

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*)

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S u m m a r y

Influence of the amount of food consumed in the larval stage on the weight and size of the imago of *Osmia rufa* was investigated under laboratory conditions. Adult bees of *Osmia rufa* the larvae of which consumed a double portion of pollen, averaged over two cells, weighed (males 74.0 mg, females 114.0 mg) more than the bees (males 49.0 mg, females 89 mg) which, during their larval stage, consumed only single portions of pollen provisioned for them by the female in the cells. The correlation was determined between the weight of an adult bee and the weight of cocoon. The average cocoon weight of males fed with a single portion of pollen was 9.80 mg whereas that of males fed with a double portion was 17.87 mg. The corresponding values for females were 16.42 and 22.56 mg. A greater width of the third abdominal tergite and of the fore wing of the insects fed with the increased pollen portion indicates that increased amount of food positively affects the body dimensions of *O. rufa* imago.

These findings suggest that to obtain well-developed bees in the management of *O. rufa* a rich nutrition base is required.

Keywords: *Osmia rufa*, body weight, nutrition, cocoon.

INTRODUCTION

In the population of the red mason bee *Osmia rufa* L., reared to be used for crop pollination there is a wide variation among the insects for body size and weight. Body length of red mason bee males varies from 8 to 10 mm that of females from 10 to 12 mm (Wójtowski 1979). The largest adult males weigh around 100 mg and are five times heavier than the lightest ones. Adult females weigh from 45 mg to 140 mg (Giejdasz 2002). As demonstrated in many studies bee weight can be related to other insect parameters that are important with regard to their use. In solitary bees the length of effective flights is body size-related (Abrol and Kapil 1994). In honey-bee keeping heavier queens are noted for

greater fertility (Petrov 1955). In *Osmia lignaria*, successful survival of the winter diapause was dependent on body size (Tepedino and Torchio 1982). In the red mason bee the weight of pollen loads collected and carried by the females on the ventral brush is positively correlated with female body weight (Giejdasz 1998). Thus the weight of adult insects, of females in particular, may affect their usability as insects intended to pollinate crops.

The aim of the experiment was to investigate the influence of the amount of pollen fed to the larva on the weight and size of the imago body and on the weight of the hibernating cocoon.

MATERIAL AND METHODS

The experiment material was made up of red mason bees *Osmia rufa* L. The bees proceeded from a red nest-based management maintained in a multi-species orchard. In the spring of 2002, on being settled by females, the nest tubes were collected from the management and transferred to the laboratory where they were cut open lengthwise.

The provision collected by the female - pollen together with the egg - were collected from the cells - the nest tubes and transferred to artificial cells - holes made in styrofoam plates. One experiment group was made up of insects feeding on a provision of pollen collected in the cells by the females. Another group was made up of insects which were fed an additional portion of pollen coming from the cells of another nest, after the egg had been removed. Pollen provision with eggs were successively taken out of the cell in a red nest tube and they were transferred alternately to either group to make the two groups uniform with regard to the origin of insects. The styrofoam plates covered with transparent printing sheet were placed in an incubator at 28°C and at a relative humidity of ca. 65% where the insects underwent development. In October, after the insects had been kept outdoors for 2 weeks, they were placed in cool storage at 4°C in which they were hibernating until February 2003. At that time the insects in cocoons were taken out of storage and weighed. Only the insects which at the larval stage had consumed all pollen provision and made the cocoon were subjected to analysis. The cocoons were cut open, the imago was released, weighed and its sex was determined based on morphological differences. The weight of the cocoon was calculated as the difference between the weight of cocooned and cocoon-free imago. The insects were anesthetized with

ethyl acetate and fixed in preservative fluid. The dissecting and preparation of the 3rd abdominal tergite of the fore wing was made according to the method by Bornus et al. (1966). The measurements at the widest point of the tergite and of the wing were made using a stereo microscope attached to a camera that transferred the microscope image to be processed by the imaging software Microscann Lucia version 3.5.

T-Student test was used to compare the experiment group means of image weight, tergite width and wing width of insects fed different amounts of pollen. Curvilinear regression analysis was used to test the relationship between imago weight and cocoon weight.

RESULTS

Adult weight

Adult *Osmia rufa* males the larvae of which were fed only the pollen provision collected by the female (the single pollen provision) averaged 49.0 mg, the females averaging 89.0 mg. Adult males which at the larval stage fed on the increased pollen portion (the double pollen provision) averaged 74.0 mg, females weighing 114.0 mg. The difference in average weights of males between the two groups was 25 mg which accounted for 51% of the average male weight in the single provision group. The difference between average weight of females was the same (25 mg) which accounted for 28.1% of the average female weight in the single provision group. The adult insects doubly provisioned with pollen were significantly heavier than those which were fed only a single portion. Mean weights of males ($t=14.876$; $p<0.0001$) and of females ($t=7.073$; $p<0.0001$) were compared separately (Table 1).

Table 1.

Mean weight of hibernating *O. rufa* adults fed in the larval stage single or double pollen provision [mg]

| Sex | Pollen provision | n | Mean | SD | Min | Max |
|--------|------------------|----|--------|------|------|-------|
| male | single | 86 | 49.0a | 9.1 | 24.2 | 77.6 |
| | double | 78 | 74.0b | 12.3 | 22.3 | 93.2 |
| female | single | 38 | 89.0A | 18.6 | 56.4 | 149.8 |
| | double | 57 | 114.0B | 15.7 | 63.5 | 145.8 |

Table 2.

Mean cocoon weight of hibernating *O. rufa* adults fed in the larval stage single or double pollen provision [mg]

| Sex | Pollen provision | n | Mean | SD | Min | Max |
|--------|------------------|----|-------|------|------|------|
| male | single | 86 | 9.9a | 3.34 | 4.2 | 24.9 |
| | double | 78 | 17.5b | 4.61 | 13.0 | 34.3 |
| female | single | 38 | 17.3A | 4.87 | 6.1 | 32.5 |
| | double | 57 | 22.1B | 5.09 | 13.2 | 35.8 |

Means within a column with different letters are significantly different at $\alpha = 0.05$

Cocoon weight

The average cocoon weight of males (17.5 mg) and of females (22.1 mg) fed more plentifully at the larval stage was higher and significantly different than that of males (9.9 mg) and of females (17.3 mg) reared on a single portion of pollen (Table 2). Mean cocoon weights of males ($t=12.014$; $p<0.0001$) and of females ($t=4.584$; $p<0.0001$) were compared separately. On average, the cocoon weight of males reared on an increased provision of pollen increased by 7.6 mg (71.7%) as compared to that of males reared in cells with unmodified supply of pollen. The increase in cocoon weight of females fed more abundantly at the larval stage was 4.8 mg which accounted for 27.7% of the mean cocoon weight of females fed single pollen portions collected in the cells.

Correlation between cocoon weight and body weight of adult insects

Cocoon weight was related to the weight of the imago diapaused in the cocoon. Significant correlations were found between cocoon weight and adult body weight (males: $r=0.72$, $p<0.0001$; females: $r=0.74$, $p<0.0001$) for individuals fed the unchanged portion of pollen vs. those fed the double portion (males: $r=0.29$, $p=0.009$; females: $r=0.45$, $p=0.0005$) (Figure 1, 2).

According to the regression equation cocoon weights of males with average body weight fed the unmodified portion of pollen was 9.80 mg whereas that of males fed abundantly was 17.87 mg. Estimated in the same manner cocoon weights of females fed the unmodified pollen provision was 16.42 and that of females fed in abundance was 22.56 mg.

Cocoon weight of males reared on the

Table 3.

Mean width of abdominal third tergite of hibernating *O. rufa* adults fed in the larval stage single or double pollen provision [mm]

| Sex | Pollen provision | n | Mean | SD |
|--------|------------------|----|-------|-------|
| male | single | 45 | 1.39a | 0.092 |
| | double | 45 | 1.56b | 0.118 |
| female | single | 36 | 1.54A | 0.091 |
| | double | 43 | 1.67B | 0.076 |

Means within a column followed by different letters are significantly different at $\alpha = 0.05$

Table 4.

Mean width of fore wing of hibernating *O. rufa* adults fed in the larval stage single or double pollen provision [mm]

| Sex | Pollen provision | n | Mean | SD |
|--------|------------------|----|--------|-------|
| male | single | 45 | 1.88a | 0.091 |
| | double | 45 | 2.02.b | 0.126 |
| female | single | 36 | 2.26A | 0,122 |
| | double | 43 | 2.45B | 0.093 |

Means within a column followed by different letters are significantly different at $\alpha = 0.05$

unchanged pollen provision averaged 19.9% of the imago body weight, cocoon weight of females fed in the same manner accounted for 18.8% of the female imago

body weight. The cocoon weight of males fed the double pollen provision accounted for 23.7% of the imago weight, the same figure for females was 19.8%.

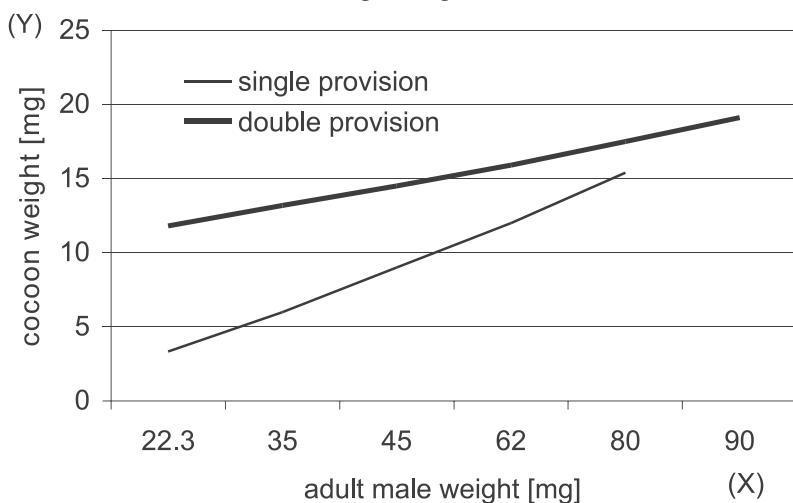


Fig. 1. Correlation between the weight of the cocoon and the weight of hibernating adult *O. rufa* males fed in the larval stage single or double pollen provision.

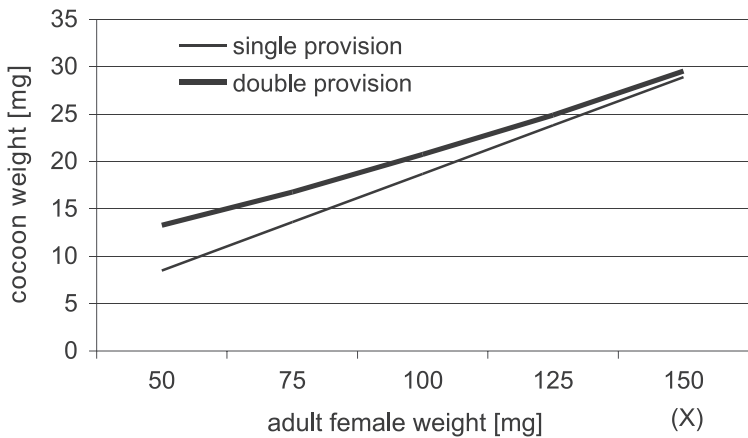


Fig. 2. Correlation between the weight of the cocoon and the weight of hibernating adult *O. rufa* females fed in the larval stage single or double pollen provision.

Width of the 3rd abdominal tergite

The mean width of the 3rd abdominal tergite of the imagines (males: \bar{x} =1.56 mm; females: \bar{x} =1.67 mm) fed on the increased provision of pollen at the larval stage was higher than that of the imagines (males: \bar{x} =1.39 mm; females: \bar{x} =1.54 mm) reared on a single pollen provision. Males ($t=7.958$, $p<0.0001$) and females ($t=7.414$, $p<0.0001$) were compared separately (Table 3).

Fore wing width

The mean width of the fore wing of the imagines (males: \bar{x} =2.02 mm; females: \bar{x} =2.45 mm) fed with the increased provision of pollen at the larval stage was higher than that of the imagines (males: \bar{x} =1.88 mm; females: \bar{x} =2.26 mm) in the group reared on unmodified pollen provision. Males ($t=6.711$, $p<0.0001$) and females ($t=8.083$, $p<0.0001$) were compared separately (Table 4).

DISCUSSION

The correlation between the weight of the imago in the genus *Osmia* to nest size was documented in the reports by different authors. Tepedino and Torchio (1989) reared cultures of *Osmia lignaria* using nest tubes 5, 6, 7 and 8 mm in diameter.

They found that body size increased in proportion to nest tube diameter. A similar relationship was found by Bosch (1994) in his study of the body weight of *Osmia cornuta* in tubes 7 and 8 mm in diameter. Instead, Wilkaniec et al. (2000) reported that the average body weight of *Osmia rufa* in nest tubes 8-9 mm in diameter was not higher than that of insects reared in tubes 7-8 mm in diameter. It was confirmed by a detailed study of the relationship between nest tube diameter of 5-9 mm and adult body weight in *Osmia rufa*. The study demonstrated that the correlation is curvilinear of second degree. The maximum body weight is attained by the females in nest tubes of 7.5 mm and by the males in nest tubes of 7.0 mm (Giejdasz 2002). Popovici-Bazosanu (1910) thought that the factor deciding about the body weight in *Osmia rufa* is the amount of pollen. The amount of pollen provision collected in the cell by an *Osmia rufa* female is proportional to nest tube diameter (Giejdasz 1998). Thus the diameter of the nest tube and weight of the insect growing therein can be only indirectly linked to each other through the amount of pollen provision. Tepedino and Torchio (1989) also found that higher body size was characteristic those *Osmia lignaria*

adults which were reared in nests completed earlier by the females. The reason for that may be a larger supply of forage plants for bees at a time of their first flights. The fact that cells to rear females are the first to be established and that the amounts of pollen collected there are larger than those in male-cells accounted for in a similar way.

The experiment confirmed the influence of the amount of consumed pollen on the weight of imago in the red mason bee. It also demonstrated that the bee can attain a larger body weight by ingesting an additional amount of pollen. Likewise, cocoon weight which is positively correlated with insect body weight was higher in bees fed more plentifully. However, in the group of males fed an additional amount of pollen the increase of cocoon weight relative to imago weight was greater than that in females. Being lighter than the females, the males may have attained the limit body weight faster, the energy from the surplus pollen provision having been used to make the cocoon. The absence of such an influence in females suggests that the surplus energy from the additional food provision to the larvae was used to build the body tissues in the first place and only then to build the cocoon.

After the work on the honeybee by Bornus (1960) in which the body size was positively correlated with the width of the 3rd abdominal tergite and with the width of the fore wing, analogous measurements were made in the red mason bee. The results allow the statement that the amount of consumed pollen by the red mason bee influences the weight of imago. The significant differences between the feeding treatment groups give evidence that the increase in body weight could not have been due exclusively to more storage materials being deposited in the body but was also related to the increase in insect body size. The body size in *Osmia cornuta* is

correlated to the amount of pollen supply consumed during the larval stage (Bosch, Vincent 2002)

The amount of supplies collected in the cells and consumed by *Osmia rufa* L. influences the weight and size of the imago. A further consequence is also an increase in cocoon weight in relation to imago weight which becomes particularly manifest in males. In rearing of effective pollinators is necessary to provide nesting bees abundant pollen sources. It gives more chance to obtain well-developed progeny with great body dimensions and weights.

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WPLYW ILOŚCI POKARMU W OKRESIE ROZWOJU LARWALNEGO PSZCZOŁY MURARKI OGRODOWEJ (*Osmia rufa* L., *Megachilidae*) NA MASĘ CIAŁA IMAGO

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

W populacji murarki ogrodowej *Osmia rufa* L., utrzymywanej w celu zapylania roślin wielkość i masa owadów jest zróżnicowana. Celem tego doświadczenia było zbadanie wpływu ilości pyłku kwiatowego zjedzonego przez larwę na masę i wielkość ciała formy imaginalnej oraz masę oprzędu owada zimującego.

Materiał doświadczalny stanowiły pszczoły murarki ogrodowej *Osmia rufa* L. Wiosną 2002 roku z gniazd wyjmowano jaja wraz z zapasami pyłku kwiatowego i przenoszono do sztucznych komór lęgowych, które przetrzymywano w cieplarni w temperaturze 28°C. Grupę I stanowiły owady żerujące na porcji pyłku kwiatowego zgromadzonego w komorze lęgowej przez samice. Grupa II były to owady, którym podano dodatkową porcję z komór lęgowych innego gniazda. Owady zimowały od października 2002 do lutego 2003 roku w temperaturze 4°C. Po tym okresie ustalono masę ciała owadów dorosłych oraz masę oprzędów. Pomiarów szerokości skrzydła I pary i III tergitu dokonano wykorzystując komputerowy program analizy obrazu. Przeciętna masa imago w grupie I (samce: 74,0 mg; samice: 114,0 mg) była wyższa niż w grupie II (samce: 49,0 mg; samice 89,0 mg). Średnia masa oprzędów, która była dodatnio skorelowana z masą imago w grupie I samców wyniosła 9,9 mg, a w grupie II 17,5 mg. Oprzędy samic ważyły odpowiednio 17,3 i 22,1 mg. Masa oprzędów skorelowana była silniej z masą imago w grupie I niż w grupie II. Średnia szerokość trzeciego tergitu odwłokowego imago (samce: 1,56 mm; samice: 1,67 mm) oraz średnia szerokość skrzydła I pary imago (samce: 2,02 mm; samice: 2,45 mm) w grupie II były wyższe od szerokości tergitu imago (samce: 1,39 mm;

samice: 1,54 mm) oraz szerokości skrzydła (samce: 1,88 mm; samice: 2,26 mm) w grupie I. Zjedzenie przez larwę murarki ogrodowej podwojonej porcji pyłku kwiatowego spowodowało zwiększenie masy ciała owadów dorosłych oraz ich rozmiarów. Można, zatem twierdzić, że jednym z warunków uzyskania dorodnych pszczół, efektywnych zapylaczy roślin jest zapewnienie owadom w czasie ich rozwoju bogatej bazy pokarmowej, zasobnej w pyłek kwiatowy.

Słowa kluczowe: *Osmia rufa*, masa ciała, żywienie, oprzęd.