Gladiators: A New Order of Insect

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By Joachim Adis, Oliver Zompro,
Esther Moombolah-Goagoses and Eugène Marais

Gladiators: A NEW ORDER OF INSECT

Imagine being the very first person ever to see a butterfly, a beetle or a wasp. Imagine the sense of wonder at a world so wide that it contains not just undiscovered species, genera or families but entire orders of life yet to be named. Carl Linnaeus must have had such a feeling 250 years ago as he was sorting recently discovered plants and animals into the taxonomy he had invented. So probably did E. M. Walker, who in 1914 was the first to describe rock crawlers (Grylloblattodea), bringing the number of orders in the insect class to 30.

A mystery in amber is solved on a desert mountain with a discovery that has stunned entomologists

MYSTERIOUS AMBER FOSSIL preserved this adult male insect for millions of years. The fossil was a critical clue in the discovery of the new Mantophasmatodea order. The insects have evolved; gladiators today have thinner front legs and have heads that are less triangular and more rounded.

Most entomologists thought that was the final total: although there may be millions of insect species still to identify (about 1.2 million have been named so far), for nearly a century we have assumed that every newfound species will fall into just those 30 basic categories. To biologists, the natural world no longer seemed as wide and as wild as it once did. But in June 2001 one of us (Zompro) received bits of amber that would change the way we look at the insect world, giving us a taste of the old joy of discovery—and renewing our awe at the variety of life.

Frozen in Time

THE CHUNKS OF AMBER, from a collection at the University of Hamburg in Germany, were dug up in the Baltic. As the tree sap solidified some 45 million years ago, it had captured several insect larvae that looked utterly different from any Zompro had seen before.

A month later Zompro, who was then working on his doctoral studies at the Max Planck Institute for Limnology in Plön, was visiting the Natural History Museum in London when curator Judith A. Marshall showed him a desiccated bug found in Tanzania in 1950. It was clearly the carcass of an adult male, but no one had been able to identify what manner of insect it once was. Zompro snapped a few pictures and returned to Germany.

A few days later another piece of amber arrived in the mail. This one, from a private collection, entombed a fossilized adult male of some kind. As Zompro examined it under the microscope, he was struck by how much it resembled the exoskeleton he had just seen in London.

Now Zompro knew he was onto something. He showed the new amber fossil to his thesis adviser (Adis), who suggested that he sift through the collections of several European museums for other unidentified bugs of this sort. Hunting in one museum after another, Zompro turned up no matching specimens. But at the Berlin Natural History Museum, he at last struck gold: a little alcohol-filled bottle containing the embalmed body of an adult female insect that looked conspicuously like the mysterious bug in amber.

As Zompro and Adis painstakingly studied these two additional specimens, one prehistoric and the other picked off the ground in Namibia almost a century ago, their excitement grew. At first glance the animals, with their strong hind legs, resembled grasshoppers. But they lacked wings, which most grasshoppers have. Their front legs were studded with thorns, like those that praying mantids use to capture and hold their prey as they eat them alive. But the heads and hind legs of these baffling insects were clearly different from those of a mantis. From above they looked almost like plant-eating walkingsticks. Yet their second body segment was too short for a walkingstick, and their guts contained body parts from other insects, proof of carnivory.

These were no trivial differences, and our collaborators Klaus-Dieter Klass and Niels P. Kristensen found other novel structures inside the insects' bodies. With so many fundamental distinctions in body shape and diet, it took only a few hours to conclude with certainty that these organisms fit in no existing insect order. We would have to create a category for them, one on a par with the flies, the beetles and the termites.

We settled on the scientific name Mantophasmatodea because the animals look like a bizarre cross between a mantis (order Mantodea) and a walkingstick (order Phasmatodea). But among ourselves we took to calling the beasts "gladiators," inspired by their fearsome appearance and the armor that covers them as nymphs.

THE AUTHORS

JOACHIM ADIS, OLIVER ZOMPRO, ESTHER MOOMBOLAH-GOAGOSES and *EUGÈNE MARAIS* collaborated on the discovery of the Mantophasmatodea order. Adis is senior scientist in the tropical ecology working group at the Max Planck Institute for Limnology in Plön, Germany. He is also lecturing professor at the University of Kiel in Germany and at several universities in Brazil. He is affiliated with the Smithsonian Institution as a research entomologist. Since 1975 his work has focused on the ecology and survival strategies of millipedes, spiders and insects in Amazonian wetlands. Zompro is a doctoral student of Adis's at the Max Planck Institute. Since 1980 he has reared more than 130 species of walkingstick and walkingleaf insects. He has specialized in the evolution and ecology of the Phasmatodea order of insects. Moombolah-Goagoses is chief curator of the National Museum of Namibia in Windhoek. Marais is curator of the Namibian National Insect Collection in Windhoek.

THOMAS KUJAWSKI *ASA-Multimedia (preceding page and above)*

AN ORDER IS BORN

GLADIATORS

ANATOMY OF GLADIATORS shares many characteristics with that of grasshoppers, walkingsticks and mantises. But gladiators are different in critical ways from those and all other insect orders. A new order, Mantophasmatodea, was therefore announced in April. So far it contains at least three living and two extinct species.

INSECT ORDERS

Common Name	*Scientific Name*
Flies	*Diptera*
Twisted-wing parasites	*Strepsiptera*
Scorpionflies	*Mecoptera*
Fleas	*Siphonaptera*
Moths, butterflies	*Lepidoptera*
Caddisflies	*Trichoptera*
Ants, wasps, bees	*Hymenoptera*
Beetles	*Coleoptera*
Lacewings, antlions	*Neuroptera*
Dobsonflies	*Megaloptera*
Snakeflies	*Raphidioptera*
Book lice	*Psocoptera*
Lice	*Phthiraptera*
Bugs	*Heteroptera*
Thrips	*Thysanoptera*
Stoneflies	*Plecoptera*
Webspinners	*Embioptera*
Angel wings	*Zoraptera*
Cockroaches	*Blattodea*
Mantids	*Mantodea*
Gladiators	***Mantophasmatodea***
Termites	*Isoptera*
Earwigs	*Dermaptera*
Rock crawlers	*Grylloblattodea*
Walkingsticks	*Phasmatodea*
Grasshoppers, crickets	*Orthoptera*
Dragonflies	*Odonata*
Mayflies	*Ephemeroptera*
Silverfish	*Zygentoma*
Jumping bristletails	*Archaeognatha*
Aphids, cicadas	*Homoptera*

SIDE VIEW

DEATH GRIPPERS
Spikes on front legs, like those on a mantis, hold prey while it is eaten alive

JUMPING LEGS
They are not as developed as those of a grasshopper

ANIMAL EATERS
Powerful mandibles are evidence of a carnivorous lifestyle. Most grasshoppers and walkingsticks are vegans

TOP VIEW

FLIGHTLESS
Gladiators have no wings; many mantises and most grasshoppers have four

LONG, STRAIGHT BODY
Like a walkingstick

UNEXAGGERATED THORAX
In stick insects the second thorax segment is longer—usually much longer—than the first, and the third segment is merged with the abdomen

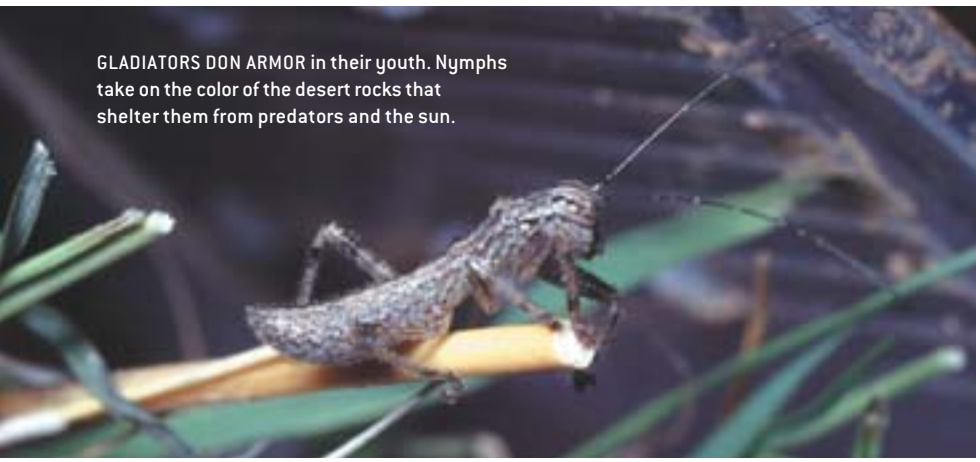
HOOKED FEET
Apparently unique to gladiators

WALKINGSTICK

MANTIS

GRASSHOPPER

THOMAS KUJAWSKI *ASA-Multimedia (top two photographs)*; JOHN MOORE *(bottom row)*



GLADIATORS DON ARMOR in their youth. Nymphs take on the color of the desert rocks that shelter them from predators and the sun.

Although we suspect that the gladiators share a common ancestor with the mantids and stick insects, it will take more work to establish their exact position within the evolutionary tree of insect life. DNA analyses to do just that got under way this past April.

Bug Hunt in the Desert

THE FIRST QUESTION we wanted to answer was: Are gladiators still alive, or did the order pass into extinction since the Tanzanian gladiator was collected half a century ago? Adis e-mailed photographs of the insects to colleagues around the world, asking them to look for similar specimens in their own collections.

A mature gladiator and two larvae turned up at the University of Leeds in England. They had been found in the Brandberg Massif of Namibia sometime between 1998 and 2000. And one of us (Marais) located two animals matching the description. Marais had collected one of them himself in Namibia in 1990; the other was picked up by a Namibian student in 2001.

While Marais was in Germany, he drew up plans with Zompro and Adis to mount an expedition in Namibia to search for living gladiators. On the last day of February 2002, 10 scientists from five countries set out into the tropical Namib Desert. The team made its way to the Brandberg, a circular inselberg that, like an enormous granite pimple, towers 1,800 meters over a barren plain in Erongo province. Locals call it Dâures: Burning Mountain. Remote and protected, the Brandberg is the only home of several endemic animals.

The search began in early March on a high, stony plateau surrounded by tall boulders. Zompro and the other entomologists were all out exploring. John Irish, a Namibian taxonomist, was beating grass bushes with sticks to see what insects might fall out. A few hours into the search, Irish bent down and stared carefully at something in his hand.

"I think I've got something for you, Oliver," he said. In his palm lay a small larva, a gladiator in the second stage of its life. That evening another team member found four more larvae. We could hardly contain our excitement. Unbeknownst to science, this chain of life had remained intact for more than 45 million years!

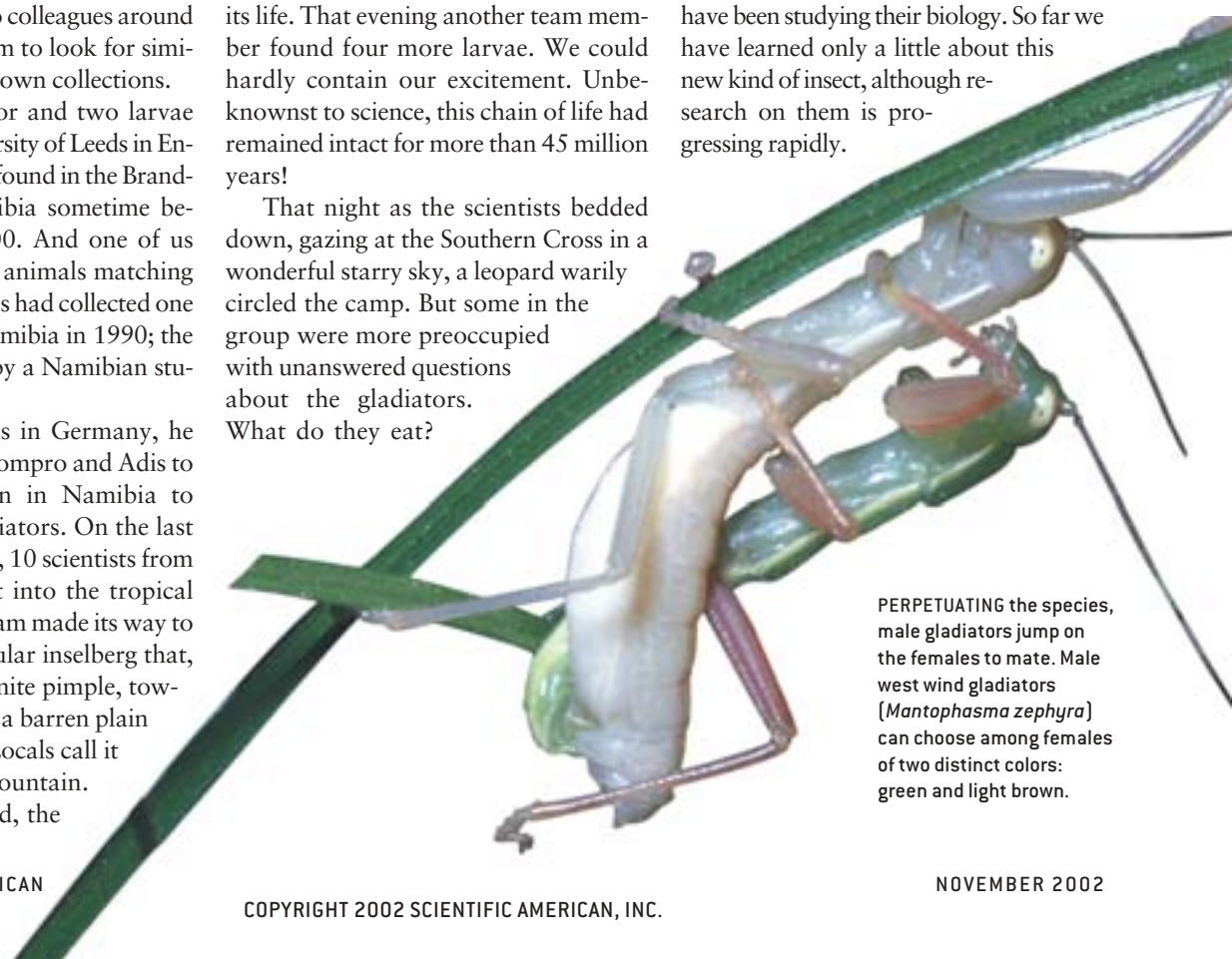
That night as the scientists bedded down, gazing at the Southern Cross in a wonderful starry sky, a leopard warily circled the camp. But some in the group were more preoccupied with unanswered questions about the gladiators. What do they eat? How do they find water? How do they survive flash floods and daily temperature swings of 25 degrees Celsius (40 degrees Fahrenheit)? To answer such questions, we needed to observe how gladiators behave at all stages of their life.

The group wanted to search other parts of the massif—and other nearby mountains—but the weather conspired against a rapid descent. Temperatures over 44 degrees C (110 degrees F) made clambering down the steep slopes arduous. Periodic downpours turned trickling brooks into life-threatening whitewater. But the rains also transformed a landscape of yellow, gray and brown into a verdant expanse of vegetation.

By mid-March, Zompro and his colleagues were into the neighboring mountains. A nocturnal hunt netted yet another species of gladiator; we had now identified four distinct species in the new order. And the next day Zompro was able to make the first observations of how the insects behave in the wild.

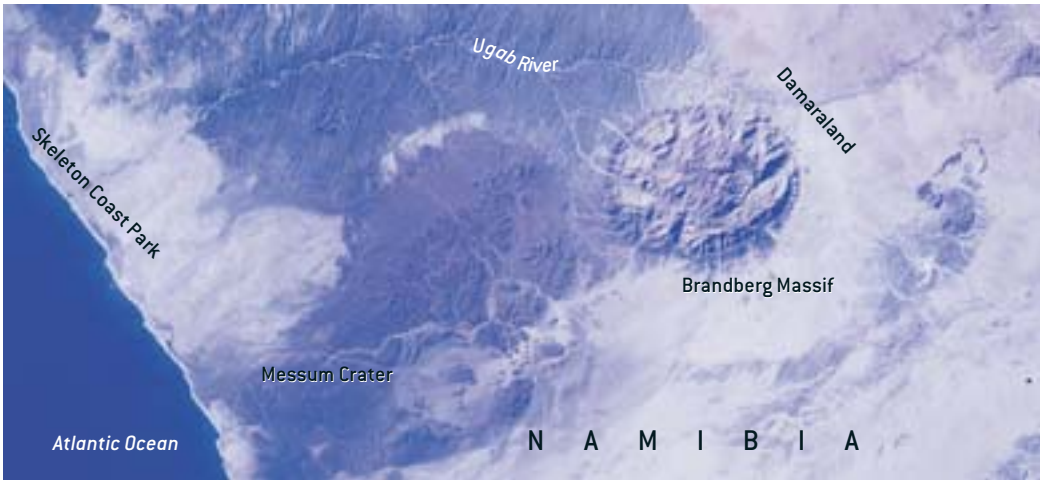
Life as a Gladiator

A DOZEN GLADIATORS were captured alive and taken to Germany, where we have been studying their biology. So far we have learned only a little about this new kind of insect, although research on them is progressing rapidly.



THOMAS KUJAWSKI *ASA-Multimedia*

PERPETUATING the species, male gladiators jump on the females to mate. Male west wind gladiators (*Mantophasma zephyra*) can choose among females of two distinct colors: green and light brown.



EXPEDITION in search of gladiators began in late February. On a tip from Marais, a team of 10 entomologists journeyed by truck and helicopter into the vast, desolate Namib Desert. They began their search on the Brandberg Massif, an isolated mountain (*left*) that is Namibia's tallest. There and in the neighboring mountains of Damaraland, co-author Zompro and the others discovered two living species of gladiators.

On the mountainside we saw gladiators hiding in grass tufts and rock crevices during daylight. They were well camouflaged, their body colors blending in with the surrounding plants and rocks. At nightfall they came out to hunt for prey.

Gladiators are carnivorous, and they eat a variety of other insects, some as large as themselves. In the wild we saw them feeding on small moths, silverfish and cockroaches. In captivity they seemed to prefer living flies and crickets. Dead mealworms also suit their tastes.

The animals use their powerful forelegs to wrestle small prey to a standstill. Larger meals they grasp with their middle legs as well (carnivorous grasshoppers use a similar four-handed hunting technique). Big flies are first killed with strong bites to their neck. Then the gladiators devour the flies headfirst. They eat every part of their prey except the wings and legs. We have seen young gladiators, when injured, fall victim to cannibalism.

The larvae grow very fast, molting their skins several times as they mature into adults. They appear to have adapted their entire life cycle to the short rainy season, which in the Brandberg lasts just a few months. It is not yet known how and where female gladiators lay their eggs in the wild.

The unexpected discovery of a new order in the insect kingdom has stunned many entomologists. Some immediately started scanning their collections for more specimens—29 recently turned up in museums in South Africa, and new field studies have found gladiators to be abundant in the Western Cape province.

Other research groups around the world quickly offered to assist in our continuing studies of the gladiators' behavior, life cycle and reproduction. Romano Dallai of the University of Siena in Italy is looking into the shape and structure of the male insect's sperm. Teams led by Michael F. Whiting of Brigham Young University and Roger K. Butlin of the University of Leeds are analyzing the gladiators' DNA. These experiments may by the end of this year give us a clearer picture of where Mantophasmatodea fits within the branches of the insect class, the broadest and bushiest part of the tree of life.

But the fact that the evidence of this new order sat in museums, unnoticed for decades until a chance encounter (and an alert student) put the pieces together, makes us wonder. Are there more orders of insects we have yet to discover? To bug lovers like us, the natural world suddenly seems a bit wider and wilder than we had imagined it to be. SA

MORE TO EXPLORE

Mantophasmatodea: A New Insect Order with Extant Members in the Afrotropics. Klaus-Dieter Klass, Oliver Zompro, Niels P. Kristensen and Joachim Adis in *Science,* Vol. 296, pages 1456–1459; May 24, 2002.

A Review of the Order Mantophasmatodea (Insecta). O. Zompro, J. Adis and W. Weitschat in *Zoologischer Anzeiger,* Vol. 241 (in press).

Oliver Zompro maintains a Web site on the new order at **www.mantophasmatodea.de**

THOMAS KUJAWSKI *ASA-Multimedia (photographs);* LUNAR AND PLANETARY INSTITUTE *(satellite image)*