

Bombardier beetles: Superheroes of the insect world

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An Orb-weaver spider sits in its web, waiting for its free food delivery. Suddenly, it feels vibrations in its web and immediately knows what's up: a struggling beetle just got caught in the predator's trap. *Dinner's ready!* It quickly approaches, seizing the chance to devour a new victim. As the spider attacks, though, the meal reveals a secret weapon. With a loud 'pop', the beetle's bum explodes, firing scorching heat and noxious chemicals right at the surprised spider's face. Not a fan of hot food, the predator hastily retreats, leaving the beetle to free itself of the pesky web and amble away. This was no defenceless prey; this was a badass Bombardier Beetle.

Thanks to being so diverse, beetles are an incredibly successful order of the insect family; almost one in four of all known species is a beetle¹. Many different beetle species use nasty chemical defences, but Bombardier Beetles and their biological 'cannons' take the idea of chemical warfare to a whole new extreme. Species in the genus *Brachinus* (called *Brachinini*) shoot a biochemical spray at a whopping 100°C² - the temperature of boiling water - and swivel their 'gun turret' to aim the spray at the attacker's face. This barrage can kill small predators such as ants, and freaks out bigger critters such as frogs and mice, leaving the beetle to slip away unnoticed. It's basically a superpower. Understandably then, very few predators are brave enough to take on a Bombardier Beetle more than once³.

Superhero origin story

Scientists have made big steps in uncovering the biological machinery behind the marvellous Bombardier Beetle's bottom. The internal chemical factory consists of four glands: two secretory glands that manufacture an explosive chemical cocktail, a reservoir that stores the cocktail and a reaction chamber that provides the ignition 'spark'. The chemicals in the cocktail are called hydrogen peroxide (what people bleach their hair with) and hydroquinones². As soon as the beetle feels threatened, it squeezes the reservoir's stored cocktail into the reaction chamber, whose enzymes make things blow up. As the chemical cocktail sloshes in, the enzymes immediately break the hydrogen peroxide down into oxygen gas and steam, blowing out of the beetle's 'nozzle' like air from an untied balloon. Moreover, enzymes breaking down hydroquinones into quinones heat up the mix to scalding temperatures. Thanks to these explosive events, a loud, sizzling steam erupts from the nozzle at the attacker, who at this point is seriously considering a change in cuisine.

Ready, aim, FIRE!

It's impressive just how precisely Bombardier Beetles, particularly the *Brachinini*, aim their jets. When attacked by Wolf spiders in one study, every shot by the Bombardier Beetles hit their attackers at full blast; they were even able to aim towards their own front legs⁴! This incredible aim is possible because they have an intricate bottom, comprised of a flexible abdomen and a fancy set of deflector plates directing the flow⁵. Thus, sneaking up on them from any direction would be a pretty bad idea.

Given the bizarre way that Bombardier Beetles superheat and expel the spray, it's natural to wonder: "Why doesn't this weapon fry the beetle too?". It turns out that these beetles have the insect equivalent of 'blast walls' surrounding their reaction chamber, so it's much easier for the vapours to surge through the nozzle rather than into the beetle³. Weirdly too, each blast of gas actually stops chemicals from entering the reaction chamber, shutting down the reaction. This happens roughly 500 times per

second – too fast to see with the naked eye – and possibly stops the reaction chamber from having a meltdown⁶. In fact, this makes the Bombardier Beetle's bum really more like a machine gun than a cannon.

Every beetle has its Kryptonite

Like all superheroes, the Bombardier Beetle isn't invincible. Some cunning Orb-weaver spiders dump extra webbing on the beetle's gun nozzle, immobilising it and rendering the artillery useless⁷. Blue Jays have also figured out that jiggling the beetle under their wings protects them from its spray and soon leaves it drained of ammunition⁸ – a bit like the local bully holding you in a headlock until you give them your lunch money. Worrying as this may be, vulnerability to these tactics is a price worth paying for otherwise being virtually 'predator-proof'.

Of course, scientists don't play around with Bombardier Beetles just for 'funsies'. There are real ways we can use this research to improve our own technology. For one, the hard-core ways that the beetle protects itself from its own chemistry might help refine our own explosion containment systems. Furthermore, understanding the biochemical reactions could let us design new, efficient propellant systems³. In light of these potential technological contributions, it's clear that, one day, everyone will owe a huge amount of respect and admiration to the Bombardier's bum.

References

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