Comparison of different stimulation methods on the colony initiation of subtropical area bumblebees *Bombus eximius* of Taiwan

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DateJuly 7, 2015

Abstract No.BBP-014

Abstract

The bumblebee *B. eximius* has potential as a pollinator for crop pollination programs in subtropical area of Taiwan. In this study, the different of stimulation methods effects on colony initiation of *B. eximius* queens were compared to increase rearing efficiency and reduce production costs. Total of 62 queens obtained from field in central and north Taiwan. Use four different stimulation methods: only queen alone (q), one queen and one *B. eximius* pupa (qep), one queen and two honeybee workers (qh) and one queen with one newly emerged *B. eximius* worker (qew). The result that four group in egg laying ratio, colony production ratio, progeny queen production ratio as show below: q (50.0, 30.0, 66.6%), qep (77.7, 61.1, 71.4%), qh (50.0, 35.7, 57.1%) and qew group (85.0, 75.0, 80.0%), respectively. The colony initiation time, total number of queens in four group as show below: q (16.00±3.24 days, 16.33±1.53), qep (6.50±2.24 days, 21.57±6.63), qh (17.57±2.15 days, 18.29±2.87) and qew group (5.24±1.99 days, 22.87±4.98), respectively. The result showed that adding the *B. eximius* worker and add pupa (qep) is the good methods for simulative the queen staring laying egg in mass production the subtropical area bumblebees colony of Taiwan.

Key words: bumblebee, colony initiation, Taiwan
**Introduction**

Bumblebees are one of the most important pollinators for crop growth in greenhouses (Free 1993). Their behavior of buzz pollination is critical for crop flowers that do not produce nectar, such as tomatoes. Techniques have been developed to rear colonies in captivity (Sladen 1912; Roseler 1985; Duchateau & Velthuis 1988). Bumblebees as pollinators in pollination programs were developed for commercial use in Belgium and the Netherlands in 1987 (Ruijter 1997). Soon after that, many other groups developed their own commercial pollination programs in Canada, China, Japan, New Zealand, and the USA (Velthuis & Doorn 2006).

There is much information available on how best to rear bumblebees under artificial conditions (Velthuis & Doorn 2006). This is very important of rearing bumblebee colonies is stimulating foundresses to start egg laying. Several methods have been described, such as adding a male pupa, adding frozen pupa, young honeybee workers or bumblebee workers. But the rearing data related with subtropical area bumblebees’ species are limited. *B. eximius* has potential as a pollinator for crop pollination programs in Taiwan (Chiang *et. al.*, 2009), therefore this study is compared the effects of different stimulation methods; one queen with one *B. eximius* worker, one bumblebee queen with three young honeybees workers and the *B. eximius* queen along on the colony development of *B. eximius*.

**MATERIALS AND METHODS**

Total of 62 queens obtained from field in central and north Taiwan. All colonies were kept at a temperature of 26 ± 2 °C and with humidity of 65 ± 10%, and illuminated with red light in an incubator. Sugar syrup was prepared with equal volumes of sugar and water, and a slight amount of sodium benzoate to delay the decline time. Fresh pollen was collected from honeybee pollen collectors and then frozen at -20°C for preparation, and pollen clumps were made by mixing with 50% sugar solution and fresh pollen.

![Fig. 1 Put one pupa with queen(qep group) to stimulate rapid laying egg on the pupa(arrow indicate)](image-url)
Use four different stimulation methods: only queen alone (q), one queen and one *B. eximius* pupa (qep) (Fig. 1), one queen and two honeybee workers (qhw) and one queen with one newly emerged *B. eximius* worker (qew) (Fig. 2). Colony development was trace daily observation; the days of queen first egg laying, the time of emergence of the worker and total number of workers, males and queens. For statistical analysis, all of data compared used ANOVA and Turkey-Kramer HSD test and the proportional analysis by χ² test.

![Image](image_url)

**Fig. 2** Put one *B. eximius* worker with queen(qew group) to stimulate rapid laying egg on the bottom board (arrow indicate)

**Results and discussion**

The result that four group in egg laying ratio, colony production ratio, progeny queen production ratio as show in Table 1: q group (50.0, 30.0, 66.6%), qep group (77.7, 61.1, 71.4%), qhw group (50.0, 35.7, 57.1%) and qew group (85.0, 75.0, 80.0%), respectively. These treatments were significant differences in term of egg laying, colony production ratio according to the chi-square values (p<0.01, χ²=48.76, 53.48, df=3). Colonies produced progeny queens varied from 57.1% to 80.0%, but no significant difference between treatment groups (χ²=3.12, p=0.175).
Table 1 *Bombus eximius* queens characteristics that egg laying ratio, colony production ratio and progeny queen production ratio depend on the difference stimulate.

<table>
<thead>
<tr>
<th>Colony characteristics</th>
<th>Treatments</th>
<th>q</th>
<th>qep</th>
<th>qhw</th>
<th>qew</th>
<th>(\chi^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg lay(%)</td>
<td></td>
<td>50.0</td>
<td>77.0</td>
<td>50.0</td>
<td>85.0</td>
<td>48.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(n=10)</td>
<td>(n=18)</td>
<td>(n=14)</td>
<td>(n=20)</td>
<td></td>
</tr>
<tr>
<td>Colony produce(%)</td>
<td></td>
<td>30.0</td>
<td>61.1</td>
<td>35.7</td>
<td>75.0</td>
<td>53.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(n=10)</td>
<td>(n=18)</td>
<td>(n=14)</td>
<td>(n=20)</td>
<td></td>
</tr>
<tr>
<td>Progeny new queen(%)</td>
<td></td>
<td>66.6</td>
<td>71.4</td>
<td>57.1</td>
<td>80.0</td>
<td>3.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(n=3)</td>
<td>(n=14)</td>
<td>(n=7)</td>
<td>(n=15)</td>
<td></td>
</tr>
</tbody>
</table>

n: number queen or colonies

In Table 2, the result show the colony initiation time the total number of workers and total number of queens in four group as show below: q (16.00±3.24 days, 81.33±19.14, 16.33±1.53), qep (6.50±2.24 days, 111.90±17.68, 21.57±6.63), qhw (17.57±2.15 days, 72.29±23.72, 18.29±2.87) and qew group (5.24±1.99 days, 104.00±15.72, 22.87±4.98), respectively.

The qep group and qew group, queens started laying eggs were significantly shorter than the other two groups. In total number workers, qep group produced 111.90±17.68 and 104.00±15.72 in qew group which significantly product more workers than the q and qhw groups.

Table 2 Colony characteristics on different stimulated starting treatments.

<table>
<thead>
<tr>
<th>Colony characteristics</th>
<th>Treatments</th>
<th>q</th>
<th>qep</th>
<th>qhw</th>
<th>qew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colony initiation times (days)</td>
<td></td>
<td>16.00±3.24</td>
<td>6.50±2.24</td>
<td>17.57±2.15</td>
<td>5.24±1.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(n=5)</td>
<td>n=14</td>
<td>n=7</td>
<td>n=17</td>
</tr>
<tr>
<td>Total number of workers</td>
<td></td>
<td>81.33±19.14</td>
<td>111.90±17.68</td>
<td>72.29±23.72</td>
<td>104.00±15.72</td>
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<tr>
<td></td>
<td></td>
<td>(n=3)</td>
<td>(n=14)</td>
<td>(n=7)</td>
<td>(n=15)</td>
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<td>18.29±2.87</td>
<td>22.87±4.98</td>
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<tr>
<td></td>
<td></td>
<td>n=2</td>
<td>n=10</td>
<td>n=4</td>
<td>n=12</td>
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</table>

For the commercial mass production bumblebee colony, rapid colony initiation and successful colony production are very important to reduce the cost. The number workers per colony is an important point in evaluating the potential pollination efficiency of bee pollinator. There were many different starting methods such as two queens put in same box, queen with a
same/different species bumblebee worker, honeybee worker, bumblebee pupa (worker/male), frozen bumblebee pupa are used to stimulate queen to laying eggs (Ptacek 1985,1991; Asada and Ono 2000; Yoon and Kim 2002; Kwon et al. 2003; Gretenkord and Drescher 1997; Gurel and Gosterit 2008). In table 2 showed that qep and qew group produce more workers (111.90±17.68 and 104.00±15.72) than q and qhw groups (81.33±19.14 and 72.29±23.72), similer the history research.

In this study, we first test different methods to stimulate the subtropical area bumblebee queen to laying egg. The result showed that *B. eximius* queen with the worker (qew) and add pupa (qep) is the good methods for simulative the queen start laying egg for mass production subtropical area bumblebees colony (Fig. 3). This has important implications for the development of greenhouse agricultural system in subtropical area.

![Fig. 3 Use qep and qew treatment to stimulate queen start laying egg, and production more number of workers.](image)

**Reference**


Gretenkord C, Drescher W (1997) Successful colony foundation and development of experimentally hibernated *Bombus terrestris* queens depending on different starting


