Observations on the Biology of *Plagiognathus chrysanthemi* (Hemiptera: Miridae), a Pest of Birdsfoot Trefoil in Ontario[1]

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ABSTRACT

In eastern Ontario, in 1959 and 1960, a small mirid, *Plagiognathus chrysanthemi* (Wolff), caused severe damage to Viking birdsfoot trefoil. Feeding injury killed many of the newly formed buds and one or more florets on the larger buds; only about 20% of the buds reached the bloom stage and most of these were partly damaged. The insect had not previously been reported as a pest of economic importance in North America. Other important host plants were: the true clovers, *Trifolium* spp.; *Medicago sativa* L.; *Vicia cracca* L.; *Chrysanthemum leucanthemum* L.; *Potentilla argentea* L.; and *Verbascum thapsus* L. After wintering in the field most of the eggs hatched within a 10-day period in late May. The nymphs underwent five instars in about 34 days and were most abundant from May 26 to June 26. The adults appeared in late June and fed on buds and blooms for 10 to 14 days before laying eggs. The females lived 20 to 66 days and laid 12 to 179 eggs, averaging 80. The eggs were laid in July and August and entered a diapause until the following spring. In birdsfoot trefoil, most of the eggs were laid in the top 2 to 5 inches of the green stems and in the peduncles; these parts measured 0.64 to 1.60 mm. in diameter, averaging 1.04 mm. General descriptions of the eggs, nymphs, and adults are given.

During the past few years a small mirid, *Plagiognathus chrysanthemi* (Wolff), has proved in eastern Ontario to be an important pest of birdsfoot trefoil and of potential economic importance in other forage crop legumes, especially alfalfa. The insect feeds on the developing buds and appears to be important only in crops grown for seed production; the single generation of nymphs is most abundant in June and therefore only the first annual growth is seriously affected.

The writer first recorded *P. chrysanthemi* in abundance in clovers, alfalfa, and birdsfoot trefoil during insect surveys in eastern Ontario in 1951 (Guppy 1958), and later in the same crops in southwestern Ontario and in the Kapuskasing area. Occasional observations up to 1958 associated the injury caused by this insect with poor yields of seed of Viking birdsfoot trefoil. Hence, critical studies on the biology of this mirid were begun in 1959. This paper

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presents certain aspects of its life-history and behavior in eastern Ontario as determined in the field, largely in birdsfoot trefoil, from 1959 to 1961.

Of European origin, *P. chrysanthemi* has been known in North America for about 75 years, but until recently the only published host record on this continent was that of ox-eye-daisy, *Chrysanthemum leucanthemum* L. (Knight 1921). In Canada, the first record of the insect in forage crop legumes was that of the writer, and more recently the Canadian Insect Pest Review reported its occurrence in clovers and alfalfa in the Quebec City area. In the United States, Neunzig and Gyrisco (1955) recorded the insect in birdsfoot trefoil in New York, and McCollum (1958) reported *Plagiognathus* spp. in this crop in Vermont, apparently in abundance.

In Europe, *P. chrysanthemi* has been recorded from many species of plants, including the true clovers and alfalfa (Kullenberg 1946). However, only Blattny et al. (1948) reported it as a pest of economic importance; along with other important plant bugs, the insect damaged alfalfa flowers and pericarps. Very little has been published on the biology of this mirid other than Kullenberg's discussion of host relationships, behavior, and seasonal development.

P. chrysanthemi occurs throughout the British Isles and continental Europe, and in Algeria, Turkestan, North Africa, Amuria, Caucasus, Siberia, and China (Butler 1923; and Carvalho 1958). In Canada it has been recorded only in Ontario, Quebec, Nova Scotia, and British Columbia, and in the United States in Maine, New Hampshire, Vermont, New York, Pennsylvania, Massachusetts, and California.

GENERAL METHODS

Field studies were conducted at Richmond, Ontario, 15 miles southwest of the Central Experimental Farm, Ottawa, in 1959 and 1960. Rearing studies were made in field cages at Merivale, 5 miles south of Ottawa, from 1959 to 1961. Occasional observations were made in other areas of eastern Ontario from 1958 to 1961, and near Sarnia in southwestern Ontario in 1960 and 1961, and at Kapuskasing, Ontario, in 1959 and 1961.

Most phases of the study were carried out in fields of Viking birdsfood trefoil. Samping was done by making systematic sweeps with an insect sweep net as outlined by Guppy (1958).

Longevity and fecundity of adults were studied in small cages on individual stems of birdsfoot trefoil. The cages, 2 inches in diameter by 8 inches long, consisted of a cellulose acetate frame covered with nylon mesh cloth. Plant injury and nymphal development on various species of plants were observed by caging groups of 10 to 15 bugs on potted plants; these cages consisted of cellulose acetate cylinders 6 inches in diameter and 15 inches in height with six 2-inch-diameter screened vents in the sides and a nylon mesh sock covering the top. Occasionally, nymphs were reared in 8-ounce glass jars having screened tops; the jars were partly filled with fine sand, moistened periodically to prevent desiccation, and fresh plant cuttings were supplied daily.

LIFE-HISTORY AND BEHAVIOR

Eggs.—The eggs are laid within the stems of the hosts. They are cylindrical, slightly curved, rounded at the posterior end and tapered slightly from the center to the anterior end, which is compressed and truncated. The chorion is finely punctated, transparent, and shiny. When the egg is first laid the contents are pale yellow, but vary from pale yellow to pale orange after a few days. The eggs average 0.95 mm. in length and in width taper from 0.24 mm. to 0.16 mm., with the narrowest part just below the cap.

The eggs were laid in July and August but showed no observable development before freeze-up. Apparently an obligatory diapause was initiated shortly after the eggs were laid and terminated in the following spring in late April or May.

Eggs held in cold storage at 2° C. for 7 months were observed at room temperature. As the embryo formed, a small vesicle filled with fluid developed at the anterior end of the egg between the head of the nymph and the embryonic membrane. The eyes appeared about 6 days later as bright red spots just below the vesicle. One to two days before the egg hatched the truncated anterior end of the chorion ruptured along the midline, exposing the end of the embryonic membrane which bore a thickened oblong cap. Hatching required about 12 hours. The mature embryo moved slowly forward into the vesicle in the neck of the egg until the cap on the embryonic membrane gave way; the nymph was free of the eggshell and fully mobile in about 15 minutes.

In the laboratory, the eggs hatched in 11 to 17 days, averaging 14.

Nymphs.—The nymphal instars number five. The newly hatched first-instar nymph is pale yellow and its body is sparsely clothed with hairs; the appendages are translucent and the eyes bright red. Dorsally a small dense, yellow spot occurs within the abdomen but this spot becomes obscured after feeding begins. Nymphs of the later instars differ from those of the first instar mainly in color pattern, size, and development of wing pads; the head is yellowish, the eyes brown, the thorax yellowish green, and the abdomen a dull pale green. The head, thorax, and abdomen have prominent black hairs dorsally. In the last three instars, the tibiae and femora bear dark spots similar to those found on the adults but many of them are indistinct, especially on the fore legs. Measurements of 35 specimens of each instar are recorded in Table 1.

Feeding and Injury.—In the laboratory, the nymphs moved about shortly after hatching but none was observed to feed for the first 3 to 4 hours. In the field, the nymphs were observed during the day among the developing floret buds and the leaflets

Table 1.—Measurements (mm.) of 35 specimens of each instar and of male and female adults of *P. chrysanthemi.*

Stage	Width of head[a]		Length[b]	
	Mean	Range	Mean	Range
Nymph				
First instar	0.30	0.28–0.32	0.84	0.61–0.99
Second instar	.39	.37– .51	1.19	1.05–1.33
Third instar	.49	.47– .50	1.66	1.38–1.92
Fourth instar	.61	.58– .64	2.26	1.92–2.56
Fifth instar	.72	.70– .76	2.89	2.40–3.20
Adults				
Female	.76	.72– .80	3.70	3.52–3.88
Male	.76	.70– .80	4.11	4.00–4.24

[a] Across compound eyes.
[b] Nymph, vertex to tip of abdomen; adult, vertex to tip of wing.

surrounding them. They were seldom found on other parts of the plants. Nymphs caged on the potted dandelion and ox-eye-daisy were on the flower heads most of the time.

On birdsfoot trefoil the nymphs appeared to feed only on the buds and the small leaflets that surrounded the younger buds. When a newly formed bud was attacked, necrotic areas appeared on the florets and on the leaflets; the entire bud usually died and the peduncle did not develop. When the older buds were attacked only the florets fed upon died; and if one or more florets per umbel survived, the peduncle developed normally. The very young leaflets that were fed upon either died or remained small, the larger ones continuing to grow but becoming deformed. Typical injury on birdsfoot trefoil buds is shown in Fig. 1.

In the field, florets that bloomed did not appear to be damaged; however, on potted plants the occasional bud that escaped damage often died soon after blooming and may have been injured by the nymphs.

On potted alfalfa in cages, *P. chrysanthemi* caused the entire bud racemes to whiten and die, a condition commonly referred to as bud blasting. The exact manner of attack was not determined but in control cages this condition did not occur. Red clover buds did not appear to be so sensitive to feeding as did those of the trefoil or alfalfa; small groups of florets in one or two areas of the clover heads died but the rest of the florets bloomed normally. Possibly the compact and hairy nature of the red clover florets in the early bud stage, plus the added protection of the head bracts, prevented early attack and destruction of the entire bud. In ox-eye-daisy and other wild hosts no visible damage was observed on buds or blooms.

Although feeding was observed on the leaves of some of the potted plants, this type of injury did not appear to affect the plants adversely. The nymphs occasionally fed at the margins of necrotic areas that occurred on leaves; these areas may have originated from insect injury.

When nymphs died in the cages others often fed on the corpses and on one occasion a nymph fed on the corpse of a tiny dipterous species which was trapped in a droplet of water on the wall of a cage. However, at no time did they appear to have predatory tendencies.

Duration of Instars.—The durations of the nymphal instars were estimated in the seasonal history studies. The average number of days spent in the first, second, third, fourth, and fifth instar, respectively, were: 4, 6, 5, 8, and 8 days in 1959; and 5, 6, 7, 8, and 8 days in 1960. The total nymphal period averaged 31 days in 1959 and 34 days in 1960.

Adult.—The adult females are pale green to grayish green, and are slightly shorter and more robust than the males. The males are grayish green at first but with age the body becomes heavily mottled in black. The wings of both sexes are clothed with black recumbent hairs. Two distinct rows of black

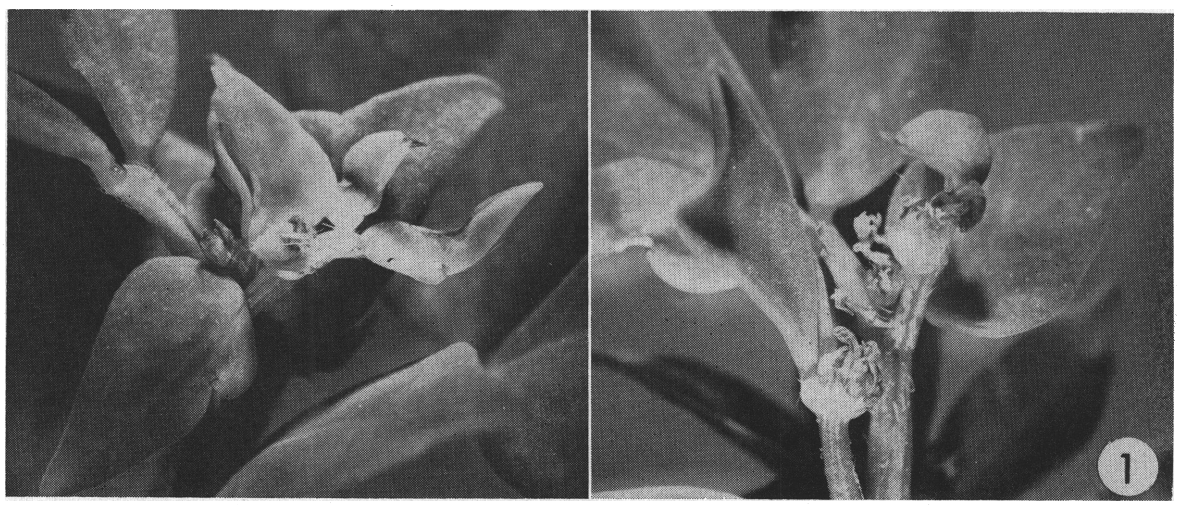

FIG. 1.—Buds of birdsfoot trefoil injured by feeding of nymphs of *P. chrysanthemi.*

spots occur on the anterior face of the femora and black spots surround the base of hairs or spines on the tibia. Measurements of specimens collected at Ottawa are recorded in Table 1. A more detailed description of the adults is given by Blatchley (1926).

Feeding.—The adults fed throughout their life span and were active during the day from early morning until late evening. On birdsfoot trefoil, red clover, and alfalfa feeding was observed on buds and blooms and occasionally on the leaves of the two latter species. When they were caged on ox-eye-daisy, dandelion, and mouse-eared chickweed they were observed to feed only on the blooms.

Oviposition.—Egg laying was observed only once, on July 10, 1958, about 8:20, E.S.T., just before dark.

In the field, in birdsfoot trefoil, the eggs were laid within the nonlignified portion of the stems or in the peduncles, the egg caps being just below the epidermis. The oviposition slits were not visible under low magnification at first but within a few days scar tissue developed, forming a tiny elliptical brownish spot on the stem. After the plants matured and died the tissue shrank and the scars around the egg caps appeared as minute blisters on the stem. Measurements of the egg sites in green plants, and similar measurements of dry plants containing eggs overwintered in the field, are recorded in Table 2. Of 125 eggs dissected from green plants, 69 were in the stems and 56 in the peduncles. Eggs laid in the main stems were 2 to 24 inches from the top of the stem and those in the side branches, 2 to 10 inches from the tip. Most of the eggs were 2 to 5 inches from the tips of the stems or branches. The eggs were laid anywhere in the peduncles, which were usually 3 to 7 inches long. There were from 1 to 9 eggs at each oviposition site on the stems and from 1 to 11 eggs in each peduncle. In potted plants, large numbers of eggs were laid in close proximity if suitable stems for egg laying were limited.

The search for eggs was time consuming; and probably because only a small amount of plant material was examined, the only other host in which eggs were found in the field was ox-eye-daisy. Six eggs were found in one stem in late August. The stem was dry and measured 0.96 to 1.04 mm. in diameter, within the ranges in Table 2. Measurements of oviposition sites on potted palnts, including the trefoil, ox-eye-daisy, alfalfa, and red clover, were also within the ranges given in Table 2.

Table 2.—Measurements of stems of birdsfoot trefoil containing eggs of *P. chrysanthemi,* measured shortly after oviposition and after a winter in the field.

Condition of stem	Number of observations	Stem diameter, mm.	
		Range	Mean
Green	125	0.64 – 1.60	1.04
Weathered	102	0.40 – 1.50	0.86

Fecundity and Longevity.—Field observations indicated that most of the adults lived 4 to 6 weeks. In the field cages, the males lived 2 to 3 weeks and the females 3 to 6 weeks when they were caged in groups; when caged in sexual pairs, the males lived only 4 to 10 days but the females lived 20 to 66 days, averaging 43.

No fully developed eggs were found in females less than 10 days old. The preoviposition period was 10 to 14 days and the oviposition period, 6 to 50 days. Egg formation was continuous throughout the life span of the females, and those that lived the longest usually laid the most eggs. Seventeen females laid 12 to 179 eggs, averaging 80 per female. The female that laid 179 eggs died 2 days after the last eggs were laid, and contained no eggs; these eggs were laid over a period of 36 days, averaging 5 per day. Eggs were not laid every day and the maximum number laid by any one female in 24 hours was 12.

Dissection of wild females showed that their abdomens never contained more than 30 fully developed eggs at one time, and in most females there were only 10 to 20 eggs.

Dispersal.—In the study fields, a notable decline in the populations of *P. chrysanthemi* occurred during the transition from nymph to adult. For example, on June 25, 1959, there were 1,250 fifth-instar nymphs and 410 adults per 100 net sweeps, but 4 days later when the number of fifth-instar nymphs had decreased to 275 there was no proportionate increase in the adult population; by July 2 there were only 144 adults per 100 sweeps. In 1960, a similar population change occurred. This rapid change appeared to be due to the adults moving out of the fields, and not to mortality factors operating within the fields. Every year, during late June and July, adults of *P. chrysanthemi* became widely distributed locally and were observed in many locations where the nymphs had not been recorded earlier; this fact suggests that movement of the adults from the nymphal habitat is a normal behavior pattern. However, in 1959 and 1960, bud damage in the study fields was severe and therefore the sudden movement of the adults out of the fields may have been caused partly by the lack of bloom for food.

SEASONAL HISTORY

One complete generation of *P. chrysanthemi* occurs annually in eastern Ontario. The winter is spent in the egg stage within the stems of the hosts. The eggs hatch from mid-May until early June, most of them hatching within a 10-day period in late May.

Seasonal development of the five nymphal instars is indicated in Fig. 2. Fewer nymphs of the first, second, and third instars were captured per 100 net sweeps than of the fourth and fifth instars; therefore, the seasonal development pattern shown for each instar is independent of the others. The percentage shown for any one instar on each sampling date is the percentage of the total number of that instar captured on all 13 sampling dates.

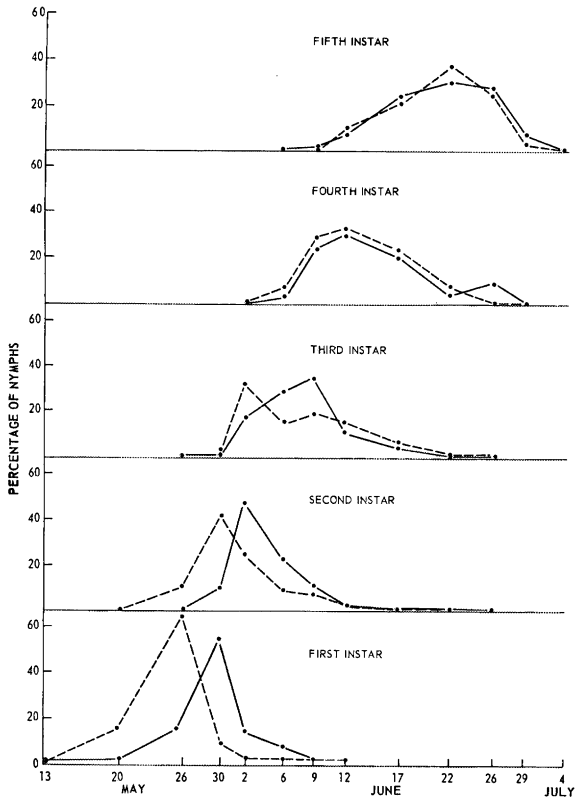

FIG. 2.—Percentages of nymphs of *P. chrysanthemi* captured in birdsfoot trefoil on 13 consecutive sampling dates in 1959 (solid lines) and 1960 (broken lines).

Newly hatched nymphs were found as early as May 13 and an occasional fifth-instar nymph was observed as late as July 6. The peak period of abundance of the nymphs was from about May 26 to June 26. The first-instar nymphs appeared about 4 days later in 1959 than in 1960, but by the time the insect reached the fourth and fifth instars, the seasonal development pattern for both years coincided almost perfectly (Fig. 2).

In 1959, the largest numbers of nymphs of each instar recorded per 100 net sweeps was, for the first to fifth instars respectively, 447, 562, 456, 600, and 1,171. The numbers were slightly smaller in 1960. The largest total numbers of *P. chrysanthemi* recorded were 1,725 on June 22, 1959, and 1,307 on June 23, 1960; on these dates approximately two-thirds of the populations were fifth-instar nymphs and the remainder were fourth-instar nymphs and new adults.

The first adults were observed on June 12 and 20 in 1959 and 1960, respectively, and in both years they became abundant after June 22. About 50% of the population had transformed to the adult stage by June 25 and by July 2 only an occasional nymph was observed. The new adults fed for 10 to 14 days before laying eggs. Most of the eggs were laid during July but an occasional gravid female was found in the field until mid-August. One adult, captured on August 11, 1960, laid 77 eggs before dying on August 29.

HOST RELATIONSHIPS

Nine species of plants were found to be hosts of *P. chrysanthemi* in eastern Ontario and these and four other species of plants were fed on by the insect in field cages. The hosts recorded in the field were: red clover, *Trifolium pratense* L.; alsike clover, *Trifolium hybridum* L.; Ladino clover, *Trifolium repens* L.; alfalfa, *Medicago sativa* L.; birdsfoot trefoil, *Lotus corniculatus* L.; tufted vetch, *Vicia cracca* L.; ox-eye-daisy, *Chrysanthemum leucanthemum* L.; silvery cinquefoil, *Potentilla argentea* L.; and common mullein, *Verbascum thapsus* L. Second-instar nymphs were reared to the adult stage on yellow rocket, *Barbarea vulgaris* R. Br.; common dandelion, *Taraxacum officinale* Weber; common mouse-ear chickweed, *Cerastium vulgatum* L.; and white sweet clover, *Melilotus alba* Desr.; although these four species of plants often occurred in situations where *P. chrysanthemi* was abundant the insect was not observed on them.

In the rearing cages, nymphs fed on common timothy, *Phleum pratense* L., but none survived beyond the fifth instar. They lived only 2 to 3 days on lamb's-quarters, *Chenopodium album* L.; prickly annual sow thistle, *Sonchus asper* (L.) Hill; and common milkweed, *Ascelepias syriaca* L.

Adults were observed on other species of plants in the field but feeding was not observed and no attempt was made to rear the insect on them.

In Europe, 33 species of plants have been recorded as hosts of *P. chrysanthemi* (Kullenberg 1946); six of the nine hosts recorded in Ontario during this study were included in the list but one notable exception was *Lotus corniculatus,* a plant indigenous to Europe. The main European hosts were listed as follows: Three species of Compositae, namely, *Achillea millefolium* L., *Matricaria inodora* L., *C. leucanthemum,* and two species of Leguminosae, *T. pratense* and *T. hybridum.*

Kullenberg (1946) lists timothy, *P. pratense,* as a host in Europe but it does not appear to be a host in Ontario. Timothy was closely examined because of its common occurrence in the legume crops but *P. chrysanthemi* was collected in it only where vetch or other legumes were present. As noted earlier, the nymphs fed on timothy in cages but none reached the adult stage.

In Ontario, the common occurrence of *P. chrysanthemi* on the cultivated legumes, common vetch, and ox-eye-daisy supports Kullenberg's observation that the main hosts are species of Compositae and Leguminosae.

P. chrysanthemi appears to feed largely on the reproductive parts of most of the hosts, although some feeding occurred on leaves in the rearing cages. Observations to date on potted plants indicate that the nymphs do not complete development on certain

hosts unless buds or blooms are present. On birdsfoot trefoil, when most of the buds were killed before the nymphs neared maturity, only an occasional one reached the adult stage but when buds and bloom were abundant the survival rate was high. On oxeye-daisy bearing bloom, 12 of 15 nymphs caged per plant reached the adult stage, but when all of the buds and blooms were removed only 1 of 15 nymphs matured. On dandelion, 13 to 15 nymphs became adults when blooms were present but none survived when there were no blooms. However, there was one exception; there were no buds or blossoms on *Verbascum thapsus,* and 9 of 15 nymphs matured to adults. When blooms and buds were removed from many of the plants, new buds soon developed and therefore it was not possible to compare development of the insect on all species of plants with and without bloom. Further work is required before definite conclusions on feeding habits can be reached.

ECONOMIC IMPORTANCE

Although *P. chrysanthemi* has been abundant in red clover, alfalfa, and birdsfoot trefoil in eastern Ontario for the past 10 years, it has caused severe damage only to Viking birdsfoot trefoil seed fields. In 1959 and 1960, one field each year had populations of 1,725 and 1,307 bugs per 100 net sweeps, respectively. The crops were a total loss for production of seed. Both fields were in the second crop year and had produced good yields of seed the previous year. In 1960, records of damage were obtained; in late June, 10 samples of 50 stems each were taken at random from the 15-acre study field and all the buds and bloom on each stem were examined for injury. When there were less than five or six florets per umbel in bloom the writer assumed that the missing floret had been damaged; records of bud damage indicated that this assumption was true. The results are recorded in Table 3.

The undamaged umbels had five to seven florets during the bud stage and usually five or six when in bloom. Seventy-three percent of the umbels that bloomed had only one to three florets per raceme. Of the umbels in the bud stage, 21% were not damaged, 16% had less than four florets damaged and 47% had four or more florets damaged. In the latter group most of the buds were damaged beyond recovery. About 14% of the buds were yellowed and showed no sign of insect injury. Table 3 gives only a partial picture of the damage because the buds that may have died from insect damage earlier in June could not be recognized. The writer estimated that in the normal bloom period of this crop only about 20% of the buds bloomed.

Table 3.—Number and percentage of buds and blooms of birdsfoot trefoil damaged by *P. chrysanthemi,* Ottawa, Ontario, 1960.

Number of florets per umbel	Umbels per fifty-stem sample	
	Number	Percentage
Umbels in bloom,	38	
4 to 6 healthy florets	10	26.3
1 to 3 healthy florets	28	73.7
Umbels in bud stage,	206	
all florets healthy[a]	45	21.8
1 to 3 florets damaged	33	16.0
4 to 6 florets damaged	98	47.6
all florets yellowed	30	14.6

[a] Largely newly formed buds still subject to damage in the field.

Other mirids, such as *Lygus* and *Adelphocoris* spp., were very scarce in the birdsfoot trefoil in June 1960, and the writer believes that any bud damage caused by them was negligible.

In Viking birdsfoot trefoil, populations of *P. chrysanthemi* were large when the previous year's crop had been harvested for seed but small when it had been harvested for hay. The eggs were laid in the plants before the seed crop matured and were returned to the field in the crop residue during combining. Under hay production apparently most of the eggs that were laid in the field were removed with the crop. It appears that severe damage occurs only when the first annual growth is harvested for seed 2 or more years in succession, the damage occuring in the second and subsequent years. This may apply also to other varieties of birdsfoot trefoil and to alfalfa and similar crops. However, the severity of damage depends on the coincidence of the bloom period of the crop and nymphal development. For example, the writer has never observed severe damage in Empire birdsfoot trefoil; this variety blooms later than Viking and appears to escape serious injury by the nymphs which mature before the main bloom period occurs.

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