Control of Biting and Annoying

E. F. LEGNER • R. D. SJOGREN • G. S. OLTON • L. MOORE

Table 1. Emergence of *Hippelates collusor* adults from soil treated with granular applications of Urea applied on the surface at Mecca, California May 4 - June 8, 1966.

Average Number Adults Emerged/square meter						
354 lb.[1]		708 lb.		1417 lb.		Control
Avg.	% reduction	Avg.	% reduction	Avg.	% reduction	Avg.
211	0	150	10.4*[2]	143	14.6*	168

[1]Active urea per acre.
[2]Significant at 95% level = *

Naturally breeding field populations of *Hippelates* eye gnats and *Leptoconops* biting gnats were reduced with granular and spray applications of urea to the soil. Control ranged from 10 to 96 percent depending on the dosage and application method (disced or surface-applied). Possible modes of action are mechanical abrasion of gnat larvae, and the favoring of fungal infections. The use of urea as a substance harmless to natural enemies may be beneficial in the integrated control of pestiferous soil arthropods.

Table 2. Emergence of *Hippelates collusor* adults from soil treated with granular applications of urea disced-in 6 inches at Mecca, California June 22 - July 5, 1966.

Average Number Adults Emerged/square meter						
354 lb.[1]		708 lb.		2834 lb.		Control
Avg.	% reduction	Avg.	% reduction	Avg.	% reduction	Avg.
68	58.3*[2]	68	58.3*	43	73.6*	163

[1]Active urea per acre.
[2]Significant at 95% level = *.

It was observed in laboratory tests that additions of synthetic urea to the rearing medium killed larvae of the eye gnat, *Hippelates collusor* (Townsend). Mortality was direct through contact with this fertilizer. Therefore, field tests were conducted to test the effectiveness of urea against natural *H. collusor* populations and also against the biting gnat, *Leptoconops kerteszi* (Kieffer), which breeds in river bottoms and moist sandy soils in southern California.

Effects on natural enemies

Earlier tests by B. R. Bartlett of the Division of Biological Control, Riverside, showed that urea, a common fertilizer, is not lethal to a wide array of beneficial organisms. It was subsequently demonstrated that the principal natural enemies of *Hippelates* and *Leptoconops* could also survive urea treatments.

The longevity of five to ten individuals caged with the control materials was compared with the longevity of others in vials containing urea granules and in vials that had plaster-of-paris bases and were wet with urea concentrates. The *Hippelates* parasites tested were *Spalangia drosophilae* Ashmead, *Phaenopria occidentalis* Fouts, and *Hexacola* sp. Eye gnat predators tested were mixed cultures of the staphylinids, *Apocelis analis* LeConte, *Lobrathium lituarium* LeConte, *Neobisnius paederoides* LeConte, *Philonthus aluminis* Erichson, *Philonthus hepaticus*

Gnats with Fertilizer

Table 3. Emergence of *Hippelates collusor* adults from soil treated with granular applications of urea, disced-in 6 inches at Thermal, California June 24 - November 4, 1968.

Average Number Adults Emerged/ square meter				
354 lb.[1]		2834 lb.		Control
Avg.	% reduction	Avg.	% reduction	Avg.
First trap set				
12	58.6	1	96.7*[2]	31
Second trap set (soil disced)				
39	0	50	0	35

[1]Active urea per acre.
[2]Significant at 95% level = *.

Erichson, and *Platystethus spiculus* Erichson; the carabid, *Agonoderus maculatus* LeConte; and the dermapteran, *Euborellia annulipes* (Lucas). Predators of *Leptoconops* tested were the carabid, *Bembidion* sp., and the staphylinids *Carpelimus* spp. *Myllena* sp., *Neobisnius paederoides* LeC., and *Philonthus gradicollis* Horn.

There were no detectable differences in longevity between cultures exposed continuously to urea and the control, up to 30 days.

Table 4. Emergence of *Leptoconops kerteszi* adults from Santa Ana River bottom soil treated with granular applications of urea applied on the surface. August 14 - November 11, 1969.

Average Number Adults Emerged/ square meter						
119 lb.[1]		238 lb.		475 lb.		Control
Avg.	% reduction	Avg.	% reduction	Avg.	% reduction	Avg.
33	51.8*[2]	28	57.9*	28	57.9*	68

[1]Active urea per acre.
[2]Significant at 95% level = *.

Field experiments

Experiments were conducted in the breeding habitats of *Hippelates collusor* in 1966 and 1968 and in the *Leptoconops kerteszi* habitat near the Santa Ana River in 1969 to 1972.

Dosages of low biuret urea were based on practical fertilizer applications on commercial citrus orchards in the Coachella Valley (600 to 1,300 pounds per acre), and on rates equivalent to the estimated current cost of insecticide applications near the Santa Ana River. The synthetically produced urea chosen produced a maximum of only 0.15 percent biuret, a compound that is toxic to some vegetation.

Urea was especially suitable for this study because it leaves little or no residue. Urea is converted to ammonic nitrogen, carbon dioxide, and nitric nitrogen and does not appreciably increase soil salinity even when used in large quantities over a long period.

In the first experiment, a 4-year-old citrus orchard near Mecca with a history of high *H. collusor* density was selected. The orchard, which had an alfalfa cover crop, was cultivated three times to a depth of 8 inches one day after irrigation on April 21, 1966. Four days later the orchard was divided into 16 separate units, each unit containing five citrus trees on each side and 528 square feet of cultivated alfalfa. This unit constituted one replicate.

Granules (size #5-8) of low biuret,

Emergence traps for collecting *Hippelates* and *Leptoconops* adults from the soil.

45 percent urea were used in the treatments. Each dosage (354, 708, and 1,417 pounds per acre active material) was spread over the plots by hand. Control plots were untreated. The experimental design was completely random, and each treatment was replicated four times.

Immediately after application, treatments were wet with 31 gallons of water per replicate to begin dissolving the granules. Controls received the same water treatment. Two hours later, eight emergence traps (see photo) were placed at random in each replicate. Soil was banked around each trap to keep emerging gnats from escaping from the trap area and to prevent further wetting during irrigations. *H. collusor* adults that emerged were collected weekly for 6 weeks, and their average oven-dry weight was measured.

In a second *H. collusor* experiment, the soil in the same orchard was cultivated three times to a depth of 12 inches on June 9, 1966. Granular urea applications (354, 708, and 2,834 pounds/acre active material) were made the same day, followed by a fourth cultivation to mix the granules into the breeding habitat in the soil to a depth of about 8 inches. The orchard was flood-irrigated 4 hours after the treatments were applied. Four days later emergence traps were placed in each plot, and adults were collected for 3 consecutive weeks thereafter.

In a third experiment, a 30-year-old date grove near Thermal with a cover of sudan and bermuda grasses, was irrigated on May 29, 1968. Four days later the grove was cultivated three times to an 8-inch depth. Granular treatments were applied by hand in a randomized complete block design to 528-square-foot plots (2,834 pounds/acre urea, active material) followed by a fourth cultivation to mix the granules into the soil. Emergence traps were fixed 10 days after treatment on June 16, and five weekly adult emergences were recorded.

The traps were removed on August 1 after emergence was complete. The grove was disced three times to a depth of 8 inches on September 9, and the traps were reset at random in the plots 10 days later without additional treatments. Six weekly adult collections were gathered.

Flood irrigations were made during the three experiments on the average of every 16 days; however, none of this water entered the emergence traps.

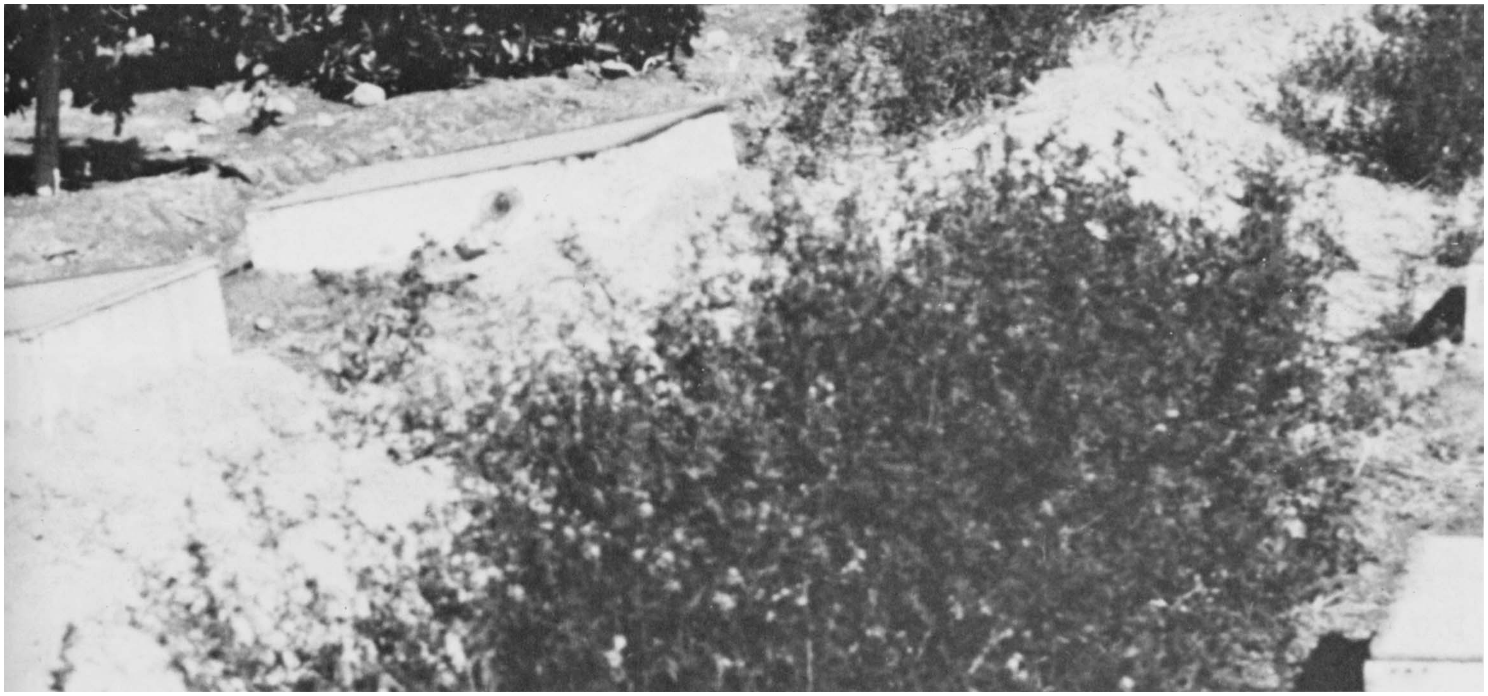
For one *Leptoconops kerteszi* experiment, a site in the Santa Ana River bottom near Norco was selected because it had a substantial biting gnat density with a minimum sample variation. Experimental plots were arranged contiguously in the area with each plot measuring 45 by 15 feet (675 square feet). Plots were replicated four times, and treatments were applied at random as granules and dissolved granule sprays directly to the soil surface on August 8, 1969 (118.8, 237.6, and 475.2 pounds/acre urea, active material). The same traps that were used in the *Hippelates* experiments were set at random in the plots at the rate of six per plot, and emerged adults were collected weekly for 4 weeks.

On September 20, the six traps in each replicate were moved to new positions randomly within the same plot, and weekly collections were resumed for another 4 weeks. A final trap movement was made on October 21, and four weekly collections were made.

In a final experiment in July 1970, urea granules were aerially applied at 237.6 pounds/acre over a broad expanse of breeding area adjacent to the Santa Ana River. Gnat emergence data were gathered by placing emergence traps randomly in breeding areas at several points along the river.

Results

Weekly emergence records of *Hippelates collusor* adults from soil treated with surface urea applications without cultivation showed a slight significant control effect for the medium and high dosages only. Gnat emergence increased where low dosages were applied (table 1). There were no significant differences in the oven-dry weights



of adults collected during the first 3 weeks of emergence.

Results of the second *Hippelates* experiment, in which granules were mixed into the soil by one cultivation after application, are shown in table 2. Here, emergence was significantly reduced by more than 50 percent at all dosage levels for the three weekly collections (not shown in table 2). There were no significant weight differences.

Similar results were obtained in the third experiment where treatments were also mixed into the soil (table 3). However, recultivation following the first period of emergence increased emergence from the treated areas. This is thought to have resulted from the increased growth of vegetation produced in the treatments by the fertilizer effect of urea.

Table 4 shows significantly reduced *Leptoconops* emergence from all urea dosages applied to the soil surface without cultivation. The fact that *L. kerteszi* larvae and pupae develop primarily in the upper inch of soil may be responsible for the significant effects at low dosages compared to the *Hippelates* experiments. The reduction was especially noticeable in the weekly collection data (not shown in table 4). One treatment was sufficient to reduce significantly the *Leptoconops* emergence for at least three field generations from August 14 through November 11. There were no significant interactions nor total emergence differences between spray and granular applications. Females predominated in all replicates, and no significant gnat size differences were detected among treatments.

Results with the aerial applications in 1970 were identical to those shown in table 4, indicating the relative constancy of response to urea treatments.

Discussion

The level of control achieved in both *Hippelates* and *Leptoconops* experiments may, under certain conditions, warrant wide-spread application. The degree of annoyance to humans caused by the gnats is difficult to measure and varies according to meteorological conditions. Often a 50 percent reduction, as shown in most of these tests, will suppress the pest population sufficiently to a tolerable level.

In the long run, continuously reducing gnat population densities by 50 percent or more could lower the breeding threshold, especially in the presence of uninterrupted activity by natural enemies.

The mode of action by which urea reduces gnat densities is not known. Concurrent laboratory tests have largely eliminated the possibility of any repellent action on the larvae of either species. Starvation is probably not involved, as indicated by the uniformity of oven-dry weights of survivors. It was observed that dissolved urea recrystallizes in a myriad of jagged crystals. This could interfere with larval respiration and possibly abrade the larval integument. Also, the mode of action might favor a pathogenic organism in the soil. The abundance of *Saprolegnia* fungi pathogenic to gnat larvae in some soil cultures treated with urea favors this hypothesis. However, there is no experimental evidence to indicate the material does not act as a stomach poison.

Further studies to define the active component that causes the insecticidal action of urea could lead to a more practical application of substances that reduce the natural breeding potential of pestiferous soil arthropods without creating gnat resistance or destroying natural enemies.

E. F. Legner is Professor of Biological Control, Department of Entomology, University of California, Riverside; R. D. Sjogren is Director, Metropolitan Mosquito Abatement District, St. Paul, Minnesota; G. S. Olton is Assistant Entomologist, Department of Entomology, University of Arizona, Tucson; and L. Moore is Entomologist, Coachella Valley Mosquito Abatement District, Thermal, California.