Citizen science and estimation of species abundances in a habitat-structured space

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Aim

- Joint work with Clément Calenge (ONCFS), Christophe Giraud (U. of Orsay) and Romain Julliard (MNHN).
- Estimate relative species abundances in habitat-structured spaces.
- Estimate species and observers preferences for different habitats.

Data

Observations of common birds in Aquitaine (23 species), 2 databases:

- STOC: "standardized" data, 48 sites visited, precise instructions.
- LPO: "non-standardized" data, 440496 observations in 2086 municipalities.

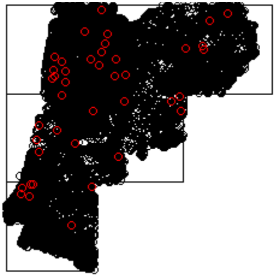

Figure: In black: positions of the non-standardized data, in red: positions of the standardized data.

Model: distribution of birds

- Space is divided into large squares indexed by $j \in [\![1, J]\!]$.
- We consider several species indexed by $i \in [\![1, I]\!]$: A_{ij} is the abundance of species i in square j.

- Space is divided into several habitats, indexed by $h \in [\![1, H]\!]$.
- V_{hj} is the area (volume) of square j occupied by habitat h.
- Probability that an individual of species i in square j is in habitat h:

$$\frac{S_{ih}V_{hj}}{\sum_{h'} S_{ih'}V_{h'j}}.$$

Model: distribution of observers

- 2 datasets indexed by $k \in \{1, 2\}$.
- Sites (1st dataset) and municipalities (2nd dataset) are indexed by $c \in \{1, C\}$.
- An observer in the cell c is in habitat h with probability:

$$\frac{q_{hk}}{\sum_{h' \in c} q_{h'k}}.$$

- An individual of species i is observable in habitat h with probability:

$$\alpha_h P_{ik}.$$

- An individual of species i is reported with probability:

$$R_{ik}.$$

Model

We observe:

$$X_{iv} \sim \mathcal{B}ernoulli(p_{iv}),$$

with

$$p_{iv} = R_{ik}\left(1 - (1 - \alpha_{H_v} P_{ik})^{A_{iv}}\right),$$

where

$$A_{iv} \sim \mathcal{B}\left(A_{ij}, \frac{S_{iH_v} V_{H_v c}}{\sum_{h'} S_{ih'} V_{h'j}}\right)$$

and

$$\mathbb{P}(H_v = h) = \frac{q_{hk}}{\sum_{h' \in c} q_{h'k}}.$$

Finally we observe:

$$X_{ick} \sim \mathcal{P}\left(A_{ij} E_{kc} P_{ik} \sum_{h \in c} \frac{q_{hk}}{\sum_{h' \in c} q_{h'k}} \frac{\alpha_h S_{ih} V_{hc}}{\sum_{h'} S_{ih'} V_{h'j}}\right).$$

JAGS: test with generated data

Real value: $A_{62}/A_{61} = 4.8$

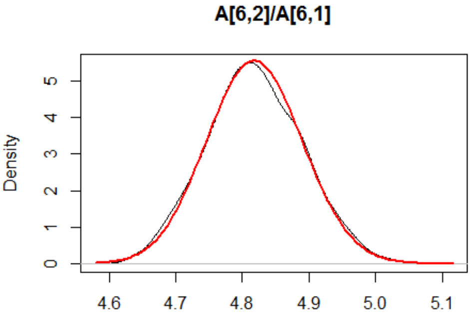

Figure: In red: Expected density. In black: estimated density.

$mean = 4.818536$, $sd = 0.07182255$.

Impact of habitat structure

Real value: $A_{62}/A_{61} = 4.8$.

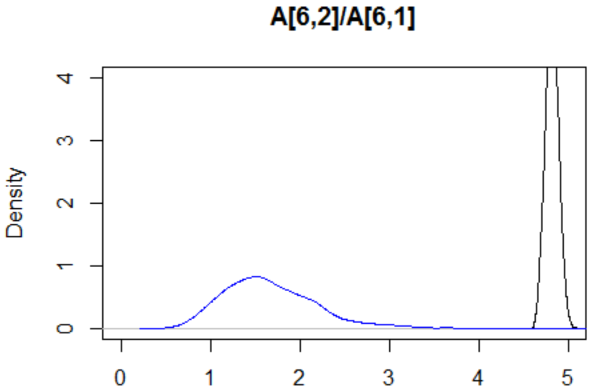

Figure: Estimation of the relative abundance A_{62}/A_{61}. In black: with habitat structure. In blue: without habitat structure.

JAGS: real data

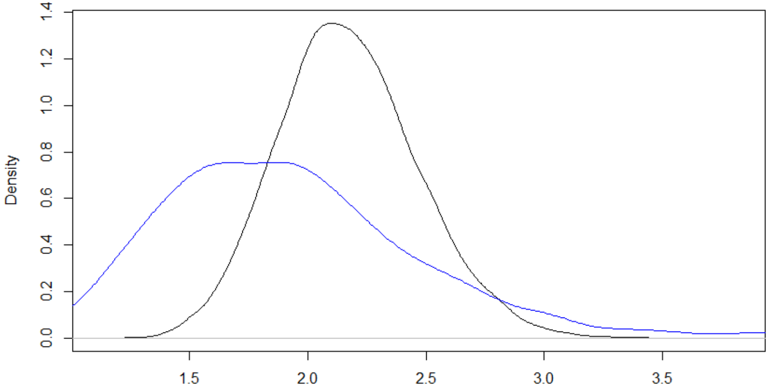

Figure: Estimation of the relative abundance A_{62}/A_{61}. In black: with habitat structure. In blue: without habitat structure.

"Real" value: $A_{62}/A_{61} = 2.783838$.

Outlook

- Quantify the advantages of spatial structure integration.
- Consider more types of habitats.
- Distinguish two types of non-standardized data: form data and opportunistic data.