AMERICAN MUSEUM OF NATURAL HISTORY

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STUDY TAKES CLOSE LOOK AT FORMIDABLE CAMEL SPIDER JAWS

FLAGELLA OF MALE SOLIFUGAE HAVE SINGLE EVOLUTIONARY ORIGIN, PLAY IMPORTANT ROLE IN REPRODUCTION

For the first time, researchers have created a visual atlas and dictionary of terms for the many strange features on the fearsome-looking jaws of a little known group of arachnids. Called camel spiders, baardskeerders [beard-cutters], sun spiders, wind scorpions, and other colorful names, Solifugae are an order of arachnids that are neither spiders nor scorpions. Their jaws, or chelicerae, are the largest for body size among the group of animals that possess these specialized mouthparts—including horseshoe crabs, sea spiders, and arachnids—and bear most of the structures used for their classification. Despite their prominence in folklore around the world, solifuges have scarcely been studied, and much remains unknown about their biology.

In research out today in the *Bulletin of the American Museum of Natural History*, scientists from the Museum, the National Museum of Namibia, and Texas A&M University present the first comprehensive analysis of jaw morphology across Solifugae.

"Our limited understanding of the incredible jaws of these arachnids, together with terminology that is unstandardized and even contradictory, has hindered our ability to classify them and figure out where they fit in the arachnid tree of life because, much like the cranial anatomy of vertebrates, the jaws of solifuges contain most of the relevant information," said Lorenzo Prendini, a curator in the Museum's Division of Invertebrate Zoology and an author on the paper. "The last time there was a major publication of this kind on camel spiders was in 1934, which, considering how conspicuous and ubiquitous they are in some parts of the world, is almost unbelievable."

There are about 1,100 species of camel spiders, which range in size from tiny, a few millimeters long, to about 15 centimeters (six inches) in length. The arachnids look like big,

hairy spiders with an extra pair of legs—which are really pedipalps, leg-like structures ending in an adhesive sucker, and used like arms for grasping, holding, and climbing. Mostly found in dry environments, solifuges are abundant in the savannas, steppes, and deserts of Africa, the Middle East, central Asia, the southwestern United States, Mexico, and South America. They differ most obviously from their spider and scorpion relatives in three ways: their massive two-segmented jaws, which can be up to one-third of their body length and are armed with teeth and spine-like and horn-like processes of various sizes; the flagellum, found on the jaws of adult males in most species and thought to play a major role in reproduction; and the malleoli, racquet-shaped sensory organs on the underside of the first segment of the last pair of legs.

"In most solifuge families, species identification is based primarily on features of the jaws, yet no comprehensive survey of these character systems has ever been done," said Tharina Bird, a senior curator at the National Museum of Namibia and lead author of the paper.

Bird, Prendini, and co-author Robert Wharton, a professor at Texas A&M University, studied the jaws of 188 camel spider species representing all solifuge families from historical collections at the Museum and elsewhere, including material collected during expeditions by Prendini and Bird over the past decade—no easy feat. These arachnids, nicknamed the "Kalahari Ferrari," can reach speeds up to 10 miles per hour and generally only come out at night during the warm season, although some species are active only during the mid-day heat.

"Camel spiders are extremely difficult to collect and study, which may explain why they are so poorly known," Prendini said. "They're very seasonal, short-lived, and fast-moving animals. Many live in the hottest, driest, and most dangerous places in the world, and usually only the adult males can be identified to species with any confidence."

Combining observations from high-resolution microscopy of the specimens' jaws with existing literature, the researchers proposed nearly 80 terms—many of them new—for structures of similar appearance and position, to serve as common language for future work. Mucron organ, for instance, refers to a small, circular organ on the side of the mucron, or toothless section of the upper jaw, and which turned out to be common in solifuges although it had never been mentioned before. Or flagellar shaft, an elongated,

variously shaped portion of the flagellum found in many species, which contains two canals, one with an external opening thought to secrete a fluid which plays a part in reproduction.

"It's really vital that everyone be on the same page in terms of scientific language about this group," Bird said. "That way, if I'm describing a particular structure, e.g. a tooth, of a species I found in Africa, someone who sees a similar structure on a species in China can accurately determine if it is the same structure, and can communicate about it unambiguously."

In doing this work, the researchers made several important discoveries about the flagellum of male camel spiders. This unique structure can look very different among species—from long, thin, and whip-like to short, stout and spoon-shaped, flat and blade-like, or even concave and bowl-shaped. But it is homologous, meaning that it has a single origin in the common ancestor of Solifugae. Although the flagellum, along with the rest of the jaw, is thought to play an important role in the mating behavior of camel spiders, and was observed to transfer sperm to the female in at least one species, little is known about its precise function.

"We lack data because hardly anyone can keep camel spiders alive long enough to breed them in captivity, and observing solifuges mating in the wild is even more difficult," Prendini said. "They are high-octane creatures, they burn out quickly. So, there are still many unknowns about how they live."

This work formed part of the Global Survey and Inventory of Solifugae (www.solpugid.com), and was funded in part by National Science Foundation grants # DEB 0640245 and # DEB 0640219. Additional support was provided by the JRS Biodiversity Foundation, Lund University, an AMNH Collections Study Grant, two grants from the AMNH Theodore Roosevelt Memorial Fund, and an Ernst Mayr Travel Grant from the Museum of Comparative Zoology, Harvard University.

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The American Museum of Natural History, founded in 1869, is one of the world's preeminent scientific, educational, and cultural institutions. The Museum encompasses 45 permanent exhibition halls, including the Rose Center for Earth and Space and the Hayden

Planetarium, as well as galleries for temporary exhibitions. It is home to the Theodore Roosevelt Memorial, New York State's official memorial to its 33rd governor and the nation's 26th president, and a tribute to Roosevelt's enduring legacy of conservation. The Museum's five active research divisions and three cross-disciplinary centers support approximately 200 scientists, whose work draws on a world-class permanent collection of more than 33 million specimens and artifacts, as well as specialized collections for frozen tissue and genomic and astrophysical data, and one of the largest natural history libraries in the world. Through its Richard Gilder Graduate School, it is the only American museum authorized to grant the Ph.D. degree. In 2012, the Museum began offering a pilot Master of Arts in Teaching program with a specialization in Earth science, which is the only non-university affiliated such program in the United States. Annual attendance has grown to approximately 5 million, and the Museum's exhibitions and Space Shows can be seen in venues on five continents. The Museum's website and collection of apps for mobile devices extend its collections, exhibitions, and educational programs to millions more beyond its walls. Visit amnh.org for more information.

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