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OPERATIONAL NOTE

EXPERIENCES WITH THE LARGE-SCALE OPERATION OF THE BIOGENTS SENTINEL™ TRAP

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ABSTRACT. We obtained 160 Biogents Sentinel™ traps (BGS-traps) to monitor adult mosquito populations for the Area-wide Pest Management Program for the Asian tiger mosquito (*Aedes albopictus*) in New Jersey. We deployed between 90 and 110 BGS-traps weekly from May through October of 2008, 2009, 2010, and 2011. Here we detail our experience: challenges with acquisition, defects in construction, as well as actions taken to correct problems we found and preempt them in the future. Further, we describe the impact of these problems on our research and provide a cost analysis of repairs.

KEY WORDS *Aedes albopictus*, Asian tiger mosquito, surveillance, cost and benefit

In 2008, Mercer County Mosquito Control (MCMC) and Monmouth County Mosquito Extermination Commission (MCMEC) began a large surveillance effort as part of the Area-wide Pest Management Program for the Asian tiger mosquito (*Aedes albopictus* (Skuse)) in New Jersey, a collaborative effort with Rutgers University and US Department of Agriculture–Agricultural Research Service (USDA-ARS) (Unlu et al. 2011). Similar to most daytime biting species, *Ae. albopictus* is not strongly attracted to standard surveillance equipment such as light traps (Meeraus et al. 2008, Farajollahi et al. 2009). The Biogents-Sentinel™ trap (BGS-trap; Biogents AG, Regensburg, Germany) was chosen because of its proven efficacy at capturing *Ae. albopictus* (Farajollahi et al. 2009).

In early 2008, we ordered 100 BGS-traps and BG-Lures™ from BioQuip® (Rancho Domingo, CA), the sole US distributor. At the same time, we obtained, pro bono, 20 traps from the manufacturers of the BG-Lure, AgriSense™ (Pontypridd, South Wales, United Kingdom). In 2010, we purchased 40 additional traps and realized the BGS-trap had undergone several design and material changes. Because we confronted challenges that were unique to each trap model, we will refer to theses traps separately as the 2008 model and the 2010 model. The following is the description of the difficulties encountered with deploying these BGS traps in a large-scale surveillance project, the solutions developed to address them, and a summary of associated monetary costs.

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The initial group of 2008 model BGS-traps constituted an investment of almost US$30,000 in addition to the required batteries and battery chargers. The traps arrived in July 2008 after a wait of almost 5 months. Mercer County was allocated 46 traps and Monmouth County received 62. Mercer County inspected all BGS-traps upon arrival in order to ensure they were ready for immediate use and found 16 traps (35%) were inoperable. The primary causes were missing battery clips, improper wiring, and inoperable fans (Fig. 1). The needed repairs delayed the start of surveillance and added cost (Table 1).

Both Mercer and Monmouth county personnel found damage to the trap carrying cases immediately after use, specifically, broken zippers, detached handles, and torn cases. We began tying the handles together to close the cases, keeping the trap and its parts secure. This method of containment proved ineffective, and several mounting poles and intake funnels were lost. By the end of the 2008 season, all carrying case zippers had failed, in that the slider body had become detached or the teeth no longer held their bond. Additionally, circular swatches of material began to tear out of the bags. We posited that this was due to wearing from contact with the intake funnel. To prevent further loss of parts, MCMEC replaced all their original carrying cases with inexpensive small nylon laundry bags and MCMC had replaced all their carrying bags with a tote-style bag (Table 1). When the 2010 model traps were received, all carrying cases were replaced before they were put to field use.

In 2008 through 2010 intake funnels were not individually available for purchase. Upon request from MCMC in 2010, BioQuip provided MCMC 2 replacement intake funnels. However, these replacement intake funnels did not fit the 2008 model traps and these traps remained inoperable

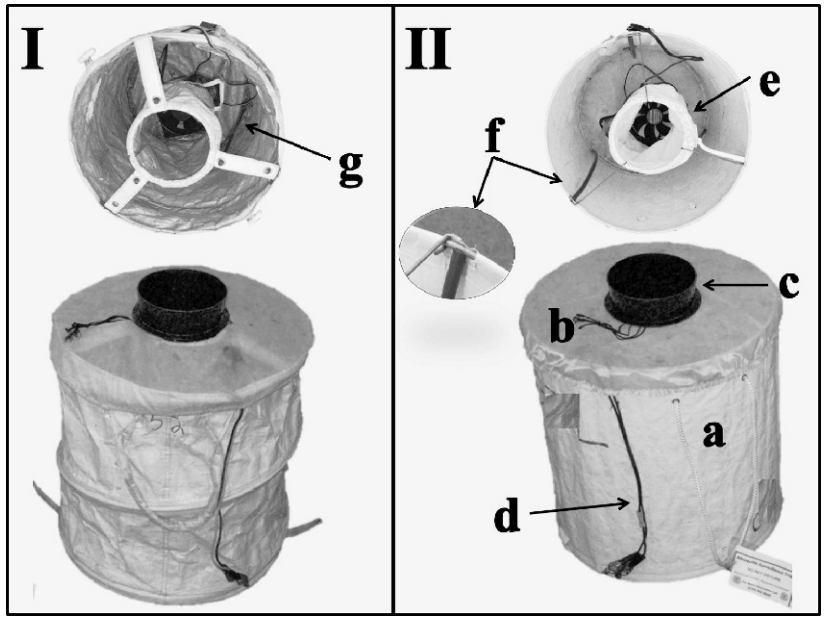

Fig. 1. (I) 2008 model Biogents Sentinel™ trap and (II) 2010 model. Bottom: fully assembled trap, side view. Top: interior view. a: white plastic trap body, b: white gauze cover, c: intake funnel (attached catch bag not visible), d: fan power cable and battery connector clips, e: inner suction tube, f: 2010 model mounting poles and mounting contact point, g: 2008 model mounting pole.

for another year. Currently, replacement intake funnels are available for sale from BioQuip, and fit both the 2008 and 2010 model traps.

Additionally, the elastic edges of many of the white gauze covers lost their tension (Fig. 1). The loss of elasticity caused several of the covers to blow off the traps in slight wind conditions. From 2008 through early 2010, the elastic in 53% of the gauze covers of Monmouth County's 2008 model traps had completely degraded and required repair before they could be redeployed. To address this problem, MCMEC and MCMC replaced the elastic in the white gauze covers with stronger and more durable elastic. However, this is only practical in the 2008 model, where the elastic of the gauze cover fits in a sleeve around the edge. It can be replaced by pulling out the spent elastic and then feeding fresh elastic through the sleeve with a safety pin. In the 2010 model, the elastic is stitched directly to the material (there is no sleeve), making repair more complicated and labor intensive. At the time of this writing, replacement gauze covers have become available for purchase from BioQuip. However, this was not the case in 2008 and 2009, though BioQuip did accommodate our

Table 1. Costs incurred due to repair of 2008 and 2010 model Biogents Sentinel™ traps by Mercer (MCMC) and Monmouth (MCMEC) counties.[1]

	2008 model traps				2010 model traps			
	No. traps repaired		Total repair cost ($)		No. traps repaired		Total repair cost ($)	
Repair	MCMC	MCMEC	MCMC	MCMEC	MCMC	MCMEC	MCMC	MCMEC
Wire	39	59	142.35	386.45	20	24	75.50	157.20
Battery clip	39	59	158.34	9.44	20	24	82.80	3.84
Fan	22	12	483.78	337.80	8	4	176.72	112.60
White gauze cover	5	31	0.00	196.85	1	0	6.95	0.00
Intake funnel	2	0	0.00		2	0	18.00	0.00
Catch bag	10	0	0.00	55.50	10	0	55.50	0.00
Carry case	37	59	321.90	145.73	20	24	106.20	59.28
Electrical tape	3	0	4.47	0.00	5	15	7.65	20.25
Total per county	157	220	1,110.84	1,131.77	86	91	529.32	353.17
Total per trap model	377		2,242.61		177		882.49	

[1] The cost calculation 1) inoperable traps due to missing parts, 2) the original purchase prices, 3) administrative costs for shopping and purchasing repair parts, 4) replacement of lure zip bags, 5) overhead costs on employees, 6) repairs to nets is not included.

requests by sending MCMC gauze covers free of charge.

By the end of 2008, the catch bags began coming apart at the seams and the elastic strings that hold the net in place while mounted on the intake funnel began to break. This allowed specimens to escape from the catch bag, making the overall capture rates underrepresented. Multiple catches were removed from final statistical analyses. After many repairs to catch bags, MCMEC replaced all of them with custom-made nets during the summer of 2009. The MCMC replaced 20 catch bags in early 2011 after they became available for purchase from BioQuip.

The fans in 2 BGS-traps also suffered breakage in 2008 as a result of regular trap use. Initially, when traps were disassembled for storage the intake funnel was put into the inner suction tube, as it sits when the trap is assembled. (The inner suction tube supports the intake funnel and holds the fan at its bottom [Fig. 1]). However, we found the diameter of the intake funnel was, in several traps, smaller than that of the support pipe and the catch pipe would press on the fan, breaking the blades. To prevent future damage, the catch pipe is left outside of the trap when placed in the carrying case for storage. In addition, during the 1st 3 seasons (2008–10) of trap use, 25 (23%) of the fans were replaced due to mechanical failure. Because replacement fans are not offered by BioQuip, nor are they available directly from the manufacturer, we have purchased computer cooling fans from several sources (CDW-G® [Vernon Hills, IL], RadioShack® [Fort Worth, TX], and TigerDirect [Miami, FL]) to replace them. We have not been able to obtain fans to the exact specifications of the BGS-trap fans (120-mm brushless, 2,300 rpm, 7 blades), but have purchased similar fans from RadioShack (brushless, 120-mm, 3,000 rpm, 5 blades), TigerDirect.com (ThermalTake®; 120-mm brushless, 2,000 rpm, 7 blades), and CDW-G® (StarTech.com; 120-mm brushless, 2,000 rpm, 7 blades).

During 2008, we observed incidents due to trap construction and materials that involved considerable liability. A Monmouth County employee, setting a trap with a defective battery connector, received an electric shock while attaching the trap to the battery, causing a 2nd-degree burn. Mercer County inspectors were alerted by a resident that the trap set on their property was smoking and possibly on fire. This trap was immediately retrieved and inspected, revealing the likely cause of the fire was faulty wiring, which therefore posed a considerable fire risk. To prevent further incidents, we rewired all traps before the 2009 field season using 22-gauge wire, a heavier gauge than what is used in construction by the manufacturer. At the time of rewiring, battery clips were also replaced. Our current standard operating procedure is to rewire all newly acquired BGS-traps and replace all clips before the traps are put to use.

Although we had relayed our concerns and recommendations repeatedly both to BioQuip and directly to Biogents, the 40 BGS-traps we purchased in 2010 were discovered to have many of the 2008 model's defects. During initial inspection, several traps were observed to have battery clips detached from the power cable and carrying case zipper slider bodies separated when opened. We therefore conclude that the 2010 model suffers from the same basic lack of quality materials and endurance required for high-intensity field deployment.

In addition to the flaws already identified in the 2008 model, we also detected a defect in the construction of the 2010 model trap's housing. In both models, the outer body of the trap is composed of a white plastic rip-stop fabric, shaped by metal rings at the top and bottom of the trap. In the 2010 model trap, the mounting poles affix to the metals rings to support the trap (Fig. 1). On initial inspection of the new traps, we found the plastic of the trap body had not been removed from this point of contact, causing support rods to slip and the traps to collapse. After this problem was discovered, the plastic was excised with a scalpel in all faulty traps prior to being redeployed in the field.

Also noteworthy is the durability of the trap body fabric. While the 2008 and the 2010 BGS-trap model are constructed using slightly different fabric, both were found to be delicate and tears occurred. The tears were repaired by adhering white duct tape over the tear on both the outside and inside of the trap.

The BGS-trap manufacturer recommends using the BGS-trap in conjunction with the BG-Lure, which steadily releases compounds found in human skin (Kröckel et al. 2006). The lure consists of media, moistened with these compounds, enclosed in a mesh pouch, and held in a zipper storage bag to prevent desiccation when not in use. Upon receiving the 2010 shipment of BG-Lures, we found that many greatly exceeded the level of moisture observed in lures from previous years. Liquid had leaked out of their individually sealed zipper bags and into the shipping bag. Throughout the mosquito season, we observed these retained a higher level of moisture in comparison to those we had used in previous years. Further, the mesh pouches of the 2010 lures were constructed using a much thinner mesh. The pouch ends were closed with tape, rather than staples as in previous years. The mesh was easily torn and the moisture from the lure caused the tape adhesive to fail, spilling the contents of the pouch. Fortunately, the lures we received in 2011 and 2012 were not found to have the same high moisture level as in 2010, although the mesh continues to be much thinner than the mesh used in 2008. Torn mesh and open pouch ends can easily be repaired using small plastic zip ties.

We caution that in studies that require the use of repeated-measures analyses, trap failures can significantly impact statistical power (Keselman et al. 2001). The poor construction and materials of the BGS traps has led to numerous trapping failures impacting the evaluation of our control efforts. In response, both MCMC and MCMEC programs maintain 3 to 4 auxiliary traps for each weekly trapping event and we continue to make every effort to maintain and monitor trap function. To date we have replaced the wiring, clips, and carrying cases of all 2008 and 2010 model traps. Additionally, 34 (32%) fans were exchanged in the 2008 model traps and 12 (30%) in the 2010 model traps.

In our experience, after the traps are refurbished, they no longer require major maintenance and failure rates have reduced satisfactorily. Our experiences have allowed us to be prepared for any minor issues and it is now standard practice in both Monmouth and Mercer counties to keep in inventory approximately 15 replacement fans, 5 white gauze covers, and 5 intake funnels for repairs during the active mosquito season. All vehicles that are utilized for surveillance operations are outfitted with trap repair kits containing pliers, zip ties, white duct tape, electrical tape, and several spare parts. Likewise, all traps undergo a preseason inspection and necessary repairs are made.

Cost has been incurred from the BGS-traps through the price of repair, as well as the irreplaceable loss of data and trapping effort. They have also exposed us to personal injury and property destruction liabilities. Our collective assessment is that the poor construction of BGS-traps leads to unacceptable rates of failure and repair costs. However, despite the cost and effort associated with the traps, our experience has proven the BGS-trap an excellent tool for surveillance of *Ae. albopictus* (Fonseca et al. 2013). Since 2008, the BGS-trap has enabled us to examine the temporal and spatial population dynamics of *Ae. albopictus* and evaluate the effectiveness of multiple methods of control.

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