# Reduced reproductive success in small populations of the fragmented grassland species *Primula veris* L. and *Gentiana lutea* L.

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As a consequence of human activities many plant species today exist only in fragmented and isolated populations. Small populations are more likely than large populations to become extinct due to stochastic fluctuations of environmental conditions and demographic stochasticity. Small populations are also threatened by inbreeding and loss of genetic variation that reduces their chances to adapt to environmental changes. In addition, important interactions between species, e.g. plant pollinator mutualisms, may become disrupted in small populations. One of the first processes affected by reduced population size is often replication. We studied reproductive success in relation to population size in two declining species of nutrient-poor grasslands, *Gentiana lutea* and *Primula veris*.

In 27 studied populations of *Gentiana lutea* (1 to 3430 flowering plants), reproductive success was significantly related to population size. The number of seeds per fruit and per plant increased strongly with population size (Figure 1), but seed mass decreased. Total seed yield was higher in large than in small populations. Reproduction was especially affected in populations consisting of less than about 200 flowering plants. Differences among populations in mean plant size did not account for these relationships, suggesting that variation among populations in habitat quality was not responsible for the observed patterns. The reduced reproduction in small populations is therefore probably the result of pollinator limitation or inbreeding. in a pollinator-exclusion experiment, bagged flowers showed the same reproduction patterns as plants in small populations: a high seed abortion rate, very low seed set but larger seeds. The number of plants in 20 studied populations of *Primula veris* (9 to 13060) was not related to 14 out of 18 investigated habitat variables. Plants were smaller in large populations. However, the number of fruits, the number of seeds per fruit and consequently the number of seeds per plant (Figure 2) were significantly higher in large than in small populations. Individual seed mass was lower in large populations, but the higher number of seeds more than compensated for this and seed yield per plant was higher in large populations. Reproduction in *P. veris* was especially reduced in in populations smaller than about 50 flowering plants. As in *G. lutea* differences among populations of *P. veris* in mean plant size did not account for the observed relationships, suggesting that lower habitat quality was not responsible for these patterns. Because *P. veris* is an obligate outbreeder and a heterostylous species in which only crosses between morphs result in seed set, lack of suitable pollination is alikely explanation for the reduced reproduction in small populations of *G. lutea* and *P. veris* will reduce their tolerance to variations in mortality and may in the long term result in the decline and extinction of local populations. The results of this study suggest, that population size alone may be an unreliable predictor of population persistence , even for long lived plant species. A population may consist of many plants although reproduction is far from sufficient to produce sufficient recruits to the population.

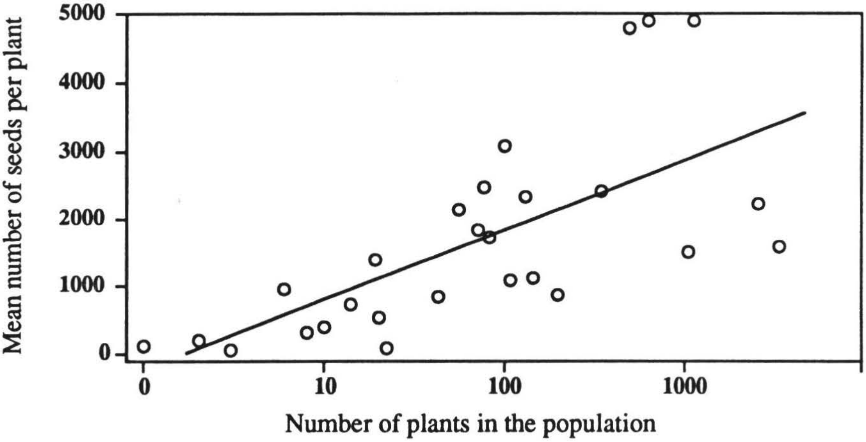


Fig. 1: The relationship between the mean number of seeds per plant and population size in *Gentiana lutea* ($r^2 = 0.46$, d.f. = 25, $p < 0.001$).

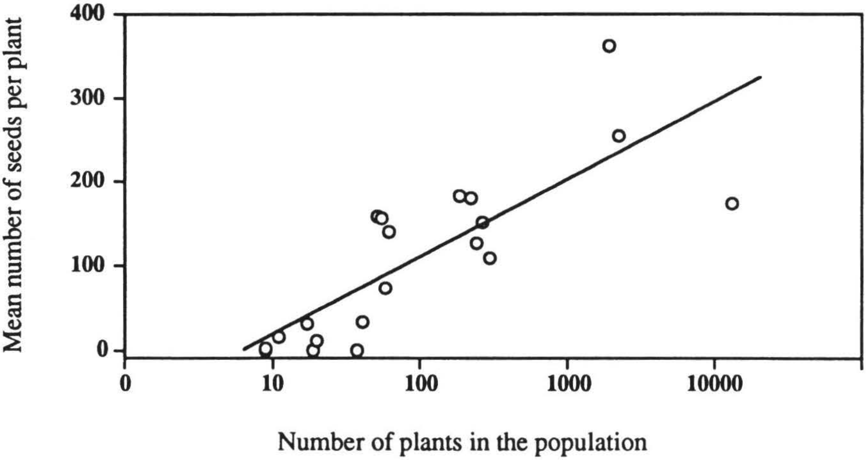


Fig. 2: The relationship between the mean number of seeds per plant and population size in *Primula veris* ($r^2 = 0.65$, d.f. = 18, $p < 0.0001$).

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