Part 2: Definition of Fitness

The fitness of an individual $F(m_x)$ is then defined such that:

$$\frac{F(m_a)}{F(m_b)}=\frac{P_s(m_a)}{P_s(m_b)}$$

In this case, an individual's fitness will have a direct relation to its chance of survival relative to the other individuals in its population.

If, then, we define:

$$\boxed{F(m_a)\equiv\alpha_m P_s(m_a)}$$

we obtain the following:

$$\frac{F(m_a)}{F(m_b)}=\frac{\alpha_m P_s(m_a)}{\alpha_m P_s(m_b)}$$

which is equivalent to our original definition, for α_m, a positive scalar.

Here α_m is arbitrary in relation to the individual's probability, but not when individuals are compared against each other; the scalar α_m must be consistent throughout the population, but need not be consistent across generations.

Since:

$$P_s(m_{avg})=\frac{n_e}{n_m}$$

then:

$$\alpha_m P_s(m_{avg})=\alpha_m\frac{n_e}{n_m}$$

$$F(m_{avg})=\alpha_m\frac{n_e}{n_m}$$

$$\boxed{\alpha_m=F(m_{avg})\frac{n_m}{n_e}}$$

And since:

$$\boxed{F(m_{avg})=\frac{\sum F(M)}{n_m}}$$

then:

$$\alpha_m=\frac{\sum F(M)}{n_m}\frac{n_m}{n_e}$$

$$\boxed{\alpha_m=\frac{\sum F(M)}{n_e}}$$

So the scalar α_m is dependent on the total fitness and the expected number of survivors alone. Moreover, we can now determine an individual's chance of success using the following:

$$F(m_x)=\alpha_m P_s(m_x)$$

$$P_s(m_x)=\frac{F(m_x)}{\alpha_m}$$

$$\boxed{P_s(m_x)=\frac{F(m_x)}{\sum F(M)}n_e}$$

An individual's survival, then, is not so much dependent on the total number of individuals to choose from as the total fitness of those individuals. (Of course, more individuals means more total fitness, so the values are still related.) The number of expected survivors, then, acts as an indicator of selective pressure – the lower n_e is set to, the higher the selective pressure must be to bring about this change.

An individual's chance of success can also be determined as follows:

$$F(m_x)=\alpha_m P_s(m_x)$$

$$F(m_x)=F(m_{avg})\frac{n_m}{n_e}P_s(m_x)$$

$$\boxed{P_s(m_x)=\frac{F(m_x)}{F(m_{avg})}\frac{n_e}{n_m}}$$

Which is an individual's fitness compared to the average fitness, times the average survival rate. This is, perhaps, the more intuitive of the two formulas.