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Ballistic high-powered spider webs overcome dangerous prey defenses

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Predator–prey interactions are a major selective force shaping kinematic performance, driving the evolution of extreme speed and power in animal movements[1]. Small animals such as mantis shrimps, trap-jaw ants and slingshot spiders achieve some of the fastest biological movements to capture prey by using latch-mediated spring actuation mechanisms that produce power outputs several orders of magnitude greater than muscle alone[2–4]. These known power-amplified systems are actively controlled by the predator and act on non-specific prey. Here, we report a unique spring-actuated snare in the Australian ballista spider *Propostira* sp. that is selectively triggered by the defensive behavior of a specific prey — the green tree ant, *Oecophylla smaragdina*. We argue that the prey specialization of the ballista spider has driven the evolution of exceptional snare performance.

Propostira sp. (Theridiidae) was found on trees close to the foraging trails of *O. smaragdina*, a locally abundant, arboreal, highly aggressive and territorial species[5]. On trees occupied by these ants, the ballista spider took refuge during the day on the underside of leaves and ventured out from their refuge 30 minutes after sunset (Figure 1A,B; n = 15). Upon leaving its refuge, the spider began an exploratory phase during which it descended on a silk line to substrates up to 50 cm away. When it landed on a suitable substrate, it laid down an anchor point and returned to the core web by laying a tension line. Repetition of this process resulted in a fan shaped array of 15–60 tension lines that were bundled close to the substrate (Figure 1B and Video 1 at https://bit.ly/4cKtVGT) where the lines were laid out in a scaffold in the shape of a small cone (Figure 1B,C). In the final phase, the cone scaffold was densely wrapped with a thinner type of silk (Figures 1C and S1 and Video 2 at https://bit.ly/4cKtVGT). The spider then retreated to a position several centimeters above the cone. Very soon after the cone was wrapped (5–55 seconds; n = 12), *O. smaragdina* ants were attracted to it (Figure 1E).

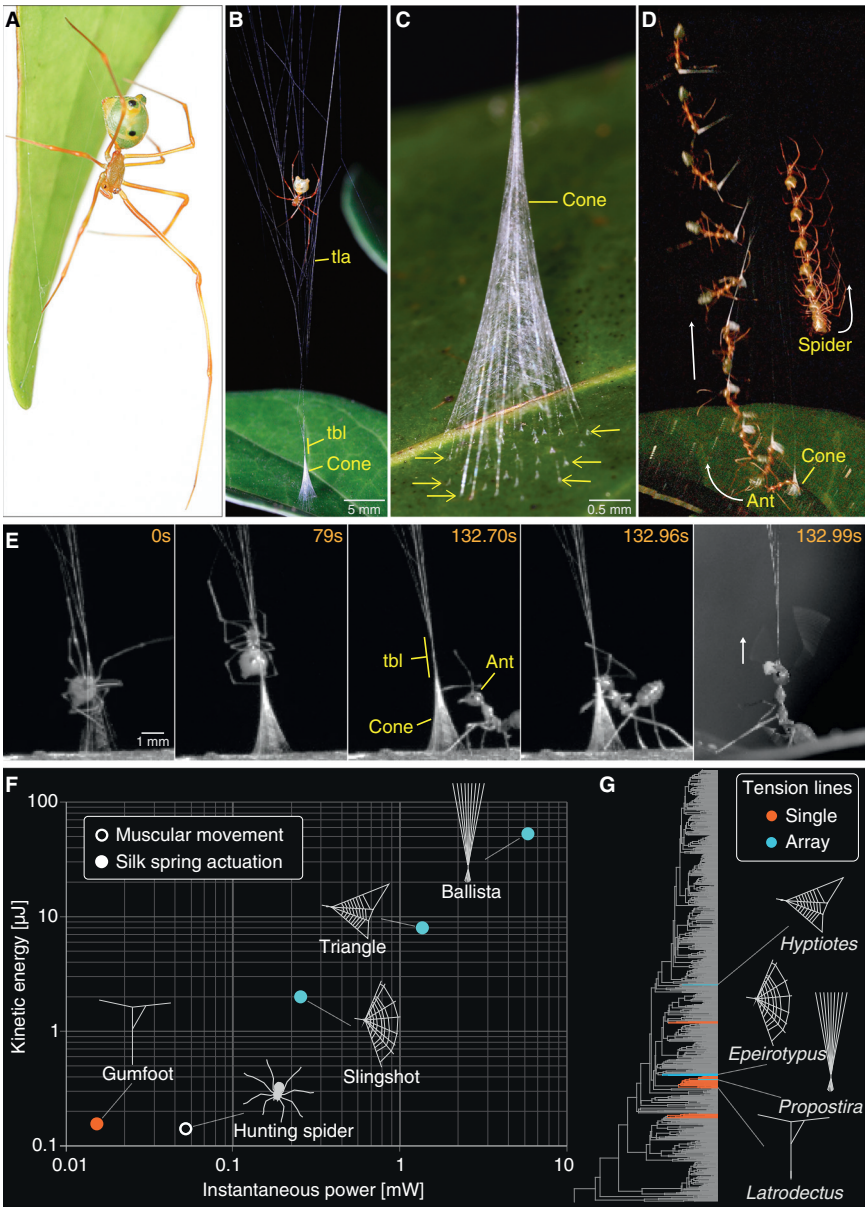

Figure 1. Power-amplified snare of the ballista spider lures and hauls up green tree ants.
(A) Ballista spider (*Propostira* sp.) rests underneath a leaf during the day. (B) Ballista spider waits for the prey in its web at night. (C) Magnified view of the silken cone that acts as a lure with arrows highlighting cone attachments. (D) Overlaid high-speed video frames illustrate the trajectory of the hauled ant. Images are chosen to best represent the ant being pulled up and are not at regular time intervals. Arrows show the direction of movement of the ant and the spider. See Videos 1–3 at https://bit.ly/4cKtVGT. (E) Left–right: capture sequence: 0s, spider starts to wrap the cone; 79s, fully wrapped cone and the spider begins to retreat upwards to wait; 132.70s, green tree ant, *Oecophylla smaragdina*, is attracted to the cone; 132.96s, the ant lunges and bites the cone; 132.99s, the cone is disconnected from the substrate and the ant holds the silk of the collapsed cone in its mandibles before being hauled up. (F) Comparison of average kinematic performance of spider prey capture strategies (details in Supplemental information; data shown include this study and[3,4,9,10]). (G) Spider phylogeny with colored branches indicating lineages with silk snares utilizing elastic energy storage (highlighted genera correspond to systems shown in panel F). tbl, tension bundle line; tla, tension line array.

Within milliseconds after probing the cone with its antennae, the ant displayed aggressive behavior, elevated its gaster, and bit the silk cone (Figure 1E). The ant's aggressive behavior is similar to that exhibited towards non-nestmates[5]. The biting destabilized the cone and detached it from the substrate within 42.12 ± 16.09 ms (n = 5), leading to a rapid contraction of the tension lines. While still holding the cone with its mandibles, the ant was pulled off the substrate and propelled into the core web (Figure 1D,E), reaching distances of up to 28.19 cm from the substrate (mean ± s.d. = 13.37 ± 8.57 cm, n = 5), with peak accelerations of 1367 m/s² (mean ± s.d. = 1108.96 ± 166.14 m/s²; n = 5) and maximum velocities of 4.36 m/s (mean ± s.d. = 3.83 ± 0.68 m/s, n = 5, Video 3 at https://bit.ly/4cKtVGT). The spider moved only after the ant had been hauled up and was no longer in contact with the substrate. The spider then moved upwards on the web and waited until the ant was fully entangled before approaching to wrap it in silk. In one of 12 instances, the ant triggered the snare but was not hauled up; without the added mass of the ant, the snare accelerated at 4732.89 m/s² and reached a maximal velocity of 13.47 m/s.

The maximal instantaneous power density of the snare's spring actuation was estimated at 11.73 MW/kg (mean = 1.02 MW/kg; Table S1 and Supplemental information), 3.4–4.5 orders of magnitude higher than muscle actuation. Achieving the observed maximal acceleration requires a silk prestrain of 0.9–1.5% (Supplemental information) that is on average below the elastic limit of spider dragline silk (yield at 1.5–3.2% strain, n = 4). The estimated kinetic energy density (mean = 9.34 kJ/kg; maximum = 78.17 kJ/kg) exceeds that reported for other spring-actuated spider webs, including the slingshot spider[3,4], that have evolved independently (Figures 1F,G and S1). These results indicate that the architecture of the ballista spider's snare enables exceptionally high instantaneous power amplification by storing elastic energy in the silk and rapidly releasing it, analogous to a loaded spring (Figure S1).

Such exceptionally high instantaneous power amplification of the ballista spider's snare has likely evolved to rapidly transport captured individual ants far from the vicinity of the ant trail and nests. *Oecophylla* ants are equipped with large adhesive pads on their feet that create forces of over a hundred times their body weight[6]. The contraction of the tension bundle line must overcome these forces in addition to the ant's weight, a potential explanation for the requirement of additive forces of many tension lines in this spider's snare. The observed high accelerations may be a by-product of this force maximization due to the rapid energy release of dragline silk in its elastic phase.

The snare of the ballista spider appears to be the only known web to exhibit a strong preference towards capturing a single prey species. Across all our observations (n = 35), *O. smaragdina* were the only ants captured by the ballista spider, revealing an apparent prey specialization. These ants are abundant (up to five million workers in a single arboreal nest), making them a reliable resource all year round. We tested this prey exclusivity by releasing other nocturnal ant species present on the same tree (*Camponotus* sp., *Crematogaster* sp., *Iridomyrmex* sp.) near the cone while the spider remained in its waiting position. All three ant species walked close to the cone but did not react to it. This suggests that the spider may add pheromones to the cone during the final construction stage (wrapping) to specifically lure *O. smaragdina* workers and induce aggressive attack, thereby triggering the ballistic snare. Spiders are indeed known to use pheromones to attract prey[7], such as moths and ants, or for aggressive mimicry to shelter and forage inside *Oecophylla* nests[8]. Given the species-specificity of the ballista spider's snare, identifying the pheromones deposited on the cone would be a key next step in understanding this prey specialization.

Unlike most ant predators, the ballista spider overcomes the challenge of isolating individual ants from a highly aggressive group by deploying a ballistic snare triggered by the prey itself. This power-amplified trap highlights how extreme ecological specialization can drive the evolution of exceptional biomechanical performance.

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DECLARATION OF INTERESTS

The authors declare no competing interests.

SUPPLEMENTAL INFORMATION

Supplemental information including one figure, one table, experimental procedures and author contributions can be found with this article online at https://doi.org/10.1016/j.cub.2026.04.066.

A video abstract is available at https://doi.org/10.1016/j.cub.2026.04.066#mmc2.

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