

Who's Dying for Sex?

Scientists refine the calculation of when it's really worth it

By SUSAN MILIUS

Maydianne Andrade still remembers the first time she saw a true femme fatale—and her willing partner—in action.

Andrade, then a graduate student at the University of Toronto, had placed a male and a female Australian redback spider together and settled back to watch. As in many spider species, the two made an odd couple, she acknowledges: "The female's about the size of a marble, and the male's a rice grain."

Just a year before, in 1992, New Zealand researcher Lynne Forster had published the first description of mating redbacks. Her observations suggested that this desert species presents a real-life example of what had been only a tentative prediction at the extremes of mating-behavior theory.

Males of some other species, such as the redback's North American relative the black widow, occasionally lose their lives in close encounters. Before this report, however, there wasn't a clear example of males that encouraged females to chew them up. Forster's description of redbacks suggests that males don't just risk death to mate; they beg for it.

The fatal courtship can take quite a while, Andrade found. "The male moves around the web, making what seem to be vibrational signals for several hours," she remembers. "Then, he's climbing onto the female's abdomen and climbing off—basically there's a bunch of false starts. I was watching, and it's 6 hours later, and I was thinking, 'This is never going to happen.'"

After 7 1/2 hours of fidgeting, Andrade saw the spectacle that Forster had described. "When it finally happened, it was incredible," she recalls.

Like many other male spiders, a redback can fertilize females with either of a pair of structures that uncoil from his head. Called palps, they look like boxing gloves, according to Andrade.

The male inserts a palp into one of the openings of the female's reproductive system—he has a choice of two abdominal targets. Then, using the inserted or-

gan as a pivot point, he flips around to dangle close to her mouth parts.

"They end up in this posture where his abdomen is above her fangs. She's piercing his abdomen and releasing digestive enzymes, and you can see his legs pulsing in time with sperm transfer," Andrade says. "In the building where I was working, I remember late at night running around looking for someone to tell."

Since then, she's found many people to



A female redback spider (left), an Australian relative of the black widow spider, will not attack a male (right) unless they're mating. Some 65 percent of males fail to survive a sexual encounter.

tell, as she and other researchers have worked to refine the understanding of the pros and cons of sexual cannibalism. Now at Cornell University, she's documenting the male's side of the story, starting with what benefits might make it worthwhile to sacrifice his life for 10 to 25 minutes of sex. Recently, she's been studying whether he has any romantic future to lose when he flips onto those fangs.

Other researchers have looked at similar questions of mating theory in another legendary system, that of praying mantises and their relatives, as well as in spiders of lower celebrity status. As Andrade puts it, "Some of the most powerful tests of a theory are at the extremes."

"At one time I tried to get the emotion out of 'cannibalism,' but it's a word that just won't go away," sighs Gary Polis of the University of California, Davis. His 1981 review of

scorpion cannibalism, or as he called it, "intraspecific predation," raised the question of whether males are just victims or whether evolutionary pressures push them toward collusion in their own demise. Mates eat mates all over the animal kingdom, but sorting out which selection pressures act on whom has been difficult, Polis says.

When Andrade first saw the redback mating, she already knew that theorists like Ruth Buskirk of the University of Texas at Austin and her colleagues had predicted that suicide during sex could be adaptive.

"The theory predicted it in the extreme, but to many scientists it seemed really unlikely that it would ever be that extreme," Andrade says. In 1984, Stephen J. Gould of Harvard University, for example, wrote an essay dismissing the possibility that evolution could ever make sexual suicide the best course.

To see if the spiders really embody this extreme phenomenon, Andrade studied benefits that a male might reap by offering himself as a snack. In nature, 65 percent of redback matings end with a dead male. In theory, the unlucky suitor might serve as a nutritional boost to give his offspring a head start in life, but at 1 to 2 percent of the female's body size, he hardly even counts as a square meal.

Comparing cannibalistic matings with less traumatic ones, Andrade found no significant difference in egg weight or number of eggs per sac.

She did notice brisk competition among males in the wild. The several hundred eggs that a female lays in one egg sac don't necessarily have the same father. Providing dinner might give a male some kind of edge in the contest for egg share, Andrade speculated. So, she offered laboratory females two consecutive partners and compared their success.

The trick to fathering more eggs seemed to be spending more time fathering. And the trick to prolonging that transfer of sperm seemed to be getting eaten. "A female allows the mating as long as she's preoccupied with consumption," Andrade says. The mate-eating females chowed down just seconds after the male dangled his body over her fangs. Her mouthparts kept moving throughout the mating.

Not infrequently, after transferring the sperm from one palp, a male manages an encore with the same female. After a second courtship that lasts about 2 minutes, he inserts the other palp and again somersaults over her fangs. Even males that are "visibly partially digested" have managed this, Andrade reports.

"The interesting thing is that cannibal-

ism doesn't seem to interfere with sperm transfer," she says. A stripe of tissue around a male cinches his abdomen as he starts mating, and Forster speculated that the constriction helps to maintain enough pressure for the hydraulics of mating even as the lower part of his body gets eaten away.

In one experiment, Andrade clocked sperm transfer of five cannibalistic matings. The median was 25 minutes. However, 12 other males, who survived their procreative encounter, managed only around 11 minutes of mating. Because of that difference, cannibalized males essentially fathered twice as many eggs as an uneaten male.

A mate that turns into dinner enjoys another perk. "It means the male won't be as likely to be cuckolded," Andrade says. In nine cannibalistic pairings, six of the females rejected a second male entirely. Yet in 23 survivable encounters, 22 of the females accepted the attentions of a subsequent male.

The dynamics of this whole system reminds Andrade of katydids mating. Males don't insert their own body parts but rely on a stick-on sperm packet covered with a tasty dollop of protein. As soon as he attaches the packet to the base of a female katydid's abdomen, it starts delivering sperm. She also immediately bites at it, getting the protein at first. When she finishes that, she takes another helping, this time the sperm packet itself. Thus, the bigger that first protein blob, the longer it keeps her occupied and the longer the packet delivers sperm.

Many male arthropods give food to prospective mates, Andrade pointed out in 1996, when she published her first spider death-benefit analysis. As she puts it, "Male facilitation of cannibalism probably evolved through sexual selection as the most extreme mating gift."

Since then, Andrade has been studying whether a male loses all that much, sexually speaking, if he dies during his first mating. If his prospects look slim enough for the future, then suicide might not be that much of a reproductive loss.

Andrade had noticed that even when she provided a refuge for males who survived sex, five of seven didn't bother to leave the female's web and eventually died of old age. Also, Andrade discovered that the tip of each insertable organ of male redbacks breaks off after a single use, raising questions about future function.

Back in the field in western Australia, Andrade explored related factors, such as whether a male has a reasonable chance of making it alive to a second female's nest. Because so few adult males

seem to make the attempt, she monitored youngsters leaving their juvenile webs to search for a female.

It wasn't pretty. More than 80 percent of them perished before reaching another web. Small animals, they fell prey to other spiders. "And then there are ants—that's the most gruesome," Andrade says. Twice she saw a young male blunder into a train of foraging ants, which clustered around, ripped the spider's legs off, and carried it away for dinner.

Dehydration and starvation also take their toll on the journey. Spiders get their water from prey, and a spider away from a web is a spider away from food and drink, she explains.



A redback male, dwarfed by the female's huge abdomen, starts to climb into position for risky business. Once he starts the actual sperm transfer from an organ on his head, he will flip the rest of his body over to dangle in front of her fangs.

Negotiating such a perilous journey probably would do a once-mated male little good, speculates Andrade. Even if he reaches a second female's web, Andrade doesn't think he'd be able to accomplish much.

In the laboratory, she presented males with two well-fed females in succession. Everything went well for the first mating; thousands of spiderlings resulted. For the second mating, everything looked the same, Andrade says, but none of the eggs hatched.

After their first mating, redback males are "functionally sterile," she and Erin Banta, also of Cornell, reported in Lewisburg, Pa., at the 1999 annual meeting of the Animal Behavior Society. She warns against jumping to conclusions as to why, however.

"It could be behavioral," Andrade notes. As in many other male spiders, redbacks' palps have no direct connection to their gonads, and males fill them by ejaculating onto a web and dipping the palps into the puddle of sperm. Andrade hasn't seen any evidence of redback males attempting refills.

Despite the mysteries remaining, Forster and Andrade's redback-spider observations have convinced Polis, among others, that the predictions of male complicity were correct. Some males really do

seem adapted to sacrificing themselves.

"At one point, the female releases him, and he comes back to her mouth," Polis points out. "That's as clear as it's going to get."

Suicidal suitors are not what Michael R. Maxwell found when he looked into the private lives of praying mantids.

Maxwell, then at the University of California, Davis, started combing the locale in the early 1990s for bordered and Mediterranean mantids. He knew the laboratory tales and naturalists' anecdotes: A voracious mantid female beheads her mate without diminishing his performance.

"I was pretty much of a doubting Thomas," Maxwell remembers, and he wanted to see what happens in the wild.

What he observed justified the stereotype, reports Maxwell, who recently moved to the University of California, San Diego. Females killed the males about 20 percent of the time. "The headless males do what the books say they do," Maxwell notes. In the bordered mantid, a male with his head still attached mates for 4 hours on average, but Maxwell observed headless encounters that lasted up to 24 hours.

Female mantids do not dwarf the males the way female redback spiders overshadow their mates.

A bordered mantid female might grow to 2 1/2 inches compared with the male's 2 inches. Yet the females can still overwhelm and kill a male. They have more musculature and longer front legs with longer spines. "In boxing terms, the females have a longer reach," says Maxwell.

His fieldwork gave him considerable sympathy for a male's courtship plight. Females are normally placid, but "I would try to do obnoxious things like measuring them or marking numbers on them," he says. A female's attack is "about as painful as getting a fishhook caught in your thumb," Maxwell says. He started wearing heavy cotton gloves, much like a falconer.

Another field study of a mantis, the celebrated praying mantis species in Europe, came out in 1992. It reported findings similar to the ones Maxwell was accumulating. This species also cannibalizes mates in the wild, said Sue Lawrence, now of the Scottish Natural Heritage in Aberdeen.

In the California mantids, Maxwell didn't observe overt suicidal behavior by males, he reported last year. Unlike redback spiders, male mantids, at least those still attached to their heads, approached females very, very carefully.

Maxwell often saw males dash toward a female from the rear, staying away from

the formidable killing apparatus of her front legs. Males usually dismounted with getaway leaps or aerial takeoffs. At other times, males crept toward a mate, freezing if she looked in their direction. "It was like Woody Allen courting Sharon Stone," Maxwell says.

Even if he didn't see evidence for overt suicide, he still checked for possible benefits of male sacrifice. Male redback spiders are so small, "they're popcorn" to the female, he says, but a male mantid makes a substantial meal.

A 1988 study by Tim R. Birkhead, at the University of Sheffield in England, and his colleagues had reported that females that ate their mates produced larger clutches of eggs. Birkhead's team, however, had limited the females' food. Females on a more generous diet, Maxwell found, would accrue no reproductive benefit by eating the father of their offspring.

While the theory that suicidal males equal nutritional boosts for female mantids remains controversial, Maxwell leans toward the view of sexual cannibalism proposed in 1997 by Göran Arnqvist of the University of Umeå in Sweden and Stefan Henriksson. Studies of fishing spiders led them to their basic conclusion: Nobody benefits.



A female bordered mantid, the larger of the pair, has knocked the head off a male (on her back) but not diminished his performance.

Or rather, nobody benefits as an adult.

Instead, cannibalism is just an accidental side effect of the evolutionary pressure for female rapacity. The females that start life with a strong tendency to attack first, fast, and furiously get more food and grow larger. Once they're adults, that extra size gives them a major advantage over their daintier sisters in producing more offspring.

A tendency for adults to shred their suitors is nothing more than the aftereffects of a bug-eat-bug childhood, the researchers suggest.

Arnqvist and Henriksson demonstrat-

ed the reproductive benefits of youthful female voraciousness in their fishing spiders. Although females of this species nail a mate from time to time, males issue no invitations to do so.

One biologist suggests sexual cannibalism should be viewed in terms of the more general phenomenon of one organism eating another of the same species. David W. Pfennig of the University of North Carolina at Chapel Hill reviewed cannibalism across many species and can list a variety of both costs and benefits.

As a general phenomenon, cannibalism is widespread, according to Pfennig. Insects, spiders, fish, mammals—lots of species are taking a bite of their neighbors. On the upside, cannibalism is a handy way to get nutrition. Presumably, a conspecific meal has precisely the compounds that the diner needs.

Unfortunately, that food probably also has precisely the diseases and parasites that can attack the eater.

The disease risk is bad enough when eating a youngster (SN: 5/19/98, p. 295), as many cannibalistic species do. Pfennig, however, predicts that an animal chomping on an adult will pick up even more pathogens.

Therefore, even for the survivor, cannibalistic mating, he worries, could be the ultimate in unsafe sex. □

Astronomy

Gamma-ray bursts: Going the distance

Astronomers may have identified a new and quicker way to determine the distance to those mysterious flashes of energetic radiation known as gamma-ray bursts. If the finding proves correct, scientists could use bursts to probe some of the earliest events in the cosmos.

Although Earth-orbiting satellites record a burst popping off at least once a day, astronomers have measured the distance to only a handful. That's because scientists must find the fleeting, visible-light counterpart to the gamma rays and then determine its redshift—the amount by which the expansion of the universe has shifted the light to redder, or longer, wavelengths.

Two researchers have now closely examined the six bursts for which astronomers have measured distances. Enrico Ramirez-Ruiz, now at the University of Cambridge in England, and Edward E. Fenimore of the Los Alamos (N.M.) National Laboratory calculated the intrinsic brightness of each flash. They found that the most luminous flashes flicker the most, while those that are intrinsically dimmest vary the least.

If that pattern holds true, scientists would have a new way to determine distance. They would simply compare the luminosity of a burst, as indicated by the flickering, with the observed brightness, which declines as the inverse square of distance.

Ramirez-Ruiz and Fenimore presented their findings last month at the annual gamma-ray-burst symposium in Huntsville, Ala. If the link between flickering and brightness proves reliable, a burst could serve as a new yardstick for measuring distances to other objects. Because bursts are bright enough to be detected from far away, the yardstick would allow astronomers to measure distances deep in space and far back in time, Fenimore says.

"The correlation looks good, but there are still very few data points," says Stan Woosley of the University of California, Santa Cruz.

At the conference, Jay P. Norris of NASA's Goddard Space Flight

Center in Greenbelt, Md., presented evidence for another type of distance indicator. Norris finds that the more luminous the measured burst, the smaller the lag time between its high-energy and low-energy photons. —R.C.

FAME to gaze at the stars

Howdy neighbors! If all goes according to plan, astronomers 5 years from now will be getting a lot more familiar with 40 million of the closest stars in our galaxy.



Artist's depiction of the new spacecraft.

A new spacecraft, set for launch in 2004, will chart the position, velocity, brightness, and distance of Milky Way stars up to 8,000 light-years from the sun. That reach is 25 times that of any previous mission. By measuring the location of the stars 20 times as accurately as any other craft has, FAME will search for other solar systems and improve estimates of the size and age of the cosmos. It will also

help elucidate the nature and distribution of the invisible material, called dark matter, that pervades the universe.

NASA announced funding for the 5-year mission, known as FAME (Full-sky Astrometric Mapping Explorer), last month.

Searching for telltale wobbles in the motion of stars as they move across the sky, FAME will deduce the presence of unseen planets and failed stars known as brown dwarfs. Because the craft can find planets that orbit at great distances from their parent stars, it may uncover evidence of entire planetary systems, rather than just single, massive planets that tightly circle their parents.

To scan the sky, FAME will shift position using a lightweight solar sail rather than rocket fuel (SN: 8/21/99, p. 120). —R.C.