WARNING ODOR OF THE NORTH AMERICAN PORCUPINE (Erethizon dorsatum)

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Abstract—Volatile compounds in the lipid coating of the lower-back quills of the North American porcupine, Erethizon dorsatum, were collected using headspace trapping on Tenax and analyzed by gas chromatography–mass spectrometry (GC-MS), GC with organoleptic detection, and GC with a chiral stationary phase. Over 50 components were isolated, primarily oxygenated aliphatics, lactones, and isoprenoids. The most abundant constituent was tetradecyl acetate, which does not contribute significantly to the odor of the quill lipids. GC with a wide-bore capillary column and a human nose as detector was used to determine the retention time of the peak with the characteristic porcupine odor. Comparison of this organoleptic chromatogram with those obtained with a flame ionization detector and GC-MS showed the compound to be a δ-decalactone. The racemic mixture of this optically active substance does not possess the unique odor. Resolution of the enantiomers of δ-decalactone by GC with a chiral cyclodextrin phase shows that the isomer possessing the characteristic porcupine odor is the (R)-δ-decalactone. We suggest the biological function of this compound is to serve as a warning odor, which, in conjunction with an initial quill strike, produces a conditioned aversion in potential predators.

Key Words—Erethizon dorsatum, porcupine, quill lipid volatiles, warning odor, enantiomeric separation, δ-decalactone.

INTRODUCTION

Aposematism (warning behavior) is common in well-defended animals that are subject to predation. By limiting mutual injury, the warning behavior benefits
both the predator and its potential prey. Warnings may be transmitted in any of the sensory modalities; thus examples are known of aposematic coloration (Cott, 1957, McIver and Latkin, 1990) and of acoustic aposematism (Dunning and Roeder, 1965; Mohr, 1965; Masters, 1979). Olfactory aposematism has been cited less often. Rothschild and coworkers (Rothschild et al., 1984; Guilford et al., 1987; Moore et al., 1990) described a Mullerian complex of warning odoration in insects; Dumbacher et al. (1992) noted that chemically defended birds of the genus *Pitohui* emit a strong sour odor.

We report on olfactory aposematism in the North American porcupine, *Erethizon dorsatum*. The warning odor is released in conjunction with quill erection and is part of a trimodal signal. The porcupine sends a visual signal in the form of contrasting black-and-white areas along its lower back and tail. An acoustic signal may be added in the form of tooth-clacking. Finally, the olfactory signal consists of a pungent odor released from the skin of the lower back (Roze, 1989). All three signals are transmitted effectively in the porcupine’s natural travel habitat, the nocturnal forest floor.

A histological study of porcupine skin shows well-developed sebaceous glands associated with quills of the rosette (lower back) region (Chapman and Roze, 1997). The rosette quills are also supplied with powerful piloerector muscles, which, upon quill erection, cause a dimpling of the skin and possible sebum expression, with which the warning odor is associated. In addition, rosette quills possess osmesthetic modifications for odor dispersal (Roze and Chapman, unpublished data). Because of these osmesthetic modifications, the quills of the lower back become saturated with the warning odor upon arousal. We used the odor-saturated quills to isolate the odor components and to identify the active principle.

**METHODS AND MATERIALS**

**Quill Samples.** The porcupines sampled were resident in the Catskill Mountains, Greene Country, New York. Approximately 50 individuals were caught by hand and becalmed by injection with 100 mg/ml ketamine HCl at a dose of 10 mg/kg (Parke-Davis Co., Morris Plains, New Jersey). Approximately 100 odoriferous quills (approximately 1.5 g) were removed with tweezers from the rosette area, sealed in 40-ml Teflon-capped vials, and immediately stored in Dry Ice in a styrofoam cooler. Later the vials were transferred in the laboratory to a −20°C freezer for storage before analysis. When warmed to room temperature, the quill samples released the intense characteristic odor of the porcupine.

**Collection of Volatiles.** Volatile components emitted from the quill samples