OPERATIONAL NOTE

EFFECT OF VEGETATION PATTERNS ON EFFICACY OF A GROUND ULV SPRAY OF AQUARESLIN® AGAINST A NATURAL POPULATION OF *CULEX PIPIENS PALLENS*

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ABSTRACT

A field study was conducted to evaluate control efficacy of ground ultra-low-volume (ULV applications (Aquareslin® against a natural population of *Culex pipiens pallens* in three different vegetation areas (dense, open (grassland, and sparsely vegetated in Changping county, Beijing City, China. Over 80% population decline rates (PDRs were achieved from the different vegetation levels. Significantly higher PDR was achieved in the sparsely vegetated habitat compared to the dense and open habitats. Significant higher reduction (% of parity in female mosquitoes was found in the open grassland and sparse vegetation level, compared with the dense vegetation level. Control efficacy of ground ULV spray against a natural population of *Cx. pipiens pallens* was impacted by the different vegetation levels.

Key Words: permethrin, ULV spray, habitats, vegetation pattern, parity

INTRODUCTION

Culex pipiens pallens Coquillett is a member of the *Cx. pipiens* complex (Zhao and Lu, 1994, Wu et al. 2014), which is distributed widely in the northern part of China and is considered a vector of *Wuchereria bancrofia* (Lu 1999). Source reduction and catch basin management are the primary methods for control of *Cx. pipiens pallens*. However, ground ultra-low-volume (ULV) applications of adulticides is still one of the important control measures in mosquito abatement programs around the world (Mount 1998).

Cx. pipiens pallens mosquitoes preferentially feed on birds and rest in vegetated areas (Lu 1999). Adult mosquitoes need vegetation for sugar feeding, water drinking, resting, and hiding (Xue 2008). The vegetation coverages directly relate to the population abundance of adult mosquitoes. The high number of mosquitoes usually resulted in the high number of service requests by residents (Davidson et al. 2016, Davis et al. 2022). A few field experiments have shown that the presence of vegetation influenced the adulticiding efficacy (Linley & Jordan 1992, Floor et al. 1991, Lothrop et al. 2002, Barber et al. 2007). Focks et al. (1987) documented that gravid female mosquitoes remain sequestered during treatment periods in places that are well protected from aerosols. Lothrop (2002) and Barber et al. (2007), confirmed that vegetation density impacted the control efficacy of ground sprays of permethrin and malathion against caged salt marsh mosquitoes.

The objective of the current study was to determine the effectiveness of the Ultra-Low-Volume (ULV) spray of Aquareslin®, a permethrin product against a natural population of *Cx. pipiens pallens* and the parity states of the female mosquitoes collected from the different vegetation density areas.

The site (5.59 hectares) located in the east part of the Changping county (N40.2161, E116.2347), Beijing, China was chosen for this study. The vegetations in the area are primarily *Bambusauentricosa multiplex* L., *Juniperus chinensis* L., *Sophora japonica* L., *Pinus tabulaeformis* Carr., and *Salix babylonica* L.

The area was divided into 3 sections based on vegetation coverage: dense (>80% coverage) sparse (approximately 30%), and open grassland. The 3 sections were next to each other with about 100 meter distance (Fig.1). The experiment was conducted at 19:30 hrs, just after sunset, in late July. Air temperatures ranged from 30.5°C to 31.5°C with a relative humidity of 50%. Wind velocity was measured with a hand-held wind meter and recorded as consistent winds of 0.7m/s during the application.

Aquareslin® with the active ingredients (A.I.) S-esbiothrin, permethrin, and PBO at 1.5:108:110 g/L was provided by Bayer Company, Beijing Branch, China and diluted at 1:9 (1 part of Aquareslin and 9 parts of tape water) before the ULV spray. The ground ULV spray rate of 15.39g AI/ha was used. A truck-mounted DYNA L30 cold aerosol generator (Curtis DYNA-Fog, Jackson, GA 30233) was used to spray the mixture materials. The spray route was designed to make sure that the Aquareslin ULV spray covered all of the habitats. The trucks traveled at a speed of 8 km/hour. Flow rate calibrations were completed prior to the treatments, and the rate of output was 590 mL/minute. The three different vegetated areas were treated by spray of the same adulticide at the same time. A fifty-meter buffer zone around each of the three vegetation areas was designated as a quarantine zone. The most upwind area in relation to the three treated areas was designated to be the untreated control area.

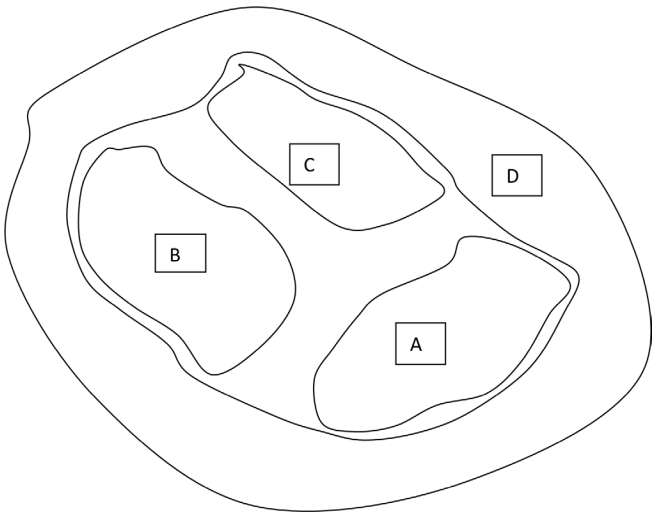

Figure 1. Diagram of the study site showing the distribution of different sections, based on vegetation pattern as well as buffer zones. A: dense vegetation area. B: sparse vegetation area; C: open grassland area. D: quarantine zone as control.

Adult mosquitoes were collected with a portable battery-operated aspirator in a mosquito net (top: 80×80 cm^2, bottom:150×150cm^2, H:120cm) hung a half meter above the ground. A volunteer (the volunteer signed the consent form and accepted the guidelines established by the institute handbook on risk associated with mosquito exposure) was in the net as the human bait to attract mosquitoes. Three collection sites were selected at central locations within each vegetated area. The pre-collection was conducted half an hour before the ULV application and post-treatment collections were conducted half an hour post application. Collection at each area was conducted for 20 minutes. All collected mosquitoes were brought to the laboratory for species identification and dissected for the parity evaluation. *Cx. pipiens pallens* was the main species collected from the all areas.

The control efficacy of ground ULV spray of Aquareslin® against a natural population of *Cx. pipiens pallens* was justified by the relative population index (RPI) and population decline rates (PDR) after spray, compared with the RPI and PDR before the spray. The RPI and PDR were calculated using the following formula:

$$RPI = \frac{Cb \cdot Tp}{Cp \cdot Tb}$$

Cb: mean density of mosquitoes in control area before treatment.

Tp: mean density of mosquitoes in test area after treatment.

Cp: mean density of mosquitoes in control area after treatment.

Tb: mean density of mosquitoes in test area before treatment.

PDR=(1-RPI)x100%

PDR: population decline rate (%)

The female mosquitoes collected were dissected under a microscope for parity status (parous and nulliparous) in the laboratory based on the description by Detinova (1962).

The data was analyzed by multiple way ANOVA and the means were separated by Tukey's HSD test.

After the ULV spray, the RPIs of *Cx. pipiens pallens* in dense vegetation area, open grassland, and sparse vegetation area were 0.16, 0.15, and 0.04, respectively (F =23.271, df=2, and P<0.05(Table 1). Therefore, the PDRs of *Cx. pipiens pallens* were 84% in dense vegetation area, 85% in open grassland, and 96% in the spare vegetation area, respectively. The percent PDR of mosquitoes caused by the ULV spray in the sparse vegetation area was significantly higher than the rates obtained from the open grassland and dense vegetation area (P<0.05). The results indicated that the droplet clouds of Aquareslin® could penetrate through the sparse vegetation pattern and a majority of the mosquitoes were killed in this area. Rathburn et al. (1989) proved that more droplets of insecticides were sampled in the open area than in the vegetated area. Other studies found that insecticide applied in moderately vegetated residential areas were less effective than in the open area with caged laboratory-reared mosquitoes (Floore et al. 1991, Baber et al. 2007). However, it was surprising that the Aquareslin® ground ULV spray in the open grassland area did not result in a significantly higher PDR, compared to the rate in the sparse vegetated area in our experiments. Migrating mosquitoes from the adjacent vegetated area may have caused the low value of the PDR of mosquitoes in open grassland. Also, the wind in the open grassland area may play a major role due to non-vegetation barrier impact during the application of Aquareslin®. This has been documented by Inman et al. (1997). The higher PDR of mosquitoes in the sparse vegetation area may have been caused by the Aquareslin® ULV spray deposited on the vegetation. The insecticides on vegetation may result in more mortality of adult mosquitoes through the contact.

The efficacy of an Aquareslin® ground ULV spray on parous rates of a natural population of *Cx. pipiens pallens* was justified by the percent parous and nulliparous female mosquitoes after the treatments, compared with the rates before conducting the ULV spray. The parous rates in the female mosquitoes before and after the ULV spray in dense vegetation area, open grassland, sparse vegetation area, and control area are presented in Table 2. After the ULV spray, the parous female mosquitoes in the open grassland area were significantly reduced (F=36.75, df = 1, P <0.05). Our field experiment showed a 100 % parous reduction in the natural population of *Cx.*

Table 1. The number of mosquitoes captured before and after an application of Aquareslin® ground ULV spray by each vegetation pattern in Changping, Beijing, China.

	Before treatment	After treatment	RPI
Dense vegetated	199	105	0.1607
Open grassland	104	9	0.1538
Sparse vegetated	76	39	0.0264
Control	12	39	

Table 2. The effect of an Aquareslin® ULV spray on parous rates (%) of female Culex pipiens pallens in three different vegetation patterns in Changping, Beijing, China.

	Before treatment			After treatment		
	Parous	Nulliparous	Parous Rate	Parous	Nulliparous	Parous Rate
Dense vegetated	12	31	27.9	9	21	30
Open grassland	7	15	31.8	0	10	0
Sparse vegetated	12	20	37.5	1	2	33.3
Control	3	8	27.3	7	21	25

T =1.176, df= 3, P = 0.325

pipiens pallens after the Aquareslin® ULV spray and these results support the observations by Zeng et al. (1991). Higher mortality in parous female *Cx. pipiens pallens* were recorded based on the Deltamethrin and Cypermethrin (Fendona) treatment, compared to the mortality in nulliparous mosquitoes (Zeng et al. 1991). Theoretically, parous mosquito and nulliparous mosquitoes had equal chances to be killed or survive. Some mosquitoes survived because they rested in secluded places, such as beneath tree bark and underneath leaves. Since there were fewer resting sites in the open grassland area, most mosquitoes collected in this area were migrating from neighbouring treated areas. Low parous mosquito collections after treatment in the open grassland area may indicate that nulliparous mosquitoes were more active in blood feeding than the parous ones.

Different vegetation patterns in treated areas affected the control efficacy of a ground Aquareslin® ULV spray against a natural population of *Cx. pipiens pallens*. Also, the ULV spray provided effective control for parous female mosquitoes in the open area.

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