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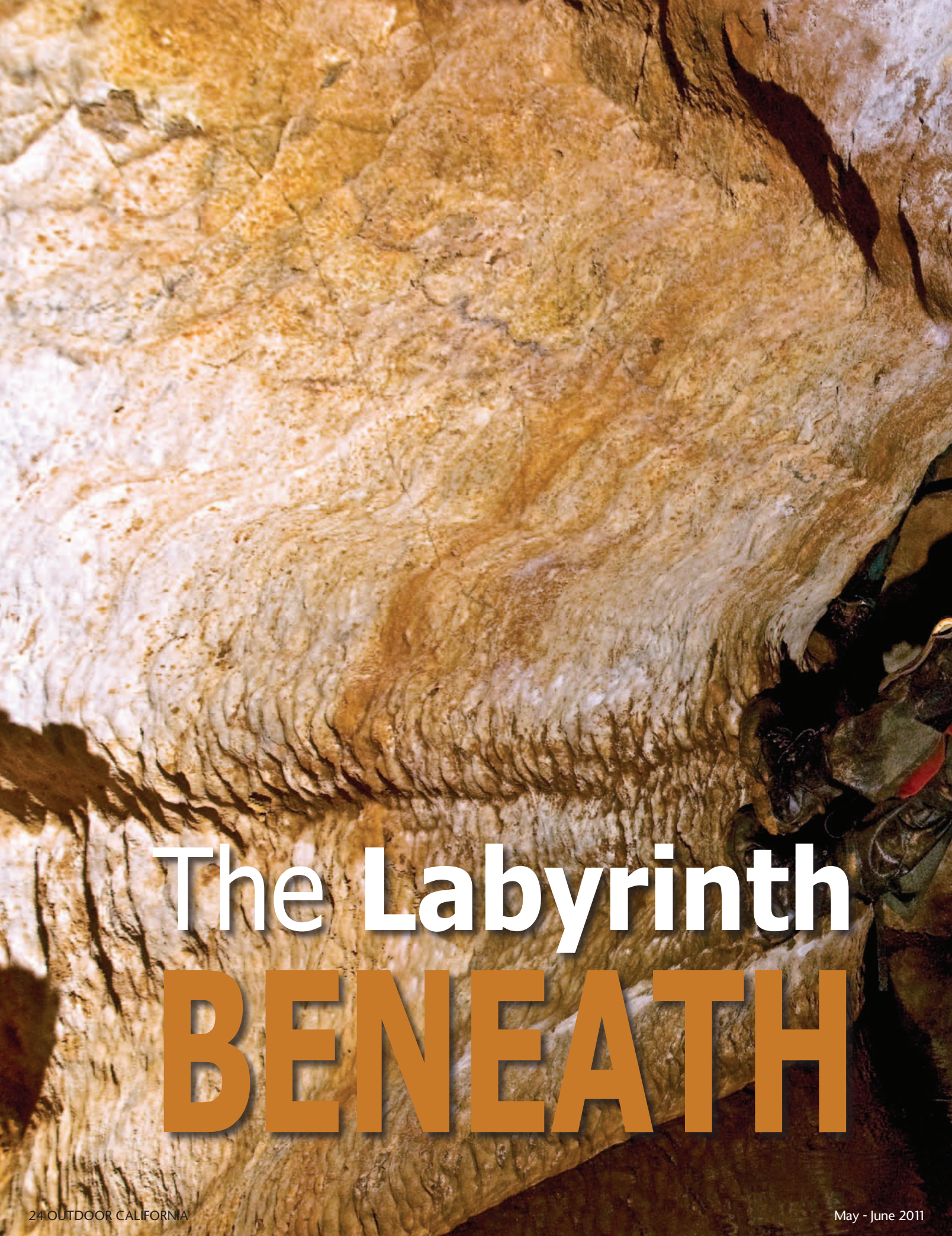
The Labyrinth BENEATH

California's Caves



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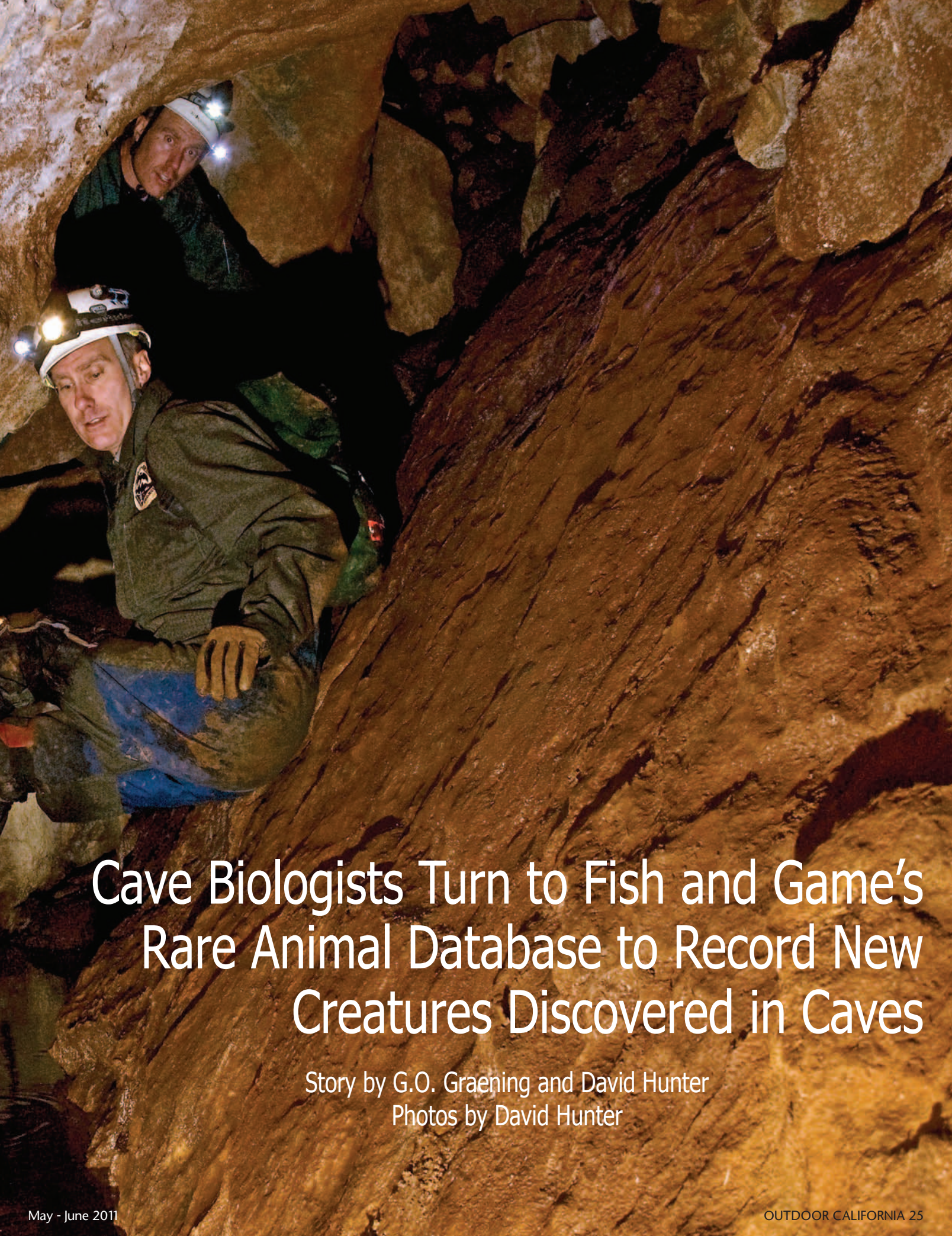


Cave Biologists Turn to Fish and Game's Rare Animal Database to Record New Creatures Discovered in Caves

Story by G.O. Graening and David Hunter
Photos by David Hunter

Natural underground spaces that are at least big enough to allow a human to enter remain one of Earth's last frontiers. Within California's 159,000 square miles are found nearly every variety of cave categorized by scientists—classic fissures formed in limestone and marble, sea caves formed by wave action, lava tubes from volcanic eruptions, alpine caves found above 10,000 feet, mud caves and bedrock crevice caves. Only the formation of a glacier cave, for obvious reasons, escapes the state's all-inclusive habitat.

Broaden the definition to include the thousands of mines and other manufactured chambers that lead under the surface and it's easy to see how at least one major cave or mine exists in every county in California. The National Speleological Society, the leading cave science organization in the world, ranks California as 15th in the nation for most caves. And what lies under the surface is even more interesting.

Inside the scores of underground openings within California rests a fantastic assemblage of animal life found nowhere else in the world, according to Dr. David Culver, an expert in the biology of subterranean animals.

"It is very likely that only a small fraction of the invertebrates specialized for living in California caves have been found, let alone described, and the state has the potential to be a hotspot of subterranean biodiversity," Culver says.

The unique characteristics of subterranean habitats—total darkness, high humidity, the absence of plant-based nutrient sources—present special challenges to anything living there. Animals that have persisted underground have developed bizarre and amazing adaptations. Some of these changes include elongated legs and antennae, flattened bodies, heightened senses of smell and hearing, loss of pigment and eyesight or the addition of sensory hairs along the entire body. Some of the most cave-adapted animals, called "troglobionts," have developed sluggish metabolic rates to survive the nutrient-poor environment of caves.

While the role of the Department of Fish and Game in this dark, uninviting world may appear small, it is, in fact, critical for researchers to effectively understand what lies beneath the surface.

The California Natural Diversity Database (CNDDB) has been available for more than three decades and serves as a repository of rare species information maintained by DFG's Habitat Conservation Branch. The program's primary function is to gather and disseminate data on the status and locations of rare and endangered animals, plants and vegetation types. The goal of the program is to help conserve California's biological diversity by providing government agencies, the private sector and conservation groups with information to promote better-informed land-use decisions and improved resource management. It is one of the largest and most complete information warehouses of biological records in the nation. While the database carries information on hundreds of thousands of birds, mammals and fishes, only a few hundred records exits of invertebrates living underground.

Darlene McGriff retired as the lead zoologist for the CNDDB. She explains because of the specialized nature of the collection process, DFG relies on researchers with other groups or partners to submit information for the database.

"The staff working on the database doesn't do any field work," McGriff says. "We depend on the researchers who are in the field to provide us with the data we need."

Once underground animals are identified, the cave team transfers all the cave records to DFG where it's entered to the CNDDB.

One of the beneficiaries of such information is Joel Despain, a cave specialist with Sequoia and Kings Canyon National Parks.

"We really need this information to manage and protect caves that are inside National Parks and their numerous inhabitants," Despain explains. "Trying to manage a cave without knowing what lives there is like trying to manage a library without knowing what books are on the shelves. What this work provides us with is basic but crucial information."

State and federal parks take seriously the care of the habitat. When caves exist within the habitat, park managers and staff protect the species that live inside, from the bats down to the smallest flatworm.

"But species like invertebrates had limited information on what kind of biodiversity we were protecting until the last 10 years," Despain says. "That's when,

Author G.O. Graening and his brother, Guy Graening, (previous pages) navigate a water-filled passage as they search for rare cave species near Volcano in Amador County. Sometimes the entrance to a subterranean habitat requires a shift in methods (this page), as the author finds when fellow cavers help him squeeze into a site near Pinnacles National Monument. With the use of a mechanical pencil, a caver collects an unknown species of millipede (upper right) for later identification. A cave-dwelling spider (right center), in the family Nesticidae, waits on an overhang for its unsuspecting prey. A signature of these types of spiders is the long string-like webs they make to snare flies. And this 6-millimeter-long harvestman (lower right) is a cave-adapted relative of the common daddy longlegs and is found only underground in Sequoia National Park.

through a funded study, we really looked and discovered around 30 new species of invertebrates within our cave system."

The study of cave life in California began in the late 1800s when unique spiders and other arachnids were found by researchers who were studying fossils. Discoveries of new cave-adapted species occurred sporadically for the next few decades but it was in the 1960s that the number of cave studies increased. That increase grew out of the popularity of sports caving.

The largest cave study in California developed as a result of the anticipated damming of the Stanislaus River in the Angels Camp area. Those who were involved in the research say the site uncovered cave invertebrates never before seen. Several species that were threatened by the construction were transplanted to an abandoned mine. Since then, the discovery of new species of cave-adapted animals in California has continued at an exponential rate.

Scientists searching for minute creatures say once inside a cavern, a variety of inventory procedures begin. Collection techniques vary—from turning rocks over by hand to operating an aspirator device to suck up smaller creatures. Others arrange elaborate pitfall traps with specialized bait that lure insects into a collection bottle where they are preserved in nontoxic antifreeze.

After exiting the cave, team members carefully transfer the collected specimens to laboratory vials and begin the laborious task of identification. Taxonomic specialists are brought in to help name the strange creatures. Again, techniques range from the traditional taxonomic exercises, such as counting hairs on the leg of a beetle under a dissecting scope, to analyzing the DNA of whole insects using gene amplification and sequencing machines in a genetics lab.

Some arachnids are even powdered with metal dust and then bombarded with electrons to produce high definition imagery of their exoskeletons using a scanning electron microscope. After identification and designation of each invertebrate with its Latin name, the specimens are preserved, bottled, labeled and deposited at the California Academy of Sciences' museum collection in San Francisco. The museum's reputation indicates it holds one of the best collections of cave invertebrates.

Scientists enter all the field data to an encrypted database. The records are plotted on digital maps using high-tech software. From there, researchers can conduct computerized exploration of larger spatial patterns that might not be obvious from the perspective of a single cave map or comparing checklists of animals by cave names.

One of the first patterns that emerged when scientists analyzed the early data was how rich California was in cave-adapted animals. The finding refuted the popular belief that cave-rich states existed only in the eastern half of the nation. California carries more than 120 animal species that are found only underground. In fact, since 1950, researchers say two new species are discovered each year.

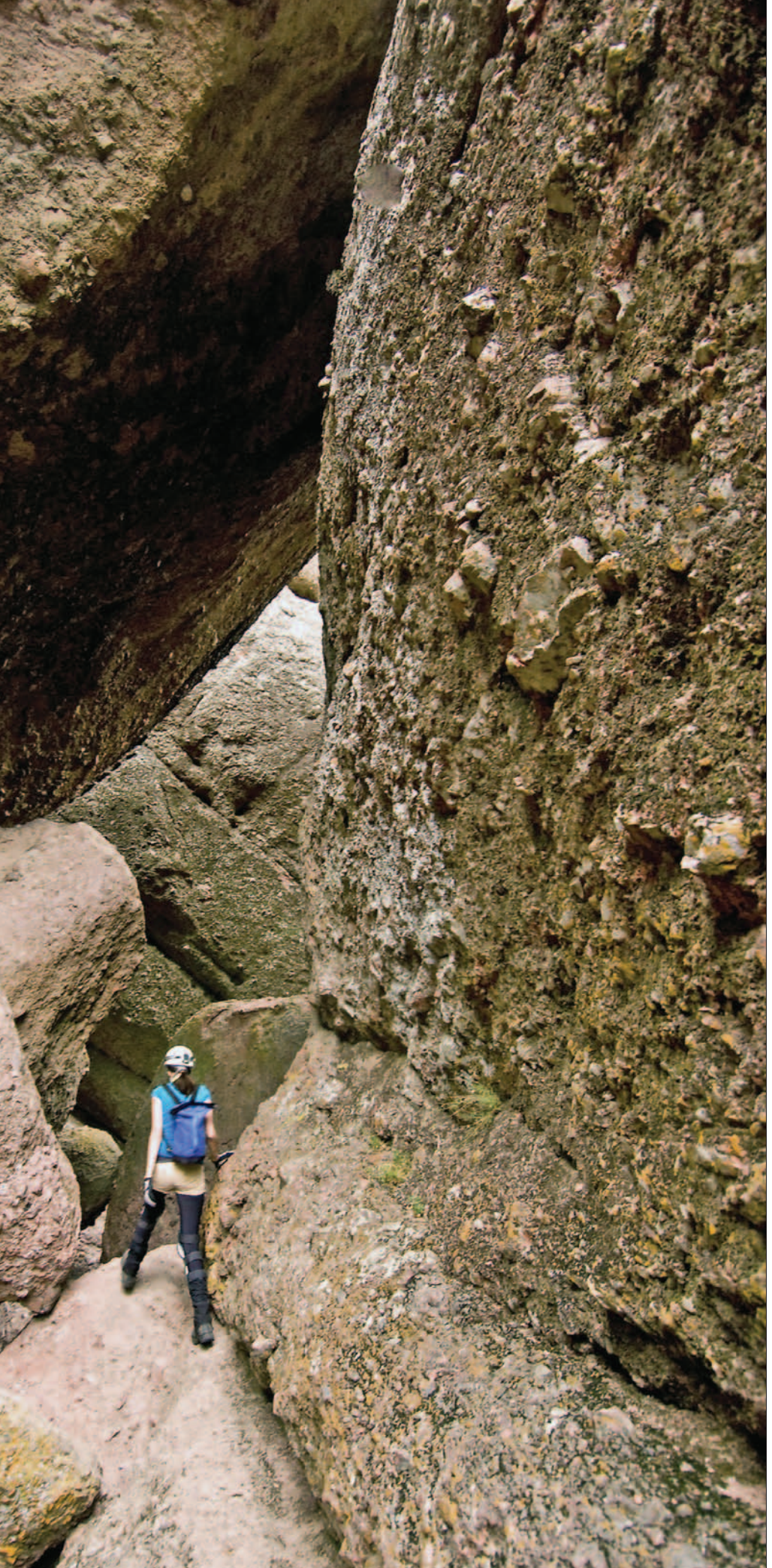
A pale and eyeless scorpion (*Uroctonus grahami*) is just one of the 45 cave-adapted arachnids found deep in California caves. There is also a cave-adapted centipede and 15 millipedes, three beetles, one silverfish, 27 crustaceans and three flatworms.

Another pattern that emerged indicated the cave regions of California were like islands, isolated from each other and the rest of the world. Cave regions in California are surrounded by lands free from caves; lands that are too hot and dry for cave animals. Such isolation serves as a breeding ground for the evolution of new species. Scientists speculate that given enough time each population of a colonizing animal could turn into a unique species in each cave. Indeed, more than half of California's cave-adapted species are known from a single cave each.

Interestingly, other cave animals are found in almost every cave region in the state. Isopods, cousins of the "roly-poly" or pill bug, are a good example. One species, Brackenridgia heroldi, is found in caves of the Sequoia and Kings Canyon national parks, in caves of the gold country of Amador and Calaveras counties and in caves in Santa Cruz. This isopod, which requires high humidity for survival, expires in sunshine. It's unlikely it colonized caves by scurrying about between cave regions. Instead, scientists believe it may have been a surface dweller throughout the area now known as California during the ice age when the surface environment was moist and cool. Later, scientists speculate, when glaciers retreated the climate changed and this isopod was forced underground into caves to escape the hot and dry environment above.

Some animals, like certain snails, are mistaken as cave-adapted. They gravitate to the calcium minerals that limestone and marble provides and use it to build their shells. Shoulderband snails, for example, are often found in or near caves and are classified as "calciphiles,"

Bear Gulch Cave, part of Pinnacles National Monument, serves as a spectacular example of a talus cave, where gigantic piles of boulders form cavities below.



meaning calcium-lovers. Other strange animals aren't really adapted to caves but instead to aquifers—the water that collects underground in the bedrock. These animals are called "stygobionts," after the mythical River Styx. There are several species of crustaceans and flatworms that live in this deep, dark and inhospitable groundwater.

Cave research has pushed the bounds of medical research as well. Medical researchers hoping to cure blindness study sightless cave animals because some are genetically-programmed to have degenerative eyeballs. The research hopes to link that discovery with helping people with degenerative retinas. Furthermore, each rare animal and plant is a chemical storehouse of new organic compounds, something that may form part of a new drug.

Caves also hold ancient bacteria, which helps microbiologists and cosmologists study the origins of life on Earth and look for life on other planets. Humans depend upon groundwater and stygobionts are sensitive to changes in the quality of this resource. The presence or absence of these groundwater-adapted animals can tell water resource managers about the health of the aquifers and connectivity between water basins.

Finally, there is the simple argument that these cave animals are unique to California and are part of the state's natural heritage and worthy of more study.

Many of California's caves are protected under public ownership; most are found within national parks and forests. Often, the most sensitive caves are guarded with gates and alarm systems. Private land owners can restrict entry or may simply keep a cave location secret. Elsewhere, some privately owned caves offer tours under colored lighting and along concrete paths. Modifying caves this way serves little benefit to the cave inhabitants, but it does allow the public to go underground without having to crawl through mud to learn about cave ecosystems.

G.O. Graening is a conservation biologist and an environmental consultant who teaches at California State University, Sacramento. He began studying cave life in 1999 and earned his Ph.D. studying cave foodwebs and cavefish.

David Hunter is a photojournalist and an elementary school teacher in Fresno. His story and photographs on the vernal pools of Big Table Mountain Ecological Reserve appeared in the March-April 2010 issue of Outdoor California.