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ARBOVIRUS VECTOR TREATMENTS, WITH THE USE OF CHEMICAL OR PHYSICAL ANTILARVALS, PLANNING THROUGH CITIZEN INVOLVEMENT: AN EFFICIENT BOTTOM-UP MODEL

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Abstract Health monitoring and containment of mosquito species, potential vectors of arboviruses, require multisectoral planning. While understanding the eco-ethological characteristics of vectors is essential for predicting their spatiotemporal development, it is equally important to assess citizens' perceptions of their presence. In 2024, the Municipality of Genoa enhanced pest control measures based on the city's characteristics, including population density and morphology. These actions were informed by data collected over the past three years from areas with the highest mosquito abundance reported by residents. Control measures included the application of biological larvicidal products and the installation of mechanical devices inside rainwater manholes to prevent oviposition in standing water. Genoa, the sixth-largest city in Italy by population, is divided into nine districts. It was one of the first entry points of *Aedes albopictus* into Europe (1990) and is currently the southernmost site in Europe where *Aedes koreicus* is present. Critical areas within each district were identified by integrating environmental indicators (e.g., demographics and geomorphology) with citizen participation. These efforts align with a "One Health" approach, aiming to prevent the potential urbanization of arbovirus vectors or the establishment of invasive species (e.g., *Aedes aegypti*). The strategy focuses on optimizing containment techniques while minimizing the unnecessary spread of chemical insecticides. Additionally, local communities, as active participants in the control plan, are kept informed about the outcomes. This includes comparing mosquito larvae and adult populations in treated areas (using chemical or physical larvicides) versus control areas (untreated sites).

Key words Mosquitoes, citizen involvement, urban areas

INTRODUCTION

Monitoring and controlling mosquito species, which act as potential vectors for arboviruses, requires multisectoral planning and an integrated approach encompassing various scientific, social, and institutional domains. Arboviruses such as Dengue, Zika, Chikungunya, and Yellow Fever are primarily transmitted by mosquitoes of the genus *Aedes*, the most common species being *Aedes albopictus*. Efforts to combat the spread of these viruses rely on a combination of strategies, including ecological and entomological surveillance as well as direct management of mosquito breeding sites.

Understanding the eco-ethological characteristics of mosquito vectors to predict their potential development in time and space is crucial. Equally important is analyzing citizens' perceptions of their presence and the associated health risks. Public awareness, active involvement, and collaboration across various sectors are essential to ensuring the effectiveness of containment actions.

MATERIALS AND METHODS

"One Health" Approach to Mosquito Control Mosquito control cannot be viewed solely from a public health perspective. Rapid urbanization and climate change present complex challenges that demand an integrated approach, recognizing the interconnectedness of human, animal, and environmental health. This concept underpins the "One Health" approach, which aims to address health, biodiversity, and environmental issues in a coordinated manner.

In this context, managing arbovirus vectors should be regarded as a global public health issue. Mosquitoes pose risks not only to human health but also to domestic animals, which can be infected by viruses such as West Nile. Additionally, preserving biodiversity is crucial, as the introduction of alien species like *Aedes japonicus* and *Aedes koreicus*, or the potential reintroduction of *Aedes aegypti*, could negatively impact local ecosystems.

The "One Health" approach has also guided the selection of non-invasive and environmentally low-impact control techniques, such as the use of biological larvicides and mechanical interventions to eliminate breeding sites. This approach has involved experts in biology, ecology, and veterinary medicine to ensure an effective and sustainable response to the challenges posed by mosquito proliferation.

"One Health" Logic and an Integrated Approach to Mosquito Control In 2024, the Municipality of Genoa intensified mosquito control actions, tailoring strategies to the city's specific characteristics, such as population density, terrain morphology, and data from citizen-reported mosquito presence over the past three years. This plan combined biological and mechanical interventions, aiming to minimize the use of chemical products while raising public awareness about the importance of collaborating with the treatment plan.

Control actions primarily involved the use of biological larvicidal products that target mosquito juvenile stages, preventing their development into adults.

Treatments of drains and manholes were conducted using (Aquatain AMF®) a larvicide with a physical-mechanical action based on polydimethylsiloxane (PDMS). Following application, a silicone film forms on the water surface. The film's low tension prevents larvae and pupae from attaching to the surface to breathe, causing suffocation, and stops adult females from laying eggs.

In addition, mechanical devices were installed inside storm drains to prevent mosquito oviposition in stagnant water. These interventions were complemented by informational campaigns to educate the public on eliminating water stagnation in gardens, balconies, and public areas, as even small amounts of water can provide ideal breeding conditions for mosquitoes.

Ecological and Behavioral Characteristics of Mosquitoes Effective mosquito control requires an in-depth understanding of their habits and the ecological factors that facilitate their proliferation. Mosquitoes of the genus *Aedes*, for instance, primarily breed in stagnant water found in containers, tires, plant pots, and drains. These species are particularly adaptable to urban areas, where they find ideal habitats for egg-laying.

The *Aedes albopictus*, commonly known as the tiger mosquito, arrived in Europe in the 1990s and quickly colonized many Italian cities, becoming a significant health concern. This species thrives in urban environments where mild temperatures, frequent rain, and water stagnation create favorable conditions for proliferation.

In 2016, the entomological monitoring conducted by the Experimental Zooprophylactic Institute of Piedmont, Liguria, and Valle d'Aosta, in collaboration with Ligurian Health Authorities and the Municipality of Genoa, identified *Aedes koreicus* for the first time (Ballardini et al., 2019). This species is a vector for arboviruses such as Chikungunya, Zika, and West Nile (Jansen et al., 2021). By 2024, *Aedes japonicus*, a mosquito species native to Asia, was detected in southern Liguria, making Genoa the southernmost site in Europe where this species has been reported. *Aedes japonicus* shares ecological traits with *Aedes albopictus* but is more resistant to cold and capable of transmitting the same viruses.

The Role of Citizens in Mosquito Control An innovative aspect of Genoa's mosquito control plan was the involvement of citizens in monitoring mosquito presence. Instead of viewing the population as passive recipients, the Municipality gathered data from resident reports to identify areas with the highest mosquito presence.

Citizen reports were instrumental in identifying critical areas across the city's municipalities. By integrating these reports with morphological and structural data, targeted larvicidal interventions were planned to use a collective intelligence approach.

Sampling Methods for Monitoring Sampling larvae and pupae was conducted using a dipper (a 0.5–1-liter container attached to a telescopic handle). Multiple water samples were taken from drains, ensuring coverage of different sections of the water surface. The contents of the dipper were then poured into a shallow tray to identify any present larvae.

Adult Mosquito Capture Using the BG-Sentinel2 Trap The BG-Sentinel2 trap, a specialized device for capturing gravid female mosquitoes, was employed. These females, seeking suitable water sources for egg-laying, are drawn to the trap, which uses stagnant water as an attractant. This water can be locally sourced or prepared to simulate natural habitats by mixing water, brewer's yeast, and hay, then allowing it to ferment for 1–2 days. The trap features an aspiration system that collects adult females, which may have completed and digested at least one blood meal and potentially carry the virus in their salivary glands.

Analysis and Comparison of Interventions: Treated vs. Control Areas To monitor the effectiveness of the implemented actions, two groups of areas were defined, homogeneous in their environmental, social, and architectural characteristics). The greatest challenge, given the unique geography of Genoa—characterized by a scarcity of flat land and an abundance of hilly terrain near the sea—was identifying adjacent areas with identical orographic features.

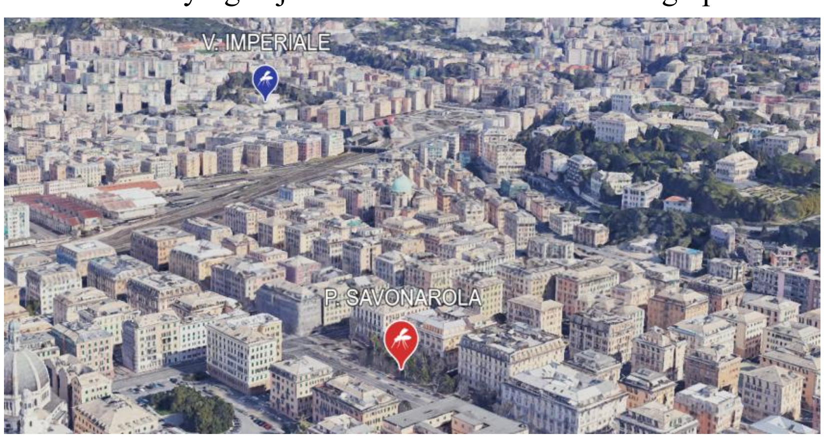

Figure 1. Treated area (P. Savonarola) and control area (V. Imperiale), with comparable environmental characteristics, except for the gradient.

This challenge, however, provided an opportunity to further evaluate the efficacy of larvicide treatments. These treatments are often applied in flat areas where potential water stagnation is significantly higher compared to hilly areas, where natural gravitational drainage typically prevents water accumulation in storm drains.

In the first group, consisting of treated areas, biological larvicide products were applied, or mechanical devices were installed to prevent adult mosquitoes from accessing and developing in larval habitats (e.g., drains and storm drains). The second group, serving as control areas, did not undergo disinfestation or structural interventions.

In both treated and control areas, traps were installed to monitor adult mosquitoes, particularly BG-Sentinel traps. These traps were monitored every two weeks by specialized naturalist technicians who recorded the number of mosquitoes captured. Larval species identification was performed by the University of Genoa (DISTAV - Department of Earth, Environment, and Life Sciences), while adult species were identified by the Experimental Zooprophylactic Institute of Piedmont, Liguria, and Valle d'Aosta.

Comparing the number of larvae and adult mosquitoes in the two types of areas allowed for an evaluation of the containment methods' effectiveness and provided the opportunity to make real-time adjustments to the disinfestation program.

RESULTS AND DISCUSSION

For the analysis of treatment efficacy, data from monitoring at Piazza Savonarola (treated) and Villa Imperiale (untreated but with similar environmental characteristics, except for its steeper terrain) were considered. Villa Imperiale, located nearby, served as a control site for assessing treatment effectiveness.

As shown in the following graph (Fig2), after the treatments commenced, Piazza Savonarola—typically characterized by a much higher frequency of mosquito presence reports from citizens—experienced a progressive reduction in the number of sampled adult mosquitoes (of all species). This trend eventually led to partial convergence with the mosquito counts observed at Villa Imperiale. Despite being nearby, Villa Imperiale's steeper terrain naturally minimizes water stagnation, reducing its suitability for mosquito proliferation compared to the flat, sea-level terrain of Piazza Savonarola.

This phenomenon can be attributed to gravitational drainage at Villa Imperiale, facilitated by the storm drain system, which results in fewer stagnant water sites. Consequently, the ecological "suitability" for mosquitoes is lower compared to Piazza Savonarola.

A plausible explanation for the observed trend is that, in the absence of structural improvements to the current drainage system—such as frequent unclogging and drying of water accumulation in flat urban areas like Piazza Savonarola—the larvicide treatment effectively reduced mosquito presence. This brought the treated area's mosquito population to levels comparable to those in urban zones with naturally less favorable ecological conditions for mosquito breeding and proliferation.

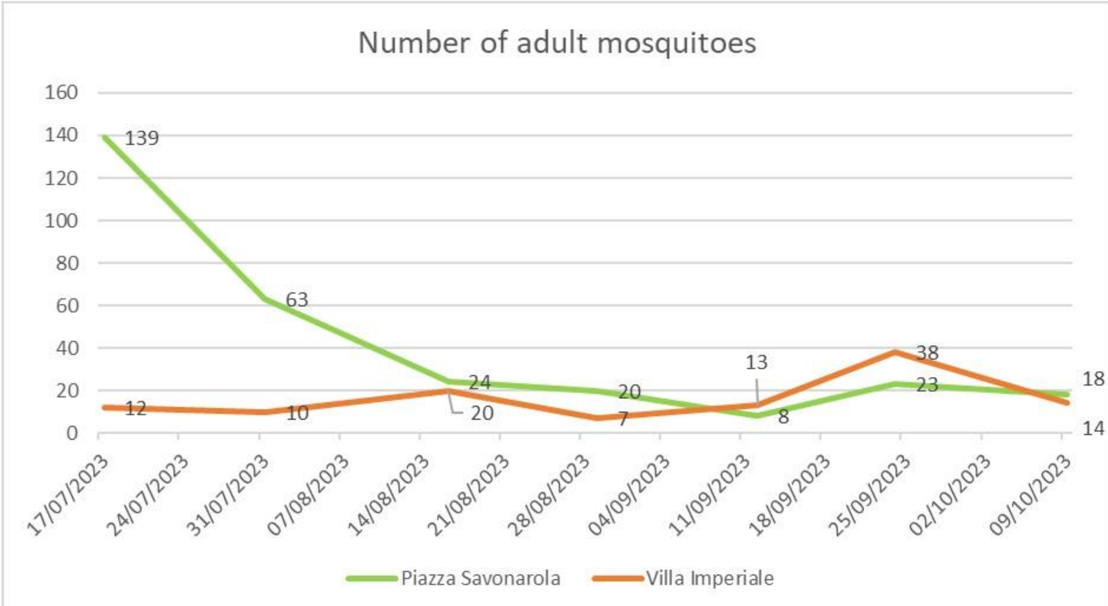

Figure2 Number of adult mosquitoes collected from the two monitored sites

CONCLUSION

The mosquito control plan implemented by Genoa's Municipality in 2024 had a significant positive impact on reducing mosquito populations and preventing the spread of arboviruses. However, combating disease vectors remains a continuously evolving challenge, requiring collaboration between citizens, institutions, and the scientific community.

The future of mosquito control must increasingly rely on innovative, eco-sustainable, and integrated techniques, with strong community engagement and ongoing advancements in prevention policies. Only through a collaborative and multidisciplinary approach can we effectively address the health threats posed by arbovirus proliferation.

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