# Bayesian analysis of movement after release for headstarted Mona Island iguana (*Cyclura cornuta stejnegeri*)


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## Abstract

The endemic Mona Island iguana (*Cyclura cornuta stejnegeri*), is an endangered species that exhibits low density, low relative abundance of young iguanas and a skewed age distribution with an excess of adults. Since 1999, a headstarting program has been implemented to increase the population size of this species. As part of the evaluation of this program, Bayesian models are used for analyzing trajectories of released individuals. These models incorporate releasing sites sex and body mass at release time as explanatory variables. We expect that the outcome of this analysis will help to determine if future modifications in release strategies are needed in order to improve success rates of current conservation programs.


## Introduction

Mona Island, located between Dominican Republic and Puerto Rico, is a Natural Reserve under the management of the Department of Natural Environment Resources (DNER). Mona Island iguana (*Cyclura cornuta stejnegeri*), is an endemic reptile species of this region which is considered endangered. A headstarting program (consisting in keeping hatchlings in captivity until they reach a size less vulnerable to the predators) has been implemented by the DNER for Mona Island iguana.

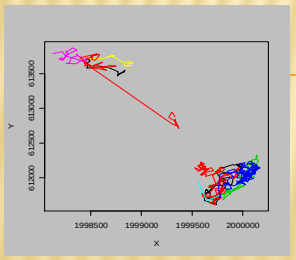
As part of the evaluation of this conservation strategy, several animals were tracked after release using radiotelemetry, in order to determine movement and dispersal range. Two release sites were used: Corral Wiewandt (CW, highly intervened by humans) and Carabinero (CAR, better preserved). Each iguana was followed for a certain period of time, and observations were not equally spaced. For each observation, UTM coordinates were obtained. Also, some characteristics of the iguana were recorded at release time. A summary of the available data is presented in (Table 1), and the trajectories for the nine studied individuals are shown in (Figure 1). All distances are measured in meters.

Ecologists managing the conservation program want to determine whether differences in iguana movement exist between the two release sites. For this, some other variables which can potentially affect the movement of an animal (as sex or size) should be taken into account .

**TABLE 1**: Morphometrics, sex, release date, release site Corral Wiewandt (CW) and Carabinero (CAR), number of recapture locations (n) for headstarted Mona Island iguanas, *Cyclura cornuta stejnegeri*.

| Iguanas | Sex | Release date | Release site | Release BM (kg) | N |
|---|---|---|---|---|---|
| 1 | F | Apr – 02 | CW | 1.32 | 69 |
| 2 | M | Apr – 02 | CW | 1.05 | 102 |
| 3 | M | Apr – 02 | CW | 1.04 | 43 |
| 4 | M | Apr – 02 | CW | 1.06 | 96 |
| 5 | F | Apr – 02 | CW | 0.95 | 4 |
| 6 | M | Aug – 02 | CAR | 1.12 | 33 |
| 7 | F | Aug – 02 | CAR | 1.05 | 17 |
| 8 | M | Aug – 02 | CAR | 1.04 | 13 |
| 9 | M | Aug – 02 | CAR | 1.01 | 41 |

**FIGURE 1**: Trajectories for the headstarted Mona Island iguanas, *Cyclura cornuta stejnegeri*




## Model Formulation

The following model is an extension of the space-state model used in Jonsen et al (2003)

$\begin{pmatrix} Y_{ij}^{N} \\ Y_{ij}^{E} \end{pmatrix}$ Observed position of iguana i at observation j with respect to release site - "Northing" (N) and "Easting" (E) -

$$\begin{pmatrix} Y_{ij}^{N} \\ Y_{ij}^{E} \end{pmatrix} = \begin{pmatrix} \alpha_{ij}^{N} \\ \alpha_{ij}^{E} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij}^{N} \\ \varepsilon_{ij}^{E} \end{pmatrix}$$

$\begin{pmatrix} \alpha_{ij}^{N} \\ \alpha_{ij}^{E} \end{pmatrix}$ real position at observation *j*

$\varepsilon_{ij}^{N}, \varepsilon_{ij}^{E}$ errors for observation *j* of iguana *i*

Independent normal distributions with common variance were assigned to the position errors

$$\varepsilon_{ij}^{N} \sim N(0,\sigma_{\varepsilon}^{2}), \quad \varepsilon_{ij}^{E} \sim N(0,\sigma_{\varepsilon}^{2})$$

For modeling trajectories, we will suppose that north-south movement and east-west movement are independent and have the same variability.

$$\begin{pmatrix} \alpha_{i(j+1)}^{N} \\ \alpha_{i(j+1)}^{E} \end{pmatrix} = \begin{pmatrix} \alpha_{ij}^{N} \\ \alpha_{ij}^{E} \end{pmatrix} + \begin{pmatrix} \eta_{ij}^{N} \\ \eta_{ij}^{E} \end{pmatrix}$$

$\eta_{ij}^{N}, \eta_{ij}^{E}$ represent the distances traveled by an animal from previous observed location

$$\eta_{ij}^{N} \sim N\left(0,\left(t_{j+1}(i)-t_{j}(i)\right)\sigma_{\eta}^{2}(i)\right)$$

where $t_{j+1}(i)$ and $t_j(i)$ are the times corresponding to observations *j+1* and *j* for animal *i*.

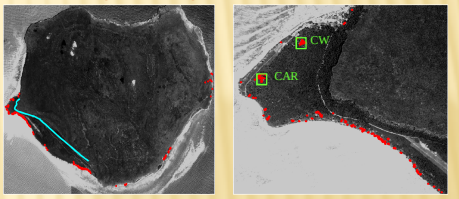
Log-linear models were used for relating $\sigma^2_{\eta}(i)$ with explanatory variables (release site, sex and body mass –kg-)

Based on expert opinion, an informative U(0,10) prior was selected for $\sigma_{\varepsilon}$ . Vague normal priors were assigned to the coefficients of the log-linear models.

Models were fitted using WinBUGS software (Spiegelhalter et al 2003). High autocorrelations in series were addressed using a thinning of 100 observations and running long chains until convergence was obtained. BOA software (Smith 2007) was used for convergence diagnostics

DIC criterion (Spiegelhalter et al 2002) was used for model selection.

Mona Island (Puerto Rico)




Headstarted iguanas

For identification, they were painted and marked with a visual number and unique combination of color beads on wire through the dorsal crest

**TABLE 2**: Effective sample size and DIC values for models fitted

| Model | pD | DIC |
|---|---|---|
| Equal variance | 520.840 | 7543.330 |
| Sex | 569.618 | 4576.720 |
| Body Mass | 569.926 | 5193.560 |
| Release Place | 602.846 | 6056.880 |
| Sex + Body Mass | 583.806 | 5309.010 |
| Sex + Release Place | 609.044 | 5798.740 |
| Body Mass + Release Place | 573.619 | 5906.340 |
| BM + RP + Sex | 653.342 | 6101.700 |

**TABLE 3**: Posterior quantities for variances, model including sex.

| Parameter | Sex | Mean | Sd | 2.5% | 97.5% |
|---|---|---|---|---|---|
| $\sigma_{\eta}$ (F) | F | 23.96 | 1.339 | 21.47 | 26.72 |
| $\sigma_{\eta}$ (M) | M | 33.6 | 0.9594 | 31.77 | 35.52 |
| $\sigma_{\varepsilon}$ | | 2.841 | 2.009 | 0.1106 | 7.385 |

## Results and Discussion

The DIC value for the model including only sex is substantially lower than DIC values for all models. According to this, no evidence of differences between release sites of influence of the body mass was found.

As no differences between release sites were found, it can be supposed that the same effort is required for getting food and resources in Carabinero and Corral Wiewandt, and no modifications seem to be required in release strategy.

Posterior quantities for the selected model show that males move longer distances than females. The precision of position measurement is consistent with the values expected by experts ( 2-3 mts).



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