Abstract

Plant population size, spatial pattern and the density of mating groups, abundance, and behaviors of the pollinator fauna are expected to influence plant reproductive success through changes in the quantitative and qualitative patterns of pollination, i.e., stigmatic pollen load size and pollen donor diversity.

In the present study, in order to know the mechanisms involved in quantitative and qualitative patterns of pollination and their consequences, the effects of population size and pollinator availability on pollination and its relation to seed set were analyzed for a number of isolated populations of *Primula sieboldii* with a heterostylous breeding system. Pollen carryover and pollen exchange on a pollinator visit were also measured.

In Chapter 1, in order to confirm the importance of pollination process in female fertility of the natural plant populations, spatial and temporal variations in fruit and seed sets and biological factors limiting them were studied in 24 *P. sieboldii* populations for three years from 1995 to 1997 in southern Hokkaido. The plants in the smaller populations (genets $\leqq$ 3) set almost no seeds consistently during the study years presumably due to lack of mating partners. In the larger populations (genets $\geqq$ 7), proportions of failed flowers without damages by fungi or herbivores were relatively high, but fruit set per flower varied among the populations in 1995 with generally poor pollinator availability. Correlations of fruit ($r = 0.589$, $P = 0.011$) and seed sets ($r = 0.688$, $P < 0.01$) with pollinator availability among the populations were highly significant in the year. The pollination failure would be the most plausible reason for the fertility variation among the populations. In the populations with less pollinator availability, mean fruit and seed sets were greater in the long-styled morph than in the short-styled morph. It is possible that

such between-morph differences are caused by partial self-compatibility of long-styled morph, which is also suggested by the results of hand pollination experiments.

In Chapter 2, the effects of population size and pollinator availability on pollination as well as its relation to seed set of *P. sieboldii* populations were investigated both quantitatively and qualitatively. The number of compatible pollen grains deposited on the stigmas was significantly lower in the relatively large populations with low pollinator availability than that of the population with sufficient pollinator services. It was likely that small compatible pollen load due to low pollinator availability led to less seed set in these populations. Seed set in the relatively small populations varied greatly among the populations, while that of the large populations with low pollinator availability was moderate. Quality of pollination, i.e., the number of pollen donor within the stigmatic compatible pollen load can be interpreted to be higher in the large populations than the small populations, because more successful mating is possible with multiple pollen donors. Seed set in the long-styled morph of *P. sieboldii* populations was significantly higher than that in the short-styled morph under the naturally pollen-limited condition (Chapter 1). This is supposed to be related to the fact that the stigmas of the long-styled morph received more compatible pollen grains, though partial or cryptic self-compatibility of the long styled morph (Chapter 1) could explain a part of the difference.

In Chapter 3, under a semi-natural setting, I quantified between-morph pollen exchange patterns in *Primula sieboldii* flowers by measuring pollen removal from the anthers on a single visit by *Bombus diversus tersatus* queen and stigmatic pollen deposition along the sequence of the visits to the opposite-morph flowers by the bee. Despite twice the larger number of pollen grains produced in a single flower of the long-styled morph compared to that of the short-styled morph, no significant difference in pollen amount removed from a flower on a single visit of the bee was found between the morphs. The stigmas of the

long-styled morph received significantly more opposite-morph pollen grains than those of the short-styled morph on a single visit by the bee. Sufficient legitimate pollen grains, surpassing the ovule number, were loaded on the stigmas of 27% and 17% of visited flowers of the long- and short-styled morphs, respectively. Therefore, stigmatic pollen load after a single visit by the bee may be insufficient for maximum seed set in most flowers. Several visits by the pollinators would be required for receiving pollen grains far more than the ovule number, which is a necessary condition for full fertilization of the ovules. The short-styled morph is thought to be more vulnerable to legitimate pollen shortage than the long-styled morph in *P. sieboldii* because of the tendency of receiving much smaller legitimate pollen load. Although most of the pollen grains from donor flowers were deposited on the first several recipient flowers subsequently visited by the bee, considerable amounts of grains traveled much further. Such extensive pollen carryover suggested the probability of mixed pollination by a single visit by the bee which carries on its proboscis pollen mixture from many flowers of different genets, if the population consists of a number of genets.