The Effects of Abate, an Organophosphorous Insecticide, on Marsh Fiddler Crab Populations[1]

by DIANA VALIELA WARD and BRIAN LOUIS HOWES
Department of Entomology and Economic Zoology
Rutgers University
New Brunswick, N.J. 08903

Fiddler crabs of the genus *Uca* have been previously described as highly sensitive to a number of pollutants encroaching on marshlands (ODUM et al. 1969; DECOURSEY and VERNBERG, 1972; VALIELA and TEAL, 1972). Thus there has been a tendency to use this genus as an indicator organism for a non-polluted marsh. Among the common pollutants of marshes at present are the organophosphorous insecticides, which have virtually replaced the chlorinated hydrocarbons for mosquito control. In spite of the wide use of these compounds, information on their effects on marsh organisms is scanty and previous experimental studies have been limited to the laboratory and to measurement of acute lethal effects. In New Jersey marshes, Abate (σ, σ, σ', σ' - tetramethyl σ, σ' - thiodi - p - phenylene phosphorothioate) is the organophosphate in heaviest use as a larvicide. This study attempts to evaluate the effects of normal Abate use (i.e., the standard rate and frequency used for mosquito control in New Jersey) on populations of *Uca pugnax* in the field.

Methods

Spatially separated experimental and control sites were established along both banks of a ditch in an unpolluted *Spartina alterniflora* marsh bordering Great Bay, New Jersey. The sites were matched as carefully as possible for vegetational cover, slope of the creek bank, width of the creek at the site, and number of fiddler crab burrows. Each site consisted of two plots 46 meters by 1.25 meters located on facing banks of the creek. The long and narrow shape of the plots was dictated by the distribution of fiddler crab burrows on the creek banks. The numbers of *Uca* present were determined by the quadrat method of FREY et al. (1973) except that the quadrats were made of aluminum and enclosed an area of 0.5 m^2. All population counts are averages of three different quadrat determinations, and each quadrat location was sampled only once during the entire experiment. The total area sampled by quadrats was about 10%

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of the total plot area available. The location of each quadrat was chosen randomly from a numbered grid system on the plots.

Abate was applied at low tide in a 2% granular formulation (on Celatom granules) by means of a Horn Seeder. The dosage was calibrated to 0.1 lb. of actual Abate (i.e. active ingredient) per acre by catching samples of the application in flat pans on the ground and weighing the granules. Three experimental applications were made, with a spacing of two weeks between applications. These dosages and conditions simulate normal use of Abate for control of mosquito larvae.

Results

Figure 1 shows the average populations of *Uca* found in experimental and control plots during the course of the study. Analysis of variance of the data from the three dates previous to any Abate application (see Fig. 1) showed that the effect of plots was not statistically significant ($F < 1$); the effect of time was statistically significant ($F = 12.19$, $P \ll .01$). Since the effect of plots was not significant, the two sites were adequately matched for initial *Uca* populations. Analysis of variance of the data from all dates after the first Abate application showed that the Abate treatment had a statistically significant effect on numbers of *Uca* ($F = 72.33$, $P \ll .01$). There was also a statistically significant change in numbers with time ($F = 74.03$, $P \ll .01$): the number of crabs increased and then decreased in all plots as the summer proceeded. The Abate X Time interaction was not statistically significant ($F = 1.92$).

Discussion

The concentration of Abate to be expected from a single application of 0.1 lb. actual Abate per acre depends on the average depth of water on the marsh: assuming a depth of 2 cm. of water, 0.5 ppm of Abate can be expected *if* we assume total release of the compound from the granules. Although no standing water was present on the plots when the granules were applied, dilution must have followed as the tide rose; 2 cm is a rough estimate of the average depth of water over a period of 24 hours. However, preliminary analyses show that much less than 100% release of Abate from the granules to the water occurs under both field and laboratory conditions (CAREY); we may expect at most one-tenth of this maximum concentration to be present in the water. On the other hand, in the field the crabs may feed directly on granules or on detritus in close proximity to granules and thus significantly increase their explosure levels over that present in the water. Therefore it is possible that two or more applications of Abate at 0.1 lb/acre resulted in levels lethal to a fraction of the population. In the laboratory, the 24-hour LC 50 of Abate for *Uca pugnax* is 3.1 ppm and the LC 20 is 0.33 (WARD and BUSCH). It should be noted that the final significant depressions in field populations of *Uca* were in the order of 20% from controls. Therefore in spite of the low release rate of

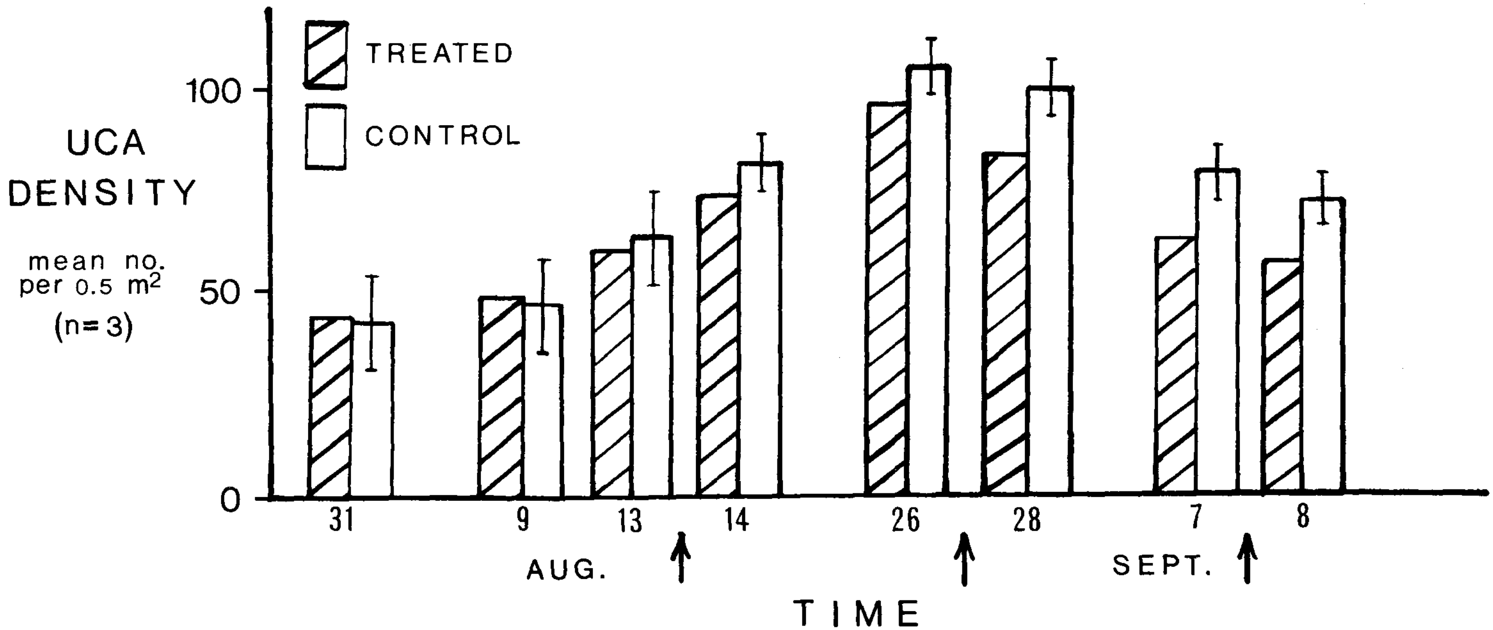

Figure 1. Density of Uca pugnax in control and Abate-treated sites of marsh near Great Bay, N. J. Arrows pointing at time axis indicate dates of Abate applications. Joint 0.95 confidence intervals shown were constructed on the basis of the analysis of variance reported in text.

Abate from the granules, cumulative effects of subsequent applications to lethal levels may operate to account for the significant effects of Abate treatment on *Uca* populations.

Another possible mechanism mediating the population decrease observed is that the concentration of Abate present may have had sublethal but significant effects on the animals, rendering them more easily subject to predation. Behavioral changes in *Uca* in response to sublethal levels of toxic chemicals in the laboratory have been demonstrated for 50% of *Uca pugnax* tested exposed to sublethal levels of mercury compounds (DECOURSEY and VERNBERG, 1972), and, somewhat less reliably, for *Uca pugnax* fed sediments containing sublethal levels of DDT (ODUM et al., 1969). In the case of Abate, the behavioral alteration consists of a slowing or disappearance of the escape reaction in response to a moving object (WARD and BUSCH). The process of behavioral alteration and increase in predation by birds until significantly lower population levels of Uca were reached could thus be taking place as well. This mechanism is made plausible by the frequent observation of clapper rails (*Rallus longirostris*) feeding on the experimental plots and in the area in general; feces of rails were commonly found on the plots as well.

The susceptibility of *Uca pugnax* to Abate should be considered in planning use of organophosphorous compounds on marshlands. Although areas of highest mosquito larva populations (mid-marsh and high marsh elevations) do not generally coincide with areas of highest *Uca pugnax* populations (near low tide marks), there are many areas of overlap where mosquito larvicides reach *Uca* populations. This is especially likely where application on relatively large areas is made by aircraft, as is commonly done. Efforts should be made to avoid areas inhabited by *Uca*. In addition, the organophosphates may reach *Uca* populations indirectly, as the compounds are redistributed by tidal movements, rains and winds. Hopefully, breakdown of the compounds occurs relatively rapidly; however, data on this phenomenon under field conditions are lacking at present.

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