Vancouver Island Marmots (*Marmota vancouverensis*) Consume Plants Containing Toxic Secondary Compounds

JEFFERY R. WERNER

Centre for Biodiversity Research, Department of Zoology, University of British Columbia, Vancouver, British Columbia V6T 1Z4 Canada; email address: werner@zoology.ubc.ca

Werner, Jeffery R. 2012. Vancouver Island Marmots (*Marmota vancouverensis*) consume plants containing toxic secondary compounds. Canadian Field-Naturalist 126(1): 55–58.

I report 68 sightings of Vancouver Island Marmots (*Marmota vancouverensis*) feeding on Green False Hellebore (*Veratrum viride*), a plentiful but highly poisonous plant. Possible explanations for this novel foraging behaviour are presented.

Key Words: Vancouver Island Marmot, *Marmota vancouverensis*, plant alkaloids, foraging behaviour, diet, plant defensive compounds, *Veratrum viride*, False Hellebore, marmot foraging.

Plants display a variety of characteristics that provide a degree of protection from herbivores. One characteristic is the production of chemicals that are distasteful or toxic to herbivores (Freeland and Janzen 1974; Iason 2005). Green False Hellebore (*Veratrum viride*), a herbaceous perennial containing high concentrations of over 50 steroidal alkaloids, is considered to be highly poisonous (Taylor 1956). Ingestion of small amounts of this plant causes severe physiological impairment in humans (Underhill 1959; Jaffe et al. 1990; Prince and Stork 2000) and vertebrate herbivores (Fyles 1920; Dayton 1960; Cheeke and Shull 1985), and it can cause death (Gosselin et al. 1976). Small experimental doses of *Veratrum californicum* (California False Hellebore) administered to pregnant livestock have caused embryonic death, abortion, and fetal abnormalities (Binns et al. 1972; U.S. Department of Agriculture 2006*).

Study Area and Methods

Observations of Vancouver Island Marmots (*Marmota vancouverensis*) were made during focal behaviour samples conducted at four mountain colonies (Heather Mountain, Green Mountain, Haley Lake, and Mount Washington) between May and October over four years (2002–2005). Werner (2005) and Brashares et al. (2010) detail this sampling methodology. For reporting purposes, multiple observations of a single individual made on the same day were scored as a single record. Green False Hellebore was positively identified in the field using Hitchcock and Cronquist (1973) and later corroborated in a laboratory setting (University of British Columbia Herbarium database; accessed 27 October 2002).

Results

Vancouver Island Marmots were observed eating Green False Hellebore (Figure 1) on 68 separate occasions, and at least 17 individual Vancouver Island Marmots were identified as having eaten Green False Hellebore on more than one occasion (in 9 of the 68 observations, the individual identity of the animal was not recorded).

On 27 June 2002, a two-year-old female that weaned young (Figure 1) consumed nearly 30 cm of the upper stem and connecting leaves of a single plant over an 11-minute period. This marmot suffered no visible effects, and she was re-sited 22 times during the following month. Similarly, in July 2005, a three-year-old female and one adult male (age unknown, but greater than four years) were observed feeding on the tips of Green False Hellebore leaves, and occasionally the flowers were consumed.

Young shoots were never observed to be eaten, nor were the roots, lower stems, or fruits. Vancouver Island Marmots fed on Green False Hellebore most frequently during July and August, although this may be an artefact of sampling effort (Figure 2). During April, May, and October, Vancouver Island Marmots were never seen consuming Green False Hellebore, despite considerable time spent in observation (nearly 400 hours combined during those months). During some years, snow persisted into late May and this resulted in Green False Hellebore being largely unavailable until June.

Discussion

These are the first confirmed cases of Vancouver Island Marmots feeding on Green False Hellebore and —to my knowledge—of any marmot species eating substantial quantities of plant parts (see Armitage 1979) containing secondary compounds considered injurious to herbivores and humans.

Marmots are likely capable of detecting plant secondary compounds (including alkaloids), and Yellow-bellied Marmots (*Marmota flaviventris*) are able to avoid ingesting species that contain them (Armitage 1979). Frase and Armitage (1989) report that *Veratrum* species were not eaten by Yellow-bellied Marmots during two years of observation, despite this plant contributing to upwards of 50% of the plant biomass at particular sites. In a 30-year retrospective, Armitage (2003) identified this plant genus as having never been recorded in the diet of Yellow-bellied Marmots.

Veratrum viride has been recognized as a possible food plant for marmots (Hansen 1975; Heard 1977;

FIGURE 1. Reproductive female Vancouver Island Marmot (*Marmota vancouverensis*), aged two, eats *Veratrum viride* on Green Mountain, Vancouver Island, British Columbia, on 16 June 2002. Conspicuous bite marks on leaf tips (foreground) were made by this individual moments previous. Photo: J. Werner (300 mm telephoto, 1/500 sec, f/4).

Milko 1984; Nagorsen 1987; Barash 1989), although the authors provide no direct evidence for their claims and appear to have received direction from a single unpublished reference (Gray 1967*) that does not positively identify *V. viride* as part of marmot diet.

I consider three alternative explanations for Vancouver Island Marmots feeding on *Veratrum viride*: first, this marmot species may not possess sufficient discernment to completely minimize intake of Green False Hellebore during bouts of feeding. During feeding, Vancouver Island Marmots, Hoary Marmots (*Marmota caligulata*), Olympic Marmots (*M. olympus*), Yellow-bellied Marmots, Bobak (or Steppe) Marmots (*M. bobak*), Long-tailed (or Golden) Marmots (*M. caudate*), and Woodchucks (*M. monax*) employ rapid bite patterns between long pauses devoted to vigilance (Blumstein et al. 2001), and the number of plant species browsed often appears to be in proportion to what is immediately available (Werner and Brashares, unpublished data). However, selective foraging has been identified in the Vancouver Island Marmot (Milko 1984; Martell and Milko 1986) and other marmot species (Hansen 1975; Armitage 1979; Barash 1989; Frase and Armitage 1989; Stallman and Holmes 2002; Armitage 2003). Because Green False Hellebore was plentiful at all study sites and the Vancouver Island Marmots that were observed eating Green False Hellebore were all adults (range of two to six years or more), I assume these foraging choices were "intentional" rather than first-time experiences.

Second, it is possible that Vancouver Island Marmots are immune to the toxic qualities of specific alkaloid compounds. This is unlikely, however, given the widespread observations of lethal and sub-lethal effects of false hellebore intake in birds and amphibians (Christensen and McLean 1939), sheep, goats, and cattle (Fyles 1920; Binns et al. 1972; Cheeke and Shull 1985; Mulligan and Munro 1987), humans (Underhill 1959; Gosselin et al. 1976; Jaffe et al. 1990; Prince and Stork 2000), and other mammal species (Dayton 1960; U.S. Department of Agriculture 2006*).

A third possibility is that ingesting false hellebore may, at times, be beneficial. Eating plants which contain specific secondary compounds can be a strategy

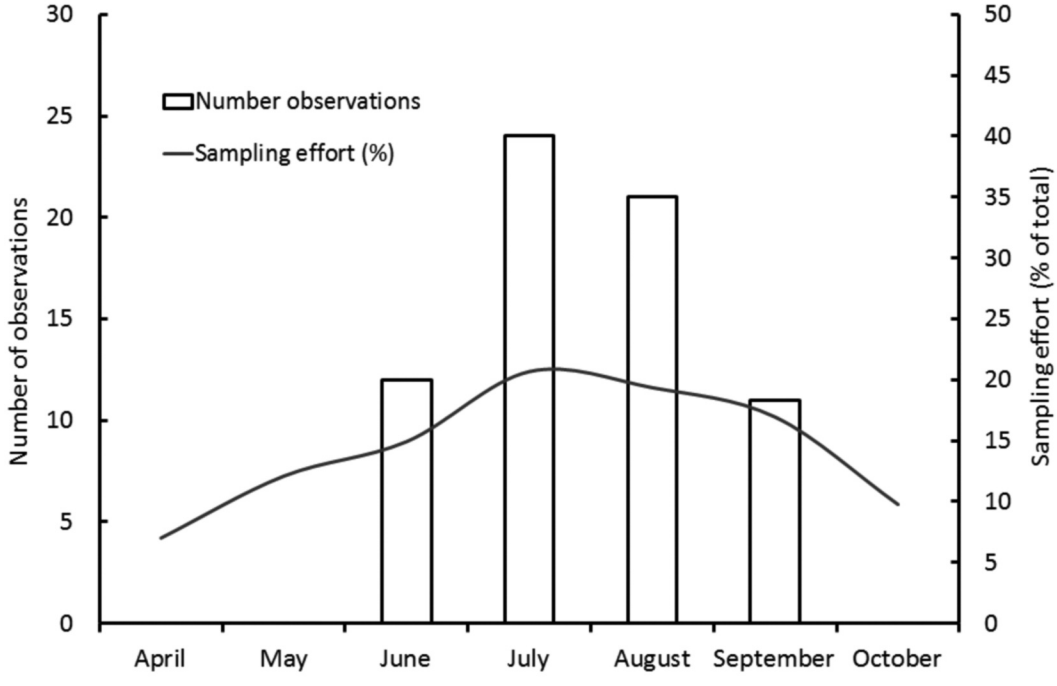

FIGURE 2. The number of independent observations of Vancouver Island Marmots (*Marmota vancouverensis*) consuming Green False Hellebore (*Veratrum viride*) and the percentage of all time (>1300 hours) spent observing across the four active seasons in 2002, 2003, 2004, and 2005 (sampling effort). Vancouver Island Marmots were typically still hibernating during a portion of April/May in each year of study and entered hibernation during October, and this accounts for the low proportion of observations during those months.

to neutralize other toxins (Foley et al. 1999; Rozman and Klaassen 2001), to enhance amino acid absorption (Iason 2005), to strengthen the immune system and/or to fight parasites (Marley et al. 2003) in mammalian herbivores. The consumption of Green False Hellebore by Vancouver Island Marmots likely contributes to a coherent nutritional strategy (Foley et al. 1999; Iason and Villalba 2006), and this finding has important implications for our understanding of marmot ecology and plant–herbivore interactions.

Acknowledgements

Sixteen field staff contributed to the field component of this study. Particular thanks are due to R. Landucci, F. Iredale, and F. Griffith, whose initial observations led to the identification of this unusual foraging behaviour. A. Bryant, D. Doyle, R. Elner, the Vancouver Island Marmot Science Advisory Group, and the Vancouver Island Marmot Recovery Team provided input and support during the initial planning stages. For funding and logistical support, I thank Environment Canada, the British Columbia Ministry of Water, Land and Air Protection (now Ministry of Environment), the staff at Mount Washington Alpine Resort, TimberWest, and the Department of Zoology and Centre for Biodiversity Research at the University of British Columbia. Additional funding was provided by the Natural Sciences and Engineering Research Council of Canada.

Documents Cited (marked * in text)

Gray, D. 1967. Behavior and activity in a colony of hoary marmots (*M. caligata*) in Manning Park, B.C., and a comparison of behaviour with other marmot species. Honor's thesis, University of Victoria, Victoria, B.C., Canada.

U.S. Department of Agriculture. 2006. Poisonous Plant Research: False Hellebore (*Veratrum californicum*). United States Department of Agriculture. http://www.ars.usda.gov/Services/docs.htm?docid=9992.

Literature Cited

Armitage, K. B. 1979. Food selectivity by yellow-bellied marmots. Journal of Mammalogy 60: 628-629.

Armitage, K. B. 2003. Observations on plant choice by foraging Yellow-Bellied Marmots. Oecologica Montana 12: 25-28.

Barash, D. P. 1980. The influence of reproductive status on foraging by hoary marmots (*Marmota caligata*). Behavioural Ecology and Sociobiology 7: 201-205.

Barash, D. P. 1989. Marmots: Social Behavior and Ecology. Stanford University Press, Stanford, Calif.

Binns, W. M., F. R. Keeler, and **L. D. Balls.** 1972. Congenital deformities in lambs, calves and goats resulting from

maternal ingestion of *Veratrum californicum*: hair lip, cleft palate, aplasia and hypoplasia of metacarpal and metatarsal bones. Clinical Toxicology 5: 245-261.

Blumstein, D. T., J. C. Daniel, and **A. A. Bryant.** 2001. Antipredator behavior of Vancouver Island marmots: using congeners to evaluate abilities of a critically endangered mammal. Ethology 107: 1-14.

Brashares, J. S., J. R. Werner, and **A. R. E. Sinclair.** 2010. Social 'meltdown' in the demise of an island endemic: Allee effects and the Vancouver Island marmot. Journal of Animal Ecology 79(5): 965-973.

Cheeke, P. R., and **L. R. Shull.** 1985. Mycotoxins. Pages 135-139 *in* Natural Toxicants in Feeds and Poisonous Plants. *Edited by* P. R. Cheeke and L. R. Shull. AVI Publishing, Westport, Conn.

Christensen, B. V., and **A. P. McLean.** 1939. The assay of Veratrum viride. Journal of the American Pharmaceutical Association 28: 74–82.

Dayton, W. A. 1960. Notes on western range forbs: Equisetaceae through Fumariaceae. Forest Service, U.S. Department of Agriculture, Washington, D.C. Agriculture Handbook 161. 254 pages.

Foley, W. J., G. R. Iason, and **C. McArthur.** 1999. The role of plant secondary metabolites in the nutritional ecology of mammalian herbivores: how far have we come in 25 years? Pages 130-209 *in* Nutritional Ecology of Herbivores. *Edited by* H-J. G. Jung and G. C. Fahey. Proceedings of the Vth International Symposium on the Nutrition of Herbivores. American Society of Animal Science, Savoy, Ill.

Frase, B. A., and **K. B. Armitage.** 1989. Yellow-bellied marmots are generalist herbivores. Ethology, Ecology and Evolution 1: 353-366.

Freeland, W. J., and **D. H. Janzen.** 1974. Strategies in herbivory by mammals: the role of plant secondary compounds. American Naturalist 108: 269-289.

Fyles, F. 1920. Principal poisonous plants of Canada. Dominion of Canada Department of Agriculture, Dominion Experimental Farms Bulletin (second series) 39: 112.

Gosselin, R. E., H. C. Hodge, R. P. Smith, and **M. N. Gleason.** 1976. Clinical Toxicology of Commercial Products. Fourth edition. Williams and Wilkin, Baltimore.

Hansen, R. M. 1975. Foods of the hoary marmot on Kenai Peninsula, Alaska. American Midland Naturalist 94(2): 348-353.

Heard, D. C. 1977. The behaviour of Vancouver Island Marmots (*Marmota vancouverensis*). M.Sc. thesis, University of British Columba, Vancouver, British Columbia, Canada.

Hitchcock, C. L., and **A. Cronquist.** 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle.

Iason, G. 2005. The role of plant secondary metabolites in mammalian herbivory: ecological perspectives. Proceedings of the Nutrition Society 64: 123-131.

Iason, G., and **J. Villalba.** 2006. Behavioral strategies of mammal herbivores against plant secondary metabolites: the avoidance–tolerance continuum. Journal of Chemical Ecology 32(6): 1115-1132.

Jaffe, A. M., D. Gephardt, and **L. Courtemanche.** 1990. Poisoning due to ingestion of *Veratrum viride* (false hellebore). Journal of Emergency Medicine 8(2): 161-167.

Marley, C. L., R. Cook, J. Barrett, R. Keatlinge, N. H. Lampkin, and **S. D. McBride.** 2003. The effect of dietary forage on the development and survival of helminth parasites in ovine faeces. Veterinary Parasitology 118: 93–107.

Martell, A. M., and **R. J. Milko.** 1986. Seasonal diets of Vancouver Island marmots, *Marmota vancouverensis*. Canadian Field-Naturalist 100: 241-245.

Milko, R. J. 1984. Vegetation and foraging ecology of the Vancouver Island marmot (*Marmota vancouverensis*). M.Sc. thesis, University of Victoria, Victoria, British Columbia, Canada.

Mulligan, G. A., and **D. B. Munro.** 1987. The biology of Canadian weeds. 79. *Veratrum viride* Ait. Canadian Journal of Plant Science 67: 777-786.

Nagorsen, D. W. 1987. *Marmota vancouverensis*. Mammalian Species 270: 1–5.

Prince, L. A., and **C. M. Stork.** 2000. Prolonged cardiotoxicity from poison lilly (*Veratrum viride*). Veterinary and Human Toxicology 42(5): 282-285.

Rozman, K. K., and **C. D. Klaassen.** 2001. Absorption, distribution, and excretion of toxicants. Pages 107–132 *in* Casarett and Doull's Toxicology: The Basic Science of Poisons. *Edited by* C. D. Klaassen. McGraw-Hill, New York.

Stallman, E. L., and **W. G. Holmes.** 2002. Selective foraging and food distribution of high elevation yellow-bellied marmots (*Marmota flaviventris*). Journal of Mammalogy 83(2): 576-584.

Taylor, C. A. 1956. The culture of false hellebore. Economic Botany 10: 155-165.

Underhill, J. E. 1959. A case of hellebore poisoning. Canadian Field-Naturalist 73: 128-129.

Werner, J. R. 2005. The endangered Vancouver Island marmot: Allee effects and reintroduction success. M.Sc. thesis, Centre for Biodiversity Research, Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada.

Received 16 February 2012
Accepted 15 April 2012