The Delivery of *Bacillus thuringiensis* to Adult Mosquitoes

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Introduction

- There are approximately 3,000 mosquito species found globally.
- Mosquitoes are among the most efficient vectors of animal and human pathogens, causing many debilitating and often fatal diseases.
- Globally, malaria is the most prevalent vector-borne disease, with over 2.4 billion people around the world at risk of contracting this disease.

Impact of Mosquito-Borne Disease

- Between 1-3 million deaths occur annually from malaria, most in children from sub-saharan Africa.
- Every 30 seconds a person dies from malaria.
- Another vector-borne disease of particular concern to children's health is dengue virus, the second most important tropical disease with approximately 50 to 100 million cases of dengue fever and 500,000 cases of Dengue Hemorrhagic Fever (DHF) each year.
- DHF is fatal to approximately 40% of children that contract this painful and deadly virus.
- Regionally important vector-borne diseases: Yellow fever, Chikungunya, Rift Valley fever, West Nile virus, Japanese encephalitis, and filariasis, that are particularly dangerous for children.

Current Techniques for Preventing Mosquito-Borne Disease

- Vaccines/Drugs
  - No vaccine available for malaria or dengue, despite decades of research
  - Drug resistant *Plasmodium* a problem in many areas of world
- Pesticides – Outdoor and Indoor Spraying
  - Expensive
  - Kill non-target arthropods
  - Ineffective in areas w/ pesticide resistance
  - Human health and environment
- Bednets
  - Not enough bednets for entire family
  - Improper use
  - Not effective against dengue
  - Cannot be used in schools, churches, restaurants…

ProVector™

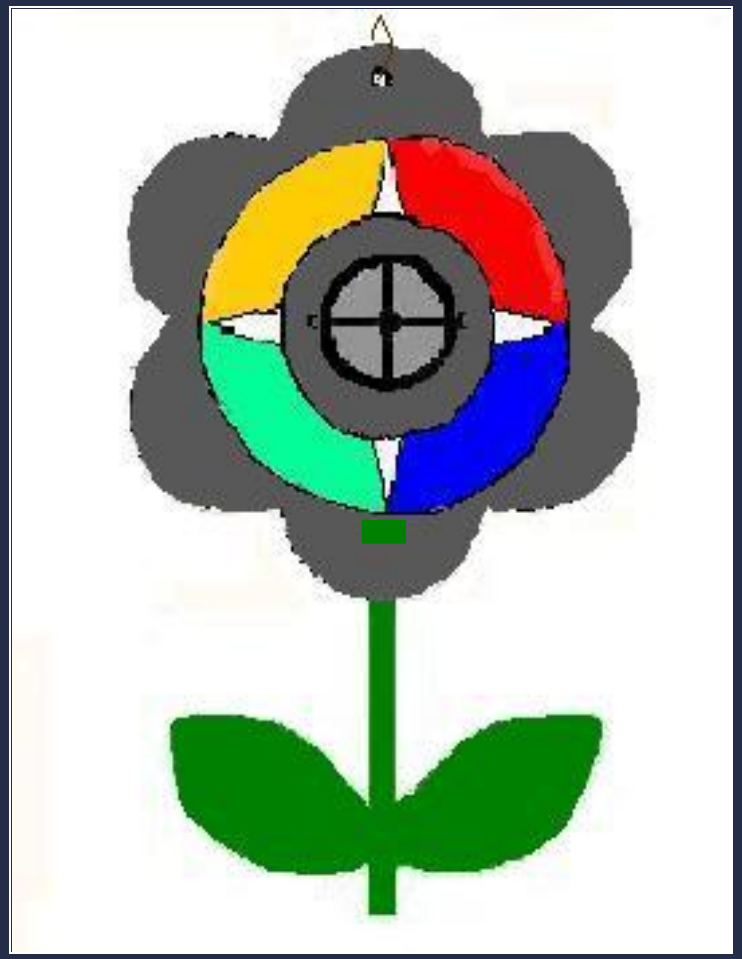
The ProVector™ imitates the look, smell and taste of flowers in order to trick the adult male and female mosquito into ingesting the Bti formulation.

What is *Bacillus thuringiensis israelensis (Bti)*?

- Naturally occuring, rod-shaped bacterium common in soils
- Remains in dormant stage as a spore until ingested
- First discovered in 1977 the Negev Desert, Israel, by Goldberg & Margalit
- Mosquito and black fly larvicide
- Has been used effectively since 1982 for insect control
- Damages digestive system, causing larvae to starve to death
- Affects target organisms only
- Bio-friendly; considered virtually non-toxic by EPA

ProVector™

- Developed by Dr. Tom Kollars at MEVLABS, Inc.
- Economical and environmentally safe device for killing adult mosquitoes
- First device to deliver *Bti* directly to adult mosquitoes
- Does not have harmful effects on non-target species



ProVector™ Cont'd…

Early ProVector™ prototype w/ mosquitoes

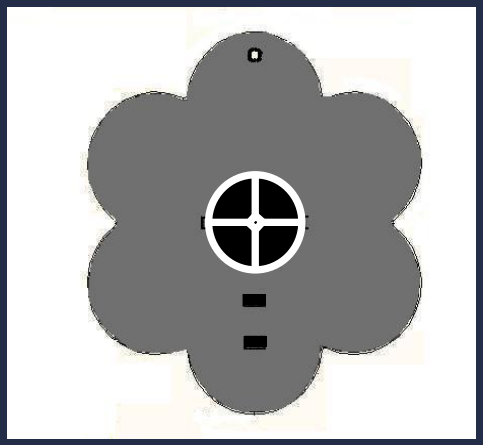
- ProVector™ can help entire household, 24 hours a day
- One refill disc lasts six months & will kill approximately 10,000 mosquitoes
- ProVector™ is used indoors to effectively reduce mosquito populations

Parts of the ProVector™

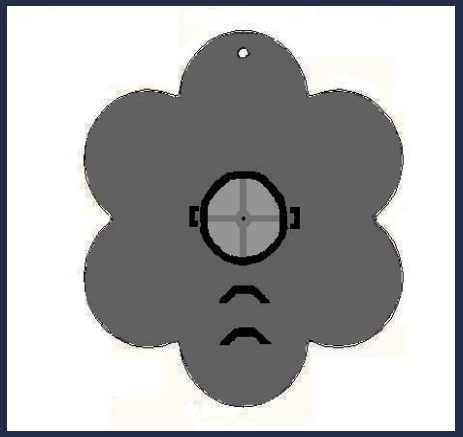
Plastic flower w/ color, chemical attractants & refill disc containing Bti.

COMPLETED PROVECTOR FLOWER

Color wavelengths are optimized to attract different mosquito spp.

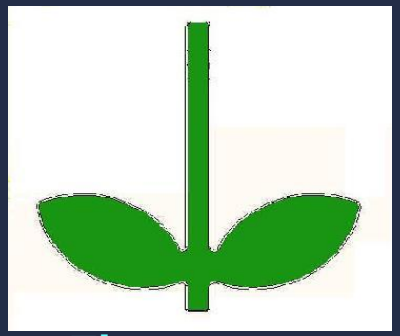


Flower - front

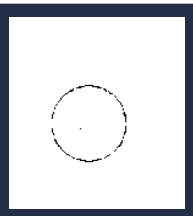


Flower - back

Center of the flower contains fine mesh that allows only mosquitoes to feed through - blocking non-target species from eating the bait.

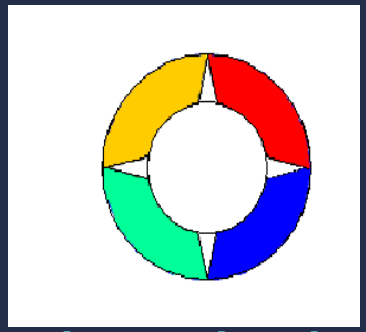


Flower stem



Refill holder

ProVector™ Bti refill

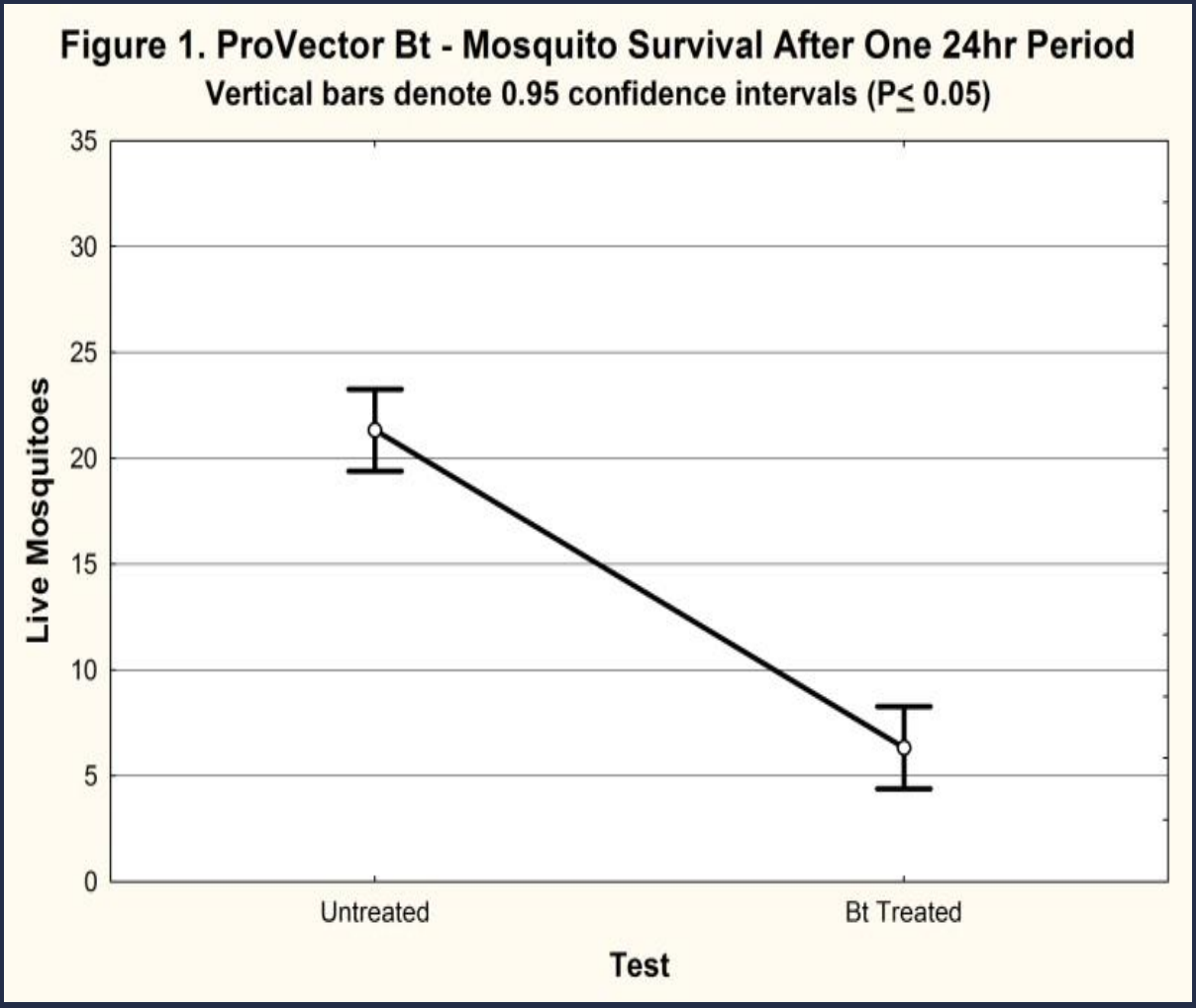


Flower decal

Laboratory Trials

Georgia Southern University

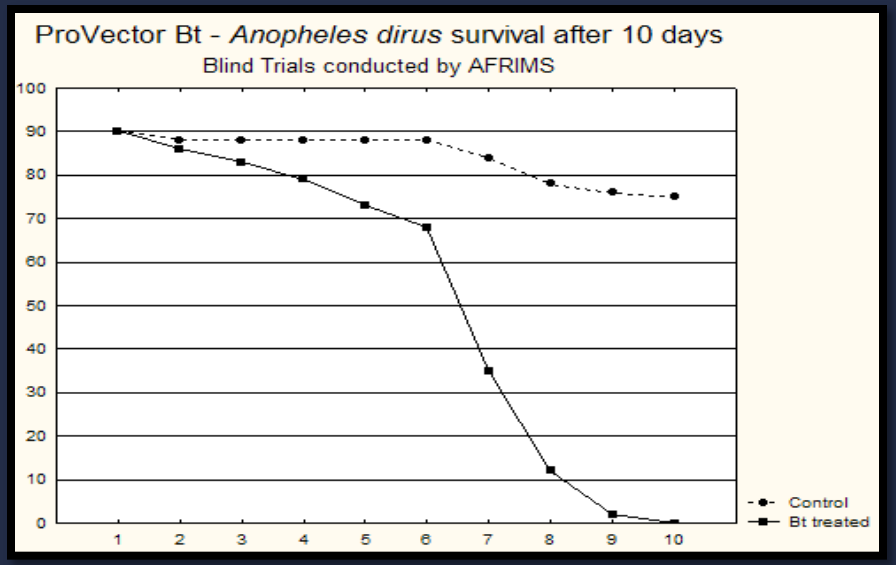
The efficacy of the ProVector™ Bt formulation against *Aedes aegypti* (transmits dengue virus) was 80% within 24 hours after one feeding.

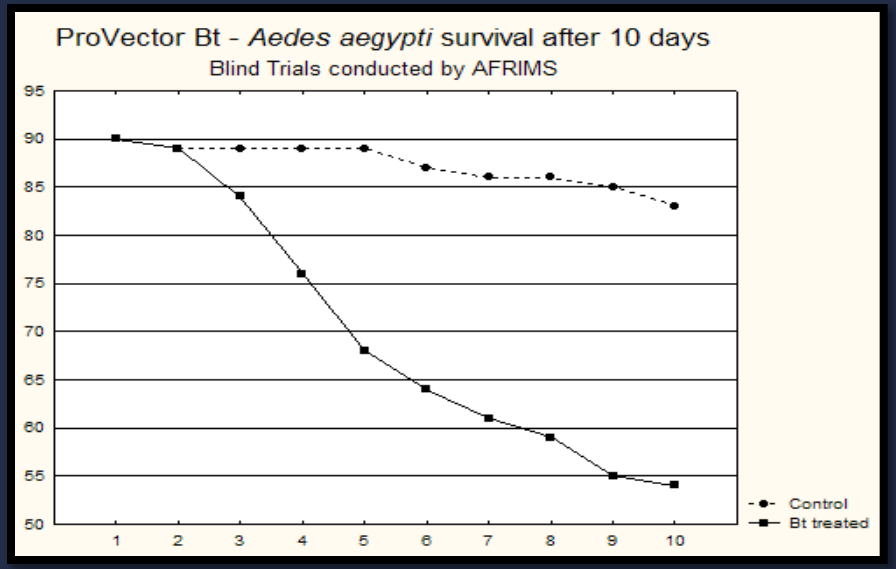


Walter Reed Army Institute - Thailand Trials

Walter Reed Army Institute of Research (Thailand)

Scientists found a 100% reduction in *Anopheles dirus* mosquitoes carrying malaria in 10 days (American Mosquito Control Association, 2009). These results indicate a reduced mosquito population and an interruption of the malaria life cycle in the mosquito.

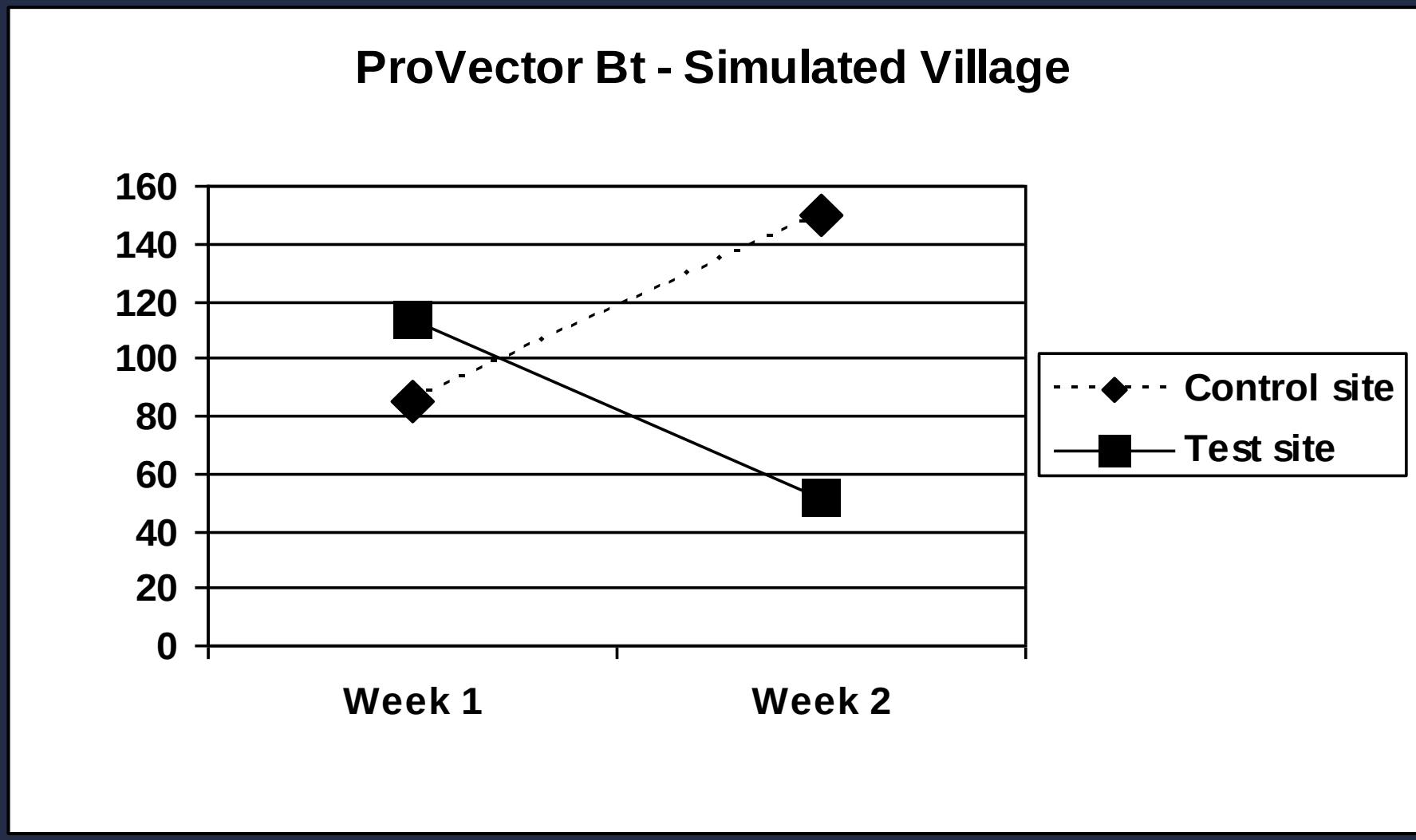




Georgia ProVector™ Field Study

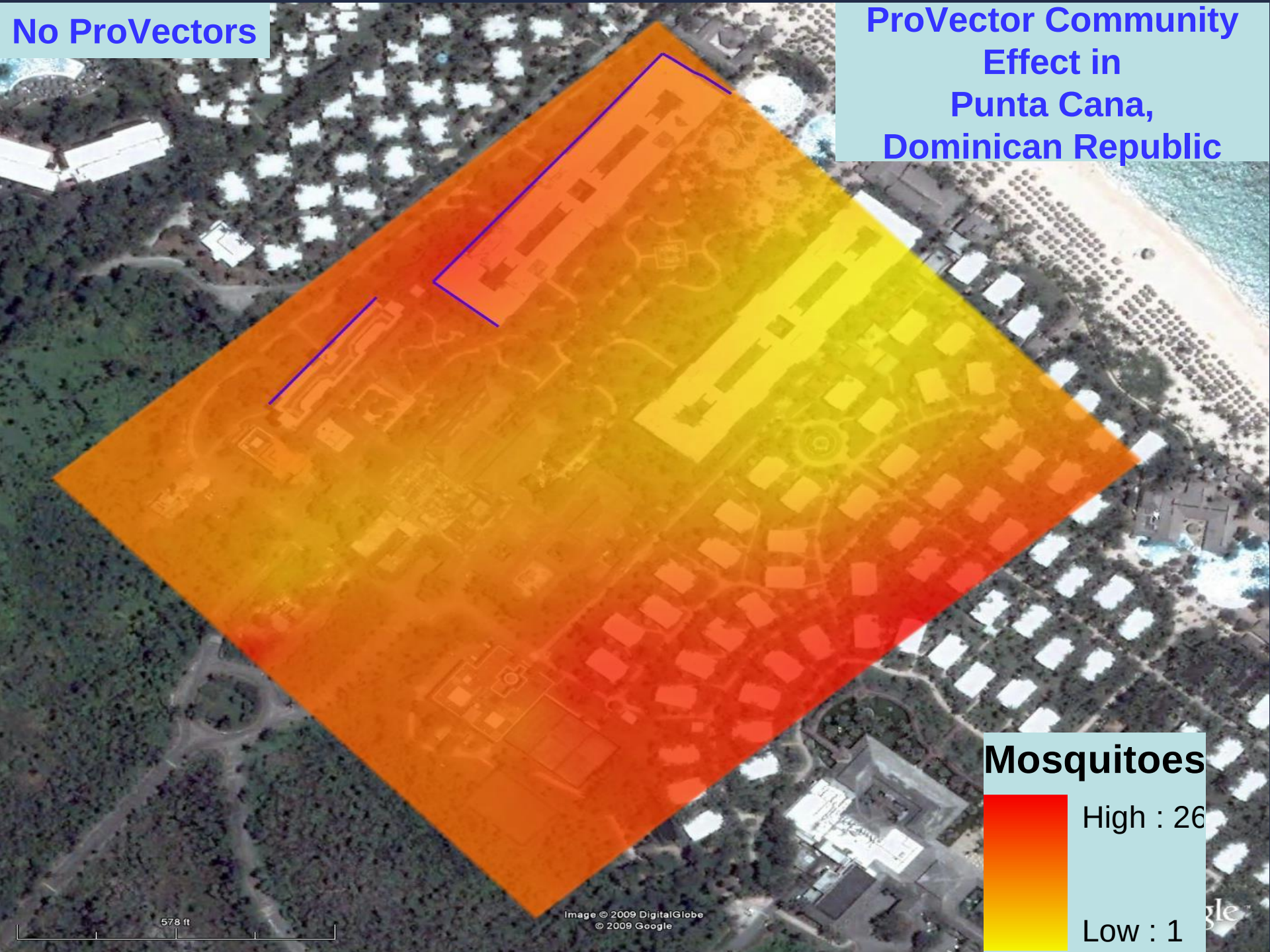
Georgia Field Study – Test Site

Georgia Field Study - Results



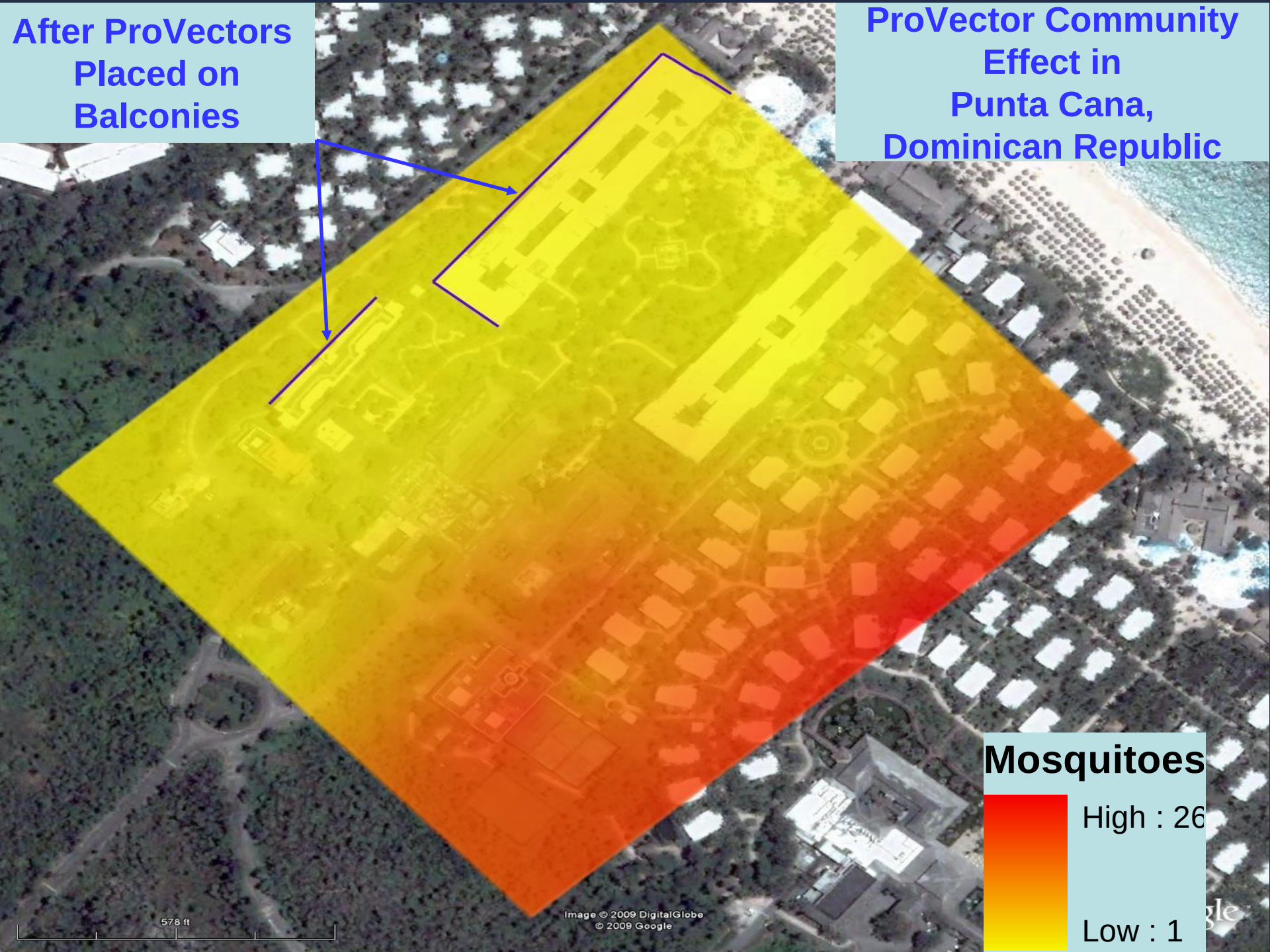
Punta Cana, DR

Map provided courtesy of www.mapcruzin.com


No ProVectors
ProVector Community Effect in Punta Cana, Dominican Republic
Mosquitoes
High : 26
Low : 1
578 ft
Image © 2009 DigitalGlobe
© 2009 Google

After ProVectors Placed on Balconies

ProVector Community Effect in Punta Cana, Dominican Republic



ProVector™ Field Trials

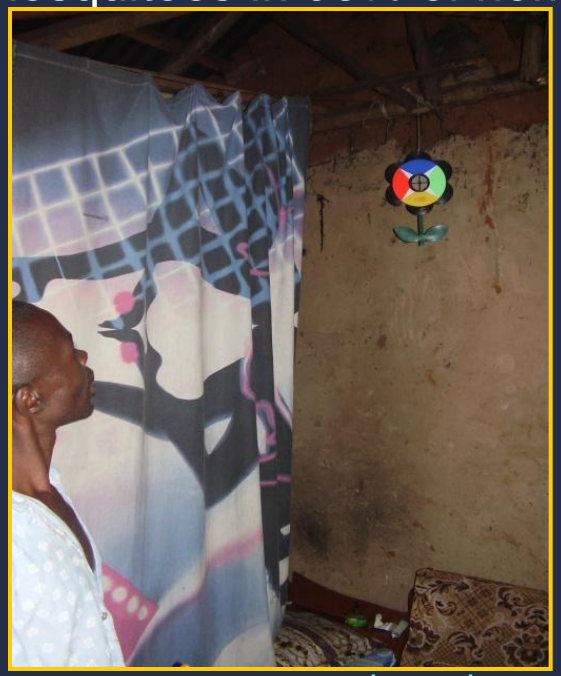
Georgia – Within 2 weeks the ProVector Site had a 3X lower mosquito population than the Control Site with no ProVectors.

Kenya – ProVectors have been placed in two communities near Kisumu in collaboration with Walter Reed Project.

Thailand – Collaboration with Vector-Borne Disease Laboratory, Mahidol University.

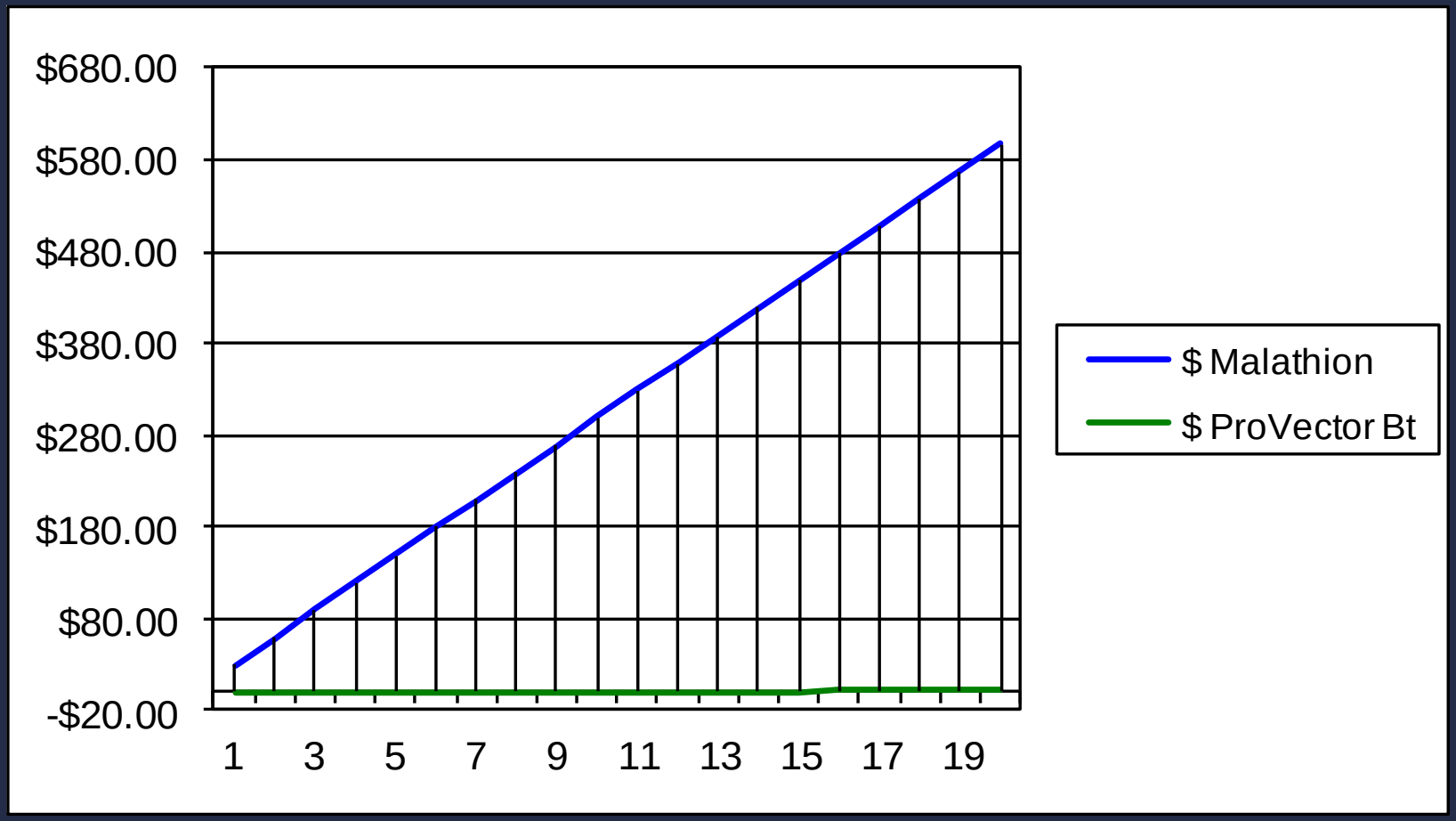
Dominican Republic – Hotel workers have reported a reduction in mosquito bites in the hotel areas where ProVectors are placed.

Uganda – Uganda Virus Institute Ministry of Health reported elimination of mosquitoes in 95% of homes in urban and rural homes.

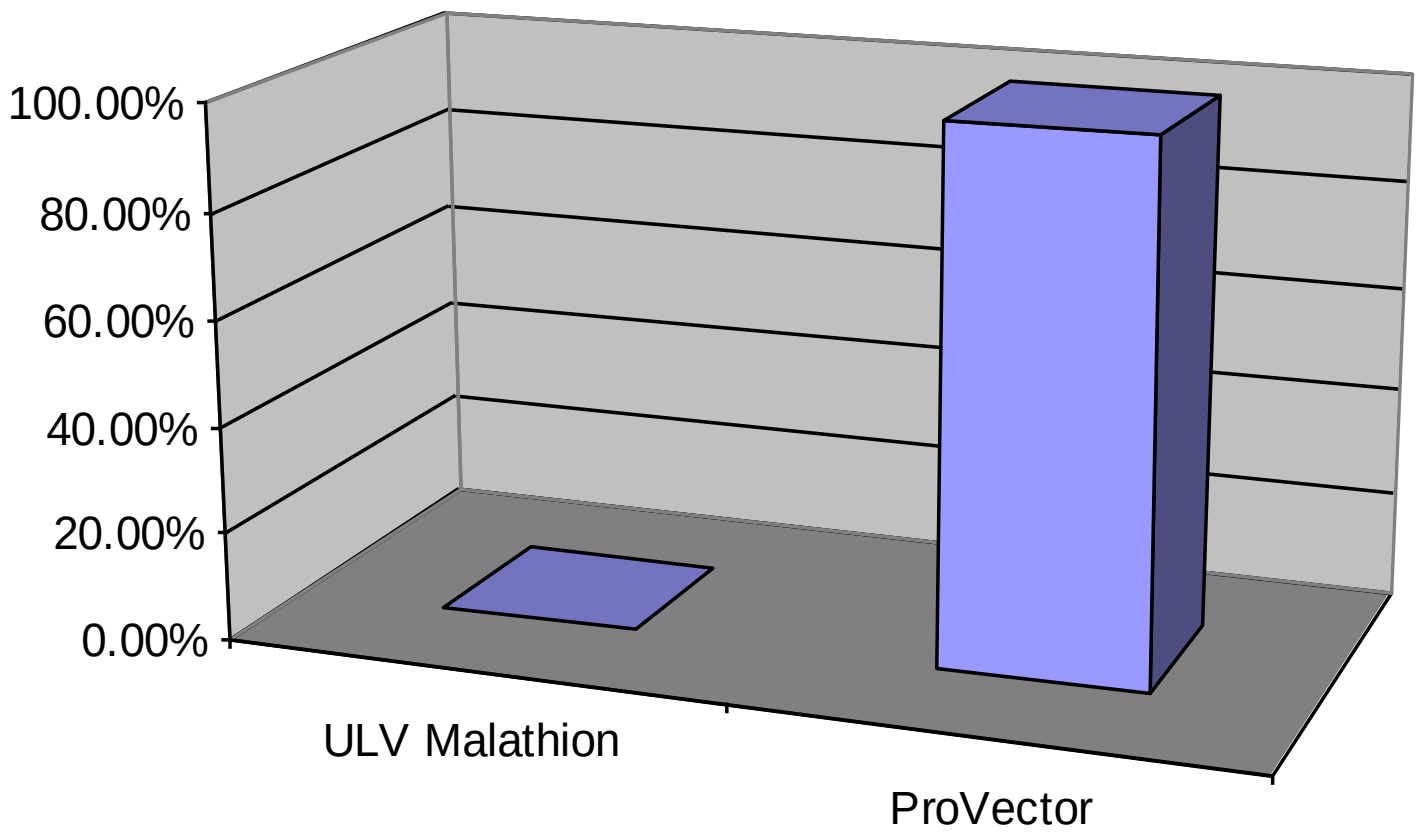


Photos by: Dr. Louis Mukwaya, Uganda Virus Institute, 2009

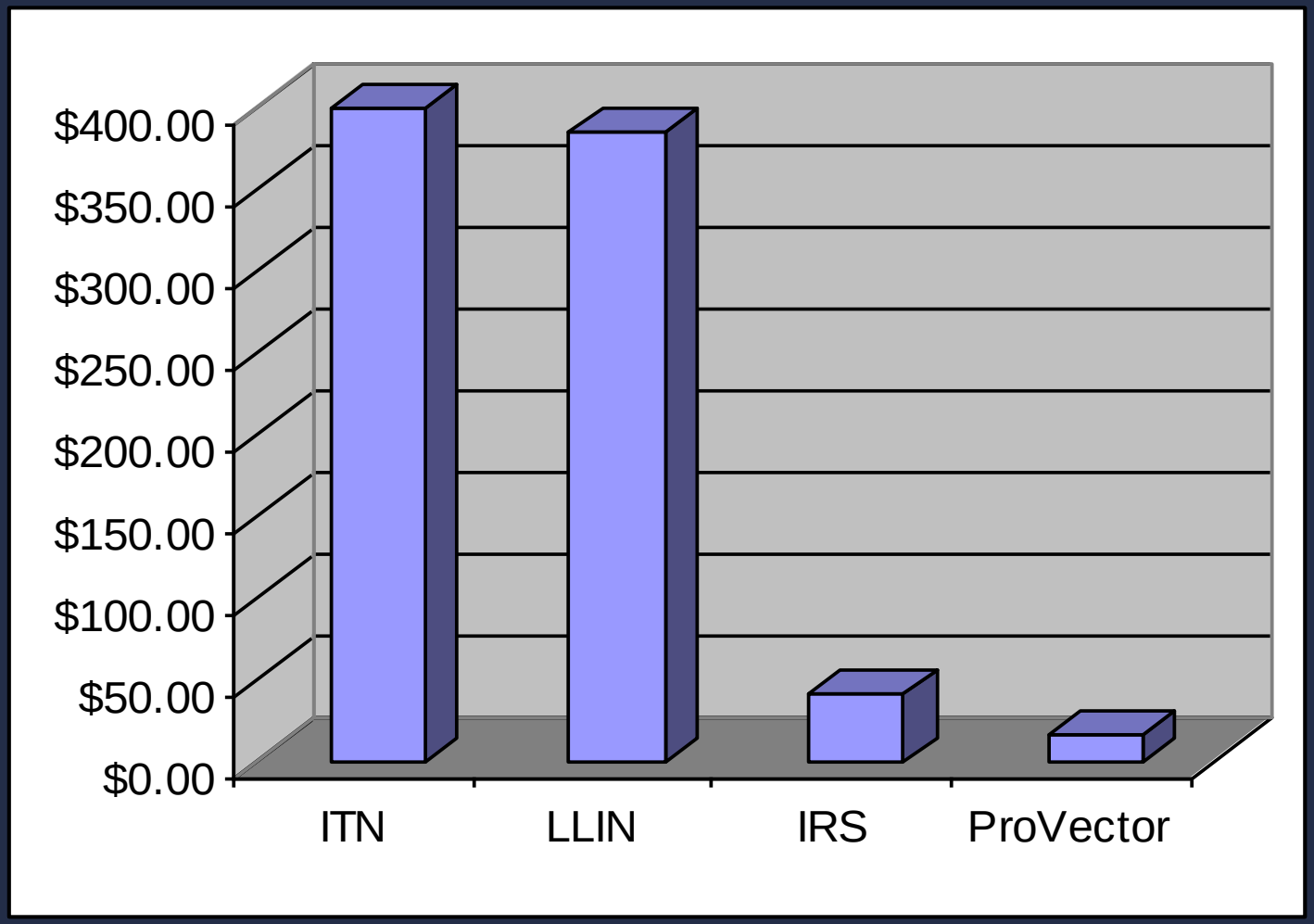
Estimated price difference in controlling *Anopheles* species between Malathion (ULV) and ProVector™ Bt during 3 week period



Target Specificity between Malathion (ULV) and ProVector™



Estimated cost to protect seven family members using indoor methods of mosquito control (non-subsidized cost during 2 yr period)



AEMRN ProVector™ Community Projects in Africa

- Current
  - Conakry, Guinea: school, 50 homes
  - Kibera, Kenya: orphanage, school, 200 homes
  - Kibera, Kenya: Ushirika Maternity Clinic
  - Kisumu, Kenya: Hospital, 40 homes
  - Nairobi, Kenya: 150 homes
  - Kabondo, Kenya: 200 homes
  - Entebbe, Uganda: 50 homes
- Planned
  - Cape Coast, Ghana: 500 homes, 2 schools
  - Accra, Ghana: 500 homes, 2 schools
  - Kitale, Kenya: Kitale Hospital, 500 homes
  - Kabondo, Kenya: 200 homes in village
  - Kampala, Uganda: Hospitals, 500 homes

AEMRN ProVector™ Community Projects

- Designed to spatially eliminate mosquito populations and reduce malaria transmission using ProVector™ Bt
- Use 200-500 ProVector™ Bt to safely and rapidly control mosquito populations in villages
- Staffed by only public health professionals
- Funds are need to support existing projects and expand into new villages and countries in Africa

ProVector™ Summary

- Plastic flower with visual attractants
- Refill disc containing Bti, chemical and gustatory stimulants
- One refill disc lasts six months & will kill approximately 10,000 mosquitoes
- ProVector™ is used indoors to reduce mosquito populations
- Can be used alone but recommend use with ITN or LLIN
- ProVector, LLC develops Community Projects
- MIT Holding, Inc. is licensed to manufacturer and distribute the ProVector™

BARAHONA, DOMINICAN REPUBLIC

Photo courtesy of Children of the Nations (COTN), 2009