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Biology and host preference of *Oxicesta geographica* (Lepidoptera: Noctuidae) candidate agent for biological control of *Euphorbia esula* complex (Euphorbiaceae) in North America[1]

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Abstract:

The biology and host specificity of *Oxicesta geographica* F. from Romania, Hungary, and Southwestern Russia were studied to evaluate the potential of this moth as a new biological control agent of leafy spurge, *Euphorbia esula* L., "complex" in North America. This oligophagous, multivoltine tent caterpillar is common on perennial spurges in southeastern Europe and Asia Minor and prefers dry, open sites. Results of no-choice feeding tests with first instars on 93 plant species and biotypes, distributed in 33 families, show that *O. geographica* completed its life cycle mainly on plants of *Euphorbia*, subgenus *Esula*, and occasionally fed and developed on species in other subgenera of the genus. Studies of late instars did not show any important extensions of the host range.

Keywords:

Noctuid moth, host range, larval survival test.

Leafy spurge, *Euphorbia esula* L. (Euphorbiaceae) (=*E. virgata* Waldstein & Kitaibel of many authors, Dunn 1979), is a complex of species and biotypes of Eurasian origin that has become a serious problem in North American rangelands, pastures, and recently

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in cropland and urban areas. It becomes an irreversibly dominant weed on rangelands and pastures, displacing useful forage plants (Harris *et al*. 1985) and produces an irritant that causes dermatitis to humans and animals (Kingsbury 1964). The problem is most severe on uncultivated lands, but leafy spurge can also reduce crop yields by 10-100% (Derscheid & Wrage 1972). Leafy spurge infested 451 counties in 25 states in the United States at the time of Dunn's (1979) study. The area of most serious infestation in North America is defined by a circle 1,930 km (1,200 mi) in diameter, centered in northeastern Montana; this area covers parts of nine states in the United States and five provinces in Canada and encompasses 1 million ha (nearly 2.5 million acres) (Lacey *et al*. 1985). A conservative estimate of losses to leafy spurge in the United States, in terms of expenditures for control and losses of rangeland productivity, was given as $10.5 million annually by Noble *et al*. (1979). A biological control program against leafy spurge was started by Agriculture Canada in 1962 and by the Agricultural Research Service, U.S. Department of Agriculture in 1973, and 11 insect species have been evaluated and introduced as biological control agents in North America to date (Harris *et al*. 1985, Pecora & Dunn 1990). Although six species have become established, it is likely that effective biological control will be achieved only if the combined attack of natural enemies in various climatic zones and habitat types extends over the entire vegetative season (Pecora & Dunn 1990). This article reports our studies on the biology and larval host range of the moth *Oxicesta geographica* F. (Lepidoptera: Noctuidae), a specialized defoliator of *Euphorbia* spp. in southeastern Europe and Asia Minor.

Materials and methods

The studies were conducted at the Biological Control of Weeds Laboratory USDA-ARS Europe, Rome, Italy (1984 to 1990) and the CAB International Institute of Biological Control (IIBC) Laboratory, Delemont, Switzerland (1987 to 1989).

Host Plants and Geographical Distribution. Larvae of *O. geographica* have been reported to be associated with *E. stepposa* Zoz ex Prokhanov (Popescu-Gorj & Draghia 1974, Popescu-Gorj & Konig 1976) and *E. cyparissias* L. (Seitz 1914). Spüler (1908) and Lhomme (1923) recorded the species on common toadflax (*Linaria vulgaris* L. (Scrophulariaceae)), but these authors probably misidentified the host because of the similar appearance of some *Euphorbia* species and *L. vulgaris* before flowering.

Oxicesta geographica is a species of the continental steppe biome; it is found predominantly in areas of open light sandy soils and dry conditions or rangeland pastures of low productivity, the typical habitats of *E. seguieriana* Necker, and *E. stepposa* in eastern Europe, or in small undisturbed areas around cultivated fields (e.g., corn, sugar beet, wheat) on *E. virgata*. The establishment of the moth appears to depend on a high density of spurge population. It is known from southern Romania (Popescu-Gorj & Konig 1976), Austria, Hungary, Yugoslavia to northern Greece, Turkey, and Russian Moldavia and Georgia (former southwestern USSR). The distribution of *O. geographica* is shown in Fig. 1.

The genus *Oxicesta* Hübner (1822) belongs to the family Noctuidae, subfamily Pantheinae (Poole 1989). Balachowsky (1972) listed four pest species belonging to the subfamily, all in the genus *Apatele* Hübner 1809-13. These species feed mainly on forest trees, but may attack fruit trees or cultivated plants in the genera *Beta, Brassica, Fragaria, Humulus, Lavandula*, and *Medicago*. *Simyra dentinosa* Freyer, another noctuid moth that is being studied by the ARS as a biological control agent of leafy spurge, belongs to the same subfamily.

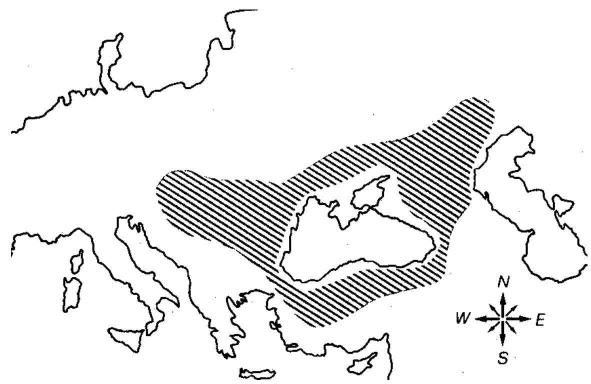

Fig. 1. Distribution of *O. geographica* in Eurasia.

The other two palaearctic species of *Oxicesta* have also been recorded on plants of the genus *Euphorbia. Oxicesta chamaesyces* Guenee was found on *E. chamaesyce* L. (Seitz, 1914), *E. characias* L. and *E. stepposa* (Spüler, 1908), and on *Sedum* sp. (Crassulaceae) (Lhomme, 1923). Garcia-Barros (1984) noted that *O. serratae* Zerny is associated with *E. serrata* L.

Host Range of Larvae. Host range was determined in laboratory tests by exposing neonate larvae to 101 species and varieties of plants, which are distributed in 33 families. Heywood (1978) was used as a guide in constructing the test plant list. Larvae used in the tests were reared from eggs collected in the field (first generation larvae), or from eggs laid in the laboratory by adults reared from larvae collected in the field (second or third generations). Two methods were used for conducting the tests.

Method A. (USDA-ARS laboratory for Romanian material). Host range was determined in two laboratory tests by exposing neonate larvae to 39 species and varieties of plants, which are distributed in 13 families. Five neonate larvae were placed in each cage (transparent plastic tubes; 20-cm diameter, 50-cm height), which enclosed a potted plant (greatest diameter 22 cm). There were five plants per species, and controls were *E. virgata* plants from the collection site in eastern Romania. Fresh plants were replaced when necessary. Tests were conducted under natural photoperiod, 23.5 ± 6.8° C, and 61 ± 20% RH, between 12 May and 13 July 1988.

During 1990 an additional larval survival test was carried out with 22 plant species of which 15 are in the family Euphorbiaceae (14 in the genus *Euphorbia*), and seven are in other families. Two *O. geographica* populations (from Romania and Southwestern Russia) were used for these tests. A minimum of five replications were made for each plant, using ten neonate larvae on each potted plant. Three replications were made using neonate larvae from eggs collected near Focsani (Romania), and two with first instars from Stavropol Southwestern Russia. Additional replications were made testing seventy third instars (for target test plants) from the two populations to determine if the feeding behavior is different during the development of the larvae.

Method B. (IIBC laboratory for Russian and Hungarian material). During 1987, tests were made with material from the Southwestern Russia and Hungarian populations, and their progeny. During 1988 and 1989, tests were made exclusively with a Hungarian population. Colonies of first to third instars, found at Tompa, southern Hungary on *E. stepposa* and *E. seguierana*, were reared on Canadian leafy spurge until pupation under laboratory conditions. All of the pupae were kept in the laboratory until adult emergence. Adults were reared in 1-liter plastic cylinders with the walls covered with white paper. Eggs, laid on the paper, were incubated at 20 ± 1° C, and a photoperiod of 16:8 (L:D) hours. Neonate larvae were transferred in groups of 10 and 20 to petri dishes 9-14-cm diameter and provided with leaves and cut shoots of the test plant species. Larger larvae were reared in half-liter plastic containers. No-choice larval feeding tests were conducted from July until mid-September (temperature 20 ± 1° C, photoperiod 16 hours). A minimum of 20 first instars was used for each of the 44 plant species tested. The potential extension of the host range by late instars, previously reared on a Canadian biotype of leafy spurge or *E. lucida* Waldestein & Kitaibel, was studied using groups of 10-20 third-instars from the Hungarian population for each of the 20 plant species tested.

Data Analysis. The data were analyzed by using the procedures of the Michigan State University Microcomputer Statistical Program (MSTAT 1986). Regression analysis was used to examine the relationship between temperature and insect development. The variability of the differences in larval survival rate and in the time spent to complete larval development was analyzed with analysis of variance (ANOVA) and with the Duncan's (1955) multiple-range test. The remaining survival data were analyzed with *t*-test, to determine if larval development was dependent on the plant species, larval instars, and replication effects.

Results

Life History. Adults apparently emerge in nature during late April to early May, as eggs were found as early as 2 May, 1989 in Romania. Young colonies (first and second instars) were found during May to early June in Hungary and Romania; mature larvae were collected during late October in Romania.

Oxicesta geographica has five instars. There were four generations in the laboratory. Because, in nature, eggs were collected on 2 May and 10 June, the first three instars were collected on 10 June, and mature larvae were collected on 20 October, it can be assumed that the species breeds continuously during the warm part of the year. Larvae fed in silken webs on the apices of *Euphorbia* spp. plants, causing extensive damage, First instars, typically in groups of 20-30, fed on flower buds and tender leaves for ≈4 days before they molted and moved together to a new branch or group of branches or to a new plant. Fifth instars were solitary feeders and consumed less than the other instars.

In the laboratory, larvae reached the pupal stage after ≈4 wk (26.8 ± 5.3° C, and 46.5 ± 16.5 RH); they pupated in light yellow silk cocoons spun on stems. The pupal stage lasted 9 to 13 days.

Fifteen pairs of adults lived 5 to 8 days under laboratory conditions. Oviposition started 1 to 3 days after mating. Eggs were laid mostly on the lower surfaces of leaves of *Euphorbia*. The number of eggs laid per female ranged between 60 and about 450. In nature, single egg batches consist of >300 eggs. The egg stage lasted 9 to 12 days and egg fertility was 99%.

The rate of egg, larval, and pupal development is correlated with temperature ($P < 0.05$) (Table 1). The incubation period was 6 days at 30° C but 30 days at 15° C. The percentage of hatching at these temperatures was also variable, probably a result of inadequate humidity. No eggs hatched at 10° C.

Table 1. Effects of temperature on development rate (for 50% of the population) and survival of immature stages of *O. geographica*

	Temperature, °C										
	10		15		20		25		30		
Stage	No. days	% Surv.	No. days	% Surv.	No. days	% Surv.	No. days	% Surv.	No. days	% Surv.	r^2
Egg development	–	0.0	30	20.0	13	50.0	8.5	50.0	6	5.0	0.999
First instar	22	0.0	13	90.0	7	93.8	4.5	97.5	3	92.5	0.961
Second instar	–	–	12	72.5	6	86.3	4.5	87.5	2.5	87.5	0.938
Third instar	–	–	11	35.0	7	73.8	5.0	77.5	3	82.5	0.942
Fourth instar	–	–	20	0.0	5	62.5	4.0	75.5	2	82.5	0.966
Fifth instar	–	–	0	0.0	19	20.0	14	40.0	8	67.5	0.923
Pupal development	–	0.0	34	40.0	20	73.3	10	44.0	8.5	70.0	0.964
Total[a]	–	–	–	–	77	2.8	50.5	4.4	33	1.3	–

[a] Total number of days (time in days from oviposition to adult emergence) and total survival (number of adults produced by a cohort of 100 eggs).

Larvae did not develop at 10° C, but a few first instars survived for 3 wk at this temperature. About 35% of the larvae reached the fourth instar at 15° C, however, these larvae were very small and all died within 20 days. At 20° C only 20% of the larvae completed their development after 44 days and moths emerged within 20 days after pupation. No continuous development was possible at 10 and 15° C.

In summary, the period of time required for one generation (egg to adult) ranged from 33 days at 30° C to 77 days at 20° C, but development at the higher temperature was accompanied by very high egg mortality.

Two parasitoids, *Aleiodes rugulosus* (Nees) and *Apanteles* sp. (both Hymenoptera: Braconidae), were reared from the few larvae collected in Romania during October 1984 and 1988, respectively; the percentage of parasitism (only *Apanteles* sp.) of the Hungarian population was very low.

Host Range Tests with First Instars. Larvae completed development on 13 species in the genus *Euphorbia* and on four biotypes of North American leafy spurge (Tables 2, 3, and 4).

Table 2. Plant species or varieties used in no-choice feeding tests with first instars of *O. geographica.*

Plants related to leafy spurge (Euphorbiaceae)			
Order	Subgenus	Species	
Euphorbiales	*Esula*	*Euphorbia virgata* W. & K.-Focsani[a]	a
		E. virgata-Saskatchewan[a]	bc
		E. virgata-Nebraska[a]	a
		E. virgata-Wisconsin[a]	a
		E. virgata-Montana[a]	a
		E. ceratocarpa Tenore[a]	a
		E. oblongata Grisebach[a]	c
		E. palustris L.[a]	b
		E. polychroma Kerner von Marilau[a]	c
		E. cyparissias L.[a]	b
		E. lucida W. & K.[a]	bc
		E. seguieriana Necker[a]	b
		E. amygdaloides L.[a]	c
		E. stepposa Zoz ex Prokhanov[a]	b
		E. puplus L.	b
		E. dendroides L.	a
		E. characias L.	a
		E. lathyris L.	ab
		E. platyphyllos L.	b
		E. roemerana Scheele	a
		E. wulfenii (Hoppe *ex* Koch)	c
	Agaloma	*E. corollata* L.	ab
		E. marginata Pursh	ab
		E. antisyphilitica Zuccar	ab
	Myrsinitae	*E. myrsinites* L.[a]	c
		E. rigida Bieb.	a
	Euphorbium	*E. tirucalli* L.	ac
		E. milii Desmoulins	a
		E. milii Desmoulins[a]	b-c
	Chamaesyce	*E. maculata* L.[a]	ab
		E. supina Rafinesque-Schmaltz	a
		E. serpyllifolia Persoon	a
	Poinsettia	*E. heterophylla* L.	a
		E. pulcherrima Willdenow	ac
		Acalypha hispida N. L. Burman	c
		Codieaum variegatum Blume	ab
		Mercurialis annua L.	a
		Mercurialis perennis L.	c
		Pedilanthus tithymaloides L.	c
		Pedilanthus macrocarpus Bentham	b
		Manihot esculenta Crantz	b
		Ricinus communis L.	ab

Plants related to leafy spurge (Euphorbiaceae)			
Order	Subgenus	Species	
Violales	Cistaceae	*Helianthemum apermium* L.	a
		H. nummularium (L.) Miller	b
Geraniales	Geraniaceae	*Geranium rotundifolium* L.	a
		Pelargonium zonale Aiton	a
		Petargonium sp.	b
	Linaceae	*Linum usitatissimum* L.	ac
		Linum flavum L.	b
Asterales	Compositae	*Cynara scolymus* L.	a
		Lactuca sativa L.	a
		Achillea millefolium L.	b
		Artemisia absinthium L.	b
		Centaurea maculosa Gussone	b
		Parthenium argentatum Gray	b
Fabales	Leguminosae	*Medicago sativa* L.	a
Fagales	Corylaceae	*Carpinus betulus* L.	b
	Fagaceae	*Quercus* sp.	b
	Betulaceae	*Betula* sp.	b
Salicales	Salicaceae	*Populus* sp.	b
Sapindales	Ruataceae	*Ruta graveolens* L.	a
	Hippocastanaceae	*Aesculus hippocastanum* L.	b
Ericales	Ericaceae	*Calluna vulgaris* Hull	b
Scrophuraliales	Scrophulariaceae	*Linaria vulgaris* Miller	ab
		Verbascum lycnitis L.	b
Polemoniales	Convolvulaceae	*Ipomoea grandiflora* Roxburg	a
		Ipomoea batatas L.	b
	Solanaceae	*Solanum tuberosum* L.	b
		Lavandula angustifolia Miller	b
	Labiatae	*Mentha spicata* L.	b
Polygonales	Polygonaceae	*Rumex acetosa* L.	b
		Rheum raponticum L.	b
Capparales	Cruciferae	*Alyssum argentum* Allioni	b
		Brassica oleracea L.	b
		Brassica sp.	a
Gentianales	Asclepiadaceae	*Asclepias syriaca* L.	ab
		Asclepias speciosa Torry	a
		Vincetoxycum hirundunaria Medicus	b
		Hoya bella W. J. Hooker	b
	Apocynaceae	*Vinca major* L.	a
	Umbelliferae	*Daucus carota* L.	b
Rosales	Rosaceae	*Rosa* sp.	a
		Sanguisorba minor Scopoli	b
		Fragaria vesca L.	a
		Malus sp.	b
		Prunus sp.	b
	Crassulaceae	*Sedum album* L.	ab
		Sempervicum tectorum L.	b
Urticales	Urticaceac	*Ficus elastica* Roxburg	a
Commelinales	Graminaceae	*Triticum aestivum* L.	a
		Zea mays L.	a

a, Plant species tested with the Romanian population; b, plant species tested with the Hungarian population; c, plant species tested with the Russian population.
[a] Plant species on which *O. geographica* developed through the complete life cycle.

Table 3. Larval survival test during 1990: percentage of larvae surviving to pupal stage (Romanian and Russian populations).

Test plants	First instars[a] Romania	First instars[a] Russia	Third-instars[b] Romania	Third-instars[b] Russia
Plants related to leafy spurge (Euphorbiaceae)				
E. virgata (control)[a]	30.00	30.00	60.00	52.22
E. virgata (Oregon)[a]	26.67	35.00	55.00	60.00
E. maculata (Montana)[a]	0.00	0.00	13.33	7.50
E. milii	–	–	–	–
E. corollata	–	–	–	–
E. roemerana	–	–	–	–
E. rigida	–	–	–	–
E. tirucalli	–	–	–	–
E. lathyris	–	–	–	–
E. antisiphylitica	–	–	–	–
E. marginata	–	–	–	–
E. heterophylla	–	–	–	–
E. pulcherrima	–	–	–	–
E. supina	–	–	–	–
Ricinus communis	–	–	–	–
Plant species in other orders of the superorder Rosidae				
Fragaria vesca	–	–	–	–
Vinca major	–	–	–	–
Rosa sp.	–	–	–	–
Sedum album	–	–	–	–
Humulus lupulus	–	–	–	–
Brassica sp.	–	–	–	–
Medicago sativa	–	–	–	–

a, Groups of larvae on potted plants; 10 larvae on each potted plant and 5 potted plants per test plant; b, groups of 70 larvae (30 Romanian and 40 from Russia) distributed in four potted plants.
[a] plant species on which some development of larvae occurred.

Among the 13 plant species suitable for larval development, 11 belong to the subgenus *Esula*. Contrasting results (possibly caused by different rearing procedures used in the two laboratories) were obtained on the two spurge species outside the subgenus *Esula*. *Euphorbia maculata* (subgenus *Chamaesyce*), a native spurge from North America, was occasionally accepted by larvae of the Romanian population but not by those of the Russian and Hungarian populations. In contrast, *E. milii* Desmoulins (subgenus *Euphorbium*) was accepted, one time each, by the latter two, but never by the Romanian population.

The Romanian population required less time to complete larval development (F = 286.16, df = 50, P < 0.001) and the general survival rate was higher (F = 9.39, df = 60, P < 0.001) (Table 4), which was possibly the result of more suitable rearing conditions (higher temperature in laboratory facilities) and better food quality (potted plants versus cut shoots and leaves). No sustained feeding was observed outside the genus *Euphorbia* and the family Euphorbiaceae. Survival of second and third instars was significantly lower on *Carpinus betulus* L. than on leafy spurge (ANOVA: F = 719.93, df = 8, P < 0.001). The second molt on *C. betulus* occurred on average four days later than on *Euphorbia* spp., and the third instar did not gain weight and died shortly after molting.

Table 4. Larval survival test for first instars of *O. geographica.*

Test plants[a]	No. larvae[b]	% Larvae surviving to stage[c]					No. days to reach pupal stage[d]	
		II	III	IV	V	P	Mean ± SD	*n*
E. virg. (control)[e]	25a	100	100	92	80.0	60.0AB	19.87 ± 1.51A	15
E. virg. (Wisconsin)	25a	100	80	72	60.0	60.0AB	19.60 ± 1.50A	15
E. virg. (Montana)	25a	100	88	76	64.0	60.0AB	20.33 ± 1.11A	15
E. virg. (Nebraska)	25a	92	76	64	64.0	64.0A	20.06 ± 1.57A	16
E. virg. (Saskatchewan)	130bc	63.8	55.4	49.2	33.8	20.0CD	41.25 ± 1.60B	26
E. cyparissias	120b	57.5	42.5	32.5	30.0	10.8CD	44.61 ± 2.90BC	13
E. lucida	110bc	71.8	63.4	59.1	49.1	37.3ABC	43.00 ± 3.70B	41
E. seguieriana	60b	66.7	60.0	53.3	35.0	16.7CD	44.30 ± 2.80BC	10
E. oblongata	20c	60.0	60.0	60.0	60.0	35.0ABC	47.00 ± 4.00CD	7
E. amygdaloides	20c	55.0	50.0	15.0	10.0	10.0D	49.00 ± 4.24D	2
E. palustris	30b	86.7	66.7	60.0	50.0	30.0BC	43.00 ± 2.29D	9
E. polychroma	20c	65.0	65.0	65.0	60.0	30.0BC	44.50 ± 2.43B	6
E. milii	50bc	4.0	2.0	2.0	2.0	2.0	58.0	1
E. myrsinites	40c	20.0	15.0	12.5	12.5	7.5D	53.33 ± 2.89BC	3
E. ceratocarpa	25a	84.0	64.0	60.0	40.0	24.0CD	20.33 ± 1.37E	6
E. maculata	25a	84.0	52.0	24.0	16.0	8.0D	21.50 ± 0.71A	2
E. stepposa	20b	90.0	70.0	75.0	60.0	20.0CD	46.50 ± 1.29C	4
E. corollata	20b	100	80.0	–	–	–	–	
E. peplus	20b	70.0	60.0	45.0	–	–	–	
E. wulfenii	10c	10.0	–	–	–	–	–	
E. lathyris	50b	40.0	20.0	–	–	–	–	
Carpinus betulus	40bc	45.0	20.0	–	–	–	–	

[a]Test plants on which development did not occur are reported in Table 2.
[b] A, Romanian population; B, Hungarian population, C, Russian population.
[c] Percentages followed by different letters are different at P = 0.01 (Duncan's multiple-range test; LSD value = 18.08; SEM = 4.805.
[d]Averages followed by different letters are different at P = 0.01 (Duncan's multiple-range test; LSD value = 2.914; SEM = 0.7694).
[e]E. virg. = *Euphorbia virgata*.

Host Range Tests with Third Instars. The potential extension of the host range by the late instars: was tested with third instars (Hungarian population) on 36 species in 14 families (Table 5). The host range was extended to *E. lathyris* (subgenus Esula) with only 3% of the larvae completing their development, but no larvae reached the pupal stage on *E. milii* and *E. maculata*. Development to pupae on leafy spurge, *E. cyparissias*, and *E. lucida*, starting with third instars was significantly higher than when starting with first instars (ANOVA: $F = 7.89$, 20.25, and 10.55, respectively, $df = 4$, $P < 0.05$). Larval development was higher on *E. heterophylla* L. and *E. wulfenii* Hoppe *ex* Koch, but no larvae reached the pupal stage on these hosts. Some 70% of the third instars molted to the fourth instar on *E. antisyphilitica* Zuccar without feeding. Some nibbling, but no larval development occurred on *Carpinus betulus*, confirming that it is not a suitable host plant.

During 1990, no differences were observed between Romanian and Russian populations, under laboratory conditions (Table 3). Feeding and larval development were observed only on the control (*E. virgata* from Romania), *E. esula* from Oregon, and *E. maculata*. Some differences in survival were noted between neonate and third instars on *E. maculata*. The percentage of larval survival was very low for neonate larvae and only one larva reached the pupal stage (2%), but it did not complete its life cycle, compared with the third instars, seven of which reached the pupal stage (four from the Romanian population and three from the Russian population [10%]). Two larvae completed development (one from each population [2.85%]). No feeding was observed on any of the other plant species tested, and larvae died in 3-4 d; the lack of survival on *E. milii* confirmed that this species is an unsuitable host.

Discussion

O. geographica is a well-defined species, taxonomically, The host range of the larvae is restricted to the genus *Euphorbia* (13 species), with a clear preference for the subgenus *Esula* (10 species); but larvae also developed on one species in the subgenus *Myrsinitae (E. myrsinites* L.), one species in the subgenus *Euphorbium* (*E. milii*), and one species in the subgenus *Chamaesyce* (*E. maculata*). No feeding occurred on any of the other 80 test plant species (29 Euphorbiaceae species and varieties, and 51 species in other families). Within the subgenus *Esula*, only a few herbaceous species and the woody species *E. dendroides*, *E. characias*, and *E. wulfenii* seemed to be unsuitable host plants. The inconsistency of the larvae, among the three populations, in feeding and developing on *E. corollata*, *E. milii*, and *E. maculata* may have been caused by different rearing conditions or genetic differences. *O. geographica* is generally restricted to species in the subgenus *Esula*, and the larvae may feed on plants outside the subgenus *Esula* under certain circumstances. Although *E. maculata* (subgenus Chamaesyce), a native American species sympatric with leafy spurge (Pemberton 1985), proved suitable occasionally for *O. geographica* under no-choice conditions, this does not necessarily indicate that this plant species would be acceptable under natural conditions.

O. geographica is a continental species occurring in dry areas and has been recorded from most of the herbaceous perennial spurges present in such areas (e.g., *E. seguieriana, E. stepposa, E. cyparissias*, and *E. virgata*). In contrast, the moth has never been found on spurges growing in humid or shaded habitats (e.g., *E. lucida*, *E. palustris, E. amygda-*

loides, or *E. polychroma*), although these species have demonstrated in the laboratory to be suitable host plants for development of the larvae. In addition, *O. geographica* has never been recorded on any annual species.

Oviposition preferences and larval host ranges for insects that feed externally are not always correlated (Wiklund 1975), and it may be that the adults of *O. geographica* will not oviposit on many species that are suitable for larval development. Additional multiple-choice host-specificity tests, and open-field oviposition tests with critical U.S. biotypes of *Euphorbia* spp. should be conducted to gain a better understanding of this insect as a biological control agent.

Table 5. Larval development of third instars of *O. geographica* (Hungarian population) and survival to stages IV, V, and P.

		% Larvae surviving to stage		
Plant species	No. of larvae	IV	V	P
Euphorbia virgata[a,b]	30	93.3	63.3	40.0
E. cyparissias[a]	10	100	100	60.0
E. lucida[a]	30	93.3	76.7	56.7
E. lathyris[a]	30	66.7	33.3	3.3
E. myrsinites[a]	10	100	100	30.0
E. wulfenii	10	90.0	40.0	–
E. milii	20	66.7	53.3	–
E. heterophylla	20	–	–	–
E. marginata	20	–	–	–
E. pulcherrima	20	–	–	–
E. tirucalli	20	–	–	–
Acalypha hispida	10	–	–	–
Mercurialis perennis	10	–	–	–
Ricinus communis	20	–	–	–
Pedilanthus tithymaloides	10	–	–	–
Manihot esculenta	20	–	–	–
Calluna vulgaris	20	–	–	–
Solanum tuberosum	20	–	–	–
Rumex acetosa	20	–	–	–
Sanguisorba minor	20	–	–	–
Betula sp.	20	–	–	–
Malus sp.	10	–	–	–
Rosa sp.	20	–	–	–
Carpinus betulus	20	–	–	–
Corylus sp.	10	–	–	–
Medicago sativa	10	–	–	–
Populus sp.	10	–	–	–
Asclepias syriaca	30	–	–	–
Vincetoxycum hirundinaria	10	–	–	–
Daucus carota	20	–	–	–
Brassica oleracea	20	–	–	–
Achillea millefolium	10	–	–	–
Parthenium argentatum	20	–	–	–
Humulus lupulus	10	–	–	–

[a]Plant species on which *O. geographica* fed and completed its life cycle.
[b]Leafy spurge Canadian biotype (Saskatchewan).

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