EFFECTS OF AERIAL APPLICATIONS OF NALED ON *CULICOIDES* BITING MIDGES, MOSQUITOES AND TABANIDS ON PARRIS ISLAND, SOUTH CAROLINA[1]

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ABSTRACT. Field experiments were conducted during 1981 and 1982 to evaluate the effectiveness of ultra low volume (ULV) aerial applications of naled (Dibrom® 14) against natural populations of *Culicoides* biting midges, mosquitoes and tabanids at Parris Island, SC. Effectiveness of the applications was measured by trapping natural populations of all 3 groups of insects and by bioassays with caged mosquitoes and biting midges.

The first test (1981) consisted of 2 applications of a 1:5 mixture of Dibrom 14 in heavy aromatic naphtha (HAN) at a rate of 1.5 oz/acre (0.25 oz/acre Dibrom 14) on the same day spaced ca. 20 min apart. A very low reduction (24%) in the biting midge population following this treatment indicated that the dose of active ingredient (0.5 oz/acre) was inadequate under the prevailing weather conditions, which included marginally high winds.

The second test (1982) consisted of 2 applications of undiluted Dibrom 14 at a rate of 1.0 oz/acre each on 2 consecutive days. Results of this test showed that the larger dose of undiluted Dibrom 14 (2 oz/acre total) provided excellent control (99%) of biting midges, as well as mosquitoes and tabanids, for 3 days after the treatments.

INTRODUCTION

Biting midges (*Culicoides* spp.) are a severe nuisance problem in many coastal areas of the United States and other parts of the world. They are a particularly serious problem at the Marine Corp Recruit Depot (MCRD), Parris Island, SC, where high spring and fall biting midge populations inflict numerous bites upon the military personnel exposed during training and bivouac exercises. Prolonged scratching of bites has caused cellulitis problems in some individuals that require medical attention. In 1976, the Preventive Medicine Unit of the U.S. Naval Hospital, Beaufort, SC, recorded 200 skin infection cases from *Culicoides* bites. This resulted in numerous hospitalizations and the loss of 1,500 man-days at a total cost of $25,000 including pay and hospitalization (unpublished data). Other biting insects, including mosquitoes and, to a lesser extent, the tabanid, *Chrysops fuliginosus* Wiedemann, contribute to the annoyance problem at the MCRD.

Parris Island was selected as a site to conduct research for the development of control techniques for biting midges in coastal areas. Reported here is an evaluation of ultra low volume (ULV) aerial adulticide applications made over the entire 8047 acres (3257 ha) of the island, which includes 3274 acres (1325 ha) of dry land, 4344 acres (1758 ha) of salt marsh, and 429 acres (174 ha) of salt water creeks and ponds (Fig. 1). The dry land area includes a mixture (ca. 50%) of open and forest (primarily pine and pine-hardwood) areas. The salt marsh area contained a vegetative cover of cordgrass, *Spartina alterniflora* Loiseleur. The island is bounded by Archers Creek on the north, the Beaufort River on the east, Port Royal Sound on the south, and the Broad River on the west and is only partially isolated from surrounding biting midge populations. Previous studies by Giglioli et al. (1980) in the Cayman Islands indicated that aerial applications of fenitrothion were effective for biting midge control on an isolated island. Kline et al. (1981) reported that organophosphate compounds presently used for adult mosquito control had potential for use against biting midges, based on laboratory wind tunnel evaluations.

The purpose of these experiments was to evaluate the effectiveness of ULV aerial applications of Dibrom® 14, an 85% formulation of naled (1,2-dibromo-2,2-dichloroethyl dimethyl

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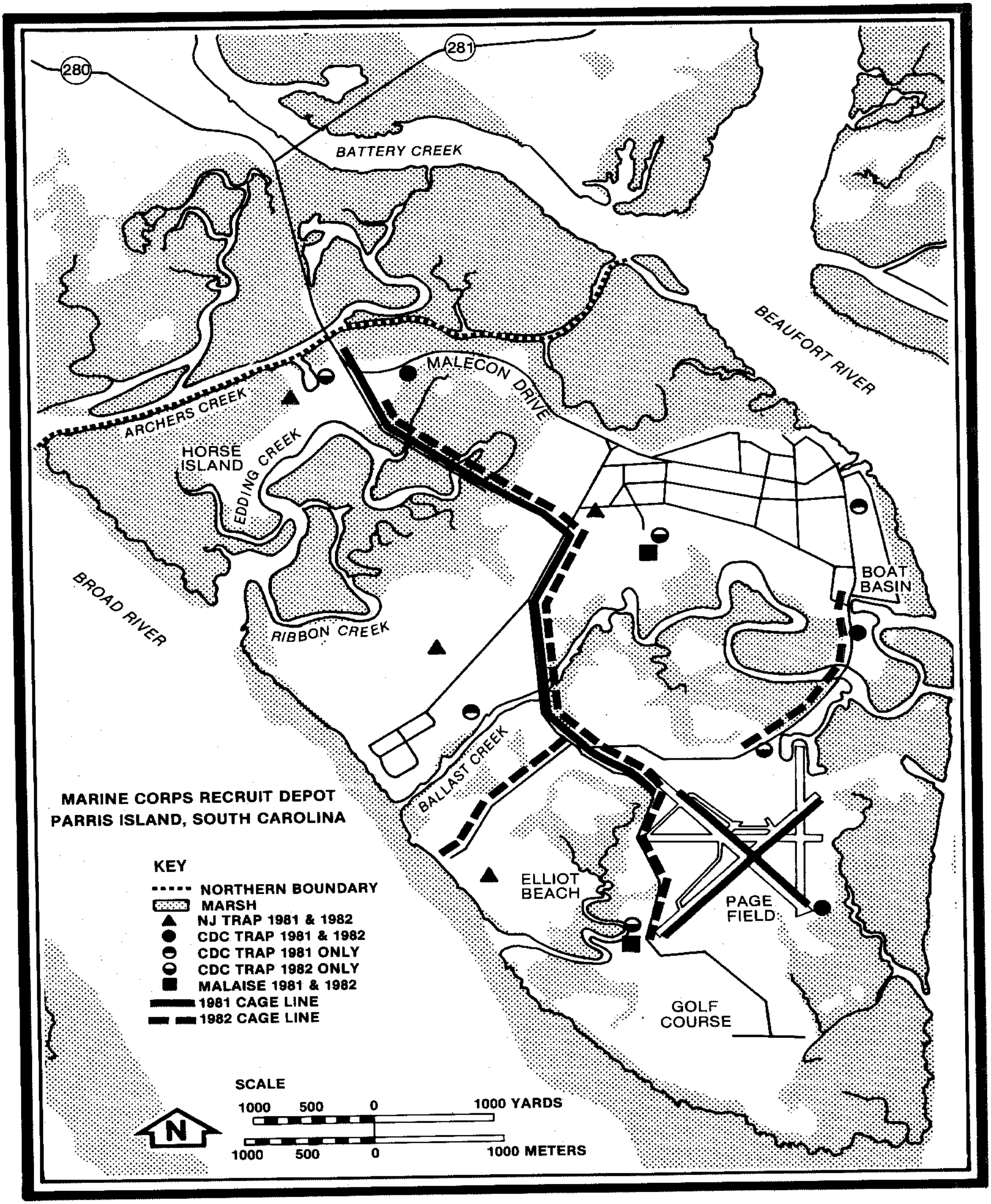

Fig. 1. Map of Parris Island, SC, showing the type and location of traps used to survey biting insect populations and the placement of caged insects for evaluation of aerial application experiments.

phosphate), against natural populations of adult biting midges on Parris Island. The effectiveness of the applications for control of mosquitoes and *Chrysops fuliginosus* was also assessed.

METHODS AND MATERIALS

Two aerial application experiments were conducted (1981 and 1982) using U.S. Air Force UC-123K aircraft (Table 1). The planes were equipped with TeeJet® nozzles (Spraying Systems Co.) oriented 45° down and forward (into the wind) on wing booms. Air speed during applications was 160 mph (257 km/h). The applications were timed to coincide with the first spring population peak of biting midges and suitable weather for aerial applications. Weather measurements during the insecticide applications were made by a meteorological team from the Marine Corps Air Station (MCAS), Beaufort, SC.

The 1981 experiment consisted of 2 applications of a 1:5 mixture of Dibrom 14:heavy aromatic naphtha (HAN) at a rate of 1.5 oz/acre (110 ml/ha) which contained 0.25 oz/acre (18.3 ml/ha) of Dibrom 14 each on the same day spaced ca. 20 min apart to take advantage of any flushing action from the first application. Two aircraft were used for these tests. A swath width of 2000 ft (610 m) was used for each aircraft, however, each spray run of the second aircraft was offset by 1000 ft (305 m). Thus, the overall effect of both applications was similar to an application of 0.5 oz/acre (36.5 ml/ha) of Dibrom 14 with 1000 ft (305 m) swaths. The planned altitude for these tests was 300 ft (91 m), however, the first aircraft flew at 250 ft (76 m) due to high winds at the upper altitude.

The 1982 experiment consisted of 2 applications of undiluted Dibrom 14 at the rate of 1.0 oz/acre (73.1 ml/ha) each on 2 consecutive days. A swath width of 1000 ft (305 m) was used for both applications. The altitude was 200 ft (61 m) and 150 ft (46 m) for the first and second applications, respectively.

A combination of natural population surveys and caged insect bioassays was used to measure application effectiveness. For this study, CO_2-baited CDC light traps and unbaited New Jersey light traps were used for assessment of natural biting midge and mosquito populations and malaise traps were used for the tabanid population. Trap locations during the 1981 and 1982 tests are recorded in Fig. 1. The 4 New Jersey and 2 malaise trap locations were the same for both tests. Five baited CDC traps were operated during the 1981 test and 7 for the 1982 test. In the 1982 test, some CDC trap locations were altered to provide better coverage of the treatment area.

Survey traps were also placed in an untreated (check) area for comparison with those in the treated area. For the 1981 test, the check area was located on Lemon Island, SC, ca. 2 mi (3.2 km) west of Parris Island and consisted of 2 baited CDC traps and 1 New Jersey trap. For the 1982 test, the check area was located at Sam's Point, SC, ca. 10 mi (16.1 km) northeast of Parris Island and consisted of 3 baited CDC traps and 1 New Jersey trap.

CDC traps were placed ca. 4 ft (1.2 m) above the ground on metal stakes. CO_2 gas was metered from 20 lb (9.1 kg) pressurized cylinders at a flow rate of 200 cc/min with a floating ball flowmeter, pressure regulator, and needle valve. The CDC traps were powered by 6 volt Gel-Cell® batteries that were changed and recharged daily. The New Jersey traps were located near 120 volt AC power sources. The CDC and New Jersey traps were operated 24 hr/day to provide suction trap action during daylight, as well as darkness, because the peak activity period for one of the predominant biting midge species, *C. hollensis* (Melander and Brues), includes some early morning and late evening daylight hours. Specimens from traps were collected daily between 1600 and 1700 hr.

Based on trap collections on the day before treatment, the *Culicoides* species present during the 1981 test were primarily *C. hollensis* (97.3%) with a few *C. melleus* (Coquillett) (2.6%). The

Table 1. Summary of weather conditions (ground level) and spray parameters during aerial adulticide applications at Parris Island, SC.

Spray date	Time of spray Start	Time of spray End	Flight altitude (m)	Flight headings (°)	Swath width (m)	Wind direction (°)/speed(km/h) Start	Wind direction (°)/speed(km/h) End	Temperature (°C)/RH (%) Start	Temperature (°C)/RH (%) End
				1981 Experiment					
April 7	1729	1753	76.2	138/318	609.6	080/13	090/13	16/51	16/58
April 7	1750	1811	91.4	138/318	609.6	090/13	090/13	16/58	16/58
				1982 Experiment					
April 21	1815	1845	61.0	098/278	304.8	210/07	Calm	23/80	22/81
April 22	1745	1820	45.7	098/278	304.8	050/11	020/06	20/67	18/66

trap collections of mosquitoes and tabanids during the 1981 test were too low for control evaluations.

During the 1982 test, 3 species of biting midges were present as follows (based on trap collections before treatment): 80.6% *C. hollensis*, 12.4% *C. melleus* and 7.0% *C. furens* (Poey). The mosquito species present during the 1982 tests included 31.4% *Culex quinquefasciatus* Say, 22.8% *Aedes vexans* (Meigen), 18.1% *Anopheles crucians* Wiedemann, 17.2% *Ae. taeniorhynchus* (Wiedemann), 8.3% *Ae. sollicitans* (Walker) and 2.1% *Ae. infirmatus* Dyar and Knab. The only tabanid collected in sufficient numbers for control assessment was *Chrysops fuliginosus*. Data analysis for these tests was based on the sum of both sexes of all species collected for each of the 3 insect groups.

In addition to the natural population surveillance, caged mosquitoes and biting midges were placed in the treated area to measure spray distribution and effectiveness. Caged insects were available for all but the first 1982 application. *Aedes taeniorhynchus* females reared in the laboratory at Gainesville, FL were used in the caged insect bioassays as described by Haile et al. (1982) and Mount et al. (1970). Mosquitoes were placed in cages (25/cage) and transported to Parris Island on the day of treatment. The mosquitoes were transferred to clean holding cages ca. 30 min after exposure and held for 12 hr before recording mortality. The biting midges used in cages were field-collected from Parris Island on the day of application using a modified CDC trap baited with CO_2. They were aspirated into cages (ca. 25/cage) constructed of ½ pint (0.24 liter) cylindrical paper cartons with 40 ga brass screen wire on the top and bottom. Cages of both insects were placed on wooden stakes ca. 4 ft (1.2 m) above the ground. During the 1981 applications, 65 cages of mosquitoes were placed in the treated area (Fig. 1), at ca. 0.1 mi (0.16 km) intervals, along with 11 cages of biting midges. During the second application in 1982, 30 cages each of mosquitoes and biting midges were placed along roadways of the island at ca. 0.2 mi (0.32 km) intervals (Fig. 1). A limited number (4–6) of cages of both insects were also placed in the check areas to monitor the natural mortality in the cages, which was very low (less then 8%) in these tests. No corrections for natural mortality were made in the analysis of mortality in the treated area.

RESULTS AND DISCUSSION

Results of the 1981 applications indicated only a low level of control of *Culicoides* biting midges after the application of 0.5 oz/acre (36.5 ml/ha) of Dibrom 14. The surveillance trap collections of biting midges in the treated area actually increased from 888/trap before treatment to 2,575/trap on the day after treatment. However, trap collections in the check area also increased (1,238 to 4,696/trap) and, assuming that the same rate of increase would have occurred in the treated area, 24% control could be attributed to the aerial applications. The results of the caged insect bioassays were only slightly better with a mean mortality of 58% in caged biting midges and 67% in caged mosquitoes.

We think that the most important factors contributing to the low level of control for the 1981 applications include the low dose of active ingredient, marginally high winds and high spray altitude. The combination of these factors resulted in an inadequate penetration of toxicant into vegetated areas. This lack of penetration was demonstrated by the pattern of kill in the caged mosquitoes, where an average of 87% mortality was obtained in cages placed in open or sparsely vegetated areas and only 40% kill was noted in cages protected by dense vegetation. Observations in the treatment area during the applications suggest that the insecticide produced an increase in biting by the *Culicoides*, however, the dose of active ingredient was apparently too low to provide significant relief from biting.

The survey trap collections during the 1982 test indicated a satisfactory reduction in the natural population of *Culicoides* spp., as well as mosquitoes and *Chrysops fuliginosus*, (Fig. 2) following the 2 applications of 1.0 oz/acre (73.1 ml/ha) of undiluted Dibrom 14. Trap collections on the day following the second spray were reduced by more than 99% compared to the day before the first treatment. This level of suppression was maintained for at least 3 days following the last treatment. Trap collections of biting midges and mosquitoes (no *Chrysops fuliginosus* were collected) in the check area (Sam's Point) were consistently lower than those on Parris Island, but counts remained relatively stable throughout the test period (Fig. 3). Part of the reduced trap collections on Parris Island could have resulted from environmental effects, however the depth and duration of the reduction indicate that the sprays were the major factor. The reduction in numbers of specimens collected in traps in the treated area on the day following the first application (before the second spray) was 63, 80 and 69%, for *Culicoides* spp., mosquitoes and *Chrysops fuliginosus*, respectively. However, these values do not represent the full impact of the first application since many of the specimens in the post treatment trap collections were collected during and immediately after the spray application. This is particularly true for *Culicoides* spp. since ground observations indicated that biting activity increased as a result of the chemical application, as it did in the 1981 test. However, observations during both 1982 spray applications showed that the increase in biting activity lasted only ca. 5 min before the effects of the insecticide began to suppress *Culicoides* spp. biting.

Further evidence of the effectiveness of the 1982 sprays was indicated by the high mortality of caged insects in the treated area during the second spray, which averaged 95% for *Culicoides* spp. and 96% for mosquitoes. Only insects in cages placed at the northern end of the spray

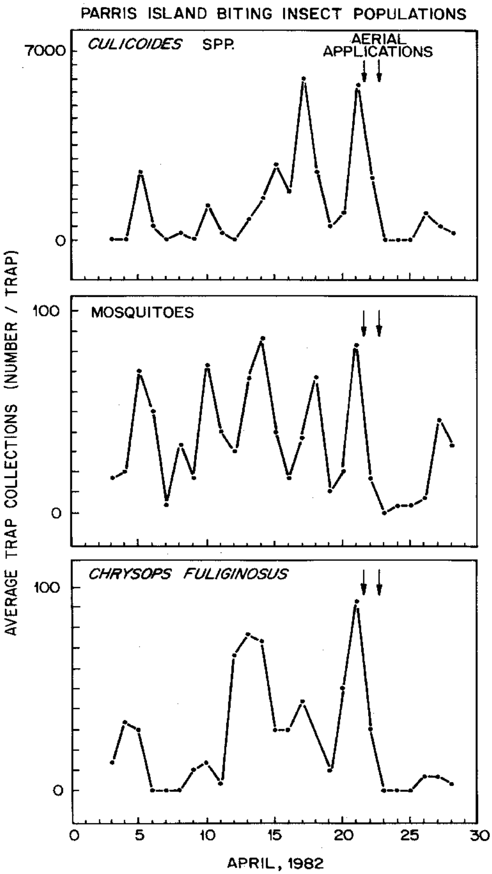

Fig. 2. Graphs of the natural population trends of *Culicoides* biting midges, mosquitoes and *Chrysops fuliginosus* based on average trap collections during April 1982, showing the effects of aerial applications of 1.0 oz/acre of Dibrom 14® on April 21 and 22.

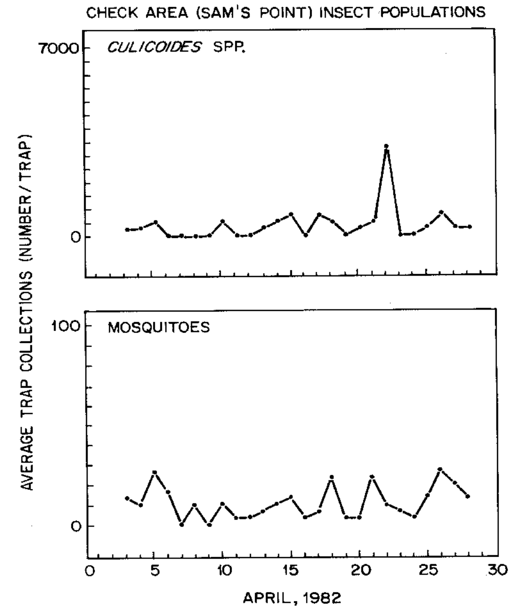

Fig. 3. Graphs of the natural population trends for *Culicoides* biting midges and mosquitoes in an untreated area (Sam's Point) during the 1982 aerial applications.

area (which was the windward side for this application) had significantly less than 100% mortality because of spray offset downwind. The high mortality in caged insects over the remainder of the island, whether open or vegetated, indicated that good penetration of vegetation was obtained with the higher dose of active ingredient applied in the 1982 test.

In conclusion, the 1982 experiment shows that ULV aerial applications of insecticides can be effectively used to reduce populations of *Culicoides* spp., as well as mosquitoes and tabanids, in non-isolated coastal areas, when the applications are made with sufficient toxicant dose levels and frequency. Additional field tests are needed to further define the effect of weather conditions, chemical dilution, operational parameters and application interval on overall efficiency and duration of control.

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