

• Introduction

- Black flies (Diptera: *Simuliidae*) are small dipterans which females are hematophagous. As some species are mammophilic, and even antropophilic, public health problems can appear in urban areas where those insects are found, as allergic reactions can be severe in sensitive patients. Their development is associated with river reaches with high currents, as the preimaginal phases are aquatic and reophilic.
- Public Health issues related with Black flies have been occurring in the central region of Spain (Madrid and Toledo provinces) for over two decades. During the summer of 2018 Madrid City Council received an unusual number of complaints related with insect bites near the Manzanares river. Consequently, the Vector Control Department of Health Madrid performed a series of inspections at different points of the river. As a result, the verification of the presence of black flies, an emerging pest in urban areas of Spain, and recorded in high density for the first time in the city. In 2019 a similar situation, but with a lower density, was recorded in the city of Leganés. Later followed by the city of Toledo in the Tajo river and other municipalities in the Guadarrama, Tajuña, Jarama and Henares river, where Lokímica has undergone monitorization tasks.
- Urban pest management is a municipal competence in Spain. Once black flies are present and generate enough troubles in cities or towns with riversides or near them, they are included as one of the local pests to be controlled under Integrated Pest Management Programs. City councils will carry out public tenders involving the private sector, enforcing public units or mix both. Today Lokímica is responsible for multiple municipal or supra-municipal black fly management services, several of them in the central Spanish region.

• Material and Methods

- In this context, diagnosis of the situation, monitoring and other actions related to entomological surveillance and management of Black Fly have been conducted. Diagnosis was carried out in areas with optimal conditions for Black Fly breeding. Measuring physical-chemical parameters and sampling substrates and vegetation (macrophytes and helophytes) for the determination of *Simuliidae* larvae and pupae density. Recommendations for a Pest Control Plan were concluded. As well as a risk analysis with GIS of population and singular elements (schools, sports areas, etc.) exposed.
- Based on the initial surveillance of black flies, confirmation of biting activity and risk analysis, different activity sections of the river are recognized. Afterwards, again based on several factors (estimated speed of the water, accessibility, distance to housing areas and biting pressure) monitoring sites and larvicide treating points are established.
- Larvae density is calculated by counting the number of larvae in certain amount of vegetation (kg). Density is compared before and after each treatment in every monitoring site.
- The mean effectiveness per km from the treatment point is also estimated.
- Citizenship complaints are recorded and if necessary, based on Public Health authority's requirement, adult trapping and adulticide treatment is carried out.
- All information is noted and technical reports are prepared based on it. Evaluation of each municipal program is carried out and improvements are implemented.



Fig.1. From top-left to bottom-right: Black fly eggs, larvae, pupae & adult; example of human legs with multiple bites; larvicide & adulticide treatment; example of a Black Fly Management Municipal Map (red square indicates treating points, green triangle corresponds to monitoring spots and yellow circles are biting sites reported by citizens).

• Results

Species identification

- Different preimaginal black flies breeding surfaces (rocks, vegetation, etc.) are inspected in the different sampling sites. Vegetation is randomly selected for evaluation in laboratory in each evaluation area. Then, the vegetation is weighted and eggs, larvae and pupae are taken. Pupae are identified to species level following different taxonomic keys.
- The most abundant species that we have found on different rivers on Central Spain are: *Simulium lineatum*, *S. pseudequinum*, *S. rubzovianum* (previously *S. velutinum*), *S. ornatum complex* (*S. ornatum* and *S. intermedium*), *S. erythrocephalum* and *S. sergenti*. Other species found only in some specific areas are: *S. equinum* and *S. ruficorne*.
- From a Public Health perspective *S. erythrocephalum* has the greatest impact as it is the most anthropophilic species. The highest densities are recorded in the months of May and June.

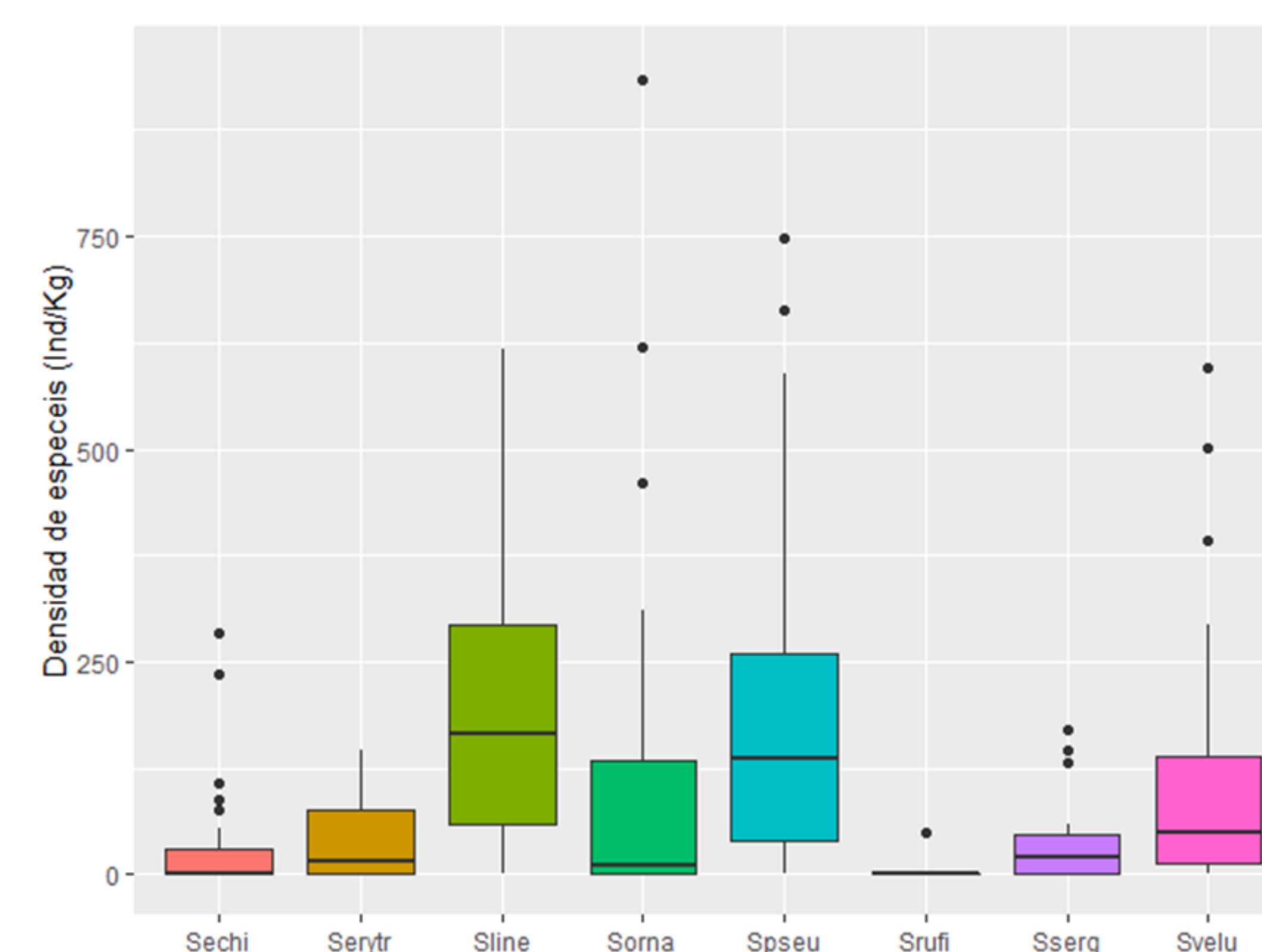


Fig 2. Box plot of the density of the different black fly species identified.

Treatment

- Black fly control activities are mainly focused on control of larval populations. For this purpose, *Bacillus thuringiensis sbsp. israelensis* (Bti) is poured in river reaches based on identified pupae during the Entomological Survey phase.
- Bti doses is calculated based mainly on the river flow rate, the pouring speed of the sprayer and the required product final concentration.
- Since 2018 the average effectiveness of larvicide treatment per km from the control point was estimated in 96%. A high reduction in the possible black fly citizenship complaints in the following weeks after the treatment has been observed.
- Only one adulticide treatment has been required (June 2022), in previously non-treated area, due to excessive adult presence and multiple citizenship complaints of biting.

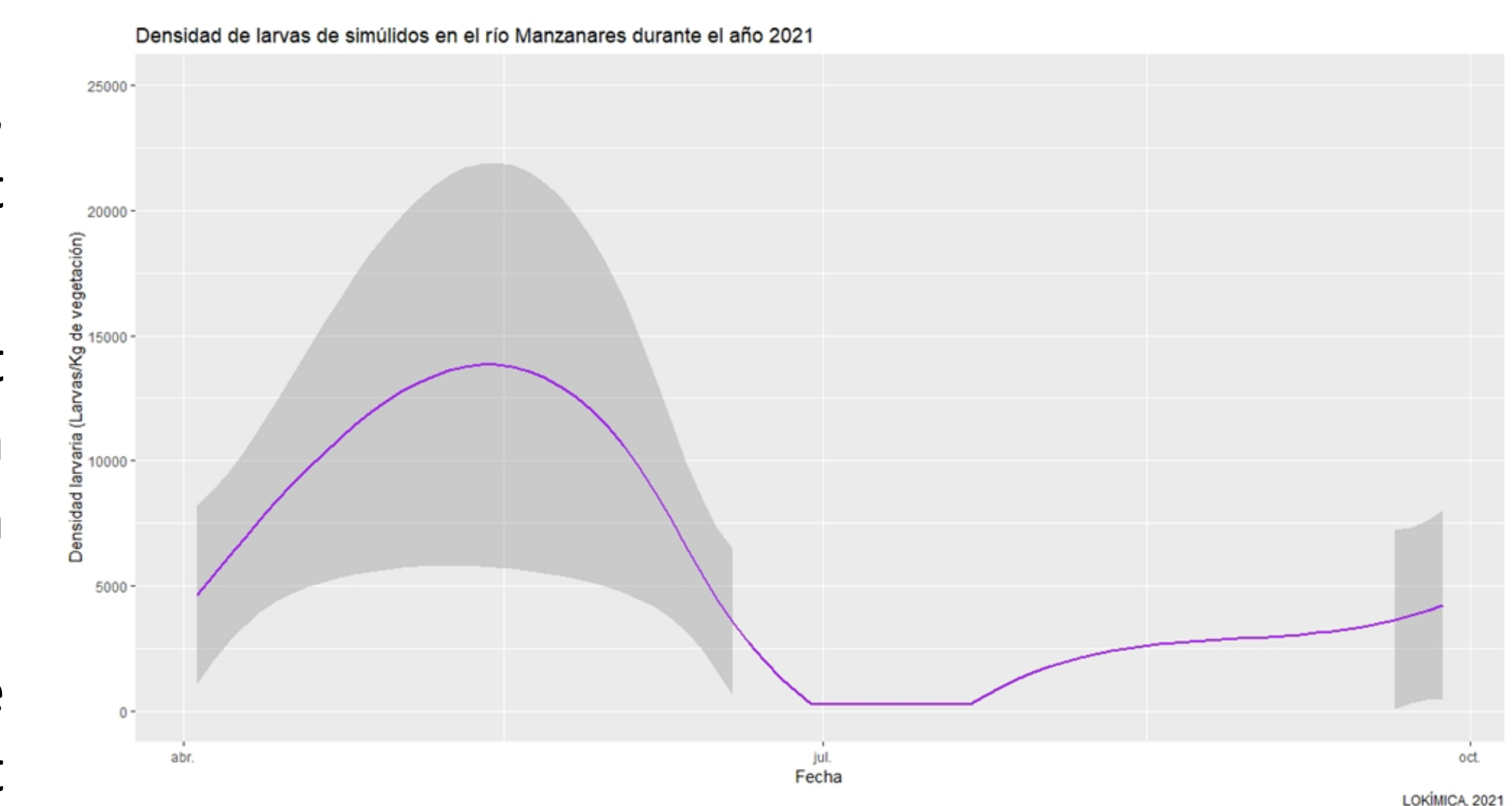


Fig 3. Example of a chart with the density of larvae from April to October in 2021.

• Conclusions & Further Research

- Black fly control programs are expensive and they are mainly funded by municipal budgets, although the problem is at a river basin level.
- Population management requires thorough work, mainly surveillance, before treatments plans are developed. Deep knowledge on the territory and location of breeding sites is essential.
- Larvicidal treatment is an effective preventive control measure. Although, we rely exclusively on Bti as the active ingredient for controlling larvae population in natural rivers.
- On most occasions as economical resources come when adult activity already causes troubles, larvicide preventive treatments begin late in the season, reducing overall effectiveness.
- Black fly management programs benefits should be quantified economically in order to help convince decision makers.
- Black fly management programs should be focused on a river basin or sub-basin scale and not a municipality level.
- Larvicide treatments are preventive measures, control programs should begin before adult biting activity starts.