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Die Mimikry zwischen Eidechsen und Laufkafern (Mimicry Between Lizards and Ground Beetles), by Almuth D. Schmidt. 2004. Edition Chimaira, Frankfurt am Main, Germany (www.chimaira.de). 374 pp. Hardcover. ¤ 58.00 (approximately US $75.00). ISBN 3-930612-69-0.

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For more than a century, warning coloration and mimicry have fascinated evolutionary biologists and natural historians. In fact, these phenomena helped convince late 19th Century biologists of the power of natural selection.

During the 20th Century, studies of mimicry were common; but reptiles and amphibians were bit players in these studies. A few species were notable exceptions, of course (e.g., coral snakes, egg-eating snakes; reviewed in Pough 1994); but these involved one herp mimicking another. Cases of a herp mimicking an invertebrate are rare (Autumn and Han 1989; Gans 1987; Parker and Pianka 1974; Vitt 1992) and often anecdotal.

In 1977 we proposed that a ground-dwelling lizard in the Kalahari Desert mimicked a beetle (Huey and Pianka 1977). The possibility that a lizard could mimic a beetle must have seemed ludicrous to many, and no doubt some of our colleagues wondered whether we'd spent too much time out in the Kalahari sun. Our evidence was circumstantial; but we were convinced that this was mimicry, and that it involved both color and locomotor behavior.

The model is the juvenile lacertid lizard, *Heliobolus lugubris*, and the mimic is a carabid beetle, *Anthia* spp. Adult *H. lugubris* are sand colored and reasonably cryptic, but juveniles are decidedly conspicuous against the red Kalahari sand. Juveniles have jet-black bodies, with broken white stripes—only their tails are sand colored (Fig. 1). No other lacertid in the Kalahari changes color so dramatically during ontogeny. Nor does any other lacertid of which we are aware.

Both juvenile and adult *H. lugubris* are wide foragers (Huey and Pianka 1981), but they differ strikingly in the way they move. Adults move like normal lacertids (with lateral undulations), but juveniles often move stiff legged, with their backs arched and their tails pressed to the ground (Fig. 1). When the juveniles 'metamorphose' to the adult coloration, they switch from arch-walking to a normal walking style. Juvenile *H. lugubris* are the only lizards known to use arch-walking.

We didn't do a formal phylogenetic analysis, but we realized that two unique features of the juveniles (coloration, arch walking) must be evolutionarily derived and thus called for explanation. When we looked around the Kalahari, we soon noticed carabid beetles (*Anthia*). These beetles are black-and-white, a classic aposematic pattern, and often abundant. Locals refer to them as "oogpisters" (which translates euphemistically as "eye squirter"), because these beetles squirt from their abdomen a noxious mixture of formic acid, tiglic acid, and other compounds (Scott et al. 1975). As far as we were aware, no vertebrate predator ate these noxious beetles.

To us the observed patterns strongly suggested that the beetles were noxious models and that juvenile *H. lugubris* (approximately

FIG. 1. An arch-walking juvenile *Heliobolus lugubris* (photograph courtesy of A. Schmidt).

the same size as the beetles) were Batesian mimics, involving both color and movement. We noted that juveniles of this species had a low tail-break frequency relative to other juvenile lacertids in the Kalahari, and we interpreted this as evidence of the efficacy of the mimetic resemblance (but see Schoener 1979).

In the late 1990s we began to hear rumors that a German graduate student (Almuth Schmidt) was studying this mimicry complex for her thesis. She has published a few papers on this over the years, but has now synthesized her work in well-illustrated book. Naturally, we were excited to see her book, to find out how well our ideas stood up, and to learn what new evidence she had uncovered.

Her book is largely in German (a language that has sadly decayed from our brains during ontogeny). Fortunately, all of the table and figure legends are in both English and in German; and the book has a 3-1/2 page summary in English. So the essence of her study is accessible even to an English-restricted audience.

Schmidt worked mainly in two nature reserves in the Limpopo Province of South Africa, rather than in the Kalahari. She presents a diverse set of studies involving careful observations as well as clever experiments. Her studies solidly reinforce the idea of mimicry. Here is a small sample of the kinds of evidence she has garnered:

1) The geographic range of the lizards overlaps with that of abundant carabid beetles (a dozen species of *Thermophilum* and three species of *Anthia*), which serve as models.

2) As juvenile lizards grow, their color and patterns shifts progressively, matching the color of size-matched species of beetles!

3) In staged encounters with beetles, most predators (birds, mammals, monitor lizards) consistently avoided the beetle after being sprayed only once. Thus beetles are indeed strongly noxious, and seemingly unforgettable.

4) Arch-walking juveniles were avoided 100% of the time by visually hunting snakes, but were invariably attacked by the same snakes if they moved normally. Thus arch walking is highly effective against visual predators. (Note: it was against us, too! More than once we briefly confused juvenile lizards for beetles.)

5) Most remarkably, juveniles change their behavior when encountering different snakes. When they encounter a visual hunter, they either remain immobile or use arch-walking. But, when they encounter a snake that hunts using olfaction, they run away at high speed!

Schmidt's studies are inventive and comprehensive, and she has put together one of the most impressive studies of models and mimics we've seen. Her findings will be of considerable interest not only to herpetologists, but also to any behavioral and evolutionary ecologists interested in predation, aposematic coloration, and mimicry. In particular, her discovery that juveniles modify their evasive behavior in response to different kinds of predators is remarkable and deserves to be widely highlighted.

Acknowledgments.—We thank Almuth Schmidt for permission to publish her photograph of an arch-walking *H. lugubris* and for discussion.

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The Musk Turtle Book, by John B. Iverson, with a **Section on Husbandry**, by Richard Cary Paull. 2003. Green Nature Books, P.O. Box 105, Sumterville, Florida 33585, USA. 78 pp. Soft cover. US $29.95 + $3.95 postage. ISBN 1-888089-58-X.

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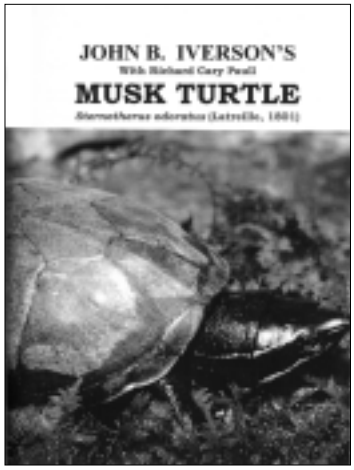

Musk turtles are ubiquitous denizens of many types of fresh waters in North America. Populations can be very large, and as such these little turtles are likely important components of aquatic ecosystems as both predators and prey. Anyone who has kept Stinkpots in an aquarium knows that they are quite entertaining and easy to maintain, and it is fortunate that commercial collecting has been restricted in many states because they undoubtedly would be popular in national and international trade. There are a number of musk turtles other than Stinkpots (*S. carinatus, S. depressus, S. minor*), however, and despite this little book's title, these are not covered except exceedingly cursorily in Paull's 5 page section on "Other Musk Turtles."

The book (really a booklet) consists of 40 pages of large bold text by Iverson on the natural history of Stinkpots, 9 pages on husbandry and other musk turtles by Paull, 4 pages of biography (including pictures of the Iverson family and Paull with his granddaughter), and 19 pages of literature cited (with references to early