Report on the Study Tour in the Sacramento-Yolo Mosquito and Vector Control District (SYMVCD), in California, United States of America (USA): July 20th - August 14th, 2023

SUBMITTED TO:

Pan-African Mosquito Control Association

(PAMCA)

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1. General introduction

The Sacramento-Yolo Mosquito and Vector Control District (SYMVCD) in collaboration with the Pan-African Mosquito Control Association (PAMCA) invited two representatives, one from Rwanda and the second from Mali. The invitation was about the exchange program, sharing ideas and methods regarding mosquito control to learn about new and innovative ways to identify and control mosquitoes and the diseases they carry.

The study tour started on the 20th of July and ended on 14th August 2023. During our stay we rotated through various departments and operations and learnt from different components of the program including administration, surveillance systems, laboratory functions, ecological management, fisheries program, control methods and Visit to University of California Devis.

2. Objectives of the study tour

a. To learn from SYMVCD Experience in Mosquito control
b. To share experience of Rwanda in mosquito vector surveillance and control
c. To identify opportunities to implement learnt experience
d. To explore potential collaboration between SYMVCD and Rwanda

3. Mosquito control at SYMVCD

Mosquitoes transmit a variety of diseases of human and animal pathogens importance. Over 20 different species are found in Sacramento and Yolo counties and are capable of transmitting malaria parasites, West Nile (WNV), Saint Louis encephalitis (SLEV), western equine encephalitis (WEEV) viruses, and canine heartworm.

a. Ecology & main vectors

i. Culex tarsalis

This mosquito specie is abundant in Sacramento and Yolo counties, and can be found in cities, and towns. Is an effective vector of West Nile, western equine encephalitis, and Saint Louis encephalitis viruses. Is found all year, but most active during the summer and fall. *Culex tarsalis* breeds in wetlands, duck clubs, rice fields and irrigated crops. It prefers feeding on birds but can also feed on mammals and humans.

ii. Culex pipiens

Mostly found in towns and cities, can also be found in rural areas. Vector of West Nile and Saint Louis encephalitis viruses. Mostly active during the summer and fall but can be found year-round. *Culex pipiens* preferred breeding habitats are ponds, fountains, bird baths, buckets, neglected swimming pools, and dairy lagoons and catch basins. Prefers to feed on birds but will feed on humans if available.

iii. Anopheles freeborni

This was an important vector of malaria parasites in California back in the 1800's and early 1900's, it remains a good vector although malaria has been eliminated in the area. *Anopheles freeborni* is abundant in mosquito rice growing regions of Sacramento and Yolo, it breeds in rice fields, wetlands, duck clubs, and rain pools. The mosquito specie is

known for its nuisance as females fly long distances to find populated areas in search of human blood meal, is more active in the summer and fall and briefly active in the spring.

iv. Aedes vexans

Even if they are not important vector of human diseases, they are source of nuisance and mostly outdoor biters, females are active day and nighttime and are good fliers (up to 10 miles) in search of a blood meal. They breed in irrigated pastures and woodland water pools. active early spring through late fall.

v. Aedes sierrensis

This mosquito is not an important human disease vector but can constitute nuisance when breeding sources are near human activity. Vector of dog heartworm, breeds in water filled tree holes. Adult female mosquitoes generally feed on small mammals.

vi. Aedes melanimon

Is an important secondary vector of western equine encephalitis among wild rabbits. Mostly found in inland valleys of Sacramento and Yolo Counties. It breeds in wetlands, duck clubs and irrigated pastures. It can be a source of nuisance in areas surrounding breeding habitat. It prefers feeding on mammals and is most active during the spring and fall.

b. Mosquito surveillance systems at SYMVCD

The primary goal of the mosquito surveillance program at SYMVCD is to prevent nuisance, mosquito-borne diseases in humans and animals and evaluation of deployed mosquito control activities. There surveillance program includes mosquito abundance, disease activity, and pesticide resistance. The surveillance program enables the application and deployment of specific and effective mosquito control measures.

c. Surveillance tools, equipment, and resources

i. **Mosquito abundance:** monitored year-round at permanent sites spread throughout Sacramento and Yolo Counties.

ii. **Mosquito trapping:** trapped throughout Sacramento and Yolo Counties then sorted by location, species, and sex. Female *Culex* mosquitoes are separated into batches of up to 50 mosquitoes per pool.

iii. **Laboratory testing:** Collected mosquitoes are tested for West Nile virus (WNV), St. Louis encephalitis virus (SLEV), and western equine encephalitis virus (WEEV). On a weekly basis Female *Culex pipiens* and *Culex tarsalis* are tested as are the most important encephalitis vectors in the area. Positive pools lead to enhanced trapping and control efforts. Routine encephalitis virus surveillance (EVS) is performed from May to October.

iv. **Sentinel chickens:** They are a surveillance tool used to monitor and track virus activity in Sacramento Yolo area. Blood samples are collected every-other week during the mosquito season from well-kept

chickens in the area and the blood is tested for antibodies against WNV, SLEV, and WEEV.

v. **Dead bird surveillance**: From mid-April through mid-October, in collaboration with The California Department of Public Health (CDPH), dead birds are collected, and tested for WNV. Residents where collected dead birds tested positive for WNV are notified to avoid mosquito bites and potential exposure to the WNV.

vi. **Surveillance for other mosquito-borne diseases**: In addition to the WNV, WEEV, and SLEV, SYMCVD also performs surveillance of emerging or re-emerging mosquito-borne diseases especially malaria since two malaria vector species are found in the area. In case of any reported case of malaria in Sacramento Yolo area (Most of the cases are imported since the region has eliminated malaria since the 1950s), The laboratory proceeds by trapping mosquitoes in the area surrounding the malaria case. Collected female *Anopheles freeborni* and An. *punctipennis* are tested for malaria parasites.

vii. **Pesticide resistance management:** SYMCD practices pesticides product rotation to avoid resistance, and continually monitors resistance levels in both adult and larval mosquitoes and develops control strategies to counter the emergence of resistance.

4. Administration and governance

The Sacramento-Yolo Mosquito and Vector Control District was formed On June 18, 1946, following the need to protect the population against mosquito-borne diseases and nuisance. The district is governed by a board of trustees, representing cities or the counties within the district's boundaries. The board of trustees consists of 13 members including:

- Officers: President, Vice President, Secretary
- Other Members (10)

During the time of our visit, SYMCVD had a staff of 73 employees spread across several functions and activities of the district.

- **Administrative office**

- Manager (1)
- Assistant Manager (1)
- Administrative Managers (2)
- Program Coordinator (1)
- Senior Administrative Assistant (1)
- Administrative Assistant (1)

District administration department ensures the proper functioning of the district including:

- Customer Service and general reception,
- Management of human resources, finances, payment of salaries, general staff capacity development and other administrative duties
- Reporting to the board of trustees

- **Laboratory**
- Laboratory Director (1)
- Biologist (1)
- Vector Ecologist (1)
- Microbiologist (1)
- Laboratory Technicians (7)

- **Fisheries**
- Fisheries Supervisor (1)
- Field Technicians (2)

- **Public information & education**
- Public Information Officer (1)

- **Ecological management**
    - Ecological Management Supervisor (1)
    - Ecological Management Technicians (2)

- **Mapping & information technology**
    - Mapping/Systems Coordinator (1)
    - Information Technology Administrator (1)

- **Shop**
    - Supervisor (1)
    - Mechanics (2)

The district's shop is responsible for vehicles/heavy machines maintenance, reparation and installation of various types of Equipments.

- **Mosquito control operations**
    i. NORTH SACRAMENTO COUNTY
    - Supervisor (1)
    - Field Technicians (8
    ii. SOUTH SACRAMENTO COUNTY
    - Supervisor (1)
    - Field Technicians (8)
    iii. AEDES CREW
    - Supervisor (2)
    - Field Technicians (3)
    iv. NORTH YOLO COUNTY
    - Supervisor (1)
    - Field Technicians (5)
    v. SOUTH YOLO COUNTY

- Supervisor (1): Will Hayes
- Field Technicians (6)

vi. CATCH BASIN CREW

- Supervisor (1)
- Field Technicians (6)

5. Funding

The district's primary revenue source is the property tax at about 1 cent out of every 1 dollar of tax collected. The annual District's budget to finance all its activities amounts to 19 million US dollars.

6. Other relevant information

Aside from mosquitoes which were our center of interest, SYMVCD has other programs responsible for surveillance and control of:

- Ticks, vector of bacterium Borrelia burgdorferi that cause the Lyme disease,
- Yellowjackets that cause nuisance and other public safety issues,
- Other arthropods: ants, termites, springtails, mites, solitary and carpenter bees, long-horned beetles, honeybees, wasps, spiders, stored product pest beetles, moths, bedbugs, and midges.

7. Programs/activities engaged in and accomplished during the study tour

Our study tour lasted 20 days, from July 20th July to August 14th, 2023.During this period, we had access to the different services of SYMCD and were able to work side by side with staff from different services including: laboratory, fisheries, ecological management, mapping, mosquito control operations (catch basin crew, aedes crew, sacramento & yolo counties), public information & education.

8. Day-to-Day activities engaged in

- **Laboratory**

A. Setting and retrieving traps:

i. Encephalitis Vector Surveillance (EVS) Trap: Uses carbon dioxide in dry ice, targets host-seeking mosquitoes; used for encephalitis viruses' surveillance,

ii. Gravid traps: Useful for mosquito abundance and encephalitis viruses' surveillance, it uses water infused with fermented hay and hog chow to attract gravid females seeking an oviposition location,

iii. Biogents Sentinel Trap (BG-S): For trapping Aedes aegypti and Aedes albopictus, it uses carbon dioxide to attract mosquitoes,

iv. Locker Trap: Used for mosquito abundance surveillance, it runs continuously with compressed liquid carbon dioxide to attract host-seeking mosquitoes.

B. Mosquito identification and lab testing

Collected mosquitoes were returned to the lab:

i. Counted, identified to species and sex.
ii. Culex pipiens and Culex tarsalis were pooled in collections of up to 50 females by location and trap type,
iii. Tested for the SLEV, WEEV, and WNV using PCR techniques.

C. Sentinel chickens
Blood sampling from chickens kept in sentinel chickens flock for testing of antibodies against SLEV, WEEV, and WNV.

D. Dead birds
i. Observed dissection of died birds for the detection,
ii. Samples (brain tissues) taken from dead birds were tested in the lab for WNV, WEEV and SLEV

E. Quality control of vector control tools
i. Pesticide resistance testing using CDC protocols, the district maintains susceptible colonies of Culex pipiens and Culex tarsalis to be used as reference,
ii. Field efficacy trial using bioassay cages of adult mosquitoes and droplet impingers, they are deployed to assess spray events.

F. Visit to UC Davis

A one-day visit to the University of California, Davis, school of veterinary medicine was organized, the aim was to visit the lab and insectary of Professor Gregory Lanzaro and especially his work on genetically modified mosquitoes using gene engineering technology, with expected outcome of GM mosquitoes that cannot transmit malaria parasites.

- **Mosquito and vector control operations**
The two counties of Sacramento and Yolo comprise 2,013 square miles of urban, commercial, and agricultural land, divided into 27 geographical zones, teams of technicians provide services in those zones, ranging from larval to adult mosquito surveillance and control to reduce nuisance mosquitoes, and respond to WNV activity.

With field teams we were able:

i. To conduct inspections of various types of mosquito breeding sources:
- Catch basin program**:** Monitor (water and sewer systems),
- Swimming pool program: Identification of neglected swimming pools in residential areas,
- Detection of invasive aedes mosquitoes: conducted door-to-door inspections,

ii. To observe aerial spraying with aircraft or even with drones over agricultural mosquito breeding sources, and receive explanations from technical teams,
iii. To apply larvicides in water/sewer systems or mosquitofish wherever indicated,
iv. To conduct ground treatments with truck mounted foggers and back packs,

v. To respond to home service requests including treating neglected swimming pools, delivering, and stocking mosquitofish, and treating yellowjacket
vi. To participate in cemeteries inspection, vases were emptied and flipped over in their holders or treated with water absorbing crystals,
vii. To work in fisheries Department, responsible for breeding mosquitofish (*Gambusia affinis*) used as a predator of mosquito larvae, worked with field teams on their introduction to mosquito breeding sources (creeks, rice fields, abandoned swimming pools…)
viii. To work with ecological Management, that consists of altering mosquito environment, managing aquatic sources, and by doing so, the opportunity for mosquitoes to develop is eliminated. Ecological management acts by promoting effective drainage, controlling emergent vegetation, and advising on the best timing of irrigation.

9. Key lessons documented about how mosquito control is conducted in the US, and in SYMVCD in particular

SYMCD uses a robust mosquito surveillance program as part of the Integrated Vector Management (IVM) approach, the system provides real-time data on mosquito abundance and disease activity mostly, West Nile virus that is the most predominant mosquito borne disease in California. Located areas are mapped and integrated in software platforms for better planning and implementation of vector control operations.

Vector control operations are implemented in a synchronized manner and all of them are outdoor interventions:

- Immature stages: larvicide or mosquitofish
- Adult mosquitoes: ground treatments with truck mounted foggers and back packs, aerial applications
- Ecological Management: bush cutting, ditch cleaning.

All the above operations are strongly supported by the education of the public about mosquito and West Nile virus prevention methods using advertising and media campaigns through a variety of community events, school programs and partnership with local groups.

Considering the small number of personnel who accomplish big tasks, someone may conclude that the use of new technologies, modern equipment and a multi-tasking group is a good solution and a good lesson that could serve as an example of an effective abatement and vector control program.

10. Applicable contextual opportunities

The visit to SYMVCD allowed us to explore new mosquito surveillance, control strategies, methods, and techniques for:

i. **<u>Rwanda</u>**

- Continue conducting entomological surveillance in country including the increasing of entomology lab capacities,

- Explore an increase in the entomological sites/or use of automated mosquito traps in entomology surveillance,
- Explore collaboration between Rwanda and SYMVCD in the knowledge and skills transfer in the use of new technologies in the field of entomology and vector control,
- Apply IVM in vector control and not rely only on indoor interventions, add outdoor control tools such as mosquito fish, larviciding, drone technology etc..

ii. Mali

- Capacity building,
- A possible future collaboration

11. Conclusion and recommendations

The visit to the SYMVCD was a good opportunity for us to explore the design, implementation of IVM concepts, the use of modern tools and technologies in the field of mosquito and vector control to control and fight against mosquito borne diseases as well as mosquito abatement program, it was also crucial to learn the level of involvement of the authorities in the financing and applications of mosquito control interventions.

12. Acknowledgements

We would like to express our deepest appreciation to our respective supervisors, Dr Emmanuel HAKIZIMANA, and the late Dr Mamadou Coulibaly who offered us the opportunity to participate in the SYMVCD study tour.

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Furthermore, we would also like to acknowledge with much appreciation the crucial role of the management of SYMVCD who agreed to welcome us and finance all the expenses related to the visit, gave permission to use all the district's facilities. A special thanks goes to the SYMVCD team who made our learning task easier.