Recharging Centers for Disease Control Light Trap Batteries with Solar Panels

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Abstract

Although Centers for Disease Control (CDC) light traps and other battery-powered traps can be deployed virtually anywhere, one of their principal drawbacks is that the batteries have to be recharged daily. Thus, recharging with a solar panel would render them much less labor-intensive. To that end, a system was designed to connect a solar panel to the battery of a CDC light trap to recharge the battery. There was no significant difference between traps connected to solar panels(solar traps) and traps not connected to solar panels (control traps) in the number of Aedes vexans, Coquillettidia perturbans, Culiseta inornata, and Aedes dorsalis that they collected. Batteries connected to solar panels operated traps significantly longer than batteries without solar panels. Making the operation of traps less labor-intensive would increase the number of traps that can be deployed and/or the number of sites sampled.

Key words: solar, CDC light trap, *Aedes vexans*, *Coquillettidia perturbans*, *Culiseta inornata*, *Aedes dorsalis*

Introduction

Battery-powered traps have been the best method to sample populations of mosquitoes and other biting flies for more than half a century. During this period, many different types of traps have been designed for different purposes. (Silver, 2008).One of the most widely-used battery-operated traps is the Centers for Disease Control (CDC)miniature light trap developed by Sudia and Chamberlain(1962). Its popularity arguably can be attributed to its versatility, dependability, its ability to attract a large number of different mosquito species and features such as the air gate and photoswitch. The principal advantage of the CDC light trap and other battery-powered traps is that, unlike AC-powered traps such as the New Jersey Light Trap (Mulhern 1942), battery-powered traps can be deployed virtually anywhere, because their power source is very portable. However, with the exception of brand-new batteries, the batteries typically used with these traps cannot supply more than 12 to 18 hours of current sufficient for optimal function of the trap. Therefore, the CDC light trap must be visited every 24 to 48 hours to replace the depleted battery with a recharged battery.

The advent of solar panel technology has made it possible to recharge a trap's battery with a solar panel, enabling the battery to provide adequate current to the trap for an extended period and thus making trapping less labor-intensive.The present study was conducted to:

1. Determine whether a solar panel could recharge a CDC light trap's battery sufficiently enough to operate the trap for an extended period of time.
2. Test whether the use of a solar panel affects the sampling ability of the CDC trap.

Materials and Methods

A 6-watt, 6-V SunWizeSolCharger solar panel (GoGreenSolar.com, West Covina, CA) was used to recharge CDC light trap batteries. A trap and solar panel were attached to a support structure made of 3.8 cm diameter white polyvinyl chloride (PVC) piping (Fig. 1). The trap was attached to a 45-cm horizontal piece of PVC that was attached to a 2-m vertical PVC support pole by a "T"-shaped PVC connector. The solar panel was screwed to a metal support structure that was screwed to a 10-cm X 10-cm X 1-cm wooden block. Ideally, in order to give the panel optimal exposure to solar radiation and to maximize power production, the solar panel should be tilted at an angle approximately equal to the latitude of the site and facing within 15 degrees of due south (Gunerhan and Hepbasli, 2007). The latitude of the field site was 48.94 degrees north, so the metal was bent to approximate this angle. The bottom of the wooden block was glued to a 10-cm length of PVC pipe that was attached to the "T"-shaped PVC connector. To hold the PVC support structure upright,a 1m X 2.5cm X 2.5cm cedar stake was driven ~20cm vertically into the ground and the PVC support pole was slid down on the stake like a sleeve. The battery was placed inside a plastic battery case to prevent rain and dew from collectingon the battery terminals and potentially causing electrical failure. The solar panel and the trap were wired directly to the battery (Fig. 2). The wires connecting the trap and solar panel with the battery were passed down through the center of the PVC piping and then out a hole 60 cm from the bottom of the piping to connect to the battery. The control circuit for the CDC light trap's fan, bulb, and photo switch was included in the trap's design. To maximize the amount of power output from the solar panels, the traps were put in open fields in both trials of this study so that they were in the sun the whole day.

The first trial was conducted toascertain whether the solar panels influenced the number of mosquitoes collected by the traps. The field site was an uncut, rectangular hayfield that measured 240 m north to south and 80 m east to west and was bordered by a road to the south and trees on the other three sides 0.5 km north of Belcourt, ND. Aminiature CDC light trap (cat. # 2848BQ, BioQuip Products, Inc., Rancho Dominguez, Ca) with a UV blacklight lamp and a photo switch that turns the light on at dusk and off at sunrise was used. Seven CDC light traps connected to solar panels and 7 control traps without solar panels were assigned random positions in 2 north-south rows of 7 in the middle of the field. The traps were positioned 30 m apart (Meyer et al., 1984). Each trap was powered by a 36-Ah PS-6360NB battery (Power-Sonic Corp., San Diego, CA). The control traps were hung on the same type of PVC support structure as the traps connected to solar panels, but they did not havesolar panels. All traps were set up on the afternoon of August 13, 2011 and operated for 3 consecutive nights. An hour after sunrise each morning, the insect collection bag on each trap was replaced.The voltage of batteries on all traps was measured and recorded daily with a handheld multimeter. Mosquitoes collected in each trap were identified to species using Darsie and Ward (1981).

Because the mosquito capture data from trial one were not normally distributed, a non-parametric test, the Wilcoxon Rank-Sum Test of Independent Samples (Statdisk, Pearson Education, Inc., Upper Saddle River, NJ), was used to find out whether mean numbers of females of each species collected by the control traps and the solar traps were significantly different. Only data for species that were collected by more than half the traps were statistically analyzed. The 3 nights' catch data from each trap were combined, and the total numbers of females of each species collected in each trap were analyzed statistically. A second trial was conducted to determine the differences in battery life between systems with solar panels installed and the controls. The site, a lawn about 60 m north to south and 130 m east to west with a house in the northwest corner, was 6.5 km northwest of Belcourt, ND. The lawn was bordered by a pond to the south and trees on the other 3 sides. The trap used was the UV LED CDC light trap (cat. # 2770, BioQuip Products, Inc., Rancho Dominguez, CA) with an in-line photo switch (cat. # 2796, BioQuip Products, Inc., Rancho Dominguez, Ca) that turns the trap on at dusk and off at sunrise. The UV LED CDC light trap was developed by Cohnstaedt et al. (2008) to require less energy and to deliver wavelengths within the range of 385 to 395 nanometers, which are more attractive to medically important dipterans than light sources in earlier iterations of the CDC light trap.

Two different types of batteries were used: the 6-V, 12-Ah UB6120 battery (EnerSys Energy Products Inc., Warrensburg, MO) and the 6-V, 36-Ah battery used in the first trial. Six traps, 3 of which had 12-Ah batteries and 3 of which had 36-Ah batteries, were connected to solar panels. Six control traps, 3 of which had 12-Ah batteries and 3 of which had 36-Ah batteries, were not connected to solar panels. All 12 traps were hung on the type of PVC support structure described above. Instead of a cedar stake, a 2-cm diam. length of rebar 1.5 m in length was used to hold each structure upright. Traps were deployed at 20 m intervals (Freier and Francy 1991 at randomin a 3 X 4 Latin square pattern. At sunset each day, the charge on the batteries was measured with a handheld multimeter and any loss of function (LED not lit or fan not spinning) was noted. Traps were deployed on the afternoon of May 31, 2012 and operated for 21 consecutive nights.

Results

Females of twelve species were collected by the light traps in trial 1:*Aedescinereus*Meigen, *Aedesvexans* Meigen, *Anopheles earlei*Vargas, *Anopheles walker* Theobald, *Coquilletidiaperturbans*(Walker), *Culextarsalis* Coquillet, *Culisetainornata*(Williston), *Aedesdorsalis* (Meigen), *Aedesexcrucians* (Walker), *Aedesflavescens*(Mueller), *Aedespunctor*(Kirby), and *Aedesspenceriispencerii*(Theobald). Only 4 species were collected in numbers large enough for statistical analysis (Table 1). There was no significant difference between the solar and control traps in the number of *Ae. vexans*, *Cq. perturbans*, *Cs. inornata*, and *Oc. dorsalis* that they collected ($P > 0.05$, Wilcoxon Rank-Sum Test of Independent Samples).

Trial two continued for three weeks, the trial was ended at that point because it is doubtful that anyone would operate a light trap for more than this length of time without at least collecting the insects from it. If insects were being collected from the trap, one might as well change the battery at the same time. Each trap connected to a solar panel functioned each night for the duration of the 21-night trial. The 3 control traps powered by 12-Ah batteries ceased functioning after 2, 3, and 6 d. The 3 control traps powered by 36-Ah batteries ceased functioning after 7, 10, and 10 days. Amongst the traps powered by 12-Ah batteries, those connected to a solar panel functioned significantly longer than those not connected to solar panels ($P < 0.01$, t-test of independent samples, Microsoft Office Excel 2007). Similarly, amongst the traps powered by 36-Ah batteries, those connected to a solar panel functioned significantly longer than those not connected to solar panels ($P < 0.01$, t-test of independent samples, Microsoft Office Excel 2007). Amongst the control traps, those powered by 36-Ah batteries operated for significantly longer ($P < 0.02$, t-test of independent samples, Microsoft Office Excel 2007) than those powered by 12-Ah batteries.

Discussion

The use of solar panels in trial 1 to recharge light trap batteries did not modify the ability of the traps to attract and collect mosquitoes (Table 1). The solar panel was not expected to influence a trap's ability to collect mosquitoes, but it was necessary to verify it empirically. The species collected were typical for light trap collections in the part of North Dakota in which the study was conducted (Hanson et al., unpublished data).

Because trial one did not last long enough to deplete the control traps' batteries, trial two was conducted to find out whether a solar panel really extends battery life.The results of trial 2 show that the solar panels can maintain adequate voltage in both types of batteries for much longer than possible without solar panels. Therefore, the solar panel extends the length of time a battery can operate a trap in the field without needing recharging with a standard AC-powered battery charger. Making the operation of traps less labor-intensive would increase the number of traps that can be deployed and/or the number of sites sampled. The ability to deploy more traps could increase the number of dipterans collected.

Arguably the major drawback to using battery-powered traps is that one must visit each trap often to replace the discharged battery with a recharged battery. Before the development of the UV LED CDC light trap, CDC light traps drew so much power that their batteries had to be recharged after either 1.5 or 4 nights, depending upon the type of bulb used (Cohnsteadt et al. 2008). The UV LED CDC light trap draws .24 A, thus consuming roughly 2.4 Ah/night when operated for a 10 h/night. Therefore, a 12-Ah battery and a 36-Ah battery should be able to power a UV LED CDC light trap for ~5 and ~15 nights respectively, which approximates the results of this study for the 12-Ah batteries but exceeds the results for the 36-Ah batteries. Cohnsteadt et al. (2008) found that 17.5 Ah of battery power could operate UV LED CDC light traps for 8 consecutive nights, and which agrees with the results of the present study with 12-Ah and 36-Ah batteries.

Furthermore, the present study shows that the UV LED CDC trap can operate unaided for at least 21 days with a solar panel. Future studies will measure whether the solar panels can maintain adequate voltage in the batteries when they are attached to light traps that draw more current than the type of trap in the present study. Because much, if not most, trapping of dipteran vector species is conducted in wooded areas, future research should examine how well solar panels can recharge CDC light traps in wooded areas. Lower light levels in wooded areas may necessitate a type of solar panel different from the one in the present study. For that reason, future studies may include another type of solar panel.

All batteries lose capacity over time. Future studies will determine the life cycle – defined as the number of cycles for which the battery maintains at least 80% of its original capacity – for the batteries in this study. However, thebatteries' performance will likely diminish over longer periods of time. For long-term applications, one should potentially consider a different battery or solar panel depending upon individual needs.

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References

Cohnstaedt LW, Gillen JI, Munstermann LE. 2008. Light-Emitting Diode Technology Improves Insect Trapping. *J Am Mosq Control Assoc* 24:331-334.

Darsie RF Jr, Ward RA. 1981. Identification and geographical distribution of the mosquitoes of North America, north of Mexico. *MosqSyst* 1 (Supp):1-313.

Freier JE, Francy DB. 1991. A duplex cone trap for the collection of adult *Aedes albopictus*. *J Am Mosq Control Assoc* 7:73-79.

Gunerhan H, Hepbasli A. 2007. Determination of the optimum tilt angle of solar collectors for building applications.*Build and Environ* 42:779-783.

Meyer, R. P., W. K. Reisen, M. W. Eberle, M. M. Milby, V. M. Martinez, B. R. Hill. 1984. A time segregated sampling device for determining night host-seeking patterns of female mosquitoes.*Proc Pap CalifMosq Vector Control Assoc* 52:162–166.

Mulhern TD. 1942. The New Jersey mechanical trap for mosquito surveys. N J AgricExpStaCirc 421:1-8.

Silver JB. 2008. *Mosquito ecology: field sampling methods*. 3rded. New York: Springer.

Sudia WD, Chamberlain RW. 1962. Battery operated light trap, an improved model. *Mosq News* 22:126-129.

Table 1. Mean number± standard errorof females captured in 7 control traps and 7 solar traps in trial 1. Means in the same row followed by the same letter are not significantly different (P > 0.05, Wilcoxon Rank-Sum Test).

Species	Control traps	Solar traps
Aedesvexans	5.0a± 2.9	2.0a± 0.9
Coquilletidiaperturbans	7.1a ± 4.0	4.4a ± 1.5
Culisetainornata	4.1a ± 1.0	4.1a ± 2.0
Aedesdorsalis	7.3a ± 2.9	7.3a ± 2.5

Table 2. Mean number ± standard error initial voltage, final voltage and decrease in voltage (initial – final) of 12-Ah batteries and 36-Ah batteries . Means in the same row followed by the same letter are not significantly different (P < 0.01 for 12-Ah batteries and P < 0.0001 for 36-Ah batteries, t-test of independent samples, Microsoft Office Excel 2007).

		Control traps	Solar traps
12-Ah batteries	Initial voltage	6.3 ± 0.2	6.8 ± 0.4
	Final voltage	2.8 ± 0.1	5.7 ± 0.1
	Voltage decrease	3.6 ± 0.1a	1.1 ± 0.3b
36-Ah batteries	Initial voltage	6.1 ± <0.1	6.1 ± <0.1
	Final voltage	3.1 ± 0.1	5.8 ± <0.1
	Voltage decrease	3.0 ± 0.1a	0.2 ± <0.1b

Figure 1.The solar-powered CDC light trap system. The bag on the trap prevents rain and dew from damaging mosquitoes in the collection bag attached to the trap.

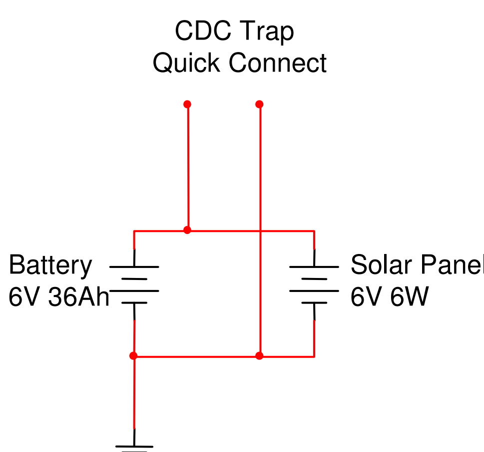

Figure 2.Wiring diagram for the solar-powered CDC light trap system.