SHORT COMMUNICATION

Failure of a Permethrin Treatment Regime to Protect Cattle Against Bluetongue Virus

BRADLEY A. MULLENS, 1 ALEC C. GERRY, 2 AND ROBERT K. VELTEN

Department of Entomology, University of California, Riverside, CA 92521


ABSTRACT Holstein heifers in a confined feedlot setting on a southern California dairy were either sprayed individually along the ventral midline using 0.2% permethrin (250 ml/animal) (two pens) or were not treated (two pens). Treatments (n = 6 dates) were applied every 2 wk during the peak fall bluetongue virus transmission season (22 August—29 October). Animals seronegative for bluetongue virus antibodies at the initial bleeding on 15—18 September (n = 106 in the treatment pens and n = 117 in the control pens) were bled again for testing 2 mo later (12—13 November). Seroconversion rates were not significantly different: 56% for the treated animals and 48% for the controls (P > 0.2). The area has many essentially contiguous, confinement dairies with wastewater ponds that produce large numbers of Culicoides sonorensis Wirth & Jones, the primary bluetongue virus vector. Further, these dairies presumably provided a large reservoir of virus-infected cattle to infect vectors in the immediate area. Under these severe virus challenge conditions, permethrin applied at 2-wk intervals failed to reduce exposure to bluetongue virus.

KEY WORDS Culicoides, Ceratopogonidae, bluetongue, permethrin, animal protection

BLUETONGUE VIRUSES CONTINUE to cause significant disease in susceptible U.S. ruminants, particularly wild and domestic sheep, and to impact trade with bluetongue-free regions such as western Europe (Roberts et al. 1993). These trade restrictions cost U.S. producers an estimated $125 million annually (Tabachnick 1996).

The principal vector of bluetongue viruses in domestic animal settings in the United States is considered to be the biting midge Culicoides sonorensis Wirth & Jones (formerly C. variipennis sonorensis Wirth & Jones) (Holbrook et al. 2000). Adequate levels of vector control theoretically should result in reduced exposure to insect-transmitted pathogens. This might be accomplished through control directed at the larval habitats (Holbrook et al. 1993), use of repellents (Braverman and Chizov-Ginsberg 1997), or possibly use of insecticides applied to animals. Some studies have been done on the susceptibility of C. sonorensis to insecticides, including fast-acting pyrethroids. Hair samples removed from cattle treated with fenvalerate ear tags were toxic to C. sonorensis in the laboratory for at least 70 d (Holbrook 1986). A 65% permethrin spot-on applied to the dorsum of goats interfered with blood-feeding by laboratory C. sonorensis through dorsal hair samples for up to 65—67 d (Mullens 1993). More recently, field trials showed that treatment of cattle with a 0.2% permethrin belly spray significantly reduced (~80%) the number of C. sonorensis able to feed on and then leave treated calves (Mullens et al. 2000). The effect lasted 7—10 d, but prior bioassays suggested that it was possible for C. sonorensis to feed to some degree through treated hair before being killed (Mullens et al. 2000).

The current study reports results of a trial to determine if application of permethrin might affect bluetongue seroconversion rates of cattle in the field.

Materials and Methods

A commercial 1,200-cow dairy herd in the Chino Basin of western San Bernardino County, CA, was selected for the test. This region contains ~250,000 cows in a 75-km² area. As with other local dairies, Holstein-breed cattle were held in confinement and fed hay and concentrates. The lack of pasture space has resulted in most dairies having wastewater ponds, most of which support populations of C. sonorensis (Mullens 1989). We have detailed records on both C. sonorensis activity and bluetongue seroconversion rates on this dairy for the years 1993—1997 (Gerry et al. 2001). Most seroconversions occurred beginning in late August to mid-September, peaked in late September through October, and seroconversions were essentially completed by mid-November.

In August 1998, four adjacent pens of dairy heifers, 10—16 mo old, were selected. Pens measured 62 by 44 m and held ~100 heifers each. The row of pens ran north-to-south, perpendicular to the prevailing westerly breezes. The front length of the pens had self-
locking head stanchions, and an entire pen of heifers could be locked up or released simultaneously during the morning feeding. The first pen was randomly assigned to a treatment or control (nontreatment) regime, and the remaining pens followed in an alternating fashion. Numbered from south to north, pens 1 and 3 were controls, and 2 and 4 were treatments. Heifers were individually identified by ear tag number. Animals were not transferred from their pens during the study.

Beginning 22 August, all heifers in the treatment pens were sprayed with an aqueous solution of 0.2% permethrin (Atroban 11% EC). Although the concentration was higher than the label rate (0.05%), the total amount of insecticide and the 2-wk frequency of applications were based on label recommendations for control of other cattle pests using a whole-body permethrin spray. Using a calibrated, low-pressure sprayer (114-liter capacity) mounted in a truck, a person walked along behind the locked animals and applied 250 ml of solution per animal using a long-handled spray wand and a cone nozzle. The wand was inserted between the hind legs, and a single pass was made from the brisket to the udder. Another single pass was made along the belly from each side of the animal, thoroughly wetting the belly for a distance of 20 cm to either side of the ventral midline. This is the preferred feeding area for C. sonorensis on cattle (Jones and Akey 1977, Mullens et al. 2000). Animals were treated every 2 wk, for a total of six applications (22 August, 4 September, 18 September, 1 October, 15 October, and 29 October). Applications were made in the morning, when winds were mild, but westerly breezes further minimized drift among pens.

Presence of bluetongue virus antibodies was detected using a commercially available c-ELISA (Bluplate Special, Diagxotics, Wilton, CT) as per the manufacturer’s instructions. Each plate had several positive and negative control sera. This test quantifies the amount of bluetongue serogroup-specific antibodies in the serum, but does not distinguish among serotypes. Most cattle seroconvert within 10 d after being exposed to bluetongue virus, although some animals require 10–20 d for antibodies to be detected (Ashfar et al. 1993). Because of this time lag, we began the spraying 23 d before the first blood samples were taken, ensuring that no initially seronegative animals at the first bleeding actually had been exposed before the insecticide treatments began. Blood samples were taken from the jugular vein into 10-ml Vacutainers (Becton Dickinson and Company, Rutherford, NJ), labeled by individual ear-tag number and date. A new needle was used for each animal. The clotted blood was centrifuged, and 2 ml of serum was removed and frozen (−20°C) for subsequent testing. The first blood samples were taken on 15 and 18 September. Heifers clearly seronegative (<30% inhibition on the ELISA) from the first bleeding were rebled at the end of the trial (12–13 November). The numbers of initially seronegative animals seroconverting at the end of the trial were compared using chi-square analysis (α = 0.05).

Results and Discussion

By pen, seroconversion was 28/65 (43%) and 28/52 (54%) in control pens 1 and 3, respectively. Seroconversion was 25/52 (48%) and 34/54 (63%) in treatment pens 2 and 4, respectively. The numbers seroconverting during the treatment period clearly were not significantly different for the first two pens ($\chi^2 = 0.291$, df = 1, $P > 0.5$), for the second two pens ($\chi^2 = 0.907$, df = 1, $P > 0.2$), or for the pooled permethrin-treated compared with pooled control groups ($\chi^2 = 1.35$, df = 1, $P > 0.2$). Overall, a total of 59/106 (56%) heifers converted in the permethrin-treated groups, versus 56/117 (48%) in the control groups (Fig. 1).

The observed seroconversion was higher than the 18–38% yearly incidence shown at this site in the prior 3-yr period (Gerry et al. 2001). At the initial bleeding in mid-September, 32% of heifers already had seroconverted and thus were not specifically used in the study. Some of these heifers were up to 16 mo of age and conceivably could have been exposed the prior year. Still, this prevalence suggested that transmission may have begun somewhat earlier than in past years.

Prior field trials had shown substantial reduction (~80%) in engorged C. sonorensis taken in enclosure traps used with calves treated with 250 ml permethrin on the belly (Mullens et al. 2000). The effects were clear at three and 7 d posttreatment. Even though efficacy had declined substantially by 10 d posttreatment, it would seem that good protection for 7 d posttreatment, if present, might have been reflected in some reduction in seroconversion of heifers treated at 2-wk intervals. However, insects in that prior study may have fed and then died before they could fly to the inside of the netting for collection. Thus, the data do not necessarily mean the treated animals actually were bitten less, i.e., “protected.”
The hair in the belly region is relatively sparse, particularly near the umbilicus and udder, both favored locations for *C. sonorensis* feeding. As opposed to other body regions, then, insects would perhaps make little contact with treated hair and might begin feeding before being incapacitated by insecticide residues. While total engorgement was reduced by contact with high permethrin residues on hair in laboratory bioassays, a number of female *C. sonorensis* fed before being incapacitated (Mullens et al. 2000). If this also was the case with naturally feeding insects in the current study, it might have contributed to the lack of reduction in bluetongue seroconversion rates.

Other studies have demonstrated reduced numbers of biting Nematocera as a result of pyrethroid treatment of animals in the field. For example, again using an enclosure trap approach, Shemanchuk and Taylor (1984) showed significant reductions in blood-fed black flies leaving cattle for about 2 wk after treatment with 10% permethrin ear tags. Field studies also have shown reductions in naturally engorged mosquitoes in the vicinity of permethrin-treated cattle herds (Nasci et al. 1990, Focks et al. 1991). Nevertheless, few studies have examined insecticides in the context of interrupting disease-agent transmission to animals by biting flies. Probably the most thorough studies have been with tsetse flies and African trypanosomiasis, in which case disease-control benefits actually may exceed apparent reduction in vector biting rates (Baylis and Stevenson 1998).

In the current study, we were testing the potential of permethrin for short-term animal protection, and it did not appear useful at the rate and frequency used. However, the test herds were situated in the middle of a region with high vector biting rates (Mullens and Gerry 1998) and thousands of nearby untreated cattle that could serve as a virus reservoir. In more isolated settings one might treat a larger proportion of available hosts, resulting in suppression in vector populations and thus biting rates over a longer time frame. Testing of insecticides and/or repellents in such a scenario might be particularly useful.

Acknowledgments

We appreciate the assistance of the Van Ryn Dairy in these studies. The permethrin was kindly supplied by B. G. Endris (Schering-Plough Animal Health, Union, NJ). Thanks are due to E. T. Schmidtmann, USDA-ARS, Laramie, WY, for helpful comments on an earlier draft of the manuscript.

References Cited


Received for publication 15 August 2000; accepted 8 May 2001.