Net reproductive rate

The total number of offspring that an average individual (including females, males, and those died in immature stage) can produce during its lifetime. The magnification that a population will increase after one generation.

$$R_0 = \sum_{x=0}^{\infty} \sum_{j=1}^{m} s_{xj} f_{xj}$$

$$= \sum_{x=0}^{\infty} l_x m_x$$

$$= 11.4$$

$$l_x = \sum_{j=1}^{m} s_{xj}$$

$$m_x = \frac{\sum_{j=1}^{m} s_{xj} f_{xj}}{\sum_{j=1}^{m} s_{xj}} = \frac{\sum_{j=1}^{m} s_{xj} f_{xj}}{l_x}$$

Chi (1988) proved

$$R_0 = \frac{N_f}{N} F$$

where N_f is the number of female adults emerged from the total individuals N used at the beginning of life table study and F is the mean fecundity of this N_f females. This relationship is valid for the age-stage, two-sex life table and female age-specific life table. For two-sex life table: N-N_f = N_d +N_m (number of dead in preadult stage + number of male adults). For female life table: N-N_f = N_d (number of dead in preadult).

Finite rate of increase

The finite rate is the population growth rate as time approaches infinity and population reaches the stable age-stage distribution. The population size will increase at the rate of λ per time unit.

$$\sum_{x=0}^{\infty}\left(\lambda^{-(x+1)}\sum_{j=1}^{m} f_{xj} s_{xj}\right)=1$$

➡ TWOSEX life table uses this one.

$$\sum_{x=1}^{\infty}\left(\lambda^{-x}\sum_{j=1}^{m} f_{xj} s_{xj}\right)=1$$

Intrinsic rate of increase

It is the population growth rate as time approaches infinity and population reaches the stable age-stage distribution. The population size will increase at the rate of e^r per time unit.

$$\sum_{x=0}^{\infty}\left(e^{-r(x+1)}\sum_{j=1}^{m} f_{xj} s_{xj}\right)=1$$

TWOSEX life table uses this one.

$$\sum_{x=1}^{\infty}\left(e^{-rx}\sum_{j=1}^{m} f_{xj} s_{xj}\right)=1$$

Intrinsic rate of increase

$$\sum_{x=0}^{\infty}\left(e^{-r(x+1)}\sum_{j=1}^{m} f_{xj}s_{xj}\right)=1$$

$$l_x=\sum_{j=1}^{m} s_{xj}$$

$$\sum_{x=0}^{\infty}\left(e^{-r(x+1)} f_{x,female}s_{x,female}\right)=1$$

$$m_x=\frac{\sum_{j=1}^{m} s_{xj}f_{xj}}{\sum_{j=1}^{m} s_{xj}}=\frac{\sum_{j=1}^{m} s_{xj}f_{xj}}{l_x}$$

$$\sum_{x=0}^{\infty}\left(e^{-r(x+1)} l_x m_x\right)=1$$

$$\sum_{x=0}^{\infty} e^{-r(x+1)} l_x m_x=1$$

$$\sum_{x=0}^{\infty} e^{-r(x+1)} l_x m_x=1$$

TWOSEX life table uses this one.

How many digits should you report?

$$\lambda = e^r$$

$$\lambda = 1 \Leftrightarrow r = 0$$

$$r = 0.1460, \lambda = 1.15$$

$$r = 0.1460, \lambda = 1.1572$$

Mean generation time

It is the period that a population requires to increase to R_0-fold of its size as time approaches infinity and the population settles down to a stable age-stage distribution.

$$\lambda^T = R_0$$

$$T = \ln R_0 / \ln \lambda$$

$$\lambda = e^r$$

$$\lambda^T = e^{rT} = R_0$$

$$T = \frac{\ln R_0}{r}$$

Stable age-stage distribution

It is the proportion of individuals in each age-stage unit as population increases at the rate of λ (or e^r) per time unit. This distribution will remain constant.

Age	Egg	Larva	Pupa	Female	Male
0	1	-	-	-	-
1	0.8755	-	-	-	-
2	0.7665	-	-	-	-
3	0.2684	0.4027	-	-	-
4	0.1175	0.4701	-	-	-
5	0.0514	0.463	-	-	-
6	-	0.4054	0.045	-	-
7	-	0.3549	0.0394	-	-
8	-	0.2762	0.0691	-	-
9	-	0.1209	0.1511	-	-
10	-	0.0794	0.1588	-	-
11	-	0.0463	0.1622	-	-
12	-	0.0203	0.1623	-	-
13	-	-	0.1421	-	-
14	-	-	0.1089	0.0156	-
15	-	-	0.0817	0.0136	-
16	-	-	0.0358	0.0358	0.0119
17	-	-	0.0209	0.0313	0.0209
18	-	-	-	0.0274	0.0274
19	-	-	-	0.024	0.024
20	-	-	-	0.021	0.007

Age	Egg	Larva	Pupa	Female	Male
0	13.97	-	-	-	-
1	12.24	-	-	-	-
2	10.71	-	-	-	-
3	3.75	5.63	-	-	-
4	1.64	6.57	-	-	-
5	0.7189	6.47	-	-	-
6	-	5.66	0.6294	-	-
7	-	4.96	0.5511	-	-
8	-	3.86	0.965	-	-
9	-	1.69	2.11	-	-
10	-	1.11	2.22	-	-
11	-	0.6476	2.27	-	-
12	-	0.2835	2.27	-	-
13	-	-	1.99	-	-
14	-	-	1.52	0.2173	-
15	-	-	1.14	0.1903	-
16	-	-	0.4997	0.4997	0.1666
17	-	-	0.2917	0.4375	0.2917
18	-	-	-	0.3831	0.3831
19	-	-	-	0.3354	0.3354
20	-	-	-	0.2936	0.0979

Life expectancy (e_{xj})

It is the time that an individual of age x and stage y is expected to live. It is calculated as

$$e_{xj} = \sum_{i=x}^{\infty} \sum_{y=j}^{m} s'_{iy}$$

where s'_{iy} is the probability that an individual of age x and stage j will survive to age i and stage y. s'_{iy} is calculated by assuming $s'_{xj} = 1$.

Reproductive value (v_{xj})

Fisher (1930) defined the reproductive value as the contribution of individuals of age *x* and stage *y* to the future population. In the age-stage, two-sex life table it is calculated as

$$v_{xj} = \frac{e^{r(x+1)}}{s_{xj}} \sum_{i=x}^{\infty} e^{-r(i+1)} \sum_{y=j}^{m} s'_{iy} f_{iy}$$

This formula is based on the age-stage, two-sex life table. You have to cite following three papers in addition to Fisher (1930):

Huang, Y. B. and Hsin Chi. 2011. The age-stage, two-sex life table with an offspring sex ratio dependent on female age. Journal of Agriculture and Forestry 60(4): 337-345.

Tuan, Shu-Jen, Chung-Chieh Lee and Hsin Chi. 2014a. Population and damage projection of *Spodoptera litura* (F.) on peanuts (*Arachis hypogaea* L.) under different conditions using the age-stage, two-sex life table. Pest Manag Sci. 70: 805 -813.

Tuan, Shu-Jen, Chung-Chieh Lee and Hsin Chi. 2014b. Population and damage projection of *Spodoptera litura* (F.) on peanuts (*Arachis hypogaea* L.) under different conditions using the age-stage, two-sex life table. Pest Manag Sci. 70: 1936.