Skaters on the

Scripps Biologist Pursues Elusive Marine Insect

BY JANET HOWARD

Facing page, A sea skater, genus *Halobates* (enlarged).
Above, Marine entomologist Lanna Cheng scoops sea skaters from the water's surface at Grand Cayman Island.

Sea

As a young girl growing up in Singapore, the last thing Lanna Cheng dreamed of was a career studying bugs. The daughter of a public-school headmaster and a gynecologist, Cheng instead pictured herself becoming a scholar of Chinese linguistics.

A scholarship that offered her an opportunity to major in science at the University of Singapore, however, changed all that. Searching for a project for her master's thesis, Cheng decided to study an intriguing group of insects called pond skaters, known for their ability to "walk on water."

The choice turned out to be a serendipitous one. After graduating from the University of Singapore, Cheng went to England on a Commonwealth Fellowship and received a Ph.D. in insect population ecology from Oxford University in 1969. During a trip to Israel to attend a scientific meeting, Cheng met Scripps marine biologist Ralph Lewin. Two years later the couple married, and Cheng found herself in the peculiar position of being an entomologist surrounded by oceanographers.

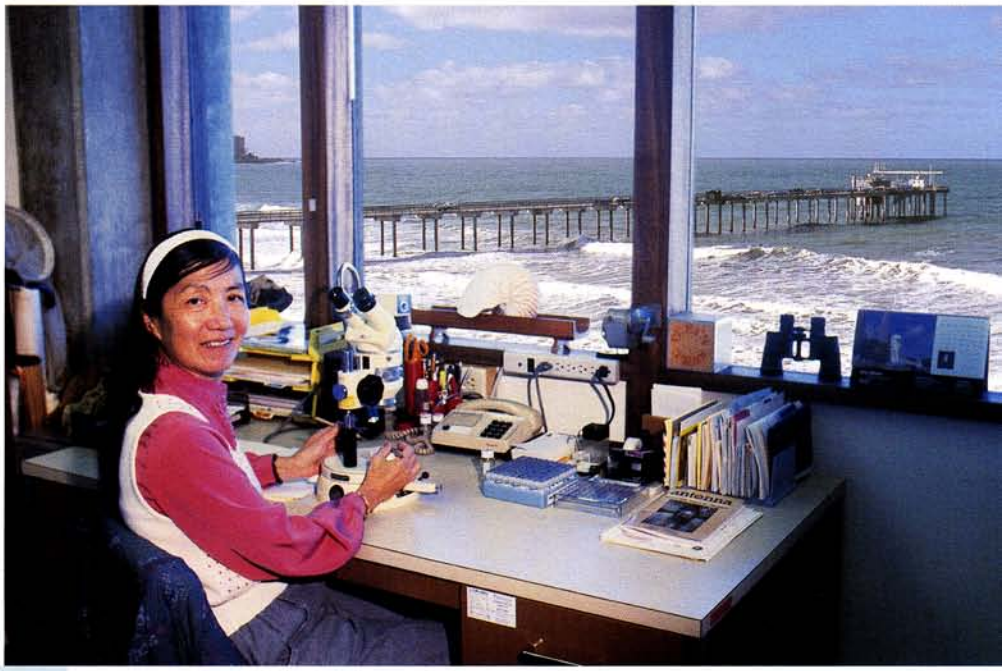
"I remember thinking, 'What am I going to do here?'" said Cheng, relaxing in her office overlooking Scripps Pier. "Then I remembered my master's research days working with a group of insects that live on water—including the sea."

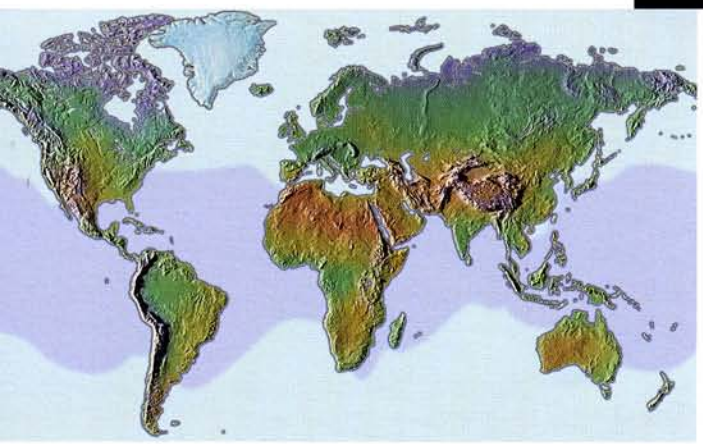
While few entomologists at the time had heard of marine insects, even fewer oceanographers were aware of the existence of such creatures living on the open ocean. Cheng quickly set up shop at Scripps and began what would become a lifelong career studying the tiny, wingless insects called *Halobates*, or sea skaters.

Cheng was in a unique position to study these and other marine insects, which until then had been largely neglected by scientists. She soon realized that there are at least a few thousand species belonging to many different orders and living in various marine environments. She decided to bring all the scattered information together in one book, *Marine Insects*, which she edited and published in 1976. It remains the only reference work on the subject.

Today, Cheng, a research biologist at Scripps, is one of only a few marine entomologists in the world. After almost 30 years of studying sea skaters, she still marvels at their ability to survive on the open ocean.

"Just think about this tiny thing living way out there on the open ocean..."





Above, Cheng in her office overlooking Scripps Pier. She has devoted her career to the study of marine insects such as the sea skater. **Left,** The global oceanic range of *Halobates* is shown by the shaded areas of the map.

"They are only about one-half a centimeter (about two hundredths of an inch) in body length. Just think about this tiny thing living way out there on the open ocean and having to cope with tropical sunshine, storms, rain, and heavy seas. How do they do it?" she asked.

Halobates was first described by Estonian naturalist Johann Friedrich Eschscholtz, who discovered the insect in 1822 while on a cruise around the world. There are now some 44 known species of *Halobates*. One Australian species, *Halobates lannae*, was named for Cheng. While the majority of species live on coastal waters, Cheng has dedicated most of her time to studying the five species that live on the open sea, the only insects known to live there.

Perhaps the most intriguing thing about *Halobates* is how they manage to walk or skate across the surface of the ocean. The secret lies in the tiny water-repellent hairs on their legs and feet that allow them to "tiptoe" across the surface of the water. These hairs help to spread the insects' weight over a larger surface area, preventing them

Above and bottom, Cheng (pictured above and below) and colleagues developed special nets and techniques to collect the tiny and fragile marine insects they study.

from sinking. They also provide better contact with the thin film that coats the ocean surface.

"It's actually the surface tension of the sea-air interface that allows them to stand on the water," Cheng explained. "As long as the surface tension is maintained, they are able to move normally. But if the surface tension is lowered by pollutants such as detergents, they just flop on the surface and eventually sink."

Tiny, hook-shaped hairs also cover the sea skaters' velvety bodies. Only about 1.5 microns in length (a micron is one millionth of a meter), these hairs trap a layer of air against the surface of the insects' bodies, making them buoyant.

"Their bodies are basically enclosed in an air bubble, so if they are pushed down under the water, they just pop up again," said Cheng.

When an animal is caught in rough seas and trapped beneath the surface for short periods, this air bubble provides the sea skater with enough oxygen to survive.

"They have an arrangement we call a mechanical gill," said Cheng. "When the oxygen content becomes low inside the air bubble, more diffuses in from the surrounding seawater and provides the insect with enough oxygen to breathe."

In order to demonstrate this, Cheng conducted a simple experiment during a 1973 cruise aboard R/V *Thomas Washington*, in which she kept a number of *Halobates* submerged in sea water for up to 16 hours.

"When I released them, they bobbed back up to the surface and seemed quite happy," she said. "But if I boiled the water first, so that there was no oxygen in it, cooled it, and then submerged the *Halobates*, they drowned in about 20 minutes because the air layer surrounding their bodies was depleted of oxygen."

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Above, Although some of these insects are found on the ocean's surface, a variety of insects also inhabit coastal mangrove swamps such as these in Palau.

Globe-trotting Couple
Shares Eclectic Interests

It doesn't take long for a visitor to Scripps scientists Lanna Cheng and Ralph Lewin's cozy La Jolla home to realize the inhabitants are not your run-of-the-mill neighbors.

Above the fireplace, for example, hangs what appears to be an unusual metal sculpture. In truth, however, it is a piece of melted aluminum the couple discovered on a beach on Enewetak Atoll—a site in the Northern Marshall Islands where the United States conducted nuclear tests between 1948 and 1956. (Cheng and Lewin are quick to assure guests that they had the piece tested to confirm it was not radioactive.)

Enewetak Atoll is only one of many exotic places the couple has visited in the name of science. They have floated down the Nile and collected research materials in Tonga and the Cook Islands. Indeed, a large map on a wall in their study is blanketed with pins marking spots around the world to which they have traveled. One of their latest expeditions was to Inner Mongolia to collect brine shrimp samples for a collaborative biotechnology project the two scientists are working on in China.

"We are trying to develop a system so that the Chinese scientists can use salt ponds to produce brine shrimp to feed mariculture organisms such as shrimps and crabs," Cheng said.

Even though Lewin studies algae and Cheng sea skaters, the two scientists often back each other up on field expeditions. They rarely have trouble communicating with the locals on foreign treks; between them, they speak several languages, including Esperanto—an international language based on common Latin roots.

Lewin, whose father was an Esperantist, learned the language while growing up in England. "It is a very easy language to learn," he said in a clipped British accent. "With a very fine pen, I wrote the grammar on the back of a postage stamp."

Cheng and Ralph Lewin in their backyard, holding a Palauan carving that depicts native subjects, including the sea skater (detail below).

While Lewin owes his penchant for Esperanto to his father, it is clearly his mother who set him on the road to becoming a poet.

"When we were kids, my mother used to give us birthday presents, and she would put a card on each with a four-line verse," he said. "So I started doing these verses and it just grew on from there."

Lewin has published several books of poetry to date, including *The Biology of Algae and Diverse Other Verses* and *The Biology of Women and Other Animals.*

Lewin is the first to admit his poems are somewhat eclectic. "I like to write about topics that generally aren't dealt with," he said. "I don't write about roses; I don't write about love; I don't write about sunsets. I'm much more likely to write about a toad smattered in the road."

Members of the San Diego Early Music Society, Cheng and Lewin enjoy concerts featuring Renaissance and Baroque music. They also have dabbled in music themselves and were members of a group that played at Renaissance fairs and informal gatherings. Perhaps their most notable performance, however, was in 1973, at the end of a cruise on which Cheng successfully captured her first live samples of sea skaters. As the couple piped out a tune on their recorders, scientists on board sang a madrigal (music by Thomas Campion) dedicated to the tiny bug:

"E'er the wily *Halobates*
Sees our spray, and skates away ...
The more we tow, the more we get.
Tow then swiftly o'er the foam
And fill our neuston net."

Sea skaters can skate as fast as one meter (about one yard) per second, but it is not known how far any given insect travels in its lifetime.

"Theoretically, there is nothing to stop them moving from one part of the ocean to another, but we really don't know how far they can go because we cannot mark them and then later recapture some of them," she said, laughing at the prospect of tracking such tiny insects across the oceans.

Another interesting characteristic of sea skaters is their ability to spend their entire lives on the open ocean without sustaining damage from exposure to ultraviolet radiation from the sun.

"We found that *Halobates* have something in their cuticle [external covering] that excludes about 99 percent of the ultraviolet radiation," she said. "If we could find out what it is, *Halobates* potentially could help us develop a 'super sunblock.'"

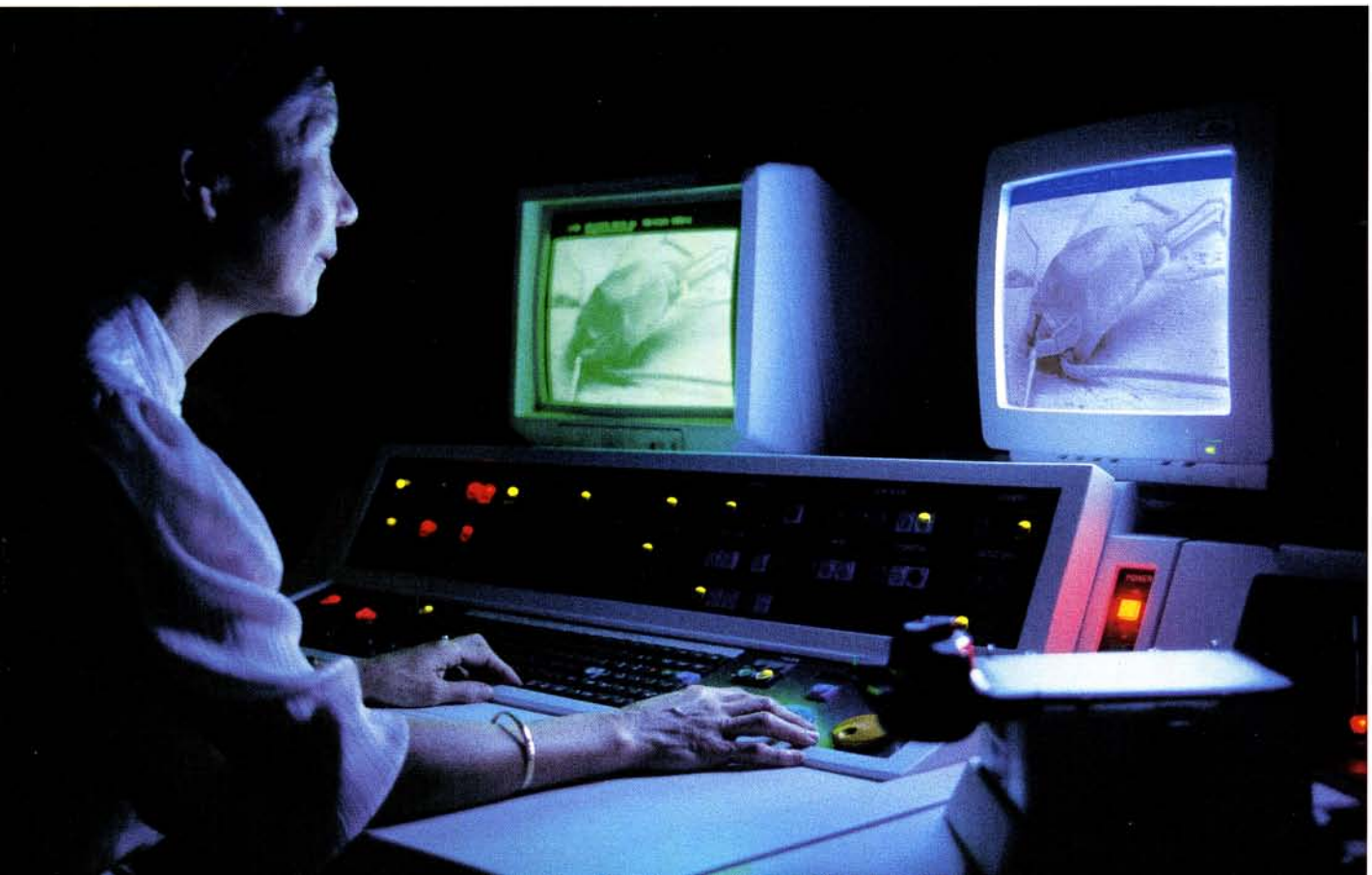
Cheng suspected that the insects' cuticle may contain melanin, the same substance found in human skin, to protect them from the sun. But analyses she conducted in conjunction with chemists at UC San Diego found no trace of melanin. The substance that protects sea skaters from UV radiation remains a mystery. Chemists would need a gram of cuticle material to conduct further tests. That's equivalent to at least 1,000 insect skins—more than Cheng is able to collect during any given cruise.

Indeed, collecting sea skaters has proved to be one of Cheng's greatest challenges.

"The best way to catch them is to hang a light off the side of the ship at night, because they are attracted to light," she said. "There were times I have seen the sea apparently boiling with these silvery creatures crowding at the surface under the light, and they were all *Halobates*. It was marvelous."

"Their bodies are basically enclosed in an air bubble..."

In order to collect the insects while the ship is under way, Cheng deploys a fine-meshed net called a manta net over the side of the ship. The net, which is towed for many miles, is suspended between two pontoons so that it is half in and half out of the water. It simply skims off the insects and other minute organisms that live on the ocean sur-



face. Because of the high cost of conducting oceanographic cruises, Cheng generally relies on colleagues around the world to send her samples of *Halobates* that they have collected while conducting other oceanographic research.

Sea skaters feed primarily on zooplankton trapped at the sea-air interface—including fish eggs, fish larvae, and small fishes—grasping their prey with their short front legs and sucking them dry.

"We don't know how they find their food, whether they 'smell' their prey from afar, detect them by the ripples as they struggle at the surface, or just wait until they bump into them," said Cheng.

Whether the young insect nymphs, whose bodies measure only about a millimeter in length (four hundredths of an inch), feed on the same prey as adults is not known. Cheng wonders whether they may also rely on nutrients from the rich organic surface film that coats the ocean.

A mature female can hold as many as 25 to 30 eggs in her body cavity. While members of coastal species deposit their eggs on fixed substrates such as tree trunks or rocks, the open-ocean species lay eggs on just about anything that floats, including empty seashells, wood, feathers, and even lumps of tar.

Cheng is the first scientist to successfully keep open-ocean sea skaters alive in the laboratory, but she is still unable to rear them. She has also collected eggs at sea and transported them back to the lab, where they have hatched over a period of about a month. She has been unable to keep the hatchlings alive, however, for more than four or five days.

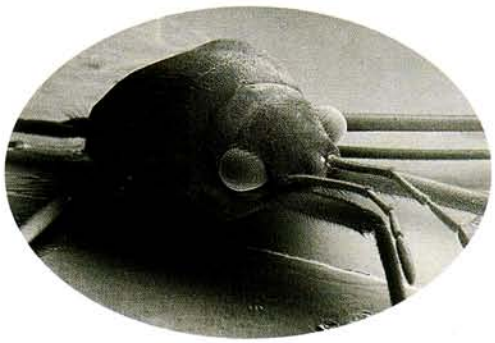
"I have tried everything I can think of to feed them, but they don't survive," she said. "As soon as the reserve from the egg is gone, they die."

Scientists are unsure how sea skaters locate mating partners, but Cheng suspects that they are initially brought together by surface winds and currents. Once they are within a meter or so of each other, they most likely rely on a pheromone or chemical attractant to signal one another, she said.

Despite years of work studying sea skaters, many things about these tiny insects remain a mystery. Cheng is in the process, for example, of using molecular biology techniques to determine where *Halobates* evolved and how closely the five species of open-ocean sea skaters are genetically related. While all five species are found in the Pacific, only two are found in the Indian Ocean and one in the Atlantic.

After nearly 30 years of study at Scripps, it is clear that Cheng has no plans for slowing down in her pursuit of knowledge about this unusual animal.

"We certainly have a lot more to learn about these unique and curious little creatures, which are the only insects to brave the rigors of the ever-changing oceans," she said.



Facing page, Cheng at the controls of the scanning electron microscope in the Scripps Analytical Facility (see story p.13). **Right and above,** Images of *Halobates* are magnified 26 times and 75 times actual size.