

A Field Test of the Potential of a Local Flatworm, *Dugesia Tigrina*, for Biological Control of Mosquitoes in Temporary Pools

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An indigenous flatworm species, *Dugesia tigrina* (Girard), was tested for use as a biological control of mosquitoes in temporary pools in North Dakota. Pools with mosquito populations were stocked with flatworms at densities ranging from 100 to 2000 per pool. Mosquito populations were monitored throughout the season. Flatworm populations were assessed at the end of the season. Flatworm populations increased over the season but mosquito populations were not effectively controlled by the flatworms.

Introduction

Planarian flatworms have long been known to be predators of immature mosquitoes (Lischetti, 1919; Stage and Yates, 1939). Recently, efforts have been made to utilize several species of flatworms for mosquito control under a variety of environmental situations. Because of growing concerns about the use of conventional chemical control methods, these studies have high interest for mosquito control agencies. The planarian species studied here, *Dugesia tigrina*, has been successfully used to control mosquitoes in catch basins in Ontario (George, 1978). The closely related species, *Dugesia dorotocephala* (Woodworth), has shown potential for control of mosquitoes in California (Legner and Yu, 1975; Medved and Legner, 1974; Legner, 1977; Yu and Legner, 1976). In addition, Case and Washino (1979) have demonstrated that a flatworm in the genus *Mesostoma* can control mosquitoes in California rice paddies.

Because *Dugesia tigrina* occurs locally we tested the potential of this flatworm to control mosquitoes in temporary pools containing feral mosquito populations.

Materials and Methods

Dugesia tigrina (Figure 1) were collected from rocks below two dams on the Red River in Fargo from May through August of 1977. Planarians were sprayed off the rocks into a bucket using a garden sprayer, then removed from the bucket with a camel's hair brush or a pipette. A laboratory culture was maintained in aquaria and planaria were fed on a diet of mosquito larvae. Large numbers of planaria were easily held and maintained for stocking mosquito infested pools.

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Fifteen pools (1 × 2 × 0.2m) were constructed and lined with two layers of 3-mil black plastic sheeting. Mosquitoes colonized the pools soon after they were filled with water. By June 10, 1977, 12 pools were completed and stocked at ransom with 0 (three replications), 50 (three replications) and 100 (six replications) *D. Tigrina* per pool. More replications of 100 planaria per pool were set up because we anticipated increasing the stocking rate to 1000 in some replications when additional planaria were available. On July 8 and 26 two pools were increased to 1,000 planaria per pool. By August we saw the need to test higher predator densities so three additional pools were constructed and two were treated with 2,000 planaria; the third was used as an additional control. Therefore, by August 10, 15 pools were stocked at the rates shown in Table 1.

In order to sample planaria populations, five ceramic tiles (117 cm²) were placed in each pool. Planaria congregated on the under-side of these tiles and were easily checked to determine relative populations among the



Figure 1. Flatworms about to capture and feed on a mosquito larva.

pools. Debris and silt falling into pools made this sampling method unworkable by late summer so final planarian populations were estimated by taking 11.5 cm² samples of the plastic and overlying debris. Ten samples were taken from the sides and 10 from bottoms of pools. These samples represented ca. 5% of the total submerged area of the pools and were multiplied by 20 to estimate the total planaria population.

Mosquito populations were sampled 12 times between June 28 and October 4 using a standard 400 ml long-handled mosquito larva sampling dipper of the type used by mosquito control agencies. Larvae were collected, preserved in 70% ethanol and counted in the laboratory.

Results and Discussion

Mosquito population data were too erratic for statistical analysis. The only treatments that reduced mosquito populations below that of controls were 1,000 and 2,000 planarians per pool (Fig. 2). The reduction in pools treated with 1,000 *D. tigrina* was mainly due to a

very low mosquito population in pool #2 which was contaminated with hydra (probably *Hydra americana* Hyman). These may have been responsible for a portion of the mortality in this pool. Hydra are known predators of mosquito larvae (Qureshi and Bay 1969; Legner, Sjogren and Hall 1974; Mulla and Tsai 1978). Hydra probably entered the pool with *D. tigrina* collected from the Red River. A few hydra could have been inadvertently transferred from the bucket that held freshly caught *D. tigrina* to a container used to hold planarians until their release. Contamination probably occurred when more *D. tigrina* were added to the pool on July 8, 1977. This was a single collection from the Red River and would explain why only one pool was contaminated.

Mosquito control workers in Fargo, N.D. use five mosquito larvae per dip with a 400-ml dipper as a guide to chemically treat a breeding site (personal communication, Goodwin Hoff, City Sanitarian, Fargo, North Dakota). The number of larvae per dip from all pools was generally well above this figure. The lack of mosquito control coupled with the extreme stocking ranges, i.e. 500 and 1000 *D. tigrina* per m², indicated that *D.*

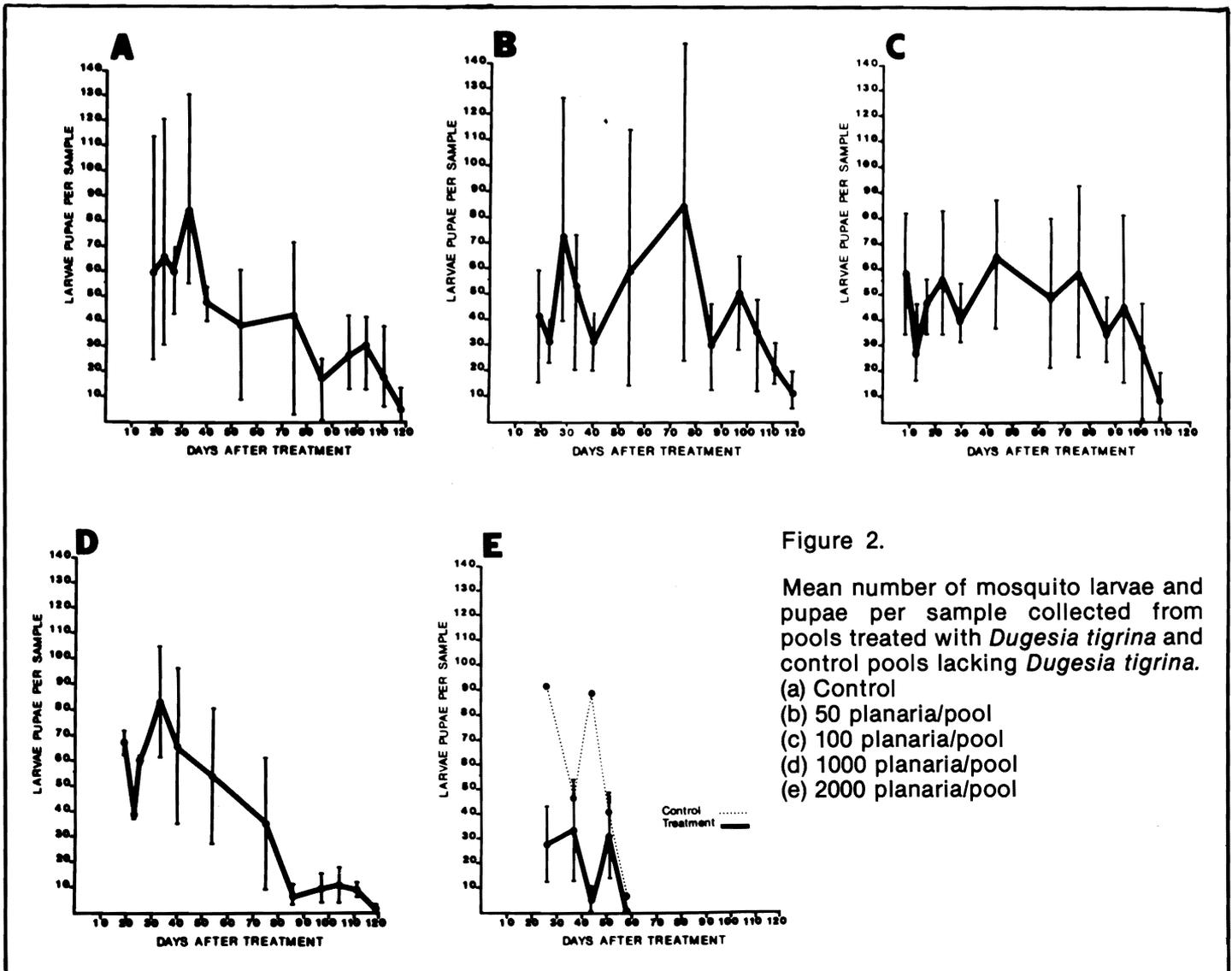


Figure 2.

Mean number of mosquito larvae and pupae per sample collected from pools treated with *Dugesia tigrina* and control pools lacking *Dugesia tigrina*.
 (a) Control
 (b) 50 planaria/pool
 (c) 100 planaria/pool
 (d) 1000 planaria/pool
 (e) 2000 planaria/pool

tigrina alone was not an adequate control for feral mosquitoes and that further field trials would be of no value.

Final population estimates of *D. tigrina* populations indicated increases of 6.8x in pools treated with 50 planarians, 11.6x in pools treated with 100 planarians, and 1.2x in pools treated with 1000 planarians (Table 2). There was a decrease of 7.4x in pools treated with 2000 planarians. Tsai and Legner (1977) reported increases of 13x in 46 days for *D. dorotocephala* reared under highly controlled conditions on a diet of mosquito larvae. A possible cause for the dramatic decrease in populations of pools treated with 2,000 *D. tigrina* may be that these pools could only support a little more than 500 *D. tigrina* per m². Treatments in pools 13 and 15 exceeded the carrying capacity and thus the population crashed. Pools stocked with 1,000 *D. tigrina* had only a small average increase compared to pools stocked at lower rates which also indicates an optimal population density just over 500 planaria per m².

Problems in the design of the pools were encountered. The most serious problem was punctures in the plastic lining. On July 18, 1977, pool #11 was almost dry and the situation was not remedied by several fillings. The pool was drained, relined, filled, and treated with 1,000 *D. tigrina* on July 26. Pool #6 had to be relined on August 10; however, during the operation all *D. tigrina* possible were recovered (150 individuals) and restocked into the repaired pool. Planaria in pool #15 suffered a large die-off on August 11, three days after the initial treatment. Dead *D. tigrina* were easily seen on the clean plastic bottom of the pool. Comparison of the number of planaria on the tiles in pools 13 and 15 indicated a population of only 400 *D. tigrina* surviving in pool #15. No dead *D. tigrina* were observed in pool #13. Sixteen-hundred planaria were added to pool #15 later that same day. No further die-offs were noted and the cause of this mortality in pool #15 was undetermined.

No planarians were recovered from pools used as controls. This indicated *D. tigrina*'s lack of ability to disperse into new bodies of water.

TABLE 1. Completion and treatment dates of pools with *D. tigrina*, 1977, Fargo, N.D.

Pool	Date filled	<i>D. tigrina</i> per pool	Date treated
1	8 June	50	10 June
2 ^a	"	100	"
3	"	0	"
4	"	100	"
4	6 June	0	"
6 ^b	"	100	"
7	"	100	"
8	3 June	50	"
9	"	0	"
10	"	100	"
11 ^a	"	100	"
12	"	50	"
13	8 August	2000	8 August
14	"	0	"
15 ^c	"	2000	"
2	8 June	1000	8 July
11	26 July	1000	26 July

^a Treatment increased from 100 to 1000 *D. tigrina* on dates indicated.

^b Pool repaired 10 August.

^c Pool restocked 11 August to correct for a large die-off of planarians.

TABLE 2. Initial stocking rates and final population estimates of estimates of *Dugesia tigrina* in pools used for field studies on mosquito control.

Initial Stocking Rate	Final population estimate
50	340 ^a
100	1165 ^b
1000	1240 ^c
2000	270 ^c

^a Mean of three pools.

^b Mean of four pools.

^c Mean of two pools.

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Carcass Evaluations

The thirteen parameters of gross carcass evaluations were measured. No significant differences ($P < .05$) were observed for live animal weight, leg widths, fat thickness (12th-13th rib), carcass conformation scores, leg conformation scores, quality grade or calculated yield grades among the oat varieties or the control ration. However, carcasses resulting from Dal oats fed lambs were found to yield significantly lower hot and cold carcass weights, shoulder widths, loin eye areas and kilograms of kidney fat ($P < .05$) than the control ration fed lambs. There were no significant differences ($P < .05$) among the oat varieties for these parameters or between the control ration and either Froker or Hudson oat fed lambs. These results oppose those of Cox (1946) who reported that no difference in carcass parameters were observed when lambs were fed several levels of energy.

Differences in hot and cold carcass weights and shoulder widths indicate a lower dressing percentage for Dal oat fed lambs. The differences in kidney fat (kgs) would tend to indicate a less than desirable amount of finish on these carcasses. This was evident also in quality grades obtained for these lambs. Dal oat fed lambs tended to grade on quality grade lower (good grade) than lambs fed the control or other two oat varieties (choice grade). These data oppose that of Ray and Mandigo (1966). They concluded that lambs fed high energy rations yielded lower quality carcasses than lambs fed lower energy rations. However, when the loin eye areas were expressed on an area per kilogram of hot carcass weight, the significant differences between the Dal and control ration fed lambs were eliminated. This further indicates a lower dressing percent of the Dal oat carcasses. Lambs fed the three oat rations yielded carcasses that were one grade leaner than control ration fed lambs, but this also was not significantly different ($P < .05$).

Economic Considerations

Although lamb growth performance was not affected by oat variety fed, there were slight economic advantages for Hudson and Froker oat-fed lambs in the evaluation of days to market over Dal oats fed lambs. Lambs fed Hudson and Froker oats rations averaged 136 and 147 days to market, respectively. Dal oats fed lambs averaged 157 days to market. This analysis may

become important when considering production costs for fattening lambs.

Not only did Dal oats fed lambs take longer to market, but their carcass quality grades tended to be one grade lower than either Froker or Hudson oat fed lambs. This would indicate that the lambs fed Dal oats should have been fed to heavier slaughter weights. Again, an economical disadvantage due to increased production costs of the longer feeding period and possible decreased returns due to decreased carcass quality and/or penalties for less desirable heavy weight lambs.

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