discussed here.

In trial A at Salinas, one application of selected rates of Penncap M 2E was applied as full-coverage sprays on September 12, 1978. A wetting agent (Triton AG98) was added to one treatment.

Counts, made 1, 2, and 3 weeks after application, were based on the number of living pupae and larvae in 20 leaves from each of four replications. Larvae and pupae were counted after the leaves had been held in plastic bags for 7 days. The most effective rate was 1 pound active ingredient per 100 gallons water, which provided good control for up to 14 days after application (table 1).

In trial B at El Modena, 12 weekly applications of Vydate 2E, SBP 1513 1E, and Penncap M 2E were made from November 4, 1978, to January 29, 1979. Originally Temik 10G, applied twice a month, was to be evaluated along with these other materials, but applications were discontinued because of very poor control.

A randomized design was used with four replications per material. Each plot covered one-fourth of a 10,000-square-foot greenhouse. Insecticides were applied by a handsprayer to the point of runoff. Twelve yellow 1-square-foot sticky traps, 3 feet above the ground, were evenly spaced throughout each treatment area. All materials except Temik 10G (later switched to Vydate 2E) provided satisfactory control (table 2).

When these tests were conducted, several materials applied weekly controlled *L. trifolii* on chrysanthemums. In 1977, many of these materials were not registered for use on chrysanthemums in California. By 1980 both permethrin (Pounce 3.2E and Pramex 2E) and Oxamyl (Vydate 2E) were granted registration in California, but during the summer of 1980, these materials failed to provide control even with applications as often as every 3 days. In our field trials, Penncap M 2E was the only material that satisfactorily reduced leafminer populations. A 24C "special local needs" registration for Penncap M 2E for use on greenhouse mums in California has been granted.

The seriousness of the leafminer problem in California, which has been intensified by the failure of most conventional insecticides, has demonstrated the need for considerable basic research. Investigations of this insect with respect to bionomics, natural enemies, sampling methodology, toxicology, and the like are under way to develop a leafminer management program.

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TABLE 1. Effectiveness of Varying Rates of Microencapsulated Methyl Parathion for Control of *Liriomyza trifolii* in Chrysanthemum Leaves, Trial A, Salinas, 1978

	Post-treatment count of larvae and pupae after*		
Insecticide	7 days	14 days	21 days
Penncap M 2E:			
1.0 lb ai/100 gal	2 a	4 a	27 c
0.50 lb ai/100 gal	9 b	20 b	32 c
0.50 lb ai/100 gal + Triton AG 98† (2oz/100 gal)	8 b	22 b	42 c
0.25 lb ai/100 gal	22 c	44 c	33 c
0.12 lb ai/100 gal	77 d	68 c	61 c
Check	98 d	92 c	56 c

*Means in the same column followed by the same letter are not significantly different ($p > 0.01$), Duncan's Multiple Range Test. Data were transformed (log [X + 1]) for analysis when necessary.
†Low-foam general-purpose agricultural adjuvant.

TABLE 2. Effectiveness of 12 Successive Applications of Selected Insecticides to Control *Liriomyza trifolii* on Chrysanthemums, Trial B, El Modena, 1978-79

	Mean number of adults per trap on following dates:															Leafminer-free cuttings*
Insecticide	10/31	11/7	11/14	11/21	11/28	12/5	12/12	12/19	12/27	1/3	1/9	1/16	1/23	1/30	2/6	%
Temik 10G† (4 lb ai/acre)	418	564	320	245	372	158	285	184	72	22	138	151	153	287	321	20.0
Vydate 2E (8 oz ai/100 gal)	1,092	1,165	563	328	312	449	326	184	80	63	90	227	143	83	61	97.0
SBP 1513 1E (1.0 oz ai/100 gal)	—	836	569	393	188	97	81	67	13	17	4	11	5	13	4	97.0
Penncap M 2E (8 oz ai/100 gal)	—	368	168	112	58	24	10	12	1	7	5	2	1	1	1	97.0

*Based on grower's assessment.
†Discontinued after 11/26; Vydate 2E was used thereafter.

Liriomyza trifolii could become a problem on celery

John T. Trumble

An outbreak of leafmining flies in the genus *Liriomyza* occurred on celery in Ventura County, California, during the summer and fall of 1980. Leafminers reared from celery and squash grown in the area were identified as *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae), providing the first evidence of economically important infestations of this species on celery in California.

Celery leaf mined by *Liriomyza trifolii.*

Previously, *Liriomyza sativae* Blanchard had been identified as a minor celery pest, occasionally developing to economic levels on a five- to ten-year cycle. The introduction of *Liriomyza trifolii* into California and its subsequent migration to celery represent a new and serious threat to celery production in California.

Florida growers have had considerable difficulty in controlling this leafminer on both celery and ornamental plants. Most pesticides used by Florida's celery growers have had an effective-use time of only 2.5 years, after which, repeated chemical selection of tolerant leafminers has produced populations resistant to the pesticide. Thus, experiments were begun in California to study the biology and population dynamics of these leafminers on celery.

Leaf samples were collected weekly from celery planted at the University of California's South Coast Field Station, Santa Ana. Two leaves were removed from each of 100 randomly selected plants, sealed in plastic containers, and transported to the laboratory. Each leaf was examined under a dissecting microscope with substage lighting for number of active larvae, empty mines, and parasitized larvae or parasite pupae. One month after collection, the containers were opened, and all emergent insects were classified and counted. Occasionally leafminer adults and mined leaves were collected from celery near Oxnard, Ventura County, and from tomatoes in Orange County. Species determinations were made as adults became available.

Biology and damage

Adult flies damaged celery leaves when feeding. Females pierced the upper surface of the leaves with their ovipositors, turned around, and then sucked the contents from the disrupted cells. Some feeding punctures also served as egg laying sites. Adult males, which apparently were unable to penetrate the leaf surface, fed at punctures created by the females. Most punctures were 1 to 2 millimeters in diameter and often gave the leaves a stippled appearance, particularly when adult populations were large.

The economic importance of *L. trifolii* is primarily due to feeding by the larvae. The maggots mine the mesophyll portion of the leaves between the upper and lower leaf surfaces, creating serpentine mines and white blotches visible on the upper surface. A single celery trifoliate frequently served as host for up to 10 larvae.

Most mines occurred in leaves on the older, outer stalks of the celery plant, which die before harvest or are stripped off during the harvest. In fact, rapidly growing celery plants often outgrew light to moderate leafminer infestations. However, under heavy population pressure like that which occurred in Ventura County, most of the celery leaves were mined, and light-brown puparia were found on the leaves, soil surface, and in large numbers at the base of the petioles in the center of the plants.

The presence of puparia in marketed celery may present an economic problem through reduction of consumer acceptance. Fortunately, attempts to rear adults from puparia collected from celery in grocery stores were unsuccessful (n = 1,000) and indicated that standard processing and storage techniques had killed the insects.

Of all plant growth stages, celery transplants suffered the greatest damage. In some fields, the upper 20 percent of the leaves was killed, giving the initial impression that herbicides had been applied to the crop. Extensive damage to the transplants slows maturation by reducing photosynthesis and may substantially reduce yields from regions where celery is continuously cropped.

Population dynamics

Liriomyza sativae and *L. trifolii* both developed in the experimental planting of fall celery in Santa Ana. However, *L. trifolii* was present in greatest numbers throughout the study (fig. 1). Occasional sweep-net collections from commercially grown celery in the Oxnard area produced only *L. trifolii*. A peak in *L. sativae* populations 8 weeks after transplanting coincided with removal of a nearby tomato field, suggesting that this species can readily migrate from tomatoes to celery. Adults reared from tomato fields near celery plantings were more than 98 percent *L. sativae*, and many leaf samples contained no *L. trifolii*. Thus, these two species appear to segregate on the basis of host preference, even though both tomatoes and celery are suitable hosts. However, when celery fields were harvested, *L. trifolii* readily moved into tomato plantings. Since the life cycle from egg to adult took only about 20 days, the generations overlapped, and all stages of the pest were present during most of the crop growth period.

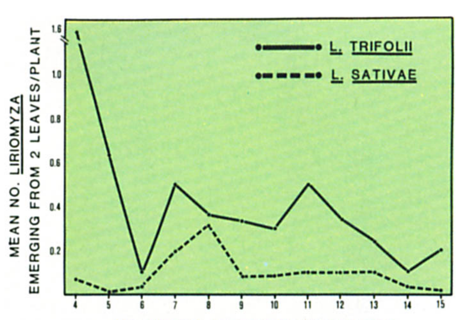

Fig. 1. Occurrence of *L. trifolii* and *L. sativae* in celery, Orange County, fall, 1980.

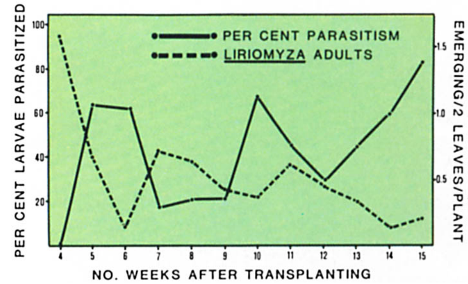

Fig. 2. Effect of parasites on *Liriomyza* spp. attacking celery, fall, 1980.

In untreated test plots, populations of *Liriomyza* spp. declined rapidly within 6 weeks after the celery was transplanted (fig. 2). This decline was in response to intense pressure from a variety of parasites. When leafminer populations rebounded at 7 and 11 weeks after transplanting, the parasite populations rapidly increased and suppressed the pest populations. Parasites in the genera *Digliphus, Halticoptera, Chrysocharis,* and *Chrysonotomyia* were responsible for most of the leafminer control.

Although the leafminer outbreak was successfully constrained by natural enemies in these experiments, lack of chemical use allowed populations of other pests to cause economic damage. Feeding by the beet armyworm, *Spodoptera exigua* (Hübner), and the cabbage looper, *Trichoplusia ni* (Hübner), resulted in low yields and a commercially unacceptable crop. Unfortunately, most pesticides currently available for worm control also kill leafminer parasites, resulting in a resurgence in leafminer populations. Therefore, the next phase of this research is to investigate a wide selection of pesticides to identify those that effectively control the lepidopterous pests and leafminers, while minimizing adverse effects on natural enemies of *Liriomyza* spp.

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