The attractiveness of moth webbings in the cone traps placed in grain on the females confirms olfactometer laboratory trials showing kairomonal activity of webbings produced by different species of pyralid Lepidoptera for *H. hebetor* (Strand et al. 1989). Moreover, foraging *H. hebetor* were shown to enter into bulk grain in previous studies (Schöller, 2000). In the present study, female *H. hebetor* were shown to exploit signals from moth webbings in bulk grain, too. Consequently, parasitisation of Indian meal moth larvae can be expected below the grain surface, too. This behaviour of *H. hebetor* can also be used to monitor the foraging behaviour of the wasps under practical conditions of storage. In wheat, more *H. hebetor* were trapped compared to oats. This might be due to the three-dimensional structure of the bulk grain.

Both male and female *H. hebetor* were caught with the cone traps. The capture of females in unbaited traps indicates this trap type is able to record passively the movement activity of the parasitoids. Males could potentially be attracted by already caught females, however, in our trials, a significantly higher number of females in the baited traps did not result in a significant increase in the number of males caught.

The results on monitoring showed the possibility to record data on the phenology of the Indian meal moth and *H. hebetor* under practical conditions. The abiotic conditions in different grain stores are subject to wide variation, consequently more field trials are needed in order to develop recommendations for biological control of the Indian meal moth.

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**References**


A preliminary study of growth and development of *Cheyletus malaccensis* (Oudemans) under different humidity conditions

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DOI 10.5073/jka.2018.463.117

**Abstract**

*Cheyletus malaccensis* (Oudemans) is a species of predatory mite, which is widely distributed in grain storage, and is a potential natural enemy of stored-product pests. Based on the typical temperatures and humidities that occur in granaries, the growth and development of *C. malaccensis* was studied at 24°C with different relative humidities (RH 65±2%, 75±2%, 85±2% and 95±2%). During this study, *C. malaccensis* was fed on *Acarus siro* (Linnaeus), a very important stored grain pest to investigate its potential to control this pest and production of this natural enemy in the laboratory. The results showed that *C. malaccensis* has five developmental stages, egg, larva, protonymph, deutonymph and adult. The deutonymph stage is absent in males. For females, the developmental time from egg to adult was shortest at 85±2 % RH and averaged 16.3 days; developmental time was longest at 65±2 % RH and averaged 18.6 days. The male mites in the 95±2% RH trials had the shortest developmental time which averaged 12.6 days; it was longest at 65±2% RH where it averaged 14.7 days. At 95±2
% RH, the male adult lived 83.5 d and its longevity from egg to adult was 95.8 d. Humidity had a significant effect on how long the adults lived and the duration of all developmental stages. At 85±2 % RH, the maximum average number of eggs per female, oviposition period and daily fecundity were 493.0, 46.2 d, and 10.3, respectively. This study provides basic biological parameters for *C. malaccensis*, a potential biological control agent for mite pests infesting stored grain.

**Key words:** *Cheyletus malaccensis*; development, reproduction, biological control

![Fig. 1](image1.png) The development stages of *C. malaccensis*, A: Egg B: Larva C: Protonymph D: Deutonymph E: Hypopus F: Female G: Male

![Table 1](image2.png) The developmental duration of *C. malaccensis* at different relative humidity conditions

<table>
<thead>
<tr>
<th>Relative humidity (%)</th>
<th>Egg (d)</th>
<th>Larva</th>
<th>Protonymph</th>
<th>Deutonymph</th>
<th>Life history (d)</th>
<th>Adult (d)</th>
<th>Development duration of all stages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>65±2%</td>
<td>2.9±0.26</td>
<td>2±0.18</td>
<td>4.3±0.15</td>
<td>0.07</td>
<td>1.84</td>
<td>0.31</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*Fig. 1* The development stages of *C. malaccensis*, A: Egg B: Larva C: Protonymph D: Deutonymph E: Hypopus F: Female G: Male

*Table 1* The developmental duration of *C. malaccensis* at different relative humidity conditions
Note: The data in the table are means±SE. *Mean significantly different (P<0.05).

### Table 2: The development duration of stages and oviposition between C. malaccensis and C. eruditus

<table>
<thead>
<tr>
<th>Prey</th>
<th>Predator</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Sex</th>
<th>Egg No. of eggs (P&lt;0.05)</th>
<th>Larva No. of eggs (P&lt;0.05)</th>
<th>Protonymph No. of eggs (P&lt;0.05)</th>
<th>Deutonymph No. of eggs (P&lt;0.05)</th>
<th>Life history</th>
<th>No. of eggs/oviposition per female period</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. putrescentiae</td>
<td>C. malaccensis</td>
<td>24-25</td>
<td>75</td>
<td></td>
<td>4.3 ± 0.75</td>
<td>3.5 ± 0.69 (P&lt;0.5)</td>
<td>5.5 ± 0.21</td>
<td>7.9 ± 0.21</td>
<td>19.5</td>
<td>73 ± 6 (P&lt;0.5)</td>
<td>Zhaopeng Shen</td>
</tr>
<tr>
<td></td>
<td>C. eruditus</td>
<td>25</td>
<td>80±5</td>
<td>Male/ Virgin</td>
<td>3.9 ± 0.74</td>
<td>6.7 ± 0.34</td>
<td>18.0 ± 0.34</td>
<td>47.6±0.9</td>
<td>15.3±0.6</td>
<td>Emmanouel</td>
<td></td>
</tr>
<tr>
<td>L. destructor</td>
<td>C. malaccensis</td>
<td>18-22</td>
<td>75</td>
<td></td>
<td>3.3 ± 0.5</td>
<td>4.5 ± 0.43</td>
<td>13.2 ± 0.34</td>
<td>18.0±0.34</td>
<td>77±10.7</td>
<td>14±16</td>
<td>Yanxuan Zhang</td>
</tr>
<tr>
<td></td>
<td>C. eruditus</td>
<td>25</td>
<td>76</td>
<td></td>
<td>3.3 ± 0.5</td>
<td>4.5 ± 0.43</td>
<td>13.2 ± 0.34</td>
<td>18.0±0.34</td>
<td>77±10.7</td>
<td>14±16</td>
<td>Barker</td>
</tr>
<tr>
<td>A. ovatus</td>
<td>C. malaccensis</td>
<td>25±0.1</td>
<td>75±2</td>
<td>Female</td>
<td>3.3 ± 0.5</td>
<td>4.5 ± 0.43</td>
<td>13.2 ± 0.34</td>
<td>18.0±0.34</td>
<td>77±10.7</td>
<td>14±16</td>
<td>Saleh M</td>
</tr>
<tr>
<td></td>
<td>C. eruditus</td>
<td>25</td>
<td>80±5</td>
<td>Male</td>
<td>3.3 ± 0.5</td>
<td>4.5 ± 0.43</td>
<td>13.2 ± 0.34</td>
<td>18.0±0.34</td>
<td>77±10.7</td>
<td>14±16</td>
<td>Barker</td>
</tr>
<tr>
<td>D. gallinae</td>
<td>C. malaccensis</td>
<td>25</td>
<td>80±5</td>
<td></td>
<td>4.7 ± 0.43</td>
<td>4.38 ± 0.67</td>
<td>18.3 ± 0.34</td>
<td>47.6±0.9</td>
<td>15.3±0.6</td>
<td>Macon Toldi, Faleiro</td>
<td></td>
</tr>
<tr>
<td>A. siro</td>
<td>C. eruditus</td>
<td>24</td>
<td>75</td>
<td></td>
<td>5.0 ± 0.7</td>
<td>7.2 ± 0.24</td>
<td>6.3 ± 0.15</td>
<td>18.0±0.34</td>
<td>77±10.7</td>
<td>14±16</td>
<td>Foihuan He</td>
</tr>
</tbody>
</table>

### Table 3: The oviposition of C. malaccensis parthenogenetic at different relative humidity conditions

<table>
<thead>
<tr>
<th>Relative humidity (%)</th>
<th>65±2</th>
<th>75±2</th>
<th>85±2</th>
<th>95±2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of eggs per female</td>
<td>418.0±91.90</td>
<td>427.3±178.44</td>
<td>493.0±104.52</td>
<td>348.2±101.06</td>
</tr>
<tr>
<td>Oviposition period</td>
<td>45.4±10.57</td>
<td>44.7±18.10</td>
<td>46.2±8.21</td>
<td>34.0±7.39</td>
</tr>
<tr>
<td>No. of eggs laid by each female per day</td>
<td>9.5±0.33</td>
<td>9.4±0.99</td>
<td>10.3±1.20</td>
<td>9.0±1.70</td>
</tr>
<tr>
<td>Max. no. of eggs laid by each female per day</td>
<td>23.6±1.81</td>
<td>19.3±1.86</td>
<td>20.0±1.20</td>
<td>21.2±3.30</td>
</tr>
<tr>
<td>Pre-oviposition</td>
<td>3.2±1.09</td>
<td>2.3±1.15</td>
<td>3.0±1.00</td>
<td>1.3±1.50</td>
</tr>
<tr>
<td>Post-oviposition</td>
<td>3.6±2.40</td>
<td>2.7±2.67</td>
<td>7.0±2.67</td>
<td>7.2±1.29</td>
</tr>
</tbody>
</table>

Note: The data in the table are means±SE.

### References


Nakatani Yoshiyuki, 1975. Cheyletus malaccensis Oudemans, Patterns of each stage of 1903 [J]. Hygienic animals, 26:151-165.

Evaluation of the potential value of the F1H and F2H Diatomaceous earth formulations as grain protectants against Rhyzopertha dominica (Fabricius) (Coleoptera: Bostrichidae)

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DOI 10.5073/jka.2018.463.11

Abstract
An insecticidal efficacy of two newly developed grain protectant formulations were assessed against lesser grain borer Rhyzopertha dominica (Fabricius) (Coleoptera: Bostrichidae) on wheat and corn after 6 months period of. Tested formulations, marked as F1H and F2H, based on inert dust, laurel leaves, lavender essential oil, corn oil, silica gel (both F1H and F2H) and pyrethrin (only F2H) were tested at six doses (from 100 ppm to 600 ppm) depending on formulation and type of grain. The appropriate weights of each formulation, were added separately to plastic containers containing 10 kg of wheat or corn. An initial population of 200 adults of R. dominica were added into each container and left under natural environmental conditions for up to 6 months. A commercial diatomaceous earth (DE) insecticide, Celatom® Mn 51, was used for the comparison of the results, in addition to the untreated control. After six months, both formulations showed higher insecticidal effect than DE Mn 51 in corn and in wheat. Furthermore, the initial population of R. dominica, introduced in wheat was suppressed almost completely, with only 0.7%-5.3% live adults found, depending on formulations and dose. The order of efficacy was F1H>F2H>DE Mn 51. Similar suppression of the initial population was recorded in corn, where F1H was slightly more effective than F2H with 2.0%-10.6% and 4.1%-9.5% live adults found, respectively. At the same time, in the treatments with DE Mn 51 there were 4.7%-74.7% and 33.4%-56.1% live adults in wheat and corn, respectively.

Keywords: inert dust, botanicals, grain protectant, stored product insects, insecticidal effect