PREDACEOUS COCCINELLID OVIPOSITION RESPONSES TO *JUNIPERUS* WOOD

ПРИВЛЕЧЕНИЕ ЯЙЦЕКЛАДУЩИХ САМОК ХИЩНЫХ КОКЦИНЕЛЛИД ДРЕВЕСИНОЙ МОЖЖЕВЕЛЬНИКА

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In laboratory experiments at Belleville and Guelph, Ont., four species of coccinellids, *Cycloneda munda* (Say), *Adalia bipunctata* (L.), *Coccinella transversoguttata richardsoni* Brown, and *Coleomegilla maculata lengi* Timberlake, revealed strong attractances to *Juniperus virginiana* L. (juniper) for oviposition. This attractancy was due to the specific odour of *Juniperus* wood. Egg laying rates were not affected by distances up to 70 cm in laboratory cages in a greenhouse where temperatures ranged from 24.0° to 29.5°C. This phenomenon may be used to aggregate ovipositing coccinellid females in places where aphids are expected to occur in damaging numbers.

Лабораторными экспериментами в исследовательском институте в Беллевилле и Гуэлфском университете (Канада, провинция Онтарио) было выявлено сильное привлекающее действие древесины можжевельника виргинского **Juniperus Virginiana L.** на яйцекладущих самок четырех видов хищных кокцинеллид **Cycloneda munda** (Say), **Adalia bipunctata** (L.), **Coccinella transversoguttata richardsoni** Brown и **Coleomegilla maculata lengi** Timberlake.

Специфический запах древесины можжевельника привлекает самок для откладывания яиц. В лабораторных садках в теплице при температуре от 24°C до 29,5°C и освещенности от 65 до 1000 фут-свечей интенсивность откладки яиц на можжевельник в пределах 70 см не зависела от удаленности привлекающего материала от источника корма для кокцинеллид.

Обработка «нейтральных» видов древесины спиртовым экстрактом из **J. Virginiana** делала их привлекательными для яйцекладущих самок кокцинеллид.

Это явление может быть использовано для привлечения кокцинеллид в места, где ожидается значительный вред от тлей.

Introduction

Predatory coccinellids are perhaps the best known entomophagous insects. However, our knowledge of their biology is insufficient to meet the needs of extensive biological and integrated control programmes in pest control. This lack of knowledge applies particularly to reproductive behaviour. Identification of effective stimuli for oviposition may enable us to manipulate the distribution of a predator's eggs and thereby increase its efficiency as a mortality agent of aphids and other prey. Detrimental effects of oviposition stimuli also require study because of the possible long term deleterious effects on certain life stages and metamorphosis similar to those described by Smith and Bérubé (1966) with sex sterilants and Carlisle and Ellis (1967) with chemicals in paper.

Coccinellids lay their eggs in clusters on the foliage, stems, and ground litter of plants that are usually prey-infested. In confinement, eggs are laid on glass, plexiglass, paper, foliage, and, sometimes on synthetic food media (Iperti 1966; Smith 1965). The number of clusters laid at a particular site in the field does not depend on the number of prey in the vicinity (Banks 1955). Females of some species may search for oviposition sites with different characteristics from feeding sites. Such behaviour may reduce losses of eggs to predators but also increases mortality in first-instar larvae which may starve before reaching food. Opinions differ on the survival value of egg cannibalism and use of alternate foods by this stage (Banks 1957; Pienkowski 1965). However, considerable mortality among first-instar larvae occurs in the laboratory when food is situated less than ½ m from newly-hatched larvae (Boldeyrev and Wilde 1969).

This is a report of progress made in laboratory and field studies on the effects of "red cedar" and other woods on the oviposition responses of coccinellids. W. H. A. Wilde first observed that "red cedar" stimulated oviposition and pupation of coccinellids in 1957 and 1958 in apple orchards of the Kootenay Valley in British Columbia. As a result of these observations the present studies were initiated by visiting Exchange Scientist M. I. Boldyrev of the Michurinsk Horticultural Institute, U.S.S.R., in Canada for international co-operative studies on integrated control of orchard insects. Preliminary investigations of Boldyrev and Smith at the Belleville Research Institute of the Canada Department of Agriculture in February 1968 were continued by Boldyrev and Wilde at the University of Guelph and by B. C. Smith at Belleville.

Materials and Methods

Specimens of *Cycloneda munda* (Say), reared at the Belleville Research Institute, were the first coccinellids tested. Three other species of coccinellids, *Adalia bipunctata* (L.), *Coccinella transversoguttata richardsoni* Brown, and *Coleomegilla maculata lengi* Timberlake, were used in the later phases of the investigations at the University of Guelph.

Identification of the coccinellids was confirmed by members of the Entomology Research Institute, Ottawa. Valuable data regarding food and survival habits of test coccinellids were obtained from W. J. Brown of this institute.

Various species of finished wood are mistakenly called "red cedar" (Anonymous 1961). In these experiments the western red cedar, *Thuja plicata* Donn., *Juniperus virginiana* L., and *Juniperus scopulorum* Sarg. were the main woods tested. On a limited scale, *Juniperus communis* L. and *Thuja occidentalis* L. (eastern white cedar) were used in the experiments. Other woods used in these oviposition trials were black spruce (*Picea mariana* (Mill) BSP), white pine (*Pinus strobus* L.), fir (*Abies lasiocarpa* (Hook.) Nutt.), and California redwood (*Sequoia sempervirens* Endl.).

Preliminary tests using some of the above-named cedar and juniper woods in 15-cm diameter by 25-cm plastic cages were carried out at Belleville. This type of cage was soon abandoned in favour of larger cages (Fig. 1) 30 cm square by 45 cm high with clear plexiglass fronts and sides and top covered with saran screen. A sliding door front provided access to the cage interior.

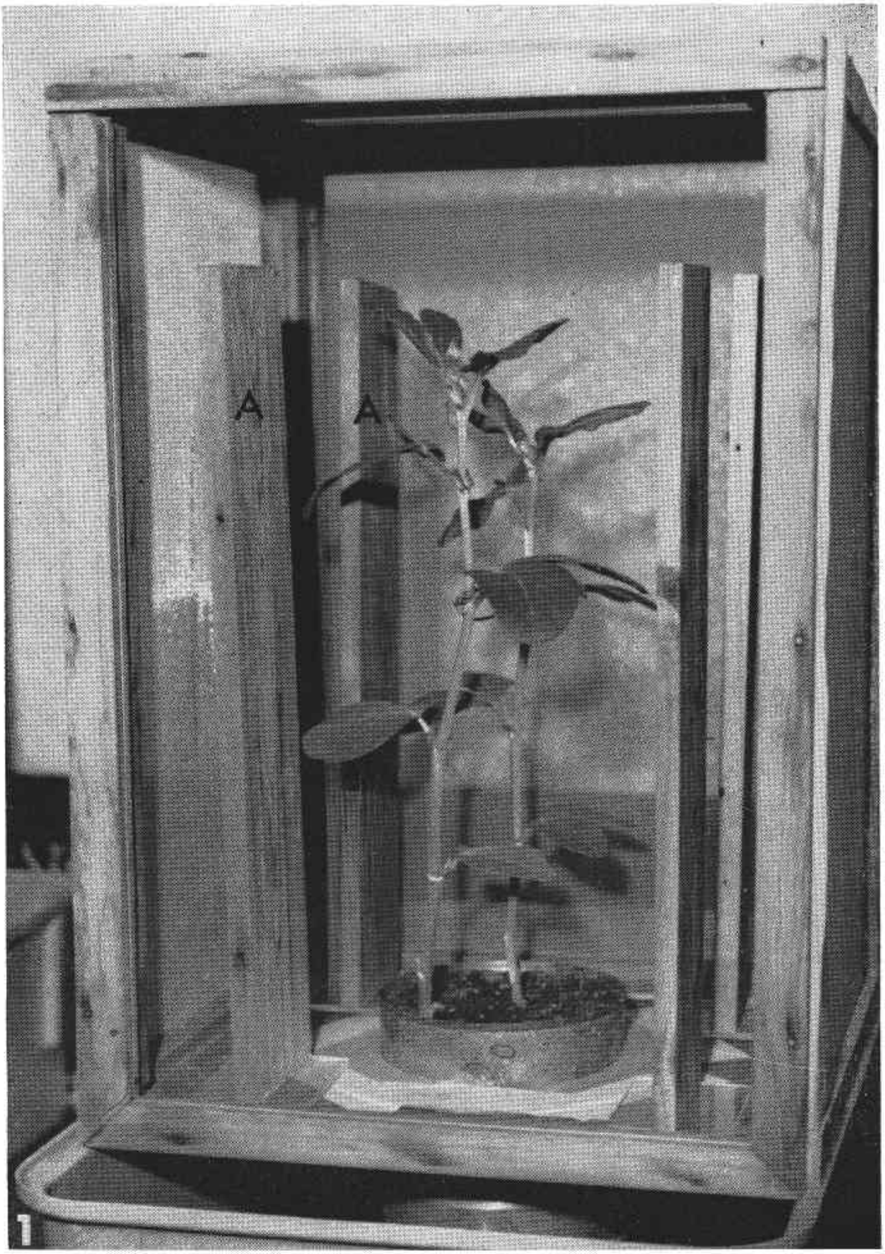

FIG 1. Laboratory cage 30 cm square and 45 cm high and placement of boards (A) used to test coccinellid oviposition responses to *Juniperus* and other woods.

In the first experiments with the round plastic cages, all boards used were 16 cm long, 4 cm wide, and 1.2 cm thick, held upright by a plastic lintel. In all following experiments board size was 33 cm long, 6.4 cm wide, and 0.9 cm thick. These larger boards were attached to a 5-cm wide, 6.2-cm long, and 0.3-cm thick plastic base by two 15-mm × 7-mm screws.

After oviposition responses to juniper had been observed, the role of distance from oviposition sites to prey was investigated. This required larger experimental cages and the most suitable one devised was 90 cm long, 61 cm wide, and 61 cm high. Two sliding doors each 30 cm wide and 61 cm high at the fronts of the cages provided access to the interior. Saran screen, 32 by 32 mesh, was used on the frame. Base of the cage was ¼-in. plywood drilled to allow various size pots containing food for aphids to be tightly placed and extend through the cage base into watering trays.

Juniper wood extracts were prepared from quantities of juniper shavings placed in 75 or 90% alcohol in an 8-oz. screw-top sealed jar for 24 hours. Test spruce boards were treated with this extract while spruce check boards were treated with 75 or 90% alcohol only. These extract experiments were carried out to determine if the response factor in the juniper was odour or texture of the wood. In other tests, juniper and white cedar boards were wrapped in yellow crepe paper to exclude oviposition responses due to colour or texture.

Broadbean, *Vicia faba* L., was the host plant used for rearing the pea aphid, *Acyrthosiphon pisum* (Harr.), food for the coccinellids. While most of the coccinellid food used was live and fresh, some prepared food was provided test coccinellids by drying and grinding populations of *A. pisum.*

Petri dishes, 9 cm in diameter and 1 cm deep, with a 2.5-cm by 3.7-cm screened window placed in the lid, were used to rear most of the coccinellids. The remainder were reared in standard 61-cm high and 23-cm square cages placed over potted beans. All tests were carried out in a conventional greenhouse with a temperature range of 24.0° to 29.5°C.

Results

Varietal Response

In order to verify that certain types of wood were attractive to coccinellids and conducive to coccinellid egg laying, five species of wood of a size described previously were tested individually in plastic cages containing live aphid food. These aphids were placed daily in the cage at a rate of five for every coccinellid. When aphid host plants were used in test cages, daily insertion of aphids was not necessary. In this initial experiment, only *C. munda* was tested and revealed the attractancy of juniper wood for *C. munda.* Of the species of wood tested, excluding *S. sempervirens,* only *J. virginiana* initiated oviposition responses in *C. munda.*

Egg laying in the cage containing juniper totalled 7 egg clusters on the juniper and an equal number on the cage plastic. In all other cages, egg clusters were laid in random numbers from 6 to 15 on plastic portions only of each cage. No eggs were laid on western red cedar, white cedar, spruce, pine, or fir.

With the transfer of test coccinellids and aphids to more suitable and larger cages, egg laying results were obtained using 10 adult *C. munda* as test coccinellids. Broadbean was used for maintaining populations of the pea aphid, *A. pisum,* which served as food for the coccinellids. Egg counts made twice per day (9:00 A.M. and 3:30 P.M.) reduced errors in egg and cluster counting that might have occurred because of cannibalism. This experiment was carried out at the Belleville Research Institute and in this test, *C. munda* laid 12 clusters containing 123 eggs on *J. virginiana,* 1 cluster of 4 eggs on *P. mariana,* 1 cluster and 8 eggs on the host plant, and no eggs on any other part of the cage.

TABLE I

Oviposition responses by four species of coccinellids to various oviposition sites (C, clusters; E, eggs; H.P., host plant)

	Sites							
	J. virginiana		*Thuja* sp.		H.P.		Cage	
Coccinellid	C	E	C	C	C	E	C	E
C. munda	10	113	0	C	6	47	1	9
A. bipunctata	15	246	0	0	1	9	0	0
C. transversoguttata	9	213	0	0	0	0	0	0
C. maculata	10	148	1	3	1	12	1	7
	J. scopulorum		*Thuja* sp.		H.P.		Cage	
	C	E	C	E	C	E	C	E
A. bipunctata	25	360	0	0	3	35	14	146
	J. communis		*Thuja* sp.		H.P.		Cage	
	C	E	C	E	C	E	C	E
A. bipunctata	3	69	3	53	8	135	3	62

Initial experiments showing attractancy of *C. munda* to *J. virginiana* were used to determine if similar responses occurred in *A. bipunctata*, *C. transversoguttata*, and *C. maculata*. The same test procedures were used in these trials as were used with *C. munda*. To reduce colour differences, only brown *Thuja* boards were used in later colorimetric test responses. Table I shows coccinellid egg-laying responses to three species of *Juniperus*, one species of *Thuja*, aphid host plants, and the cage itself, during experiments carried out at the University of Guelph.

On the basis of results illustrated in Table I, the greatest oviposition attractancy per one species of coccinellid, *A. bipunctata*, was *J. scopulorum* followed by *J. virginiana*. *J. communis* was least attractive.

Coccinellid attractancy for *Juniperus*, relative to distance from prey host plants, was investigated. In these experiments five *J. virginiana* test boards in a test cage were situated 15 cm apart, radiating out in a single line from the first board placed immediately adjacent to the prey host plant. A total of 15 *C. munda* adults were used in this test.

Clusters and egg totals on boards beginning with the board nearest the host plant, followed by those distal from this board, were as follows: board No. 1 had 3 clusters and 20 eggs; board No. 2 had 2 and 8; No. 3 had 4 and 23; No. 4 had 2 and 19; board No. 5 had 2 and 25. The host plant itself had 3 and 20 while all parts of the cage including the plastic screen had 2 and 18.

A similar experiment was made using *A. bipunctata* but with board placement slightly altered by staggering two rows of three boards as illustrated in Fig. 2. Two species of wood, *Thuja* and *Juniperus*, alternated in the rows with one board of each wood species placed 2.5 cm from the prey host-plant pot-edge and alternate wood species placed in line at distances of 20.4 cm.

Egg clusters and individual egg totals on *Juniperus* boards beginning with the one closest to the prey host plant were as follows: board 1 had 2 and 23; board 2 had 3 and 37; and board 3 had 2 and 26. No eggs were laid on *Thuja* boards.

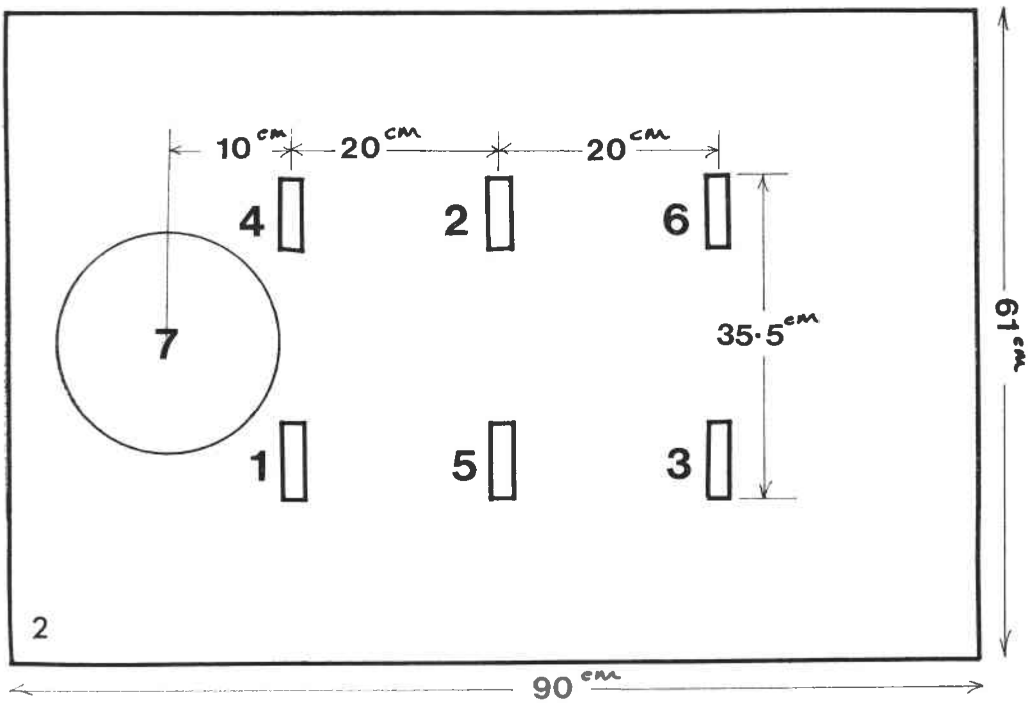

FIG. 2. Schematic showing locales of test boards (*Juniperus* — 1, 2, 3 and *Thuja* — 4, 5, 6) and aphid host plant (7) in a cage used to determine the effects of distance on oviposition and prey seeking by coccinellids.

Three egg clusters and 38 eggs were laid on the host plant and 1 cluster and 7 eggs were laid on all other parts of the cage.

To assess the role of colour as a major factor influencing the egg-laying responses of *A. bipunctata*, two *J. virginiana* and two *T. plicata* boards were wrapped in yellow crepe paper and placed in a test cage with 10 *A. bipunctata*. *A. bipunctata* laid 20 clusters totalling 273 eggs on *J. virginiana*, 2 clusters totalling 19 eggs on *T. plicata*, 1 cluster with 9 eggs on the prey host plant, and 1 cluster with 10 eggs on the cage interior.

Results from other attempts to assess the role of colour as one of the possible major factors influencing coccinellid responses to test boards are listed in Table II. *Thuja* boards, similar in colour to *Juniperus*, and white-coloured *Thuja* boards were selected to provide a contrasting colour but having similar texture and odour. *A. bipunctata* and *C. transversoguttata* (10 specimens each) were the only two coccinellid species tested for colour response. Results (Table II) indicate that these species prefer lighter-coloured egg-laying areas in *Thuja*. Egg laying in the cage and on the host plant, considerably greater than on either colour of *Thuja*, strengthened the previous observation that *Thuja* wood colour was not a stimulus for coccinellid oviposition.

Coccinellid egg-laying responses to alcohol extracts from *J. virginiana* were investigated. Extracts were prepared and applied to previously-tested species of non-attractive boards, viz. spruce. Spruce test boards, coated with either juniper

TABLE II

Comparison of coccinellid oviposition responses to two colours of boards of *Thuja plicata* and other oviposition sites (C, clusters; E, eggs)

Coccinellid	Sites							
	White		Brown		Host plant		Cage	
	C	E	C	E	C	E	C	E
A. bipunctata	3	69	0	0	5	96	8	117
C. transversoguttata	1	6	0	0	6	156	2	76

extract or with 75 or 90% alcohol alone, were placed in test cages with 10 specimens of *C. munda.* Table III illustrates results from these tests.

Discussion

Oviposition Site Preferences

The first experiments with five species of test boards indicated *J. virginiana* was a preferred egg-laying site for *C. munda.* Further testing verified this preference by illustrating that three other species, *A. bipunctata*, *C. transversoguttata*, and *C. maculata*, responded similarly. Distance of test boards from host plants had little or no effect on egg laying in laboratory experiments.

It was assumed that several major factors could be involved in coccinellid egg-laying responses to *Juniperus* wood. Colour, texture, and odour were three of the possible factors investigated in these experiments.

The fact that *A. bipunctata* was able to recognize *J. virginiana* covered with paper and ignored *T. plicata* similarly covered indicated that odour attracted *A. bipunctata* to juniper. Experiments with brown and white *Thuja* boards showed a very slight preference by the coccinellid for white *Thuja* boards. Hence the attractance of *Juniperus* wood was not due to a preference for the brown colour.

Experiments with spruce wood treated with *Juniperus* extracts indicated egg laying on spruce could be induced by these extracts. Because spruce treated with alcohol and with a texture similar to the *Juniperus*-extract-treated boards was not conducive to egg laying, texture of the treated boards was not considered as an attractive factor.

With the elimination of colour and texture as major attractants, specific odours of *Juniperus* wood can be considered the major stimulus for coccinellid

TABLE III

Effects of alcohol extracts of *J. virginiana* applied to boards of *P. mariana* on the oviposition behaviour of *C. munda* (C, clusters; E, eggs; H.P., host plant)

Place of expt.	Sites							
	P. mariana and extract		*P. mariana* and alcohol		H.P.		Cage	
	C	E	C	E	C	E	C	E
Belleville	7	84	2	27	0	0	2	28
Guelph	6	64	0	0	2	25	1	15

egg laying. *Juniperus*-attracting factors may be another means for aggregating ovipositing female coccinellids in places where prey may occur and this would augment the usage of synthetic foods described as a potential aggregating medium by Smith (1966).

While these experiments did not include a study of pupating responses to *Juniperus*, this is a future area of needed research. Other areas would be cannibalism in coccinellid egg clusters laid under the stimulus of *Juniperus*, the role of hyperpredation on eggs and other coccinellid life stages which could be unusually high in areas of *Juniperus* stimulation, the effect of *Juniperus* on population dynamics of coccinellid olfactory response in the field to *Juniperus* stimulus. The latter, easily observed in the laboratory, could be very different under field conditions and under extremes of climate which are not reproducible in laboratory trials.

The practicality of *Juniperus* board usage in the field, a possible means for a reduction in application of control chemicals, will require considerable investigation. Placement and timing of boards in infested food hosts such as fruit trees, field crops, and other food crops are just two of the major areas requiring investigation. The integration of this attractancy phenomenon with existing control practices also presents major problem areas not readily resolved by existing data.

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