Smart Weapons

With an arsenal of quills and chemicals, the porcupine mounts one of nature’s most robust defenses against predators.

By Uldis Roze

It is a clear, midsummer midnight in the Catskill Mountains of upstate New York, and I am trying to capture Loretta, an adult female porcupine. In preparation, I am wearing heavy vinyl gloves to protect myself from Loretta’s bristling armor of quills. I plan to scoop her up and place her temporarily into an auger, three-gallon picnic cooler, then make some measurements and observations for my research on the social structure of her species. But Loretta has other plans. She strikes my glove hard with her tail. The thick vinyl stops most of the quills, but many sharp points still pierce the fabric and dig painfully into my fingers and palm. My hand feels useless from the pain. Round one goes to Loretta.

Porcupines, for the most part, have a sweet and trusting disposition that comes only to those who have little reason to be afraid. Of course, quills are the animal’s best-known defense. Each quill is between one-half and four inches long, with one-way barbs for burrowing into the victim’s body and an antibiotic coating to limit the damage if the porcupine quills itself. The quills number in the tens of thousands and cover every inch of its body, with the exception of its face, belly, and the undersides of its limbs and tail.

But there is more to a sense of security than merely possessing an advanced weapon. If your enemies attack you, you may win in the end, but you still risk being injured in the process. To avoid a fight at all, you have to deter an attack with warnings. Your enemies have to realize that you possess your weapon, and be reminded, in no uncertain terms, that if you’re attacked, you will use it. Thus porcupines broadcast a distinct, pungent warning odor when their quills are erected. Furthermore, the quills contain a fluorescent material that brightens the quills at night, when the porcupine is most likely to meet predators. Those evolutionary adaptations ensure a safe fancy for porcupine offspring and relatively long life for the adult—one radio-tagged female lived in my Catskills study area for twenty-one years.

I strip off the quill-perforated glove with my teeth, and finish the capture barehanded. I clip the cooler’s lid over Loretta to immobilize her dangerous tail and lower back. Little drops of blood speckle my hand and fingers. But I have been lucky—none of the quill tips have broken off to travel deeper into my body. I weigh my prickly friend, note that she is lactating, and then let her go. She moves off briskly to her baby in the woods. But Loretta has left something of herself behind—a small forest of quills embedded in my rubberized gloves. Removing a well-rooted quill can take more than ten pounds of force.

Contact with a porcupine’s tail leaves quills embedded in, and even piercing through, a heavy vinyl glove. Removing a well-rooted quill can take more than ten pounds of force.

In a later experiment I discover the extraction tension for individual, well-rooted quills can be twenty-five times higher than my first calculation suggests, or in excess of ten pounds apiece! Even if the extraction force were “only” 6.7 ounces per quill, extracting all eighty-four quills at once would take a pull of more than thirty-five pounds. That is well above Loretta’s body weight—thirteen pounds—and far more force than she could conceivably exert on her own, especially considering that porcupines have relatively little muscle compared with other mammals.

So how did Loretta separate herself from the glove? Not by pulling her quills out of it. Instead, she shed them from her skin. Does that solve the paradox? It might if eighty-four quills could be removed from Loretta’s skin with a force roughly equal to her weight—about two and a half ounces per quill. I do the obvious experiment. I anesthetize Loretta and seven other porcupines with a quick-acting drug, and measure the withdrawal tension of a few of the animals’ quills. The average quill-withdrawal tension is 3.2 ounces per quill, still too much for a little animal to disengage quickly from her target. In other words, when Loretta struck my glove, she should have remained stuck to it, tied
down like a briskly Gulliver by multiple tiny bonds. The inward push was probably vi-

active force drove the quill root deeper into the skin when the quill tip struck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-

active force drove the quill root deeper into the skin of the porcupine. The inward push was probably vi-

active force drove the quill root deeper into the skin when the quill tip struck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-
faction: the force needed to separate a quill follicle from the skin of the porcupine may drop after the quill has been driven into an adversary. Consider one of the quills stuck in my rubberized glove. When the quill tip stuck the glove, an equal and opposite re-

<image:1170x756>
It’s an eerie experience, smelling porcupine in a bottle—one has a sense of imprisoned wildness.

The puzzle was resolved when the investigators realized that commercial delta-decalactone has a strong interest in sending an unambiguous message. A message that says “porcupine here” is preferable to one that says “perhaps porcupine here, perhaps something else.” If a predator has ever had a prior painful encounter with a porcupine, the unique odor would be more likely to trigger the impulse to retreat.

A chemical name is also a specific entry into the large dictionary of natural odors. Smells make up a rich natural language for most mammals, playing a key role in social structure, navigation, and much else. But people for the most part are insensible to the variation and meaning of smells, both for our species and others. At present, the best tool for learning the rudiments of such languages is chemistry.

Chemistry will also help decipher other mysteries of the porcupine, including the fluorescent characteristics of porcupine quills—yet another mechanism of warning off nocturnal predators. That may be a mystery I leave for another scientist. To him or to her, I can offer a very good pair of used vinyl gloves.

Chemical detective work identified the molecule responsible for the porcupine’s distinctive warning odor. The odor was found in eighty-nine volatile compounds detected by a gas chromatograph-mass spectrometer (GC-MS) (a). Washing the same sample of eighty-nine chemicals in three increasingly strong solvents led to three extracts, one of which smelled of porcupine (b). The GC-MS showed that the extract was made up of just three major organics, including the compound authentic R- or S-delta-decalactone (c). A second run of the raw porcupine mixture of eighty-nine chemicals through the GC-MS split the output simultaneously between a strip-chart recorder and a human nose, confirming the odor is delta-decalactone (d). But a commercial sample of delta-decalactone didn’t smell of porcupine (e).

The puzzle was resolved when the investigators realized that commercial delta-decalactone has a strong interest in sending an unambiguous message. A message that says “porcupine here” is preferable to one that says “perhaps porcupine here, perhaps something else.” If a predator has ever had a prior painful encounter with a porcupine, the unique odor would be more likely to trigger the impulse to retreat.

A chemical name is also a specific entry into the large dictionary of natural odors. Smells make up a rich natural language for most mammals, playing a key role in social structure, navigation, and much else. But people for the most part are insensible to the variation and meaning of smells, both for our species and others. At present, the best tool for learning the rudiments of such languages is chemistry.

Chemistry will also help decipher other mysteries of the porcupine, including the fluorescent characteristics of porcupine quills—yet another mechanism of warning off nocturnal predators. That may be a mystery I leave for another scientist. To him or to her, I can offer a very good pair of used vinyl gloves.

Chemical detective work identified the molecule responsible for the porcupine’s distinctive warning odor. The odor was found in eighty-nine volatile compounds detected by a gas chromatograph-mass spectrometer (GC-MS) (a). Washing the same sample of eighty-nine chemicals in three increasingly strong solvents led to three extracts, one of which smelled of porcupine (b). The GC-MS showed that the extract was made up of just three major organics, including the compound authentic R- or S-delta-decalactone (c). A second run of the raw porcupine mixture of eighty-nine chemicals through the GC-MS split the output simultaneously between a strip-chart recorder and a human nose, confirming the odor is delta-decalactone (d). But a commercial sample of delta-decalactone didn’t smell of porcupine (e).

The puzzle was resolved when the investigators realized that commercial delta-decalactone has a strong interest in sending an unambiguous message. A message that says “porcupine here” is preferable to one that says “perhaps porcupine here, perhaps something else.” If a predator has ever had a prior painful encounter with a porcupine, the unique odor would be more likely to trigger the impulse to retreat.

A chemical name is also a specific entry into the large dictionary of natural odors. Smells make up a rich natural language for most mammals, playing a key role in social structure, navigation, and much else. But people for the most part are insensible to the variation and meaning of smells, both for our species and others. At present, the best tool for learning the rudiments of such languages is chemistry.

Chemistry will also help decipher other mysteries of the porcupine, including the fluorescent characteristics of porcupine quills—yet another mechanism of warning off nocturnal predators. That may be a mystery I leave for another scientist. To him or to her, I can offer a very good pair of used vinyl gloves.

Chemical detective work identified the molecule responsible for the porcupine’s distinctive warning odor. The odor was found in eighty-nine volatile compounds detected by a gas chromatograph-mass spectrometer (GC-MS) (a). Washing the same sample of eighty-nine chemicals in three increasingly strong solvents led to three extracts, one of which smelled of porcupine (b). The GC-MS showed that the extract was made up of just three major organics, including the compound authentic R- or S-delta-decalactone (c). A second run of the raw porcupine mixture of eighty-nine chemicals through the GC-MS split the output simultaneously between a strip-chart recorder and a human nose, confirming the odor is delta-decalactone (d). But a commercial sample of delta-decalactone didn’t smell of porcupine (e).

The puzzle was resolved when the investigators realized that commercial delta-decalactone has a strong interest in sending an unambiguous message. A message that says “porcupine here” is preferable to one that says “perhaps porcupine here, perhaps something else.” If a predator has ever had a prior painful encounter with a porcupine, the unique odor would be more likely to trigger the impulse to retreat.

A chemical name is also a specific entry into the large dictionary of natural odors. Smells make up a rich natural language for most mammals, playing a key role in social structure, navigation, and much else. But people for the most part are insensible to the variation and meaning of smells, both for our species and others. At present, the best tool for learning the rudiments of such languages is chemistry.

Chemistry will also help decipher other mysteries of the porcupine, including the fluorescent characteristics of porcupine quills—yet another mechanism of warning off nocturnal predators. That may be a mystery I leave for another scientist. To him or to her, I can offer a very good pair of used vinyl gloves.

Chemical detective work identified the molecule responsible for the porcupine’s distinctive warning odor. The odor was found in eighty-nine volatile compounds detected by a gas chromatograph-mass spectrometer (GC-MS) (a). Washing the same sample of eighty-nine chemicals in three increasingly strong solvents led to three extracts, one of which smelled of porcupine (b). The GC-MS showed that the extract was made up of just three major organics, including the compound authentic R- or S-delta-decalactone (c). A second run of the raw porcupine mixture of eighty-nine chemicals through the GC-MS split the output simultaneously between a strip-chart recorder and a human nose, confirming the odor is delta-decalactone (d). But a commercial sample of delta-decalactone didn’t smell of porcupine (e).

The puzzle was resolved when the investigators realized that commercial delta-decalactone has a strong interest in sending an unambiguous message. A message that says “porcupine here” is preferable to one that says “perhaps porcupine here, perhaps something else.” If a predator has ever had a prior painful encounter with a porcupine, the unique odor would be more likely to trigger the impulse to retreat.

A chemical name is also a specific entry into the large dictionary of natural odors. Smells make up a rich natural language for most mammals, playing a key role in social structure, navigation, and much else. But people for the most part are insensible to the variation and meaning of smells, both for our species and others. At present, the best tool for learning the rudiments of such languages is chemistry.

Chemistry will also help decipher other mysteries of the porcupine, including the fluorescent characteristics of porcupine quills—yet another mechanism of warning off nocturnal predators. That may be a mystery I leave for another scientist. To him or to her, I can offer a very good pair of used vinyl gloves.