Chemical Ecology: Integrated Vector Management as an Alternative to Insecticides

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Plan

1. Background

Importance of mosquito-borne diseases (MBD)

Vector control of mosquitoes: a critical part of the global strategy

Chemical ecology: a promising alternative to insecticides

2. Methods

Bioassay using modified-cage system

Chemical synthesis of new candidate compounds based on coumarin derivatives

Field work using BG sentinel and CDC light traps

3. Results

Isovaleric acid (attractant) and DEET (repellent)

New family of active compounds based on coumarin derivatives

4-hydroxycoumarin as attractant for *Aedes albopictus*

4-hydroxycoumarin as attractant for *Anopheles* spp.

4. Discussion

5. Acknowledgments

Importance of mosquito-borne diseases (MBD)

- 2.7 million deaths/year Worldwide
- 700 million people/year at risk of transmission
- 90 % of mosquito-borne illnesses occuring in Africa
- 28 % of emerging diseases (Zika, Chikungunya, Nil fever, etc.)

The main vector mosquitoes

Aedes

Culex

Anopheles

Vector control of mosquitoes: a critical part of the global strategy

Insecticides

Most important and effective component of vector control

Ex: Pyrethroids, organochlorines, organophosphates and carbamates

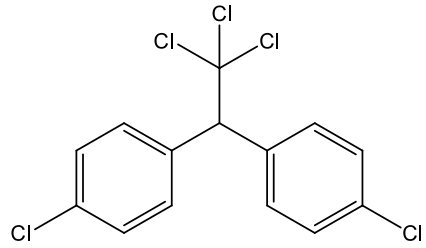
Problems

Environmental pollution

Broad spectrum of insecticide actions

Re-invasion of untreated populations

Resistance of vector mosquito populations



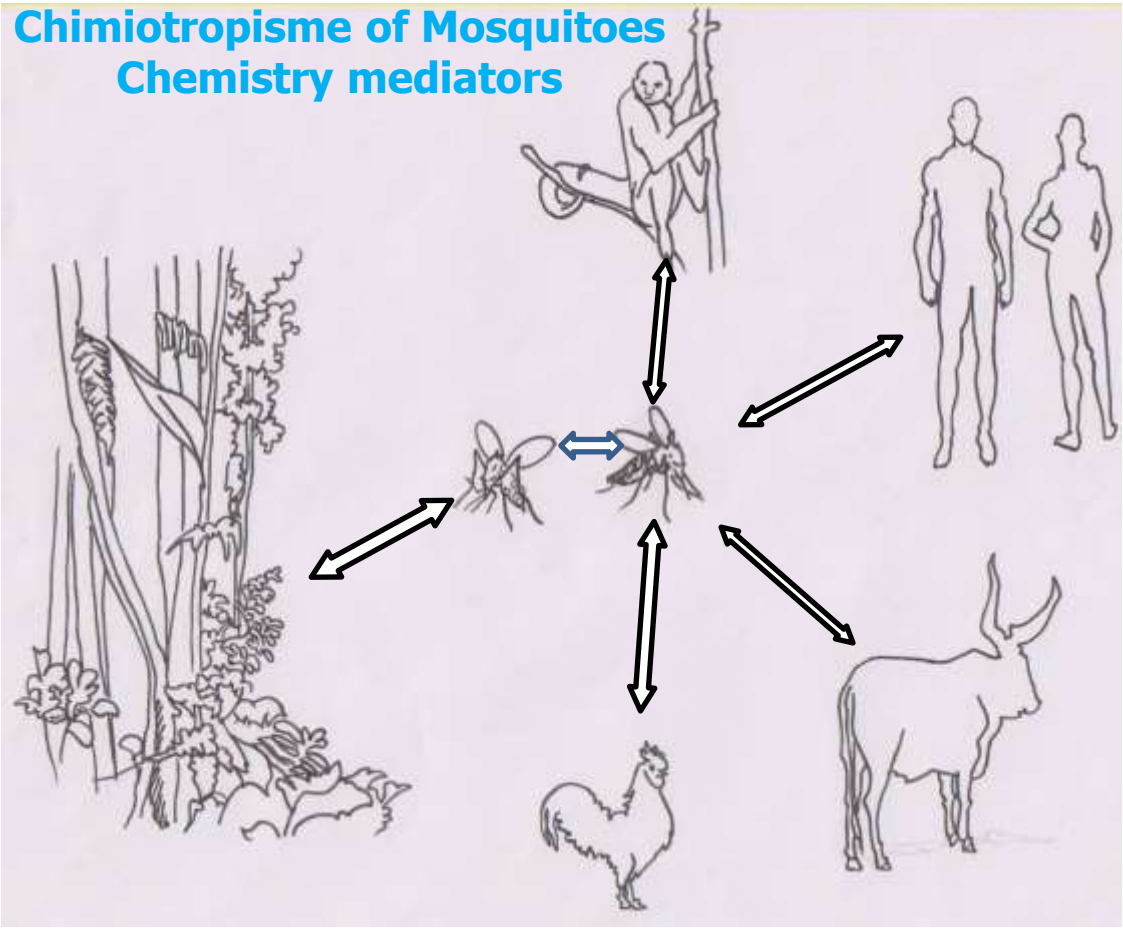
Nobel Price Muller (1948)

Silencious Spring : Rachel Carlson 1962

Ex: Dichloro-Diphényle-Trichloroethane (DDT)

Tolle (2009)

Chemical ecology: a promising alternative to insecticides



Ex: Pheromones, Kairomones, etc.

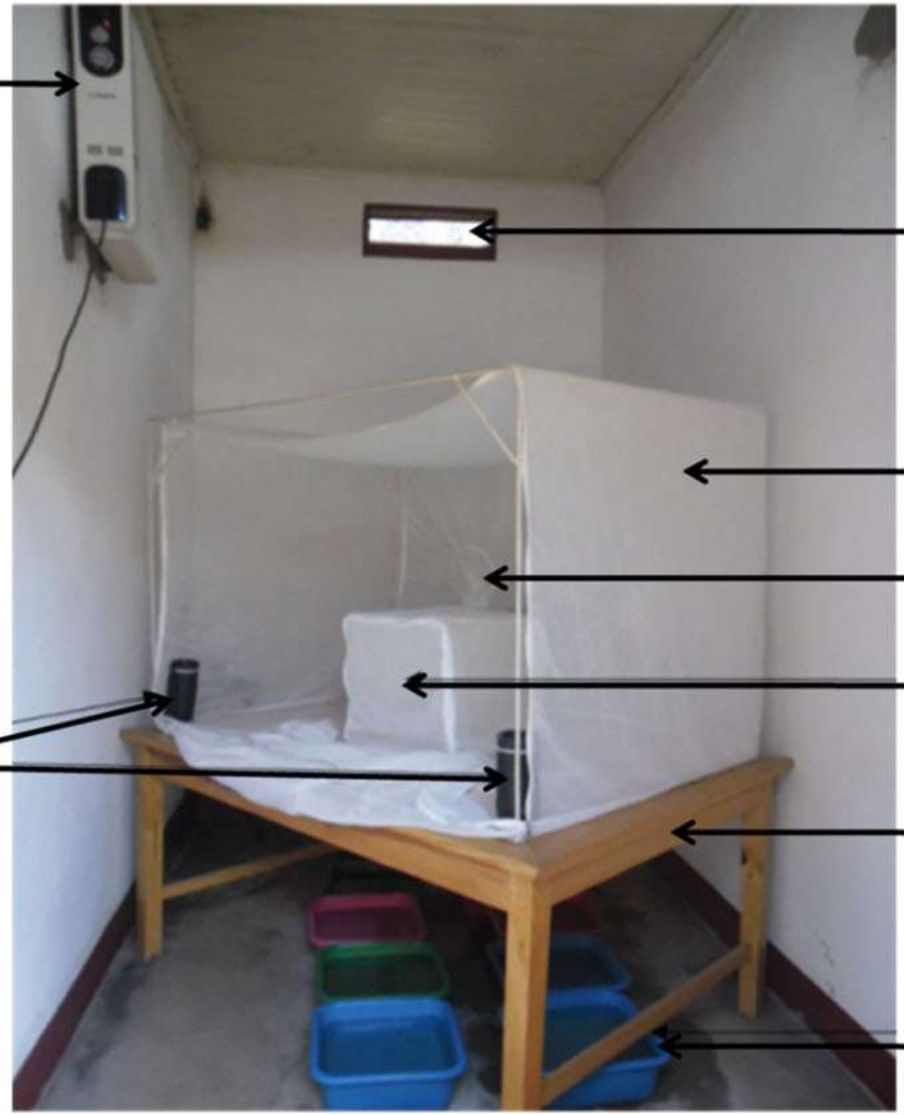
Close and selective interactions

Host – Vector – Semiochemical

Biocontrol

- **Attractants**
  - Mass trapping of target species
- **Reppelents**
  - Protection of exposed populations

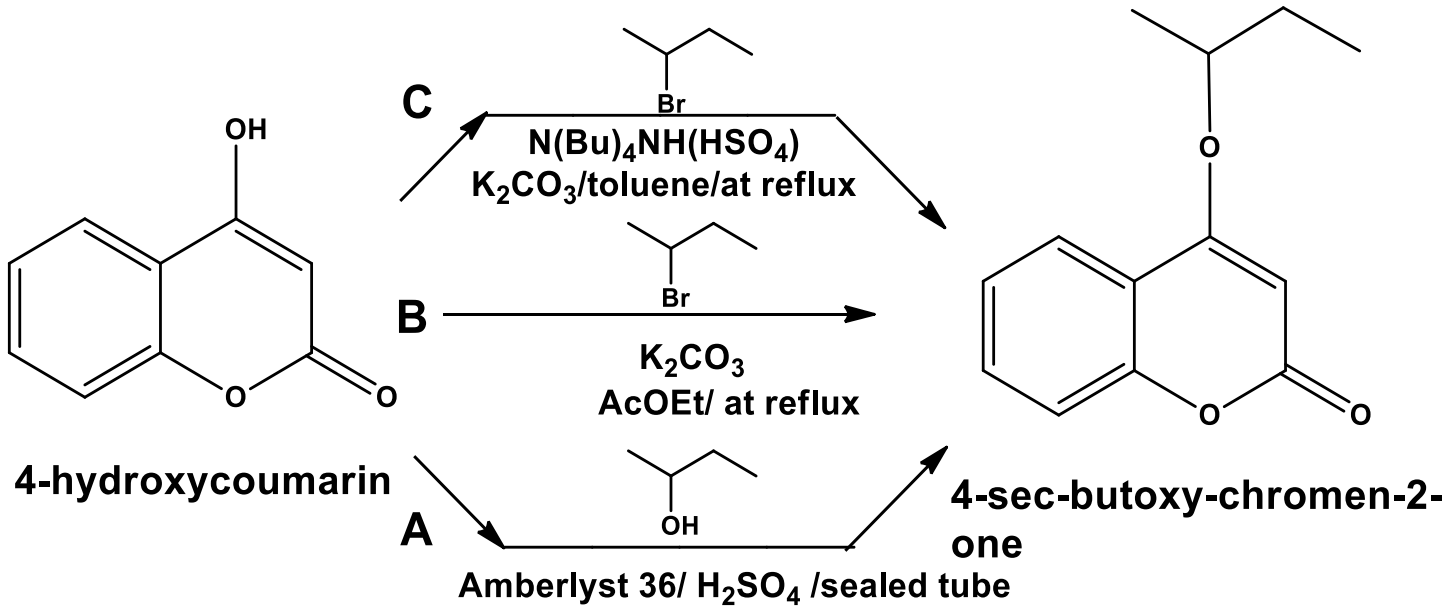
Bioassay using modified-cage system



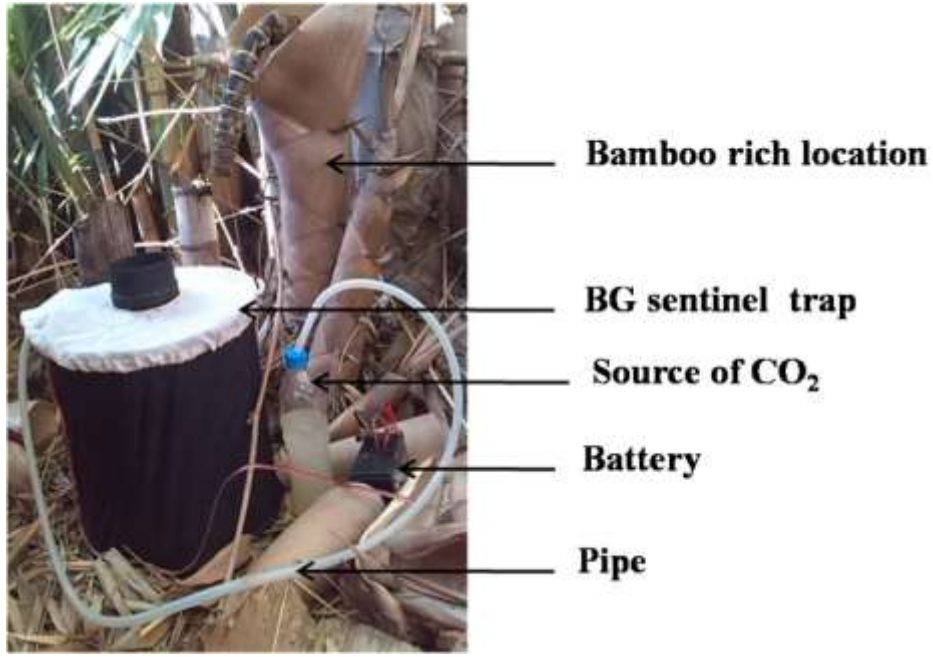
Chemical synthesis of new candidate compounds based on coumarin derivatives

Three different synthetic pathways:

- (C) Williamson type synthesis of ether
- (B) Phase transfert catalysis
- (A) Acid catalysis



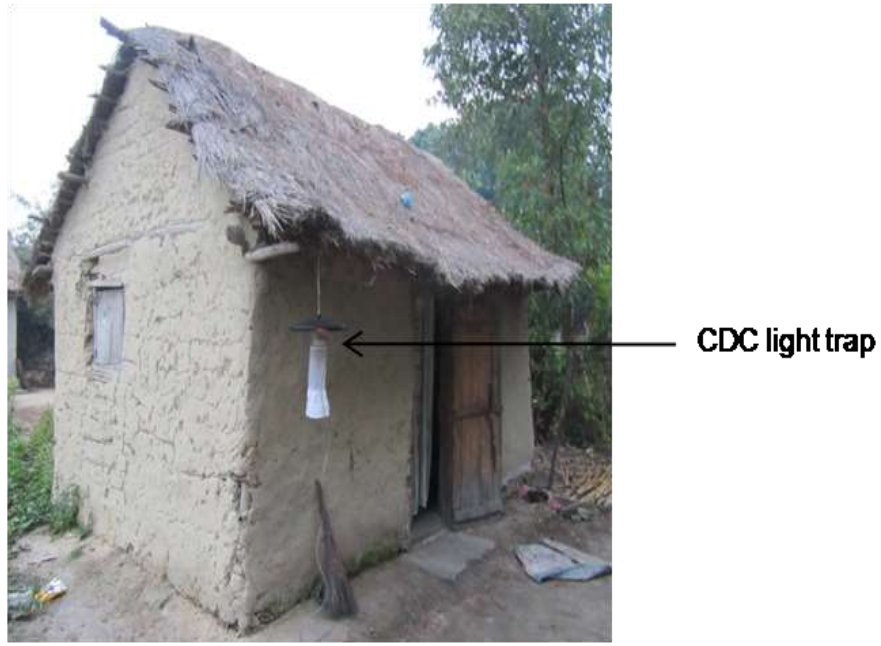
Field study using BG sentinel and CDC light traps



BG sentinel trap

(Biogent)

for *Aedes albopictus*

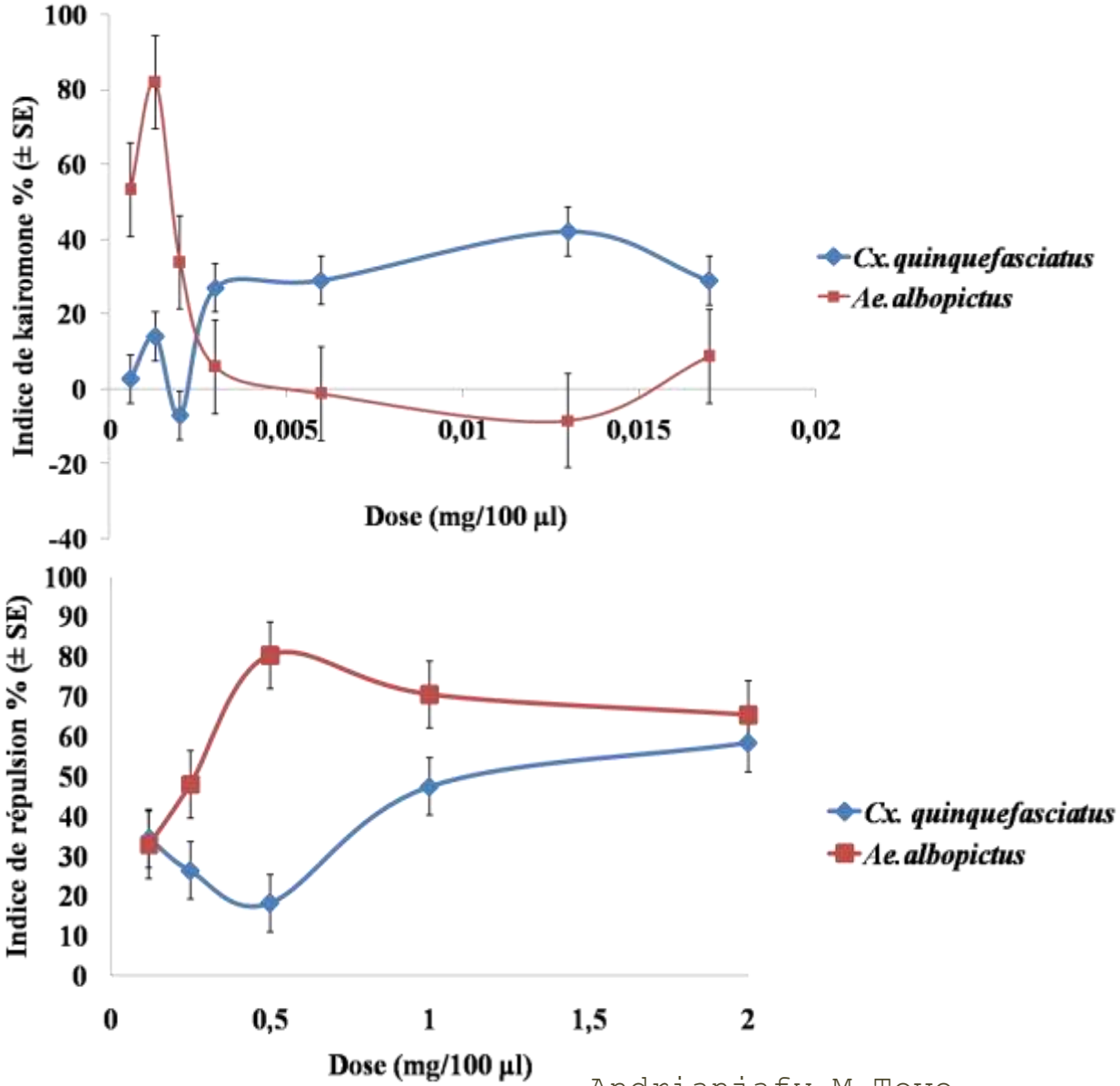


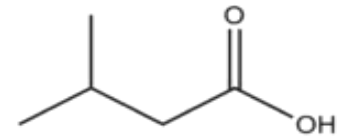
CDC light trap

(Center for Disease Control)

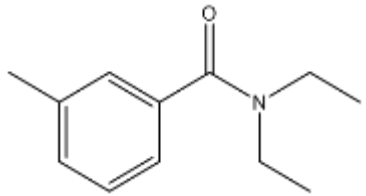
for *Anopheles* spp.

Isovaleric acid (attractant) and DEET (repellent) by modified-cage



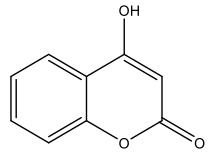
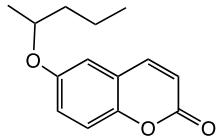
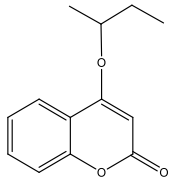
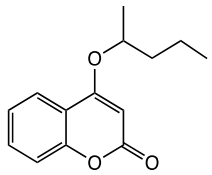


Isovaleric acid

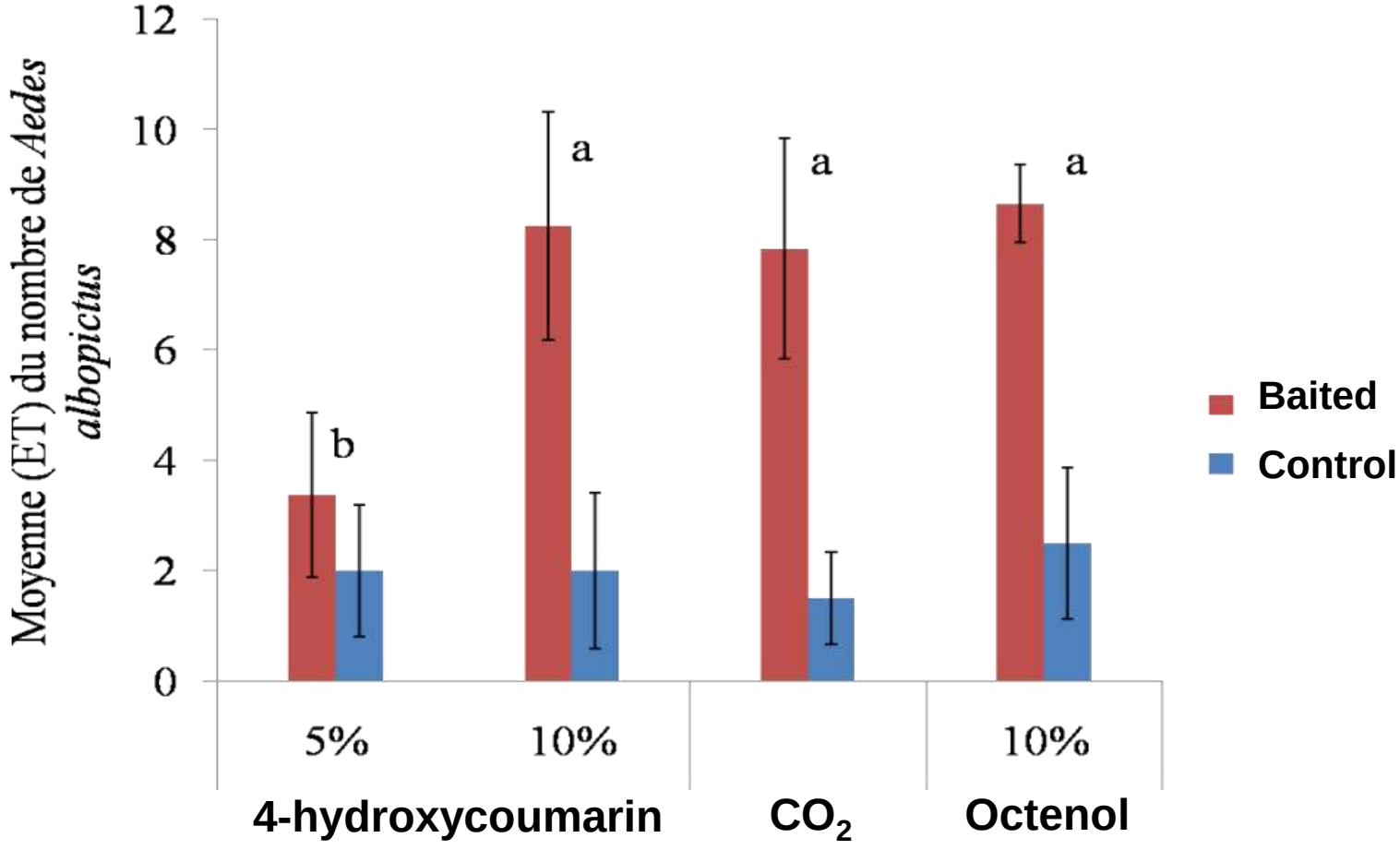


N,N-diethyl-metatoluamide

New family of active compounds based on coumarin derivatives

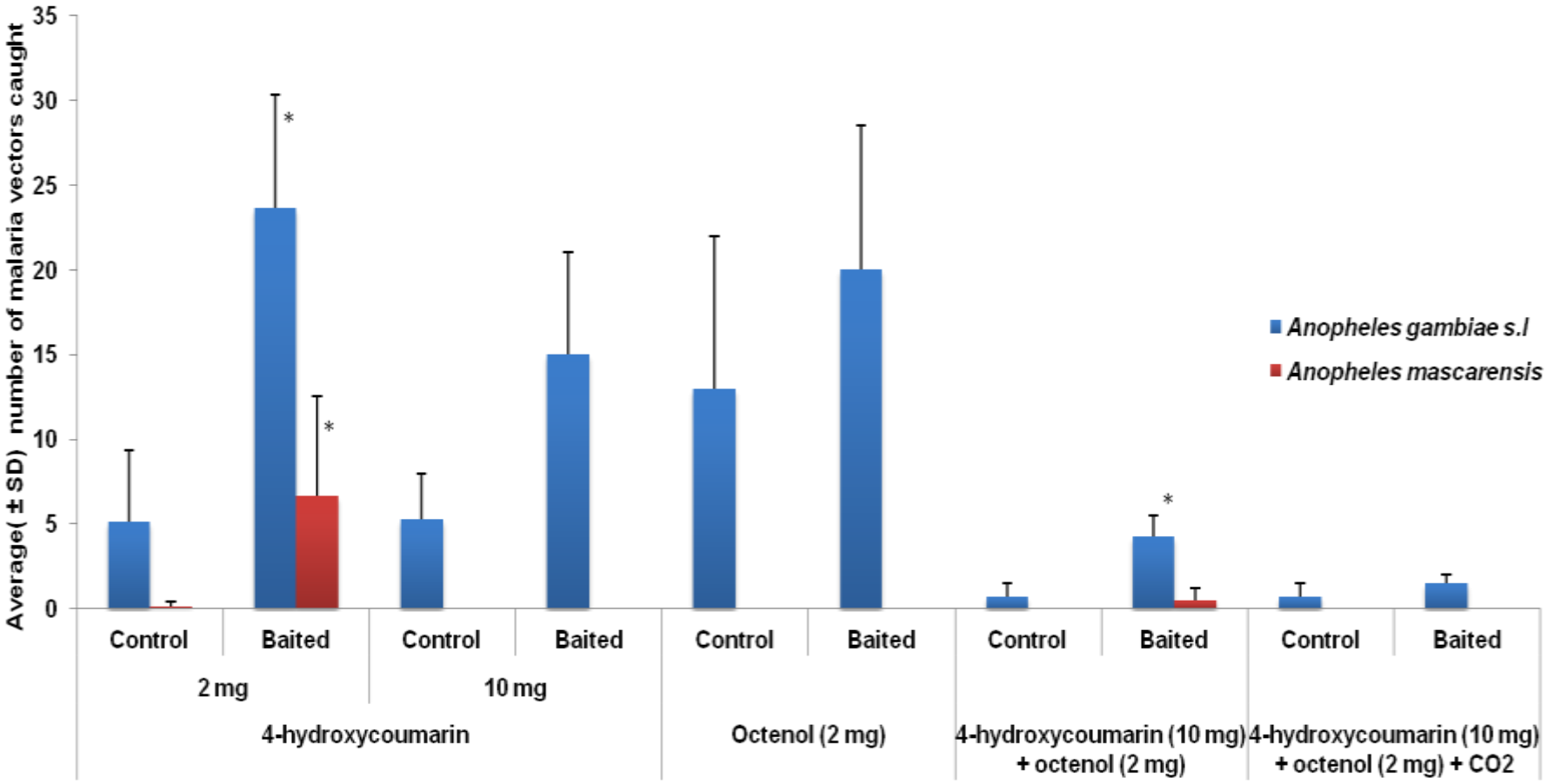
Compounds	Structure	Dose (mg/ml)	Effects	Index (%)
4-hydroxycoumarin		10	Attractant	65
6-sec-pentoxycoumarin		10	Attractant	40
4-sec-butoxycoumarin		10	Repellent	50
4-sec-pentoxycoumarin		10	Repellent	20

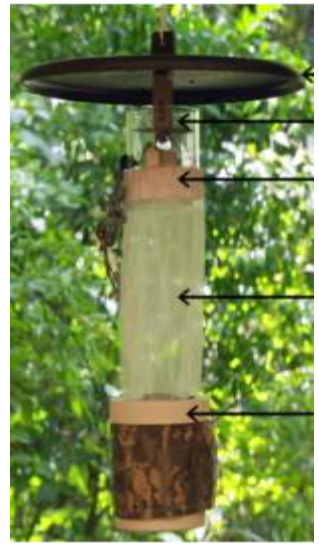
4-hydroxycoumarin as attractant of *Aedes albopictus*



Average (± SD) number of *Aedes albopictus* collected in the control and baited traps using BG sentinel trap

4-hydroxycoumarin as attractant of *Anopheles* spp.





Average (± SD) number of *Anopheles* malaria vectors caught in the control and baited traps using CDC light trap

New bioassay: modified-cage system

❖ Products	Effects	Species
Isovaleric acid	Attractant	*Aedes albopictus* and *Culex quinquefasciatus*
DEET	Repellent	

❖ **Difference in behavioral response of the two species towards attractant and repellent products**

Hao et al. (2012)

Bernier et al. (2007)

⇒ **Validating the effectiveness of the proposed bioassay**

Comparison of the different chemical synthesis ways

Chemical synthesis	Yields	Types of synthesis	Atomic economy
Williamson type	Low (5%)	Nucleophilic attacks Williamson (1850)	Bad (toluene, NaBr)
Phase transfert catalysis	High (70%)		
Acid catalysis	Medium (52%)	Nucleophilic substitution Trost (2002)	Good (water, recyclable catalyst)

Coumarin structural modification and mosquito behavioral response

Nature and position of hydroxyl substitutes in the coumarin cycle ⟹ **Influenced the behavioral response** of mosquitoes (attractant or repellent)

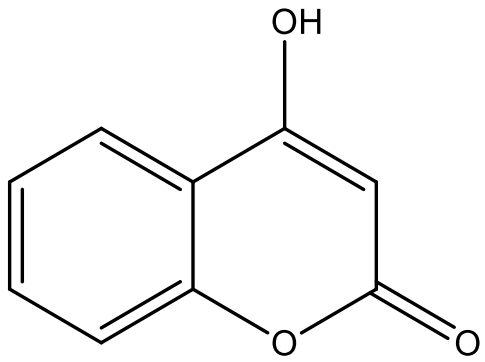
Vialle et al. (2011)

Branching and change in the carbon chain ⟹ **Affected the efficacy** of products

Vialle et al. (2013)

Effectiveness of 4-hydroxycoumarin as attractant of mosquitoes

- **Attractant effect** on *Ae. Albopictus*
(comparable to octenol and CO_2 with high selectivity)



- **Attractant effect** on *Anopheles* spp.
(high selectivity to the malaria vectors)

5. Acknowledgments

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