Excercise 2

Population density of the mite *Acarus siro* was recorded every 3 days during 28 days. The following densities were found:

165, 145, 139, 125, 105, 101, 88, 81, 73, 69

- What is the intrinsic rate of increase (*r*) and what was the initial density ?
- How long it takes for a population to decrease to half size?
- Project population growth for another 5 weeks using estimated *r* and $N_0 = 69$.
- What would be the estimated rate if you know the initial and final density?

```
mite<-c(165, 145, 139, 125, 105, 101, 88, 81, 73, 69)
ti<-c(1,4,7,10,13,16,19,22,25,28)
plot(ti,mite,type="b")

lmi<-log(mite)
plot(ti,lmi)
summary(lm(lmi~ti))
exp(5.132735)

log(0.5)/-0.033217

time<-1:35
Nt<-69*exp(-0.033*time)
plot(time,Nt,type="b")

(log(69)-log(165))/27
```

Matrix analysis

Net reproductive rate (R_0)

- average number of offspring produced by a female in her lifetime

$$R_0 = \sum_{x=0}^{n} l_x m_x$$

Average generation time (T)

- average age of females when they give birth

$$T = \frac{\sum_{x=0}^{n} x l_x m_x}{R_0}$$

Expectation of life

- age specific expectation of life
- o .. oldest age

$$e_x = \frac{T_x}{l_x} \qquad L_x = \frac{l_x + l_{x+1}}{2} \qquad T_x = \sum_{x}^{o} L_x$$

Intrinsic growth rate (*r*)

- when Leslie model show exponential growth the potential rate of increase can be determined from

$$r \approx \frac{\ln(R_0)}{T} \qquad \lambda \approx \frac{R_0}{T}$$

- Euler (1760) found how to estimate *r* from the life table

$$\sum_x l_x m_x e^{-rx} = 1$$

- *r* can be estimated from is the only dominant positive eigenvalue of the transition matrix (λ_1.. finite growth rate)

$$r = \ln(\lambda_1)$$

Stable age distribution (SCD)

- relative abundance of different life history age/stage/size categories
  - population approaches stable age distribution:

    $\boldsymbol{N_0} : \boldsymbol{N_1} : \boldsymbol{N_2} : \boldsymbol{N_3} :....: N_s$ is stable

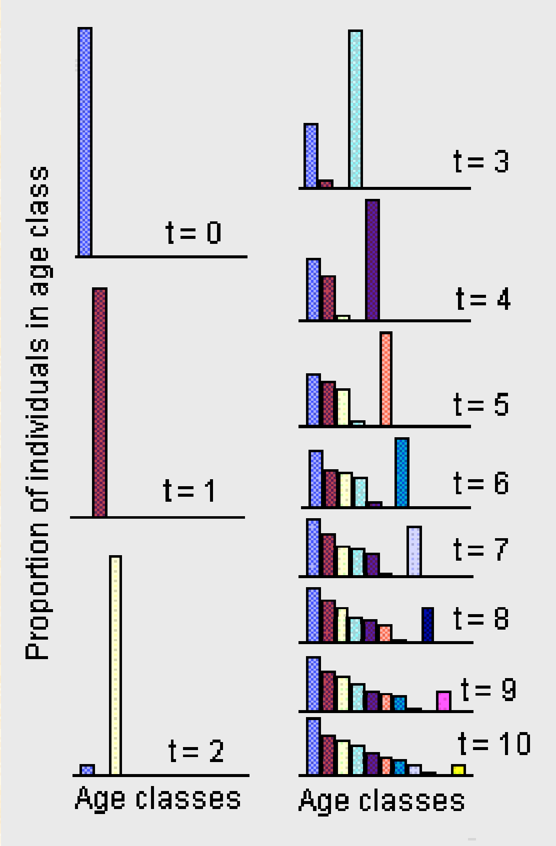
- once population reached SCD it grows exponentially
  - proportion of individuals ($\boldsymbol{c}$) in age x

$$c_x = \frac{l_x e^{-rx}}{\sum_x l_x e^{-rx}}$$

  - $\mathbf{w}_1$ .. right eigenvector of the dominant eigenvalue
- provides stable age distribution
- scale $\mathbf{w}_1$ by sum of individuals

$$\mathbf{A}\mathbf{w}_1 = \lambda_1 \mathbf{w}_1$$

$$SCD = \frac{\mathbf{w}_1}{\sum_{i=1}^{S} \mathbf{w}_1}$$

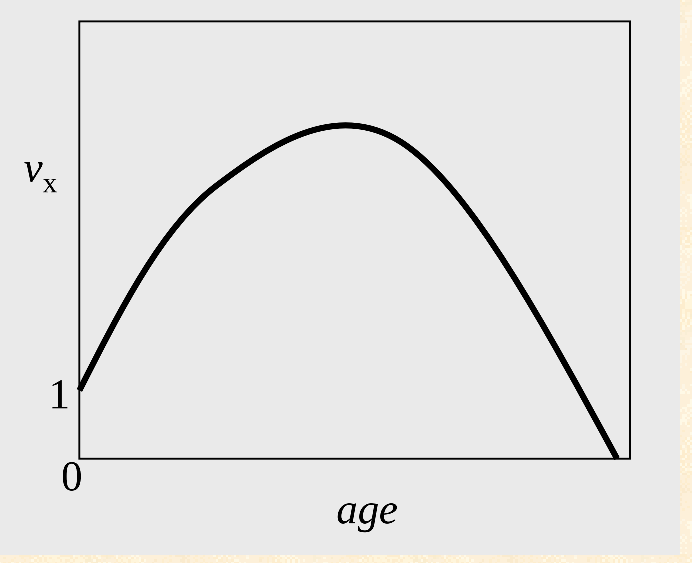


Reproductive value (RV)

- identifies age class that contributes most to the population growth
- measures relative reproductive potential of an individual of a given age
- when population increases then early offspring contribute more to v_x than older ones
- $\mathbf{v}_1$ .. left eigenvector of the dominant eigenvalue

$$\mathbf{v}_1\mathbf{A} = \lambda_1\mathbf{v}_1$$

- provides reproductive values
- $\mathbf{v}_1$ is proportional to the reproductive values scaled to the first category



$$v_x = \frac{\sum_x^o l_x m_x e^{-rx}}{l_x e^{-rx}}$$

$$RV = \frac{\mathbf{v}_1}{\sum_{i=1}^{S}\mathbf{v}_1}$$

Sensitivity (*s*)

‣ identifies which process (survival or fertility) has largest effect on the population increase (λ_1)
- examines change in λ_1 given small change in processes (a_{ij})
- sensitivity is larger for survival of early, and for fertility of older classes

$$s_{ij} = \frac{\delta\lambda_1}{\delta a_{ij}} = \frac{v_{ij} w_{ij}}{\mathbf{v.w}}$$

← sum of pairwise products

Elasticity (*E*)

‣ weighted measure of sensitivity
- measures relative contribution to the population increase
- impossible transitions = 0

$$E_{ij} = \frac{a_{ij}}{\lambda_1}\frac{\delta\lambda_1}{\delta a_{ij}}$$

Excercise 3

Perform demographic study of the common fox using life table menu in POPULUS. The fox breeds in pulses and the data were collected using pre-breeding census.

x	lx	mx
0	1	0.000
1	0.8	0.000
2	0.32	2.000
3	0.12	2.100
4	0.06	2.300
5	0.024	2.400

- Plot standardised survival (l_x) with age. Which survival curve type it corresponds to?
- Plot fecundity (m_x) and reproductive value (v_x) with age.
- Construct Leslie transition matrix and project

it over a period of another 20 years using initial vector (10, 12, 6, 5, 4, 2). When does the population reach stable age distribution?

- What is R_0, T, and r ?

Conservation biology

- to adopt means for population promotion or control

Conservation/control procedure

1. Construction of a life table
2. Estimation of the intrinsic rates
3. Sensitivity analysis - helps to decide where conservation/control efforts should be focused
4. Development and application of management plan
5. Prediction of future

Excercise 4

There is a butterfly species that appears to be rare. You perform a life-history study and gain data on survival and reproduction. You also observe which factors determine stage-specific survival.

stage	px	mx	mortality
egg	0.7	0	frost in winter
larva 1	0.6	0	parasitoids
larva 2	0.4	0	parasitoids
larva 3	0.5	0	bird predation
larva 4	0.3	0	parasitoids
pupa	0.2	0	habitat destruction
adult	0	80	

- Estimate λ using POPULUS and find whether the population increases or decreases?
- Perform sensitivity analysis in POPULUS by replacing each stage-specific survival by 1 and identify which factor has most dramatic effect on population increase.
- Suggest a conservation plan.

Excercise 5

You observe a population decrease in a duck species. You perform a life-history study with post-breeding census and find that duck has birth-pulse breeding. You obtain the following data:

x	lx	mx	mortality
0	1	0	racoons
1	0.2	2	foxes
2	0.1	3	parasite
3	0.03	5	virus
4	0.002	1	old age
5	0		

- Make simple population projections in POPULUS.
- Create transition matrix in R and find stable class distribution and reproductive values.
- Perform sensitivity analysis to identify important processes.
- Suggest a conservation plan.