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Studies on the effect of *Osmia rufa* L. (*Apoidea, Megachilidae*) on the effectiveness of pod and seed development in the subgenus *Glycine*

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Abstract

Three abundantly blooming forms of *Glycine tabacina* and one *G. tomentella* form were studied. The experiment was conducted under isolated conditions. The effect of *Osmia rufa* L. on the fertility of raceme flowers was studied. It was found that the *G. tabacina* and *G. tomentella* flowers were intensively penetrated by the insects. A very clear increase (3-4 fold) in pod development was observed. The results of the experiment indicate that geitonogamic pollination has a favorable influence on the effectiveness of the blooming of the chasmogamic flowers of the studied species.

Key words: Glycine, Osmia rufa L., raceme fertility

INTRODUCTION

The domesticated soybean, *Glycine max* (L.) Merril, is a self-pollinating plant with only a very small tendency towards cross-pollination (Caviness 1970, Jaycox 1970, Beard and Knowls 1971). Although many authors have observed honey-bees (*Apis mellifera* L.) visiting soybean flowers, there is no consensus of opinion on the effect of insects on increasing the seed yield. According to Erikson (1975a, b) and Erikson et al. (1978), genetic factors determine the attractiveness of flowers. The size and chasmogamic nature of the flowers in racemes as well as the poor growth of the pollen tubes through the pistil styles of several wild forms from the subgenus *Glycine* suggest that they are allogamic. The solution to these questions requires a series of analyses, among which is the determination of the effect of environmental factors. As the first step, studies were begun to find if the yield could be increased by changing the manner of pollination of the chasmogamic flowers in the raceme.

MATERIAL AND METHODS

Three forms of *Glycine tabacina* and one form of *G. tomentella* were studied. The experiment was run in duplicate in a greenhouse using isolators, where a single isolator constituted a replicate. Two pots with four plants were placed in the isolator. A species of *Osmia rufa* L. (*Osmia bocormis* L.) was used for pollinating the plants. These are wild bees belonging to gastrilegidae. The pollen storing and transporting apparatus is found on these bees on the lower part of their abdomen, covered by yellow-brown setose hairs, which form what is called the pollen brush. These insects were obtained through controlled breeding in nest traps on reed stalks (Wójtowski and Wilkaniec 1969, Wójtowski 1979). Inhabited traps were stored in a refrigerator at a temperature of 4°C in order to synchronize flight of the bees with the blooming of the flowers. Before the flowers began to bloom, the reed stalks were cut open and the cocoons removed. They were left at room temperature until the first insects emerged (around three days). Next, the cocoons were placed in the isolators with the plants whose racemes had begun to bloom. The insects which had emerged in each isolator were counted, and cocoons were added so that the total number of insects amounted to 10. In order to ensure full nourishment, bunches of blooming lotus and red clover were periodically put into the isolators (for a few hours daily). After the insects had completed their flights, underdeveloped racemes were removed.

Plants from isolators where no insects had been introduced were used as controls. The effectiveness of blooming of racemes was expressed as the ratio of the number of pods to the number of flowers in the raceme.

RESULTS AND DISCUSSION

Under natural conditions, *Osmia rufa* L. visits a wide range of plants producing a large variety of flower types and sizes (Wójtowski and Feliszek 1977). The observations carried out here show that the chasmogamic flowers in racemes of *G. tabacina*: Chinchilla, 1077, WIR 367157 and *G. tomentella* PJ 245332 were also attractive for *Osmia rufa* L. These insects readily penetrated the racemes, and were amazingly systematic in doing so. They visited each developed flower in turn and only then did they transfer to the next raceme. The activity of the insects depended on the degree of insolation. On sunny days they worked on the flowers all day, on cloudy ones, however, their activity was very limited. Turning on artificial illumination in the greenhouse did not induce the insects to flight. It should be noted that *Osmia rufa* found enough food in the flowers of the analysed forms of *Glycine tomentella* and *G. tabacina*. The placement of bunches of blooming red clover and lotus, plants considered to be eagerly visited by insects from *Apoidea*, did not decrease their interest in the inflorescences of plants from the subgenus *Glycine*. As the result of visitation by *Osmia rufa*, the number of pods in *Glycine tabacina* and *G. tomentella* racemes increased 3-4 fold (Table 1). However, no effect of the insects on the effectivity of ovule fertilization was found. The differences in the number of seeds per pod and the differences in the number of abortive seeds between the plants visited by the insects and the controls were statistically insignificant (Table 1).

The clear improvement in pod formation observed in racemes was probably the result of better transfer of pollen to the pistil stigma. The penetration of flowers by the insects could have caused tearing of the anther wall, which increased the possibility of the pollen falling out from the anther chambers. From the evolutionary point of view, it is very interesting to note that most wild *Glycine* species produce deeply cleistogamic, self-pollinating flowers and colored, chasmogamic flowers which react by increasing their fertility as the result of pollination by insects. It seems that in these species, a phenomenon has been found which is characteristic for a number of perennial papillionaceous plants considered subject to cross--pollination. It has been observed that insects can work on one plant from the genus *Meliotus, Trifolium, Lotus* or *Medicago* for a long time, and then transfer to the nearest-growing plant (Łączyńska-Hulewicz 1958, Barcikowska 1966, Tellhelm 1968). In nurseries, these can be, e.g., plants from one clone. Fertilization occurs, therefore, as the results of pollination by the pollen of the same plant or plant with the same genotype. Studies on perennial papillionaceous plants have shown that this type of pollination, called geitonogamy, increases the formation of pods compared with autogamy (Łączyńska-Hulewicz 1958, Barcikowska 1966). Spiss (1976) holds the opinion that geitonogamy is undoubtedly one of the most important factors increasing the proportion of seeds from self-pollination in nurseries, more so than one would expect.

Knowledge about geitonogamy is also significant when interpreting results dealing with self-compatibility or self-incompatibility in plants. Self--incompatibility, which is usually assessed on the basis of self-pollination of individual flowers, is underestimated in comparison to natural conditions if the pollen is transferred from different flowers of the same genotype. It seems that from the observations made here, it can be concluded that the chasmogamic flowers of *Glycine tabacina* and *G. tomentella* racemes

Table 1

The effect of *Osmia rufa* L on the pod and seed setting of four forms from the subgenus *Glycine*

Form	Number of racemes per plant		Number of flowers per raceme		Number of flowers per plant		Number of pods from a plant (racemes)		Number of pods on raceme		Percentage of pod setting		Number of seeds per pod		Percentage of abortive seeds	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Glycine tabacina																
Chinchilla	12.1	12.5	15.5	14.1	187.6	176.3	38.5	8.7	3.2	0.7	20.4	5.0	3.99	4.15	28.4	26.1
1077	6.8	8.0	9.2	10.8	62.6	86.4	14.4	4.0	2.1	0.5	22.8	4.6	5.82	5.78	10.5	12.3
WIR 367157	8.2	9.0	12.5	12.3	102.5	110.7	17.6	4.4	2.1	0.5	17.2	4.0	5.78	5.65	5.5	7.1
Glycine tomentella																
PI 245332	19.3	18.2	9.5	9.6	183.4	174.7	30.3	9.1	1.6	0.5	15.1	5.2	3.40	3.17	15.7	19.6
Table $F_{\alpha=0.05} = 10.13$ Calculated F	0.1396		0.0060		0.0449		11.979		11.33		23.191		0.0216		0.3739	
$NIR_{\alpha=0.05}$							6.20		1.97		3.40					

1 — isolators with *Osmia rufa* L.
2 — isolators without *Osmia rufa* L.

are functional, able to form pods and seeds, and that this ability is clearly enhanced by geitonogamic pollination. It can be supposed that the geitonogamic effect is somewhat of an evolutionary remnant from the primary, allogamic way of reproduction.

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*Badania wpływu murarki ogrodowej (*Osmia rufa* L.) na efektywność wiązania strąków i nasion w podrodzaju Glycine*

Streszczenie

Obiektem badań były obficie kwitnące 3 formy *Glycine tabacina* i 1 forma *G. tomentella*. Założono doświadczenie w warunkach izolowanych. Analizowano wpływ murarki ogrodowej

(*Osmia rufa* L.) na płodność kwiatów kwiatostanów groniastych. Stwierdzono, że kwiaty *G. tabacina* i *G. tomentella* były intensywnie penetrowane przez owady. Obserwowano bardzo wyraźnie zwiększone (3-4-krotne) zawiązywanie strąków. Wyniki doświadczenia wskazują, że geitonogamiczny sposób zapylenia wpływa korzystnie na efektywność kwitnienia chasmogamicznych kwiatów gron u badanych gatunków.