New study shows small prey able to detect predators by a chemical in their urine

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Calero Creek Trail Bobcat. Image: Don DeBold

(PhysOrg.com) -- A team of biologists from Harvard Medical School have isolated a chemical found in the urine of many, if not all carnivores, that small rodents can smell and that causes them to respond accordingly; i.e. to move away or avoid areas where the chemical is present. In a paper published in the *Proceedings of the National Academy of Science*, the team found that the chemical, 2-phenylethylamine which is found in the urine of virtually all animals, is much more highly concentrated in predators, and rodents such as mice are able to detect and react to it.

The team, led by Assistant Professor of Cell Biology, Stephen Liberles, knew going in that rodents and other small prey are afraid of something in the urine of meat eaters, such as bobcats, but wanted to know what exactly in the urine was giving them away. To find out, the team started

by studying olfactory receptors in mice, figuring it might be easier to see what the mice are finding and reacting to, rather than simply randomly looking for every single chemical that appeared in predator urine. They started with TAAR4, a well known receptor family generally known to be responsible for strong reactions in rodents. They also knew that something in bobcat urine was able to set off these receptors in rodents, which is why bobcat urine is sold to farmers to keep rodents away.

Eventually, after much work, they were able to isolate the chemical in the bobcat urine that was setting off the receptors in the rodents; 2-phenylethylamine. In the bobcats, this chemical was found to be in very high concentrations, which made the researchers begin to wonder if it might be found in very high concentrations in all predators, which would mean, small prey would be able to smell it regardless of species.

To find out, the team undertook an exhaustive survey of many types of predators from as many sources as they could find, which mostly meant testing zoo animals. To give them something to compare with, they also tested as many herbivores as they could get their hands on. They also tested humans.

Their results showed that across the board, carnivores had much higher levels of 2-phenylethylamine in their urine than did any of the non-meat eating animals; though the researchers are not clear just yet on whether the high levels of the chemical in the urine is due to eating meat, or if it's simply a trait of animals that happen to eat meat. Finding that out is their next goal.

More information: Detection and avoidance of a carnivore odor by prey, *PNAS*, Published online before print June 20, 2011, doi: 10.1073/pnas.1103317108

Abstract

Predator–prey relationships provide a classic paradigm for the study of innate animal behavior. Odors from carnivores elicit stereotyped fear and avoidance responses in rodents, although sensory mechanisms involved are largely unknown. Here, we identified a chemical produced by predators that activates a mouse olfactory receptor and produces an innate behavioral response. We purified this predator cue from bobcat urine and identified it to be a biogenic amine, 2-phenylethylamine. Quantitative HPLC analysis across 38 mammalian species indicates enriched 2-phenylethylamine production by numerous carnivores, with some producing >3,000-fold more than herbivores examined. Calcium imaging of neuronal responses in mouse olfactory tissue slices identified dispersed carnivore odor-selective sensory neurons that also responded to 2-phenylethylamine. Two prey species, rat and mouse, avoid a 2-phenylethylamine odor source, and loss-of-function studies involving enzymatic depletion of 2-phenylethylamine from a carnivore odor indicate it to be required for full avoidance behavior. Thus, rodent olfactory sensory neurons and chemosensory receptors have the capacity for recognizing interspecies odors. One such cue, carnivore-derived 2-phenylethylamine, is a key component of a predator odor blend that triggers hard-wired aversion circuits in the rodent brain. These data show how a single, volatile chemical detected in the environment can drive an elaborate danger-associated behavioral response in mammals.