

- Lin, D.N. 2008. No skink — Introduction and pest control of invasive *Mabuya multifasciata*. *Quarterly Journal of Nature Conservation* 61:30–36 (in Chinese).
- Lin, H.C., K.F. Hwung, and T.H. Lu. 1995. Food of snakes from Taiwan. *Notes and Newsletter of Wildlifers* 3(2):19–21 (in Chinese).
- Lue, K.Y., M.C. Tu, and G.S. Shang. 2002. *The Transition Kingdom — Guidebook of Amphibians and Reptiles of Taiwan*. SWAN, Taipei (in Chinese).
- Maki, M. 1931. *A Monograph of the Snakes of Japan*. Dai-Ichi Shobo, Tokyo.
- Mao, J.J., G. Norval, W.B. Kung, and H.N. Chang. 2006. *Bungarus multicinctus multicinctus* (Many-banded Krait). Diet. *Herpetological Review* 37:350.
- Mao, S.H. 1970. Food of the common venomous snakes of Taiwan. *Herpetologica* 26:45–48.
- Mao, S.H. 1993. *Common Terrestrial Venomous Snakes of Taiwan*. National Museum of Natural Science, Special Publication No. 5, Taipei.
- Norcal [sic], G. and J.J. Mao. 2006. Mountain Wolf Snake (*Lycodon rubistrati rubistrati*): A description of the defensive behavior. *Sauria* 28(4):47–50 (note that the surname of the first author is a typographical error for Norval).
- Pope, C.H. 1935. *The Reptiles of China*. The American Museum of Natural History, New York.
- Slowinski, J.B. 1994. The diet of kraits (Elapidae: *Bungarus*). *Herpetological Review* 25:51–53.
- U.S. Department of the Navy (Bureau of Medicine and Surgery). 1991. *Poisonous Snakes of the World*. Dover Publications, New York.
- Voris H.K. and H.H. Voris. 1983. Feeding strategies in marine snakes: An analysis of evolutionary, morphological, behavioral and ecological relationships. *American Zoologist* 23:411–425.
- Yang, S.L. 1994. The irrigation system evolved on the social and spatial organization of the Taoyuan Plateau. Unpublished M.S. Thesis, National Taiwan Normal University, Taipei (in Chinese).
- Yo, C.W. and Z.J. Wong. 2007. Preliminary inventory of herpetological resources of North Cross Road. *Quarterly Journal of Nature Conservation* 59:38–47 (in Chinese).
- Zhao, E.M. and K. Adler (eds.). 1993. *Herpetology of China*. Society for the Study of Amphibians and Reptiles. Oxford, Ohio.
- Zhao, E.M., M.H. Huang, and Y. Zong. 1998. *Fauna Sinica, Reptilia. Volume 3: Squamata, Serpentes*. Science Press, Beijing, China (in Chinese).

## Blocked-flight Aggressive Behavior in Snakes

D. Bruce Means

Coastal Plains Institute and Land Conservancy, Tallahassee, Florida 32303

Every naturalist accumulates field observations and experiences worthy of expanding into full-blown research projects. More often than not, however, the information languishes undeveloped in memory, paper piles, and these days, computer files. Some interesting observations on snake behavior I have made over the years are among my many unfinished projects.

Experienced naturalists know that most snakes flee when encountered in nature. More sedentary, slow-moving, or cryptic snakes will remain still or coiled in order to go unnoticed. Rattlesnakes, when disturbed, coil and rattle. After a while, they also may move away from the intruder, perhaps continuing to rattle as they break out of their coil and flee. A few snakes, however, do something different.



KATHY STEINHEIMER

**Fig. 1.** A Cottonmouth (*Agkistrodon piscivorus*) “chasing” the author while engaged in aggressive behavior during blocked flight with head raised, striking, flattening its body, vibrating its tail, and moving directly toward the author. This snake did not follow the author when he stepped aside, but raced to safety into the water beyond.



JAMES VALENTINE

**Fig. 2.** A Cottonmouth mouth-gaping as it crawls toward the author.



D. BRUCE MEANS

**Fig. 3.** An Eastern Cornsnake (*Pantherophis guttatus*) crawling toward the author, striking forward, as he blocks its escape from a dirt road.

That different behavior was first displayed to me when an adult Eastern Cottonmouth (*Agkistrodon piscivorus conantii*) rose up like a cobra and menacingly crawled toward me in front of a dozen students (Fig. 1). I had just guaranteed my field class that Cottonmouths do not chase people. In those few moments, as I rapidly backed up from the approaching snake, a potential behavioral study was born (see Chapter 8 in Means 2008).

We had encountered the snake one warm late afternoon in May, when snakes — and Cottonmouths especially — are most likely to move. It was crossing a wide, sandy road in the Apalachicola National Forest of the Florida panhandle. The adjacent swamp from which the Cottonmouth had emerged was drying up from a severe drought, and the snake probably was looking for new aquatic habitat or a drying waterhole from which to gorge on the concentrated aquatic animals.

As so often happens with snakes, it stopped crawling as my vehicle approached and was fully stretched out in a “frozen” posture. I lined up the students on the road shoulder from which the snake had come and I took a position on the other side, blocking its forward motion. Our movements stimulated it to coil up and do its “Cottonmouth” display, with its attention focused on me, who was closest to the snake and gesticulating to the group. After a few minutes, the snake suddenly rose up cobra-like and began crawling rapidly at me with the forward one-fourth of its body raised.

With its neck spread slightly, the snake continued to advance as I backedpedaled, making a few striking parries as it neared my feet. When I stepped sideways from the snake’s trajectory (which was directly toward a swamp on the other side of the road), I was gratified that the snake maintained its original direction and did not turn to follow (or “chase”) me. Its “aggressive” behavior obviously was a bluff to assist the snake in making its getaway into the safety of the swamp.

Realizing that this poorly trafficked, wide sandy road between two swamps offered an ideal site to study this behavior, my wife, Kathy Steinheimer, and I road-cruised this 0.5-km stretch ten times in the next two years. She videotaped 16 episodes of me interacting with Cottonmouths. Cottonmouths “chased” me 10 of 17 times that I blocked their movement. It simply appears to be bluffing behavior, but aggressive nevertheless. I call it shammed (bluffed) aggression during blocked flight.

Cottonmouths engaged in such aggressive flight exhibited several characteristic behaviors, including crawling rapidly toward me, raising the head and neck off the ground, expanding the jaws, flattening the body, vibrating the tail, tongue-flicking, lunging and striking forward, and rarely, musk-squirting. A great deal of variation exists in the intensity of these behaviors. A few displayed the behavior as they dashed toward the cover of the roadside vegetation. Some assumed the classic coil-up and mouth-gape defense first and then broke into aggressive flight within a few minutes.

I was able to initiate flight behavior in a coiled Cottonmouth simply by flipping it over on its back by means of my snake hook. Upon righting itself, the snake ended up lying in a straight position. It then either coiled again and mouth-gaped, or fled, at which time I could step in front of it. Other Cottonmouths were relatively placid, coiling repeatedly and refusing to flee. Of the 17, one hid its head under its body when coiled and refused to break out of that posture. Another mouth-gaped as it crawled rapidly toward me (Fig. 2). Another interesting behavior we noted is that when fleeing Cottonmouths crawled out of the sandy roadbed and entered the roadside vegetation, they sped up their forward motion and became even more animated in their aggressive bluffing.

Allen and Swindell (1948) were the first to describe aggressive flight in the Cottonmouth: “One three footer, when approached, struck upward so hard that he lifted his body off the ground. He advanced, coiling and striking repeatedly, following the retreat of the observer. Others have been seen to charge deliberately with open mouth. Most attackers seem to do so in a bluffing manner rather than in vicious pursuit.”

More recently, studies have analyzed Cottonmouth defensive behaviors in response to being stepped on or approached closely, and to being picked up with an artificial arm (Gibbons and Dorcas 2002, Gludas and Winne 2007). In these studies, caged snakes or those with unrestricted opportunities to flee were less likely to display aggressive flight behavior. Apparently, the behavior is most likely to be triggered when free-ranging snakes are blocked along a chosen trajectory after they are already in flight.

My intention in videotaping these “chase” episodes was to do a study of Cottonmouth behavior during blocked flight by analyzing the filmed sequences. Alas, when I returned from an overseas trip, I discovered that the





KATHY STEINHEIMER

**Fig. 4.** An Eastern Brownsnake (*Pseudonaja textilis*) coming straight for the author as he backs away.

tape containing the episodes had been accidentally overwritten with soap operas, so the project has not been resurrected. Because the two of us were busy videotaping the short-lasting behavior, we took few still photos, which only show “snapshots” of the full behavior.

Over the years, I have encountered similar shammed aggression during blocked flight by several species of snakes. The behavior is induced only when one places one’s body in front of a moving snake, blocking its escape. Many snakes, especially colubrids, will turn and flee in another direction, but some do not. In snakes as small as Pigmy Rattlesnakes (*Sistrurus miliarius barbouri*), I stimulated similar bluffed aggression episodes in two of seven individuals. I even encountered an Eastern Corn Snake (*Pantherophis guttatus*) crossing a road that rose up and tried to bluff me out of its way (Fig. 3).



D. BRUCE MEANS

**Fig. 5.** A Southern Banded Watersnake (*Nerodia fasciata*) mimicking the aggressive flight behavior of the Cottonmouth, sham-striking forward with head raised, body inflated, and jaws widened.

In Victoria State, Australia, I deliberately stepped in front of a crawling Eastern Brownsnake (*Pseudonaja textilis*) and got another surprise (Fig. 4). Not only did it rise cobra-like and move threateningly towards me, but it also seemed purposefully to exaggerate the undulations of its body in the loose gravel of the road. This fast-moving snake is extremely venomous and responsible for more snakebite deaths in Australia than any other species (Whitaker et al. 2000). Fortunately, as I stepped out of its trajectory, it did not turn toward me but attempted to make good its escape in the direction it was fleeing. Whittaker and Shine (1999) described 455 defen-

sive responses of free-ranging Eastern Brownsnakes to experimental close encounters with humans, but scored only 12 of these in which the snake advanced towards the observer. Of these, only three advances were judged to be offensive. In their study, however, they did not report attempts to block the path of the snake once it began to flee. Researchers have observed that many other large Australian elapids react to an intruder by rising up, flattening the neck, opening the mouth, and continuing in the direction of the intruder (Johnson 1975, Greer 1997).

My most interesting encounter with a bluffing snake has to be an example of behavioral mimicry. One morning in June 2002, I was walking along the sparsely vegetated floodplain of the Escambia River in western Florida when, suddenly, a snake rose up cobra-like and crawled rapidly upright while I walked at a safe distance alongside it taking photos of what I assumed was another Cottonmouth engaged in aggressive bluffing. Its body proportions, pattern, and behavior were so like a Cottonmouth that I didn’t discover its true identity until I looked at my digital readout. It was a perfect Cottonmouth mimic, a Southern Banded Watersnake, *Nerodia fasciata* (Fig. 5).

Diverting many species of snakes from the beeline trajectory of their intended direction is often difficult. This has been particularly evident to me during attempts to photograph moving snakes. Many seem fixated on the original direction of their movement so that one cannot easily make a snake reverse its heading. Drag the snake backwards and it will repeatedly crawl forward along its previous track.

I believe that the “aggressive bluffing” behavior I have witnessed in the Cottonmouth, Pigmy Rattlesnake, Corn Snake, Eastern Brownsnake, and Banded Water Snake were elicited under the special circumstances of encountering the snakes in habitats familiar to them and by blocking their escape along a direction they had chosen. Future studies of aggressive behaviors exhibited during blocked flight should take these *a priori* conditions into account.

I probably do not have time in my life to travel the world looking for opportunities to block the escape path of wild snakes, but maybe by reporting these observations — about which I feel sure Henry Fitch would have enjoyed reading — will stimulate other naturalists to watch for “bluffed aggression during blocked flight” in snakes everywhere. I suspect that most experienced field herpetologists have had similar encounters with snakes, and the list of snake species that do this may be long. I cannot help but wonder if shammed aggression behaviors are more prevalent in venomous snakes, since they are more likely to survive an attack by envenomating the intruder if the bluff doesn’t work. Maybe someone will conduct in-depth studies and a more complete review of this interesting behavioral phenomenon in snakes, although I urge snake-lovers not to try these potentially dangerous experiments, and professional herpetologists who might do so should wear proper snake boots and other snakebite-prevention apparel, unlike me in Figures 1 and 4.

#### Literature Cited

- Allen, E.R. and D. Swindell. 1948. The Cottonmouth Moccasin of Florida. *Herpetologica* 4 (Supplement 1):1–16.
- Gibbons, J.W. and M.E. Dorcas. 2002. Defensive behavior of Cottonmouths (*Agkistrodon piscivorus*) toward humans. *Copeia* 2002:195–198.
- Glaudias, X. and C.T. Winne. 2007. Do warning displays predict striking behavior in a viperid snake, the Cottonmouth (*Agkistrodon piscivorus*)? *Canadian Journal of Zoology* 85:574–578.
- Greer, A.E. 1997. *The Biology and Evolution of Australian Snakes*. Surrey Beatty & Sons, Chipping Norton, New South Wales, Australia.
- Johnson, C.R. 1975. Defensive display behavior in some Australian and Papuan-New Guinean pygopodid lizards, boid, colubrid and elapid snakes. *Zoological Journal of the Linnean Society* 56:265–282.
- Means, D.B. 2008. *Stalking the Plumed Serpent and Other Adventures in Herpetology*. Pineapple Press, Sarasota, Florida.
- Whitaker, P.B. and R. Shine. 1999. Responses of free-ranging Brownsnakes (*Pseudonaja textilis*, Elapidae) to encounters with humans. *Wildlife Research* 26:689–704.
- Whitaker, P.B., K. Ellis, and R. Shine. 2000. The defensive strike of the Eastern Brownsnake, *Pseudonaja textilis* (Elapidae). *Functional Ecology* 14:25–31.