# Using Unmanned Aerial Vehicles (UAV) for population size estimation of free-roaming dogs: challenges, benefits and comparison with a capture-recapture method

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## Introduction

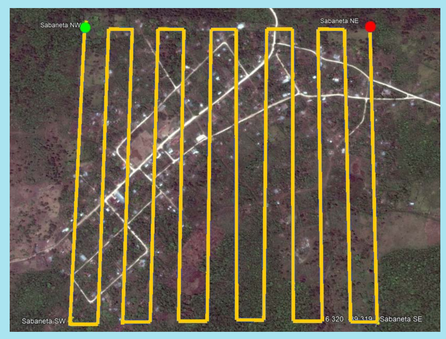
Many disease control strategies are based on the analysis of the basic reproduction number $R_0$ (number of secondary cases produced by an infected individual in a completely susceptible population). Thanks to $R_0$, it is possible to calculate the required vaccination coverage in a population to eradicate an infectious disease. In addition, it is of upmost importance to know the size of the population of interest to properly plan control programs. Census studies and capture-recapture methods are used since decades to estimate population sizes, but these methods are resource demanding and do not capture unowned animals. The aim of this study is to assess the challenges and benefits of using UAVs for population size estimation of free-roaming dogs and compare it with census data and a method combining capture-recapture and a Bayesian model.

## Methods

### Data collection

The data were collected in Petén department, Guatemala

- Selection of three areas based on their expected dog density:
  - La Romana: rural area – low dog density
  - Sabaneta: rural area – medium dog density
  - Poptún: urban area – high dog density
- Marked as many dogs as possible in 1km$^2$ (door-to-door, dogs older than 4 months) by collars
- Simultaneous data collection through:
  - Fly the UAV and take pictures
  - Transect walk and count the dogs with and without collar

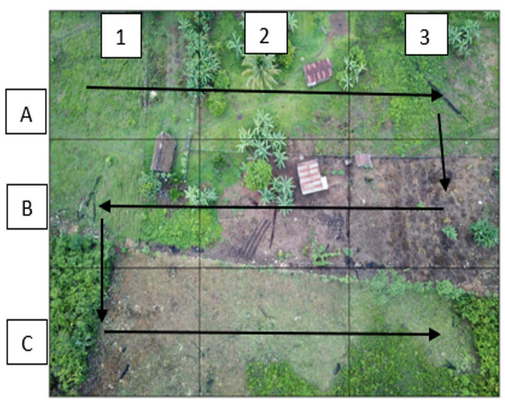



Transect lines flew by the UAV in Sabaneta, Guatemala, May 2018

Transect lines walked by the team in Sabaneta, Guatemala, May 2018

### UAV

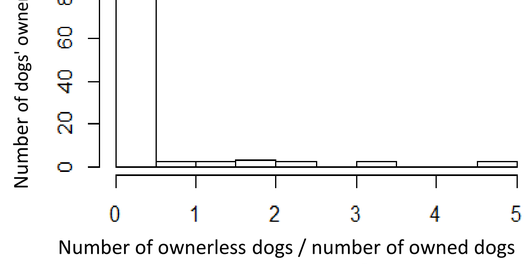
- Selection of the pictures with suitable quality and environment of potential presence of dogs
- Distinction of nine quadrants
- Dog counting in the selected pictures blinded by two researchers




UAV's flight picture: identification of quadrants and orientation of the picture revision

### Bayesian model

- Number of marked and unmarked dogs recaptured followed hypergeometric distributions
- Prior data on dog confinement and number of owned and ownerless dogs living in the area collected by questionnaire
- Implementation of the model in OpenBugs




A log normal distribution was fitted on the data and incorporated in the model.

## Results

| Population size estimation | | La Romana | Sabaneta | Poptun |
|---|---|---|---|---|
| **UAV** | Maximum number of dogs counted during a flight | 8 | 35 | 33 |
| **Bayesian model based on capture-recapture** | Estimated number of owned dogs (95% credibility interval) | 74.6 (72.1 - 79.0) | 262.5 (261.9 - 282.3) | 500.5 (410.8 - 613.5) |
| | Estimated number of ownerless dogs (95% credibility interval) | 0.12 (0.04 - 0.25) | 0.13 (0.05 - 0.28) | 0.26 (0.09 - 0.59) |
| **Human:dog ratio** (2017-2018) | Estimated number of owned dogs including puppies calculated by the health authorities for vaccination campaigns | 130.2 (h:d ratio = 5:1) | 193.8 (h:d ratio = 5:1) | - |
| **Dog census** (2017-2018) | Number of owned dogs including puppies | **110** | **289** | **-** |

## Discussion

- The Bayesian model estimates are consistent with the census. We recommend the utilization of this model for population size estimation of free-roaming dogs based and capture-recapture regardless of the origin of the data (UAV or walking transects).
- UAVs enable recording pictures from places where access is challenging (e.g. backyards). The area covered is precisely delimited, the transects lines are regular and the study is easily reproducible. However, underestimation of population size was found to be high, analyzing the pictures is time-demanding and the UAV recordings are highly depending on the weather conditions (e.g. impossible with strong wind or rain).
- To improve UAV data, the first possibility is to improve its sensitivity (e.g. fly at a lower altitude and when the dogs are more likely to roam in the streets or utilization of infrared thermal imagery). The second possibility is to combine UAV and capture-recapture methods, so that the UAV flight replace the transect walks.
- This study produced useful preliminary outcomes for the usefulness and challenges of UAVs. In the future, UAVs and capture-recapture methods could be combined to better estimate the population sizes and therefore to inform the health authorities for vaccination campaigns.

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