CHAPTER IV

Morphometry and Biology
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INTRODUCTION

The forest and agricultural pests were studied by many workers from morphological and biological perspectives. The cucurbits, as a group, are attacked the most in their early stages by red pumpkin beetle, very often the attack of which can be so heavy that the crop might have to be resown. The beetles are found concealed in groups under dry weeds, bushes and plant remains or in the crevices of soil. They resume activity as soon as the season warms up and their life span is up to 60 to 85 days. The adult beetle is red, oblong and approximately 6-8 mm long having glistening yellowish-red to yellowish-brown elytra that are uniformly covered with fine punctures (Rahman, 2006). Das and Ishahaque (1998a) reported that adult beetles were elongate, oblong and brilliant orange red in colour and the ventral surface of the abdomen was completely black and clothed with silvery hairs. A single female can lay 150 to 300 eggs (Srivastava and Butani, 1998). Eggs are laid singly or in batches of 8-9 in the moist soil usually around the host plant. Eggs are spherical in shape and yellowish-pink in colour (Rahman, 2006). The eggs need contact moisture for development (Melamed- Madjar, 1960) and they hatch in 6-15 days and the grubs remain below the soil surface. The grubs are yellowish white and when in the soil cause injury to the roots (Maniruzzaman, 1981) but full-grown ones are creamy-yellow and about 22mm long. They feed on roots, underground stems of creepers and on fruits lying in contact with the soil. Pavlakos (1939) noticed that R.
foveicollis has one generation a year in Greece; development from egg to adult requires 47 to 55 days.

Pavlakos (1945) found that eggs hatch in 9 to 14 days, the larval stage lasts 29 days and the pupal stage 15 to 18 days. He also added that R. foveicollis has one generation a year in Greece and overwinters as adult. According to Al-Ali et al., (1982) the adult lives up to a maximum of 29 days and the female produces variable numbers of eggs in up to four layings. They also reported four generations in a year from Iraq. The pupal stage lasts 7-17 days and the beetles, on emergence, begin to feed and breed. The life cycle completed in 26-37 days and the pest breeds five times from March to October. Shaheen (1973) reported that, the sex ratio was found to be almost constant. Almost equal numbers of males and females emerged in each generation.
MATERIALS AND METHODS

i) Morphometry of grubs and pupae:
For the study of morphometry of grubs, the different instars were collected from the respective petridish (9 mm in diameter) in rearing box (50cmx50cm) where the grubs were nourished properly in laboratory condition. The pupae were collected from the petridish beneath the moistened soil. Grubs and pupae were weighed in an electronic balance. The length and breadth of head capsule were measured by ocular micrometer. Body length was measured by a callipar (Deshmukh et al., 1977). Ten (10) replications were taken and consisted of 10 individuals for each grub instar and pupal stage. ANOVA was employed to find the difference among the various parameters and Standard Error of mean (SEm) also calculated.

ii) Morphometry of adult beetles:
For the study of morphometry of adult beetles, the insects were collected from the cultivators' crop field. Collections were done by hand picking method and were sexed. Randomly 10 adult males and females were individually weighed on an electronic balance. The length and breadth of body and different body parts were measured by callipar (Deshmukh et al., 1977) and ocular microscope. ANOVA was employed to find the difference among the various parameters and Standard Error of mean (SEm) also calculated.
i) Morphometry of grubs and pupae:

RESULTS

Grub stages:

The grubs were scarabeiform. Freshly hatches larvae were smooth, pale yellow in colour. The head capsule was brownish with long setae. The anal shield was slightly darker. There were distinct three pairs of thoracic legs. The body length of I-instar was shorter than the other grub stages which were measured as 3.55±0.27mm whereas maximum length was recorded in case of IV-instar (11.45±0.099mm) (Table 11). The body lengths in descending order of grubs were as follows:

IV-instar (11.45±0.15mm) > III-instar (8.40±0.36mm) > II-instar (6.04±0.25mm) > I-instar (3.55±0.27mm). The body width of grub stages showed that it was highest in IV-instar (1.14±0.01mm) whereas the lowest was recorded in I-instar (0.38±0.01mm). The body widths of grubs in descending order were as follows:

IV-instar (1.14±0.01mm) > III-instar (0.76±0.05mm) > II-instar (0.65±0.02mm) > I-instar (0.38±0.01mm).

In case of head capsule the length was recorded to be the highest in IV-instar (0.71±0.04mm) whereas the lowest in I-instar (0.30±0.01mm). The lengths of head capsule in descending order were as follows: IV-instar (0.71±0.04mm) > III-instar (0.50±0.02mm) > II-instar (0.42±0.01mm) > I-instar (0.30±0.01mm).

The widths of head capsule were recorded to be the highest in IV-instar (0.40±0.02mm) whereas the lowest in case of I-instar (0.22±0.01mm). The lengths of head capsule in descending order were as follows: IV-
Table 11. Morphometry of grubs and cocoon of *R. foveicollis*.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Body</th>
<th>Head capsule</th>
<th>Wt (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length (mm)</td>
<td>Width (mm)</td>
<td>Length (mm)</td>
</tr>
<tr>
<td>I- instar</td>
<td>3.55±0.27</td>
<td>0.38±0.01</td>
<td>0.30±0.01</td>
</tr>
<tr>
<td>II- instar</td>
<td>6.04±0.25</td>
<td>0.65±0.02</td>
<td>0.42±0.01</td>
</tr>
<tr>
<td>III- instar</td>
<td>8.4±0.36</td>
<td>0.76±0.05</td>
<td>0.50±0.02</td>
</tr>
<tr>
<td>IV- instar</td>
<td>11.45±0.15</td>
<td>1.14±0.01</td>
<td>0.71±0.04</td>
</tr>
<tr>
<td>Cocoon</td>
<td>5.97±0.09</td>
<td>3.01±0.03</td>
<td>1.00±0.02</td>
</tr>
</tbody>
</table>

C.D. at p<0.05 7.51 (NS) 21.76 (NS) 7.43 (NS) 9.73 (NS) 4.69 (NS)

Note: '*' : Mean of ten replications, each replication consisted of ten individuals; '+' : SEm; 'NS': Non-significant.
instar (0.40±0.02mm) > III-instar (0.35±0.01mm) > II-instar (0.33±0.02mm) > I-instar (0.22±0.01mm).

The body weight was recorded to be the highest in IV-instar (10.94±0.99mg) whereas the lowest was recorded in I-instar (0.25±0.05mg). In descending order the body weight were as follows: IV-instar (10.94±0.99mg) > III-instar (4.75±0.77mg) > II-instar (3.31±0.66mg) > I-instar (0.25±0.05mg).

Pupal stage:

The pupae were slightly curved so that the head was pressed against the prosternum. The pronotum was large and broad and covered the head. Pupation took place under moist soil. The body lengths of pupae were measured 5.97±0.09 in length and 3.01±0.03 mm in width) (Table 11). The head capsule was measured as 1.00±0.00mm in length and 0.96±0.01 mm in width. The weight measured 9.39±0.23mg. ANOVA did not show any significant variation of length and weight among grubs and pupae. Standard Error of mean (SEm) was calculated.

**DISCUSSION**

The freshly hatched grubs are smooth, pale yellow in colour and head capsule brownish with long setae which corroborates the findings of Das and Ishahaque (1998a). Full grown grubs measured as 11.45±0.15mm in length and 1.14±0.01mm in width. This finding corroborates the earlier findings of Hussain and Abdullah (1926) and Das and Ishahaque (1998a). The pupae measured as 5.97±0.09mm in length and 3.01±0.03mm in width which agrees the work of Das and Ishahaque (1998a) who studied
in Jorhat of Assam. No morphometric variation was found among other authors may be due to prevailing similar environmental conditions as well as availability of food substances.

ii) Morphometry of adult beetles

RESULTS

Adult beetles were elongate, oblong and brilliant orange in colour. The ventral surface of the abdomen was completely black. Compound eyes were prominent, bulging coal black. The males were smaller than the females in shape. Male and female could be differentiated by the shape of abdominal sternite. Male emerginated apically but female slightly notched. Moreover, female abdomen was broader at the base and more triangular in shape than that of the male abdomen.

The measurement of body length was found to be 6.93±0.34mm in male whereas 8.14±0.35mm in case of female (Table 12). The male and female body lengths were found to be significantly different (p<0.05) from each other. The body width was recorded to be slightly broad in case of female (3.66±0.18mm) than that of males (3.20±0.21mm). Body width differed significantly (p>0.05) for both the sexes. Weight of the body measured as heaviest in case of female (7.67±0.38mg) than male (6.22±0.34mg) which was observed as significantly different (p<0.01) for both the sexes.

The head capsule was observed as longer in length in case of females (1.89±0.11mm) than males (1.65±0.08mm). The width of head capsule was also broader in case of females (1.64±0.06mm) than males.
Table 12. Morphometry of adult male and female of *R. foveicollis*.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Body</th>
<th>Head capsule</th>
<th>Antenna</th>
<th>First leg</th>
<th>Second leg</th>
<th>Third leg</th>
<th>Fore wing</th>
<th>Hind wing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>wd</td>
<td>W</td>
<td>L</td>
<td>wd</td>
<td>NSG</td>
<td>L</td>
<td>wd</td>
</tr>
<tr>
<td>Male</td>
<td>6.93±0.34</td>
<td>3.2±0.21</td>
<td>6.16±0.08</td>
<td>436±0.16</td>
<td>4.26±0.11</td>
<td>4.72±0.11</td>
<td>5.44±0.13</td>
<td>0.36±0.01</td>
</tr>
<tr>
<td>Female</td>
<td>8.14±0.76</td>
<td>3.66±0.18</td>
<td>1.56±0.11</td>
<td>6.16±0.18</td>
<td>4.62±0.13</td>
<td>5.31±0.13</td>
<td>5.86±0.13</td>
<td>0.36±0.01</td>
</tr>
<tr>
<td>C.D. at p&lt;0.05</td>
<td>2.09*</td>
<td>2.07**</td>
<td>2.47**</td>
<td>3.15**</td>
<td>1.26(NS)</td>
<td>1.72**</td>
<td>1.90*</td>
<td>1.76*</td>
</tr>
</tbody>
</table>

Note: '*' Mean of ter individuals, '±': SE, 'L' length (mm), 'wd': width (mm), 'W': weight (mm), 'NSG: no. of segment, '**': significant at p<0.05, '***': significant at p<0.01, 'NS': non-significant.
The significant difference (p<0.01) of the length and width of head capsule were observed in both the sexes. The lengths of antennae were observed as longer in females (4.61±0.18mm) than the males (4.36±0.19mm). No significant (p>0.05) variation of the antennal length for both the sexes had been observed.

In case of first pair of legs, length and width were measured as larger in females (length= 4.62±0.13mm, width= 0.39± 0.02mm) than males (length= 4.25± 0.11mm, width= 0.34±0.01mm). No significant (p>0.05) variation for length was observed whereas width was found to be significantly varied (p<0.05) for both the sexes.

The length of second pair of legs were recorded to be longer in case of females (5.31±0.13mm) whereas shorter in males (4.72±0.11mm) and found to be significantly varied (p<0.01) for both the sexes. The width was recorded to be same for both the sexes (female= 0.35±0.01mm, male= 0.35±0) without showing any significant difference (p>0.05) in both the sexes.

The length of third pair of legs was observed longer in females (5.86±0.13mm) than males (5.44±0.13mm) where no significant variation for both the sexes had been observed. The width was observed slightly longer in females (0.45±0mm) than males (0.41±0.01) where the significant variation (p<0.05) for both the sexes had been observed.

Regarding wings, the length of fore wings were found to be longer among females (6.99±0.26mm) than males (5.12±0.03mm) whereas width was noticed almost same (male= 2.23±0.15mm, female= 2.22±0.14). No significant variation (p>0.05) for length and width of fore wings among
both the sexes were recorded. The length of hind wings recorded to be larger for females (8.38±0.22mm) where significant variation (p<0.05) for both the sexes had been observed. The width of hind wings revealed to be broader in females (3.22±0.06mm) than males (3.06±0.03mm) without showing any significant variation (p<0.05) in both the sexes (Table 12).

DISCUSSION

The study of the morphometry of adult beetles reveals that the body, head capsule, antennae, legs and wings are comparatively larger in females than males. It can be said that the body sizes of females are larger than males which corroborates Das and Ishahaque (1998a). The adult male measured 6.93±0.43mm in length and 3.20±0.21mm in breadth whereas females measured as 8.14±0.35mm in length and 3.66±0.18mm in width which support the works of Das and Ishahaque (1998a). This may be due to nutritional availability, hereditary or agro climatic conditions which can influence in this region.
b) Biology

Biological study of *R. foveicollis* on *C. maxima* during three crop seasons (2004-05):

**MATERIALS AND METHODS**

Biological study of *R. foveicollis* was studied on *C. maxima* during three crop seasons viz., Summer, Autumn and Winter during the year 2004-2005. This study conducted on petridish (9 mm in diameter) in a wooden cage (50 x 50 x 50 cm size) covered by fine mosquito net (2mm mesh size) in the Departmental Laboratory. The adult males and females were collected from the cucurbit field and released in rearing box. The adults were nourished by fresh pumpkin leaves which were grown in our own experimental plot. The fresh leaves were kept on the petridish above the moistened soil. Study of biology was carried out in three seasons viz, Summer, Autumn and Winter. The twigs contained leaves properly wrapped by cotton from the lower side were inserted to the conical flask filled-up with water. There were five replications and each replication consisted of three pairs beetle. After releasing the adult male and female, observations were continued for subsequent studies on the biology that included copulation period, pre-oviposition period, oviposition period, post-oviposition period, incubation period/egg stage, larval period, pupal period and adult longevity. For determining sex ratio 100 adults in each season were collected randomly from cultivators’ field and sex ratio was determined. The growth index (G.I.) was calculated by employing the...
following formula: G.I. = n/t, where ‘n’ is the per cent immature attained adult stages and ‘t’ is the time taken to complete the life cycle.

RESULTS

i) Copulation:

Copulation could take place at any time of the day. The male was easily attracted to the female. Before copulation both the insects performed a short courtship for 1-2 hours. During this period the male chased the female who seemed to express her annoyance. After sometime, the male was found on the dorsum of female, opened the female genitalia by inserting tarsal claws and inserted its aedeagus and remained in coitus. Copulation took place during day and night lasted for 5.00±0.44 hours in summer, 6.00±0.70 hours in autumn and 27.00±4.05 hours in winter (Table 13). During the act of copulation the female moved normally with the male on its back.

ii) Oviposition:

The pre-oviposition period varied from 3 to 17 days and was influenced by the prevailing climatic conditions. It was observed 3.00±0.44, 7.00±0.70 and 15.00±2.09 days during summer, autumn and winter seasons, respectively (Table 13). The oviposition was not continuous and there was an interval of 3 to 4 days between subsequent laying. Oviposition period lasted for 32±2.02, 24±1.22 and 24±2.02 hrs. during summer, autumn and winter seasons, respectively. Whereas post-oviposition periods continued from 3±0.54, 3±0.54 and 4±0.89 days during summer, autumn and winter seasons, respectively. The female
laid eggs singly in each batches consisted of 34 to 74 nos. after each copulation. Fecundity was recorded as 33+5.04, 48+3.75 and 63+4.04 nos. during summer, autumn and winter seasons, respectively.

iii) Life stages and developmental periods:

a) Egg stage:

Freshly laid eggs were yellowish, spherical and sculptured. The colour of the egg shell changed to orange and then brown nearest to hatching. Eggs were incubated on very wet soil beneath the pumpkin leaves or moistened filter paper in petridish or the pumpkin twig contact with the water of conical flask in rearing cage. Incubation period lasted for 8+0.89, 9+0.83 and 11+0.70 days during summer, autumn and winter seasons, respectively. The eggs measured 0.70+0.06 mm in width.

b) Grub stage:

The grubs were scarabeiform. Newly hatched grubs were smooth, pale yellow in colour. The head capsule was brownish with long scale. The anal shield was slightly darker. There were three pairs of thoracic legs. The larval period was found shorter during summer season and longer during winter. The grubs passed through four instars.

First instar:

The period of this instar continued for 2.60+0.24, 3.80+0.37 and 4.00+0.54 days during summer autumn and winter seasons, respectively (Table 13). In this stage they started feeding on fresh young pumpkin leaves. The first instar grubs were very tiny and creamy coloured. They were found to move very quickly. Grubs remain hidden beneath the
leaves or nearby the edge of leaves. The grubs of this stage were measured to be 3.55+0.27 mm in length (Table 11).

**Second instar:**

In this stage they were found to increase in size and fed on fresh leaves voraciously contact with the soil. They were also observed as fast runner. Length of the grubs was recorded as 6.04+0.25 mm (Table 11). The instar period lasted for 3.40+0.24, 2.08+0.20 and 3.80+0.37 days during summer, autumn and winter seasons (Table 13).

**Third instar:**

In third instar period their speed was found to be decreased and fed on fresh leaves. The instar period varied as 3.40+0.24, 3.80+0.37 and 3.00+0.31 days during summer, autumn and winter respectively (Table 13) and the length of this stage was recorded to be 8.4+0.36 mm (Table 11).

**Fourth instar:**

The movement in this stage become sluggish or stopped. Feeding activity also recorded to be stopped. They were trying to search a suitable place to take shelter beneath the soil. The grubs of this stage were found to be largest among all the stages of grubs and the length was registered as 11.45+0.15 mm (Table 11). This stage varied from 4.40+0.24, 4.20+0.20 and 6.00+0.54 days during summer, autumn and winter, respectively (Table 13).

c) **Pupal stage:**

Pupation took place under the moist soil. The pupae were slightly curved so that the head was pressed against the sternum. The pronotum was large and broad covered the head. The pupal stage was measured as
Table 13. Biological study of *R. foveicollis* on *C. maxima* during summer, autumn and winter seasons (2005).

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average temp (°C)</td>
<td>31.26±0.40</td>
<td>30.81±0.36</td>
<td>25.36±0.38</td>
</tr>
<tr>
<td>Average rainfall(mm)</td>
<td>23.19±0.36</td>
<td>24.60±0.15</td>
<td>12.95±0.36</td>
</tr>
<tr>
<td>Average RH (%)</td>
<td>81.80±1.12</td>
<td>89.02±0.86</td>
<td>78.52±1.36</td>
</tr>
<tr>
<td><strong>Stage/Instars</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copulation period (hrs)</td>
<td>5.0±0.44*</td>
<td>6.0±0.70*</td>
<td>27.0±4.06*</td>
</tr>
<tr>
<td>Pre-oviposition period (days)</td>
<td>3.0±0.44</td>
<td>7.0±0.70</td>
<td>15.0±2.09</td>
</tr>
<tr>
<td>Oviposition period (days)</td>
<td>32.0±2.08</td>
<td>24.0±1.22</td>
<td>24.0±2.02</td>
</tr>
<tr>
<td>Post-oviposition period (days)</td>
<td>3.0±0.44</td>
<td>3.0±0.54</td>
<td>4.0±0.89</td>
</tr>
<tr>
<td>Fecundity (nos./female)</td>
<td>33.0±5.04</td>
<td>48.0±3.75</td>
<td>63.0±4.04</td>
</tr>
<tr>
<td>Egg stage (days)</td>
<td>8.0±0.89</td>
<td>9.0±0.83</td>
<td>11.0±0.70</td>
</tr>
<tr>
<td>Grub stage (days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I- instar</td>
<td>2.6±0.24</td>
<td>3.8±0.37</td>
<td>4.0±0.54</td>
</tr>
<tr>
<td>II- instar</td>
<td>3.4±0.24</td>
<td>2.8±0.20</td>
<td>3.8±0.37</td>
</tr>
<tr>
<td>III- instar</td>
<td>5.4±0.24</td>
<td>3.8±0.37</td>
<td>3.0±0.31</td>
</tr>
<tr>
<td>IV- instar</td>
<td>4.4±0.24</td>
<td>4.2±0.20</td>
<td>6.0±0.54</td>
</tr>
<tr>
<td>Pupal stage (days)</td>
<td>7.0±0.44</td>
<td>8.4±0.50</td>
<td>11.0±0.63</td>
</tr>
<tr>
<td>Adult stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (days)</td>
<td>47.0±2.52</td>
<td>44.0±2.91</td>
<td>58.0±2.30</td>
</tr>
<tr>
<td>Female (days)</td>
<td>50.0±1.58</td>
<td>50.0±2.34</td>
<td>67.0±2.58</td>
</tr>
<tr>
<td>Sex ratio (F: M)</td>
<td>1: 1.5</td>
<td>1: 1.6</td>
<td>1: 1.06</td>
</tr>
<tr>
<td>One complete life cycle (days)</td>
<td>34.2±1.24</td>
<td>39.0±1.18</td>
<td>45.6±1.20</td>
</tr>
<tr>
<td>G.I.</td>
<td>2.026</td>
<td>1.32</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**Note:** '±': SEM; '*' Based on five replications and each replication consisted of 3 pairs beetle.
5.97+0.09 mm in length (Table 11). The pupal period varied from 7.00+0.44, 8.40+0.50 and 11.00+0.63 days during summer, autumn and winter respectively (Table 13).

d) Adult stage:

**Emergence:** The pupal skin splits along the dorsum of the thorax which bulges out of the T-shaped split to help the beetle to emerge. The newly emerged adults were elongate, oblong and brilliant orange red in colour.

**Adult male:** The average life span was found to be 47.00+2.52, 44.00+2.91 and 58.00+2.30 days during summer, autumn and winter (Table 13). The body length was measured to be 6.93+0.34 mm (Table 12).

**Adult female:** The average life span was found to be 50.00+1.58, 50.00+2.34 and 67.00+2.58 days during summer, autumn and winter respectively (Table 13). The size of female was comparatively larger than the male. The abdomen was broader and posteriorly blunt. Length of the body of female beetle was recorded as 8.14+0.35 mm (Table 11).

iv) Sex ratio:

Random collection of adult beetles from crop field revealed that sex ratio did not vary among three seasons. The female population outnumbered the male during all the seasons (Table 13). During autumn sex ratio was recorded to M: F= 1:1.6. in summer M: F= 1:1.5 and during winter 1:1.06.

v) G.I.:

Growth index was recorded to be maximum during summer (2.06) followed by autumn (1.32) and less in winter (1.04).
Plate. 3. Photograph showing the damage on the leaf of *C. sativus* by adult *R. foveicollis*.

Plate. 4. Photograph showing the copulation of *R. foveicollis* on the leaf of *C. maxima*.

Plate. 5. Photograph showing the cocoon of *R. foveicollis* on soil.
v) Number of generations:

In the present investigation four to five overlapping generations were observed per year.

**DISCUSSION**

The study on the biology of *R. foveicollis* reveals that the copulation, pre-oviposition, oviposition, post-oviposition and incubation period varied during three crop seasons viz., summer, autumn and winter. Maximum time period required completing the life cycle during winter season and in summer it took minimum time duration which is in agreement with the earlier findings of Das and Ishahaque (1998a). According to them maximum life span of this beetle is recorded in winter whereas minimum in summer. The fecundity was recorded as 33.00+ 5.04 to 63+ 4.04 nos. which contradicts the works of Shaheen (1973) in Egypt and Das and Ishahaque (1998a) in Assam. Fecundity was recorded to be the highest during winter where average RH was recorded as 78.58% which supports the findings of Chaudry and Alikhan (1990). The egg incubation periods ranging from 8.00+ 0.89 to 11.00+ 0.70 days that partially supports the report of Shaheen (1973) and Das and Ishahaque (1998a). But it also partially supports the findings of Saini (1958) who reported incubation period ranges from 7 to 11 days in northern Pakistan depending upon the ambient temperature. The mean incubation period in different generations are highly agrees with Pavlakos (1945) who found that egg hatch in 9 to 14 days. Grubs period was found shortened during summer may be due to rise in temperature (Das and Ishahaque, 1998a).The total
duration of grub period studied by Pavlakos (1945) who stated the larval period lasts for 29 days. But Shaheen (1973) and Das and Ishahaque (1998a) reported the total grubs duration ranges from 19 to 20 days which more or less corroborates our findings. Pavlakos (1943) and Melamed-Madiar (1960) reported only three larval moults which also support our present study. Al-Ali et al. (1982) found that under field condition during spring and early summer (18.5 to 29.5°C) in Iraq, the red pumpkin beetle underwent only three larval instars which contradicts our findings. The four larval instars found in our present study may be due to prevailing moderate to high temperature and RH which may be considered as optimum conditions in this region.

The pupal stage varies from 7.00±0.44 to 11.00±0.63 days which partially supports the works of Hussain and Abdullah (1926), Shaheen (1973) and Das and Ishahaque (1998a). But this finding favours the work of Saini (1958) who found pupal stage lasts for 8 to 11 days in northern Pakistan. The observations of Hussain and Abdullah (1926), Pavlakos (1939), Shaheen (1973) and Das and Ishahaque (1998a) who found that to complete life cycle it requires 45 to 55 days. These findings are almost similar to our present findings during winter. But it does not support the findings during other two seasons. In case of autumn it was observed as 39.00±1.18 days and 34.20±1.24 days in summer which partially supports the findings of Alikhan and Yousuf (1985) who observed R. foveicollis requires 31+2 days in Pakistan. The duration of life cycle in this region may vary due to the varied aero-climatic conditions and availability of host in this zone.
Adult longevity recorded during summer and winter range from 44.00±2.91 to 50.00±2.34 days corroborates Hussain and Abdullah (1926) and Shaheen (1973). Das and Ishahaque (1998a) also reported the average life span of adult is 50.40 days in Jorhat of Assam which agrees our present findings during summer and autumn seasons. But in winter it was recorded to be quite longer (male= 58.00± 2.30, female= 67.00± 2.52) may be due to the regional variation along with the influence of climatic factors. The average temperature and RH which recorded by Das and Ishahaque (1998a) were comparatively less than our present findings during winter season. This may be due to the fall of temperature and RH during that period.

Female outnumbered the male in all the study seasons. Sex ratio of male and female recorded as 1:1.5, 1:1.6 and 1:1.06 during summer, autumn and winter, respectively are in agreement with the findings of Shinde and Purohit (1978) and Das and Ishahaque (1998a).

In present investigation, four to five generations of *R. foveicollis* could be observed in a year. This finding does not support the work of Shaheen (1973) who observed three generations of *R. foveicollis* in Egypt. The present finding also contradicts the findings of Pavlakos (1939, 1945) and Das and Ishahaque (1998a). Pavlakos (1939, 1945) noticed that *R. foveicollis* has one generation in a year in Greece and over winter as adult. Das and Ishahaque (1998a) found two generations in a year from Jorhat of Assam. Al-Ali *et al.* (1987) reported four generations in a year from Iraq who supports our investigation. According to Balachowsky (1963) and Pavlakos (1945) the beetle overwinters in the soil as an adult.
which disagrees our present findings. According to Pavlakos (1943) Sinha and Krishna (1969) and Al-Ali et al. (1982) the larvae and adult of *R. foveicollis* are most active at 27°C to 32°C. In our study the temperature was almost similar with the optimal range during autumn season.