Uniformity of prey can yield a spider-eat-spider world

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A Husker research team collected 605 wolf spiders of eight species, including Hogna baltimoriana (pictured), in an effort to better understand how their diets might vary or overlap. The study revealed that, when the diversity of their mutual prey is lacking, the eight-legged predators may turn to eating each other. Credit: Stella Uiterwaal / Scott Schrage

A limited menu of prey may weave a tangled food web by emboldening wolf spiders of multiple species to dine on each other and even

cannibalize their own, says a study from the University of Nebraska–Lincoln.

Ecologists have long known that predators with otherwise-similar diets can coexist by effectively divvying up the food sources of a community to ease competition and, ideally, leave enough prey for everyone. But analyses of wolf spider species in Nebraska suggest that when the diversity of their mutual prey is lacking, the eight-legged predators might instead maintain an ecological equilibrium, in part, by eating one another.

A decline in the variety of prey should spell bad news for weaker predators, which are then put into more direct competition with their stronger counterparts, said Stella Uiterwaal, who led the study while earning her doctorate at Nebraska. Predators that do manage to at least occasionally kill and eat their more competitive peers, though, could benefit in a couple of ways that collectively act as an "equalizing mechanism," she said.

"Some of your diet is now coming from that other predator, instead of the shared prey that you're competing for," said Uiterwaal, now a postdoctoral researcher at Washington University in St. Louis. "And you're also reducing the population size of that better predator, so you have fewer of them to compete with."

The study originated from what Uiterwaal observed while studying and later teaching at Cedar Point Biological Station, a lake-adjacent field site in southwest Nebraska. It was there that she and some colleagues, including doctoral adviser John DeLong, realized that the wealth of local wolf spider species seemed to be defying an ecological principle by occupying more or less the same niche of the same habitat.

"We noticed that there are so many different wolf spider species that all

seem to be doing the same thing," Uiterwaal said. "And there's this classic ecological idea that species can't be doing the exact same thing. If that happens, they won't be able to persist in the environment for very long."

So the researchers spent two summers collecting specimens of eight wolf spider species and their potential prey. Wanting to get as accurate a count of that prey as possible, Uiterwaal took to plopping hollow wooden boxes onto unsuspecting plots of earth, then using a customized vacuum to suck up every ground-bound and flying insect within. Many of the captured critters also appeared on the wolf spider menu: flies, grasshoppers, crickets, butterflies, moths, aphids and, yes, other spiders.

"You name it, and they'll eat it," Uiterwaal said. "We've even seen spiders out there eating toads."

Still, cataloging the actual diets of 605 wolf spiders would require more sophisticated techniques. One of those techniques involved analyzing the DNA of the spiders' digested food in search of barcodes: DNA sequences unique to each type of prey the spiders consumed. Uiterwaal also applied a mathematical method—one she developed—that helped the team ascertain how much of each prey a spider had consumed.

Counter to the team's expectations, the diet of any one wolf spider species mostly resembled the others.

"All these spiders are essentially eating the same things—which I wasn't expecting, because you do find these spiders in slightly different places, and they look different, and they have different behaviors," Uiterwaal said. "You would expect that to reflect in their diet somehow. But it turns out that they overlap a lot."

Their discovery did leave open the possibility of a spider-eat-spider

world. Just one problem: Given the challenges of distinguishing among the DNA of wolf spider species, Uiterwaal knew the barcoding would struggle to capture any spider-on-spider predation.

The Husker team spots a wolf spider on one of its nightly expeditions to collect the nocturnal predator. Credit: Stella Uiterwaal

To account for it, she and the team also analyzed the ratio of lighter vs. heavier nitrogen atoms, or isotopes, in the tissue samples of every wolf spider they collected. Because heavier nitrogen atoms persist and accumulate through the food web, predators tend to contain more of those isotopes than do their prey—meaning that researchers can use them to estimate an animal's ranking in a local food web.

It also meant that, if wolf spiders were regularly eating each other, the

isotope analysis would likely rank them higher on the food web than the barcode-based method did. That's exactly what Uiterwaal and her colleagues found. In fact, the average ranking far surpassed what the team anticipated. In many food webs, plants rank as a 1, plant-eating animals as a 2, and the predators of those herbivores as a 3, with the predators of predators coming in at a 4. Often, DeLong said, that's about as high as a terrestrial food web seems to stretch.

The average ranking of a wolf spider species at Cedar Point Biological Station? Nearly a 6. One particular spider rated an 8.5—an especially lofty perch for a predator that, as Uiterwaal put it, "is not exactly what anyone would call the top of the food chain."

"It implies this level of complexity and predation that is probably really important in determining how the whole system works," said DeLong, associate professor of biological sciences at Nebraska. "Instead of thinking about these short food chains where everything is very vertical, it's really this recursive thing where everybody's eating everybody, kind of compounding on itself.

"The implication for how the food web is structured is really, really different than what we would have imagined going into this."

The team was in for yet another surprise. Uiterwaal decided to analyze how much certain factors—the sex and size of a predator, the characteristics of its environment, the abundance and diversity of its prey—might influence the likelihood of one wolf spider preying on another. Prior lab-based experiments had suggested that all of those variables might be playing some role. But the team found that only the variety of prey, or the lack thereof, was associated with the wolf spiders attacking their own.

Though any number of reasons could help explain the divergence,

Uiterwaal said the disparities between the lab and the wild are probably a good place to start.

"My guess is that foraging in the field is just so different compared to foraging in a Petri dish in a lab, where you don't have all these other things to worry about," she said. "You're worried about getting eaten by other spiders or other predators (in the wild). Maybe you have parasites that you're dealing with. You're also trying to find mates, find areas that are the right temperature for you. You have all these other things that are going on and that may be drowning out these effects that we see in the lab, when we're just playing with one specific variable.

"The fact that these expectations we have from the laboratory are not (necessarily) going to translate well into complex, real-life situations—that's not just about spiders. That's going to be true for any system."

DeLong credited his former advisee, whom he called a "true champion," for carrying out such an ambitious study and managing to reveal nuances that lab work might miss.

"It did pull together just really different kinds of data," he said, "to paint a different kind of story than anybody had told before."

The findings are published in the *Journal of Animal Ecology*.

More information: Stella F. Uiterwaal et al, Intraguild predation is increased in areas of low prey diversity in a generalist predator community, *Journal of Animal Ecology* (2023). DOI: 10.1111/1365-2656.13901

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