How wasp and bee stinger designs help deliver the pain

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Credit: The Ohio State University

Next time you're stung by a wasp or a honeybee, consider the elegantly designed stinger that caused you so much pain.

In a new study, researchers found that the stingers of the two species are about five times softer at the tip than at the base to make it easier to pierce your skin. The stingers are harder closer to the insect's body so they don't bend too much, or break, as you yelp in agony.

"Wasps and bees don't want to create too much pain to start with, and we believe the softer tip makes it less likely that you'll notice the initial insertion," said Bharat Bhushan, Ohio Eminent Scholar and Howard D. Winbigler Professor of mechanical engineering at The Ohio State University.

"If you felt the pain right away, you would react and swat the insect away before it finished injecting its venom."

Bhushan conducted the study with colleagues from the Indian Institute of Technology (IIT), led by Navin Kumar, associate professor of mechanical engineering. It was published October 8, 2018 in Nature *Scientific Reports*.

The scientists collected wasps (*Vespula vulgaris*) and honeybees (*Apis cerana*) near IIT. They examined the stinger in unprecedented detail using sophisticated 3-D imaging, a tool to measure hardness and elasticity, and numerical modelling to calculate the most efficient penetration angle.

"When you really study these stingers, you see how elegant and mechanically durable they are," said Bhushan, who realizes "elegant" is probably not the first word a person thinks of after being stung.

"Other words might come to mind first," he said with a laugh. "But when

you're looking at it from an engineer's perspective, the stingers really are elegantly designed."

The stingers of bees and wasps are different in some ways. The wasps' are curved, for instance, while those of the bees are straight. But they have much in common.

In both species, the stingers have two serrated lancets (think needles) that project from the end of the stinger. The lancets move back and forth to pierce the skin. A channel between the two delivers venom.

Imaging showed the stingers had hollow spaces to reduce weight while maintaining strength.

"It is a clever design to optimize the mechanical properties of the stingers without being too heavy," Bhushan said.

In addition to being softer at the tip, the study showed that the stingers were about seven times more elastic at the tip than at the base.

"The differences in hardness and rigidity along the length of the stinger helps ensure it can penetrate as deep as possible while maintaining its structure," he said.

Findings suggested that bees and wasps probably wouldn't sting straight down into a person's skin. The researchers calculated that the most efficient angle for penetration would be 6 degrees for the honeybee stinger and 10 degrees for the wasp stinger. These are the angles that would best maintain the structural stability of the stingers.

In a similar previous study, Bhushan and his colleagues investigated the proboscis of mosquitos, the part that pierces skin to draw blood. Why the fascination with insects that pierce our skin?

As an engineer who has made a career of designing products inspired by nature, Bhushan has a practical reason. He believes scientists can design a better, painless microneedle for medical purposes by mimicking some of the design elements of bees, wasps and mosquitos.

For example, he thinks needles should be designed to be softer at the tip to lessen the pain at insertion—just like the insects' pointy parts. Health care practitioners could even use this study's findings on the best angle for stinger insertion to guide their use of a new microneedle.

"We're trying to put what we learned about insect stingers to productive use by imagining the design of a better microneedle," Bhushan said.

More information: Rakesh Das et al, Biomechanical Evaluation of Wasp and Honeybee Stingers, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-33386-y

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