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Effects of Forest Fragmentation on Flower Abortion, Predispersal Acorn Predation and Acorn Production in A Temperate Deciduous Oak (*Quercus serrata*) : A Comparison between Mast and Non-Mast Years

Shin-Ichi TANABE[a*], Kazuya Kimura[a], Atsushi Ohwaki[a] and Koji Nakamura[a]

(a) Institute of Nasture and Environmental Technology, Kanazawa University,Kakuma-machi,Kanazawa,Ishikawa,920-1192,JAPAN

Forest fragmentation caused by human activities, such as urbanization, land development and/or agricultural production, reduces tree population sizes and increases their spatial isolation. Decreased availability of outcross pollen has proven to be a main cause that reduces seed production of various kinds of self-incompatible trees in fragmented forests (e.g. Nilsson & Wastljung 1987; Aizen & Feinsinger 1994). Predispersal seed predation can negatively affect reproductive success of trees but has rarely been quantified in relation to forest fragmentation (Didham et al. 1996). Sincel both of the pollen availability and the rate of predispersal seed predation generally vary greatly between mast and non-mast seeding years (Kelly & Sork 2002), impacts of fragmentation on seed production through pollen availability and predispersal seed predation may change depending on annual fluctuation of seed production. Genus *Quercus* is one of groups showing high variation of seed production among years (Sork et al. 1993; Koenig et al. 1994) and is an important component that comprises forest ecosystems in the Pan-Japan Sea Area. Forest fragmentation proceeds at an increasing rate in Japan (Miura 2001), China (Zheng et al. 1997) and Korean Peninsular (Zheng et al. 1997; Hong 1999) and poses a serious problem on biodiversity conservation in these regions. In this study, we evaluate effects of forest fragmentation on seed production of a temperate deciduous oak, *Quercus serrata*, through pollen availability and predispersal seed predation and examine whether the effects differ between years with high and low seed yields.

Q. serrata is a wind-pollinated and monoecious tree, and is commonly considered to be self-incompatible. In fact, almost all of self-pollinated flowers drop before acorn maturation (Hashizume et al. 1994). This species widely occurs across lowland forests in temperate regions and often dominates secondary forests in Japan. As well as other oak species (e.g. Sharp & Spranque 1967), *Q. serrata* shows a low level of flower:fruit ratio (Matsuda 1982; Fujii 1993) and many flowers of this species drop within several weeks after flowering. Since this period of early drops corresponds to the time during which fertilization takes place (four to five weeks after pollination: Kanazashi & Kanazashi 2003), the failure of pollination can be a plausible mechanism to explain most of the early drops (Mastuda 1982). In addition, controlled self-pollination on *Q. serrata* has proven to cause drops of most flowers within one month after pollination (Hashizume et al. 1994). In this study, we use survivorship of flowers one month after flowering as a measure of cross-pollination.

We selected eight patches of secondary forests, each of which was dominated by *Q. serrata* and was surrounded by paddy fields, in an agricultural landscape near Kanazawa University, central Japan. Areas of these patches ranged from 0.08 to 2.6 ha. We carried out biweekly monitoring of flowers and acorns and checked damages of acorns due to various kinds of insects from May to October in 2004 and 2005, using tree-climbing method to access tree crowns. We selected two to five trees per forest patch and four to six branches per tree. In each branch, five current shoots were marked for monitoring. Two seed traps (trap area = 0.75 m^2) were set under the crown of each studied tree and were collected biweekly during reproductive season of *Q serrata.*

The mean density (m^2) of sound acorns across all of studied trees was 18 times higher in 2005 than in 2004. There were positive relationships between the density of sound acorns and flower survivorship across trees in both years (stepwise multiple regression: $r^2 = 0.37$, $P = 0.03$ in 2004; $r^2 = 0.26$, $P = 0.01$ in 2005). Flower survivorship was positively correlated with patch area in 2004 with small acorn crop (Fig. 1: simple linear regression, $r^2 = 0.31$, $P = 0.009$), whereas no relationship was

[a*] Electronic Address: tshin@kenroku.kanazawa-u.ac.jp

detected between flower survivorship and patch area in 2005 with large acorn crop (Fig. 1). For predispersal acorn predation, the density of sound acorns was negatively correlated with gall rate of acorns due to a cynipid wasp (Hymenoptera: Cynipidae) in 2004 (stepwise multiple regression: r^2 = 0.33, P = 0.04) and with acorn predation rate due to oviposition of *Mechoris ursulus* (Coleoptera: Attelabidae) in 2005 (stepwise multiple regression: r^2 = 0.35, P = 0.02). However, both types of predispersal acorn predation showed no relationships with patch areas.

These results suggest that forest fragmentation affects acorn production of *Q.serrata* mainly through pollen availability and its effect on acorn production changes annually depending on size of acorn crop in a given area, exerting strong influence on acorn production in non-mast years. On the other hand, predispersal acorn predation may be unimportant for acorn production in fragmented forest patches, at least, of the landscape that we studied.

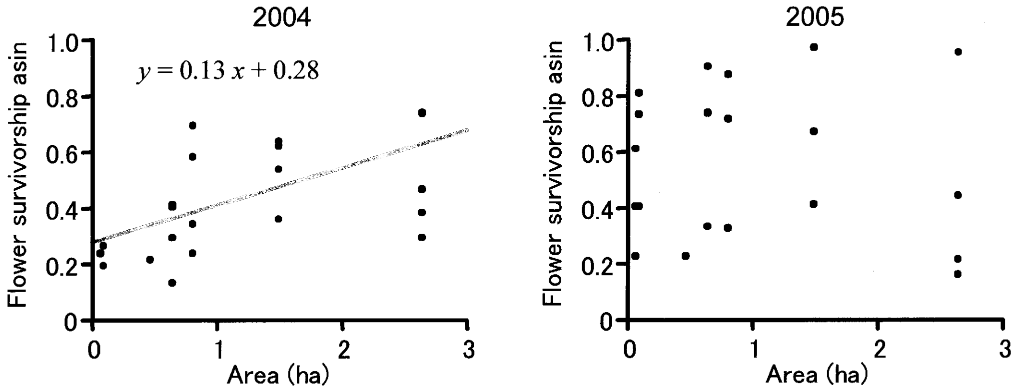

Figure 1 Relationships between flower survivorship one month after flowering and forest patch areas in 2004 and 2005

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