Life in a snowbank

Researchers find that algae is only one of many inhabitants of snowbanks

by Richard Gilluly

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Snowbanks in Colorado: Host to a highly developed and complex ecosystem.

A snowbank high in the Colorado Rockies might appear to be a fairly sterile environment. The fact is, however, that mountain snowbanks, under the right conditions, are highly developed and complex ecosystems (SN: 5/30, p. 432) containing a large variety of life forms.

Travelers to high mountain areas have long noted that in the summertime, snowbanks are of various hues, some red, some green and some yellow. That the color is imparted by algae has been known for a long time, too, but it was not generally realized that the algae are by no means the only inhabitants of the snowbanks. Protozoa, bacteria, fungi, rotifers and nematodes are also members of the system.

Researchers from various universities in Canada and the United States in recent years have studied snowbank ecosystems under grants from various Federal agencies, including the National Aeronautics and Space Administration and the Public Health Service. Their work, which has been centered at the Institute of Arctic and Alpine Research at the University of Colorado, has revealed complex interrelationships in the flow of energy and materials between the varied life forms in snowbanks in the Rockies 25 miles west of Boulder, Colo.

Most of the life forms in the snowbanks have relatives that live in more familiar and temperate environments. The snowbank organisms are specially adapted for the low temperatures, and thus are called cryophiles (or psychrophiles). Temperature conditions in the snowbank ecosystems are such that the organisms live at almost exactly 32 degrees F., says Dr. Clifford Amundsen, University of Tennessee ecologist who participated in the studies.

If the temperature were any lower, the organisms could not survive except inactively in spore form. Because sunlight striking a snowbank causes melting of snow, rather than an increase in the water temperature of already melted snow, the water on the surface of snow granules is always at 32 degrees. "The organisms live on films of water on the melting crystals," explains Dr. Amundsen.

Such conditions of slow melting are available for the organisms only in the summertime—and life in a snowbank begins to proliferate in mid-June, usually about three days after the last night freeze.

Snow that is melting too fast is unsuitable for the organisms. The most hospitable snow for them is of the very dense, packed and granulated type, which has a specific gravity of about 0.7, compared with new snow's density of 0.1.

Nutrients for growth of the organisms come from many sources. The algae are the primary producers of the snowbank ecosystem providing carbohydrates from photosynthesis. Other nutrients are minerals from the snow itself or from the underlying substrate and organic materials from detritus blown into the snowbank. Oxygen is dissolved in the water.

Once the ecosystem is in operation, a food chain is established: Algae produce nutrients by photosynthesis. Protozoa eat the algae. Bacteria and fungi decompose the protozoa and once again release organic nutrients. Dr. Amundsen says the types of algae found in snowbanks probably are incapable of fixing nitrogen, and that this vital nutrient is supplied either from organic materials or is fixed from the air by lightning. Snowbank algae will not grow in a culture without vitamins and it is speculated that these are provided in the snowbank from the bacterial decomposition of other organisms.

The researchers collected samples from the snowbanks and returned them to a growth chamber kept at the same temperature as the natural snowbanks. Lighting provided a simulated day and night cycle. All samples were observed under the microscope immediately after collection and periodically afterwards. The microscope was fitted with a stage cooled by carbon dioxide so observations could be made under conditions as near as possible to those in nature.

Amundsen

Amundsen: Organisms live on films of water on the melting crystals.

"The observations showed us that the algae don't move on their own, but are passive," says Dr. Amundsen. "They move as the water moves them. But the protozoa move around gobbling up the algae."

There are several types of snowbank ecosystems. The amount of sunlight reaching them is possibly the variable which determines the type, although there may be other factors involved. Snowbanks near or below the timberline, which are mostly shaded, are populated mainly by green algae and are colored green. The banks above the timberline, which are exposed to sunlight for long periods during the day, are dominated by red algae. In between the two are yellow and orange varieties.

One theory is that the red pigments are designed to protect the algae from direct sunlight. Another is that more nitrogen is available from detritus below the timberline and that the red pigment is somehow related to low levels of nitrogen in the higher snowbanks. But the fact that the green algae are found growing eight to ten inches below the exposed surface of snowbanks indicated that sunlight may be the key factor, says Dr. Amundsen.

The four or five species of protozoa in the snowbank systems apparently vary in numbers according to the type of algae present. The red and orange algae are encased in a tough coat that discourages the protozoa, and these tiny animals find the softer green algae far more appetizing. But, the protozoa, according to Dr. Robert Pollock of the University of North Dakota, do not rely absolutely on algae; they also eat bacteria. Protozoa are in far fewer numbers than algae: a milliliter of melted snow contains about 100 protozoan cells but several tens of thousands of algal cells.

Although the bacteria and algae make up the decomposer class of the snowbank ecosystem, there are parasitic as well as symbiotic relationships, with the fungi sometimes subsisting directly off the living algae. "But despite this sometimes parasitic relationship, there are many algae without parasitic fungi, and the algae probably need the fungi to provide breakdown products," says Dr. Amundsen.

As in any other ecosystem, the flow of matter in the snowbank system is cyclical, in this case in a simple food chain. But energy is lost to the environment in the form of heat at each level of the food chain, and it therefore must be replenished by the sun.

Despite the complexity of snowbank ecosystems, they are far simpler than most other ecosystems. This relative simplicity makes the snowbank systems easier to study. The results of the studies can provide clues about more complex environments. □