Insecticide-free Mosquito Elimination on Small Maldivian Islands

SCHUHBAUER A[5,*], JAHIR A[1,2], KAHAMBA NF[3], KNOLS TO[4], JACKSON G[2], PATTY NFA[1], SHIVDASANI S[1,2], OKUMU FO[3], KNOLS BGJ[1,2,3,4,*]

1 Culex Maldives, 4th Floor Jazeera Building, Boduthakurufaanu Magu, Male 20077, Maldives
2 Soneva Fushi, 4th Floor Jazeera Building, Boduthakurufaanu Magu, Male 20077, Maldives
3 Ifakara Health Institute, Ifakara P.O. Box 53, Tanzania
4 K&S Holding BV, Kalkestraat 20, 6669 CP Dodewaard, The Netherlands
5 Biogents AG, Weissenburgstrasse 22, 95033 Regensburg, Germany
* Correspondance: bart@culexmaldives.com, astrid.schuhbauer@biogents.com

Introduction

The islands of the Maldives have a significant mosquito problem. Although the islands have been malaria-free since 1984 and free of lymphatic filariasis since 2007, mosquitoes are not only a real nuisance, but they still pose significant health concerns because dengue, chikungunya, and possibly Zika.

The most commonly applied mosquito control measure on the Maldives is based on insecticide applications through misting or fogging, performed by professional pest control companies.

Soneva Fushi, an award winning high-end luxury resort had hired a pest control company that sprayed insecticides on a daily basis for most of the year during more than twenty years.

» **Termination of contract due to mosquitoes' resistance** to the applied synthetic pyrethroid insecticides.

» **Alternative mosquito control approach: mass trapping** combined with **larval source management** (LSM) was tested on three islands.

Kunfunadhoo Island

Starting Situation

- Mosquito population resistant to insecticides (< 25% mortality in standard WHO tube assays).
- Insect biodiversity strongly affected.
- Annual cost for insecticide applications: 110,000 USD

Materials and Methods

3 Study Islands

- **Kunfunadhoo** (focus of this poster): since June 2019, 41.4 ha, Soneva Fushi Resort, population up to 700 (staff and tourists), mass trapping treatment: 6 BG-Mosquitaire CO_2/ha and 7.2 BG-GAT/ha.
- **Medhufaru**: since June 2020, 49 ha, population up to 700 (staff and tourists), mass trapping treatment: 4.1 BG-Mosquitaire CO_2/ha and 8.2 BG-GAT/ha.
- **Thahigandu Kolhu**: since Sep 2021, 1.6 ha, uninhabited (used for day visits), mass trapping: 6.3 BG-Mosquitaire CO_2/ha, gradually increased to 18.8 BG-Mosquitaire CO_2/ha + larviciding with Bti (high number of crab holes).

Target Mosquito species on all three islands

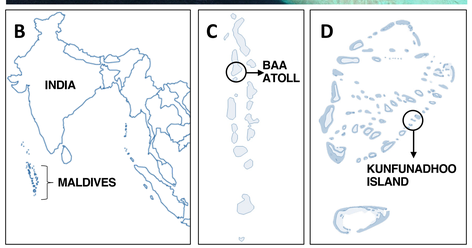
- *Aedes albopictus*
- *Culex quinquefasciatus*

Larval Source Management (LSM)

- Habitat manipulation: construction of roofs, large trees examined for ponds (inspected monthly, filled with sand), septic tanks geo-referenced and inspected monthly, lids of septic tanks sealed.
- Massive clean-up in June 2019 and July 2020: removal of >190,000 potential breeding sites (empty coconuts, coconut boats, plastic and glassware).
- Larviciding: neem oil applied on water surfaces.

BG-Mosquitaire CO_2 with rain shield (1), 5 L PET bottle containg 3 L water, 700 g sugar and 40 g yeast (2), and 1.5 L overflow bottle.

BG-GAT with stick card.



Mosquito Traps

BG-Mosquitaire CO_2: Attracts host-seeking mosquitoes.

- BG-Mozzibait sachet: host odour
- CO_2 from yeast-sugar fermentation

BG-GAT (Gravid *Aedes* Trap): Attracts gravid female *Aedes* mosquitoes.

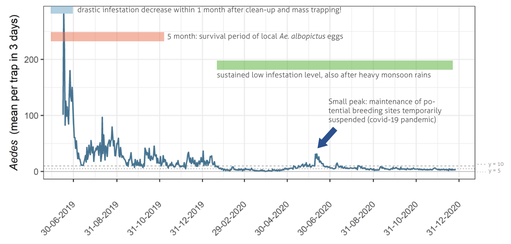
- 2 BG-GATs in the vicinity of every BG-Mosquitaire CO_2 trap
- sticky cards replaced fortnightly
- water with organic debris as oviposition attractant

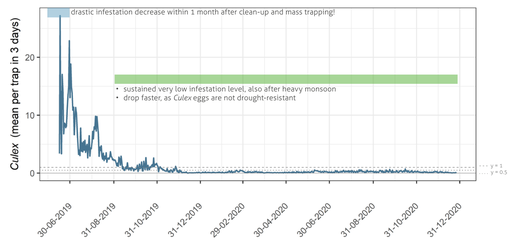
Results

Kunfunadhoo island (Soneva Fushi)

- 1 month after clean-up and mass trapping: sharp decline of both mosquito species (line charts below).
- 18 M study period: 475,224 *Ae. albopictus* & 34,660 *Cx. quinquefasciatus*
- 1st month alone: 113,085 *Ae. albopictus* & 14,559 *Cx. quinquefasciatus*

} Fast impact of LSM and mass trapping!





Suppression levels

Within-island comparison: comparison of trap catches on Konfunadhoo island from 16 June 2020 onwards with trap catches the previous year:

- *Ae. albopictus*: highest level in August 2020: 91.4 %
- *Cx. quinquefasciatus*: highest level in June 2020: 97.8 %

Between-islands comparison: Comparison between Medhufaru and Konfunadhoo. The trial on the second island (Medhufaru, 75 km apart, similar rainfall conditions) started 1 year after the trial on Kunfunadhoo island.

- *Ae. albopictus*: August 2020: 93.0 %
- *Cx. quinquefasciatus*: August 2020: 98.3 %

Cost analysis

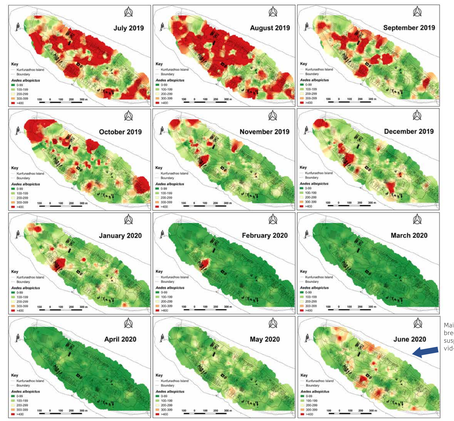
First year of operation on Konfunadhoo island: **USD 85,123** (USD 2056 per hectare).

- 51.5 % labour
- 40.8 % trap attractants (mozzibait and sugar)

Cost of the insecticide-based option for the previously contracted pest control company: **USD 110,000** per year.

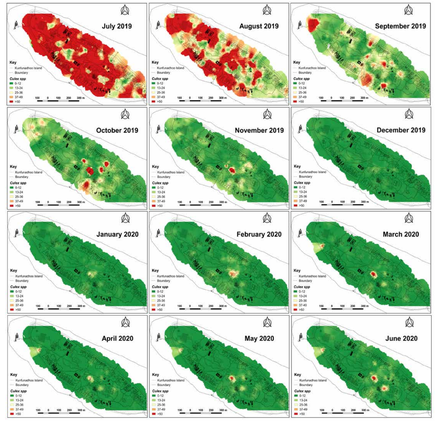
» **Trapping + LSM 22,6 % cheaper and effective!**

Ae. albopictus



Inverse distance weighted heatmaps of *Aedes albopictus* showing areas with high (red) or low (green) monthly mosquito catch rates from June 2019 - June 2020 on Konfunadhoo island.

Cx. quinquefasciatus



Inverse distance weighted heatmaps of *Cx. quinquefasciatus* showing areas with high (red) or low (green) monthly mosquito catch rates from June 2019 - June 2020 on Konfunadhoo island.
» Impact of trapping was observed faster than for *Ae. albopictus* since *Culex* eggs cannot survive a period of drought.

LSM: Examples of typical breeding sites removed: 1) Trash that can hold water (e.g., bottles or tin cans), 2) tarpaulins used in construction, 3) temporarily abandoned ponds or pools, 4) saucers under flower/plant pots, 5) empty coconuts, 6) coconut boats.

Medhufaru island

- 1 month after clean-up and mass trapping: sharp decline of both mosquito species

Thahigandu Kolhu island

- Initial trap density of 6.3 traps/ha was sufficient to drastically decrease the *Culex* population.
- For *Aedes*, a pronounced decrease began when the trap density was increasd to 7.5 traps/ha.
- When the trap density was further incerased to 18.8 traps/ha, *Aedes* mosquitoes were eliminated after 8 weeks.

Discussion

Shortcomings

- Difficult to decipher the contribution of the intervention components.
  » Argument that supports trapping as the main contributor: Intense LSM was attempted on Konfunadhoo island in 2014 and in 2016, but effects were far from those reached in the present trial that combined LSM and trapping.

Advantages in comparison to genetic control strategies

- Suppression levels comparable to those of genetic control trials were reached.

Trapping and LSM

- targets multiple mosquito species
- minimal training needed for the staff
- no mass-rearing facilities needed
- is significantly cheaper (27 - 82 % cheaper)
- can be rolled out within a few months (unlike years needed for regulatory approval for genetic control trials)

Further observations

- Return of a broad array of insects observed on Konfunadhoo within 1.5 y without insecticide spraying.
- Mass trapping + LSM could be applied prior to genetic control strategies in order to maximise their effect.

Conclusions

- It is possible to eliminate mosquitoes without insecticides
- It is possible to eliminate mosquitoes with efficient odour-baited traps and LSM
- The combination of mass trapping with LSM is cheaper than insecticide application
- Return of beneficial insects when insecticide spraying is stopped

Link to the study