COMMENTARY

The Mass Extinction of Scientists Who Study Species[1]

Craig McClain[2]

We are currently in a biodiversity crisis. A quarter of all mammals face extinction, and 90% of the largest ocean fish are gone. Species are going extinct at rates equaled only five times in the history of life. But the biodiversity crisis we are currently encountering isn't just a loss of species, it's also a loss of knowledge regarding them. Scientists who classify, describe, and examine the relationships between organisms are themselves going extinct. The millions of dollars spent globally on technology to catalog species may actually be pushing out the people we rely upon: Taxonomists and systematists. We're like young children frantic to add new baseball cards to our collections, while the actual creators of the baseball cards themselves are vanishing.

Take, for example, the aplacophorans, a rare, rare group of invertebrates closely related to octopuses, squids, snails, and clams. Most of us will never see even one of the approximately 360 known species of small (less than a couple of inches long) aplacophorans that inhabit ocean depths greater than 50 feet — but ignorance of this group is not limited to the public. Fewer than two dozen scientific papers have been published on the group since 2005, even though many new species await discovery and description — and most of these studies were done by one scientist, the venerable Amélie Scheltema of Woods Hole Oceanographic Institute. As she edges closer to retirement, she may sadly become the last to study aplacophorans. If 50% of the species of aplacophoran went extinct tomorrow, we would never know.

Amelie's story is tragically common. Martin Sørensen of the Natural History Museum of Denmark is one of the very few active kinorhynch, or mud-dragon, taxonomists. Martin also represents one of only two living taxonomists who have studied gnathostomulids. The other, Wolfgang Sterrer, is retired. Both kinorhynchs and gnathostomulids are small, less than one-tenth of an inch in length, and dwell between grains of sand and mud on the ocean floor. Fewer than 300 species are described from both of these phyla — the broadest classification into which scientists group animals — and our knowledge of them is based almost entirely on collections from the well-explored eastern coast of the United States, the Mediterranean, and the western coast of Europe.

"Even within these areas, new species appear quite often, and when I collect outside [these areas], I always expect to find undescribed taxa exclusively," Sørensen wrote in a recent e-mail to me. His new work in the East China Sea has already uncovered 15 new species. Indeed, the morning he e-mailed me, Sørensen, looking through his microscope, had just discovered another new species. "The number of taxonomists working on these obscure taxa has always been rather low (which explains our limited knowledge about them), but within the last 20 years taxonomy as a discipline has come under even harder pressure which has resulted in a further decline in the number of experts," Sørensen wrote.

This problem plagues well-known groups, too. For example, nematodes represent more than 28,000 described species of freshwater, marine, terrestrial, and parasitic roundworms. On the seafloor, they account for 85–95% of all organisms. However, a new study found the number of scientific papers describing new nematode species is half of what it was

LAURIE J. VITT

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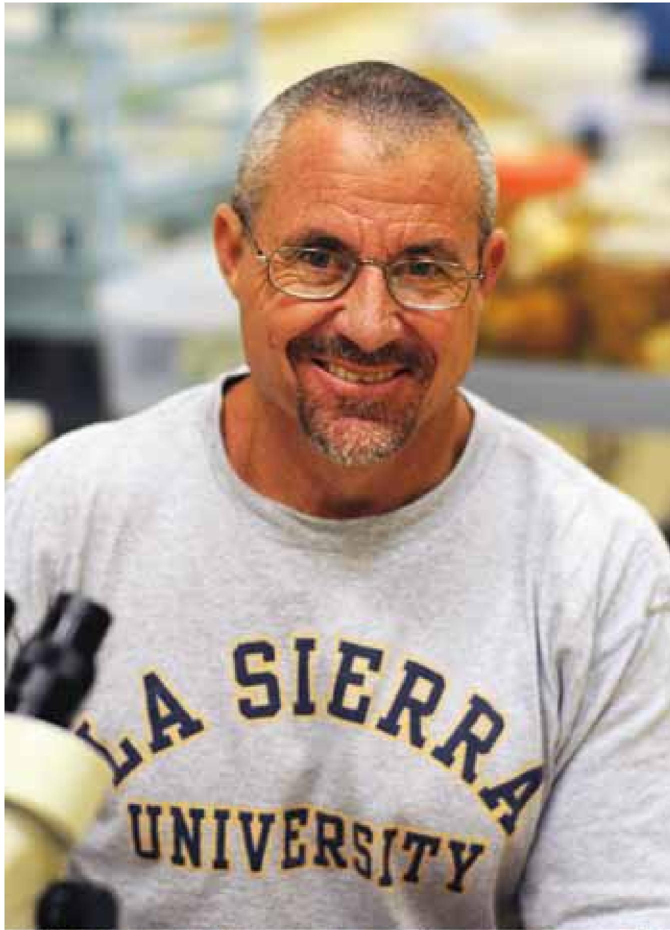
The dearth of taxonomists and systematists is not as dire for terrestrial vertebrates as for invertebrates. Nevertheless, ongoing new discoveries of mammals, birds, reptiles, and amphibians previously unknown to science provide ample evidence that we might be undermining our efforts to protect biodiversity by not supporting efforts that encourage young scientists to learn and implement the skills necessary to generate essential knowledge of life's diversity before it disappears. This and the following images feature four U.S.-based scientists actively involved in the taxonomy and systematics of amphibians and reptiles. Janalee P. Caldwell, of the Sam Noble Oklahoma Museum of Natural History and Department of Zoology, University of Oklahoma, in a field camp in Brazil. Amazonia and the Neotropics in general harbor a plethora of undescribed species. Caldwell described the dendrobatid *Hyloxalus chlorocraspedus* in 2005. Males serve as the parental frog, carrying as many as ten tadpoles on their backs before releasing them into small forest pools shortly before metamorphosis.

[1] Adapted with permission from <www.wired.com/wiredscience/2011/01/extinction-of-taxonomists/> (posted 19 January 2011).

[2] Craig McClain is assistant director of science for the National Evolutionary Synthesis Center and has conducted deep-sea research for 13 years, participating in dozens of expeditions in the most remote regions of the Pacific and Atlantic oceans. McClain focuses on the ecological and evolutionary drivers of marine-invertebrate biodiversity and body size, mostly in deep-sea systems. He often explores the consequences of food limitation on biological systems. McClain is also the chief editor of the award-winning science blog, Deep-Sea News.

a decade ago, and a third of the decade before that. Anywhere between 10,000 and 100,000 species remain undescribed.

Why the loss of taxonomists? We have devalued their contributions, both monetarily and scientifically. Some attribute the decline of these researchers to the replacement of outdated methods that would not meet the scrutiny of science today. These critics envision taxonomists as lone



L. LEE GRISMER

L. Lee Grismer, of La Sierra University in Riverside, California, in collaboration with his son and a number of national scientists, has described over 70 new species in the past six years, all from southeastern Asia and many of those from the Malay Archipelago. The aptly named *Cnemaspis psychedelica* is an insular endemic known to occur on only one of 92 poorly explored Vietnamese islands that are beginning to show a surprising degree of endemism and diversity. This discovery clearly suggests that, despite recent work, the herpetofaunal diversity of the region is barely known.

LUKE WELTON

RAFE BROWN

JOSEPH BROWN

Rafe Brown (top right), of the Natural History Museum and Biodiversity Institute, University of Kansas, with graduate students in the Philippines. *Hylarana* (formerly *Rana*) *tipanan* (center) was described by Brown and colleagues in 2000; when its IUCN Red List status was assessed in 2004, the species was determined to be Vulnerable due to a highly fragmented distribution attributable largely to a continuing decline in the extent and quality of its forest habitat on Luzon in the Philippines. The discovery of a 2-m-long lizard (bottom) in the forests of the Philippines speaks clearly to the lack of current knowledge of the archipelago's biodiversity, even as its forests are declining at an alarming rate. *Varanus bitatawa* is one of only three known species of frugivorous (fruit-eating) monitor lizards in the world. E.O. Wilson (1992. *The Diversity of Life*. W.W. Norton & Co., Inc., New York) asked: "Will it ever be possible to assess the ongoing loss of biodiversity? I cannot imagine a scientific problem of greater immediate importance for humanity. Biologists find it difficult to come up with even an approximate estimate of the hemorrhaging because we know so little about diversity in the first place. … we do not know the vast majority of species of organisms well; we have yet to anoint so many as 90 percent of them with scientific names."

museum scientists surrounded by dusty wood cabinets and bottles of formaldehyde where species description is more art than science — but this portrayal overlooks the suite of modern genetic methods that those interested in discovery and description of new species use with increasing frequency.

JESSICA KNUTH

S. BLAIR HEDGES

S. Blair Hedges, in his laboratory at Pennsylvania State University, has focused most of his attention on the West Indian herpetofauna, which has grown from 585 known species in 1991 to well over 700 today — with as many as 1,000 species possible — if they are discovered and described before falling victim to development (most attributable to the tourism industry), deforestation, and invasive species. The world's smallest known species of lizard (*Sphaerodactylus ariasae,* from the southwestern Dominican Republic) and the smallest known snake (*Leptotyphlops carlae,* from Barbados) both occur in the region.

This new breed of taxonomists includes Chris Mah of the Smithsonian National Museum of Natural History and Adrian Glover of the Natural History Museum in London, who are among the world's leading experts on sea stars and marine worms, respectively. Both demonstrate that the most informative science comes from synthesizing genetic techniques with more classical taxonomy based on knowledge of the anatomy and natural history of organisms.

Extinction of taxonomists continues despite a growing pool of funds for biodiversity programs and databases. EUNIS, EOL, OBIS … the list goes on. These databases have pooled our collective biodiversity knowledge, helping identify what drives biodiversity and set conservation priorities. Thankfully (my own research has relied upon them), thousands of hours and millions of dollars have been spent on these initiatives. However, many of these programs did not financially support taxonomists generating the data these databases required.

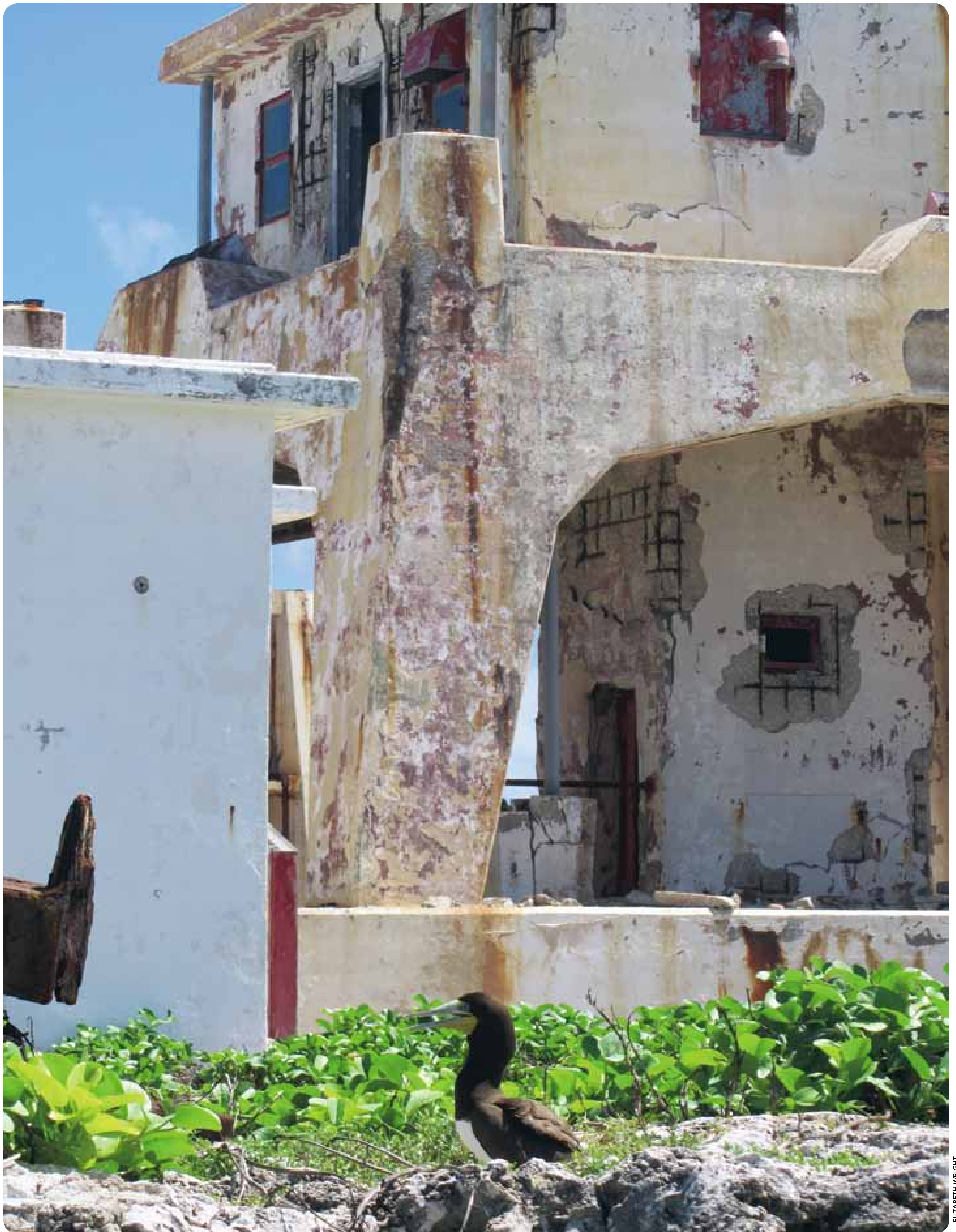
After a decade and 650 million dollars, the Census of Marine Life represents one of the largest initiatives to document biodiversity on our planet. In some regards, it was a great success, supporting 2,700 scientists to produce 2,600 new scientific publications and thousands of new species descriptions. But as the Census ends this year, no agency or organization is offering to fill the funding void previously filled by the Alfred P. Sloan Foundation. Perhaps more importantly, the Census, like many initiatives, did not provide long-term positions and appointments for those doing taxonomic work. Many biology departments within universities no longer employ a taxonomist. The remaining positions are relegated to museums.

Why? As Sørensen explains, "The declining number of taxonomists and systematists is at least to some extent linked to the fact that your scientific production today should be measurable." The units of measurement are collected grant money or the impact factor of a journal paper. Taxonomy has never been considered hot, and pure taxonomic studies are rarely funded, he wrote. Departments need grant money to operate.

Science as an institution may also be partly responsible for undercutting taxonomic work. Although a crude metric fraught with several issues, we measure the impact of a scientific paper by how many times other scientific papers have cited it. Similarly, we measure the impact of scientists by counting their cumulative citations. Unfortunately, taxonomic work is rarely cited, even when it should be.

On the other hand, the brilliant biodiversity databases we have created lead to a plethora of scientific papers. The Paleobiology Database, a comprehensive online catalog of fossil species, has already generated more than 100 publications. But the requirement for using this database, like most others, is citation of the database itself, not the nearly 35,000 papers generating the original data.

The decline in taxonomists means that at some point in the future we will be unable to train new generations of taxonomists. This problem is recognized by the National Science Foundation, which in 1994 created a program to enhance taxonomic research. While this initiative provides training, it does not create job opportunities. Other problems are taking form too. For example, in 2006, I set out to explore how biodiversity and body size were linked among animals. To do so I needed information on the largest- and smallest-sized species for each group of animals — something surprisingly not readily garnered from the published literature. I relied on my connections with taxonomists for guidance and information, but for many groups I struggled to find a contact. Even for well-known animals, I was amazed by how few scientists still studied them. My personal experience highlights how progress in biology as a whole may be impeded if we lose taxonomy. The problem we face is a loss of knowledge not yet recorded in the scientific literature. In our technological efforts to concentrate our biodiversity knowledge, we may be rendering a field and body of knowledge obsolete — and, in the process, we may be undermining our own efforts to protect biodiversity.



ELIZABETH WRIGHT

The deteriorating relicts of human presence on Sombrero have been effectively integrated into the natural ecosystem.