STRIKE!

BY JULIE ANN MILLER

A profound change comes over a rattlesnake when it strikes its rodent prey. Observations of rattlesnakes and vipers provide clues to the evolution of snake predatory behavior.

Kent Scudder opens the door cautiously and scans the floor for escapees before setting a sandal-clad foot into the laboratory's animal quarters. Ominous rattles sound from several directions. In glass tanks around the room, snakes shake their tails and raise their heads flicking forked tongues, and a small viper spits venom against the glass.

Snakes fascinate by their beauty and their undulating motions, but also by the threat of their swift strike. Scudder, working with David Chiszar and others at the University of Colorado in Boulder, focuses his research on rattlesnakes' attack. The scientists find that despite the snakes' fierce reputation, the potency of rattlesnake venom and a keen tracking ability allow, overall, a rather leisurely and cautious approach to predation.

The strategy of the rattlesnake resembles a hunter who shoots an animal with a poisoned arrow, instead of grappling with the wild prey face-to-face. Rattlesnakes generally lie quietly to ambush a rodent. When prey comes within range, the snake strikes and in a matter of milliseconds injects its venom through hollow fangs into the victim.

Then, somewhat surprisingly, the snake lets its prey go. The rodent flees, but soon slows down as the venom begins to take effect. After waiting a few minutes, the rattlesnake begins to trail its victim and before long finds and devours the dying or dead animal.

"Rattlesnakes are delicate animals and that delicacy I believe is related to the strategy to strike prey and let go," Chiszar says. In the few minutes it takes for the venom to act, a struggling mouse grasped in a rattlesnake's jaw could do considerable damage to sensitive head organs: the tongue, eyes, nasal openings and heat-sensing pits. Other snakes, such as those that kill prey by constriction, are better equipped to endure assault by struggling victims.

By releasing their prey, rattlesnakes run little risk of losing their meal. They have been called the bloodhounds of the snake world for their ability to follow a trail. Instead of sniffing along the ground, snakes pick up clues by flicking their tongues in and out of their mouths. The tongue carries odor particles from the air to sensory organs located in the roof of the snake's mouth.

A rattlesnake's interest in following a trail is primarily dependent on whether it has recently struck and envenomated prey, the scientists find. A snake just lying in its cage generally flicks its tongue fewer than two times per minute. If the snake is shown a mouse, out of reach, or exposed to mouse odors, the rate of tongue flicking remains low. But if the snake is allowed to strike a mouse, it begins flicking its tongue

as fast as 80 times per minute. Even striking an odorless, cotton model of a mouse increases tongue-flicking appreciably. Chiszar says, "Everyone who works on rattlesnakes is struck by, I mean impressed by, the change that comes over a snake that has struck."

The behavioral change in the rattlesnake after it strikes is a long-lasting condition. If scientists remove a mouse after the snake strikes it, the snake will search fruitlessly for hours. If the snake is disturbed after the strike, so that it engages in defensive behavior, it will resume its search after the danger has passed. A snake that has stopped searching will renew its quest if presented with mouse cues, visual, chemical or thermal, as long as five hours after it has struck.

To study rattlesnakes' tracking under laboratory conditions, the Colorado scientists make a trail of their own. They take a dead mouse, killed by snake venom, and drag it over a line describing a meandering pathway from one end of the snake's pen to the other. They find that the searching snake moves along the trail slowly and methodically, rarely moving its head more than 2 centimeters from the line. Approximately 75 percent of its tongue flicks are directed at the trail. If a snake has not struck a mouse prior to being exposed to the trails, no trailing behavior is observed.

The action of striking turns on a rattlesnake's search behavior, and similarly swallowing a rodent turns it off. "It's not just a matter of diminished motivation because there's already one mouse in its belly," Scudder says. The scientists demonstrated this by allowing a snake to strike a second mouse just 15 minutes after eating the first. The snake began a second search that lasted almost two hours. Chiszar says, "Eating doesn't wipe out the motivation. It resets the snake."

Chiszar hypothesizes that the action of striking a mouse creates, or recalls, an image in the snake's brain. This "search image" not only directs the snake to seek a mouse, but to seek a mouse that contains the snake's venom.

In experiments to test snakes' preference for envenomated rodents, snakes after striking were presented with two dead mice. One had been struck by another snake of the same species, the other had been killed by the scientists. The snakes spent significantly more time investigating the envenomated mouse and, when permitted, preferentially ingested it. Even if only one mouse is presented to the snake at a time, it will flick its tongue more if the mouse is envenomated.

Preliminary evidence indicates that a snake not only prefers an envenomated mouse, but it prefers to follow an envenomated mouse's trail. Chiszar and colleagues point out that under natural conditions two mouse trails will be available to a snake that has just struck. One is the trail along which the mouse wandered into the snake's striking range. The other is the trail of the fleeing, envenomated mouse. "Rattlesnakes have probably been under strong selective pressure to select the latter trail," Chiszar says.

Another role of the venom may be to orient the snake to swallow the mouse head-first. It takes a snake much longer to injest a mouse if it attempts the opposite orientation. David Duvall, now at the University of Wyoming, Scudder and Chiszar reported in ANIMAL BEHAVIOR (1980, Vol. 28, pp. 674-683) that rattlesnakes preferentially direct their tongue flicks to exudates of the head end of a dead envenomated mouse, but they don't distinguish between the ends of a mouse killed without venom (SN: 6/16/79, p. 394).

A rattlesnake's attention to an envenomated mouse leads the scientists to new thoughts about snake venom. "Venom is extremely complicated stuff. Some components don't have any known function," Chiszar says. "Our findings suggest a revolutionary way to think about venom. It not only kills, but it changes the prey." He proposes that rattlesnake venom has evolved under two tiers of selective pressure. In addition to killing, aspects of the venom have evolved to help snakes detect the trail and orientation of prey.

Experiments using European vipers, instead of rattlesnakes, have led Chiszar to consider the evolutionary origins of the strike-and-search predatory strategy. Swedish investigators Claes Andren and Goran Nilsen examined the behavior of four species of viper in experiments styled after the Colorado observations on rattlesnakes. Like the rattlesnakes, vipers show a dramatic change in behavior after being allowed to strike a mouse. Striking increased the rate of tongue flicking and the snakes' interest in searching for trails. "This trait is not unique to rattlesnakes, it is probably characteristic of the whole family Viparidae," Chiszar says.

While the strike-initiated search behavior has been observed in at least four viper species and 23 species of rattlesnake, some species show a more dramatic change than do others. Chiszar suspects the difference relates to the customary diet of a species. Those species that feed primarily on rodents are most likely to employ strike and track predation. Others, which live on rocky terrain where lizards are more abundant, would do better to hold onto their less formidable and more easily hidden prey.

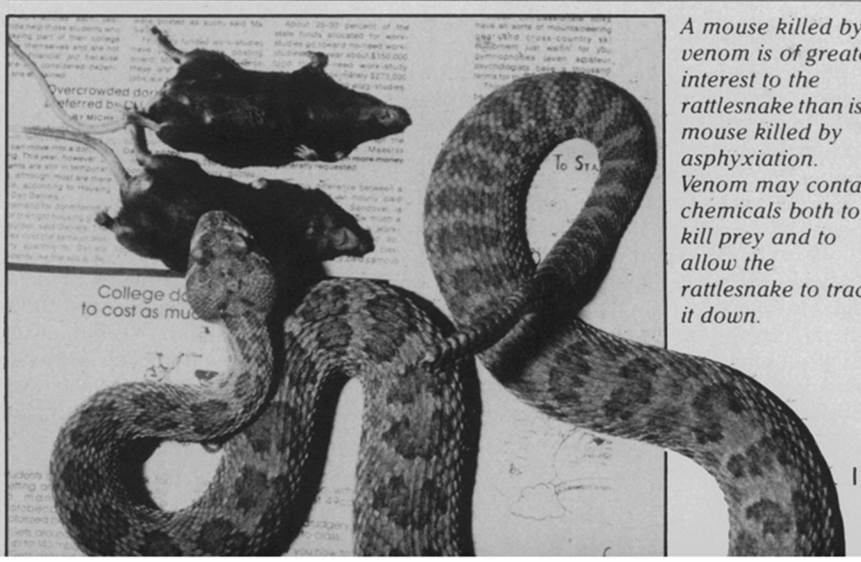
Chiszar proposes that the common ancestor of the modern vipers and rattlesnakes was committed to eating rodents and was appropriately equipped with a big head and muscular jaws. These would make it powerful enough, like a modern Gaboon viper, to hold onto a rodent after striking it.

"This method of predation works great, except for the babies," Chiszar says. A baby snake must feed itself from the very start, and it is not strong enough to hold onto a struggling rodent. Chiszar hypothesizes that the babies of the ancestral snake used a strike-and-search strategy, as current baby Gaboon vipers seem to do. During evolution some snakes prolonged the baby strategy, until it was retained throughout life. "If the behavior remains the baby strategy, then adults don't need massive heads," Chiszar says. This behavioral evolution parallels the retention of juvenile physical traits, a recurring theme (called neoteny) in studies of animal evolution.

Scudder says that their experiments have been criticized because they do not take place in a more natural environment. Most of the snakes used had been housed individually in captivity for at least two years and fed mice weekly. The scientists consider their subjects typical of long-term captive snakes. Scudder argues that the dramatic predatory behavior is so deep-rooted that it is maintained even under captivity.

The new ideas about snake evolution, venom and search images challenge the scientists who have been observing snake behavior for many years. It forces them to rub shoulders with paleontologists, chemists, neurophysiologists and even cognitive psychologists. "Right now we have a million doors to start going through," Chiszar says.

And with each new door, they confirm a view expressed by Sir Francis Galton in 1883: "The monkey may have a horror at the sight of a snake, and a repugnance to its ways, but a snake is just as perfect an animal as a monkey." □



Kent Scudder

A mouse killed by venom is of greater interest to the rattlesnake than is a mouse killed by asphyxiation. Venom may contain chemicals both to kill prey and to allow the rattlesnake to track it down.