

EFFECTS OF SEED ONION POLLINATION BY RED MASON BEE FEMALES *Osmia rufa* L. (*Apoidea*; *Megachilidae*) WITH DIFFERENT BODY WEIGHTS

Karol Giejdasz, Zdzisław Wilkaniec,
Katarzyna Piech

Department of Useful Insect Breeding,
Faculty of Animal Science A. Cieszkowski Agricultural University of Poznań.

Received 7 September 2005; accepted 14 November 2005

S u m m a r y

The study was aimed at determining the impact of body weight of red mason bee *Osmia rufa* L. females on the pollination efficiency of seed onion *Allium cepa* L. and the quality of seed yield. The results obtained demonstrated that the body weight of *Osmia rufa* females used for onion pollination had no significant effect on the pollination efficiency nor the quantity or quality of seeds. It can be observed that the percentage of fruits set compared to the number of flowers in an inflorescence tended to decrease with smaller body weights of the bee females from particular experimental groups. In addition, the other experimental results (total seed yield, germination energy and capacity) confirmed that weaker parameters of pollination efficiency and seed quality were achieved in the case of onion pollination by females with the lowest body weight.

Keywords: *Osmia rufa*, body weight, pollination, onion

INTRODUCTION

In populations of red mason been reared under controlled conditions and utilized for pollinating crops, the body weight of insects is an individual trait characterized by a high variability. The largest females weigh ca. 130 mg and are almost two times heavier than the smallest ones (Giejdasz 2002), with body lengths ranging from 10 to 12 mm (Wójtowski 1979). The weight of imagoes is determined to the greatest extent by the amount of pollen consumed in the larvae stage (Wilkaniec et al. 2004). Some authors claim that the body weight of a bee may be one of the parameters determining its value as a pollinating insect. In a single flight, heavier females of red mason bee are able to collect and transport greater loads of pollen with their ventral brush than lighter females; they are also capable of gathering substantially greater pollen

provision in their nest cells (Giejdasz 1998), which may have a decisive effect on the efficiency of their pollinating work (Tepedino and Torchio 1982, Bosch and Kemp 2004).

Species of bees with higher body weights usually cover greater distances to collect pollen, thus pollinating plants located relatively far from their nests (Abrol and Kapil 1994).

Therefore, the body weight of adult insects, especially of females, may be of significance to their functional value as insects utilized for the crop pollination.

This study was aimed at determining the impact of body weight of red mason bee *Osmia rufa* L. females on the pollination efficiency of seed onion *Allium cepa* L. and the quality of seed yield obtained under isolated conditions. The results would help to answer whether the selection of mason bee in respect of body

weight is appropriate when taking into account the requirements of the pollinated plant.

MATERIAL AND METHODS

A field experiment was carried out at a field station of the Department of Useful Insect Breeding in Swadzim near Poznań in the vegetative season of 2003, whereas laboratory analyses were run at the Department in 2004. The experimental material were roots of onion (*Allium cepa*) cultivar *Grabowska*.

In mid-April, 16 onions were planted out on each of four experimental plots (with an area size of 0.8 m²) which were covered with isolators made of a polyamide net stretched on cylinder-shaped metal scaffoldings. When 30% of flowers were observed to open in onion inflorescences, red mason bee females with a specified body weight were given access to particular isolators (one female per two onion inflorescences) and the nest material (stalks of common reed) was fixed in the isolator's interior. These plots constituted research groups differing in the body weight of the pollinating insects, whereas the plants constituted repetitions in particular experimental groups. Four weight variants (body weights with cocoon) of mason bee females were used in the study: the first one included females with body weights higher than 130 mg, the second one - those with body weights of 110-120 mg, the third one - those with body weights of 90-100 mg, and the fourth one - those with body weights below 80 mg. The bees were weighed in cocoons before their activation at a temperature of 26°C, and determined for their sex after having emerged from cocoons.

In mid-August, when seeds matured, five inflorescences with sprouts of equal sizes were cut out from each plot, fixed in gauze bags and left to dry. Next, flowers

that did not set seeds as well as pollinated flowers that set seeds were counted in each inflorescence.

The efficiency of pollination in experimental groups was determined on the basis of the number of fruits, the percent of fruits compared to flowers initiated in an inflorescence, and the weight of seeds obtained from five selected inflorescences. The quality of seeds obtained was assessed based on 1000 seed weight as well as germination energy and capacity. For germination analyses, 100 seeds from each experimental group were fixed on Petri dishes on moist gauze at a temperature of 21°C. Germinated seeds were counted first after 6 days to determine germination energy, and again after 12 days to determine germination capacity.

The means obtained were compared with a one-way analysis of variance and a Tukey test. Statistical analyses were carried out at a significance level of $\alpha=0.05$. The critical level of significance p was determined as well. In analyzing germination energy and capacity, four groups (25 seeds each) were randomly selected from each experimental variant and the mean values obtained were compared statistically and converted into percentage values. In comparing the percent of flowers in an inflorescence, analyses were carried out on data converted according to Bliss degrees.

RESULTS

Irrespective of the body weight of bees used for pollination, the number of fruits (follicles) developed in an inflorescence ranged from 106 to 454. The lowest average number of fruits per one inflorescence (221) was reported for a group of bees with the lowest body weights (below 80 mg, imago weight in cocoon), whereas the highest was in the

Table 1.

Results of onion cv. *Grabowska* pollination
by females of *Osmia rufa* with various body weights.

Female body weight (mg)*	Mean number per inflorescence			Seed yield per 5 inflorescences (g)
	flowers	fruits	non-pollinated flowers	
> 130	503.6	330.0 a	173.6 a	14.92
110-120	398.4	273.4 a	125.0 a	13.84
90-100	733.4	334.2 a	399.2 a	15.89
< 80	486.4	221.0 a	265.4 a	10.74

Means followed by the same characters are not significantly different (Tukey's test $\alpha=0.05$)

* with cocoon

Table 2.

Properties of onion seeds cv. *Grabowska* depending
on the body weight of *Osmia rufa* females.

Female body weight (mg)*	1000 seed weight (g)	Germination energy (%)	Germination capacity (%)
> 130	3.58	95 a	95 a
110-120	3.14	90 a	92 a
90-100	3.37	94 a	96 a
< 80	3.37	85 a	89 a

Means followed by the same characters are not significantly different (Tukey's test $\alpha=0.05$)

* with cocoon

variant with red mason bee females weighing from 90 to 100 mg with cocoon, and a slightly lower level was in the variant with bees whose body weight with cocoon exceeded 130 mg (Tab. 1). These differences were, however, not confirmed statistically.

The number of flowers not setting seeds per one inflorescence ranged from 72 to 906, with the lowest number of such flowers observed in a group with bees weighing 110-120 mg with cocoon and the highest was in the variant with bees weighing 90-100 mg with cocoon. The statistical analysis demonstrated that the body weight of pollinating bees did not affect the number of flowers not setting seeds either. The weight of seeds obtained

from five inflorescences appeared to be the highest in the variant with bees weighing 90-100 mg with cocoon and accounted for 15.89 g (Tab. 1). At the pollination by bees with higher body weights, the seed yield was slightly lower, whereas in the group of the lightest bees, the seed yield was the lowest and reached 10.74 g.

The mean percentage of pollinated flowers that set seeds compared to the total number of flowers in inflorescences was not significantly different, irrespective of the body weight of pollinating bees (Fig. 1). The efficiency of onion pollination by insects with body weights higher than 130 mg and those weighing from 110 to 120 mg (imago weight in cocoon) accounted for 65.5% and 68.6%,

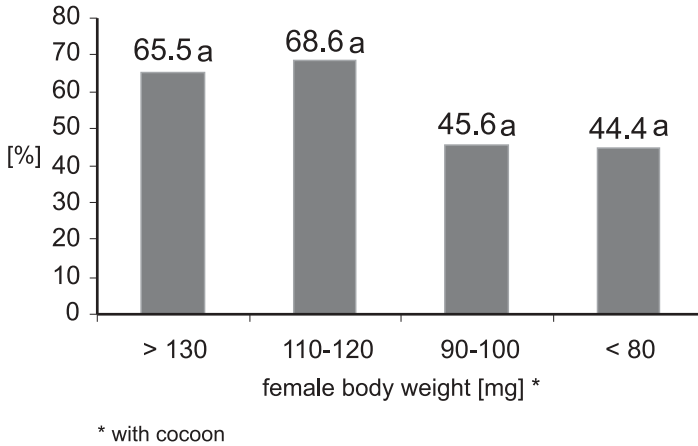


Fig. 1. Percent of pollinated flowers that set seeds in the total number of flowers in an inflorescence of onion cv. *Grabowska*.

respectively. In the two other variants with lighter bee females, the pollination efficiency reached as low as 45%.

The germination capacity of the seeds (which ranged from 89 to 96%) did not differ between particular groups. The same tendency was observed for germination energy which accounted for 85-94%. Although those differences were not significant, the lowest values of these two parameters were obtained in the variants with the lightest females weighing below 80 mg (Tab. 2). In addition, the body weight of the pollinating insects had no effect of the weight of 1000 seeds which ranged from 3.14 to 3.58 g.

DISCUSSION

Insects that pollinate flowers of seed onion under field conditions are usually honeybees, bumblebees, diptera and butterflies (Jabłoński et al. 1982; Wójtowski et al. 1980). Red mason bee is a species of wild bee, predisposed to controlled rearing and applied for the crop pollination, e.g. orchard and vegetable plant (Wilkaniec 1991).

In our study, the selection of an experimental plant was determined by the following factors: pollen of *Allium* genus is

collected by red mason bee under natural conditions (Wilkaniec et al. 2002); red mason bee has been utilized by grower in the cultivation of seed onion for years; onion is capable of self-pollination and the participation of insects is indispensable for seed production (Williams and Free, cit. Banaszak 1987; Jabłoński 1997), and although red mason bee is reluctant to visit onion, in a closed area it pollinates onion effectively (Schittenhelm et al. 1997).

In studies by other authors carried out on different pollinating insects, the percentage of seeds set in an onion inflorescence reached 60-64 % on average (Jabłoński et al. 1982; Hae Jun et al. 1998). In the reported study, the percent of pollinated flowers that set seeds ranged from 44.4% to 68.6% of fruits. Although the body weight of bee females used for onion pollination had no significant effect on seed setting, it was still observed that smaller bees tended to pollinate onion less effectively, compared to larger ones. In addition, other experimental results clearly indicate that weaker parameters of the pollination efficiency and seed quality were obtained when onion was pollinated by bees with lower body weights.

In this study, the effects of onion pollination were alike irrespective of the body weight of pollinating bees. It can be assumed, therefore, that although under isolator the body weight of bees had no direct impact on the efficiency of pollination, although perhaps in open spaces such a relationship would not be observed.

Species of solitary bees with lower body weights often re-visit the same flowers and repeat the scheme of foraging, which entails lower energy consumption, whereas heavier bees select flowers in a more random mode and are thus able to visit a higher number of flowers (Collevatti et al. 1997).

The distance and time of flights for forage are positively correlated with the body weight of bees (Gathmann and Tschardt 2002). This allows larger species of solitary bees to flight a greater distance between annual field crops and long-term crops or areas of wild flora that also constitute a reservoir for these insects (Steffan-Dewenter and Tschardt 1999).

SUMMARY

Although the weight of females has no direct significant impact on the pollination efficiency of seed onion, the results obtained suggest that in pursuit of maximal yields of the highest quality, the pollination of plants under isolators (where the number of pollinating insects is limited) should not be carried out with the smallest red mason bee females. In the rearing of the red mason bee it seems reasonable to provide such conditions for the females that would enable them to gather a greater pollen provisions in their nest cells to be used for rearing individuals with higher body weights.

REFERENCES

- Abrol D.P., Kapil R.P. (1994) - On homing ability and pollination effectiveness of bees. Mysore. *J. Agric. Sci.* 28:249-252.
- Banaszak J. (1987) - Pszczoły i zapylenie roślin. *PWRiL* Odział w Poznaniu.
- Bosch J., Kemp W.P. (2004) - Effect of pre-wintering and wintering temperature regimes on weight loss, survival, and emergence time in the mason bee *Osmia cornuta* (Hymenoptera: Megachilidae). *Apidologie* 35: 469-479.
- Collevatti R.G., Campos L.A., Schoereder J.H. (1997) - Foraging behavior of bee pollinators on the tropical weed *Triumfetta semitriloba*: departure rules from flower patches. *Insectes soc.* 44: 345-352.
- Dieringer G.; Cabrera R. L. (2002) - The interaction between pollinator size and the bristle staminode of *Penstemon digitalis* (Scrophulariaceae). *Am. J. Bot.* 89 (1): 991-997.
- Gathmann A., Tschardt T. (2002) - Foraging ranges of solitary bees. *J. Animal Ecol.* 71:757-764.
- Giejdasz K. (1998) - The amount of pollen load collected and stored in brood cells by the female of *Osmia rufa* L. (Apoidea, Megachilidae). *Pszczel. Zesz. Nauk.* 42(2): 33-34.
- Giejdasz K. (2002) - Bionomia i reprodukcja pszczoły samotnicznej murarki ogrodowej (*Osmia rufa* L., Megachilidae) (The bionomy and reproduction of the solitary red mason bee (*Osmia rufa* L., Megachilidae). Doctoral thesis. The August Cieszkowski Agricultural University of Poznań (in Polish).
- Hae Jun H., Jun Kyu S., In Jong H., Young Woo R. (1998) - Effect of pollinating insects on seed yield in seed production of onion (*Allium cepa* L.). *J. Horticulture Science*, 40(2):7-30.
- Jabłoński B. (1997) - Potrzeby zapylenia i wartość pszczelarska owadopylnych roślin uprawnych. *ISiK Odział Pszczelnictwa*, Puławy.

- Jabłoński B., Skowronek J., Woyke H. W., Doruchowski R. W. (1982) - Biologia kwitnienia, nektarowanie, zapylanie i owocowanie męskosterylnych linii cebuli (*Allium cepa* L.). *Pszczel. Zesz. Nauk.* 26: 57-104.
- Schittenhelm S, Gladis T., Rao V.R. (1997) - Efficiency of various insects in germ plasm regeneration of carrot, onion and turnip rape accessions. *Plant Breeding*, 116 (4): 369-375.
- Steffan-Dewenter I., Tscharrntke T. (1999) - Effect of habitat isolation on pollinator communities and seed set. *Oecologia* 121:432-440.
- Stout J.C. (2000) - Does size matter? Bumblebee behaviour and the pollination of *Cytisus scoparius* L. (*Fabaceae*). *Apidologie* 3:129-139.
- Tepedino V. J., Torchio P.F. (1982) - Phenotypic variability in nesting success among *Osmia lignaria propinqua* females in a glasshouse environment (*Hymenoptera: Megachilidae*). *Ecol. Entomol.* 7:453-462.
- Wilkaniec Z. (1991) - Możliwości zastosowania *Osmia rufa* L. (*Apoidea, Megachilidae*) w zapylaniu niektórych roślin uprawnych. *Rocz. AR w Pozn.* 229:173-179.
- Wilkaniec Z., Warakomska Z., Giejdasz K. (2002) - Rośliny żywicielskie pszczoły samotnicznej *Osmia rufa* L. (*Apoidea, Megachilidae*) określone na podstawie analizy pyłku z komór lęgowych. *Zesz. Nauk. PTPN*, 93:199-205.
- Wilkaniec Z., Giejdasz K., Fliszkiewicz M. (2004) - The influence of food amount consumed during the larval development on the body weight of the imago of the red mason bee (*Osmia rufa* L., *Megachilidae*) *J. apic. Sci.* 48 (1) 29-36.
- Wójtowski F. (1979) - Spostrzeżenia nad biologią i możliwościami użytkowania pszczoły murarki - *Osmia rufa* L. (*Apoidea, Megachilidae*) (Observations on the biology and possible utilization of the red mason bee *Osmia rufa* L., (*Apoidea, Megachilidae*). *Roczniki AR Poznań.* 111:203-208. (in Polish)
- Wójtowski F., Wilkaniec Z., Szymaś B. (1980) - *Hymenoptera* i *Diptera* zapylające cebule (*Allium cepa* L.) w poznańskich gospodarstwach nasiennych. *Rocz. AR w Poz.* 120:161-168.

EFEKTY ZAPYLANIA CEBULI NASIENNEJ PRZEZ SAMICE MURARKI OGRODOWEJ *Osmia rufa* L. (*Apoidea; Megachilidae*) O ZRÓŻNICOWANEJ MASIE CIAŁA

Giejdasz K., Wilkaniec Z., Piech K.

S t r e s z c z e n i e

W populacjach murarki ogrodowej utrzymywanej w chowie kontrolowanym masa ciała owadów jest cechą osobniczą, która charakteryzuje się dużą zmiennością. Największe samice są prawie dwukrotnie cięższe od najmniejszych. Zdaniem niektórych autorów np. masa ciała pszczoły może być jednym z parametrów decydujących o jej wartości jako owada zapylającego. Gatunki większych pszczół na ogół latają na większe odległości i potrafią korzystać z nektaru trudniej dostępnych kwiatów. Masa ciała pszczoły ma także wpływ na pomyślne przezimowanie, żywotność i wigor owadów, co także decyduje o efektywności pracy zapylającej.

Celem przeprowadzonego doświadczenia było ustalenie wpływu masy ciała samic murarki ogrodowej na efektywność zapylania cebuli nasiennej i jakość uzyskanego plonu w warunkach izolowanych. Eksperyment przeprowadzono na poletkach doświadczalnych w warunkach polowych na materiale wysadzeniowym cebuli (*Allium cepa*) odmiany *Grabowska*.

Niezależnie od masy ciała pszczół użytych do zapylania liczba owoców (torebek) wykształconych w kwiatostanie mieściła się w zakresie 106-454 sztuk. Średnio w kombinacji z najlżejszymi pszczołami (< 80mg, masa imago w oprzędach) uzyskano 221 owoców w

kwiatostanie, a w pozostałych (90-100 mg, 110-120 mg i powyżej 130 mg) odpowiednio: 334,2; 273,4; 330. Z kolei liczba kwiatów nie wiążąca nasion w jednym kwiatostanie wahała się od 72 do 906, przy czym najmniej było w grupie z pszczołami o masie 110-120 mg, a najwięcej w kombinacji 90-100 mg. Masa nasion uzyskanych z pięciu kwiatostanów była największa w kombinacji z pszczołami o masie 90-100 mg i wyniosła 15,89 g. Przy udziale pszczoł cięższych uzyskano tylko nieco mniejszy plon nasion. Z kolei w grupie pszczoł najlżejszych plon był najniższy i wyniósł 10,74 g.

Efektywność zapyłania kwiatów cebuli przez owady o masie powyżej 130 mg i od 110 do 120 mg wyniosła odpowiednio 65,5% i 68,6%. W dwóch pozostałych kombinacjach z samicami lżejszymi efektywność zapyłania osiągnęła poziom zaledwie 45%.

Zdolność kiełkowania nasion, która wahała się w przedziale od 89 do 96% nie różniła się między poszczególnymi grupami, podobnie jak i energia kiełkowania wynosząca 85-95%. Masa owadów zapyłających nie miała także wpływu na masę 1000 nasion, wynoszącą 3,14-3,58 g.

Wyniki doświadczenia sugerują, że najslabsze parametry efektywności zapyłania i jakości nasion uzyskano w przypadku zapyłania cebuli przez samice najlżejsze, choć różnic tych nie potwierdza analiza statystyczna. Obserwacje te pozwalają jednak na wyciągnięcie wniosku, że jeśli zamierza się uzyskać bardzo wysoki plon najlepszej jakości nasion do zapyłania roślin pod izolatorami, nie należy wykorzystywać najmniejszych samic murarki ogrodowej.

Słowa kluczowe: *Osmia rufa*, masa ciała, zapyłanie, cebula.