ronomus sp. and *Tanypus* sp. midge larvae. Since this injection method requires only one spray operator, the man hours required to control our 250 miles of flood channels will be reduced by approximately 50 percent as compared to our previous area spray method requiring two spray operators.

SOME EFFECTS OF FUMAGILLIN ON *ANOPHELES STEPHENSI*

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Fumagillin (2,4,6,8-decatetraendioic acid 4-(1,2-epoxy-1,5-dimethyl-4-hexenyl)-5-methoxy-1-oxaspiro (2.5) oct-6yl ester), an antibiotic produced by *Aspergillus fumigatus* (Aspergillales, Aspergillaceae), is effective in the treatment of infections of *Endamoeba histolytica* (Amoebida, Endamoebidae) in man and *Nosema apis* (Microsporida, Nosematidae) in the honey bee (Killough *et al.*, 1952; Katznelson and Jamieson, 1952). This indicated that the compound might be useful for the control of nosema disease in laboratory colonies of anopheline mosquitoes. During the evaluation we observed a number of side effects on our test insect, *Anopheles stephensi.*

MATERIALS AND METHODS

EXPERIMENT 1. First stage larvae of *Anopheles stephensi* were reared in 400-ml beakers containing 200 ml water and a commercial formulation[1] of bicyclohexylammonium fumagillin at 0, 5, 10, 20 and 40 ppm of the antibiotic. There were 5 replicates per treatment with 25 larvae per beaker. The larvae were reared on ground "D. & G." brand dog biscuits at $24.3 \pm 1.4°$ C. Water lost through evaporation was replenished from time to time. Pupae were counted and removed from treatment on the day of pupation. Adults were counted, dissected in physiological saline solution and examined microscopically to determine the incidence of nosema disease on the day of emergence.

EXPERIMENT 2. This experiment was similar to experiment 1 except that the larvae were transferred to beakers of untreated water after 24 hours' exposure to fumagillin. There were 4 replicates of each treatment.

RESULTS

In experiment 1 the mean larval period was lengthened in a dose-dependent manner: 8.0, 11.6, 13.3, 15.0 and 17.2 days at 0, 5, 10, 20 and 40 ppm fumagillin, respectively. Interpolation gives an estimate of 29.1 ppm as the dosage required to double the larval period. In experiment 2 the larval period averaged 1.1 times longer in treated larvae, but dose-dependence was uncertain. Mean pupal periods were not determined, but some periods of 4 and 5 days were observed in experiment 1 at higher concentrations. The normal maximum pupal period is 3 days.

Continuous larval exposure produced dose-dependent larval and pupal mortality

[1] "Fumadil B," Abbott Laboratories. This formulation contains bicyclohexylammonium fumagillin together with protective and buffering agents.

(Table 1). The LC_{90} was approximately 19.2 ppm for larvae and 12.5 ppm for pupae. Larval and pupal survival were enhanced by 24-hour exposure at all concentrations tested; dose-dependence was uncertain. The sex ratio was not significantly affected by treatment with fumagillin.

ment of larval *Anopheles stephensi* with concentrations of fumagillin that were effective against nosema disease resulted in protracted growth, defective development and mortality. In apicultural practice, the drug is administered orally to adult bees. According to Bailey (1953), fumagillin produces no apparent damage

TABLE 1.—Percent mortalities (corrected by use of Abbott's formula) in larvae and pupae of *Anopheles stephensi* exposed as larvae to treatment with bicyclohexylammonium fumagillin.

Experiment	Stage	Fumagillin Concentration (ppm)			
		5	10	20	40
No. 1 (continuous treatment)	Larva	53	79	91	95
	Pupa	54	88	96	100
No. 2 (24-hour treatment)	Larva	−12	−34	−23	−33
	Pupa	−37	−55	−49	−65

Developmental anomalies were observed in adults from all treatments except the 24-hour exposure at 5 ppm. The frequencies of these anomalies were not determined, but they were certainly greater than 50 percent in adults from the two higher concentrations used in experiment 1. Figures 1A and B show examples of stumped antennae and in Figure 1B the left palp is shortened. Figure 1C is an example of a shortened first tarsal segment and a stumped leg (arrow); all legs on this specimen are shortened or stumped. Figure 1D shows deformed wings, the right one shortened. In Figure 1E there is a perforation (arrow) near the trailing edge of the wing. In Figures 1F and G, two examples of notched wings are shown. Figure 1H illustrates a deformed wing; the left wing of this specimen is normal.

In experiment 1 the nosema disease incidence rate was 65 percent in untreated mosquitoes; treated mosquitoes were nosema-free. In experiment 2 the incidence rates were 74 percent and 71 percent for untreated and treated mosquitoes, respectively.

DISCUSSION

In the foregoing experiments, the treatto the structure or physiology of treated bees; however, the data of Gochnauer and Furgala (1962) suggest that the longevity of treated bees may be reduced. Protracted development, mortality and developmental anomalies are produced in *Culex pipiens* treated as larvae with electric shock (Schober, 1964) or with aliphatic amines (Mulla, 1967).

The antimicrobial effects of fumagillin extend to fungi, bacteria and bacteriophages, as well as to protozoa (Girolami, 1963). In the present study, differences in color, turbidity and scum formation in larval media containing different concentrations of fumagillin indicated pronounced effects on the microbiota of the larval medium. Inhibition of microbial growth could explain, in part, the mortality and lengthened developmental periods observed in the present study. Because of its relatively low toxicity to mosquito larvae and its broad spectrum of activity, it seems unlikely that fumagillin could be useful as a mosquito larvicide.

SUMMARY

The antibiotic fumagillin was found to protract development and induce mortality

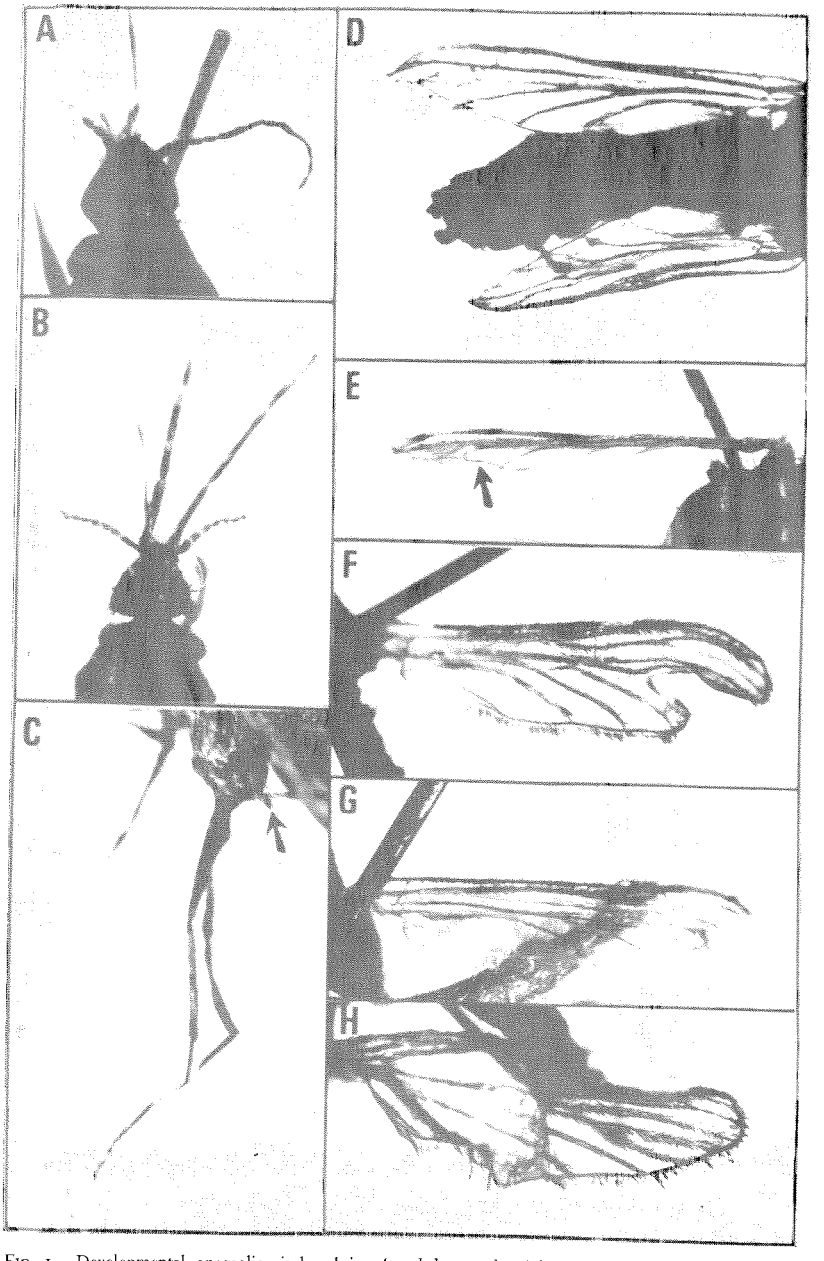

FIG. 1.—Developmental anomalies induced in *Anopheles stephensi* by treatment as larvae with the antibiotic fumagillin. (U.S. Army photograph).

and developmental defects in *Anopheles stephensi*. At safe dosages it was not effective against nosema disease in this mosquito.

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CURRENT INVESTIGATIONS IN UTAH OF THE BITING GNAT *LEPTOCONOPS KERTESZI*

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The current investigations in Utah of the biting gnat *Leptoconops kerteszi* Kieffer are supported by funds from a research grant awarded to the University of Utah by the U.S. Army Research and Development Command.[2] The study is being conducted with the cooperation of the three mosquito abatement districts in Salt Lake County and the personnel of Tooele Ordnance Depot in Tooele County. Other agencies and individuals in the state are interested and participating in parts of this study.

The objectives of this study are: (1) to determine the distribution and unknown phases of the life history and behavior of *Leptoconops* in Utah; (2) to improve methods of sampling larvae and adult populations; and (3) to improve on existing, or develop new, methods for the control of this gnat.

In current studies the distribution of *L. kerteszi* in Utah is being determined by collecting and from existing records. The field studies on the abundance, life history and behavior are being conducted on the sandy southeastern shores of the Great Salt Lake. This site is readily accessible and the gnats are extremely abundant. The field investigations are supplemented by studies conducted in environmentally controlled chambers in the laboratories at the University of Utah.

Some of the first work conducted in Utah on the biology and control of these gnats was started in 1948 by Rees and Smith (1950, 1952) on the property of the Salt Lake Refining Company located near the north boundary of Salt Lake City.

In 1964 the Marquardt Company requested assistance in controlling *Leptoconops* gnats on their experimental grounds at Little Mountain on the eastern shore of the Great Salt Lake in Weber County. The gnats were so annoying at this site for about 6 to 8 weeks each spring that the working efficiency, for day-time employees working outside of buildings, was reduced by about 20 per-

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