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REMOTE CATEGORIZATION OF MOSQUITOES: A NEW SENSOR PROTOTYPE

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Abstract In the recent years, different types of sensors have been developed for the automatic categorization of mosquitoes. Most of them have been only tested in laboratory conditions so there is a lack of studies in the field. In this study, a new sensor prototype linked to a mosquito trap was tested in the field for the automatic counting and sex categorization of mosquitoes. The sensor showed a strong linear relationship between the real and the estimated values, being useful to evaluate tendencies in mosquito populations of public health importance.

Key words Automated mosquito surveillance, intelligent sensor, real-time monitoring, machine learning

INTRODUCTION

Mosquito surveillance still relies on conventional methods that include the installation and collection of physical traps and the taxonomical recognition of the samples by professionals (ecdc, 2018). Such methods are very costly in terms of time and may not correctly characterize the dynamics of mosquito populations. In this context, the emergence of new sensors can improve mosquito surveillance by allowing the remote categorization of the captured specimens (Santos et al., 2019). These novel sensors are trained with machine learning techniques (Potamitis et al, 2014; Genoud et al., 2018; 2020). Most of the research focused on mosquito remote categorization has been performed in laboratory conditions, reaching good levels of precision (Potamitis et al., 2014; Ouyang, 2015; Potamitis and Rigakis, 2016; Genoud et al., 2018; 2020). There is a lack of studies which report the performance results of these kind of sensors in the field.

In this work, we present a novel sensor prototype connected to a commercial adult mosquito trap which is able to count mosquitoes and recognize their sex in field conditions with high precision. The results of this study are very inspiring for the future use of this equipment in mosquito surveillance plans.

MATERIAL AND METHODS

Study site. The study was conducted during summer in Barcelona province, Spain. The sensor was connected to a BG-Mosquitaire trap (Biogents, Germany) fitted with dry ice. Samples were collected twice a week for periods of 24 hours. Mosquitoes were identified to the species level with a taxonomical recognition guide (Schaffner, 2001) and were contrasted with the results of the sensor.

Sensor. The sensor, developed by Irideon S.L. (Barcelona, Spain), was previously trained in the BSL2 insectary facilities of IRTA-CReSA (Cerdanyola del Vallés, Barcelona, Spain). The remote categorization of mosquitoes in this field trial involved the application of the best machine learning model for the tasks of distinction between mosquitoes and other insects and between females and males.

Data analysis. Two samples per week were collected over the sampling period for periods of 24 hours each. The inspection of the samples was performed manually and compared by means of descriptive statistics with the estimations done by the sensor. A correlation analysis was done to examine the association between the real and estimated counts. All the analysis was made using GraphPad Prism 9.3.1 software.

RESULTS AND DISCUSSION

More than 1500 mosquitoes were counted over the whole sampling period, representing less than a quarter over the total catches. The rest was composed by a mixture of other non-Culicidae insects. Among the Culicidae, *Culex pipiens* and *Aedes albopictus* were the two most abundant species. Most of the captured mosquitoes were females.

When analysing the categorization of mosquitoes, the results showed that the real and the estimated values were very similar (Figure 1). In most of cases the real value was higher than the estimated value thus indicating that the sensor tended to count less mosquitoes than the manual examination. The estimation of total mosquitoes and females was done with more than 80% of precision. The precision for male estimation approached 60%. Day et al. (2020) reported a significant relationship between the accuracy detection of the BG-Counter (Geier et al, 2016) and the ratio of mosquitoes regarding other arthropods in the sample. This possible correlation was investigated in the present study and reported no significant relationship.

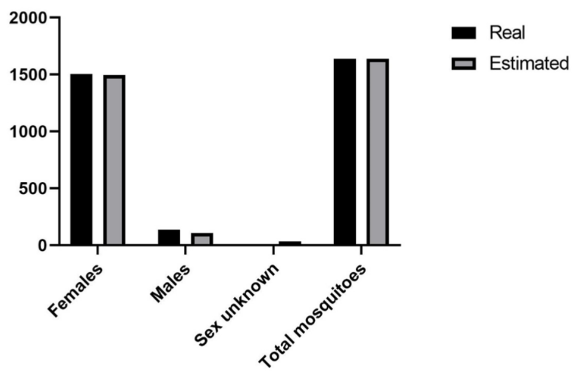

Figure 1. Comparison of the real values obtained by the manual inspection of the trap versus the estimated values made by the sensor. The unknown sex is a category that belongs exclusively to the estimated mosquitoes, when the sensor is not able to assign a specific sex to the specimen.

The correlation analysis was done between real versus estimated values. Correlations were significant for all cases (p-value < 0.001) and Pearson's coefficients were close to 1 which indicated a positive strong linear relationship between the estimations made by the sensor and the real values found in inspection of the traps. It has been demonstrated that the model is valuable for mosquito categorization and female recognition. The model is not precise to estimate males. However, the strong positive correlation between real and estimated males showed that the model can be useful to monitor tendencies in male populations.

CONCLUSIONS

The prototype of the sensor presented is this study is useful to count mosquitoes (distinguishing them from other arthropods) and females. It may be a starting point for the use of this technology in the remote monitoring of wild mosquito populations in real time.

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