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In the potato-growing section of the North Platte Valley of western Nebraska, the difficulty of producing high quality potatoes frequently is greatly increased by the presence of destructive populations of the potato flea beetle *Epitrix cucumeris* Harris. Usually foliage injury by the adults is comparatively unimportant, but larval injury to tubers often greatly reduces the quality of the crop. Since prevention of tuber injury by the larvae has proven to be difficult, a study of this problem has been undertaken by the Department of Entomology. This paper is a report on the life history and habits of the potato flea beetle, particularly as related to control in western Nebraska.

HIBERNATION.—In the fall of 1940, 4 cages (2′×2′×4′ in size and covered with cheesecloth) were placed over typical field environments and adult beetles introduced as indicated in table 1. The cheesecloth cover was removed after the beetles had gone into hibernation in order to expose them to natural conditions. Prior to insect activity in the spring, a new cover was installed. Escape of the beetles through lateral movement in the soil was precluded by a 9-inch metal strip which extended downward from the sides of the cages. Unless food was available in the form of plant growth within the cages, either green potato foliage or cut tubers were supplied as long as any of the beetles remained active in the fall. When emergence began the succeeding spring (1941), all active beetles were counted and removed at regular intervals. Collections in an alfalfa field and along an irrigation ditch using a 15-inch insect sweeping net, were made at the same time as a control.

Table 1.—Hibernation of *Epitrix cucumeris* in western Nebraska during the winter of 1940–1941.[1]

Per Cent Survival Under Different Conditions		Emergence Data, Field Cages, Alfalfa Field and Along Irrigation Ditch		
Ground cover	Survival (spring 1941) per cent	Date	Total emergence in 4 cages	Av. 500 sweeps alfalfa and ditch bank
(600 Beetles introduced for each test)				
Potato soil—		May 16–20	0	30
covered 3–4″		May 20–30	17	67
potato vines	34.5	May 30–June 10	153	76
Potato soil—bare	16.2	June 10–20	240	182
Rank growth		June 20–30	34	112
ground cherry	15.8	June 30–July 5	5	2
Alfalfa stubble	8.3			
Av.	18.7			

[1] Placed in cage between Sept. 20 and 28.

Emergence of the overwintered forms began on May 21 and continued until July 5, thus extending over a period of 45 days. The maximum daily emergence occurred during the 4-day interval from June 10 to 13, inclusive. Of the 2400 adults originally confined in the series of cages, 449 or 18.7 per cent survived the winter and emerged. As shown in table 1 the survival ranged from 34.5 per cent in soil covered with potato vines to 8.3 per cent in alfalfa stubble.

Field collections, made with an insect net, in favorable locations supplied records closely correlated with those obtained in the cage studies (Fig. 1). The overwintered beetles appeared slightly earlier in the field, the earliest date being May 16 as compared to May 21, but the

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peak of abundance of overwintered adults occurred at approximately the same time. The duration of the emergence period in the field, likewise, approximated that of the caged adults.

REARING EXPERIMENTS.—Rearing experiments were conducted in an outdoor insectary at the Scottsbluff Experiment Farm and the data thus obtained supplemented by field records and observations.

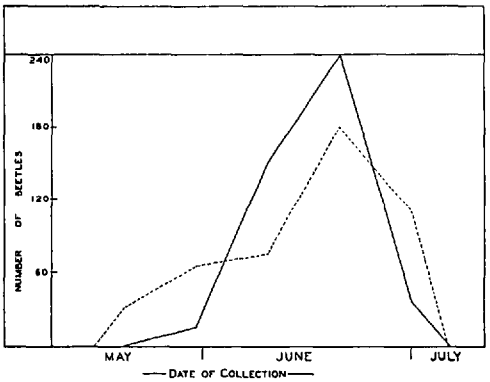

FIG. 1.—The solid line represents the number emerging, and the date of emergence, of *Epitrix cucumeris* in hibernation cages in the spring of 1941. The broken line represents the average number collected per 500 sweeps with an insect net in an alfalfa field and along an irrigation ditch.

In general, the rearing technique was similar to that employed by Johannsen (1921), Hoerner & Gillette (1928) and Anderson & Walker (1934). Instead of lantern globes, however, the cages were made of 30 mesh copper screen wire supported by a light metal frame. For obtaining data on oviposition the cages were placed on dark blue blotting paper in contact with moist sand in flower pots. Moisture was supplied through capillary action by placing each pot in a shallow pan of water. Individual eggs were placed in salve boxes, about 45 mm. in diameter and 20 mm. in height, the bottoms of which contained sand covered with blotting paper. Moisture was added if needed, but more frequently it was difficult to prevent the accumulation of excess moisture.

As the eggs hatched, the larvae were transferred to small pieces of potato tuber and placed in salve boxes. Moisture was provided by lining the bottom of the container with blotting paper and then adding water as needed. As the larvae reached maturity, an environment favorable for pupation was obtained by partially filling the box with fine soil. Newly formed pupae were removed and placed on slightly moistened soil in another salve box for the duration of the pupal period.

First generation.—In 1940, beetles began emerging from hibernation May 20, and from individuals caged between this date and May 24, two generations were reared during the year. The first eggs were deposited on May 27 and the first adult emerged on July 1. Egg deposition began 3 to 7 days following confinement and continued to August 14, or over a period of 80 days, with the peak coming June 18. These determinations are based on a total count of 15,910 eggs. The incubation period of the 5865 eggs involved in the test ranged from 3 to 11 days, averaging 5.5 days. From eggs selected at random from the above series, records were obtained on 2431 larvae, and the period of activity of these extended from June 3 to August 24. The range for individual larval development was from 13 to 29 days with an average of 18.45 days.

Pupation began June 23 and continued until August 24, or over a period of 62 days. On the basis of 287 individual records, the pupal stage was found to extend over a period of 4 to 10 days with an average of 5.8 days. First generation adults appeared on July 1 and continued to emerge until August 30, a period of 2 months.

Second generation.—As the first generation beetles in the above tests emerged in the insectary, a total of 132, selected at intervals from July 1 to 17, were placed in oviposition cages. The first eggs of the second brood were deposited on July 13, and the first adult appeared on August 12, 30 days later. Oviposition extended from July 13 to October 3, or over a period of 82 days, and the peak occurred on August 11. The incubation period of the 7838 eggs on which records were kept ranged from 3 to 20 days, averaging 5.9 days. Of the 3743 eggs placed under observation, 3252, or 86.88 per cent, hatched. Larval activity extended from July 18 to November 3 and the average larval period was 22.76 days. Some individuals completed their development in as few as 15 days while others, near the close of the season, spent up to 43 days as larvae. Cold weather prevented complete development of all that hatched in late September and thereafter. The

pupal stage ranged, on the basis of 299 individual records, from 5 to 22 days, averaging 11.16 days. Emergence of second generation adults began August 12, reached a peak September 15, and continued until early November when cold weather prevented further activity. Several of the second generation adults were placed in oviposition cages but no eggs were laid.

In 1941, 137 overwintered beetles were collected at the time of their emergence from hibernation between May 17 and June 30 and placed in cages. Egg deposition began on May 26 and the first adults emerged on July 5, 40 days later. For these beetles the oviposition period, which extended from May 26 to August 22, was 88 days, and the incubation period from 3 to 14 days, averaging 6.2 days. Of 1529 eggs under observation 1220 or 79.79 per cent hatched.

Larvae were present from June 6 until August 24. The average developmental period of the 191 larvae involved in this test was 17.7 days, with a range of from 14 to 23 days. The pupal stage ranged from 3 to 9 days, averaging 6.29 days. Although larvae continued to emerge

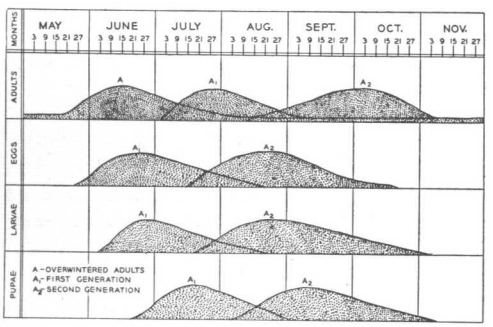

FIG. 2.—Summary of the life history records on *Epitrix cucumeris* in the insectary at Scottsbluff, Nebraska in 1941.

until August 24, no pupations occurred after August 12. Of the 191 pupae under observation, 132, or 69.1 per cent, emerged as adults. First generation adults appeared on July 5, reached a peak July 22, and continued to emerge until August 25, a period of 51 days. A summary of all the rearing records included in this report is given in table 2 and figure 2.

Four pairs of overwintered beetles were placed in individual cages at the time of their mating in the spring of 1941 and detailed records kept on the preoviposition and oviposition periods and the number of eggs deposited by each female. The preovipostion period ranged from 5 to 6 days; the oviposition period from 35 to 57 days, averaging 44.7 days; and the number of eggs per female from 161 to 215, averaging 187.2. Usually the eggs were deposited in batches of from 11 to 15 with intervals of from 1 to 2 days elapsing between successive depositions.

Table 2.—The range and average duration of the various stages of *Epitrix cucumeris* in the insectary at Scottsbluff, Nebraska.

PERIOD	GENERATION	YEAR	RANGE, DAYS	AVERAGE, DAYS	TEMPERATURE[1]
Incubation	First	1940	3–11	5.5	72.7
		1941	3–14	6.2	69.4
	Second	1940	3–20	5.9	68.3
Larval	First	1940	13–29	18.45	73.1
		1941	14–23	17.7	70.8
	Second	1940	15–43	22.76	65.7
Pupal	First	1940	4–10	5.8	75.4
		1941	3–9	6.29	72.2
	Second	1940	5–22	11.16	61.6
Total developmental	First	1940	27–50		73.7
		1941	27–46		70.8
	Second	1940	30–85		65.2

[1] This represents the average mean daily temperature for the interval from the time the first individual appeared in a given stage until the last individual in the group had transformed to the succeeding stage. The same procedure was applied to all stages of both generations.

FIELD COLLECTIONS.—In 1941, five different potato fields were selected and flea beetle collections made at regular intervals throughout the growing season. The normal date of planting for a majority of the potato crop in western Nebraska is from about June 10 to June 25. Two of the fields selected represented an early crop (planted April 26–28); one a medium crop (planted June 2); and two the late crop (planted June 20). The collections were made with a 15-inch insect net and the results recorded on the basis of the average number of beetles per 300 sweeps. The data are summarized in table 3 and shown graphically in figure 3. Since the newly emerged beetles are light colored as compared to the dark color of the overwintered individuals, the beginning of emergence of the first generation adults could be determined with a reasonable degree of accuracy. They were first collected, in the early plantings, on July 3 which compares favorably with July 1

in 1940 and July 5 in 1941 in the insectary rearings. The peak of abundance occurred on August 1. Only a slight decrease was noted in the succeeding collection on August 6. Since the fields had been harvested, further records could not be obtained. As shown in figure 3, adults were comparatively abundant in the medium planting from about July 23 to August 20, the peak being reached on August 6. There was a slight decrease from about August 20 to 30, followed by a noticeable increase during the next few days, apparently due to the emergence of second generation adults.

In the late plantings the adult population attained a moderately high level during the last few days of July, reached a peak near August 20, and was followed

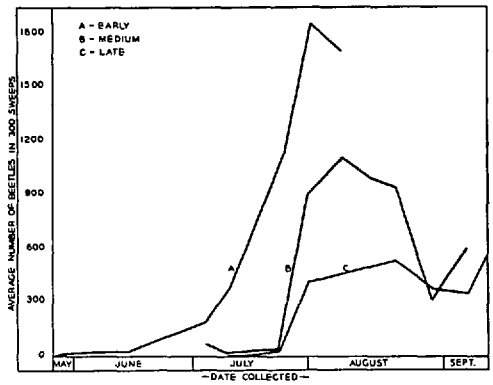

FIG. 3.—Average number of *Epitrix cucumeris* per 300 sweeps with an insect net in early, medium, and late plantings at Scottsbluff, Nebraska, 1941. Early planting made April 26–28; medium, June 2, and late, June 20.

by a slight decline during the next few days. There was a noticeable population build-up in the early part of September corresponding to that in the medium-date planting. On the basis of these data, along with other field evidence and laboratory rearing records, it seems probable that the early- to medium-planted potato crop is the principal food supply for the development of the first generation *Epitrix cucumeris* in western Nebraska; and from the eggs deposited by the first generation beetles develop the arvae which attack the late or the principal potato crop in this region.

Collections also were made at regular intervals throughout the growing season in alfalfa fields and along irrigation ditches where various weeds, including

Table 3.—Average number *Epitrix cucumeris* per 300 sweeps with insect net in early, medium, and late potato plantings, and in alfalfa field and along irrigation ditches at Scottsbluff, Nebraska in 1941.

Date Collection	Potato Field—Date Planted			Alfalfa	Irrigation Ditch
	April 26–28	June 2	June 20		
May 20				4	5
26				6	12
27				9	27
30	16			6	50
June 6	20			7	86
14	21			26	194
21	80			6	98
26	178			1	32
July 3	203	65		1	2
9	380	15	1	2	2
16	797		12	2	0
23	1172	35	32	2	2
Aug. 1	1856	917	418	0	0
6	1700	1104	[1]		
13	harvested	1010		0	3
19		954	541	0	0
28		300	363	0	0
Sept. 5		606	337	9	5
12			566	96	12
19				107	83
25				76	71
Oct. 1				42	29
9				32	21

[1] Field treated with *Dutox* dust by grower, with the result that the population trend was temporarily upset.

Physalis spp., were growing. This type of environment is representative of comparatively large areas in the potato-growing sections in the North Platte Valley. The results of these collections, which are given in table 3 and figure 4, show that considerable numbers of *Epitrix cucumeris* were present in these areas in the early spring and late summer but practically none were present during the period of potato growth.

HOST PLANTS.—In western Nebraska, apparently, the most important early spring host is the potato, including plants growing on cull piles along with an occa-

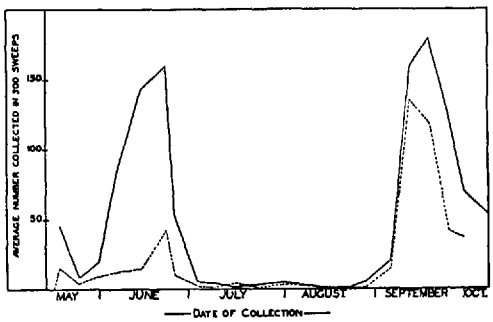

FIG. 4.—Average number of *Epitrix cucumeris* per 300 sweeps with insect net on alfalfa and on "weeds" along an irrigation ditch during the growing season of 1941 at Scottsbluff, Nebraska. (Broken line, Alfalfa, Solid line, Irrigation Ditch.)

sional volunteer plant in the field, and the early-planted crop. Occasionally tomato plants may be damaged, particularly in the early part of the growing season. A number of other plants are fed upon to some extent at various times during the season. Among these are included buffalo burr (*Solanum rostratum*), ground cherry (*Physalis* spp.), alfalfa (*Medicago sativa*), sweet clover (*Melilotus* sp.), marsh elder (*Iva xanthifolia*), ragweeds (*Ambrosia* spp.), sunflowers (*Helianthus* spp.), pigweed (*Amaranthus retroflexus*), kochia (*Kochia scoparia*) and lamb's-quarters (*Chenopodium album*). Whenever potatoes are available, feeding is largely confined to this plant. Migrations of adults from early potatoes following harvest into nearby field bean plantings frequently occur and considerable feeding has been observed in some instances. However, injury to any crops other than potatoes in this area is negligible.

At the time of harvest in late summer and early fall many adult beetles migrate from potato fields and again may be found feeding on a number of different plants. These hosts are principally the same species as those of the early spring. Often the insects can be collected in large numbers on alfalfa late in the fall, probably because these plants remain green later in the season than most others in this area. Following harvest the beetles often feed extensively on cull tubers left in the potato fields, cracked or damaged tubers being especially attractive.

As yet information on larval food plants is incomplete. Ground cherry (*Physalis* spp.) and buffalo burr (*Solanum rostratum*), both of which have been reported (1937) as hosts for the larvae, apparently are of comparatively little importance as hosts in the irrigated sections of western Nebraska under present conditions. The larvae were found feeding on the roots and tubers of potato plants throughout the season, but none was observed developing or feeding at any time on a large number of other plants examined.

SUMMARY AND CONCLUSIONS.—In the potato-growing section of western Nebraska it was found that a relatively high percentage of adult *Epitrix cucumeris* were able to survive the winter of 1940–41 in soil covered with debris or crop residue such as potato vines. Although proportionately fewer, significant numbers survived in bare soil in a potato field from which the crop residue had been removed, as well as in alfalfa stubble, and in uncultivated areas. The survival, which ranged from 34.5 per cent in soil covered with potato vines to 8.3 in alfalfa stubble, was much higher than that reported by Gui (1938) in Ohio.

In the insectary two complete generations of *E. cucumeris* developed during the season. These results agree favorably with those obtained by Hoerner & Gillette (1928) in Colorado, Hanson (1933) in Washington and Gui (1938) in Ohio where one complete and a partial second generation were observed. Jewett (1929) reported two complete broods in Kentucky.

Emergence from hibernation began about May 20 and continued until early July. A majority, however, had emerged by about June 20. The egg-laying period of the overwintered females extended from May 26 to August 22 in the insectary rearing tests, but the peak was attained shortly after mid-June with the result that a majority of the eggs were deposited previous to the time at which growth of the late potato crop was under way.

Eggs of the second generation were deposited between July 13 and October 3 with the peak abundance occurring near the middle of August. As regards the number of generations and the periods of greatest abundance, field collections and observations provided information confirming that obtained in the insectary.

On the basis of the life history data presented in this report, it seems evident that the larvae of the first generation develop largely in early-planted potatoes, and the second generation principally in the late plantings. It is concluded, therefore, that elimination of the early potato crop, including those plantings up to about June 10 (at present a relatively small proportion of the total acreage in western Nebraska), would materially reduce the likelihood of serious flea beetle injury in this area. This conclusion is in agreement with that of Hoerner and Gillette (1928) who stated that in Colorado late planted potatoes are least likely to be injured.

Although further investigations may reveal new facts on this problem, intensive collections and observations indicate that wild host plants are of comparatively

little significance in the build-up of heavy potato flea beetle populations in western Nebraska. The growth of early-planted potatoes is well under way at the time the overwintered beetles emerge, and these plants supply an abundance of food.—8-19-42.

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