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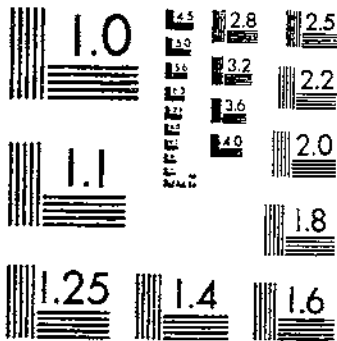
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CUCUMBER BEETLE ANTIFEEDANTS LABORATORY SCREENING OF NATURAL PRODUCTS

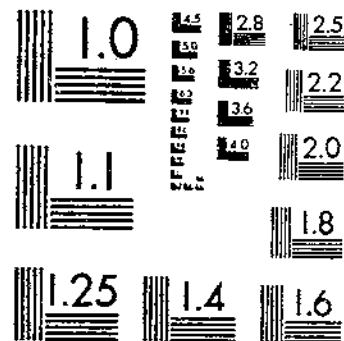
REED, D. K.

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# START



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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A



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# Cucumber Beetle Antifeedants

## Laboratory Screening of Natural Products

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### Abstract

Reed, D. K., Jacobson, M., Warthen, Jr., J. D., Uebel, E. C., Tromley, N. J., Jurd, L., and Freedman, B. 1981. Cucumber Beetle Antifeedants: Laboratory Screening of Natural Products. U.S. Department of Agriculture Technical Bulletin No. 1641. 13 p.

Cucumber beetles are destructive pests of melons in the Midwest both because of their feeding and transmission of bacterial wilt disease. Because an effective antifeedant would be an ideal control measure, more than 350 materials of biological origin have been screened against striped cucumber beetle. Such materials as neem derivatives, nerifolin, tung, and naphthoquinones appear promising and will be tested more extensively.

KEYWORDS: antifeedants, insects, cucumber beetles, feeding deterrents, neem, Azadirachtin-Salannin.

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# Cucumber Beetle Antifeedants:

## Laboratory Screening of Natural Products

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### Introduction

Insect antifeedants are chemical substances that prevent or inhibit feeding of insects. Such substances may be naturally present in a plant and after isolation, identification, and synthesis may be applied as a spray to act by direct contact or systemically. Many examples of this type of chemical governing of host selection by phytophagous insects have been reported. One of the most highly researched natural products used as an antifeedant has been the extract of neem seed kernels, *Azadirachta indica* A. Juss (6). Extracts have been examined from a number of plants for their antifeedant activity against tobacco caterpillar, *Spodoptera litura* (F.) (3).<sup>2</sup> An excellent review of current terminology is given along with some examples of natural products as insect antifeedants (4).

This publication reports on the screening of extracts from plants known to possess antifeedant or repellent activity against spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, and striped cucumber beetle, *Acalymma vittata* (F). Such screening of antifeedants is important in discovering safe, biodegradable alternatives to synthetic insecticides. The striped cucumber beetle transmits bacterial wilt, *Erwinia tracheiphila*, to melons, which results in severe crop losses. Transmittable disease such as these may be dramatically reduced by developing effective antifeedants for the host since the diseases are transmitted through minimal feeding.

### Materials and Methods

Adult female spotted cucumber beetles, reared on corn, and adult female striped cucumber beetles, reared on squash at 27°C ± 1°C, and 60 percent ± 5 percent RH (5), were collected soon after emergence and starved 24 h before testing. Leaf discs about 20

mm in diameter were cut with a cork borer from young leaves of Burpee cantaloupe plants grown in flats in a greenhouse. Test leaf discs were dipped into suspensions, emulsified with a Brinkman Polytron® (PCU-2), of the plant extracts in acetone or ethanol with 0.01 percent Tween 20® in water. Untreated leaf discs were dipped into a blank of acetone and Tween 20®. After air drying, two treated and two untreated discs were placed in the bottom of a polyethylene dish (93 mm diameter × 73 mm deep) and five female beetles were introduced. Two replicates were carried out for each treatment.

Preliminary investigations indicated that some fractions were toxic in closed dishes, so all tests were conducted using a loose-weave muslin cover, which was atomized periodically with water during the first 6 h of observation at 3, 6, and 22 h by the same observer. Results are presented as percentage eaten (percent consumed-treated × 100/percent consumed-treated + untreated), which gives a total of 50 percent when treated and untreated discs are consumed in equal amounts. The lower the percentage, the more active the antifeedant.

### Results and Discussion

Extracts of neem seeds are promising antifeedants against cucumber beetles, particularly the striped beetle, since enough observations were made to see that crude extracts of neem seed possessed a great deal of activity (table 1). Testing of fractions from crude extracts showed that activity was concentrated over a few fractions. Fractions of the hexane extract were not tested against striped beetle since no colony was available at the time of the tests. The spotted cucumber beetle colony was discontinued in early 1979 so that all subsequent screening was done only against striped beetles. The striped beetle is the more serious pest of melons because it is active early in the season and is a vector for bacterial wilt in the seedbed and the field.

Azadirachtin and salannin, both compounds from the ethanolic extract of neem seeds (fig. 1), were highly active against striped beetle feeding but relatively ineffective against a number of insects (7, 8). More detailed results of research on these compounds will be reported in a subsequent paper.

Extracts from tung nuts (table 2) also possess excellent antifeedant activity (1, 2). Our screening

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<sup>2</sup> Italic numbers in parentheses refer to Literature Cited, page 13.

Table 1.—Neem extracts and fractions

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Ethanol extract of neem seed kernels in 551.1-B	1.0	0		5	0		10
Fractions from floridin earth XS column							
643.2	1.0	52		34	14		16
643.3	1.0	46		28	57		41
643.4	1.0	8		27	43		13
643.5	1.0	0		19	0		3
643.6	1.0	0		9	0		5
643.7	1.0	0		17	0		11
643.8	1.0	0		9	0		2
643.9	1.0	0		8	0		12
643.10	1.0	0		14	0		26
643.11	1.0	0		6	0		9
643.12	1.0	0		12	0		9
643.13	1.0	0		15	0		7
643.14	1.0	0		7	0		19
643.15	1.0	25		19	0		5
643.6	1.0	0		0	0		19
Fractions from florex column							
647.2	1.0	0		0	0		6
647.3	1.0	20		13	87		13
647.4	1.0	0		3	0		0
647.5	1.0	0		0	0		12
647.6	1.0	0		3	0		2
647.7	1.0	0		12	0		4
647.8	1.0	0		5	0		6
647.9	1.0	0		1	0		6
647.10	1.0	0		0	0		0
647.11	1.0	0		0	0		0
647.12	1.0	0		0	0		4
647.13	1.0	0		0	0		3
647.14	1.0	0		18	0		5
647.15	1.0	0		7	0		3
647.17	1.0	0		14	0		18
Methanol partition of neem seed kernel ethanol extract							
Fractions from florex column							
681.1	1.0	24		33	0		20
681.2	1.0	34		31	0		17
681.3	1.0	13		9	0		0
681.4	1.0	0		0	0		0
681.5	1.0	0		0	0		0
681.6	1.0	0		0	0		0
681.7	1.0	4		5	0		0
681.8	1.0	0		0	0		0
681.9	1.0	0		0	0		0
681.10	1.0	0		0	0		0
681.11	1.0	0		0	0		0
681.12	1.0	0		0	0		0
681.13	1.0	0		0	0		0
681.14	1.0	0		2	0		0
681.15	1.0	0		2	0		0
681.16	1.0	0		5	0		0
681.17	1.0	0		0	0		0
681.18	1.0	0		0	0		0
681.19	1.0	0		0	0		0
681.20	1.0	0		2	0		0
681.21	1.0	0		0	0		0
Fractions from 681.4							
721.2	1.0	0	0	15			
721.3	1.0	0	0	3			
721.4	1.0	0	0	0			
721.5	1.0	0	0	0			
721.6	1.0	17	22	22			
721.7	1.0	0	0	0			
721.8	1.0	0	0	3			
721.9	1.0	0	0	5			
721.10	1.0	0	0	2			
721.11	1.0	0	0	5			
721.12	1.0	0	0	15			

**Table 1.—Neem extracts and fractions—Continued**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Ethanol extract of neem seed kernels in 551.1-B--Cont'd.							
Hexane partition of neem seed kernel ethanol extract							
Acetone insolubles--686A	1.0	17		24	42		41
Acetone solubles--686B	1.0	100		21	34		45
Fractions from florisil column							
687.1	1.0	19		42	0		36
687.3	1.0	63		49	24		34
687.4	1.0	10		36	27		45
687.5	1.0	19		38	42		45
687.6	1.0	33		47	29		41
687.7	1.0	0		0	0		10
687.8	1.0	0		2	0		0
Hexane extract of neem seed kernels fractions In 525.2							
Fractions from florisil column							
118.1	1.0	31	42	41			
118.2	1.0	42	44	43			
118.3	1.0	30	47	50			
118.4	1.0	38	41	50			
118.5	1.0	61	47	50			
118.6	1.0	21	25	38			
118.8	1.0	31	42	49			
Fractions from neutral alumina							
124.1	1.0	45	49	50			
124.2	1.0	6	10	18			
124.3	1.0	31	33	43			
124.4	1.0	8	11	21			
124.5	1.0	18	26	34			
124.6	1.0	0	0	1			
124.7	1.0	8	22	29			
124.8	1.0	0	0	0			
124.9	1.0	6	23	26			
Ethanol extract of neem seed kernels (oil previously expressed)--Food Industries Limited							
A13-42629	.05	49	51	49	23	36	44
	.1	34	43	46	11	27	44
	.5	25	37	37	0	0	0
Florisil fractions							
966.1	.05	53	62	50	28	32	49
	.1	36	33	50	52	50	48
966.2	.05	22	25	27	0	4	23
	.1	27	19	31	9	5	7
966.3	.05	21	14	20	0	0	22
	.1	11	11	26	0	3	9
966.4	.05	39	20	30	14	15	47
	.1	19	23	30	6	3	30
966.5	.05	27	26	49	20	16	26
	.1	18	19	33	0	0	20
966.6	.05	32	33	50	0	0	25
	.1	54	43	50	11	9	22
Pure compounds from neem							
azadirachtin	.001	-	-	-	29	30	36
	.01	23	25	40	0	0	13
	.1	59	60	47	0	0	0
	.5	-	-	-	0	0	0
Salannin	.1		21	21		11	14
	.5		19	24		2	2
	1.0		0	4		0	0



**Table 2.—Other natural product plant extracts and fractions**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Tung nuts <i>Aleurites fordii</i> Hemsl.							
Pentane extract - CH 162.1	0.1	65	40	25	37	39	26
Ether extract - CH 162.2	.05	53		31	34		34
	.1	56		37	25		24
	.2	17		19	28		36
Silicic acid fractions - CH 209.1	.1				0	12	49
	.5				5	20	49
209.2	.1				46	44	49
	.5				27	39	35
209.3	.1				0	13	45
	.5				0	5	44
209.4	.1				25	30	41
	.5				0	4	26
209.5	.1				31	35	39
	.5				0	0	13
209.6	.1				0	8	33
	.5				0	0	17
209.7	.1				10	26	42
	.5				15	21	34
209.8	.1				17	17	67
	.5				0	0	36
209.9	.1				36	38	49
	.5				30	22	36
Silicic acid fractions of 209.6							
218.7	.1				53	48	46
	.5				11	18	40
218.8	.1				61	70	52
	.5				63	54	49
Ethanol extract - CH 162.3	.1	22	33	30	46	44	41
Water extract - CH 162.4	.1	60	46	37	28	26	28
Wheat							
Ethanol extract of stems - CH 165.1	.2	52	54	52	10	13	38
Kernel extract - AI-42425	.2	41	40	48	12	22	31
Stem (bronze var.-Brookings, S.D.) extract-80% ethanol							
Methanol-soluble 968A	.1	52	53	54	57	53	52
	.5	60	53	51	52	47	49
Methanol-insoluble 968B	.1	58	56	55	64	58	51
	.5				0	4	30
Ether soluble 982A	.1				24	28	50
	.5				0	0	27
Florisil fractions - 14.1	.1				18	26	49
	.5				0	14	38
14.2	.1				42	32	43
	.5				9	11	44
14.3	.1				0	15	38
	.5				2	13	39
14.4	.1				33	27	47
	.5				21	23	41
Ether insoluble 982B	.1				23	40	48
	.5				0	0	49
Florisil fractions - 15.1	.1				60	53	49
	.5				31	24	33
15.2	.1				27	25	43
	.5				0	5	47
15.3	.1				0	0	47
	.5				18	15	39
15.4	.1				40	29	49
	.5				25	33	46
Remaining residue 982C	.1				44	42	40
	.5				21	23	48
Ether extract of Durham wheat VI96A	.1	52	50	49	46	36	46
	.5	64	55	47	0	0	33

Table 2.—Other natural product plant extracts and fractions—Continued

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Wheat—Ether extract of Durham wheat—VI96A—Cont'd.							
Florisol fractions 981.1	0.1				44	42	49
	.5				25	35	49
981.2	.1				47	55	50
	.5				55	43	50
981.3	.1				58	52	49
	.5				21	36	50
981.4	.1				16	18	49
	.5				23	16	49
981.5	.1				12	25	50
	.5				20	17	50
981.6	.1				53	46	48
	.5				37	36	49
981.1-981.6 combined	.1				53	46	49
	.5				13	31	48
Ethanol extract (80%) from VI96A marc - VI96B	.1	52	49	51	32	27	34
	.5	33	27	50	21	24	34
Oats							
Ethanol extract of straw - CH 165.2	.2	11	33	49	29	28	42
Ether extract of stems - VI97A	.1	54	60	53	50	44	48
	.5	52	54	48	18	14	39
Ethanol extract from VI97A marc - VI97B	.1	54	56	50	35	48	40
	.5	26	31	35	35	36	32
<u>Balanites aegyptiaca</u> (L.) Del.							
Pentane extract of seeds - Ent 42849	.1				52	66	50
	.5				31	29	47
Ether extract of seeds - Ent 42850	.1				41	40	50
	.5				35	29	50
Tulip tree, <u>Liriodendron tulipifera</u> L.							
Ether extract of twigs	.1				21	22	47
	.5				0	0	18
Methanol extract of twigs	.1				13	33	37
	.5				0	5	39
<u>Ailanthus altissima</u> (Mill.) Swingle							
Ether extract of twigs	.1				25	25	44
	.5				0	0	11
Florisol fractions - 44.1	.1				37	39	45
	.5				50	39	32
44.2	.1				39	46	39
	.5				32	36	44
44.3	.1				50	46	46
	.5				47	36	46
44.4	.1				79	69	50
	.5				25	35	49
Methanol extract of twigs	.1				45	44	49
	.5				20	21	29
Spicebush, <u>Lindera benzoin</u> (L.) Blume							
Ether extract of twigs	.1				0	0	50
	.5				0	0	11
Methanol extract of twigs	.1				17	26	47
	.5				0	0	46
Dogwood, <u>Cornus florida</u> L.							
Ether extract of twigs	.1				0	0	49
	.5				0	0	15
Florisol fractions - 46.1	.1				46	50	50
	.5				41	44	44
46.2	.1				27	38	49
	.5				20	18	44
46.3	.1				40	50	51
	.5				32	37	45
46.4	.1				67	59	49
	.5				24	36	44
46.5	.1				23	37	51
	.5				0	0	36
Methanol extract of twigs	.1				0	4	50
	.5				0	0	11
Water soluble fraction - 52.1	.1				24	18	39
	.5				0	0	0
Methanol soluble fraction - 52.2	.1				56	51	47
	.5				7	4	43

Table 2.—Other natural product plant extracts and fractions—Continued

Material	Dosage	Species and hours of observation							
		Spotted			Striped				
		3	6	24	3	6	24		
Greenbriar, <u>Similax rotundifolia</u> L.									
Ether extract of twigs	0.1				47	57	49		
	.5				0	0	42		
Methanol extract of twigs	.1				47	48	49		
	.5				24	27	39		
Christmas fern, <u>Polystichum acrostichoides</u> (Michx.) Schott.									
Ether extract	.1				35	41	49		
	.5				24	23	36		
Methanol extract	.1				39	41	40		
	.5				35	37	44		
Marginal shield fern, <u>Dryopteris marginalis</u> (L.) Gray									
Ether extract	.1				0	4	33		
	.5				0	0	2		
Methanol extract	.1				40	42	41		
	.5				20	23	49		
Moss #1, <u>Atrichum undulatum</u> (Hedw.) P. Beauv.									
Ether extract	.1				39	45	48		
	.5				20	19	44		
Methanol extract	.1				30	39	39		
	.5				37	41	41		
Moss #2, <u>Bryhnia novae-angliae</u> (Sull.) Grout.									
Ether extract	.1				25	13	26		
	.5				6	4	41		
Methanol extract	.1				42	44	40		
	.5				45	50	46		
Moss #3, <u>Thuidium erectum</u> Duby									
Ether extract	.1				37	13	39		
	.5				24	31	41		
Methanol extract	.1				44	40	35		
	.5				38	33	41		
White pine cones, <u>Pinus strobus</u> L.									
Methanol extract	.1				33	38	43		
	.5				6	3	37		
Fractions - 56.1	.1				28	30	49		
	.5				0	0	31		
56.2	.1				10	18	50		
	.5				24	28	38		
56.3	.1				52	47	50		
	.5				29	33	43		
56.4	.1				27	32	50		
	.5				22	33	37		
Skunk cabbage, <u>Symplocarpus foetidus</u> (L.) Nutt.									
Ether extract	.1				43	39	39		
	.5				30	32	41		
Methanol extract	.1				35	32	39		
	.5				35	39	39		
Sycamore twigs, <u>Platanus occidentalis</u> L.									
Ether extract	.1				18	28	40		
	.5				13	7	32		
Methanol extract	.1				48	40	49		
	.5				41	32	48		
Elm twigs, <u>Ulmus americana</u> L.									
Ether extract	.1				38	38	39		
	.5				0	0	45		
Methanol extract	.1				48	39	47		
	.5				63	46	48		
Beech twigs, <u>Fagus grandifolia</u> Ehrh.									
Ether extract	.1				33	30	48		
	.5				26	37	29		
Methanol extract	.1				26	30	50		
	.5				13	18	51		

Table 2.—Other natural product plant extracts and fractions—Continued

Material	Dosage	Species and hours of observation									
		Spotted			Striped						
		3	6	24	3	6	24				
Japanese honeysuckle, <i>Lonicera japonica</i> Thunb.											
Ether extract	0.1				18	15	43				
	.5				0	0	11				
Florisol fractions - 45.1	.1				65	59	50				
	.5				58	57	48				
45.2	.1				47	50	51				
	.5				50	55	23				
45.3	.1				48	52	49				
	.5				32	29	50				
45.4	.1				46	44	49				
	.5				58	61	50				
45.5	.1				38	34	40				
	.5				19	27	50				
45.6	.1				17	26	39				
	.5				0	0	18				
Methanol extract	.1				25	21	49				
	.5				6	5	18				
Bloodroot, <i>Sanguinaria canadensis</i> L.											
Ether extract	.1				6	15	41				
	.5				0	0	17				
Florisol fractions - 51.1	.1				43	41	50				
	.5				39	46	48				
51.2	.1				31	33	48				
	.5				42	42	48				
51.3	.1				48	48	51				
	.5				48	49	39				
51.4	.1				15	32	20				
	.5				0	4	9				
51.5	.1				21	13	35				
	.5				0	8	20				
51.6	.1				15	47	44				
	.5				3	12	36				
Methanol extract	.1				6	12	34				
	.5				0	0	9				
Methanol insoluble fraction - 34A	.1				54	44	46				
	.5				28	24	32				
Methanol soluble fraction											
Florisol fractions - 34.1	.1				30	26	36				
	.5				25	17	22				
34.2	.1				62	59	35				
	.5				0	0	30				
34.3	.1				0	0	29				
	.5				0	0	17				
34.4	.1				0	5	30				
	.5				0	0	31				
34.5	.1				40	43	37				
	.5				50	46	38				
34.6	.1				21	21	37				
	.5				0	8	34				
34.7	.1				47	56	45				
	.5				7	9	27				
Juniper leaves, <i>Juniperus virginiana</i> L.											
Ether extract	.1				36	31	31				
	.5				0	0	18				
Florisol fractions - 48.1	.1				39	43	47				
	.5				14	23	39				
48.2	.1				39	47	44				
	.5				22	24	23				
48.3	.1				36	36	50				
	.5				5	7	38				
48.4	.1				58	51	51				
	.5				42	39	40				
Methanol extract	.1				83	75	52				
	.5				0	5	45				
Ether soluble fraction - 53.1	.1				0	10	49				
	.5				0	8	18				
Water soluble fraction - 53.2	.1				45	45	50				
	.5				0	3	48				

**Table 2.—Other natural product plant extracts and fractions—Continued**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Holly leaves, <i>Ilex opaca</i> Ait.							
Ether extract	0.1				59	62	45
	.5				17	11	49
Methanol extract	.1				14	10	33
	.5				0	0	0
Florisil fractions - 42.1	.1				55	50	49
	.5				11	6	23
42.2	.1				56	56	38
	.5				50	50	38
42.3	.1				0	0	7
	.5				0	0	0
42.4	.1				35	46	41
	.5				20	33	35
Ether partition - 42.5	.1				47	43	42
	.5				9	24	38
Water partition - 42.6	.1				0	0	9
	.5				0	0	5
Reverse phase fractions - 43.1	.1				47	46	32
	.5				45	50	44
43.2	.1				0	0	19
	.5				0	0	0
43.3	.1				41	35	29
	.5				17	15	38
43.4	.1				0	6	18
	.5				0	0	5
43.5	.1				21	23	24
	.5				0	17	27
43.6	.1				39	32	39
	.5				0	0	39
Rose stems, <i>Rosa multiflora</i> Thunb.							
Ether extract	.1				53	52	40
	.5				41	36	36
Methanol extract	.1				70	67	49
	.5				50	34	49
<i>Baccharis megapotamica</i> (Spreng.) aerial							
Hexane extract - A13-42853	.1				21	19	42
	.5				0	0	41
Ether extract - A13-42854	.1				19	21	41
	.5				0	0	11
Parsley extract-21366-X(1)	.1				57	50	49
	.5				41	48	49
Rosemary leaf extract - 21603-X(1)	.1				53	36	46
	.5				43	36	38
<i>Heliopsis scabra</i>							
Stem and leaf extract - 42855	.1				57	53	49
	.5				33	24	29
Root extract - 42856	.1				50	43	50
	.5				32	41	47
<i>H. parvifolia</i>							
Root extract	.1				67	52	43
	.5				42	48	46
<i>Lycopodium</i>							
Ether extract - 57.1	.1				45	45	48
	.5				0	0	29
Ethanol extract - 57.2	.1				36	38	46
	.5				0	0	48
New York fern, <i>Dryopteris noveboracensis</i> (L.) Gray							
Ether extract - 57.3	.1				57	57	48
	.5				25	24	47
Ethanol extract - 57.4	.1				21	29	45
	.5				0	0	29
Lady fern, <i>Athyrium filix-femina</i> (L.) Roth							
Ether extract - 57.5	.1				45	29	47
	.5				25	19	49
Ethanol extract - 57.6	.1				45	29	47
	.5				25	19	49
Cinnamon fern, <i>Osmunda cinnamomea</i> L.							
Ether extract - 57.7	.1				42	43	49
	.5				20	13	49
Ethanol extract - 57.8	.1				33	36	49
	.5				0	5	44

**Table 2.—Other natural product plant extracts and fractions—Continued**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
<u>Baccharis megapotamica</u> (Spreng.) aerial--Cont'd.							
Field Camomile, <u>Anthemis arvensis</u> L.							
Ether extract - 57.9	0.1				35	39	49
	.5				20	24	47
Ethanol extract - 57.10	.1				40	38	42
	.5				0	26	34
<u>Malva aegyptia</u>							
Ethanol extract	.1				70	63	47
	.5				45	50	31
<u>Trewia nudiflora</u>							
Ethanol extract	.1				53	57	42
	.5				45	47	30
<u>Trewia nudiflora</u>							
Ethanol extract, (partially fractionated)	.1				42	39	36
	.5				14	8	13
<u>Bonjeania recta</u>							
Ethanol extract	.1				45	47	44
	.5				40	56	38
<u>Cayaponia ficifolia</u>							
Ethanol extract	.1				58	45	45
	.5				27	25	38
<u>Berrya ammonilla</u>							
Ethanol extract	.1				43	30	33
	.5				20	14	27
<u>Diploclisia glaucescens</u>							
Ethanol extract	.1				0	18	42
	.5				9	6	12
<u>Asphodeline liburnica</u>							
Ethanol extract	.1				42	46	44
	.5				56	50	42
<u>Cardopatum corymbosum</u>							
Ethanol extract	.1				20	25	33
	.5				27	18	31
<u>Chickrassia tabularis</u>							
Ethanol extract	.1				10	5	22
	.5				0	0	0
<u>Clitoria ternatia</u>							
Ethanol extract	.1				8	19	41
	.5				0	0	17
<u>Bassia hyssopifolia</u>							
Ethanol extract	.1				44	36	37
	.5				29	25	36
<u>Datisca cannabina</u>							
Ethanol extract, (Partially fractionated)	.1				14	20	31
	.5				23	17	27
<u>Bupleurum fontanesii</u>							
Ethanol extract	.1				29	32	36
	.5				28	26	31
<u>Butea frondosa</u>							
Ethanol extract	.1				50	51	39
	.5				35	39	40
<u>Apium selowianum</u>							
Petroleum ether extract	.1				0	15	27
	.5				0	0	0
<u>Lilium giganteum</u>							
Petroleum ether extract	.1				43	41	40
	.5				38	43	39
<u>Traqia incana</u>							
Petroleum ether extract	.1				53	55	43
	.5				58	60	41
<u>Chrysanthemum segetum</u>							
Petroleum ether extract	.1				57	58	36
	.5				64	50	46
<u>Zanthoxylum acanthopodium</u>							
Petroleum ether extract	.1				64	61	29
	.5				50	48	28
<u>Anchusa angustifolia</u>							
Petroleum ether extract	.1				25	26	31
	.5				38	46	38
<u>Schleichera trijuga</u>							
Petroleum ether extract	.1				60	55	36
	.5				55	46	30
Nerifolin from <u>Thevetia thevetioides</u>							
	.1				20	19	16
	.5				0	0	7

**Table 3.—Synthetics**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Oxazine - A1-328953	0.05	53		31	34		34
	.1	56		37	25		24
	.2	17		19	28		36
Oxazolidine - AI-382963	.05	49		41	1		11
	.1	38		27	11		10
	.2	0		13	0		0
Galactitol - AI13-19423	.1				68	56	47
	.5				63	60	49
Saccharin - A13-38107	.1				44	29	47
	.5				7	3	22
Piperine (from <u>Piper nigrum</u> berries) - A13-1439	.1				40	44	51
					33	27	30
Vernaldehyde - Ent 70178	.1				40	52	40
	.5				33	33	20
Wild tomato compounds							
2-Tridecanone - A13-4238	.1				33	41	49
	.5				43	20	38
3-Tridecanone - A13-38182	.1				45	58	47
	.5				11	7	26
5-Tridecanone - A13-38183	.1				25	42	47
	.5				0	0	41
6-Tridecanone - A13-38184	.1				33	31	41
	.5				0	11	22
Catechol - A13-3995-a	.1				19	25	48
	.5				0	11	37
Bitter substances							
Limonin - A13-37932	.1	46	38		39	40	
	.5	43	45		52	49	
Deoxylimonin - A13-37933	.1	42	47		46	38	
	.5	59	54		47	49	
Obacunone - A13-37934	.1	33	37		29	38	
	.5	26	33		19	18	
Nomilin - A13-37935	.1	45	43		55	48	
	.5	0	0		14	12	
Deacetylnomilin - A13-37936	.1	48	46		45	39	
	.5	50	49		25	31	
Lanosterol	.1				74	58	49
	.5				70	66	49
Beta-methylumbelliferone - A13-08085	.1				39	44	44
	.5				0	8	46
Umbelliferone - A13-38054	.1				56	42	49
	.5				42	41	47
Morin - A13-38057	.1				43	42	50
	.5				39	24	50
Lonchocarpic acid - A13-1135	.05				47	44	50
	.1				29	47	49
	.5				37	40	48
2-(1-Pentenyl-3-oxy)tetrachydropyran - A13-37374	.1				45	44	45
	.5				35	41	35
2-(1-Pentynyl-3-oxy)tetrahydropyran - A13-8078	.1				31	33	49
	.5				8	26	32
Terpenes							
Amorphene - Ent 44855	.1				47	54	47
	.5				7	13	44
Alpha-ionone	.1				21	36	49
	.5				0	6	27
Beta-ionone	.1				0	0	37
	.5				0	0	27
Nerolidol	.1				0	15	39
	.5				11	16	29
D-Pulegone - A13-38056	.1				0	15	49
	.5				0	0	27
Alpha-terpineol - A13-00275	.1				18	19	39
	.5				5	14	33
p-Cymene - A13-02272	.1				32	42	40
	.5				16	32	44

**Table 3.—Synthetics—Continued**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Helenin (alantolactone)	0.1				44	46	48
	.5				40	36	46
Phlorizin	.1				18	32	46
	.5				31	27	51
<b>Naphthoquinones</b>							
Juglone (5-hydroxy-1,4-naphthoquinone)	.1				0	0	9
	.5				0	0	0
Lawsone (2-hydroxy-1,4-naphthoquinone)-H4,680-5	.1				6	7	19
	.5				0	0	2
Plumbagin (5-hydroxy-2-methyl-1,4-naphthoquinone) - A13-38055	.1				30	37	50
	.5				33	31	47
1,4-Naphthoquinone - A13-24292	.1				0	0	0
	.5				0	0	0
2-Methyl-1,4-naphthoquinone - A13-5740	.1				0	0	0
	.5				0	0	0
Lapachol (2-hydroxy-3-(3-methyl-2-butenyl)-1,4-naphthoquinone) - 14290-5	.1				13	10	18
	.5				18	17	13
2-Methoxy-1,4-naphthoquinone - 18915-2	.1				14	7	5
	.5				0	0	0
Menadione (2-methyl-1,4-naphthoquinone - MS740-5	.1				0	0	0
	.5				0	0	0
1,2-Naphthoquinone - A13-14930	.1				20	20	24
	.5				0	0	0
2-Hydroxy-3(2-methyloctyl)-1,4-naphthoquinone - SN-5949	.1				46	48	41
	.5				0	0	3
2-Dimethylamino-1,4-naphthoquinone - AI-3-954	.1				7	5	2
	.5				0	6	2
B621-related structure	.1				0	0	0
	.5				0	0	0
B662-related structure	.1				0	0	0
	.5				0	0	0
<b>Anthraquinones</b>							
1-Aminoanthraquinone - A13-08918	.1				27	40	45
	.5				11	12	16
2-Aminoanthraquinone - A13-09063	.1				43	48	46
	.5				44	35	43
1,5-Dichloroanthraquinone - A13-38301	.1				33	43	23
	.5				27	32	13
1,8-Dichloroanthraquinone - A13-38302	.1				22	19	15
	.5				0	0	3
2,3-Dichloroanthraquinone - A13-03776	.1				25	27	24
	.5				9	10	24
1-Chloroanthraquinone - A13-38116	.1				8	10	17
	.5				0	0	0
2-Chloroanthraquinone - A13-64	.1				29	41	50
	.5				80	53	49
9,10-Dihydro-9-anthracene - A13-11256	.1				31	37	51
	.5				25	38	40
9,10-Anthraquinone - A13-9073	.1				46	50	49
	.5				7	19	50
2-Methylantraquinone - A13-16057	.1				46	41	47
	.5				0	0	0
2-Ethylantraquinone - A13-17614	.1				0	8	40
	.5				0	0	11
1,4-Dihydroxyanthraquinone - A13-17616	.1				40	44	48
	.5				56	62	46
1,2-Dihydroxyanthraquinone - A13-18244	.1				60	56	50
	.5				25	38	46
1,8-Dihydroxyanthraquinone - A13-38117	.1				45	38	50
	.5				20	15	31



showed activity against cucumber beetles, particularly the spotted beetle. Some fractions of the ether extract of tung nuts were active at 0.5 percent.

Among other natural products that exhibited anti-feedant properties against the striped beetle were wheat stem extracts and fractions, extracts of the tulip tree, ailanthus, spicebush, dogwood, greenbriar,

**Table 4.—Benzylphenol compounds**

Material	Dosage	Species and hours of observation					
		Spotted			Striped		
		3	6	24	3	6	24
Jurd 2317	0.063	13	30	31	45	51	31
	.125	0	0	0	0	0	0
Jurd 2325	.063	10	7	29	5	20	20
	.125	0	0	11	0	0	0
Jurd 2418	.063	47	42	42	53	33	30
	.125	0	0	5	35	16	17
Jurd 2419	.063	29	17	48	46	45	48
	.125	0	4	18	5	22	29
Jurd 2706	.063	26	33	36	32	32	38
	.125	12	15	15	21	36	25
Jurd 2714	.063	0	0	11	4	39	33
	.125	0	0	7	0	3	3
Jurd 2539	.063	5	11	15	5	32	29
	.125	0	5	5	0	0	0
Jurd 2713	.063	9	30	42	26	38	44
	.125	0	0	11	0	0	0

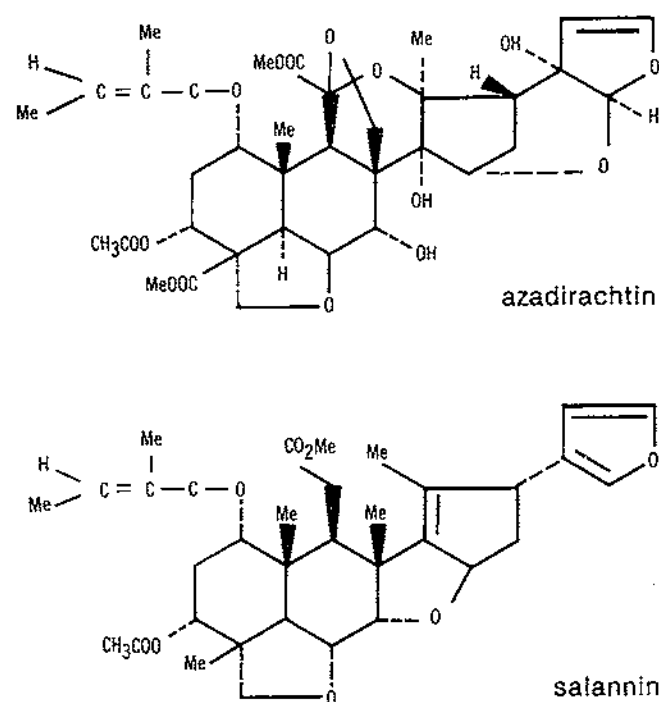


FIGURE 1.—Triterpenoids isolated from neem.

marginal shield fern, white pine cones, Japanese honeysuckle, bloodroot, juniper leaves, holly leaves, *Apium sellowianum*, and *Chickrassia corymbosum*. Nerifolol also exhibited activity.

Many natural products that were available as synthetics were also screened (table 3). Oxazolidine was considerably more active than oxazine as an anti-feedant for both species of insects. Anthraquinones and naphthoquinones possessed antifeedant activity for the striped beetle, but the naphthoquinones showed stronger activity. Juglone 1,4-naphthoquinone and 2-methyl-1,4-naphthoquinone were promising as antifeedants for the striped beetle.

The benzylphenol compounds (fig. 2) generally were active even at low concentrations (table 4). These materials were phytotoxic at higher dosages but may still be useful because of their activity.

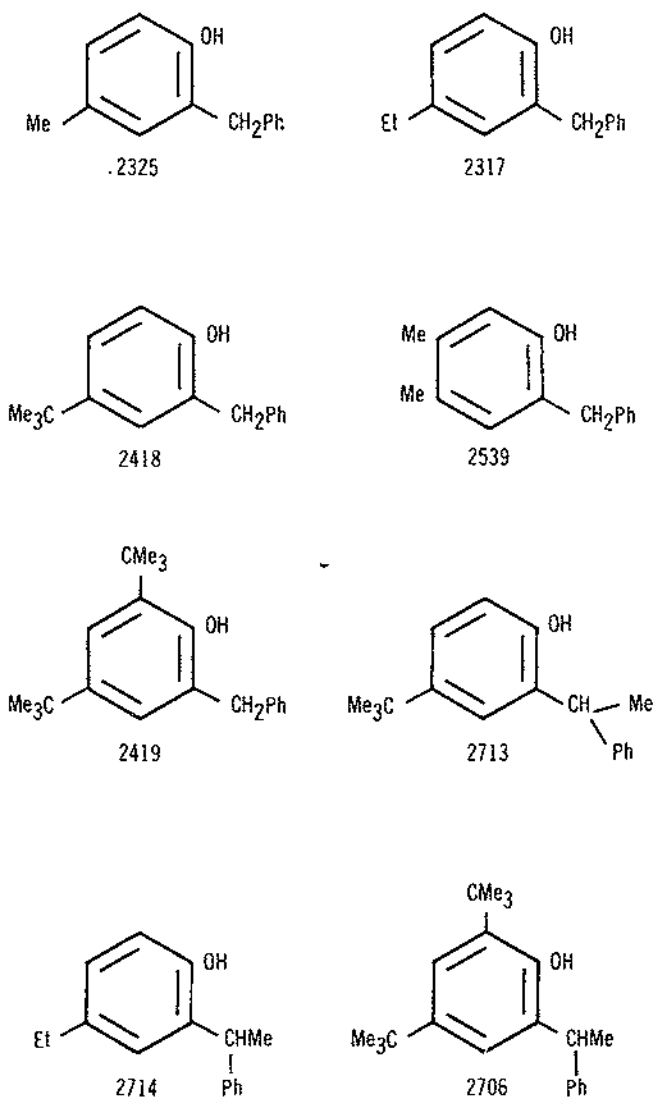


FIGURE 2.—Benzylphenolic compounds.

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