ODD for Woodhoopoe Model

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Woodhoopoe Model

This is the simplified Woodhoopoe model from Section 19.4.3 of *Agent-based and Individual-based Modeling: A Practical Introduction*. The key adaptive trait of scouting for vacant territories is left unspecified for Exercise 2 of Chapter 19.

Purpose

The purpose of the model is to illustrate how the dynamics of a population of group-living woodhoopoes, and the dynamics of its social groups, depend on the trait individuals use to decide when to leave their group. The model provides a laboratory for developing theory for the woodhoopoes' scouting foray trait.

Entities, state variables, and scales

The model entities are territories and birds. A territory represents both a collective—a social group of birds—and the space occupied by the group (territories can also be empty, though). Territories are represented as a one-dimensional row of 25 NetLogo patches, "wrapped" so that the two ends of the row are considered adjacent. The only state variables of territories are a coordinate for their position in the row and a list of the birds in them. Birds have state variables for their sex, age (in months), and whether they are alpha. The time step is one month. Simulations run for 22 years, with results from the initial two "warm-up" years ignored.

Process overview and scheduling

The following actions are executed in the given order once per time step. The order in which the birds and territories execute an action is always randomized and state variables are updated immediately, after each action.

1. Date and ages are updated. The current year and month are advanced by one month, and the age of all birds is increased by one month.
2. Territories fill vacant alpha positions. If a territory lacks an alpha but has a subordinate adult (age > 12 months) of the right sex, the oldest subordinate becomes the new alpha.
3. Birds undertake scouting forays. Subordinate adults decide whether to scout for a new territory with a vacant alpha position. Birds that do scout choose randomly (with equal probability) between the two directions they can look (left or right along the row of territories). Scouting birds can explore up to five territories in their chosen direction. Of those five territories, the bird occupies the one that is closest to its starting territory and has no alpha of its sex. If no such territory exists, the bird stays at its starting territory. All birds that scout (including those that find and occupy a new territory) are then subjected to predation mortality, a stochastic event with the probability of survival 0.8.

4. Alpha females reproduce. In the 12th month of every year, alpha females that have an alpha male in their territory produce two offspring. The offspring have their age set to zero months and their sex chosen randomly with equal probability of male and female.
5. Birds experience mortality. All birds are subject to stochastic mortality with a monthly survival probability of 0.99.
6. Output is produced.

Design concepts

This discussion of design concepts may help you design alternative theories for the scouting trait.

Basic principles: This model explores the "stay-or-leave" question: when should a subordinate individual leave a group that provides safety and group success but restricts opportunities for individual success? In ecology we can assume real individuals have traits for this decision that evolved because they provide "fitness": success at reproducing. The trait we use in an ABM could explicitly consider fitness (e.g., select the behavior providing the highest expected probability of reproducing) but could instead just be a simple rule or "heuristic" that usually, but not always, increases fitness.

Emergence: The results we are interested in for theory testing are the three patterns described at the end of Section 19.4.2: a successful theory will cause the model to reproduce these patterns. All the patterns emerge from the trait for scouting. The group size distribution pattern may also depend strongly on other model processes such as the reproduction and survival rates.

Adaptation: The only adaptive decision the woodhoopoes make is whether to undertake a scouting foray. You can consider several alternative traits for this decision that vary in how explicitly they represent the individuals' objective of obtaining alpha status to reproduce. You should start with "null" traits in which the decision is random or always the same. You could consider an indirectly-objective-seeking trait such as a simple rule-of-thumb (e.g., "scout whenever age > X"), and a trait that explicitly represents the factors that affect an individual's chance of meeting its objective.

Objectives: The subordinate birds have a clear objective: to become an alpha so they can reproduce. We also know, in this model, what processes affect the likelihood of reaching that objective. If the individual stays at its home territory, all the older birds of its sex must die for the individual to succeed to alpha. If the individual scouts, to succeed it must find a vacant alpha position and it must survive the predation risk of scouting.

Learning: The decision trait could change with the individual's experience. For example, birds could learn things on unsuccessful scouting forays that they use in subsequent decisions. (If you try learning at all, we suggest you start with simpler traits without learning.)

Prediction: The decision objective is to attain alpha status, but attain it by when? If you design a decision trait that compares the relative probability of becoming alpha for leaving vs. for staying, the trait must specify a time horizon over which that probability applies. Evaluating these probabilities would require some kind of prediction over the time horizon.

Sensing: We assume that birds know nothing about other territories and can sense whether an alpha position is open in another territory only by scouting there. However, it is reasonable to assume that a bird can sense the age and status of the others in its own group.

Collectives: The social groups are collectives: their state affects the individual birds, and the behavior of individuals determines the state of the collectives. Because the model's "territory" entities represent the social groups as well as their space, the model treats behaviors of the social groups (promoting alphas) as territory traits.

Observation: In addition to visual displays to observe individual behavior, the model's software must produce outputs that allow you to test how well it reproduces the three characteristic patterns identified

in Section 19.4.2. Hence, it must output the group size distribution illustrated in Figure 19 2, the mean age (over all months of the entire simulation) of subordinate adult birds that do vs. do not make scouting forays, and the total number of forays made by month.

Initialization

Simulations start at January (month 1). Every territory starts with two male and two female birds, with ages chosen randomly from a uniform distribution of 1 to 24 months. The oldest of each sex becomes alpha.

Input

The model does not use any external input.