# Modeling Behavior through Reproductive Value

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Historically, behavioral modeling has been largely limited to simulations and dynamic programming models. This is primarily because it is relatively easy to write 'rules' for individual behavior and relatively difficult to write continuous equations to describe it. One well-known exception has been optimal foraging, which has significantly advanced the field by producing generally applicable predictions (Schoener 1971, Charnov 1976). Models involving continuous equations are frequently more generalizable than IBMs; hence, they are perhaps more likely to generate broad theoretical advances (Grimm, 1999). Here, we present a new continuous technique for modeling behavior. Using a phyletically widespread behavior-decorating behavior-as a model system, we describe the costs and benfits associated with this behavior in terms of energetics and mortality. Net energy intake $\epsilon(d)$ is the difference between an energy gain function and a cost function, both functions of decoration level $d$ (1). Energy benefit $E(d)$ has a logistic form in $d$ while energy cost $C(d)$ is linear in $d$. Mortality benefit $M(d)$ is the inverse of predation and natural death terms (2). Predation risk $P(d)$ decreases exponentially while natural death $N(d)$ is concave up. Energy and mortality components are united through a reproduction function $R(d)$ (3).

$$\epsilon(d) = E(d) - C(d) \tag{1}$$

$$M(d) = 1 - (1 - P(d)\,(1 - N(d)) \tag{2}$$

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$$R(d) = a\,\epsilon(d)\,(1 - M(d)) \tag{3}$$

Equation (3) is quite similar to Fisher's (1958) reproductive value, which is a composite of fecundity and survivorship. The primary difference is that our model assumes a single age class. The parameter $a$ is a conversion factor from energy intake to offspring; the quantity $a\,\epsilon(d)$ is thus analogous to Fisher's fecundity term, while the inverse of mortality is analogous to Fisher's survivorship term. The result is a simple, continuous model which captures the fitness consequences of a behavior. This model can generate predictions about situations in which the behavior should or should not be selectively advantageous (*i.e.*, conditions in which $R(d)$ is increasing or decreasing), and helps explain observed variation in the behavior across taxonomic groups. Because reproductive value can be linked to population-level fecundity and survivorship parameters, the potential exists for this techniqe to bridge the gap between individal behavior and populations.

## References

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