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THE EFFECT OF *LYGUS* spp. ON CARROT SEED PRODUCTION IN IDAHO (Hemiptera: Miridae)

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SUMMARY

The feeding effects of the plant bugs, *Lygus elisus* Van D., *L. hesperus* Knight *and L. desertus* Knight, on developing carrot seed were investigated by maintaining specific population levels of these insects on second-order carrot umbels. Carrot seed yields and germination rates were negatively correlated to the numbers of lygus bugs per umbel. A population level of one lygus per umbel reduced seed yield by 20 percent and germination by 25 percent.

L. elisus and *L. hesperus* were found in about equal numbers in carrot seed fields and together made up about 98 percent of the field population of lygus bugs. One generation and a partial second of these insects develop on carrot seed plants during the growing season.

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With the development of many new and highly effective insecticides and an increasing interest in insect control among Idaho seed growers, a definite trend toward the indiscriminate use of a number of insecticides started in the early 1950's. Up to this period the extent of lygus injury to carrot seed crops was unknown. Extensive studies of lygus bug injury to alfalfa seed crops, conducted in Utah and Idaho in the early 1930's, demonstrated the effect of these insects on a seed crop. These studies also indicated that timing of control measures to coincide with plant and insect development would be critical. The research here reported was initiated to investigate the extent of lygus bug injury to carrot seed crops.

Many investigators have written of the effect of species of the genus *Lygus* and related genera feeding on blossom, fruit and developing seed of many crops. One of the earliest publications concerning this effect is that of Stedman (1899) who reported that the tarnished plant bug, *Lygus oblineatus* Say, caused injury to many orchard, small fruit and vegetable crops. Morrill (1918) wrote about the feeding of *L. hesperus* Knight and *L. oblineatus* on cotton squares and the subsequent staining of the lint.

The first specific reference to seed injury was made by Hawley (1922) when he reported that spotted or "dimpled" beans were caused by the feeding of *Lygus* and *Adelphocorus* species. Essig (1926) wrote that "According to R. H. Smith . . ." shriveling of alfalfa seed in Idaho was due to the tarnished plant bug, *L. pratensis* (Linn) (possibly *L. hesperus*?). Shull and Wakeland (1931) recorded "puncturing" of beans in the pod by *L. elisus* Van D. and Shull (1933) presented a detailed study of this phenomenon. Sorenson (1932) and Shull et al. (1934) correlated blossom drop and reduced seed yields of alfalfa with the feeding of *Lygus* spp. Hills (1941) published on the effects of *L. hesperus* and *L. pratensis oblineatus* (Say) on sugar beet seed and Baker et al. (1946) on lima beans while Romney et al. (1946) stated that the feeding of *L. hesperus* reduced seed set and germination of guayule.

Since 1950, many investigators have reported on the effect of the feeding of *Lygus* spp. on other crops.

Flemion et al., in a series of papers, recorded the presence of embryoless seeds in dill (1941) and other Umbelliferae (1946);

and suggested lygus bugs as causative agents of this condition in many species of umbelliferous plants including carrots (1949-50). Handford (1949) indited *L. campestris* L. as a new pest of carrot seed crops. Carlson (1956) reported on the presence of embryoless seed in carrots and attributed this condition and reduced seed yields to *L. hesperus*. Kho and Braak (1956) wrote that *L. campestris* was responsible for similar damage to carrot seed in Belgium.

EFFECT OF FEEDING

Methods and Procedure

The effect of lygus bugs feeding on developing carrot seed was investigated by caging lygus on carrot umbels.

Generally, the methods utilized each year were the same. Second-order carrot umbels were caged before flowering and predetermined numbers of lygus adults or nymphs of the desired species were introduced. Replicated treatments, consisting of 0, 1, 2, and 4 lygus per umbel, were arranged in a randomized block design. The cages were inspected twice a week for the duration of each test. At each inspection the number of live lygus was determined, the dead lygus were replaced and newly hatched nymphs were removed. To obtain adequate pollination of the caged umbels, about six blow flies (Calliphoridae) were maintained in each cage during the flowering period. At the end of the growing season, the seed from each umbel was harvested, threshed, cleaned and weighed. These experiments were repeated for eight years, 1952 through 1959, and germination tests were run on the seed obtained in five of these years.

Throughout the study some variations in method and procedure occurred each year as indicated below:

1952—six replications, two umbels per cage, treatments of a replication not confined to one or two plants, germination tests made;

1953—ten replications, two umbels per cage, all treatments of a replication confined to one plant;

1954 and 1955—ten replications, two umbels per cage, one from each of two plants, all treatments of a replication confined to two plants;

1956—eight replications, two umbels per cage, one from each of two plants, all treatments of a replication confined to two plants, germination tests made;

1957—ten replications, one umbel per cage, all treatments of a replication confined to one plant, two lygus species directly compared, germination tests made;

1958 and 1959—ten replications, one umbel per cage, all treatments of a replication confined to one plant, germination tests made.

The experiments for the years 1953, 1957, 1958 and 1959 were based on a single plant as a replicate; that is, all treatments of a replication were confined to one plant. This method eliminated variation due to the inherent seed-producing capability of carrot seed plants from the variation between treatments.

Further details as to date of lygus introduction, umbel maturity at the time of introduction, carrot variety, source of species of lygus are contained in Table 1.

Table 1. Lygus species, stage of insect development, percent of carrot bloom and date of lygus introduction, carrot variety, source of lygus, and year of study. Parma, Idaho.

		Lygus introduction				
Lygus species	**Stage of lygus**	**% Bloom of umbel**	**Date**	**Carrot variety**	**Source of lygus**	**Year**
spp.	Adult	0-25	6-23	†	†	1952
do.	do.	0-25	7-6	Long type Chantenay	Lambsquarter	1953
do.	Nymph	Full	6-3	†	†	1952
do.	do.	0-25	7-12	Long type Chantenay	Lambsquarter	1953
do.	do.	Full	7-10	Nantes	do.	1954
do.	do.	Petal fall	7-18	do.	do.	1955
desertus?	Adult	Full	7-10	do.	do.	1954
do.	do.	Petal fall	7-18	do.	do.	1955
elisus	do.	75-100	6-27	Royal Core Chantenay	Alfalfa	1956
do.	do.	0-25	6-17	do.	do.	1957
do.	do.	0-25	6-27	Imperida	do.	1958
hesperus	do.	75-100	6-27	Royal Core Chantenay	do.	1956
do.	do.	0-25	6-17	Imperida	do.	1957
do.	do.	0-25	6-15	do.	do.	1959

† Not reported.

During the first two years of this study, no attempt was made to differentiate between species of *Lygus* used. In southwestern Idaho *L. hesperus* is common on alfalfa and lambsquarter, the source of all the lygus bugs used. *L. hesperus* constitutes about half of the lygus population on these plants. On alfalfa *L. elisus* outnumbers *L. desertus* about 20:1; whereas, on lambsquarter *L. desertus* outnumbers *L. elisus* by about the same ratio. By color, both *L. desertus* and *L. elisus* can usually be distinguished from *L. hesperus*. Therefore, color and source were utilized to separate these three species, and all individuals questionable because of color were discarded. No attempt was made to identify the caged nymphs to species. However, since lambsquarter was the main collection source, the nymphs used were undoubtedly *L. hesperus* and *L. desertus*.

Germination tests of the 1952 seed were made at the United States Department of Agriculture Station, Beltsville, Maryland. Tests of the seed produced in the years 1956 through 1959 were

made at the University of Idaho Branch Experiment Station, Parma, Idaho.

Results and Discussion

The mean yields of carrot seed per treatment, analyses of variance and correlation are given in Table 2. The mean percent of the total seed per replication contributed by each treatment and the analyses of variance of the individual plot percentages are given in Table 3.

The results of the germination tests of the seed are given in Table 4.

These studies prove that the feeding of lygus bugs on developing carrot seed causes significant reduction in yield (Table 2) and germination (Table 4). The yield reductions are most significant when the percentages derived from individual plot yields are analyzed (Table 3). No significant differences between treatments are present in the actual yields for the years 1953 and 1957, although a significant negative correlation between numbers of lygus and yields was present for adults in 1957. When the percentages are considered, significant differences due to treatment are present except for the 1953 nymphal feeding experiment; which shows, however, a significant negative correlation of numbers of lygus and yields.

Although adults and nymphs were never utilized in the same experiment, comparison of the data for each does not indicate a difference in their effect on seed yields and germination. Comparison of the coefficients of correlation between the two, for any single year, indicates that the number of nymphs is somewhat more closely related to yield than is the number of adults.

In 1957, *L. hesperus* and *L. elisus* were directly compared as to the effect of their feeding on carrot seed yields, (Tables 2, 3, 4). The results of this one experiment indicate little difference between the feeding effects of these two species, and this is further substantiated by the indirect evidence of the studies in 1956, 1958 and 1959. In 1956, both species were utilized but in different experiments. In 1958, only the effect of *L. elisus* was studied; and in 1959, only the effect of *L. hesperus*. Comparison of the data on yields (Tables 2 and 3) does not indicate that a difference exists in the feeding effect of these two species.

However, the data in Tables 2, 3 and 5 do indicate that *L. desertus* has much less effect on yields than either *L. elisus* or *L. hesperus*. Since a mixture of this species (*L. desertus*) and *L. hesperus* was probably used prior to 1954, the damage attributed to "spp." in this table is intermediate between that for *L. desertus* and *L. hesperus*. Therefore, considering the tests utilizing specimens of only *L. elisus* or *L. hesperus*, which make up about 98 percent of the lygus populations in southwestern Idaho carrot fields as will be shown later, one or two lygus per umbel reduced yields about 45 percent and four per umbel reduced yields about 66 percent.

The germination data (Table 4) show that lygus bug feeding

Table 2. Mean yield in grams per umbel of carrot seed produced in umbel cages infested with different numbers of lygus and results of analyses of these yields. Parma, Idaho.

Species	Stage	Year	Yield — Gr./umbel: Lygus per umbel 0	1	2	4	Coefficient of correlation r	Analysis of Variance F	L.S.D. .05	.01
spp.	Adult	1952	1.47	0.78	0.17	0.26	[1]	[1]	[1]	[1]
		1953	0.73	0.33	0.52	0.39	-0.155	N.S.	N.S.	N.S.
	Nymph	1952	1.62	1.03	0.91	0.76	[1]	[1]	[1]	[1]
		1953	0.65	0.56	0.58	0.30	-0.179	N.S.	N.S.	N.S.
		1954	2.70	2.10	1.56	1.27	-0.471**	**	0.75	1.01
		1955	2.68	2.26	2.38	1.92	-0.249	*	0.60	N.S.
desertus?	Adult	1954	2.35	1.98	1.00	0.61	-0.731**	**	0.42	0.56
		1955	3.21	2.77	2.95	2.17	-0.288	**	0.59	0.80
elisus		1956	0.58	0.39	0.41	0.12	-0.247	N.S.	N.S.	N.S.
		1957	1.10	—	0.84	0.48	-0.413*	N.S.	N.S.	N.S.
		1958	0.85	0.56	0.34	0.14	-0.403**	**	0.30	0.41
hesperus		1956	0.44	0.18	0.20	0.19	-0.499**	N.S.	N.S.	N.S.
		1957	1.10	—	0.77	0.60	-0.327	N.S.	N.S.	N.S.
		1959	0.81	0.55	0.25	0.02	-0.584**	**	0.37	0.50

[1]—Original data lost; analysis by paired plot reveals high significance between all pairs except 2 and 4.

Table 3. Table 2 revised to show percent of yield of carrot seed.

Species	Stage	Year	Yield—Percent: Lygus per umbel 0	1	2	4	Coefficient of correlation r	Analysis of Variance F	L.S.D. .05	.01
spp.	Adult	1953	38.6	18.8	19.1	12.9	-0.580**	**	15.2	20.5
	Nymph	1953	35.3	29.3	27.9	21.9	-0.379*	N.S.	12.6	N.S.
elisus	Adult	1957	36.3	—	19.0	10.2	-0.541**	**	8.8	11.8
"	"	1958	44.4	32.9	13.1	5.1	-0.667**	**	10.0	13.6
hesperus	"	1957	36.3	—	14.0	13.2	-0.541**	**	8.8	11.8
"	"	1959	47.9	37.9	4.7	1.3	-0.663**	**	12.0	16.2

Table 4. Germination percentages of seed produced under attack of lygus bugs. Parma, Idaho.

Species	Stage	Year	Germination percent No. of Lygus/umbel 0	1	2	4	Analysis of Variance F	L.S.D. .05	.01
spp.	Adult	1952	79	43	47	50	*	21.0	29.1
"	Nymph	1952	74	50	56	44	*	16.4	23.1
elisus	Adult	1956	60	52	39	16	**	6.2	8.9
		1957	78	—	50	22	**	18.3	25.6
		1958	70	50	30	12	**	7.0	9.6
hesperus		1956	68	56	48	56	*	14.2	20.2
		1957	78	—	70	58	**	9.2	12.8
		1959	53	40	49	11	**	8.0	12.2

on developing carrot seed significantly reduced germination. This effect appears to be even greater than the effect on yields. In most years, highly significant reductions in germination rate were caused by a population level of one lygus per umbel. These data also indicate that *L. elisus* had a more detrimental effect than *L. hesperus*.

Table 5 presents a summary of all the tests, giving the average percent reduction in seed yield and germination caused by the feeding of one, two, and four lygus per umbel. This table presents a striking illustration of the general effect of lygus bug infestations on seed yields and germination rates.

Table 5. Percent reduction in carrot seed yields caused by one, two, and four lygus per umbel. Summary of results obtained from 1952 through 1959. Parma, Idaho.

Species	Percent Reduction Yield No. tests	Lygus/umbel 1	2	4	Germination No. tests	Lygus/umbel 1	2	4
spp.	6	28.6	37.8	50.0	2	39.2	40.0	38.6
desertus	2	14.4	32.4	48.2	—	—	—	—
elisus	3	42.9	39.3	67.9	3	26.4	33.2	75.9
hesperus	3	53.8	47.4	65.4	3	27.6	16.0	37.1
All spp.	14	22.8	36.6	54.5	8	33.1	33.0	53.7

FIELD OBSERVATION

Populations of lygus bugs in carrot seed fields were studied to determine if these populations equaled or exceeded the numbers utilized in the cage studies, and to determine the population fluctuations through the season.

Methods and Procedure

In general, individual carrot umbels of different stages of maturity were collected at periodic intervals through the season. These umbels were cut, stages of maturity noted, bagged individually and taken into the laboratory where the lygus associated with each umbel were counted. The stages of umbel development or maturity may be named as follows: early flower, less than 20 percent bloom; full flower, approximately 50 percent bloom; petal fall, flower petals are browning and dropping; green spiney, seed is green and has green spines; and brown spiney, the seed and

spines are browning. Specifically, the procedure for each year of sampling was as follows:

1956—The carrot seed field was sampled weekly from July 2 to 30, inclusive. No notes as to umbel maturity were taken.

1957 and 1958—No carrot seed fields were sampled.

1959—Carrot umbels were collected weekly from June 19 through August 6. Each weekly collection consisted of 24 umbels each of early flower, full flower, petal fall, green spiney and brown spiney stages of maturity, when available.

1960—Carrot umbels were collected twice weekly from June 16 through August 8. Twenty umbels each of full flower, petal fall and green spiney were taken each time.

1961—The carrot seed field was sampled twice weekly from June 16 through August 8. Each collection consisted of 10 umbels each of full flower, petal fall, and green spiney stages when available.

In 1961, the lygus population in a carrot seed field was sampled by sweeping the umbels on July 18, 25, and 28. These samples were taken to determine the species of lygus present and their proportionate numbers; therefore, no record was made of the number of sweeps. The numbers of nymphs and adults in the net were recorded and the adults identified to species.

Results and Discussion

The average number of lygus (both nymphs and adults) per umbel was determined for each ten-day period through the season. These figures are given in Table 6. The numbers of lygus nymphs and adults per umbel by each stage of maturity were averaged for each year and these are given in Table 7. *Lygus* spp. collected by sweeping a carrot seed field are given in Table 8.

These results indicate that lygus populations in carrot seed fields of southwestern Idaho reach damaging levels every year. The time of peak population varied by as much as one month in the three years during which this study was conducted (Table 6). During these three years, commercial seed growers treated for lygus late in June. The data indicate that this is probably the

Table 6. Average number of lygus per umbel on carrot seed plants. Parma, Idaho.

Year	June 10-20	June 20-30	July 1-10	July 10-20	July 20-30	Aug. 31-9	Aug. 9-19
1956	[1]	[1]	6.10	1.46	0.14	0.00	[1]
1959	0.07	0.40	0.68	0.89	1.26	0.50	[1]
1960	0.17	0.92	1.60	1.89	0.79	0.29	0.18
1961	0.07	1.02	0.56	0.41	0.30	0.35	[1]
Avg.[2]	0.10	0.88	1.04	1.11	0.83	0.37	0.18

[1]—No samples taken during this period.
[2]—Omitting samples taken in 1956.

Table 7. Average number of lygus on carrot umbels of different stages of maturity. Parma, Idaho.

Year	Lygus	Early Flower	Full Flower	Petal Fall	Green Spiney	Brown Spiney
1959	Adults	0.03	0.08	0.20	1.01	0.70
	Nymphs	0.06	0.21	0.35	0.82	0.10
	Total	0.09	0.30	0.55	1.83	0.80
1960	Adults	[1]	0.10	0.06	0.08	[1]
	Nymphs	[1]	0.85	1.43	0.79	[1]
	Total	[1]	0.95	1.49	0.87	[1]
1961	Adults	[1]	0.01	0.03	0.12	[1]
	Nymphs	[1]	0.19	0.38	0.75	[1]
	Total	[1]	0.20	0.41	0.87	[1]
Avg.	Adults	0.03	0.06	0.10	0.40	0.70
	Nymphs	0.06	0.42	0.72	0.79	0.10
	Total	0.09	0.48	0.82	1.19	0.80

[1]—Umbels of this maturity not sampled.

proper time, with the possible exception of the year 1959. That year, controls should have been applied about July 20.

Only one generation of lygus a year is indicated as developing on carrot seed crops, with a small partial second generation appearing in late July and early August. These small secondary peaks do not show in Table 6, which presents averages of several sucessive samples.

Data in Table 7 indicate that the green-spiney stage of umbel maturity usually harbored the most lygus. This is probably the result of the hatch of eggs laid in the umbels earlier, with peak populations showing just prior to transformation to adults.

According to the data in Table 8, the species *L. elisus* and *L. hesperus* comprised 98.5 percent of the total lygus population in a carrot seed field. Of these two, 42.7 percent were *L. elisus*. Field observations and rearing of field-collected nymphs indicate that this is the usual proportion of *L. elisus*. According to Carlson (1956) this species was of minor importance in carrot seed production in California and *L. hesperus* was the principal economic species. However, in southwestern Idaho, the study here reported found that *L. elisus* is capable of causing as much damage as *L. hesperus;* and probably causes about 40 percent of the actual reduction in yield and germination.

Table 8. Number of lygus swept from a carrot field. Parma, Idaho, 1961.

		Adults						
		elisus		hesperus		Others		Total
Date	Nymphs	No.	%	No.	%	No.	%	No.
7-18	106	112	57.7	79	41.0	3	1.3	300
7-25	23	69	33.7	132	64.4	4	1.9	228
7-28	16	77	37.6	126	61.5	2	0.9	221
Total	145	258	42.7	337	55.8	9	1.5	749

CONCLUSIONS

1. *L. elisus* Knight, *L. hesperus* Van D. and *L. desertus* Knight were found to be capable of reducing the yield and germination of carrot seed by feeding on the developing seed.

2. Two species, *L. elisus* and *L. hesperus*, make up 97-99 percent of the lygus population found in carrot seed fields in southwestern Idaho.

3. A field population of one lygus per umbel may reduce yields 20 percent and germination 25 percent.

4. Lygus populations generally reach economic levels in carrot seed fields grown in southwestern Idaho.

5. One generation of lygus a year is produced on carrot seed crops.

REFERENCES CITED

Baker, K. F., W. C. Snyder and A. H. Holland. 1946. Lygus Bug Injury to Lima Beans in California. Phytopath. 36:493-503.

Carlson, Elmer C. 1956. Lygus Bug Injury and Control on Carrot Seed in Northern California. Jour. Econ. Ent. 49:(5) 689-696.

Essig, E. O. 1926. Insects of Western North America. The Macmillan Co., New York, p. 362.

Flemion, Florence and Elizabeth Waterbury. 1941. Embryoless Dill Seeds. Contrib. Boyce Thompson Inst. 12:157-161.

Flemion, Florence and Gloria Ahlmann. 1956. Further Studies of Embryoless Seeds in the Umbelliferae. Contrib. Boyce Thompson Inst. 14:283-293.

Flemion, Florence and Esther Thayer Henrickson. 1949. Further Studies on the Occurrence of Embryoless Seeds and Immature Embryos in the Umbelliferae. Contrib. Boyce Thompson Inst. 15:291-297.

Flemion, Florence, Harriet Poole and June Olson. 1949. Relations of Lygus Bugs to Embryoless Seeds in Dill. Contrib. Boyce Thompson Inst. 15:299-310.

Flemion, Florence and June Olson. 1950. Lygus Bugs in Relation to Seed Production and Occurrence of Embryoless Seeds in Various Species. Contrib. Boyce Thompson Inst. 16:39-46.

Flemion, Florence and Betty Travis MacNear. 1951. Reduction of Vegetative Growth and Seed Yield in Umbelliferous Plants by *Lygus oblineatus*. Contrib. Boyce Thompson Inst. 16:279-283.

Hanford, R. H. 1949. *Lygus campestris* L. A New Pest of Carrot Seed Crops. Canadian Ent. 81:123-126.

Hawley, I. M. 1922. Insects and Other Animal Pests Injurious to Field Beans in New York. Mem. Cornell Univ. Agric. Expt. Sta. 55:1021-1023.

Hills, Orin A. 1941. Isolation-Cage Studies of Certain Hemipterous and Homopterous Insects on Sugar Beets Grown for Seed. Jour. Econ. Ent. 34:756-760.

Kho, Y. O. and J. P. Braak. 1956. Reduction in the Yield and Viability of Carrot Seed in Relation to the Occurrence of the Plant Bug, *Lygus campestris* L. Euphytica 5:146-156.

Morrill, A. W. 1918. Insect Pests of Interest to Arizona Cotton Growers. Arizona Agric. Expt. Sta. Bull. 87:186-190.

Romney, Van E. 1946. Control of Lygus Bugs with DDT as Related to Guayule Seed Production. Jour. Econ. Ent. 39:664-665.

Shull, W. E. 1933. An Investigation of the Lygus Species Which are Pests of Beans (Hemiptera: Miridae). Idaho Agric. Expt. Sta. Bull. 11. 42 pp.

Shull, W. E., Paul L. Rice, Harry F. Cline. 1934. *Lygus hesperus* Knight (Hemiptera, Miridae) in Relation to Plant Growth, Blossom Drop, and Seed Set in Alfalfa. Jour. Econ. Ent. 27:265-269.

Shull, W. E. and Claude Wakeland. 1931. Tarnished Plant Bug Injury to Beans. Jour. Econ. Ent. 24:326-327.

Sorenson, C. J. 1932. The Tarnished Plant Bug *Lygus pratensis* (Linn.) and the Superb Plant Bug *Adelphocoris superbus* (Uhler) in Relation to Flower Drop in Alfalfa. Utah Academy of Science Proc. 9:67-70.

Stedman, J. M. 1899. The Tarnished Plant Bug. Missouri Agric. Expt. Sta. Bull. 47. 13 pp.