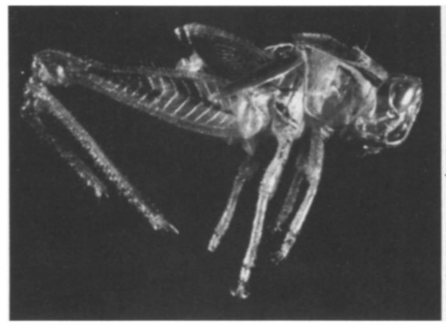
For their laboratory study, Gibbs and his co-workers established breeding colonies of lesser migratory grasshoppers gathered from 18 sites throughout California. They collected the eggs and raised the emerging young at one of three temperatures – 34°C, 32°C or 29°C – to simulate field conditions at collection sites. When the young grasshoppers molted, the researchers collected the shed "skins" and analyzed them.

Using a technique called Fourier-transform infrared spectroscopy, the team monitored changes in the physical properties of the lipids as the skins were gradually warmed.

The melting points of the lipids in the samples ranged from 39.1°C to 49.6°C, they found. Some lipids liquefied over a range of about 5°C, while others did so over a range of nearly 25°C. The lipids with the lower melting points tended to liquefy over wider temperature ranges and came from the offspring of the more northern grasshoppers.

The scientists found that all the insects could alter their lipid coats in response to new environmental conditions. However, the higher melting point of lipids in skins shed by the southern offspring "suggests that the grasshoppers can [also] adapt to their local environment in an evolutionary sense," says Gibbs.

Insects can moderate the effects of sunlight by hiding under a leaf, but in summer even the soil can reach 50°C in the hottest parts of California, the researchers note. Thus, they say, melting point could make a difference in a grasshopper's ability to survive.



Waterproofing lipids coat the molted skin of a lesser migratory grasshopper.

Other studies have focused on variations in body size or color within and among populations of a given species, but the grasshopper's lipid protection against desiccation "is a trait with important consequences for the fitness of the individual," says Mousseau.

"It's only been with recent technical developments that people have been able to delve into these properties, which are not easy to measure," he adds.

– E. Pennisi

Greenhouse snow: Melting the preconceptions

Scientists have a difficult time running controlled experiments on the climate, so they turn to computer models as surrogates. By tinkering with these mathematical replicas, researchers can gain insight into how the real climate works. Now, a study of 17 such computer models teaches that snow and global warming may interact in unexpected ways.

Researchers generally assume that decreases in total snow coverage would amplify a climate warming caused by greenhouse-gas pollution. According to the standard theory, a temperature increase would reduce the area of the globe covered by reflective, white snow, making Earth's surface darker. The newly uncovered areas would absorb more sunlight than before, heating up and thereby intensifying the greenhouse warming.

But a comparison of the world's best general circulation models suggests a more complex snow scenario, says Robert D. Cess of the State University of New York at Stony Brook. Cess led a group of 33 scientists from eight nations in a study addressing this question.

While most of the models behaved as theory would predict, some did not. In five out of 17, the reduction in snow cover elicited a negative feedback – a reaction that counteracted a small part of the greenhouse warming, the scientists report in the Aug. 23 SCIENCE.

The negative feedback arose because the retreat of the snow cover generated indirect effects. Some models showed that clouds increased over areas once covered by snow, helping to block out incoming solar radiation. In other instances, the snow loss caused Earth to emit more heat toward space – another factor that would work toward cooling the planet.

The indirect effects did not always weaken global warming. In some models, they strongly amplified the original temperature increase.

The newly found indirect effects, especially the greater heat release, caught researchers off guard. "I don't think anyone anticipated that," says Cess. Researchers now must assess whether such effects actually occur in the real world, he says.

Global circulation models contain mathematical equations that simulate how various aspects of the climate evolve over time. In global warming studies, scientists usually double the preindustrial level of carbon dioxide in the atmosphere and then watch the computerized climate respond. The forecasts resulting from these simulations have varied widely: Some models show a modest warming of about 1.5°C; others predict a temperature rise more than three times greater. These inconsistencies have fueled political debate over the seriousness of global warming.

A study led by Cess in 1989 indicated that clouds deserve most of the blame for the divergence among forecasts (SN: 8/12/89, p.106). Climate modelers readily acknowledge that the present generation of models does not do a good job of simulating cloud behavior. The latest comparison now suggests that the issue of snow cover also drives some of the disagreement among models, albeit to a lesser degree than clouds.

– R. Monastersky