A test of McGinley and Charnov’s multiple resource pool hypothesis

R. G. LALONDE

Behavioral Ecology Research Group, Department of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada, V5A 1S6

Summary

McGinley and Charnov (1988) propose that seasonal seed weight decline results from optimization of independently varying resource components: in particular, carbon and nitrogen. Canada thistle (Cirsium arvense) (L.) Scop. does not express seasonal seed weight reduction when the number of seeds competing for the plant’s resources is reduced by low pollination success. Seeds sampled from thistles treated to high and low pollination regimes were analyzed here for relative investment of carbon and nitrogen. The ratio of these two elements remained constant over the season in both treatment groups. The seasonal decline in mean seed weight displayed by this plant under high pollination is therefore not explainable by McGinley and Charnov’s multiple resource pool hypothesis.

Keywords: Cirsium arvense; multiple resource pool hypothesis; seed weight; pollination.

A robust prediction of the offspring provisioning theory originally formulated by Smith and Fretwell (1974) and its subsequent elaborations (Lloyd, 1980, 1987; Parker and Begon, 1986; Temme, 1986; McGinley et al., 1987), is that, given a specific relationship between offspring size and fitness, a parent which is provisioning propagules (e.g. eggs or seeds) should be more prone to vary propagule number than propagule size when resources vary, because there is one optimal provisioning level which maximizes the expected fitness of the parent. Nevertheless, in empirical studies of seed provisioning, it is not at all unusual to find strong variations in seed size within a plant (Harper et al., 1970; Pitelka et al., 1983; Thompson, 1984). Often this variation has been correlated with genetic (Stanton, 1984; Mazer et al., 1986; Mazer, 1987; Lalonde and Roitberg, 1988) or environmental (Willson and Price, 1979; Crawley and Nachapong, 1985; Wulff, 1986) effects which could arguably have affected the shape of the relationship between offspring size and fitness. However, an especially common pattern of seed weight variation is a decline in the mean weight of seeds with the progression of the seed provisioning period (Hendrix, 1979, 1984; Walter, 1982; Cavers and Steele, 1984). Furthermore, we recently (Lalonde and Roitberg, 1988) demonstrated that in Canada thistle (Cirsium arvense (L.) Scop.), this seasonal seed weight decline could be reversed if the total number of seeds competing for the plant’s resources over the season were experimentally reduced by controlling pollination success (Fig. 1a). These data suggest that, in some circumstances at least, plants respond to depleting resources by making increasingly smaller seeds rather than by reducing seed number.

One possible conclusion from these results is that offspring provisioning theory is simply wrong. A more productive line of inquiry is to postulate that the Smith–Fretwell model does not accurately describe seed provisioning because one or more of the assumptions underlying their theory are incorrect. Given this, the next step is to derive a new model with new assumptions.
which does explain observed patterns of seed weight variation, and then generate and test new predictions based on this model.

Recently, McGinley and Charnov (1988) proposed a new variation of the Smith and Fretwell (1974) model which does explain seasonal seed weight decline. They use the fact that ‘resources’ allocated by a plant are actually composed of several components (e.g. carbon, nitrogen, phosphorus, potassium), which can vary in availability independently of one another over the season. Their modified provisioning theory is static and consequently incorporates two assumptions:

1. Plants optimize currently available resources and do not optimize allocation of expected levels of resources.
2. The entirety of each pool of resources allocated to seed production during a reproductive bout is used.

Therefore, allocation of different resource components to seeds varies directly with their relative availability at the time of provisioning.

For their model, the authors focused on the two most common elements in provisioned seeds, carbon and nitrogen. In this model, when fitness returns from nitrogen investment increase faster than returns for carbon, the optimal investment of total resources per seed (i.e. seed weight) should be negatively correlated with the ratio of available carbon to nitrogen. The authors demonstrate that this is true even in the case where fitness returns from the two elements have identical slopes. However, they obtain this result by scaling carbon and nitrogen in different units (nitrogen is measured on a smaller scale (McGinley, pers. comm. 1988)) and equating seed weight solely with carbon allocation (their Fig. 2a). The latter assumption is indeed reasonable if