Parametrization of Earthworm Population Models

User

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0.1 Introduction

This document provides a detailed parameterization of population models for earthworms, focusing on **Lumbricus terrestris** and **Eisenia fetida**. The models incorporate survival rates, reproduction rates, and the influence of environmental factors such as soil moisture and temperature.

0.2 Model Framework

The population dynamics are modeled using discrete time steps with parameters for survival, reproduction, and environmental influence.

0.2.1 Key Equations

The population size N_t at time t is governed by:

$$N_{t+1} = N_t \cdot S_t + B_t,$$

where: - S_t is the survival rate. - B_t is the number of new individuals (births).

The birth rate B_t depends on reproduction rate R and the number of mature individuals M_t:

$$B_t = M_t \cdot R.$$

Environmental factors (temperature T and moisture W) modify S_t and R:

$$S_t = S_{base} \cdot \exp\left(-\alpha \cdot |T - T_{opt}|\right) \cdot \beta(W),$$

$$R = R_{base} \cdot \gamma(T, W).$$

0.3 Parameters for Lumbricus terrestris

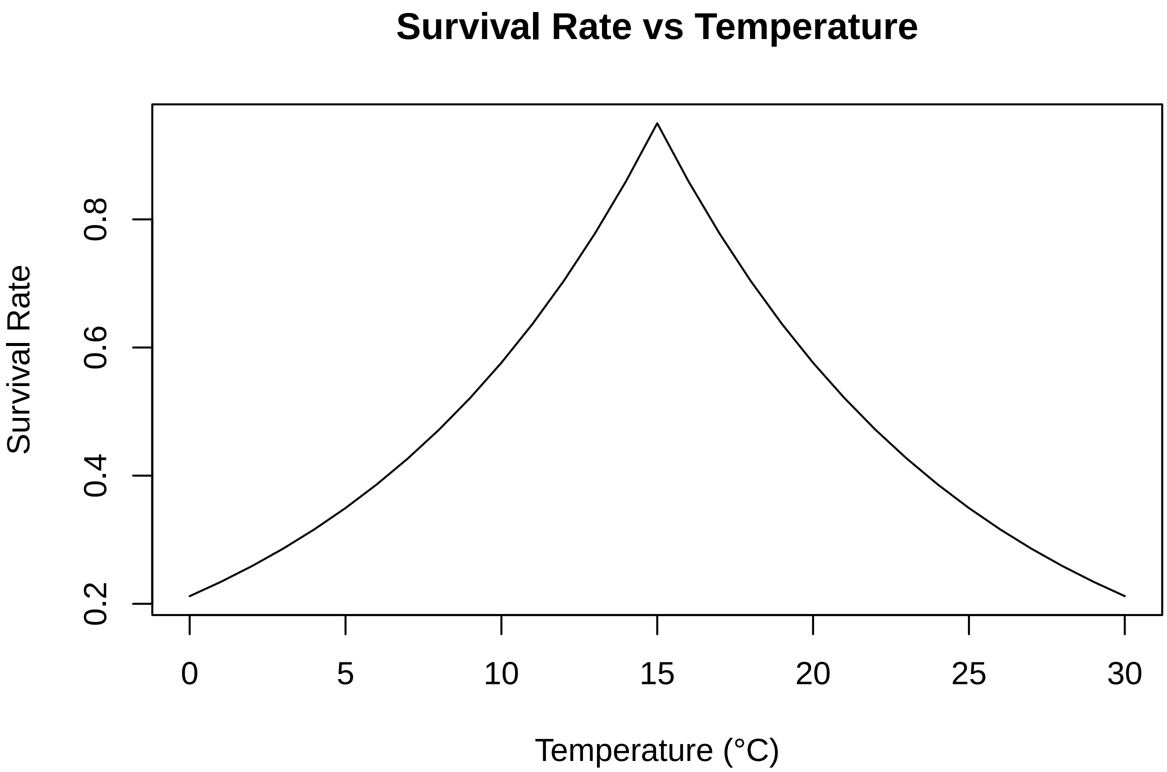
0.3.1 Survival Rates

- Optimal temperature: $10 - 20°C$.
- Survival declines exponentially outside this range.

Example:

```r
T_opt <- 15
alpha <- 0.1
T <- seq(0, 30, by = 1)
S_base <- 0.95
```

```
S_t <- S_base * exp(-alpha * abs(T - T_opt))
plot(T, S_t, type = "l", xlab = "Temperature (°C)", ylab = "Survival Rate", main = "Survival Rate vs Te
```



0.3.2 Reproduction Rates

- Average cocoon production: 2 per week per mature individual.
- Hatching success: 50%.

```
M_t <- 100 # Number of mature individuals
R_base <- 2 # Cocoons per week
hatching_success <- 0.5
B_t <- M_t * R_base * hatching_success
cat("Number of new individuals: ", B_t, "\n")
```

```
## Number of new individuals:  100
```

0.4 Parameters for Eisenia fetida

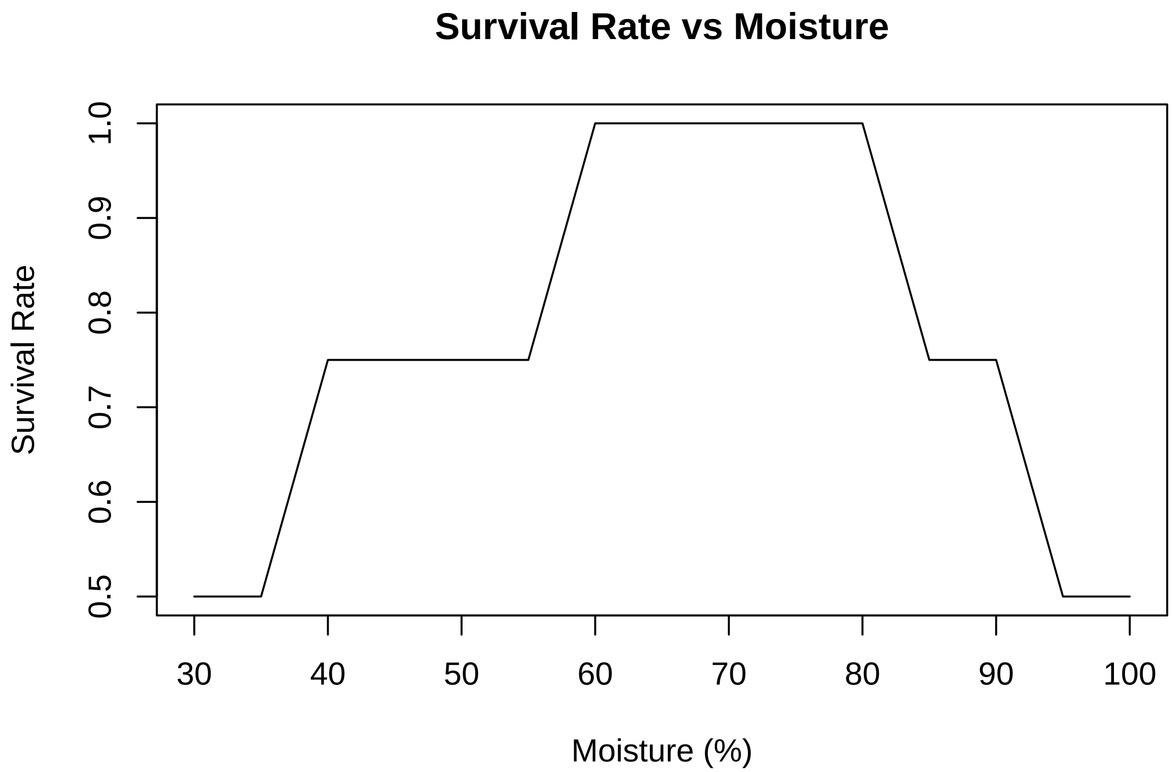
0.4.1 Survival Rates

- Optimal moisture: $60 - 80\%$.

Example:

```
W_opt <- 70
beta <- function(W) {
  if (W < 40 || W > 90) return(0.5)
  if (W >= 60 && W <= 80) return(1)
  return(0.75)
}
W <- seq(30, 100, by = 5)
```

```r
S_t <- sapply(W, beta)
plot(W, S_t, type = "l", xlab = "Moisture (%)", ylab = "Survival Rate", main = "Survival Rate vs Moistu
```



0.4.2 Reproduction Rates

- Cocoons per week: 3.
- Hatching success: 80%.

```r
M_t <- 200 # Number of mature individuals
R_base <- 3 # Cocoons per week
hatching_success <- 0.8
B_t <- M_t * R_base * hatching_success
cat("Number of new individuals: ", B_t, "\n")
```

```
## Number of new individuals:  480
```

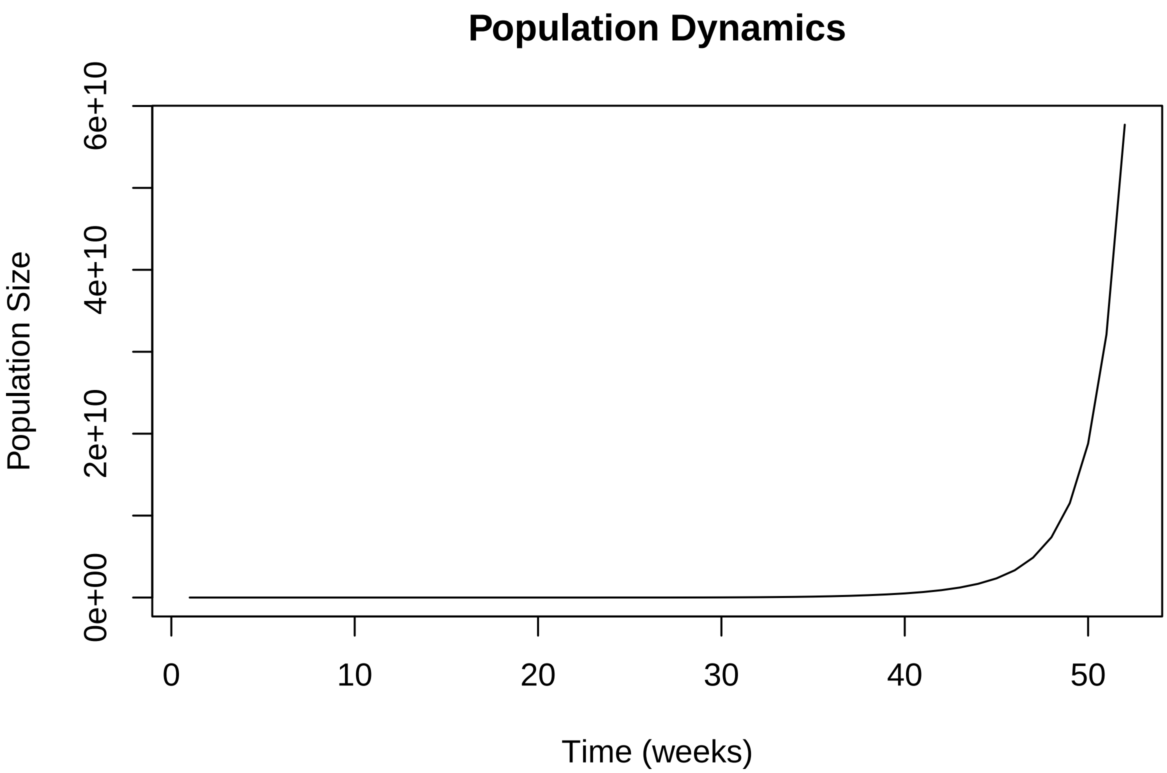
0.5 Combined Model Simulation

```r
time <- 1:52 # Weeks
N_t <- numeric(length(time))
N_t[1] <- 100 # Initial population

# Parameters
S_base <- 0.9
R_base <- 2
T_opt <- 15
alpha <- 0.1
hatching_success <- 0.5
T <- 15 + 10 * sin(2 * pi * time / 52) # Seasonal temperature variation
```

```r
for (t in 1:(length(time) - 1)) {
  S_t <- S_base * exp(-alpha * abs(T[t] - T_opt))
  B_t <- N_t[t] * R_base * hatching_success
  N_t[t + 1] <- N_t[t] * S_t + B_t
}

plot(time, N_t, type = "l", xlab = "Time (weeks)", ylab = "Population Size", main = "Population Dynamic
```



0.6 Conclusion

This document demonstrates a parameterized approach to modeling earthworm populations using environmental and biological parameters. Future refinements may include stochastic elements and data validation.