Potato (Solanum tuberosum L.) is one of the most important vegetable crops of India but for last two decades, white grub (Coleoptera: Scarabaeidae) have become the pest of national importance (Anonymous, 1974, Veeresh, 1977). In India, white grubs (Coleoptera: Scarabaeidae) popularly known as root grubs have attained the status of a serious pest in the decade of sixties. Out of the twenty-two species of white grubs recorded in Doon Valley of Uttarakhand, Holotrichia longipennis (Blanch.) is considered most destructive (Lal and Sharma, 2017).

Holotrichia longipennis is a predominant species prevalent in most of the endemic pockets of Garhwal hills (Mishra & Singh, 1990). The beetles are phytophagous and defoliate fruits and forest trees during the rainy season while the grubs are subterranean and have attained the status of a major devastating pest of a variety of Kharief crops grown under rainfed conditions at elevations ranging from 600 to 2000 m ASL (Lal, 2018 and Joshi & Kadiyal, 2007). Several workers have published at detailed biology of some commonly occurring melolonthids namely H. consanguinea and H. serrata from different states of country (Bindra and Singh, 1971, Veeresh, 1977, Yadava et al., 1977, Brar and Sandhu, 1980). No information is available on the field biology of H. longipennis on potato in Uttarakhand especially from Doon Valley, although the extent of damage and field biology of Lachnosterna coriaceae (Hope) on potatoes has been worked out in Himachal (Chandla, et al., 1988, Mishra and Agrawal, 1986 and Mishra and Chandla, 1989). In spite of its economic importance, no information was available on detailed biology of this species. Fletcher (1917) recorded this species for the first time in India. Beeson (1941) recorded the larvae of Lachnosterna longipennis damaging young plants of deodar (Cedrus deodara) in nursery and its beetles defoliating Oak (Quercus incana) and ‘Hisalu’ (Rubus lasiocarpa) in the Himalayas. Haq (1962) gave brief information on the biology of Lachnosterna longipennis (Blanch.) at Hill Fruit Research Station, Chaubatia (Almora).

Among all of these crops, potatoes are worst affected, both in Kumaun and Garhwal region. The second and third instars grubs damage the tubers by making large circular holes on them and hence render them unfit for marketing by reducing the quality of tuber to a great extent (Lal, 2018). The severity of their damage has resulted in reduction of area under potato in Dehradun district and the farmers have become reluctant in growing potatoes (Lal, 2018). As the very little and insufficient information is available on the biology of H. longipennis (Blanch.), therefore, present study was carried out on the biology of H. longipennis (Blanch.) under field conditions.
MATERIALS AND METHODS

Present study was carried out on the biology of *H. longipennis* (Blanch.) under field conditions in potato crop (Variety Giriraj) as well as in laboratory conditions at department of Zoology, D.A.V. (P.G.) College, Dehradun, during the year 2014-15.

**Study Area:** Present study was carried out in four different study sites of agricultural ecosystem of Doon Valley, Dehradun. It is located between latitudes 29º 58' N and 31º 2'N and longitudes 77º 34' E and 78º 18' E. Climatically, study area shows three distinct seasons winter, summer and monsoon. Winter season continues from October to February. Days are moderate and nights are very cold with freezing frost during winter months. Summers are very hot with maximum temperature noticed was 41ºC in day time continues from March to mid June. Monsoon season starts from mid June and continues till last week of September. The area surveyed in each site was 2 hectare. Detailed informations about the potato crops of the study sites were collected.

Sampling, Preservation and Taxonomic Identification of Specimens: A light trap with 250 watt, milky bulb was installed at Doon Valley from May, 2014 to April, 2015 to record the peak period of emergence of beetles of *H. longipennis*. Random pit sampling was done in the potato field to record the intensity of population of various stages of *H. longipennis* starting from May, 2014 to April, 2015. Five pits (1×1 m<sup>2</sup>) were dug out at a time in each month and average numbers of eggs / grubs / pupae / adults per pit were recorded out. During the active season i.e. from June to October, the sampling depth was kept 30 cm, while during the inactive season (November to April), the depth was kept up to one meter. The adults insects thus trapped are collected in a small paper bag and collected in a bottle containing ethyl acetate soaked cotton. These insects brought to the laboratory, pinned and oven dried at 60 ºC for 72 hours in order to preserve them. The insects were separated into different species with the help of available keys. The insects, which could not be identified in the laboratory, were sent to Northern Regional Station of Zoological Survey of India, Dehradun and Entomological Section of Forest Research Institute, Dehradun.

**Morphometric parameters of white grub beetles**

Ten eggs were selected randomly and measured for their length and width under microscope. The larvae from each representative instars were randomly selected, killed and size of larve was measured using digital Vernier Caliper (0-150 mm). The pupal and adult stage of beetle was also determined and measured using digital Vernier Caliper. The body of male and female adults was also measured from head to end of abdomen (Mari et al., 2004, Lal, 2018).

**RESULTS AND DISCUSSION**

The light trap collections of scarab beetles, *Holotrichia longipennis* (Blanchard) reveal that species belonging to Melonthinae is dominated in Doon Valley. The findings reveal that the emergence of beetle starts at the end of May but peak emergence was observed in the second and third week of June, 2014.

The data obtained on the biology of *H. longipennis* have been presented in Table-1.

<table>
<thead>
<tr>
<th>Life stages</th>
<th>Duration in days (Mean±SE)</th>
<th>Length (mm) (Mean±SE)</th>
<th>Width (mm) (Mean±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>14.10 ±0.25</td>
<td>1.42 ±0.01</td>
<td>1.09 ±0.01</td>
</tr>
<tr>
<td>Larva  I instar</td>
<td>26.00 ±0.70</td>
<td>9.11 ±0.08</td>
<td>1.81 ±0.01</td>
</tr>
<tr>
<td>II instar</td>
<td>30.80 ±0.84</td>
<td>20.14 ±0.18</td>
<td>3.91±0.02</td>
</tr>
<tr>
<td>III instar</td>
<td>222.0 ±1.41</td>
<td>34.19±0.21</td>
<td>5.37 ±01</td>
</tr>
<tr>
<td>Prepupual stage</td>
<td>15.40 ±0.42</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pupa</td>
<td>10.30 ±0.19</td>
<td>23.06 ±0.35</td>
<td>10.13 ±0.04</td>
</tr>
<tr>
<td>Total time duration</td>
<td>318.60 ±3.81</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Adult longevity Male</td>
<td>28.70 ±1.27</td>
<td>21.64±0.38</td>
<td>9.67 ±0.05</td>
</tr>
<tr>
<td>Adult longevity Female</td>
<td>39.60 ±1.11</td>
<td>22.23±0.19</td>
<td>10.08 ±0.02</td>
</tr>
</tbody>
</table>

Table 1: Biology and development of different stages of *Holotrichia longipennis* (Blanch.) on host plants
(a) Mating Behaviour: The males of *H. longipennis* show marked territorial behavior and chase the intruding conspecific female. This beetle copulates in a normal manner i.e., the male hold the elytra of female and the female carries him. The copulation period was 18 ± 2.52 min.

(b). Oviposition: A female beetles laid 19 ± 4.33 eggs during her life time. Their ovipositors transfer the fertilized eggs into it, so that freshly emerged grubs find their (host plants easily). The male release their grip on female prothorax after the completion of oviposition. Oviposition occurred in soil. Oviposition period was 10.9 ± 2.77 days.

(c). Life-stages: The species complete its life cycle through 4 stages as mentioned below:

(i) Eggs: The size of Fresh eggs was measured from 1.42± 0.01 in length and 1.09± 0.01mm in width. The Eggs elongate to oval in shape. They are pearly white when freshly laid. Incubation period was 14.10 ± 0.25 days.

(ii). Larval development: In the early instars, larvae were fed on host plans. The larva passes through 3 different stages:

1st instar: Elongate fusiform. 9.11±0.08 mm long and 1.81± 0.01 mm in width. Body creamy white with prominently broader. Head capsule, thorax and abdomen distinguished clearly. Head capsule light brown in color. This stage lasts for 26.00 ± 0.70 days.

2nd instar: Creamy white bodied elongated broad at middle towards posterior side, three body divisions distinct, appendages three segmented. The body measured 20.14 ± 0.18 mm in length and 3.91± 0.02 mm in breadth. This stage lasts for 30.80± 0.84 days.

3rd instar: Body elongated, 34.19 ± 0.21 mm long, 5.37 ± 0.01 mm broad, creamy white in color, gradually broaded posterior. This stage lasts for 222.0 ± 1.41 days.

(iii). Pupa: The Pupa was measured on an average 23.06± 0.35mm long and 10.13± 0.04 mm broad, creamy white, dorsum roughly convex, abdomen, creamy white without spot. This stage lasts for 10.30±0.19 days.

(iv). Adult:

Female: The female is oval, slightly larger than male and sized about 22.23±0.19 mm long, and 10.08±0.02 mm broad with shining light chestnut brown in color. The head were darker than pronotum and elytra and antennae light brown the abdomen light brown in color. This stage is last for 39.60± 1.11 days.

Male: The male were smaller than female. The male is oval, light red in color, medium sized about 21.64± 0.38 mm long and 9.57±0.05 mm broad with shining light chest nut brown in color. In male, the color of head is dark brown. This stage is last for 28.70± 1.27 days.

Haq (1962) and Shah & Shah (1990) made the similar observations about *H. longipennis* (Blanch.) and observed an average pre-oviposition period of 16.5 days and oviposition period of 12.8 days. The duration of eggs stage as determined by Misra et al., (1998) was 12 to 15 days. Shah and Shah (1990) also recorded incubation period ranging from 11 -15 days. Misra (2001) have observed the body length in three instars that were about 8-9, 18-20 and 32-25 mm and the duration were 21-26, 25-30 and 208-228 days, respectively.

The pupal period ranged 22- 28 days for this species was reported by Shah and Shah (1990) and Misra (2001). Shah and Shah (1990) also observed approximately similar description for adult beetles of *H. longipennis* from hill part of Uttarakhand. Mishra & Chandla (1989) and Mishra & Singh (1990) also observed the same trend in the field biology of *Lachnosterna cariaceae* Hope, on potatoes at Shimla in Himachal Pradesh.

The finding thus suggests that *Holotrichia longipennis* (Blanch.) is considered most destructive pests of Potatoes crop. Beetles of *H. longipennis* defoliate the various fruit/ forest trees and some wild shrubs, while the grubs, which are subterranean in habit, damage almost all the rainy season crops grown under rainfed condition. Among all of these crops, potatoes are worst affected, both in Doon Valley. The second and third instar grubs damage the tubers by making large circular holes on them and hence render them unfit for marketing by reducing the quality of tuber to a great extent. The severity of their damage has resulted in reduction of area under potato in Dehradun district and the farmers have become reluctant in growing potatoes.

Being the polyphagous nature, subterranean habit, high species diversity and diverse feeding habit of immature and
adult stages, management of white grubs is a difficult task. As the white grubs infestations is more striking in high altitude crops, where the farmers are poor and having lesser resources, the eco-friendly practices like deep ploughing after crop harvesting, cover crops and crop rotations may be used for the management of this pest. The other methods of IPM that include entomo-pathogens, bio-pesticides, seed treatment, soil application and application of chemical insecticides can be followed to overcome the white grub threats. Thus, this study provides the detailed information about the biology of this white grubs, which is an important pests of agricultural crops especially potatoes. Understanding the biology of *H. longipennis* is therefore essential for developing effective management strategies.

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**REFERENCES**