Repelling Animals from Crops Using Plant Extracts

Stanley Ries,[1]
Rebecca Baughan,[2]
Muraleedharan G. Nair,[3] and
Robert Schutzki[4]

Additional index words. animal repellent, white-tailed deer, *Odocoileus virginianus*, cottontail rabbit, *Oryctolagus cuniculus*, daffodil, *Narcissus pseudo narcissus*, bearded iris, *Iris*, catnip, *Nepeta cataria*, pepper, *Capsicum frutescens*, peppermint, *Mentha piperita*, spearmint, *Mentha spicata*

Summary. **Several plant species that are not consumed by animals were collected, extracted with organic solvents, and tested at different venues for their effectiveness as animal feeding repellents. Species with the most repellent activity were daffodil (*Narcissus pseudo narcissus*), bearded iris (*Iris* sp.), hot pepper (*Capsicum frutescens*), catnip (*Nepeta cataria*) and peppermint (*Mentha piperita*). Considerable effort was expended to isolate and identify compounds from these species responsible for repellent activity. Eight chemicals have been isolated and purified, and four of them have been identified. Both daffodil and catnip contain more than one repellent, but none of the four compounds identified were common to both species. Combinations of extracts from more than one plant species proved to have more repellent activity than extracts from individual species used alone. In several tests these plant extracts proved to be as effective or better than available commercial repellents. A plethora of additives and surfactants were tested to increase repellent activity by enhancing the spreading, penetration or persistence of the extracts.**

Plant injury and financial losses from wild animals feeding on agricultural crops continue to increase (Lemieux et al., 2000a). In the United States, the white-tail deer (*Odocoileus virginianus*) population rose about 5,000 % in the 20th century, from an estimated half-million animals to about 25 million (Winkelman, 2000). In Michigan, an estimated two million deer cause extensive crop damage and from 1978 to 1998, automobile accidents in Michigan involving deer increased from 38,000 to 65,000 per year (McCallum, 1996). Damage, from browsing by deer and cottontail rabbit (*Oryctolagus cuniculus*), has made the growing of some crops impractical. For example, some nurseries no longer grow yews (*Taxus*) and apple (*Malus*) species, and some very good fruit and vegetable growing sites are not used for that purpose due to a history of animal damage (Nolte, 1998).

There is considerable anecdotal evidence suggesting that wild animals do not feed on several indigenous and cultivated plant species such as daffodil, iris, and members of the mint (*Labiatae*) family. This research was based on the hypothesis that compounds could be extracted from these species that would repel animals, particularly deer, and rabbits.

Browsing by animals, particularly deer and rabbits, on agricultural and ornamental crops continues to be a problem (Conover and Kanis, 1988; Sheets, 1995; Swezey, 1997). Considerable research has been conducted to find effective animal repellents (Andelt, 1994; Gartner, 1992; Lemieux, 2000b; Nolte, 1995; Schoeb and McAninch, 1996) resulting in the marketing of several natural and synthetic products (Table 1). All of these products have varying degrees of repellent activity, particularly denatonium benzoate, putrescent whole egg solids and a mixture of mustard (*Brassica nigra*) oil, capsaicin and lemon (*Citrus limonia*) extract. The commercial formulations available

Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

This research was supported by The Horticulture Research Institute, Washington DC, the Michigan Departments of Agriculture and Natural Resources, the Michigan Agricultural Experiment Station and the Michigan Cherry Research Committee. Thanks are given to the organizations that provided the commercial repellents. The authors also appreciate the bulbs provided by Van Bloem Gardens, Alpharetta, Ga., and the Washington Bulb Co., Mt Vernon, Wash. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[1]Professor.

[2]Research assistant.

[3]Professor.

[4]Associate professor.

Table 1. Commercial animal repellents tested and their active ingredients as listed on the labels (1997–99).

Product	Source	Active ingredients
Bobbex	Bobbex, Inc., Newtown, Conn.	Garlic oil and dried blood
Deer Away	IntAgra, Inc., Minneapolis, Minn.	Putrescent whole egg solids
Get Away	IntAgra, Inc., Minneapolis, Minn.	Ally isothiocynate (oil of mustard), capsaicin (oleoresin of capsicum), vegetable oil and lemon extract
Deer-Off	Deer-Off, Inc., Stamford, Conn.	Putrescent whole egg solids, capsaicin and garlic
Foggy Mountain Coyote Urine	J&C Marketing, Inc., Hampden, Maine	Coyote (*Canis latrans*) urine
Hinder	Pace International, Seattle, Wash.	Ammonium soaps of higher fatty acids
Hot Pepper Wax	Hot Pepper Wax, Inc., Greenville, Pa.	Capsaicin and other caosaicinoids
Hot Sauce	Miller Chemical and Fertilizer Corp., Hanover, Pa.	Capsaicin (oleoresin of capsicum)
Ro-Pel	Burlington Scientific Corp., Farmingdale, N.Y.	Benzyldiethyl ammonium saccharide and thymol
Tree Guard	NorTech Forest Technologies, St. Louis Pk., Minn.	Denatonium benzoate or bitrex
XP-20	Easy gardener, Inc., Waco, Texas	Thiram (tetramethylthiuram disulfide)

may optimally deter animals for a few weeks, but not several months (Table 1). In addition, the formulations available to the public cost more than $10/L ($37.84/gal) as applied and this making them economically prohibitive for application to large areas (Consumer Reports, 1998).

A practical formulation of an animal repellent, particularly for white-tailed deer and cottontail rabbits, would solve one of the most expensive, vexing and annoying problems that affect commercial growers and home gardeners; that is, the damage caused by animals feeding on crop and ornamental species (McCallum, 1996).

Materials and methods

Statistical protocol. All tests, including the phytotoxicity studies, were conducted as either randomized complete blocks with at least 3 blocks and up to 10 treatments or as split plots with the main plots being time or location and subplots the repellent treatments. The variance was analyzed and the means within the treatments compared using least significant differences (LSD); and F ratios were used with single degrees of freedom for non-orthogonal comparisons when appropriate.

Preparation and application of plant material. After receipt from the wholesaler, bulbs were stored at room temperature if used within 30 d or at 3.5 °C (37 °F) when kept longer. Moisture was removed from most of the daffodil bulbs and iris rhizomes used in this study by lyophilization. In order to dry the bulbs more economically, different protocols were compared: air drying in the greenhouse, in an oven at 70 °C (158 °F), and lyophilization. Foliage was either air or oven dried. The dried material was then ground to pass through a 50-mesh screen. It was extracted sequentially with pure hexane, chloroform and methanol in either a 4.5 × 52 cm (1.8 × 20.5 inch) or a 12 × 100 cm (4.72 × 39.4 inch) glass column. The preponderance of activity was found in the methanol fractions. One exception was that the hexane extract of catnip was most active. Later extractions of plant material were with one or two of the solvents. Bioassays of the crude extracts were made at several venues throughout Michigan.

To increase specific activity of crude methanol extract, it was precipitated with chloroform and centrifuged. The supernatant was rotoevaporated to dryness then taken up in methanol to compare with the crude extract.

In tests with corn (*Zea mays*) seeds, 1.0 mL (0.03 fl oz) of each formulation was applied to 30 seeds in 50-mL (1.5-oz) beakers and allowed to air dry. The treatments were applied to runoff on plants or plant material with hand-held trigger sprayers (Science Products Co., Chicago, Ill.). Test tubes or plastic bottles were used as reservoirs. In most bioassays, the controls consisted of untreated test material. Several tests showed the surfactants or solvents used alone had no repellent activity when compared to untreated controls.

Animal bioassays. Research with deer was conducted at the Michigan Department of Natural Resources, Rose Lake Wildlife Center near East Lansing, where it was possible to withhold normal feed which increased the feeding pressure on the test materials. Ears of corn 9 to 15 cm (3.5 to 4.2 inches) long and white cedar (*Thuja occidentalis*) boughs 12 to 20 cm (4.7 to 7.9 inches) long and 8 to 12 cm (3.1 to 4.7 inches) wide, were treated with formulations of the extracts. Corn ears and cedar boughs were tied to the inside of a fence enclosing two to seven white-tailed deer. Deer preferred corn to the cedar and would often locate and consume some of the corn controls before all the treatments were distributed. The percentage of each corn ear and cedar bough consumed was visually estimated and recorded.

In the winter, tests with rabbits were conducted using pansy (*Viola tricolor hortensis*) plants grown in pots. The plants were hardened off in growth chambers, treated with formulations of the active extracts and moved outside to areas with a high population of rabbits. These tests were evaluated by a visual estimate of foliage consumed. Pansy plants remained desirable to rabbits over several weeks unless frozen during extremely cold weather.

In a test at Alpena in northern Michigan, treated ears of corn were placed in a harvested cornfield. At another site in northern lower Michigan (Baldwin), a 208 L (55 gal) drum feeder, which automatically dispensed corn in the morning and again in the evening, attracted deer, common raccoons (*Procyon lotor*) and fox and gray squirrels (*Squriolus* sp.) to the test area. The repellent treatments were applied to corn seeds, which were placed by treatment on individual 14 × 14 × 2 cm (5.5 × 5.5 × 0.8 inch) plastic trays under the feeder arranged as randomized complete blocks with three blocks. The feeder was turned off during each test period to prevent the dispersal of corn into the treatment trays and to apply additional feeding pressure. The percentage of corn seeds consumed was recorded. Sunflower seed (*Helianthus* sp.) was used similarly to corn seed in some tests with squirrels in East Lansing.

The phytotoxicity of extracts was determined by the application of extract

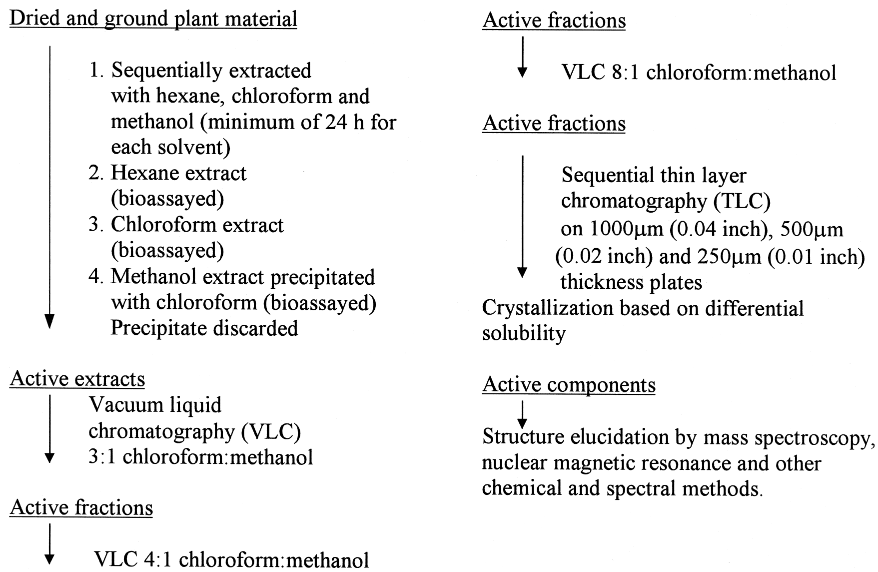

Fig. 1. Typical flow diagram for sequential solvent extraction of plant material.

formulations to the foliage of 5- to 14-d-old corn seedlings and 40- to 60-d-old pansy plants in the greenhouse, and shoots of apples (*Malus×domestica*) and cherries (*Prunus cerasus*) at the Michigan State University (MSU) Horticulture Teaching and Research Center (HTRC).

IDENTIFICATION OF ACTIVE COMPOUNDS. Extracts from daffodil bulbs, bearded iris rhizomes, and the foliage of daffodils, catnip and peppermint were obtained by sequential organic solvent extraction and fractionated further by chromatographic procedures (Fig. 1). Active fractions were further purified. Structures were elucidated using mass spectroscopy, nuclear magnetic resonance (NMR) and other chemical and spectral methods. Russell Ramsewak (Univ. of W. Indies, Dept. of Chemistry, St. Augustine, Trinidad) conducted the NMR analysis. The notation *, and ** designates differences of $P \leq 0.05$ and 0.01 respectively (Ries, 1993).

Results and discussion

Assays at Rose Lake and Baldwin showed no appreciable difference between methods of drying as measured by consumption of the treated material. Precipitation of the crude methanol extract of daffodil bulbs increased the specific activity. During a 14-d period, 20 mg·mL^{-1} (2.0%) of the precipitated material was as effective as 180 mg·mL^{-1} (18.0%) of the crude extract (Table 2).

When catnip foliage was sequentially extracted with hexane, acetone and methanol, the major source of activity occurred in the hexane extract (Table 3). The organic solvents applied alone to the corn and cedar did not repel any animals. This is not surprising since the solvents rapidly evaporate at room temperature. After 32 d, cedar boughs treated with the hexane extract at 25 mg·mL^{-1} (2.5%) remained uneaten by deer at the Rose Lake test site. The solubility of this material in hexane indicated it was lipophilic and the physical characteristics indicated it was a wax.

In a test using combinations of extracts, pepper fruit extract alone at 30 mg·mL^{-1} (3.0%) was as good as any combination of crude extracts with the exception of MSU-7, which is a formulation of extracts from daffodil bulbs, pepper and catnip with additives (Table 4). Deer rapidly consumed the ear corn controls, but avoided several of the treatments for 9 d.

A test was conducted with deer, rabbits and squirrels to compare two commercial formulations, Millers Hot Sauce (Miller Chemical and Fertilizer Corp., Hanover, Pa.) and Tree Guard (Nortech Forest Technologies, Inc., St. Louis Park, Minn.) with two concentrations of a methanol extract of daffodil bulbs. The lowest concentration, 25 mg·mL^{-1} (2.5%), of the daffodil extract repelled all of the animals in the four tests better than either of the commercial formulations (Table 5). Tests at East Lansing and Baldwin showed that squirrels had feeding preferences similar to deer and rabbits in regard to repellent materials. When observed the animals would sample

Table 2. Comparison of a crude methanol extract of daffodil bulbs with the same extract after precipitation with chloroform on the feeding activity of deer on cedar boughs at the Rose Lake Wildlife Center, East Lansing, Mich. Feed was withheld three times during the test.

Daffodil extract	Concn^z (mg·mL^{-1})	Proportion consumed (%) 1 d	4 d	14 d
Control	0	90	100	100
Crude	20	60	93	98
	60	0**	80	80
	180	0**	67	73
Precipitated	20	0**	63	72
	60	0**	0**	13**
	180	0**	0**	13**

^{z}10 mg·mL^{-1} = 1.0%.
**Significantly different from control at $P \leq 0.01$.

Table 3. Repellent activity of fractions from catnip leaves sequentially extracted with different solvents and applied to cedar boughs offered to deer at the Rose Lake Wildlife Center, East Lansing, Mich.

Treatment	Solvent	Concn^z (mg·mL^{-1})	Proportion consumed (%) 1 d	9 d	32 d
Control	None	0	77	100	100
Catnip	Hexane	25	0**	33**	37**
	Acetone	100	97	100	100
	Methanol	100	67	100	100

^{z}10 mg·mL^{-1} = 1.0%.
**Significantly different from control at $P \leq 0.01$.

Table 4. Feeding activity of deer at the Rose Lake Wildlife Center, East Lansing, Mich., on ear corn treated with methanol extracts from pepper or catnip alone and in different combinations. More than 5 cm (2 inches) of snow and rain fell during the first 5 d.

Treatment	Concn[z] (mg·mL^{-1})	Proportion consumed (%) 1 d	5 d	9 d
Control		100	100	100
MSU-7[y]		0**	0**	3**
Pepper	10	5**	67	100
	30	0**	2**	33*
Catnip	10	33**	70	83
	30	35**	68	100
Pepper + catnip	10+10	0**	17**	68
	10+30	0**	3**	40*
	30+10	0**	2**	35*
	30+30	0**	0**	5**

[z]10 mg·mL^{-1} = 1.0%.
[y]MSU-7 is a formulation of extracts from daffodil bulbs, catnip and pepper with surfactants.
*,**Significantly different from control at $P \leq 0.05$ and 0.01 respectively.

Table 5. Feeding activity of deer, rabbits and squirrels on materials treated with commercial repellents and daffodil bulb extract. Treatments were applied to cedar boughs, for deer, at the Rose Lake Wildlife Center, East Lansing, Mich., pansy plants, for rabbits, in the Horticulture Gardens at Michigan State University and sunflower seeds, for squirrels in two tests (I, II), at East Lansing. The commercial treatments were applied as sprays as recommended on the label by their manufacturers.

Treatment	Concn[z] (mg·mL^{-1})	Proportion consumed (%) Deer (4 d)	Rabbits (8 d)	Squirrels (I) (4 d)	Squirrels (II) (2 d)
Control	0	95	77	80	100
Daffodil	25	58**	45**	5**	0**
	100	2**	13**	5**	0**
Millers Hot Sauce		88	53	100	100
Tree Guard		98	60	100	100

[z]10 mg·mL^{-1} = 1.0%.
**Significantly different from control at $P \leq 0.01$.

Table 6. Consumption by deer of corn ears treated with two commercial repellents at their recommended rates and repellents extracted from different plant species at the Rose Lake Wildlife Center, East Lansing, and at Alpena, Mich.

Treatment	Concn[z] (mg·mL^{-1})	Proportion consumed (%) Rose Lake 1 d	Rose Lake 3 d	Alpena 2 d	Alpena 5 d
Control		77	77	100	100
Bobbex		67	67	1**	100
Hinder		57	57	68	100
Daffodil	100	30**	30*	3**	27**
Peppermint	100	33**	43*	1**	100
Pepper	10	60	60	92	100
Iris	50	40**	40*	100	100
Catnip	50	97	97	30**	100

[z]10 mg·mL^{-1} = 1.0%.
*,**Significantly different from control and catnip at $P \leq 0.05$ and 0.01 respectively.

the atmosphere around the treatment and either taste it or move to another sample.

Two different commercial formulations and methanol extracts of daffodil bulbs, catnip and peppermint foliage, pepper fruit and iris rhizomes were applied to ears of corn and tested at Rose Lake and Alpena. All formulations except pepper and iris extracts repelled deer better than Bobbex (Bobbex, Inc., Newtown, Conn.) and Hinder (Pace Intl., Seattle, Wash.) at Rose Lake (Table 6). At Alpena, the daffodil extract and Bobbex repelled deer for 2 d, but after 5 d the daffodil extract remained effective while Bobbex did not.

In a more extensive test, MSU-7, a formulation of daffodil, pepper and catnip extracts, was compared with commercial repellents. MSU-7 was more effective than any commercial products tested (Table 7). This test was conducted at Rose Lake and Baldwin using corn ears and corn seeds respectively.

A major goal of this research is to find an additive that will enhance the persistence of natural extracts. Kaolin clay (Surround WP, Englehard Corp., Iselin, N.J.) was used alone and in combination with MSU-7. The clay enhanced the persistence of MSU-7 (Table 8) even with exposure to rain and snow.

In studies on young (newly planted) apple and peach (*Prunus persica*) trees in northern Michigan (Ludington and Hart), severe phytotoxicity occurred with one of the MSU formulations. To determine the cause of this injury, different components of the formulation were applied alone or in combination to new shoots of apple trees at East Lansing. This test showed that the phytotoxicity was due to the extract from daffodil bulbs (Table 9). Hexane was also toxic but the methanol and surfactants used were not.

Since this research had shown that daffodil leaves also contained repellents, methanol extracts from leaves were compared to methanol extracts from bulbs. Leaf extracts were not toxic to either apple shoots or 8-d-old corn seedlings and were still effective as repellents.

Phytotoxicity of the extract from daffodil bulbs indicated that it should not be used on plants with foliage present. Two formulations developed in this research, contained pepper, catnip, clay and surfactants. One incorporated peppermint leaf extract and a green dye and was named Go Green for use during the growing season. The other contained daffodil bulb extract in place of the peppermint leaf extract and was named Go White for use on dormant plants or nongrowing material.

Table 7. A comparison of the repellent activity of a formulation developed at Michigan State University with selected commercial repellents applied at their recommended rates. The repellents were applied to corn and tested on deer at the Rose Lake Wildlife Center, East Lansing, Mich., and deer and squirrels at Baldwin, Mich.

	Proportion consumed (%)			
	Rose Lake		Baldwin	
Treatments	1 d	2 d	1 d	2 d
Control	100	100	67	100
MSU-7[z]	0**	12**	0**	70*
Deer Away (A)[y]	57*	100	53	100
Deer Away (B)[y]	70	88	43	100
Coyote urine	40*	98	3**	100
Ro-Pel	92	100	100	100
Bobbex	97	100	0**	100
Hinder	100	100	0**	100
Tree Guard	80	100	23	100
XP-20	100	100	83	100

[z]MSU-7 is a formulation of extracts from daffodil, pepper and catnip.
[y]There are two formulations of Deer Away: "A" contains putrescent whole egg solids and "B" contains mustard oil, capsaicin and lemon extract.
*,**Significantly different from control and catnip at $P \leq 0.05$ and 0.01 respectively.

Table 8. Feeding activity of deer at the Rose Lake Wildlife Center, East Lansing, Mich. on ear corn treated with repellents formulated with or without clay. More than 3 cm (1.2 inches) of snow and rain fell during the first 2 d.

	Proportion consumed (%)			
Treatment	1 d	2 d	4 d	7 d
Control	100	100	100	100
Clay (2%)	100	100	100	100
MSU-7[z]	0**	67	67	67
MSU-7 + clay	0**	0**	3**	33*

[z]MSU-7 is a formulation of extracts from daffodil bulbs, catnip and pepper plus surfactants.
*,**Significantly different from control and catnip at $P \leq 0.05$ and 0.01 respectively.

Table 9. Toxicity of different formulations of daffodil extract after 7 d when applied to new shoots of apple trees.

Treatment	Concn (%)	Injury rating[z]
Control		1.0
Methanol	40	1.0
Hexane	40	3.0*
Surfactants	0.5 and 0.2	1.0
Surfactants+soybean[y] oil	0.5 and 0.2 and 10	1.5
Daffodil in water	10	3.0*
Daffodil in methanol	10	3.5**
Daffodil with surfactants	10	4.0**

[z]Rating 1 = no injury; 5 = severe injury.
[y]*Glycine max.*
*,**Significantly different from control and catnip at $P \leq 0.05$ and 0.01 respectively.

These formulations were tested on ear corn at Rose Lake during a period of inclement weather. Go Green applied at the highest rate was most effective, with no feeding activity after 8 d (Table 10). Both formulations were tested at the same concentrations on 10-d-old corn seedlings in the greenhouse with Go White showing the only phytotoxic activity (Table 10).

Active repellents identified. Typical results using the protocol described in Fig. 1 have shown at least four different compounds present in a daffodil bulb extract. These four compounds were identified as β-sitosterol, the alkaloids tazettine and demethyl tazettine (Fig. 2) and a triglyceride. In a test using these compounds on corn seed, squirrels consumed 100% of the control and 30%, 0%, and 15% of the alkaloids, triglyceride and β-sitosterol, respectively. In another test with these compounds deer and raccoons consumed 60%, 30%, 20%, and 13%, respectively. All treatments repelled animals more than the control ($P \leq 0.01$). Four other active compounds from catnip leaves and daffodil bulbs have been isolated and purified and are in the process of being identified. Bearded iris extracts were also active as repellents (Table 6) with two or more active compounds, which do not co-chromatograph with the active compounds from either daffodil bulbs or catnip foliage.

Conclusion

Deer and rabbits regardless of feeding pressure do not consume many plant species such as daffodil, bearded iris and members of the mint family. After 4 years of research encompassing more than 450 replicated field experiments with 9000 plots, active repellent mixtures used in these tests clearly do not duplicate the repellency of the wild or naturalized species. Efforts to formulate repellents (Table 1), including this research, have failed to simulate the repellent activity of these plants over a long period of time. Two hypotheses that may explain the failure of the extracts used in these studies are: the environmental effects of moisture, temperature and light cause the physical removal or breakdown of the repellents; or the plants have another compound present that has appreciably higher specific activity than the compounds isolated to this point. For example, there may be a volatile product present that is lost during the extraction procedure. The basis for the latter hypothesis is that observations in the field indicate that there was no browsing on species such as daffodil, catnip, iris and the mints.

Table 10. Consumption by squirrels at East Lansing, Mich. of corn treated with two repellent formulations, Go Green and Go White.[z] There were both rain and snow during the period of this test. Fourteen day old corn seedlings were treated with the same formulations and rated for injury.

Treatment	Amount of formulation (%)	Proportion consumed (%) 1 d	3 d	8 d	Injury rating[y] 6 d
Control	---	63	63	100	1.0
Clay	10	33	67	100	1.0
Go Green	12.5	17**	17*	93	1.0
	25.0	0**	3**	40**	1.0
	50.0	0**	0**	3**	1.0
	100	0**	0**	0**	1.0
Go White	12.5	0**	30*	67*	2.5**
	25.0	0**	20*	47*	3.0**
	50.0	3**	3**	13**	4.0**
	100	0**	10*	17**	4.7**

[z]Go Green contains extracts from pepper, catnip and peppermint plus a green dye, clay and surfactants. This formulation is not phytotoxic and may be used on growing plants. Go White may be toxic to growing plants because it contains daffodil bulb extract which replaces the peppermint extract in the Go Green formulation.
[y]Rating 1 = no injury; 5 = severe injury.
*,**F value for comparison with control significant at $P < 0.05$ and 0.01, respectively.

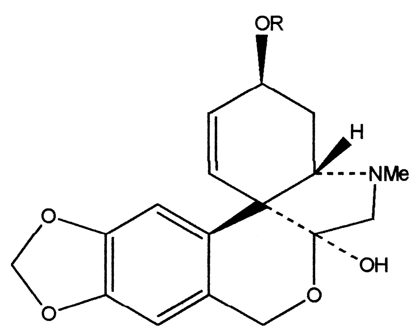

Fig. 2. Structure of two active compounds extracted from daffodil bulbs: tazettine 1, R = H and demethyl tazettine 2, R = Me.

Literature cited

Andelt, W.F., K.P.Burnham, and D.L. Baker. 1994. Effectiveness of capsaicin and bitrex repellents for deterring browsing by captive mule deer. J. Wildlife Mgt. 58:2, 330–334.

Conover, M.R. and G.S. Kanis. 1988. Browsing preference of white-tailed deer for different ornamental species. Wildlife Soc. Bul. 16:175–179.

Consumer Reports. 1998. When bambi eats your flowers. Consumer Rpt. 63:10, 32–33.

Gartner, S. 1992. The repellent effect of approved deer deterrents. Allgemeine Forst Zeitschrift 47:15, 794–795.

Lemieux, N, B.K. Maynard, and W. Johnson. 2000a. A regional survey of deer damage throughout Northeast nurseries and orchards. J. Environ. Hort. 18:1–4.

Lemieux, N, B.K. Maynard, and, W. Johnson. 2000b. Evaluation of commercial deer repellents on ornamentals in nurseries. J. Environ. Hort. 18:5–8.

McCallum, M. 1996. MVC asks DNR for better control of deer herd. Great Lakes Vegetable Growers News. 30:9.

Nolte, D.L. and M.W Fall. 1998. Efficacy of selected repellents to deter deer browsing on conifer seedlings. Special Issue: Vertebrate deteriogens. International Biodeterioration and Biodegradation. 42:2-3, 101–107.

Nolte, D.L., J.P. Farley, and S. Holbrook. 1995. Effectiveness of BGR-P and garlic in inhibiting browsing of western red cedar by black-tailed deer. Tree Planter's Notes. 46:1, 4–6.

Minnesota Department of Natural Resources Wildlife Population and Res. Unit Rpt.

Schoeb, M.C. and J.B McAninch. 1996 Efficacy of commercial deer repellents in winter. Minnesota Department of Natural Resources Wildlife Population and Res. Unit Rpt.

Sheets, K. 1995. Oh deer! Fine Gardening. Nov/Dec:54–61.

Swezey, L.B. 1997. Outsmarting bambi. Sunset. Nov:78–82.

Winkelman, B. 2000. Deer numbers spiral out of control. Lansing State J. 12 Mar. 10C.