October 1993

SIMILARITIES BETWEEN BIG GAME REPELLENT AND PREDATOR URINE REPELLENCY TO WHITE-TAILED DEER: THE IMPORTANCE OF SULFUR AND FATTY ACIDS

Rebecca Lewison
Vassar College

N. Jay Bean
Vassar College

Evgeny V. Aronov
Monell Chemical Senses Center, Philadelphia, PA

John E. McConnell Jr.
Utah State University

J. Russell Mason
Monell Chemical Senses Center, Philadelphia, PA

SIMILARITIES BETWEEN BIG GAME REPELLENT AND PREDATOR URINE REPELLENCY TO WHITE-TAILED DEER: THE IMPORTANCE OF SULFUR AND FATTY ACIDS

REBECCA LEWISON, Department of Psychology, Vassar College, Poughkeepsie, NY 12601

N. JAY BEAN, Department of Psychology, Vassar College, Poughkeepsie, NY 12601

EVGENY V. ARONOV, Monell Chemical Senses Center, 3500 Market Street, Philadelphia, PA 19104

JOHN E. MCCONNELL, JR., U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Denver Wildlife Research Center, Predator Ecology and Behavior Project, Utah State University, Logan, UT 84322

J. RUSSELL MASON, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Denver Wildlife Research Center, and Monell Chemical Senses Center, 3500 Market Street, 3500 Market Street, Philadelphia, PA 19104

ABSTRACT: In the present experiment, we evaluated the repellency of Big Game Repellent® (BGR), whole coyote urine, coyote urine with sulfur compounds removed, and water. Each stimulus was applied to an ornamental plant (hostas, *Alba marginata*) at 5 sites in the vicinity of Poughkeepsie, N.Y. At weekly intervals for 5 weeks, damage was recorded, treatments were reapplied, and plants were replaced when necessary. There was no damage to plants treated with either BGR or whole coyote urine. This was not true for plants sprayed with sulfur-free urine or water. We conclude that the repellency of coyote urine is largely a consequence of sulfurous volatiles.

Keywords: BGR, coyote, deer, fatty acid, *Odocoileus virginianus,* predator, repellent, sulfur.

Proc. East. Wildl. Damage Control Conf. 6:145-148. 1995.

Deer (*Odocoileus* spp.) are blamed for more agricultural damage than any other vertebrate in the eastern United States (Conover and Decker 1991). For example, in New Jersey, the Farm Bureau estimates that white-tailed deer (*Odocoileus virginianus*) caused more than $20 million in damage to various food and nonfood crops in 1990 (New Jersey Farm Bureau 1990). In Pennsylvania, once common plants such as the Canada yew (*Taxus canadensis*; Martin et al. 1951) are now scarce, and overbrowsing by deer is blamed (Allison 1990, Alverson et al. 1988). Not surprisingly, ornamental *Taxus* spp. also are heavily damaged (Alverson et al. 1988, Conover and Kania 1988).

To date, deer control activities have focused on increasing hunter access to private lands (e.g., Atwill 1991), manipulating hunting seasons (Conover and Decker 1991) and erecting fences (Caslick and Decker 1979). These techniques can be effective, but lethal control is not feasible in many suburban and urban areas, and fencing is sometimes too expensive.

Candidate repellents that protect localized areas from severe browse damage are being sought. Among commercially available products, Big Game Repellent® (BGR, Intagra Corp., Minneapolis, Minn.) has been shown to repel white-tailed deer and other herbivores from non-food crops and landscape plantings (HaiLs et al. 1983, Conover 1984, Conover and Kania 1987, Conover and Swihart 1990). However, the availability of BGR is being restricted, and the registrations for some formulations are being canceled (UPS. Environ. Protect. Agency 1993).

The effectiveness of BGR appears to depend upon the odor of volatile sulfur compounds and short-chain fatty acids (Bullard et al. 1978). Because the odors of predator urine, feces, and glandular secretions also repel deer (Van Haaflen 1963, Muller-Schwarze 1972, Melchiors and Leslie 1985, Sullivan et a]. 1985, Abbott et al. 1990, Swihart et al. 1991), and have a high sulfur content (e.g., Mason et al. 1993), we set out to test the proposition that the sulfur content of these substances might be responsible for their aversiveness.

MATERIALS AND METHODS

Study sites

Five independent sites in the vicinity of Poughkeepsie, N.Y. were selected for testing. All showed evidence of the presence of deer (e.g., tracks, droppings, browse lines on vegetation).

At each site, 4 hostas (*Alba marginata*) were planted in locations 10 m apart. Each plant was approximately 15 cm high and 15 cm in diameter. To discourage browsing by rabbits (*Sylvilagus floridanus*) and woodchucks (*Marmota monax*), each plant was surrounded by a hardware cloth ring that was 30 cm high and 60 cm in diameter. Every leaf on every plant was traced and length and width measurements of every leaf were made prior to planting.

Chemicals

Deer Away Big Game Repellent® was purchased from IntAgra Inc. (Minneapolis, MN) and an aqueous solution was prepared according to the label instructions. Coyote urine was obtained from captive animals at the Predator Ecology and Behavior Project, Denver Wildlife Research Center, Logan, UT. In preparation for urine collection, 3 coyotes were fed jackrabbit meat exclusively for 2 weeks. During the third week, each coyote was placed in a metabolism cage for 15 hours and urine was collected. Urine samples were pooled and refrigerated. Four L were air-shipped to the Monell Chemical Senses Center, Philadelphia, PA. Upon arrival at the Center, the urine was divided into 2 samples (2 l/sample). One sample was refrigerated immediately. The other sample was subjected to mercuric chloride precipitation for the exclusive and essentially complete removal of sulfur compounds (Golovnya et al. 1972). Briefly, 319 mg of 1 mmol mercuric chloride was dissolved in 2 ml of methanol and added to 25 ml samples of urine. The mixture was agitated for 30 min., stored for 3 hours at room temperature (23ºC), and, finally, centrifuged. The fugate (referred to below as sulfur-free urine) was collected for testing. After preparation of the sulfur-free material, both urine samples were shipped to Poughkeepsie. Upon arrival, these samples were refrigerated.

Procedure

On April 1, 1993, the 4 hostas at each of the 5 test sites were randomly assigned to 4 treatment groups (1 plant/site/group). Ace (model 11690) 32 oz All Purpose Household Sprayers were used to apply: (a) 5 ml of distilled water to the plants in group 1, (b) 5 ml of BGR to the plants in group 2, (c) 5 ml of whole coyote urine to the plants in group 3, or (d) 5 ml of sulfur-free urine to the plants in group 4.

All sites were visited every 7 days for the next 5 weeks. During each visit, treatments were reapplied, and each hosta was examined for damage. The length and width of every leaf on every plant was measured, and a tracing of every leaf was made so that the percent of available vegetation consumed from each plant could be estimated. When consumption was greater than 50%, or when more than 50% of the leaves on a plant had wilted, the hosta was replaced.

Analysis

A Friedman two-way analysis of variance by ranks was used to evaluate the data (Siegel 1956). The significance level was set at alpha = 0.10.

RESULTS

Although there were no differences in damage among weeks ($X^2 = 3.55$; df = 4; $P < 0.473$), there were differences among stimulus solutions ($X^2 = 6.42$ df = 3; $P < 0.092$). Hostas treated with BGR or whole coyote urine suffered no measurable damage (Fig. 1). The converse was true for plants treated with either sulfur-free fugate or water; hostas in these groups received high levels of damage.

DISCUSSION AND MANAGEMENT IMPLICATIONS

BGR and coyote urine were repellent to white-tailed deer. However, when sulfur compounds were removed from the urine, it was no longer aversive. Although the identity of the relevant compounds remains unknown, this result demonstrates that sulfur-containing volatiles in urine are important for repellency. This finding also is consistent with other demonstrations that sulfur volatiles are broadly repellent to mammalian herbivores (Mason et al. 1993). Although the reason(s) for the repellency of sulfur remain somewhat obscure, we have hypothesized (Mason et al. 1993, Epple et al. 1993) that the sulfur content of predator secretions and excretions reflects the amount of meat in the diet. It follows that sulfur odorants could be used as indicators of diet composition by potential prey species. Whatever the ecological reasons underlying the repellency of sulfur volatiles, it is clear that such odorants represent a new and relatively unexplored source of potential repellents for herbivores. Because sulfurous odors are attractive to omnivores and carnivores at concentrations similar to those that repel herbivores (Bullard et al. 1978, Mason et al. 1993, Mason et al. 1988), we speculate that the same volatile material could be used both as an attractant and a repellent depending upon the feeding strategy of the targeted species.

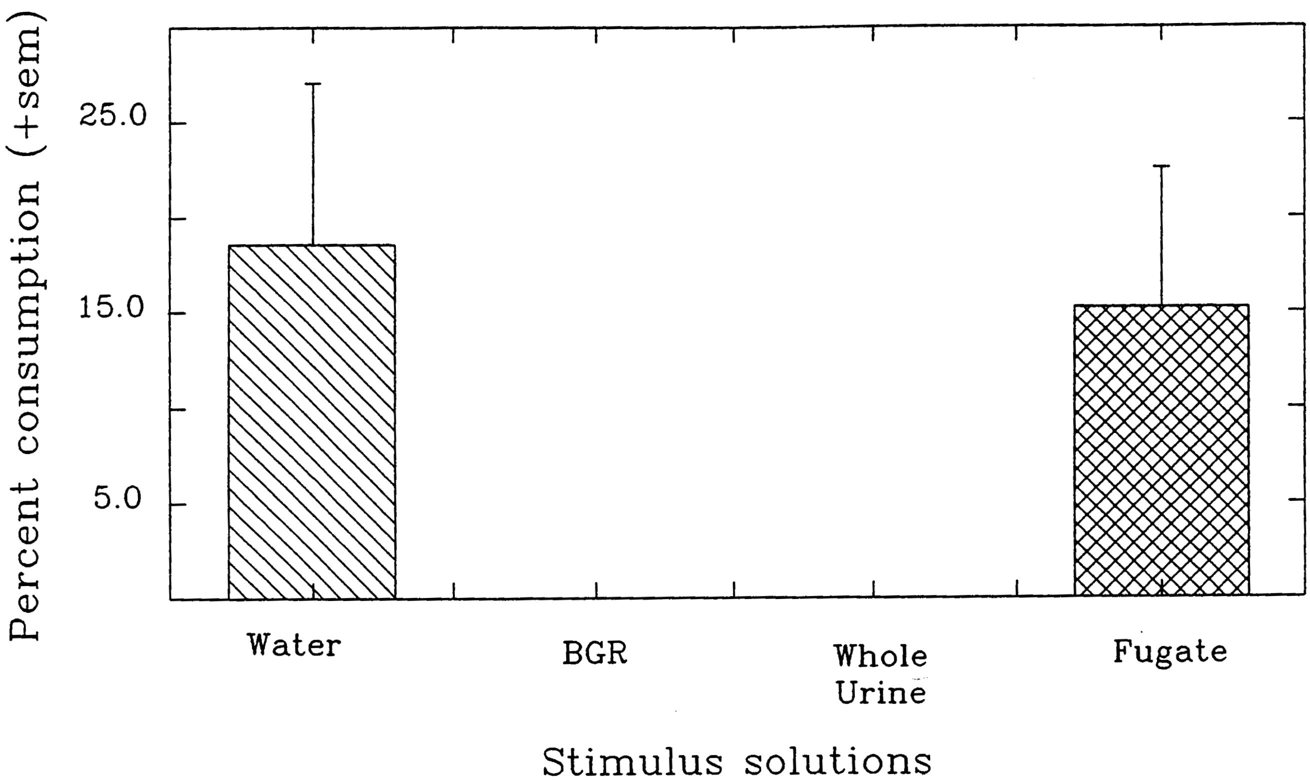

Fig. 1. Mean percent consumption of hostas treated with water, Big Game Repellent (BGR), whole coyote urine, or urine following sulfur-precipitation (Fugate). Capped vertical bars represent standard errors of the means.

LITERATURE CITED

Abbott, D. H., D. A. Baines, C. G. Faulkes, D. C. Jennens, P. C. Y. K. Ning, and A. J. Tomlinson. 1990. A natural deer repellent: chemistry and behavior. Pages 599-609 in D.W. Macdonald, D. Muller-Schwarze, and S.E. Natynczuk, eds. Chemical Signals in Vertebrates S. Oxford University Press, Oxford.

Allison, T. D. 1990. The influence of deer browsing on the reproductive biology of Canada yew (*Taxus canadensis* marsh.). III. Sex expression. *Oecologia* 89:223-228.

Alverson, W. S., D. M. Waller, and S. L. Solheim. 1988. Forests too deer: edge effects in northern Wisconsin. Cons. Biol. 2:348-358.

Atwill, L. 1991. What is the UBNJ? Field Stream 96:41,96-97.

Bullard, R. W., T. J. Leiker, J. E. Peterson, and S. R. Kilburn. 1978. Volatile components of fermented egg, an animal attractant and repellent. J. Agri. Food Chem. 26:155-159.

Caslick, J. W. and D. !. Decker. 1979. Economic feasibility of a deer-proof fence for apple orchards. Wildl. Soc. Bull. 7:173-175.

Conover, M. R. 1984. Effectiveness of repellents in reducing deer browse damage in nurseries. Wildl. Soc. Bull. 12:399-404.

_____ and D. J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildl. Soc. Bull. 19:46-52.

_____ and G. S. Kania. 1987. Effectiveness of human hair, BGR, and a mixture of blood meal and peppercorns in reducing damage to young apple treeS. Proc. East. Wildl. Dam. Cont. Conf. 3:97-101.

_____ and G. S. Kania. 1988. Browsing preference of white-tailed deer for different ornamental species. Wildl. Soc. Bull. 16:175-179.

_____ and R. K. Swihart. 1990. Reducing deer damage to yews and apple trees: testing Big Game Repellent, Ropel and soap as repellents. Wildl. Soc. Bull. 18:156-162.

Epple, G., J. R. Mason, D. L. Nolte, and D. L. Campbell. 1993. Effects of predators odors on feeding in the mountain beaver (*Aplodontia rufa*). Journal of Mammalogy 74:715-722

Golovnya, R. V, Yu. N. Arsenyev, and N. I. Svetlova. 1972. Use of heavy metal salts in the analysis of organic sulfur compounds. J. Chromatography 69:79-86.

Harris, M. T., W. L. Palmer, and J. L. George. 1983. Preliminary screening of white-tailed deer repellents. J Wildl. Manage. 47:516-519.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Plants, New York: McGraw-Hill 500pp.

Mason, J. R., N. J. Bean, and B. G. Galef. 1988. Attractiveness of carbon disulfide to wild norway rats. Proc. Vertebr. Pest Conf. 13:95-97.

_____, G. Epple, and D. L. Nolte. 1993. Semiochemicals and improvements in rodent control. In: B. G. Galef, P. Valsecchi, and M. Mainardi (eds.), Ontogeny and Social Transmission of Food Preferences in Mammals: Basic and Applied Research. Harwood Academic Press, London, (in press).

Melchiors, M. A., and C. A. Leslie. 1985. Effectiveness of predator fecal odors as black-tailed deer repellents. J. Wildl. Manage. 49:358-362.

Muller-Schwarze D. 1972. Responses of young black-tailed deer to predator odors. J. Mammal. 53:393-394

New Jersey Farm Bureau. 1990. White-tailed Deer Pest Management, New Jersey Farm Bureau, Trenton, New Jersey, 25pp.

Seigel, S, 1956. Non-parametric statistics. McGraw-Hill. New York, NY.

Sullivan, T. P., L. O. Nordstrom, and D. S. Sullivan. 1985. Use of a predator odours as repellents to reduce feeding damage by herbivores black-tailed deer (*Odocoileus hemionus columbianus*). J. Chem. Ecol. 11:921-935

Swihart, R. K., J. J. Pignatello, and M. J. I. Mattina. 1991. Aversive responses of white-tailed deer, *Odocoileus virginianus,* to predator urines. J. Chem. Ecol. 17:767-777

Environmental Protection Agency. 1993. Notice of receipt of requests to voluntarily cancel certain pesticide registrations. Fed. Regis. 58:21, 6961.

Van Haaften, J. L. 1962. A natural repellent. Pages 389-392 In: Anonymous (ed.), Transactions of the VI Congress of the International Union of Game Biologists. The Nature Conservancy, London.