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History and Biology of the Western Bean Cutworm in Southern Idaho, 1942-1977

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Much of the data and information presented here is from records gathered and prepared under the direction of former leaders of the USDA, ARS, Entomology Laboratory, Twin Falls: James R. Douglass (deceased), 1934-1957; Kenneth E. Gibson (deceased), 1957-1962; and Walter E. Peay (deceased), 1962-1972. I am grateful for the fine technical assistance of Ronald E. Peckenpaugh since 1972 and of Glenn G. Mahrt since 1974. Paula M. Jolley prepared the notations for the bibliography.

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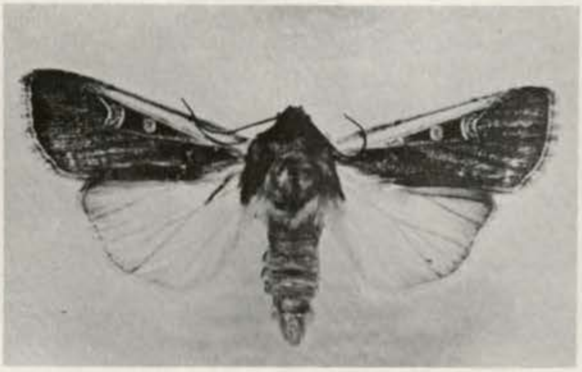


Summary

The western bean cutworm, *Loxagrotis albicosta* (Smith), has been found in Idaho only in the irrigated portions of Magic Valley and in Bingham County. It is a primary pest of dry edible beans, garden beans and corn. The Magic Valley has been an important production area of both dry edible beans and garden seed beans since the 1930's. Corn acreage has rapidly increased since 1950. The western bean cutworm was first recognized as a pest of beans in the Magic Valley in the early 1940's and as a pest of corn in 1952. Moth populations and damage to beans have fluctuated in 4- to 8-year cycles for reasons unknown. Black-light traps have been used since 1958 to monitor moth populations. These have proven to be highly correlated with damage on an area basis and are thus useful as a warning to growers. However, they are of lesser value for predicting damage in individual fields. Less information is available for sweet corn but light traps appear to be useful to this industry also.

Although moth populations and damage to beans have been cyclic and damage to sweet corn sporadic, peaks in moth population cycles as determined by black-light traps have become increasingly greater since 1958. The increasing total acreage of host plants in the area and the increasing percentage of corn may be the cause of increasing western bean cutworm populations.

Peak moth flight occurs between July 15 and August 7 with the average date July 23. The pre-oviposition period is about 4 days and the average number of eggs laid per female is 407 in laboratory studies. Egg incubation is 6 days and larvae complete development in about 31 days in the laboratory. Full-fed larvae overwinter in the soil at depths of 2 to 13 inches. Overwintering mortality was 72% in cages and 90% in the field. Plowing may be an important factor in overwintering mortality.

In addition to beans and corn, tomato was the only host found capable of supporting the western bean cutworm from eggs to full-grown larvae. Larger larvae feed readily and are capable of completing development on fruits of nightshade and ground cherry.

Growth stages of both corn and beans affect degree of infestation and damage, but this has not yet been defined well enough to be useful in surveying fields for potentially damaging populations. In sweet corn, eggs and evidence of larval feeding are rather easily observed and can be used during and soon after moth flight to assess potential damage. No satisfactory survey method is available in beans.

Information on natural biotic control agents is limited to general observations on 1 disease and 6 predators.

History and Biology of the Western Bean Cutworm in Southern Idaho, 1942-1977

C. C. Blickenstaff, Research Entomologist, Federal Research, USDA, SEA

The western bean cutworm *Loxagrotis albicosta* (Smith) is native to North America and is a pest of beans *(Phaseolus vulgaris* L.) and corn (*Zea mays* L.). It was first described in 1887 with the location given as Arizona (Smith 1887). It has been reported from Mexico, Arizona, New Mexico, Texas, Utah, Colorado, Oklahoma, Kansas, Nebraska, Iowa, South Dakota, Wyoming, Idaho and Alberta, Canada (Crumb 1956; USDA 1970 and 1977). In Idaho, the western bean cutworm is apparently confined to the southcentral irrigated areas of Elmore, Twin Falls, Cassia, Gooding, Jerome, Minidoka and Bingham counties. Crop damage is confined to beans and corn, but it has been reported as feeding on tomato, ground cherry (*Physalis* sp.) and nightshade (*Solanum nigrum* L.).

This paper summarizes records and data on history, populations, damage and biology, gleaned from unpublished records and manuscripts prepared through 1972 by former personnel of the USDA Entomology Laboratory at Twin Falls, and more recent research conducted by the author at Kimberly. Except for the single early report of damage in Bingham County in southeastern Idaho, the data presented apply to portions of the 6 Idaho counties mentioned above which comprise the area known as the Magic Valley.

Table 1. Acreages of host plants of the western bean cutworm in Magic Valley, Idaho, 1929-1974.[1]

Area	1929	1934	1939	1944	1949	1954	1959	1964	1969	1974
					FIELD CORN					
Twin Falls	3573	4311	3906	757	468	1966	5040	6492	8712	11,225
Jerome	1034	1171	2120	243	406	1532	3269	5230	4171	5111
Cassia	281	169	333	218	189	239	1302	2401	4522	7575
Minidoka	489	452	592	54	39	133	1556	2021	4216	6169
Gooding	2297	1447	3870	1263	1268	2717	5656	6508	7834	9567
Elmore	494	286	797	427	541	923	2880	2224	2424	2320
Totals	8168	7836	11,618	2962	2911	7510	19,703	24,876	31,879	41,967
Idaho	31,844	26,736	45,427	23,715	25,940	44,010	77,818	74,981	86,791	114,416
% of Idaho	25.65	29.31	25.58	12.49	11.22	17.06	25.32	33.18	36.73	36.68
					SWEET CORN *(Vegetables for sale or processing only)*					
Twin Falls	35	129	53	1070	1415	2089	3882	4162	8015	10,851
Jerome	5	1	4	121	356	22	–	–	1	227
Cassia	3	1	–	–	2	1	1	–	1752	2648
Minidoka	4	3	1	7	1	–	–	–	2	654
Gooding	14	30	1	328	583	319	258	352	1230	2751
Elmore	1	10	4	8	2	4	4	169	91	199
Totals	62	174	63	1534	2359	2435	4145	4683	11,091	17,150
Idaho	1640	2373	1693	7385	8517	11,887	12,085	11,353	20,747	25,635
% of Idaho	3.75	7.33	3.72	20.77	27.70	20.48	34.30	41.25	53.46	66.90
					DRY FIELD AND SEED BEANS					
Twin Falls	65,850	49,601	47,029	65,192	62,092	61,746	59,354	54,456	52,744	61,310
Jerome	18,872	16,830	18,329	24,660	25,643	25,650	28,271	22,239	19,562	24,169
Cassia	1276	1372	2197	8314	8459	12,523	11,589	11,943	14,182	23,080
Minidoka	2667	1274	4064	11,926	10,706	12,967	12,549	11,153	9838	10,035
Gooding	805	1059	2461	9465	11,371	11,101	7427	4613	3558	4642
Elmore	9	159	180	1167	1724	1505	678	171	469	4191
Totals	89,389[2]	70,295	74,260	120,751	119,995	125,492	119,868	84,559	100,353	127,427
Idaho	106,788	92,183	98,937	142,175	143,589	149,493	133,612	112,637	112,968	143,390
% of Idaho	83.71	76.26	75.06	84.93	83.57	83.94	89.71	75.07	88.83	94.82
Total 3 crops in 6 counties	97,619	78,305	85,941	125,247	125,265	135,437	143,716	114,118	143,323	186,544
% corn	8.43	10.23	13.59	3.59	4.21	7.34	16.59	25.90	29.98	31.69

[1]Source: U.S. Census of Agriculture, Bureau of the Census, Washington, DC.

[2]Beans grown alone; in addition, there were 26,574 acres grown with other crops.

Both cultivated beans and corn originated in Central America and their use was widespread in North America long before Spanish and European settlement (Brown and Goodman 1977; Gentry 1969). In the southwest they were cultivated by American Indians at least as far north as the Great Salt Lake in Utah (Spencer et al. 1965; Dutton 1975). In the irrigated portions of Magic Valley, bean production began in the early 1900's (Pierce and Hungerford 1929). The area soon became, and still is, the leading dry bean-producing area of the state; it is also the leading producer of seed beans in the United States. The combined production of dry edible beans and seed beans in the Magic Valley accounted for 94.8% of total Idaho production in 1974. Bean acreage has been relatively constant since about 1940. Corn acreage is much less but has been increasing steadily and rapidly since about 1950. In 1954, corn accounted for only 7.3% of the combined host acreage in this area; by 1974 it had increased to 31.7% of host acreage. Of the total corn acreage, field corn is the larger component, but sweet corn has become increasingly important with the opening of processing plants in Buhl in 1944 and in Burley in 1969. Acreages for the area are presented in Table 1 and Fig. 1.

History of Damage

The western bean cutworm was first recognized as a pest of beans in 1945. Larvae were collected that year from a bean warehouse in Kimberly, and damaged seed was also observed from the Blackfoot and Rupert areas. Bean industry personnel reported that similar damage had been noticed about 4 years earlier in those areas (Douglass et al. 1955). In 1954, the cutworm was first recognized as a pest of both field and sweet corn (Douglass et al. 1957) with infestation distributed generally in the southcentral Idaho area from Glenns Ferry to Hansen.

Records of seed and pod damage to beans in southern Idaho are summarized in Table 2 and Fig. 2. These are based on damage to untreated check plots in insecticide tests, surveys, reports from industry and general observations. Moth populations as reflected by black-light trap catches from 1958 through 1977 are also summarized in Table 2 and Fig. 3. Local processors have considered 2% damaged beans as an economic level. When damage goes above this level, time and effort in cleaning is required.

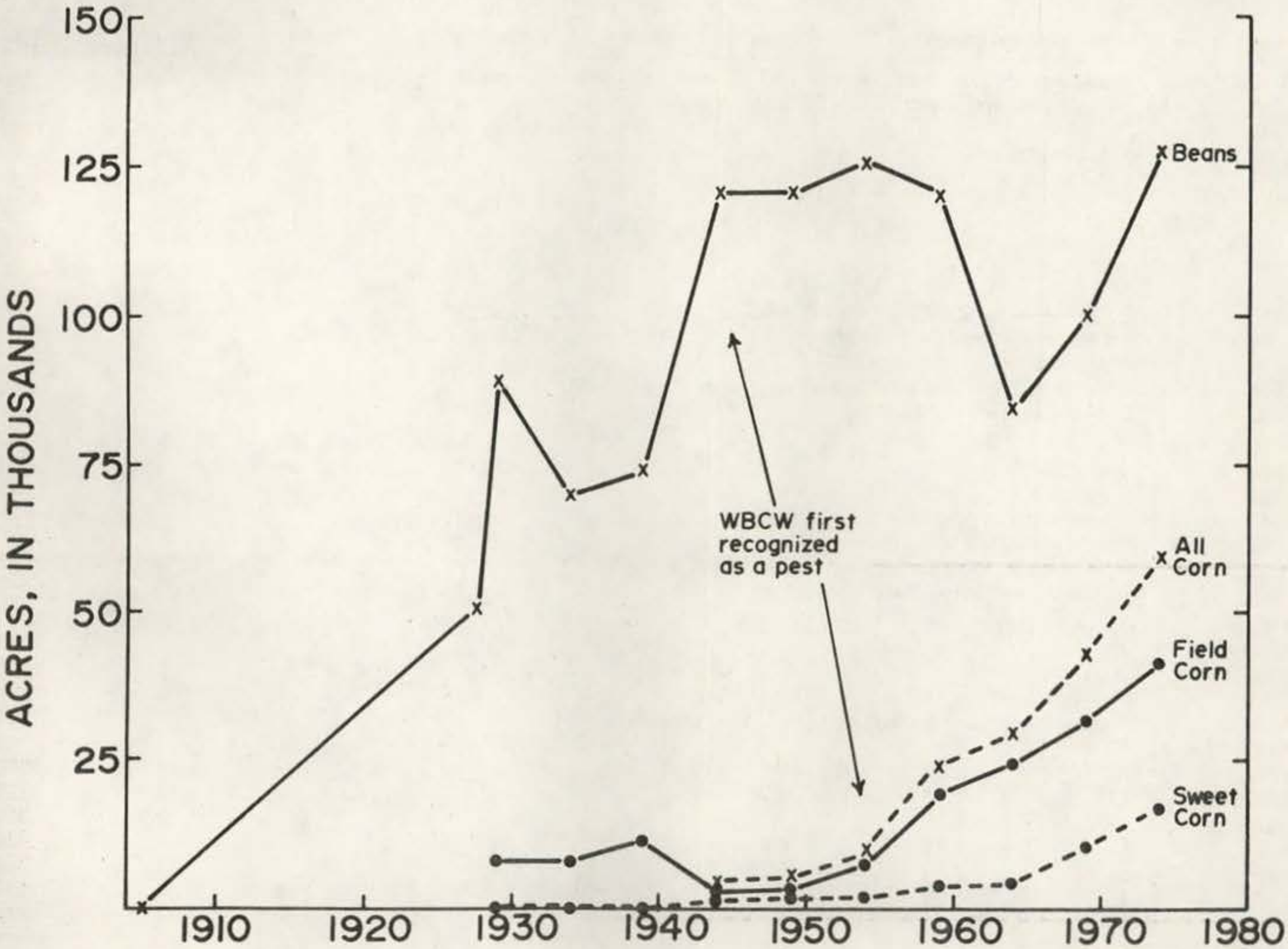


Fig. 1. Bean and corn acreages in the Magic Valley area of Idaho, 1905-1974.

Recent Commercial Records of Damage

Green Giant Corp. — Buhl

The Green Giant Corp. sweet corn growing area is in the western half of Magic Valley. In 1975, 1976 and 1977, samples of ears at harvest were examined from each field for worm damage. Essentially all damage was considered to be caused by the western bean cutworm, since corn earworm infestations in this area have occurred only on very late maturing corn. The data are summarized in Table 3.

The increase in fields infested over the 3 years (from 5.5% to 35% to 97.1% of the plantings) correlates well with area moth catches. The percentage of fields with 6% or greater ear infestations at harvest, which is considered as an economic level, was 4.4% in 1975, 11.6% in 1976 and 71.6% in 1977. No control efforts were made in 1975, although 100 acres were abandoned due to severe damage. In 1976 moth populations were monitored, a field survey for infestations was initiated and 1.1% of the fields were sprayed. In 1977 moth populations were again monitored, an intensive field survey was conducted and controls were applied to 29% of the fields.

Del Monte Corp. — Burley

Records furnished for 1976 for sweet corn grown in the area south of Burley on the eastern side of Magic Valley indicated higher infestations than occurred in the Green Giant growing area. Data for 35 fields in terms of worm-damaged ears per 100 showed 92.4% of fields

Table 2. Western bean cutworm damage to beans and black-light moth catches in southern Idaho, 1942-1977.

	Pods			Beans			Black-light traps	
Year	No. fields	% damaged	Range	No. fields	% damaged	Range	No.	Ave. no. moths
1942-45	Damage reported by industry personnel in Rupert and Blackfoot areas.							
1945	First collected and identified by ARS personnel.							
1946				8	0.6 by wt.	0 to 2.5		
1947	No statement.							
1948	No statement.							
1949				13	.8 by wt.	0.2 to 1.8		
1950	3	9.5	6.3 to 12.4	20	3.5	1.5 to 6.6		
1951	1	3.3			.66[1]			
1952	5	2.56	1.46 to 4.24		.6 [1]			
1953	7	2.48	1.48 to 4.59		.6 [1]			
1954	First recognized as a pest of corn.			161[2]	1.04	0 to 11.3		
1955	No statement.							
1956	"Infestation appeared to be somewhat heavier than in 1955."							
1957	"Virtually non-existent."						2	
1958				4[2]	.026	0 to .06	3	43
1959	"Negligible."			3	.018	.006 to .04	3	231
1960	"Very low."			1	.05		3	493
1961	"Infestation a little greater than in 1960."						3	274
1962	"More than in 1961."						3	2165
1963	"Population too low to evaluate insecticides."						3	892
1964	"So scarce, no control tests."						3	772
1965	"Damage heavy."			30[3]	.7	0 to 1.4	3	1977
1966				1	1.8		3	2431
1967				3	1	.4 to 2.1	3	1581
1968	"Damage very light."						3	698
1969	"Damage more wide spread and heavier than usual."						3	2350
1970	1	1.8			.36[1]		7	2746
1971	12	5.96	0 to 24		1.19[1]		11	2076
1972	4	1.11	.75 to 1.76		.22[1]		9	932
1973	1	0			0		9	315
1974	4	2.52	1.0 to 5.20		.36[1]		7	524
1975	5	1.23	0 to 5.85	5	.64	0 to 1.78	11	710
1976	4	3.60		4	1.04	.32 to 2.18	15	1927
1977	6	13.21		6	3.50	.34 to 6.84	16	5976

[1]Estimated from pods on basis of 5 beans per pod and 1 bean damaged per pod.

[2]From field combines.

[3]From survey of warehouses.

Table 3. Sweet corn infested by western bean cutworm, Green Giant Corp., 1975-1977.

Variety code no.	No. fields	Planting dates range	% fields infested: At any level	% fields infested: At level of 6% or more[1]	% sprayed
1975					
9	6	4/24-5/12	0	0	0
2	201	4/24-5/14	0	0	0
4	50	4/24-5/26	0	0	0
48	336	4/25-6/6	1.8	1.2	0
96	4	6/5-6/9	0	0	0
41	309	6/4-6/25	14.3	11.6	0
Totals	906		5.5	4.4	0
1976					
2	29	4/21-30	17.2	0	0
2	23	5/1-10	21.7	0	0
48	172	4/21-30	22.1	4.4	0
48	83	5/1-10	33.7	9.5	2.4
48	84	5/11-20	46.4	16.7	0
48	95	5/21-30	25.3	9.4	0
48	172	5/31-6/9	43	15.1	2.3
48	178	6/10-20	44.9	18.5	1.7
Totals	836		35	11.6	1.1

Variety code no.	No. fields	Planting dates range	% fields infested: At any level	% fields infested: At level of 6% or more[1]	% sprayed
1977					
2	88	4/25-30	89.8	60.2	13.6
2	45	5/1-7	97.8	68.9	11.1
2	19	5/8-6/4	100	52.6	31.6
48	53	4/25-30	100	81.1	37.7
48	13	5/1-7	100	38.5	23.1
48	38	5/8-14	100	68.4	15.8
48	44	5/15-21	95.4	45.4	15.9
48	33	5/22-28	97	57.6	36.4
48	109	5/29-6/4	98.2	71.6	45
48	151	6/5-11	98	75.5	37.7
48	115	6/12-18	98.3	86.1	30.4
48	25	6/19-21	96	80	4
Totals	733		97.1	71.6	29

[1]Includes those sprayed; infestation at harvest may have been less than 6%.

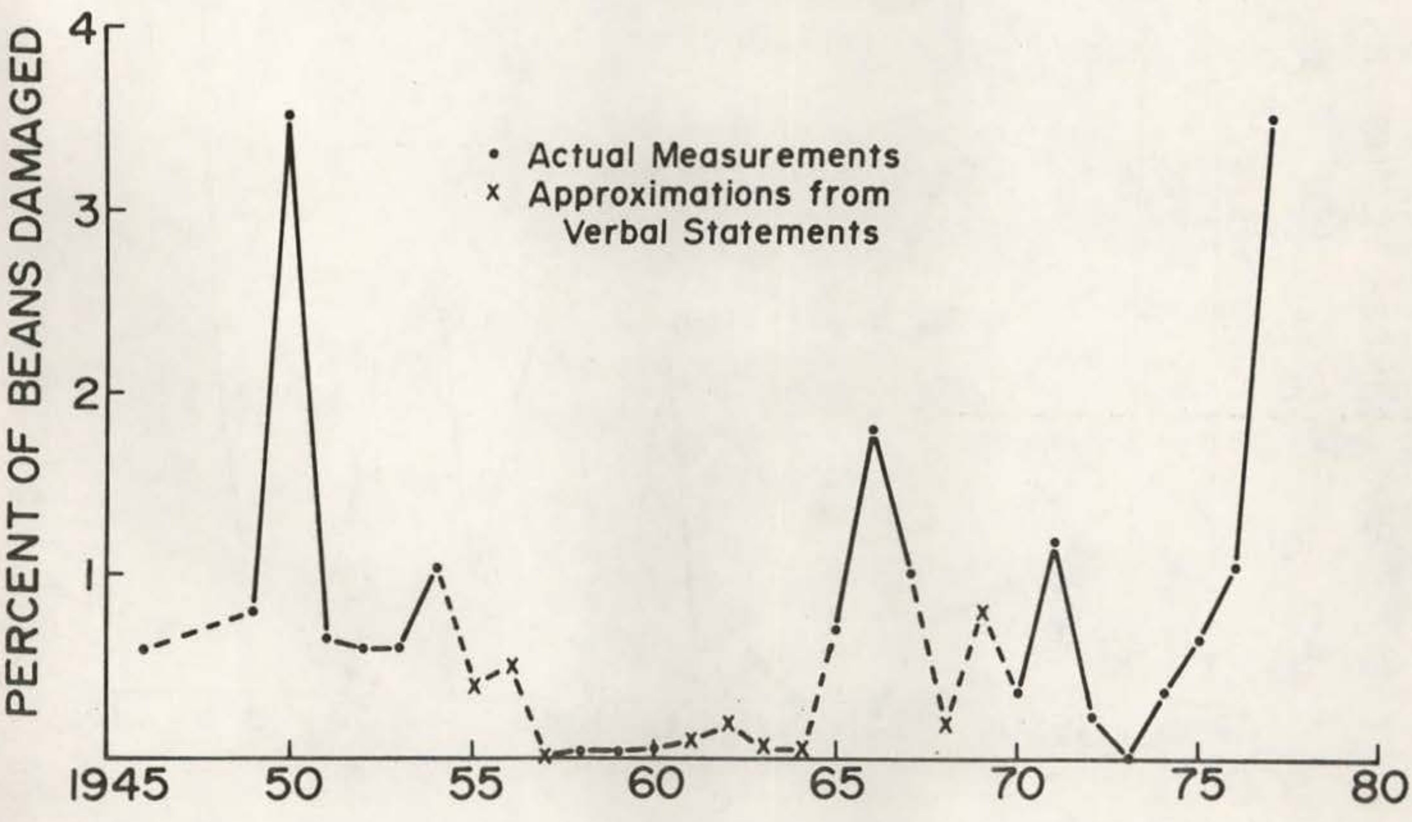


Fig. 2. Percent of beans damaged by western bean cutworm in south-central Idaho, 1946-1977.

infested, with 46.2% having 6% or more damaged ears. Control treatments were applied to 2 fields.

In 1977, 20 fields that were sprayed for western bean cutworm control averaged only 1.4% worm-damaged ears compared to an average of 14.8% for 10 untreated fields. Fields treated increased from 5.7% in 1976 to 66.7% in 1977.

Gallatin Valley Seeds — Twin Falls

Gallatin Valley Seeds provided records of western bean cutworm damage to harvested seed from 132 snapbean plantings in 1975, 52 plantings in 1976 and 121 plantings in 1977. The area involved is centered around Kimberly with a radius of about 20 miles. Within this area, the more heavily damaged fields were widely scattered.

Damage was recorded for each planting as number of seeds with worm holes in 500-gram samples. This was converted to percent of seed damaged by subtracting tare weights and using 1,984 clean seeds per pound as an average: 5 damaged seed per sample = 0.303%; 17.5 = 1.0%; 35 = 2.0%.

Plantings with one or more damaged seed per sample increased from 66% in 1975 to 76% in 1976 and 82.6% in 1977. The greatest damage to an individual planting was 0.58% in 1975, 3.7% in 1976 and 1.3% in 1977.

Overall, an average 0.143% of seed was damaged in 1975, 0.384% in 1976 and 0.225% in 1977. The decrease in 1977 was probably due to increased control efforts.

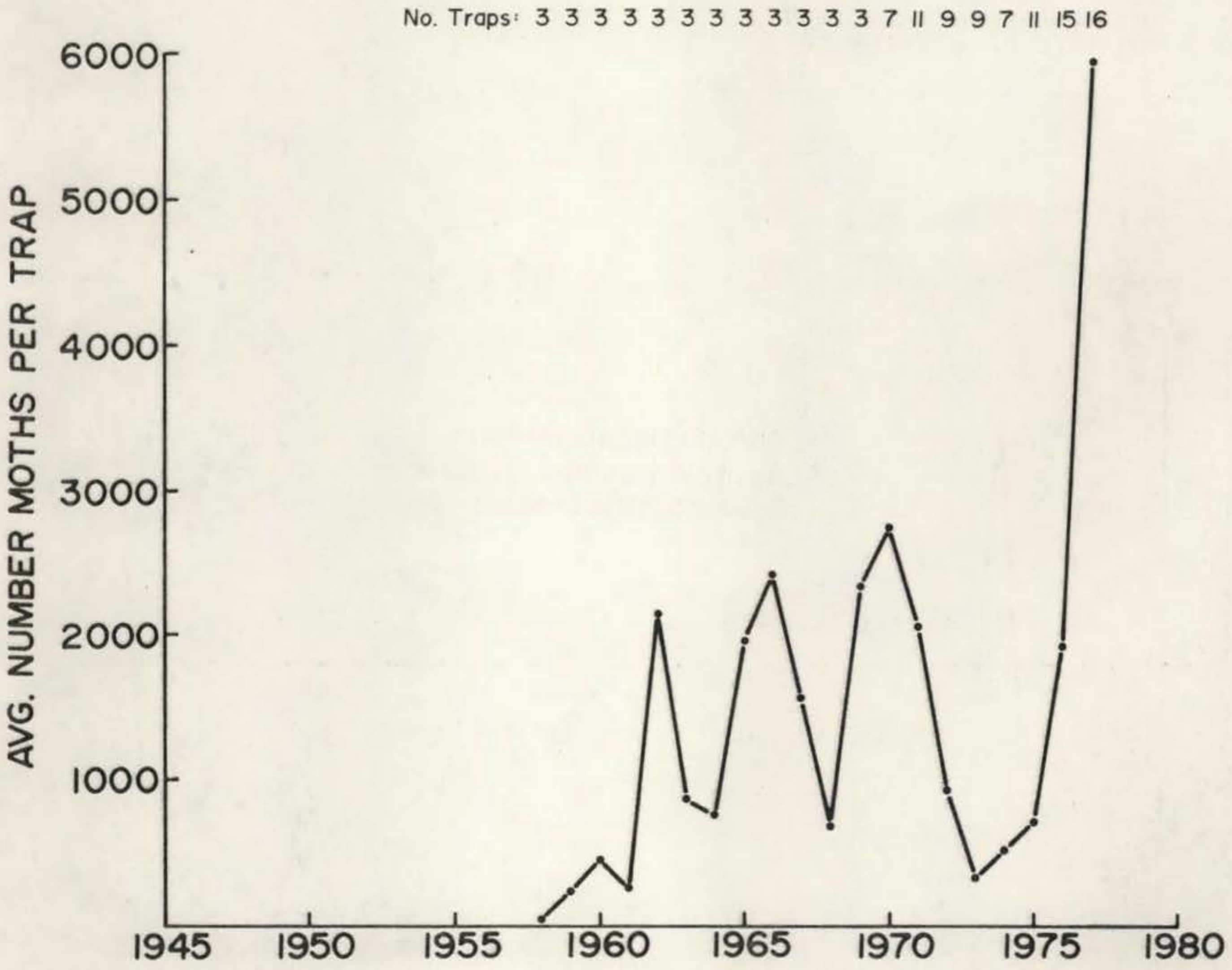
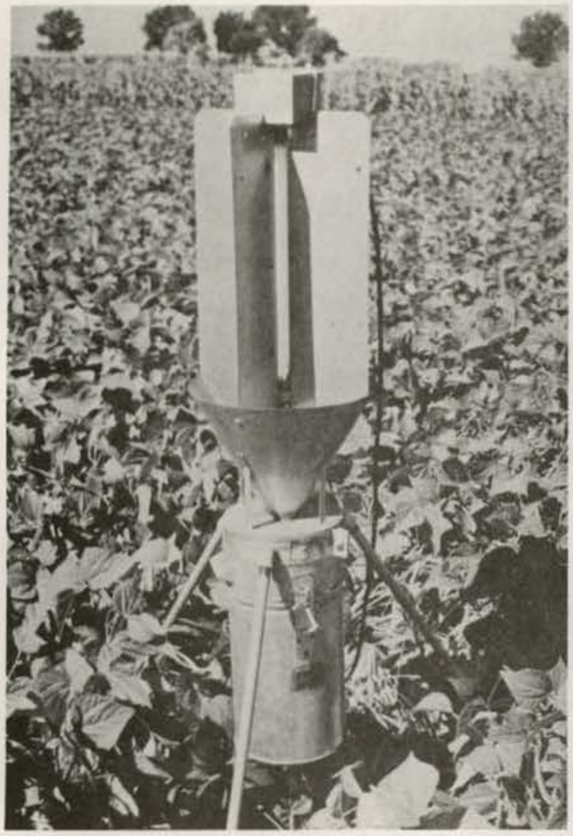
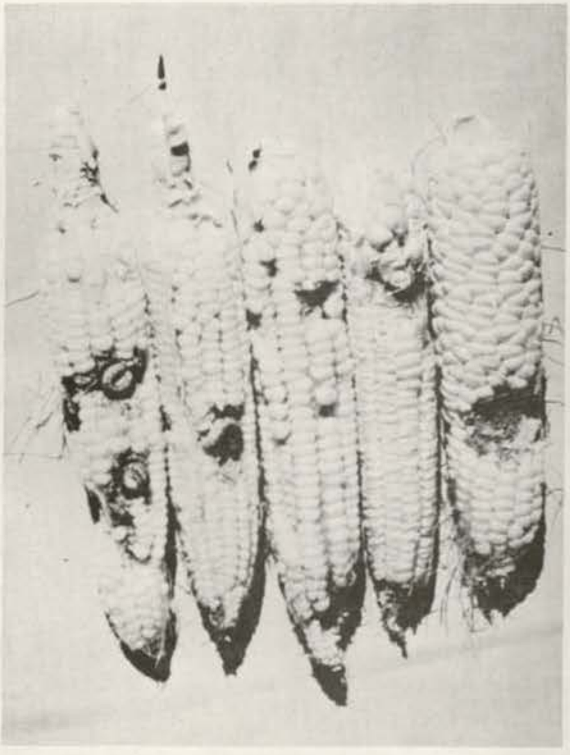


Fig. 3. Average number of western bean cutworm moths taken per trap for the season, Magic Valley, Idaho, 1958-1977.

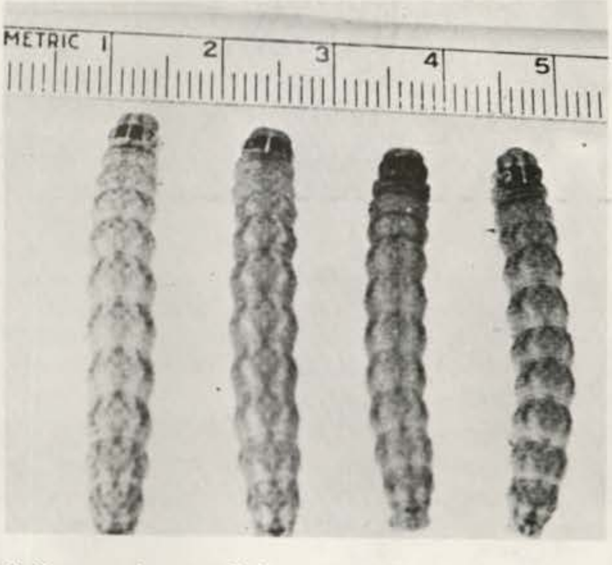


One of the black-light traps used in the study.

Seeds inside this damaged bean pod are destroyed.



Three larvae are visible in the damaged areas of this sweet corn.



Full-grown larvae of the western bean cutworm.

Research Findings and Discussion

Black-Light Trap Catches In Relation to Crop Damage

The traps used in this study have been identical or similar to the "General Purpose Black Light Insect Trap" manufactured by Ellisco Inc., Philadelphia, PA. The lamp is 15 watt G.E. F15T8-BL, or equal, wired for 110V, 60 cycle AC current. It is surrounded by 4 vertical screen baffles and mounted vertically on a tripod with the lamp from 4.5 to 6 feet above ground level. The traps were placed on field borders with power cords connected to the nearest electrical outlet. Thus, they were always near farm buildings.

The relationship between adult population levels, sampled by the black-light traps, and damage to beans by larvae has been investigated in several ways. The utility of light trap catches as a predictor of bean damage was the object of work by the late Walter Peay.[1] He summarized light trap catches and bean damage on an area basis for 13 years in an unpublished internal report. His conclusion was that "700 or more moths collected per trap by July 25 will cause 2% or more damage." This was accepted by Blickenstaff et al. (1975). Peay's data and appropriate regression statistics are shown in Fig. 4. The 2% average damage level is reached when approximately 1,500 moths were caught by July 25, or when approximately 2,350 moths were caught by August 10 (virtually the end of moth activity).

A considerably better correlation is obtained if the average total moth counts for the entire season are used (Fig. 5). These data indicated that on an area basis an average of 2% damage occurred when light trap catches averaged 3,750 total moths. These statistics should be interpreted with caution since many of the values for bean damage in Table 2 are based on meager data and data from only 3 light traps are available before 1970.

In the years 1971-1977, damage data were obtained from 22 untreated bean fields or plots immediately adjacent to light traps (Table 4). The correlation for total moths at nearest trap vs. percent seed damage (r = 0.6961) is highly significant but much lower than for area values. Fig. 6 shows that 2% damage occurred when approximately 4,440 moths were caught at the nearest trap. However, the variability is so great that the use of light trap catches as a predictor of damage in adjacent fields seems limited. The variability may be due to unknown differences in relative attractiveness of individual fields (which is masked in the area data) as well as errors by growers in reporting fields as untreated when they actually had been treated.

Nearly all of these damage values were derived from pods picked from standing plants, and considerable damage may occur after beans are cut and windrowed. Thus, the actual loss caused by a given number of moths is probably greater than indicated here.

The relationship between moths per trap and percentage of corn ears infested is similar to that for beans. For corn, all unsprayed plantings on a farm where a trap was located were considered (Table 4) and the farm means are plotted in Fig. 7. The great variation in infestation near a trap is probably due to differences in plant maturity. Using average infestation values for farms, the regression for n = 8 is Y = -3.579 + .005 X (r= .735[2]). When the average infestation value for the 1977 Loomis Co. Farm light trap is omitted, the regression for n = 7 is Y = -7.455 + .008 X (r = .953[3]). Using the latter, approximately 1,557 total moths per trap would result in 5% ear infestation at harvest.

[1]Walter E. Peay is former leader of the USDA, ARS, Entomology Department at Twin Falls.

[2]Significance at the 5% level of probability.
[3]Significance at the 1% level of probability.

Table 4. Relationship between total number of western bean cutworm moths per light trap and damage to unsprayed beans and corn in fields immediately adjacent to traps, Twin Falls County, Idaho.

Year	Location	No. moths (X)	No. holes/ 1000 pods	% pods damaged[1]	% seed damaged[1] (Y)
		BEANS			
1971	Turner	1331	19.8	(1.98)	(.50)
1972	TASCO	517	7.5	(.75)	(.19)
	Asgrow	859	9.0	(.9)	(.22)
	Turner	1059	10.3	(1.03)	(.26)
	Valentine	1668	17.6	(1.76)	(.44)
1973	Asgrow	207		0	.01
1974	Halverson	1393		5.2	(1.30)
	Thaemert	626		2.4	(.60)
	TASCO	452		1.5	(.38)
	USDA Lab, Twin Falls	223		1.0	(.25)
1975	Halverson	2083		4.9	(1.28)
	ID AES, Kimberly	1089		0.3	(.02)
	USDA, Kimberly	407		0	(.01)
	Uhlig, Murtaugh	300		0	(.01)
1976	Chase N	3760		1.4	.32
	S	3760		3.4	.85
	Asgrow	4471		2.1	(.62)
	Russell	4488		7.1	2.18
1977	Halverson	7107			5.36
	Thaemert	5830			5.69
	Griffith	6656			.34
1977	ARS, Kimberly	4988			1.97
		SWEET CORN			
			% ears infested[2]		Ave.
1976	Grieve Co. Farm	675	0, 1, 0, 7		2.0
	Nicholson Co. Farm	1100	0, 0, 0, 0, 0, 4		.7
	Reynolds	1375	0, 0, 0, 1		.2
	Kimball	1630	0, 9, 19		9.3
	Loomis Co. Farm	4856	2, 36, 39, 76		38.2
1977	Nicholson Co. Farm	2581	2, 6, 9, 10, 18		9.0
	Kimball	4591	7, 46		26.0
	Loomis Co. Farm	4974	1, 1, 8, 14		6.2

[1]Values in brackets estimated from number of holes per 1,000 pods or percent of pods damaged.
[2]At harvest. Fields within 3/8 mile of trap.

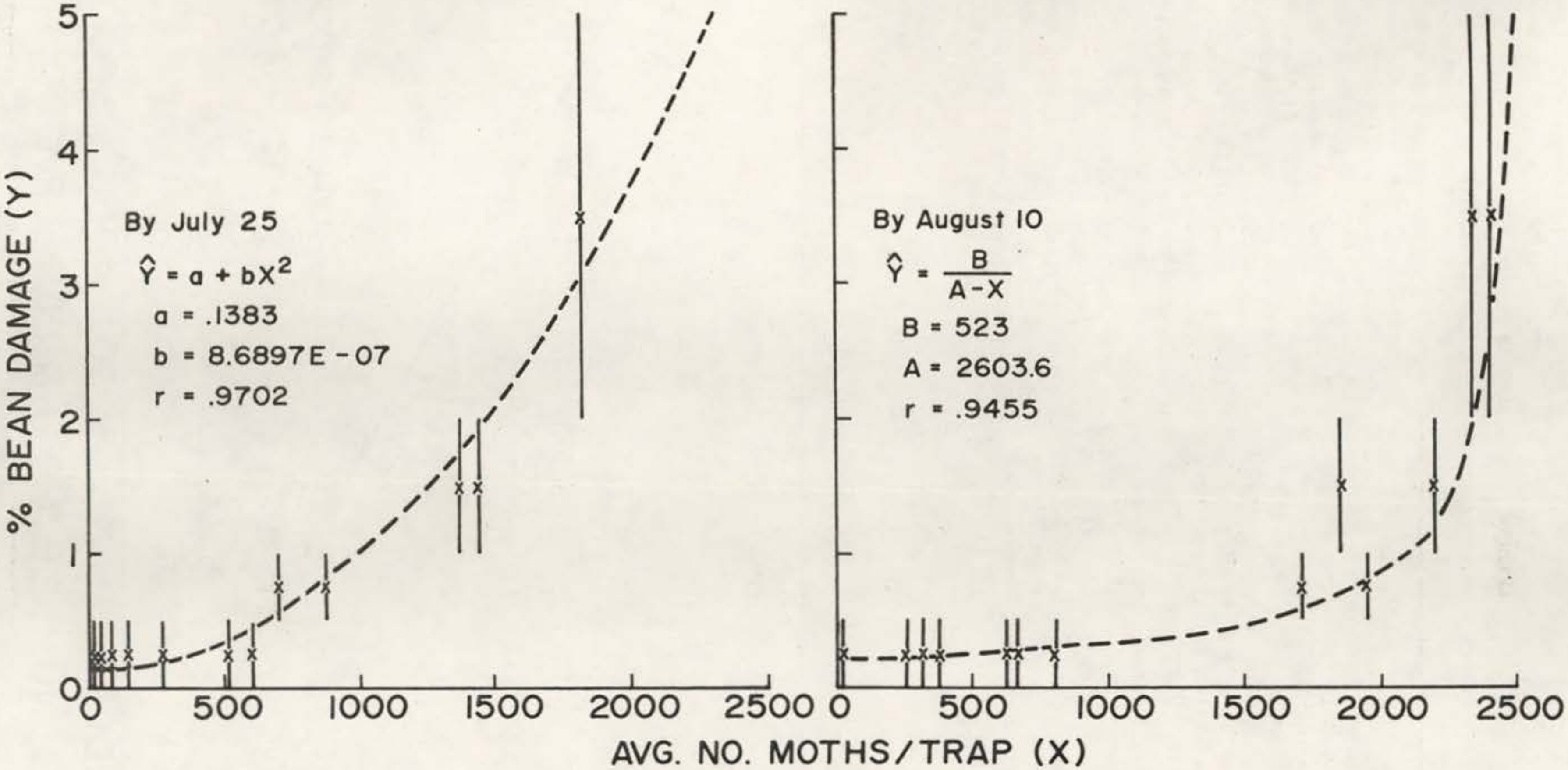


Fig. 4. Relationship between western bean cutworm light trap catches and damage to beans (W. E. Peay, 1958-1970, Magic Valley, Idaho).

Statistical Analysis of Light Trap Catches

Total light trap catch records for individual traps were available for 9 years. The number of traps per year varied from 3 to 16. During the last 3 years, traps were located near either beans or corn. Within-year variation was examined and, for the last 3 years, variation for beans and corn was compared. The data are summarized in Table 5.

Since in nearly every case the median value was less than the mean value, the distribution of trap catches was non-normal. Over the 9 years, low trap catches ranged only from 23 to 203, but high trap catches ranged from 63 to 23,108. Correlation is very close between year means and the ratio of high and low values. This is also reflected by the trend of increasing coefficient of variation with increasing year mean values. The average coefficient of variation was 77.1%.

Light traps located either near corn or near beans are also compared in Table 5. There were 1.24, 1.13 and 1.19 times as many moths taken near beans as near corn for the years 1975, 1976 and 1977, respectively. In 1977, however, the ranges for beans and corn were very unusual, with little variation among bean trap catches, but large variation among corn trap catches (CV's = 25 and 120, respectively). Therefore, the evidence that beans are more attractive than corn to moths is inconclusive.

The range of catches for each year, 1972 through 1977, was divided into 10 equal parts. The percent distribution of count (n = 67) from low to high for each part was: (1, low) 20.9, (2) 25.4, (3) 16.4, (4) 11.9, (5) 7.5, (6) 1.5, (7) 0.0, (8) 3.0, (9) 0.0 and (10, high) 13.4. Thus, 46.3% of the catches were in the lower 20% of the ranges, and 13.4% of the catches were in the highest 20% of the ranges. Every year had a preponderance of relatively low values, and one or more abnormally high values. The abnormally high values are tentatively attributed to highly attractive plantings of either corn or beans near the traps. However, factors such as trap elevation, trap exposure (most of necessity were near buildings) and inherent differences in efficiency among traps also undoubtedly had an effect.

Corn appears to have been heavily infested in only 3 years — in 1956 when beans suffered relatively light damage (Douglass et al. 1957), in 1976 when damage to beans increased and in 1977 when both beans and corn were heavily damaged (Table 2; Fig. 2).

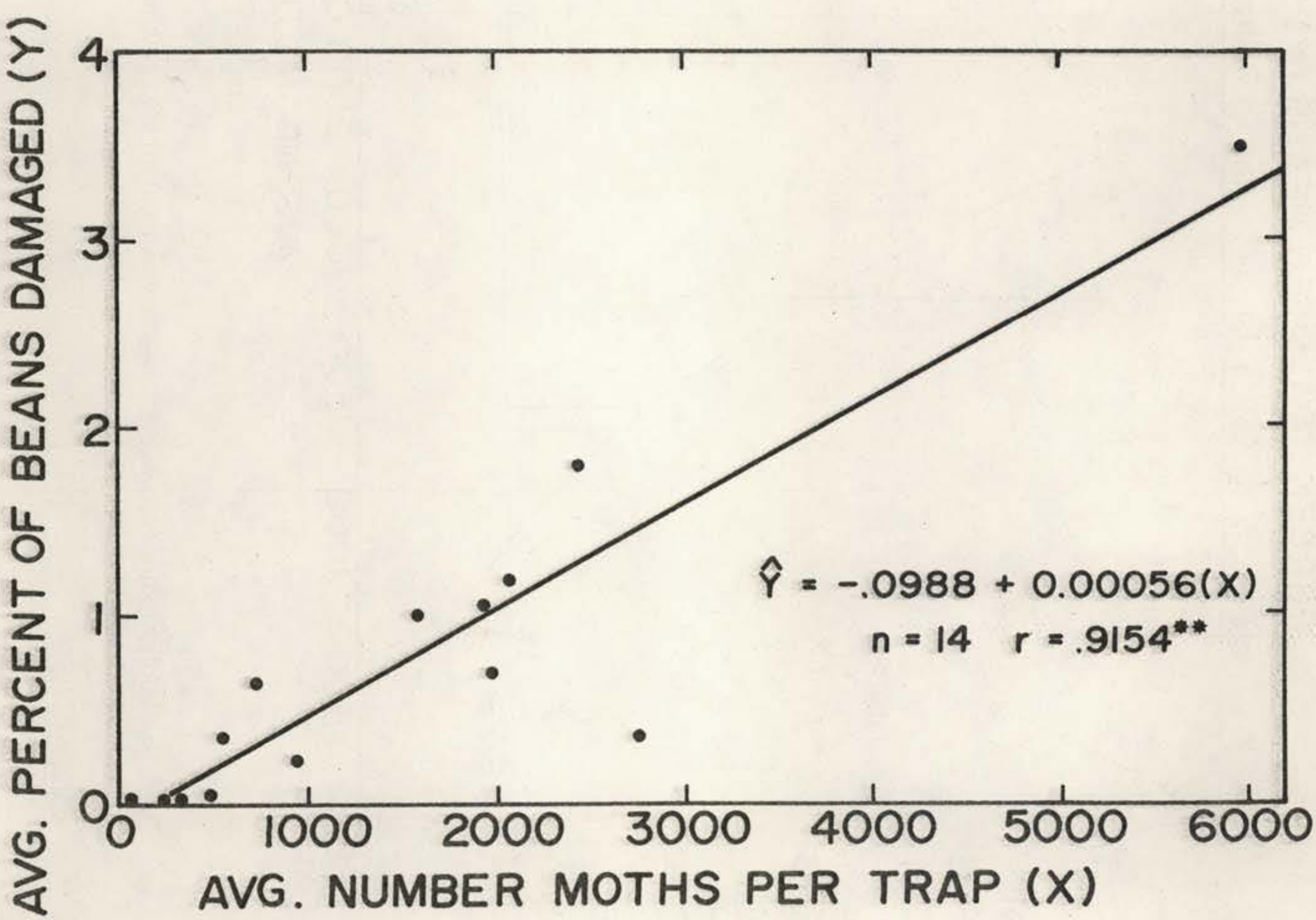


Fig. 5. Correlation between area moth populations and area bean damage (data from Table 2).

Table 5. Statistics from light trap catches in southern Idaho.

Trap location	Year	n	Number moths per trap: Mean $\bar{x}$	Median	Range		Standard deviation s	Coef. of variation $\frac{s}{\bar{x}} \times 100$
Beans	1958	3	43	44	23	63	20	46
Beans	1959	3	231	133	112	447	188	81
Beans	1960	3	493	216	186	1078	507	102
Beans	1972	9	932	859	148	2088	631	67
Beans	1973	9	315	209	93	713	234	74
Beans	1974	7	524	418	223	1393	408	77
Beans and Corn	1975	11	710	505	139	2083	545	76
Beans and Corn	1976	15	1927	1233	143	4856	1609	83
Beans and Corn	1977	16	5976	4981	203	23,108	5288	88
Beans	1975	7	764	415	300	2083	639	84
Corn	1975	4	616	628	139	1067	392	64
Beans	1976	9	2023	1233	143	4488	1741	86
Corn	1976	6	1788	1283	724	4856	1536	86
Beans	1977	6	6641	6243	4988	9617	1639	25
Corn	1977	10	5578	3617	203	23,108	6681	120

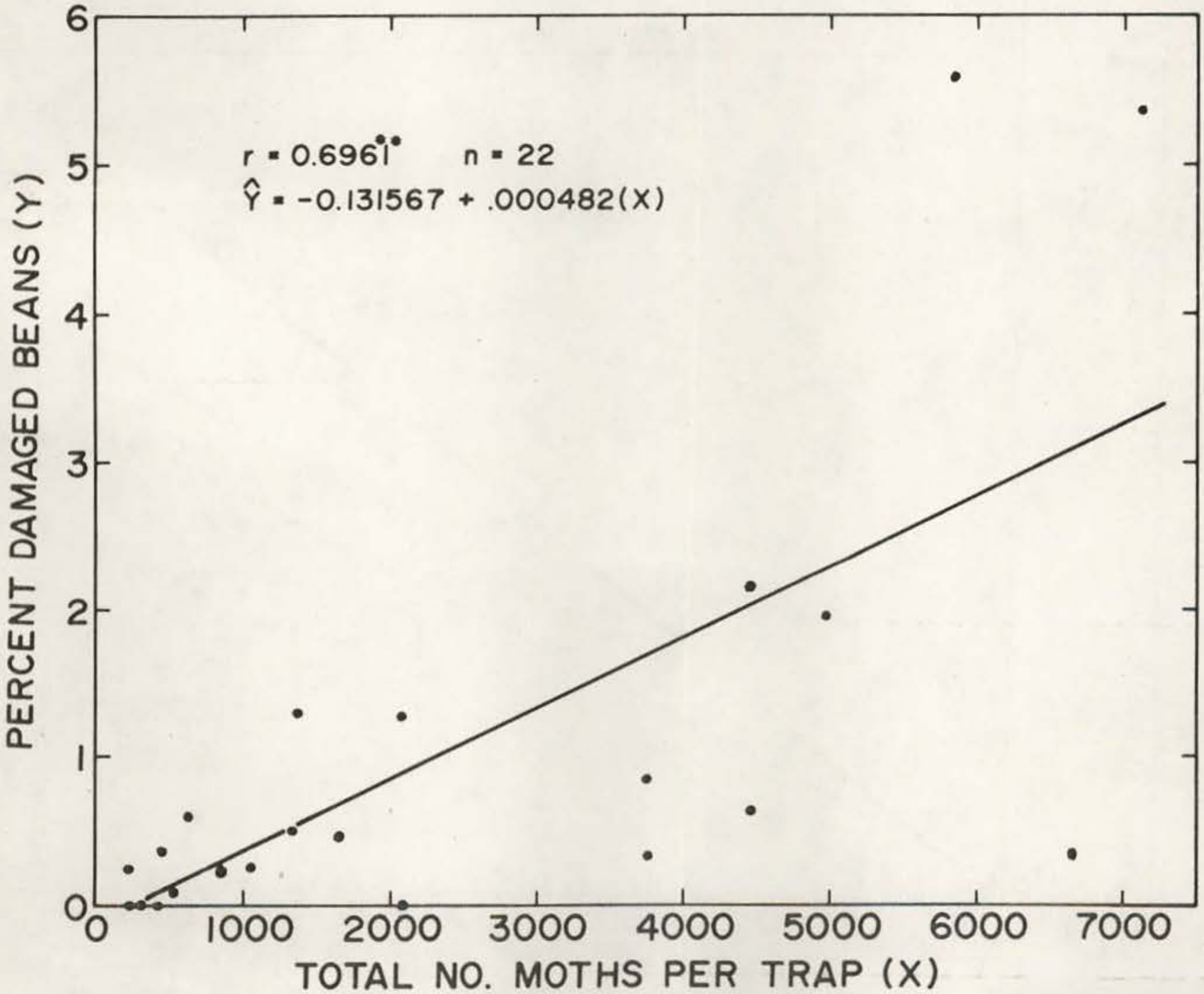


Fig. 6. Correlation between total number western bean cutworm moths and damage in bean fields adjacent to light traps, Twin Falls County, Idaho, 1971-1977.

Stage of Plant Development vs. Infestation and Damage

The effect of stage of plant growth on infestation was studied in 1975 at Kimberly. One variety of sweet corn and 2 varieties of beans were planted on 5 successive dates 1 week apart. Plant entries were randomized in 6 replicates. The same randomization was used for each planting date. Plots were 4 rows wide by 10 feet long. The 2 bean entries were chosen because of their apparent difference in susceptibility to western bean cutworm damage (Antonelli 1974).

General descriptions of plant growth stages were made during the period of moth flight. Damage was recorded as plants reached maturity — dry pods for beans and roasting ear stage for sweet corn. For beans, 500 pods were examined per plot. For corn, 2 pickings were made, the top ears first and the second or lower ears about a week later. Degree of damage to corn was arbitrarily rated from 0 (not infested) to 5 (severe damage). The data are summarized in Table 6. The June 2 planting date of corn did not develop normally and was eliminated.

The data indicate that most damage occurred to Michigan Improved Cranberry that was most mature (35% flower) during the period of moth flight. The later plantings (less mature) received progressively less damage. The trend was less distinct for UI-111, but the most mature (past 50% flower) and the least mature (0 to 30% flower) received the least damage. For corn, the greatest infestation and damage occurred to those intermediate plantings with tassels emerging during moth flight. Obviously, plant maturity had a great effect on infestation and damage. No direct comparison between beans and corn was possible from the data obtained.

A similar planting was made in 1976, but it suffered severe hail damage during moth flight and was abandoned.

In 1977, 3 varieties of beans and 1 variety of sweet corn were planted on 3 different dates. Plots were 6 rows wide and 10 feet long. Entries were randomized in 8 replicates. Stages of plant growth (for beans: LeBaron 1974) were recorded 3 times during the heavy moth flight period which extended from July 22 to August 5. Total moth catch in a nearby light

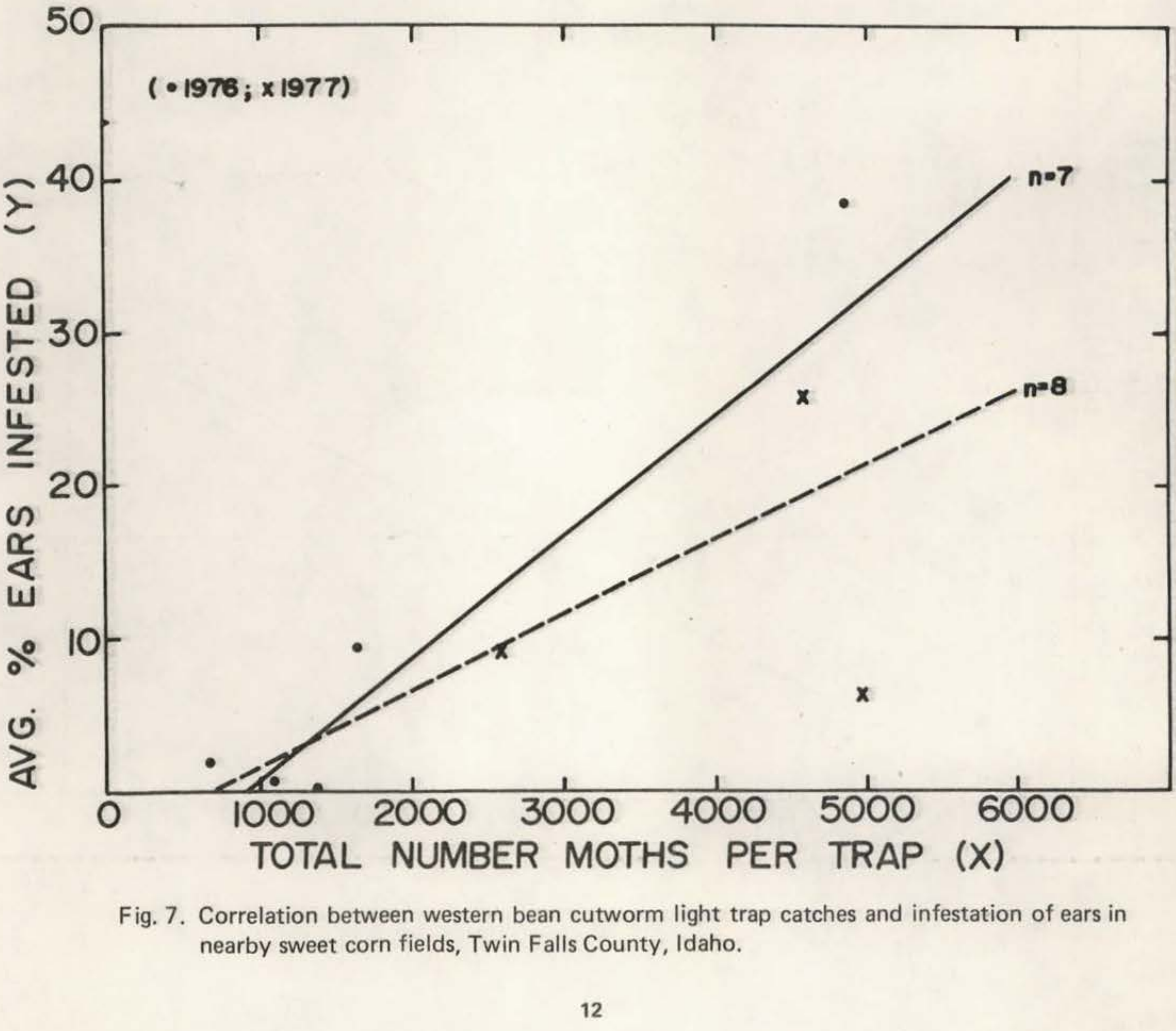


Fig. 7. Correlation between western bean cutworm light trap catches and infestation of ears in nearby sweet corn fields, Twin Falls County, Idaho.

Table 6. Stage of plant maturity during peak moth flight[1] and damage by western bean cutworm to 2 bean varieties and 1 sweet corn variety, Kimberly, 1975.

Planting date	Bean Michigan Improved Cranberry: Maturity	% damaged beans	Bean UI-111 Pinto: Maturity	% damaged beans	Sweet Corn Cultivar Green Giant Code No. 2: Maturity	No. ears	% infested ears	Damage rating
5/26	35% fl.-pods nearly fully developed	3.66	85% fl.-pods fully developed	.20	tassels out-90% silk	166	15.07	.23
6/2	1st - 90% fl.	2.26	50% fl. to pods nearly full	2.04				
6/9	0 - 63% fl.	1.31	8 - 88% fl.	1.40	tassel in boot 40% silk	259	29.76	.76
6/16	0 - 35% fl.	.86	0 - 57% fl.	2.18	tassel out 0 silk	258	31.39	.83
6/23	0 - 20% fl.	.25	0 - 30% fl.	.57	tassel in boot 0 silk	182	3.84	.04

[1]Peak moth flight occurred between July 28 and August 14. During this period 96.6% of the total moths for the season were collected in a nearby black-light trap.

trap was 4,988 indicating an abundance of moths in the area. Nearby blocks of field corn and beans may have affected the results by attracting moths in competition with some of our plots; no data were taken from the surrounding blocks.

All 3 varieties of beans for a planting date were sampled at a time when UI-111 had dropped all or nearly all leaves. In comparison, Michigan Improved Cranberry had 5 to 50% leaf drop, and R275 had 0 to 20% leaf drop. For the sample, 200 pods were picked at random from the center 2 rows of each plot and examined in the laboratory for pod and seed damage. At the roasting ear stage, all ears were picked from the 2 center rows of each corn plot and examined for feeding areas and larvae. The results are summarized in Table 7.

Table 7. Western bean cutworm damage to beans and sweet corn planted on 3 dates, Twin Falls, 1977.

Entry	Planting date [1]	Maturity rating[2] Range	$\bar{x}$	Damaged beans No.	%
MIC beans	E	3.9 - 6.7	5.1	105 b[3]	1.84
	M	2.3 - 5.9	4.2	110 b	1.96
	L	0 - 1.9	.6	116 b	1.96
R275 beans	E	5.4 - 6.9	6.0	174 c	2.09
	M	4.9 - 6.8	5.6	300 d	3.10
	L	0 - 3.2	1.4	26 a	.28
UI-111 beans	E	6.3 - 7.1	6.8	88 b	1.17
	M	5.6 - 7.0	6.1	319 d	3.91
	L	1.3 - 5.2	3.3	114 b	1.40

Sweet corn G. G. Code No. 2	No. worms/ 100 ears	No. feeding areas/ear
E: tassels showing to 90% brown silk	20	.36
M: tassels just showing to 50% silk	26	.41
L: no tassels to tassels just showing	9.5	.33

[1]E = May 20; M = May 31; L = June 15.

[2]All reproductive stages, the larger the number, the more mature (Lebaron 1974). Ratings for period July 22 to August 5, during heavy moth flight period.

[3]Values followed by the same letter do not differ at the 0.5 level of probability.

Intermediate (May 31) plantings of R275 and UI-111 suffered greatest damage among the beans. These had maturity ratings during heavy moth flight ranging from 4.9 to 7.0 (R5 = seeds discernible to feel in oldest pods; R7 = oldest pods have fully developed green seeds). Both more and less mature plantings of these varieties had significantly less damaged seed. Plantings of Michigan Improved Cranberry, where maturity ratings ranged from 0 to 6.7, had no significant differences in damage. Damage differed significantly between late plantings of MIC and R275, which had comparable maturity ratings.

The medium-planted corn, with tassels just emerging to 50% brown silk during heavy moth flight, had slightly more worms and feeding areas than either younger or older corn.

An unreplicated date-of-planting test of Green Giant Code No. 48 sweet corn near Buhl by Gene Carpenter (personal communication) in 1975 showed a close relationship between date of fresh silk and western bean cutworm infestation. He marked ears as they silked and later determined the percentage infested by both western bean cutworm and corn earworm. The data are summarized in Table 8. Western bean cutworm infestation ranged from 0

Table 8. Sweet corn infestation by western bean cutworm and corn earworm affected by date of silking (Buhl 1975).[1]

Planting[2]	Date ears tagged in fresh silk	No. ears	% infested WBCW	CEW
3	7/21-31	567	0	0
4	8/1-5	284	1.4	0
5	8/7-12	356	3.4	0
6	8/14-18	310	2.3	0
7	8/19-22	301	15.9	0
8	8/25-29	413	23.2	0.2
9	9/2-22	552	10.5	2.2

[1]Personal correspondence from Dr. Gene Carpenter, Department of Entomology, University of Idaho.

[2]The 2 earliest plantings had already silked when first ears were tagged. Peak moth flight was July 28 to August 6.

for the earliest planting that silked July 21 to 31, to 23.2% for the next to last planting that silked August 25 to 29. The latest planting that silked September 2 to 22 had less infestation.

Records of Green Giant sweet corn infestations were arranged by planting dates in Table 3. In 1975 only the latest planted corn was infested. In 1976 the trend was again for more infested fields and heavier infestations in later planted corn. In 1977, infestation was general, with only a slight trend toward heavier infestations in later plantings.

Overwintering Survival, Moth Emergence, Flight and Sex Ratio

Hibernation cages were used 11 years between 1947 and 1971 to determine time of emergence, overwintering survival and sex ratios. The cages were tiles sunk in the ground and covered with screen. Larvae were placed in the cages in the fall when mature or nearly so and were provided corn or beans as food. Larvae completed development and entered the soil. Moths were counted as they emerged the following spring and, for 3 years, recorded by sex. The data are summarized in Table 9. Survival from mature larvae to moth emergence averaged 27.7% over 7 years, ranging from 11 to 46%. Overwintering larval survival in check plots of insecticide tests was about 10% in April 1963 and about 15% in June 1964. These data were obtained by sifting soil.

The sex ratio averaged over 3 years was 1:1. Moths emerging the first 5 or 6 days were predominantly female. Average dates of first, peak and last emergence were July 11, July 20 and July 31.

Moth activity from black-light trap records is also summarized in Table 9. Average dates for first, peak and last moth flights for the Twin Falls area were July 3, July 23 and August 24. These dates do not fit well with data from hibernation cages. For the 3 years that comparable data are available — 1958, 1959 and 1971 — light traps indicated first moth flight 2.3 days earlier and peak flight 1.5 days earlier than for hibernation cages. Last moths were trapped 21 days after last emergence in hibernation cages. Since light trapping was often discontinued when moth activity became negligible, the date of last moth activity is undoubtedly even later.

The sex ratio of moths taken in light traps in 1975, 1976 and 1977 also differs from the 1:1 ratio in hibernation cages. Overall, the ratio of trapped males to females was about 2.8:1.

Table 9. Dates of western bean cutworm emergence and survival in overwintering hibernation cages, and moth activity at light traps, Twin Falls area, 1951-1977.

	Moth emergence from hibernation cages						Light trap catches			
Year	First	Peak	Last	No. larvae introduced	% survival to moths	% female	First	Peak	Last	% female
1951	7/7	7/17	7/23							
1952	7/12	7/18	7/26							
1953	7/21	7/30	8/8							
1954	7/6	7/19	7/30	377	46.2					
1955	7/19		8/12	1022	38					
1956	7/3	7/15	7/26	1148	23.8					
1957	7/12	7/24	7/29	728	11.1	47.5				
1958	7/6	7/11	7/23	200	23.5	56.5	7/3		8/9	
1959	7/8	7/21	8/4	378	29.4	48.9	7/12	7/21	8/29	
1960							6/13	7/22	8/16	
1961							7/1	7/16	8/26	
1962							7/9	7/24		
1963							7/10		9/25	
1964							7/14	8/7	9/1	
1965							7/1	7/25	8/29	
1966							7/1	7/19		
1967							7/7	7/25	8/30	
1968							7/8	7/24		
1969							6/18	7/15		
1970							7/4	8/1		
1971	7/13	7/26	8/9	1191	22.2		7/5	7/23		
1972							6/30	7/20	8/16+	
1973							7/6		8/13	
1974							7/5	7/18	8/15	
1975							7/9	7/28	8/27	28.9
1976							7/1	7/21	8/18	26.6
1977							7/1	7/27	8/19	22.9
Ave.	7/10.8	7/20.1	7/31.4		27.2	50.6	7/3.2	7/23.4	8/23.6	
Range	7/3-21	7/11-30	7/23-8/12				6/13-7/14	7/15-8/7	8/9-9/25	

Table 10. Development of life stages of the western bean cutworm in the insectary and laboratory.

	Ave. length of adult life		Ave. preovip.	Ave. no. eggs		% of eggs	Incubation period	Ave. time/instar (days)[1]							
	♂	♀	(days)	per ♀	per mass	hatched	(days)	1st	2nd	3rd	4th	5th	6th	7th	Total
1955			4.0		2-140		5.8	4.9	3.9	3.8	4.1	4.5 (123)[1]			21.2
1956	5.7	7.6	3.6	330	2-305	78.7	5.4								
1957	8.0	12.1	4.4	570	2-364	77.6	6.2	4.7 (15)	3.1	6.4	4.8	5.0	5.4		29.4
1958	7.8	7.9	3.4	282	2-233	79.8	6.1	4.7 (10)	4.9	4.7	4.6	5.0			23.8
1959				446			6.6	8.0 (10)	11.2 (5)	8.0 (2)	9.0 (1)				36.1
1962								4.7	4.3	5.0	6.0	6.8	7.8	10.4	45.0
Ave.	7.2	9.2	3.8	407		78.7	6.0	5.4	5.5	5.6	5.7	5.3	6.6	10.4	31.1

[1]Numbers in ( ) are the number of individuals observed.

If the true sex ratio is 1:1, as indicated by hibernation cages, then the black-light traps must be more attractive to males than to females. However, the ratio changed drastically within trapping seasons. In all traps, females predominated early and continued to predominate until 4 to 9 days before peak flight, after which males predominated. The typical relationship is illustrated in Fig. 8. This is in general agreement with the observations from hibernation cages that females emerged first.

Development of Life Stages In Insectary and Laboratory

From 1955 through 1959 and in 1962, moths emerging from hibernation cages were used to study the development of adults, eggs and larvae. Adults were placed in pairs or small groups in screen cages over potted bean or corn plants in an outdoor insectary and offered honeywater as food. Oviposition was monitored, and eggs were incubated at room temperatures. Newly hatched larvae were placed individually in petri dishes and daily fed bean leaves or pods. Although the numbers of individuals used to obtain the records are mostly unknown, the data are fairly consistent from year to year (Table 10).

Adults were short-lived under these conditions, averaging only 7.2 days for males and 9.2 days for females. Light trap catches indicated a longer period of life. The average pre-oviposition period was about 4 days, and the average number of eggs laid per female was 407. About 79% of the eggs hatched with an incubation period averaging 6 days. The number of larval instars varied from 5 to 8. The time required to reach the full-fed, nonfeeding condition varied from 21 to 45 days with an average of 31. Larval mortality in 1962 was 20% in the 1st-instar, 12% in the 2nd, 6% in 3rd, 3% in 4th, 2% each in 5th and 6th and 40% in 7th. No reason was given for the excessively large mortality during the last instar.

Fig. 9 is a generalized life history chart based on the preceding data. This suggests that insecticidal control will be most effective when applied between 7 and 18 days after the peak of moth flight (10 and 21 days after peak emergence from hibernation cages). This would be from peak egg hatch to peak of the second larval instar or, on average, between July 30 and August 10.

Overwintering Field Studies

The depth that larvae burrow into the soil was determined in the falls of 1962 and 1963. Foot-square samples were dug at random to a depth of 12 inches in infested bean fields. The soil was sifted in increments of 3 inches. Most larvae (62.7%) were found at soil depths between 3 and 6 inches (Table 11).

Table 11. Depth of western bean cutworm overwintering larvae and pupae in the soil.

HIBERNATION CAGES

Date	No. pupae	Depth in soil (in.) Range	$\bar{x}$
1956 June 25-26, 5 hib. cages x 25	36	5 - 11	8.5
1957 July 2, 2 hib. cages x 25	20	7 - 12	10.0
1958 July 8, 1 hib. cage x 10	4	8 - 9	8.5
1959 July 6, 1 hib. cage x 50 ?	16	2 - 13	8.2

FIELD

	No. Field	No. samples[1]	Total no. larvae	% of larvae at depth level[2] 0-3"	3" - 6"	6" - 9"
1962 Oct. 31 - Nov. 1	1	49	15	66.7	33.3	0
1962 Nov. 6 - 9	2	164	116	20.7	67.2	12.1
1962 Nov. 21	3	63	32	15.6	75.0	9.4
1962 Nov. 21 - Dec. 6	4	200	96	31.2	56.2	12.5
1963 Nov. 14 - 19	5	160	43	14.0	65.1	20.9
1963 Nov. 26 - 27	6	120	17	0	64.7	35.3
Totals		747	319	75	200	44
Percentages				23.5	62.7	13.8

[1]Samples were 1 ft.[2]

[2]No larvae were found between 9 and 12 inches.

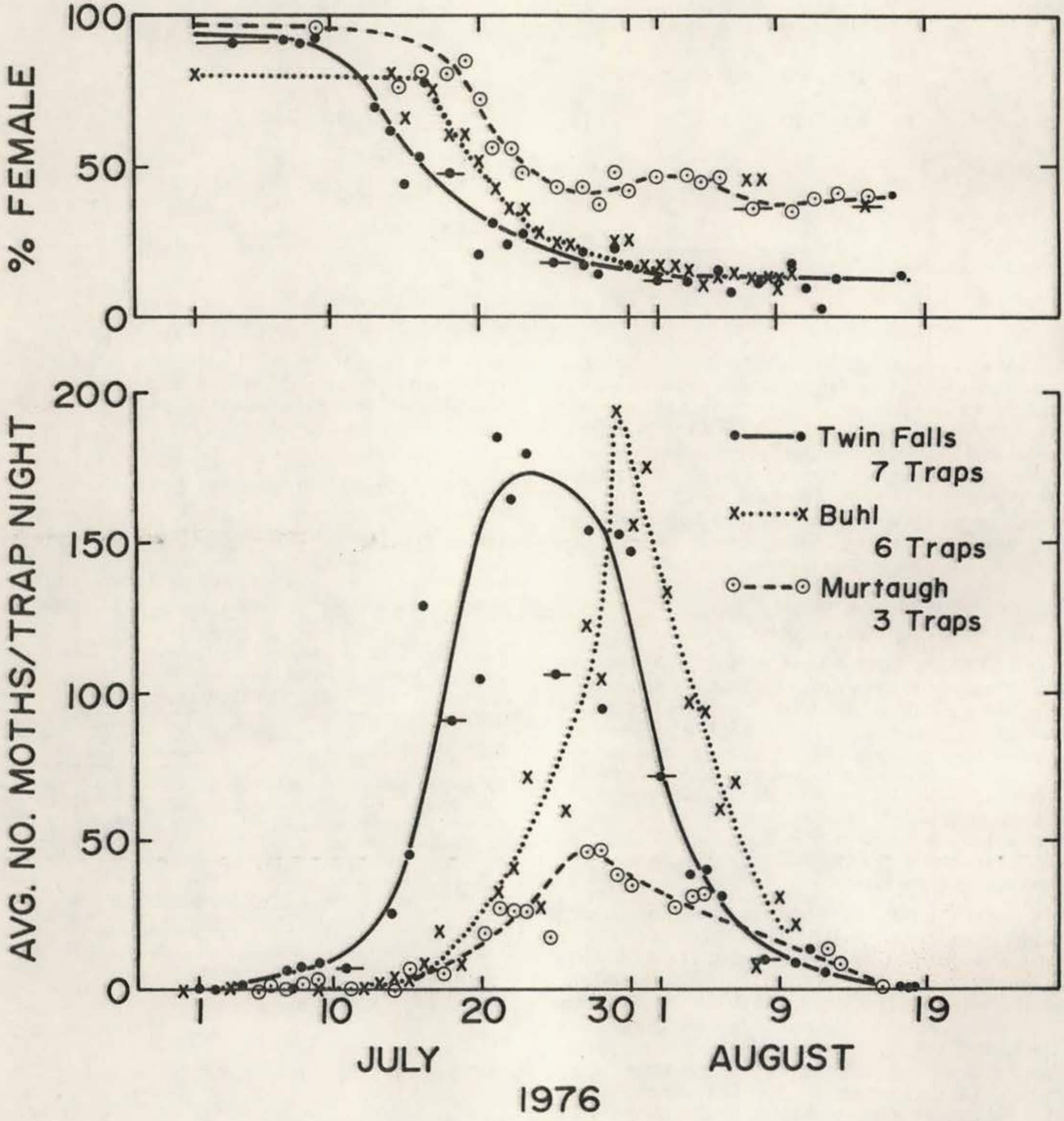


Fig. 8. Relationship between western bean cutworm seasonal change of sex ratio in light trap catches, and total light trap catches, Magic Valley, Idaho, 1976.

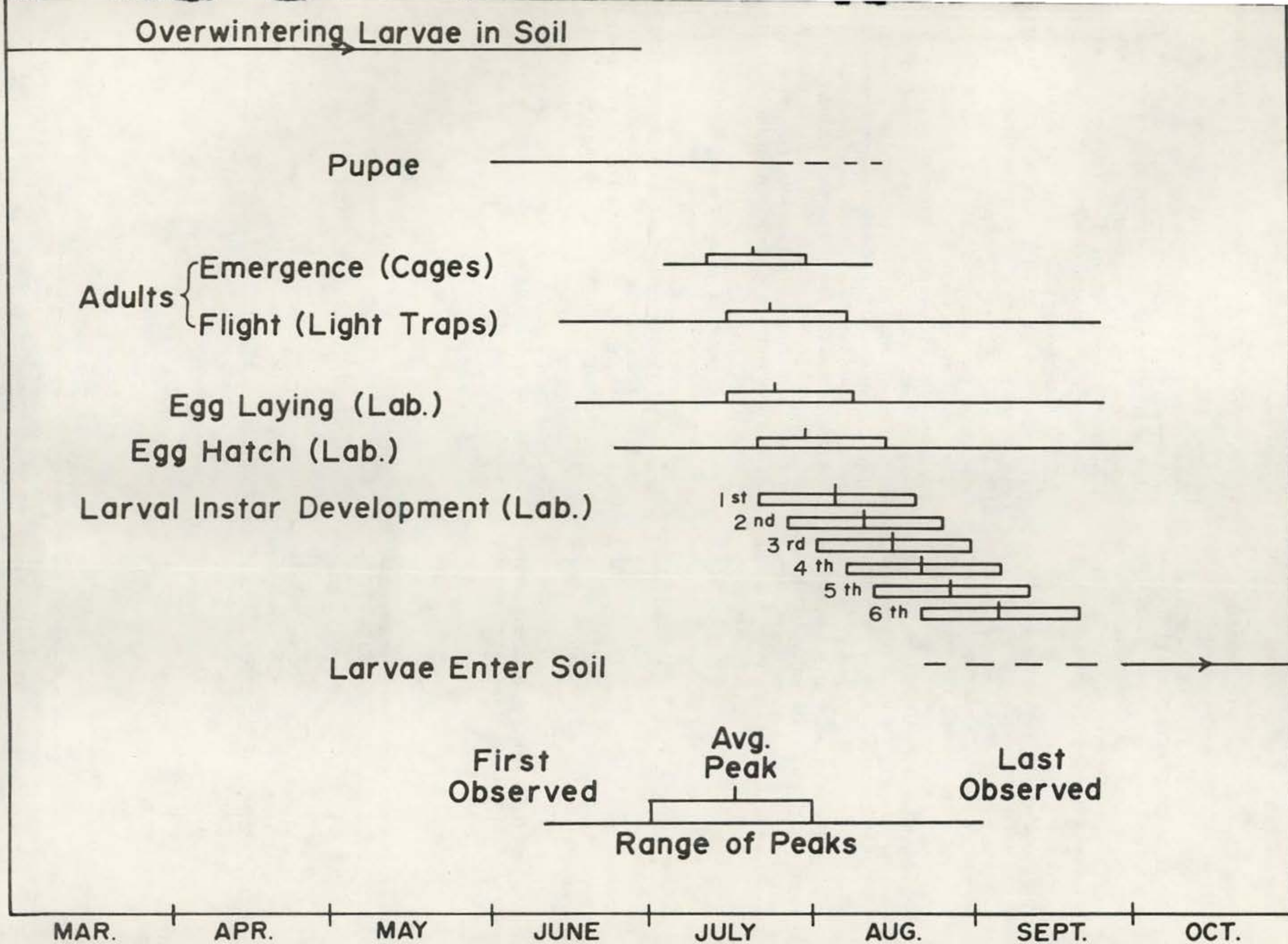


Fig 9. Western bean cutworm life history based on cage, light trap and laboratory data.

Results were approximately the same both years. In 1963 more larvae were at the 6- to-9-inch level than in 1962. No larvae were found in the 9- to 12-inch level. Larvae tended to be deeper in the soil as the fall season progressed.

The depth of pupae in the spring was determined for some of the hibernation cages during 1956 through 1959. Average depth was 8.2 inches, with the range from 2 to 13 inches. This is considerably deeper than in the fall sampling, possibly because of differences in soil type or surroundings, larval movement or increased mortality of larvae nearer the soil surface.

Overwintering mortality from November and December 1962 to April 1963 was approximately 90% in a series of 40 insecticide and cultural control plots. The study included 200 square-foot samples taken before treatments and again the following spring. Approximately the same mortality occurred in all plots. This compares with an average of 72.3% mortality in the hibernation cages (Table 9). Predation would be greater and exposure more severe under field conditions than in the somewhat protected hibernation cages.

The effect of soil disturbance on larval survival was studied by sampling previously heavily infested bean and corn fields in the fall of 1962. The fields were sampled between October and early December with the following results:

No. fields	Treatment	No. 1 ft^2 samples	No. larvae	No. larvae per ft^2
3 corn	fall plowed	42	0	0
4 bean	plowed, disked or both	171	2	.01
5 bean	undisturbed	296	160	.54

Although not strictly comparable, the results indicate that fall plowing might drastically reduce overwintering populations.

Host Plants

The western bean cutworm is native to the United States as are cultivated beans and corn. However, its status as a recognized pest is rather recent. It was suggested as a pest of beans as early as 1915 in Colorado (Hoerner 1948; McCampbell 1941), in Idaho about 1942 (Douglass et al. 1955) and in Nebraska about 1950 (Hagen 1976). It was recognized as a pest of corn much later — Idaho in 1954 (Douglass et al. 1957), Nebraska in 1957 (Hagen 1962) and Colorado in 1966 (Hantsbarger 1969).

The literature mentions 3 additional host plants. Hoerner (1948) said that immature larvae "feed on shattered beans and ground cherry fruits" after beans are harvested. Douglass et al. (1955) stated, "Before changing its habits to attack beans, the western bean cutworm fed upon the fruits of ground cherry and nightshade." This was repeated by Douglass et al. (1957) and Blickenstaff et al. (1975). LeBaron et al. (1958 and 1969) stated "it is primarily a pest of beans but will attack corn and tomatoes." Blickenstaff et al. (1975) stated that it "has also been observed feeding on tomato fruits in Idaho." These observations and statements lack solid evidence that plants other than beans and corn are suitable hosts. The statement by Douglass et al. (1955) is somewhat misleading since both beans and corn have been available in the southwest for centuries and could thus be the original hosts.

A 1951 unpublished station annual report states, "Most of the worms collected (August 9 and 22) were collected on black nightshade (*Solanum nigrum* L.) growing as a weed in bean fields." The 1956 unpublished station annual report notes, "No uncultivated breeding host has been found, but it has been observed by different workers feeding on the foliage and fruits of ground cherry...and nightshade."

In September 1956, damaged tomato fruits were examined from a garden near Declo. The damage was thought to be caused by the western bean cutworm. Western bean cutworm larvae were then confined on plants at Twin Falls. Larvae fed on both green and ripe fruits, but the

Table 12. Summary, western bean cutworm host plant study, 1977.

		Field						Laboratory					
		Uncaged 50 eggs/plt.			Caged[2]			3rd-instar		4th-instar		5th-instar	
	Insectary[1] % foliage damage	No. L. recovered	Damage to Foliage	Damage to Fruit (%)	No. L. recovered	Damage to Foliage	Damage to Fruit (%)	No. L.	Ave. no. eaten[3]	No. L.	Ave. no. eaten[3]	No. L.	Ave. no. eaten[3]
Beans	42.5							6	9.1	6	8.2	6	5.2
Corn	39.5												
Tomato		7	0	light	8	0	58	1	+	2	+	1	+
Groundcherry		0	0	0	2	0	96	1 (died)	4.0	3	7.3		
Nightshade	0							1 (died)	6.0	3	26.0		
Curly Dock	0												
Redroot	0												
Lambsquarters	0												
Sugarbeet	0												

[1]4 to 16 plants infested with 2 egg masses each.

[2]Infested with 2nd-instar larvae: 20 on tomato, 20 on groundcherry, 5th-instar larvae recovered.

[3]Seeds of beans, fruits of others.

feeding was not severe or extensive. In 1957, several male and female moths were confined on caged plants of corn, tomato and ground cherry. During 1 month of daily observation, eggs were found only on corn. Day-old larvae were transferred from beans to tomato and ground cherry without successful establishment. Full-grown larvae transferred from corn to tomato fed only slight amounts. In 1958, 5 3rd-instar larvae placed on a tomato plant fed only slightly on the fruits.

In 1977, limited attempts again were made to determine the suitability of several plants as hosts. Plants were infested with eggs in the insectary, with eggs in the field and with 2nd-instar larvae under cages in the field; 3rd-, 4th- and 5th-instar larvae were confined individually in screen-topped glass jars with single fruits (bean pods, nightshade berries, ground cherry fruits or tomato fruits). Larvae hatching from eggs did not feed on or develop on nightshade, but 4th-instar larvae fed readily when confined on berries. No larvae developed on uncaged ground cherry infested with eggs. Larvae did develop to maturity on caged plants infested with 2nd instars, and 4th-instar larvae fed readily when confined to fruits. Tomato plants supported larval development from the egg stage. Tomato is the only host, other than beans and corn, that will support full development in tests to date. The data are summarized in Table 12.

Biological Factors

The literature has no reference to parasites or predators attacking the western bean cutworm and only 1 reference to a disease. Helms and Wedberg (1976) reported laboratory reared larvae were infected by a *Nosema* sp., and that the Nosema infection of the midgut was lessened after feeding of *Bacillus thuringiensis*.

During 1970 a parttime summer employee made preliminary laboratory observations on several predators. His results, in terms of numbers of western bean cutworms consumed per predator, are summarized below.

	Eggs	1st-instar larvae	2 to 5 day old larvae
COLEOPTERA			
Ladybird beetle adults (Coccinellidae)	32 to 46/day	11 to 22/day	+
Ladybird beetle larvae	0	+	0
HEMIPTERA			
Minute pirate bug nymphs (Anthocoridae)	slight	slight	slight
Damsel bug adult (Nabidae)	75/day	?	4 to 26/day (2nd & 3rd instar)
Big-eyed adult (Lygaeidae)			+
NEUROPTERA			
Lacewing larvae (Chrysopidae)	slight	+	1 to 10/day
SPIDER	?	?	+

All of these are known to be predators of other insects. Their relative importance to the western bean cutworm is unknown.

Appendix A — Annotated Bibliography

Since little is published on the western bean cutworm, this represents as complete a bibliography as possible. The author would appreciate any additions to these references.

Antonelli, A. L. 1974. Resistance of *Phaseolus vulgaris* cultivars to western bean cutworm, *Loxagrotis albicosta* (Smith), with notes on the bionomics and culture of the cutworm. Ph.D. thesis, Univ. of Idaho. 121 p.

Discusses bionomics of the cutworm, including the life cycle, the effects of temperature on adult emergence, distribution, host plants, natural enemies and life stages. The second portion deals with plant resistance — the methods, materials and results used for determining which varieties and cultivars of beans can be classified as being resistant or susceptible to the western bean cutworm. Includes several tables and figures.

Blickenstaff, C. C., H. W. Homan and A. L. Antonelli. 1975. The western bean cutworm on beans and corn. Univ. of Idaho Current Info. Ser. 302. 2 p.

Discusses the appearance, life history, damage and control. Includes illustrations of the adult moth and damage to beans and corn.

Crumb, S. E. 1956. The larvae of the Phalaenidae. U. S. Dep. Agr. Tech. Bull. 1135. 356 p.

Gives a detailed description of the larva's appearance and distribution (page 92).

Davis, E. W., and H. E. Dorst. 1937. Noctuidae collected by light traps in central Utah. Utah Acad. Sci. Arts and Letters 14:179-94.

This is the first report of the western bean cutworm in Utah: one specimen collected July 26, 1930.

Douglass, J. R., and K. E. Gibson. 1956. A simple device for determining insect damage to seeds. U. S. Dep. Agr., Agr. Res. Serv. 33-35. 2 p.

Describes simple device for examining seed that has been used to determine western bean cutworm damage in Idaho.

Douglass, J. R., K. E. Gibson and R. W. Portman. 1955. Western bean cutworm . . . and its control. Univ. of Idaho Agr. Exp. Sta. Bull. 233. 5 p.

Gives a brief description of the four stages of *Loxagrotis albicosta* and its life cycle. Describes bean damage and illustrates with damaged beans and bean leaves. Discusses detection and control. First positive records of occurrence in Idaho were from Kimberly in 1945 and from the Blackfoot and Rupert areas in 1946.

Douglass, J. R., J. W. Ingram, K. E. Gibson and W. E. Peay. 1957. The western bean cutworm as a pest of corn in Idaho. J. Econ. Entomol. 50(5):543-5.

After cutworm damage to corn was first observed in Idaho in 1954, surveys of the distribution and damage to corn in the Snake River and Boise Valleys were made in 1955 and 1956. This reports the results of both studies and results of life history studies during the 1956 season. Illustrates damage to ears, stalks and leaves.

Hagen, A. F. 1960. Western Nebraska beans damaged by cutworms. Nebr. Agr. Exp. Sta. Quart. 7(3):5.

Gives a brief description of the life cycle and habits. Adults were first found in Nebraska in the middle 1930's but cutworms did not become an economic pest until 1950. About 1.5 cutworms per square foot can cause injury of economic importance.

______. 1962. The biology and control of the western bean cutworm in dent corn in Nebraska. J. Econ. Entomol. 55(5):628-32.

The pest was first found in corn in western Nebraska in 1957 and serious injury to corn occurred in 1960. This reports results of 1961 investigations, gives Nebraska distribution and describes moth flight, oviposition and larval habits. Results of insecticide tests where 85% of ears were infested indicated up to 32% increase in yield following aerial application of endrin 0.2 lb. ai/acre. Five insecticides were compared.

______. 1963. Evaluation of populations and control of the western bean cutworm in field beans in Nebraska. J. Econ. Entomol. 56(2):222-4.

Discusses control studies in field beans in heavily infested areas of western Nebraska during 1958, 1959 and 1960. Cage tests indicated that larval populations above 1.11/ft^2 caused injury of economic importance but did not decrease yield. Methods and chemicals used are also discussed with results tabled.

______. 1973. Western bean cutworm in dry beans. Univ. of Neb. NebGuide G73-63. 1 p.

A very brief account of life history, damage and control. Light traps were used to monitor moth populations.

______. 1976. A 14-year summary of light trap catches of the western bean cutworm in Nebraska, *Loxagrotis albicosta* (Smith) (Lepidoptera:Noctuidae). J. Kansas Entomol. Soc. 49(4):537-40.

Describes methods of monitoring western bean cutworm populations beginning in 1961 and using light traps in both dry bean and field corn growing areas of Nebraska (Parks and Gering Valleys). Results for two traps are given as 7-day summations of average daily moth catch for the 14-year period and average per day collection from both growing areas. This study may indicate a 6- to 8-year period between high populations.

______. 1976. Western bean cutworm in corn. Univ. of Nebr. NebGuide G76-290. 2 p.

Contains a brief description and life history of the western bean cutworm. Designates July 15 to 25 as the main flight of moths. The only chemicals registered for its control on corn to date are Sevin WP (carbaryl), Sevimol (carbaryl) and Dylox (trichlorfon).

Hagen, A. F., and R. E. Roselle. 1972. Western bean cutworm in Nebraska . . . and its control. Univ. of Nebr. Agr. Ext. Circ. 70-1508. 7 p.

The cutworm has been primarily a pest of field beans in western Nebraska but recently has become a pest of field corn in the irrigated areas of southwestern and central Nebraska, particularly in sandy soil. This describes the four stages of the pest with illustrations. Briefly mentions seasonal history. Discusses damage caused by the cutworm and shows damaged pods and beans and damaged corn. Discusses control using DDT, endrin and Sevin (carbaryl) and stresses precautions concerning all pesticides.

Hantsbarger, W. M. 1969. The western bean cutworm in Colorado. Colo. Ag. Chem. Proc. 2:25-7.

The cutworm has been a sporadic pest of beans for years, and an important pest on corn in northeastern Colorado since 1966. This covers the life cycle (with illustration) of the cutworm and recommendations for its control on corn. Includes a map showing the counties of distribution.

Helms, T. J., and J. L. Wedberg. 1976. Effect of *Bacillus thuringiensis* on *Nosema*-infected midgut epithelium of *Loxagrotis albicosta* (Lepidoptera:Noctuidae). J. Invert. Pathol. 28: 383-4.

Sections of the midgut of laboratory-reared larvae demonstrate the presence of a *Nosema* sp. Treatment with *Bacillus thuringiensis* decreased the severity of infection.

Hoerner, J. L. 1942. Report of investigations on bean cutworm in 1942 in cooperation with the Mesa County Research Committee. Colo. Exp. Sta. Misc. Ser. 165. 4 p.

Reports tests of six different baits under shocked beans with results ranging from 9% dead worms on the untreated plots to 69.2% dead worms on the plots using bean meal, sodium arsenate and water as bait. Gives locations of damage in Colorado.

______. 1943. Report of investigations on bean cutworm in 1943 in cooperation with the Mesa County Research Committee. Colo. Agr. Exp. Sta. Misc. Ser. 223. 3 p.

Presents a partial life history obtained from moths reared in cages. Reports on tests of several dust insecticides with hand dusters. Contact dusts gave very little control and stomach poisons show slight amounts of control. Basic copper arsenate gave the best control.

______. 1944. Report of investigations on bean cutworm in 1944 in cooperation with the Mesa County Research Committee. Colo. Agr. Exp. Sta. Misc. Ser. 251. 3 p.

Includes brief results of various insecticides tested for control of cutworm. DDT spray and dust were the most promising.

______. 1945. Report of investigations on bean cutworm in 1945 in cooperation with the Mesa County Research Committee. Colo. Agr. Exp. Sta. Misc. Ser. 287. 2 p.

A study of control using various insecticides applied as dusts and sprays. DDT gave very good control. Basic copper arsenate and cryolite gave some control, but not sufficient to justify their use.

______. 1946. DDT control of bean cutworm. Western Colo. Hort. Soc. Trans. 1945: 103, 105-7.

Results from a 4-year study of insecticides used in Mesa County. Although several insecticides were tested, DDT was the only one that gave good control.

______. 1948. The cutworm *Loxagrotis albicosta* on beans. J. Econ. Entomol. 41(4):631-5.

The oldest specimen in Colorado is from Denver dated August 13, 1896. Reports of cutworm-type injury to pinto beans in Colorado were received as early as 1915. Includes other early reports of occurrence and damage in Colorado, Nebraska, Kansas and Idaho. Discusses life history along with several tests on chemical control. All life stages are illustrated. No native host plant was found, but after beans are harvested, larvae feed on ground cherry fruits.

Keith, D. L., R. E. Hill and J. J. Tollefson. 1970. Survey and losses for western bean cutworm *Loxagrotis albicosta* (Smith), in Nebraska. Proc. North Central Branch Entomol. Soc. Amer. 25(2):129-31.

Western bean cutworm was first found in corn in Nebraska in Keith County in 1957. Before this it was primarily a pest of field beans. By the end of the 1967 season, western bean cutworm had been found in 54 counties, representing approximately 1,927,000 acres of corn. Distribution by year and county are figured. Surveys were conducted in 1968 and 1969 in Dawson County and 1967, 1968 and 1969 in Hall County. Losses are given in percent, bushel and dollar amounts.

Knowlton, G. F. 1939. Lepidoptera. Utah Agr. Exp. Sta. Mimeo Ser. 200, Pt. 2. 14 p.

Reports collections of western bean cutworm in light traps from American Fork, Logan, Spanish Fork, Providence and Oak Creek Canyon.

LeBaron, M., R. W. Portman, C. W. Hungerford and V. I. Meyers. 1958. Bean production in Idaho. Idaho Agr. Exp. Sta. Bull. 282. 24 p.

A brief account of the habits and control of the insect. The pest is a problem in southcentral Idaho where there is light, sandy soil.

LeBaron, M., L. L. Dean and R. W. Portman. 1969. Bean production in Idaho. Idaho Agr. Exp. Sta. Bull. 282 (revised). 28 p.

Briefly mentions western bean cutworm as a major pest of beans, and a minor pest of corn and tomatoes.

McCampbell, S. C. 1941. Cutworm control. Colo. Coop. Ext. Ann. Rep. p. 32-36.

Contains a brief account of baiting the bean cutworm at Mesa County after harvest. Reports losses as high as 50% on beans that had been bunched before threshing. Makes several recommendations for control.

Munson, J. D., D. L. Keith, J. J. Tollefson and A. F. Hagen. 1969. Western bean cutworms on corn . . . biology and control. Univ. Nebr. Farm, Ranch and Home Quart. Spring 1969. 2 p.

The western bean cutworm was found in southeastern Nebraska for the first time in 1968. It appears to be a more important pest of field corn than the European corn borer in central and southwestern Nebraska. Eggs or small larvae infesting 14% of plants can cause economic damage. Materials are recommended for control.

Oseto, C. Y., and T. J. Helms. 1976. Anatomy of the adults of *Loxagrotis albicosta*. Univ. Nebr. Studies, New Series No. 52. 127 p.

A detailed account of internal and external structures and systems with over 60 pages of illustrations.

Smith, J. B. 1887. North American Noctuidae. Proc. USNM 10:454.

Contains the first description of the western bean cutworm adult under the name *Agrotis albicosta*. Location is given as Arizona.

U. S. Department of Agriculture, Agricultural Research Service. 1970. Cooperative Economic Insect Reports. Vol. 20.

Reports seasonal conditions in Colorado, Idaho, Kansas, Nebraska, South Dakota: p. 118, 514, 555, 578, 604, 622, 627, 639, 670, 684, 695, 735, 831.

New county distributional records: Kansas, 3 (118); Nebraska, 7 (118), 1 (695 and 706); South Dakota, 3 (118), 1 (156), 5 (831 and 833); Utah, 1 (839 and 841); Wyoming, 3 (839 and 841).

Distribution map (786) for the U. S.; does not include Mexico and Canada.

______. 1971. Cooperative Economic Insect Report. Vol. 21.

Seasonal conditions in Colorado, Idaho, Kansas, Nebraska, South Dakota: p. 147, 198, 199, 527, 543, 564, 584, 601, 615, 630, 657, 670, 693.

New county distributional records: Kansas, 2 (128 and 147), 1 (601 and 608), 3 (615 and 620); Nebraska, 2 (657 and 664).

USDA, Animal and Plant Health Inspection Service. 1972. Cooperative Economic Insect Report. Vol. 22.

Seasonal conditions in Colorado, Kansas, Nebraska: p. 93, 520, 556, 599, 677.

New county distributional record: Kansas, 1 (677 and 685).

______. 1973. Cooperative Economic Insect Report. Vol. 23.

Seasonal conditions in Kansas: p. 508, 530, 554, 613, 739.

______. 1974. Cooperative Economic Insect Report. Vol. 24.

Seasonal conditions in Colorado, Idaho, Kansas, Nebraska: p. 115, 116, 145, 599, 624, 768, 825.

New county distributional record: Kansas, 1 (739 and 748).

______. 1975. Cooperative Economic Insect Report. Vol. 25.

Seasonal conditions in Colorado, Idaho, Kansas, Nebraska: p. 616, 639, 686, 721.

New county distributional records: Kansas, 1 (616 and 628), 1 (660 and 672), 2 (780 and 785).

USDA, Animal and Plant Health Inspection Service. 1976. Cooperative Plant Pest Report, Vol. 1. (Supersedes the Cooperative Economic Insect Report).

Seasonal conditions in Colorado, Idaho, Kansas, Nebraska, Texas: p. 432, 456, 480, 504, 505, 528, 549, 570, 690.

New county distributional record: Kansas, 1 (570 and 576).

______. 1977. Cooperative Plant Pest Report, Vol. 2.

Seasonal conditions in Colorado, Idaho, Kansas, Nebraska, Oklahoma, Texas: p. 108, 114, 464, 507, 559, 585, 615, 664, 695, 741.

New county distributional records: Oklahoma, 1 (also a new state record, p. 106 and 114), 1 (585 and 601); Kansas 1 (638 and 653), 1 (695 and 709).

Note: Records in the above USDA series before 1970 were not checked.

Walkden, H. H., and D. B. Whelan. 1942. Owlet moths (Phalaenidae) taken at light traps in Kansas and Nebraska. U. S. Dep. Agr. Circ. 643. 25 p.

Only 10 western bean cutworm moths were reported from 6 light traps operated at various locations during a 4-year period: 2 at Garden City, Kansas, in 1934; 7 at Scottsbluff, Nebraska, in 1935, and 1 at Scottsbluff in 1936.

This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use nor does it imply registration under FIFRA as amended. Also mention of a commercial or proprietary product does not constitute an endorsement.

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Antonelli, A. L. 1974. Resistance of *Phaseolus vulgaris* cultivars to western bean cutworm, *Loxagrotis albicosta* (Smith), with notes on the bionomics and culture of the cutworm. Ph.D. thesis, Department of Entomology, Univ. of Idaho. 121 p.

Blickenstaff, C. C., H. W. Homan and A. L. Antonelli. 1975. The western bean cutworm on beans and corn. Univ. of Idaho Current Info. Ser. 302. 2 p.

Brown, W. L., and M. M. Goodman. 1977. Races of corn. p 49-88. *In* Corn and Corn Improvement. Amer. Soc. Agron. Inc., Madison, WI, G. F. Sprague, (Ed.).

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Dutton, B. P. 1975. Indians of the American Southwest. Prentice-Hall, Inc., NJ. 298 p.

Gentry, H. S. 1969. Origin of the common bean (*Phaseolus vulgaris*). Econ. Bot. 23:55-69.

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Spencer, R. F., J. D. Jennings, C. E. Dibble, E. Johnson, A.R. King, T. Stern, K. M. Stewart, O. C. Stewart and W.J. Wallace. 1965. The Native Americans. Harper & Row, New York, 539 pp.

USDA, Animal and Plant Health Inspection Service. 1970. Cooperative Economic Insect Report 20(47):786.

USDA, Animal and Plant Health Inspection Service. 1977. Cooperative Plant Pest Report 2(11):114.

The State is truly our campus. We desire to work for all citizens of the State striving to provide the best possible educational and research information and its application through Cooperative Extension in order to provide a high quality food supply, a strong economy for the State and a quality of life desired by all.

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