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Review Article

Distribution, biology and management of white grubs in north-western Himalaya

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Abstract

The scarabaeid beetles are the most common leaf chafers, whereas larvae or white grubs are among the most destructive soil pests. These are polyphagous pests both in grub and adult stage and inflict heavy damage on various fruit/forest trees, their nurseries, vegetables, lawns and field crops. In north western Himalaya, 187 species of white grubs are known, of which about 20 species attack wide range of plants. Certain species such as *Brahmina coriacea* (Hope), *Holotrichia longipennis* Blanch., *Anomala dimidiata* (Hope), *Anomala lineatopennis* (Blanch.), *Melolontha indica* Hope, *Melolontha furcicauda* Ancey, *Polyphylla sikkimensis* Brenske, *Lepidiota stigma* Fab., *Maladera insanabilis* (Brenske) and *Heteronychus lioderes* Redt. are of major economic importance infesting potato, ginger, cole crops, fruit crops, field crops and forest nurseries. The biology of some annual species viz., *B. coriacea, H. longipennis, Holotrichia sikkimensis* Brenske, *A. lineatopennis* and *A. dimidiata* have already been studied. Some species like *M. indica, M. furcicauda, P. sikkimensis* and *L. stigma* are expected to require 2-3 years to complete their development. Being polyphagous, and no single method of control provides permanent solution for the white grub problem. By adopting integrated approach combining viable options such as biocontrol, physical, mechanical and chemical, this pest can be brought under control.

Key words: White grubs, distribution, bioecology, management

Introduction

The superfamily Scarabaeoidea contains an immense number of species whose larvae live in the soil and are commonly known as white grubs (Gardner, 1935). The scarabaeid beetles are the most common leaf chafers, whereas larvae are among the most destructive soil pests (Chandel *et al.*, 2021). These beetles are so named because the adults commonly feed on the foliage of trees, some feed on pollens, flowers and fruits of different plants (Chandel and Kashyap, 1997). The scarabaeids are one of the most successful groups of beetles and includes approximately 27,800 species described throughout the world (Ratcliffe and Jameson, 2004), most of them living in subtropical and tropical areas (Carpaneto, 2008). Most of the species are crepuscular or nocturnal rarely seen by casual observers except when beetles are attracted to light. Some are diurnal and occasionally found feeding on flowers and ripened fruits (Chandel *et al.*, 2009). They constitute a large distinct group of highly specialized beetles which could be easily recognized by their lamellate antennae. Larvae or white grubs are chiefly found in grasslands feeding on roots of many plants (Misra and Chandel, 2003). They are conspicuous components of the biological communities and play different roles in the dynamics and structures of terrestrial ecosystem of all the continents, feeding on plants, organic decaying matter (rotten woods, humus, dung, carrion), mushrooms and other invertebrates (Carpaneto, 2008).

The scarabs are polyphagous pest both in grub and adult stage and inflicts heavy damage on various fruit/forest trees, their nurseries, vegetables, lawns and field crops (Chandel and Kashyap, 1997). They live concealed and sudden increase in their population takes up in places having enough food and least disturbance of soil. The white grubs cause extensive damage to roots of grasses, legumes, shrubs and trees in many parts of the world (Pathania, 2014). Almost all field crops grown during rainy season *viz.* potato, groundnut, sugarcane, maize, pearl millet, sorghum cowpea, pigeonpea, cluster bean, soybean, rajmash, upland rice, ginger, *etc.* are damaged (Chandel *et al.*, 2021). The difference in vegetation, soil, altitude along with crops influences the diversity of scarab beetles (Chandel *et al.*, 1994). Pal (1977) reported that variation in climatic conditions along with different abiotic parameters such as wind speed, rainfall, humidity, moisture and temperature has a great influence on the diversity of scarab beetles. The diversity along with their ecology and biology is of great interest because of their economic importance, their role in the ecosystem, forest biodiversity as well as their grubs serving as food in some insectivorous bird food chain (Aerts and Honnay, 2011).

White grubs have always existed in nature and the earliest record of damage to crops by white grubs in India is that of Stebbing (1902) from Punjab. There is no record of serious damage until the later part of 1950s. Because of revolutionary changes in agriculture in India during the 1960s, white grubs attained the status of serious pest (Yadava and Sharma 1995). The beetles have moved into areas near the agricultural fields for feeding on shrubs/fruit trees *etc.* and have resulted in egg laying in the cultivated areas (Chandel *et al.*, 2015). Adult food is the chief environmental factor affecting the beetle's behaviour, and is one of the most important considerations in the distribution of both beetles and grubs (Veeresh 1978). The abundance and distribution of white grubs depend upon the species involved, the preferred host and its location in relation to emergence place (Veeresh 1988). In north-western Himalaya, white grubs form a major group of insect-pests damaging potato, vegetables, ginger, fruit/forest trees, their nurseries, maize and rice, and there has been a greater emphasis to check the problem of white grubs in north-western Himalaya. A check-list of the white grub species is presented based on available literature (Table 1). The host range and biology of predominant species of white grubs are discussed along with possible management strategies.

Table 1. Check-list of scarab beetles present in north-western Himalaya

S. No.	Species	HP	J&K	UK	References
Subfamily: Melolonthinae					
1.	*Apogonia blanchardi* Ritsema	-	-	+	Chandra (1992)
2.	*Apogonia carinata* Kobayashi	+	-	-	Pathania *et al.* (2015)
3.	*Apogonia clypeata* Moser	+	-	-	Chandel *et al.* (1994a)
4.	*Apogonia ferruginea* Fab.	+	-	+	Sreedevi *et al.* (2017a)
5.	*Apogonia nigrescens* Hope	+	-	-	Chandra (2005)
6.	*Apogonia orbitalis* Ritsema	+	-	-	Chandra (2005)
7.	*Apogonia proxima* Waterhouse	-	-	+	Chandra *et al.* (2012)
8.	*Apogonia setosa* Arrow	+	-	+	Chandra *et al.* (2012)
9.	*Apogonia villosella* Blanch.	+	-	+	Pathania *et al.* (2015), Chandra (1992)
10.	*Articephala himachali* Mittal	+	-	-	Chandra (2005)
11.	*Articephala lahauli* Chandra	+	-	-	Chandra (2005)
12.	*Articephala planifrons* Moser	+	-	-	Chandra (2005)
13.	*Asactopholis dehradunus* Mittal	-	-	+	Chandra (2005)
14.	*Asactopholis microsquamosa* (Frey)	+	-	+	Sreedevi *et al.* (2017a)
15.	*Autoserica phthisica* Brenske	+	-	-	Pathania *et al.* (2015)
16.	*Brahmina bilobus*	+	-	-	Pathania *et al.* (2015)
17.	*Brahmina coriacea* (Hope)	+	+	+	Beeson (1941), Chandel *et al.* (1995)
18.	*Brahmina cribricollis* (Redt.)	+	-	-	Chandra (2005)

19.	*Brahmina crinicollis* Burm ·	+	-	+	Sharma and Bhalla (1964), Sreedevi *et al*. (2017a), Chandra (2015)
20.	*Brahmina cupreus* Mittal	-	-	+	Chandra (2005)
21.	*Brahmina flavosericea* (Brenske)	+	-	+	Sreedevi *et al.* (2017), Mehta *et al*. (2008)
22.	*Brahmina kuluensis* Moser	+	-	-	Pathania *et al.* (2015), Chandra (2005)
23.	*Brahmina poonensis* Frey	+	+	-	Anonymous (2004)
24.	*Brahmina simlana* Moser	+	-	-	Chandra (2005)
25.	*Cephaloserica thomsoni*	-	-	+	Chandra *et al*. (2012)
26.	*Cryptotrogus pajni* Mittal	+	-	-	Chandra (2005)
27.	*Hilyotrogus holosericeous* Redt.	+	+	+	Bhat *et al*. (2005), Chandra *et al*. (2012)
28.	*Holotrichia anthracina* Brenske	+	-	-	Chandra (2005)
29.	*Holotrichia assamensis* Brenske	+	-	-	Chandel *et al*. (2022)
30.	*Holotrichia batillaria* (Bates)	+	-	-	Chandra (2005)
31.	*Holotrichia gradatifrons* (Bates)	+	-	-	Chandra (2005)
32.	*Holotrichia insularis* Brenske	+	-	-	Singh *et al*. (2004)
33.	*Holotrichia longipennis* (Blanch.)	+	+	+	Chandel *et al*. (1994a), Haq (1962)
34.	*Holotrichia microsquamosa*	+	-	-	Chandel *et al.* (1994a)
35.	*Holotrichia nigricollis Brenske*	+	-	-	Pathania *et al*. (2015), Chandel (2020)
36.	*Holotrichia nubiliventris* (Bates)	+	-	-	Chandra (2005)
37.	*Holotrichia occipitalis* (Bates)	+	-	-	Chandra (2005)
38.	*Holotrichia problematica* Brenske	+	+	+	Pathania *et al*. (2015), Chandel (1992), Sreedevi *et al*. (2017a), Stebbing (1914)
39.	*Holotrichia rosettae*	-	-	+	Sreedevi *et al.* (2017)
40.	*Holotrichia sculpticollis* (Blanch.)	-	-	+	Sreedevi *et al.* (2017)
41.	*Holotrichia semihirta* Frey	+	-	-	Chandra (2005)
42.	*Holotrichia serrata* (Fab.)	+	-	-	Chandra (2005)
43.	*Holotrichia seticollis* (Moser)	+	-	+	Sushil *et al.* (2006), Sreedevi *et al*. (2017a)
44.	*Holotrichia setosifrons* Khan & Ghai	+	-	+	Sreedevi *et al.* (2017a)
45.	*Holotrichia sikkimensis* (Brenske)	+	-	+	Pathania *et al*. (2015), Sreedevi *et al.* (2017a), Chandel *et al.* (1997)
46.	*Holotrichia stolizkae*	+	-	-	Chandra (2005)
47.	*Hoplosternus nepalensis*	+	-	-	Chandra (2005)
48.	*Idionycha excisa*	-	-	+	Chandra *et al*. (2012)
49.	*Lasiotropus poonensis*	-	+	-	Bhat *et al.* 2005
50.	*Lepidiota albistigma* Burm.	+	-	-	Chandra *et al*. (2012a)
51.	*Lepidiota bimaculata* (Saunders)	-	+	-	Sharma and Tara (1985)
52.	*Lepidiota mansueta* Burm.	-	-	+	Pandey (2016), Sreedevi *et al.* (2017a)
53.	*Lepidiota sticticopetra* Blanch.	-	-	+	Sreedevi *et al.* (2017)
54.	*Lepidiota stigma* (Fab.)	+	-	+	Mehta and Chandel (2007), Sushil *et al*. (2006)
55.	*Melolontha aeneicollis* Bates	+	-	-	Chandra (2005)
56.	*Melolontha cuprescens* Blanch.	+	-	+	Chandra (2005), Chandra *et al*. (2012)

57.	*Melolontha furcicauda* Ancey	+	+	+	Anonymous (2004), Sreedevi *et al.* (2017)
58.	*Melolontha guttigera* Sharp	+	-	+	Sreedevi *et al.* (2017a)
59.	*Melolontha indica* Hope	+	+	+	Bhat *et al.* 2005, Sreedevi *et al.* (2017a),Sushil *et al.* (2006)
60.	*Melolontha melolontha* (Linn.)	+	+	-	Devi *et al*. 1994, Raina and Khan (2007)
61.	*Melolontha nepalensis* Blanch.	+	-	+	Kumar *el al.* (2019), Kumar *el al.* (2007)
62.	*Melolontha virescens* (Brenske)	+	-	+	Beeson (1941)
63.	*Microtrichia cotesi* Brenske.	+	-	-	Pathania *et al*. (2015)
64.	*Polyphylla sikkimensis* Brenske	+	-	-	Rana *et al.* (2022)
65.	*Schizonycha ruficollis* (Fab.)	+	+	+	Sharma and Tara (1985), Sreedevi *et al.* (2017a)
66.	*Sophrops iridipennis* (Brenske)	+	-	+	Chandel (2020), Sreedevi *et al.* (2017a)
67.	*Maladera carinata* Khan and Ghai	+	-	-	Sreedevi *et al.* (2017)
68.	*Maladera ferruginea* (Kollar & Redt.)	+	-	-	Sreedevi *et al.* (2019)
69.	*Maladera insanabilis* (Brenske)	+	+	+	Sharma and Tara (1985), Sreedevi *et al.* (2017a)
70.	*Maladera iridescens* (Blanch.)	-	-	+	Kumar *et al*. (2019)
71.	*Maladera perpendiculris* Khan and Ghai	+	-	-	Sreedevi *et al.* (2017)
72.	*Maladera piluda*	+	-	-	Pathania *et al.* (2015)
73.	*Maladera simlana* (Brenske)	+	-	+	Sreedevi *et al.* (2017a)
74.	*Maladera sinaeivi*	+	-	-	Gupta (2019)
75.	*Maladera thomsoni* (Brenske)	+	-	-	Chandel (2020)
76.	*Serica khajiaris* Mittal	+	-	-	Chandra (2005)
77.	*Trichoserica umbrinella*	+	-	+	Sreedevi *et al.* (2017a)
Subfamily: Rutelinae					
78.	*Adoretus bimarginatus* Ohaus	-	-	+	Chandra *et al.* (2012)
79.	*Adoretus caliginosus* Burm.	+	-	-	Chandra (2005)
80.	*Adoretus costopilosus* Ohaus	+	-	-	Chandra (2005)
81.	*Adoretus duvauceli* Blanch.	+	-	+	Chandra *et al.* (2012), Kumar *et al.* (2017)
82.	*Adoretus epipleuralis* Arrow	+	-	-	Sharma and Bhalla (1964)
83.	*Adoretus frontatus* Burm.	+	-	-	Ghosh *et al*. (2000)
84.	*Adoretus incurvatus* Ohaus	+	-		Chandra (2005)
85.	*Adoretus lasiopygus* Burm.	+	-	+	Singh et al. (2003), Sreedevi *et al.* (2017a)
86.	*Adoretus lithobius* Ohaus	+	-	+	Chandra (2005), Mishra and Singh (1996), Mohapatra and Mishra (2018)
87.	*Adoretus pallens* Blanch.	+	-	-	Sreedevi *et al.* (2017a)
88.	*Adoretus serratipes* Arrow	-	-	+	Chandra *et al.* (2012)
89.	*Adoretus simplex* Sharp	+	-	+	Kumar *et al.* (2007), Sreedevi *et al.* (2017)
90.	*Anomala aureoflava* Arrow	+	-	-	Chandel *et al*. (2022)

91.	*Anomala bengalensis* (Blanch.)	+	-	+	Sreedevi *et al.* (2017a)
92.	*Anomala biharensis* Arrow	-	-	+	Chandra *et al.* (2012)
93.	*Anomala cantori* (Hope)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
94.	*Anomala chlorosoma* Arrow	+	-	+	Chandra (2005), Sreedevi *et al.* (2017a)
95.	*Anomala comma* Arrow	+	-	-	Pathania *et al.* (2015)
96.	*Anomala dimidiata var. barbata* Burm.	+	-	+	Sushil *et al.* (2006)
97.	*Anomala dorsalis* (Fab.)	+	-	+	Sreedevi *et al.* (2017a), Chandra (2005)
98.	*Anomala flavipes* Arrow	+	-	+	Chandra *et al.* (2012), Sharma and Bhalla (1964)
99.	*Anomala fraterna* Burm.	-	-	+	Chandra *et al.* (2012)
100.	*Anomala fulviventris* Arrow	+	-	-	Chandra (2005)
101.	*Anomala lineatopennis* (Blanch.)	+	-	+	Mishra *et al.* 1998, Chandra (2005)
102.	*Anomala marginata* (Fab.)	+	-	+	Sreedevi *et al.* (2017a)
103.	*Anomala nainitali*	-	-	+	Shah (1983)
104.	*Anomala nilgirensis* Arrow	-	-	+	Sreedevi *et al.* (2017a)
105.	*Anomala pellucida* Arrow	-	-	+	Chandra *et al.* (2012)
106.	*Anomala pictipes* Arrow	-	-	+	Sreedevi *et al.* (2017a)
107.	*Anomala polita* (Blanch.)	+	-	+	Chandel *et al.(*1994a), Sreedevi *et al.* (2017a)
108.	*Anomala propinqua* Arrow	+	-	+	Sreedevi *et al.* (2017a), Chandra (2005)
109.	*Anomala ruficapilla* Burm.	+	-	+	Chandra *et al.* (2012), Sreedevi *et al.* (2017a)
110.	*Anomala rufiventris* Redt.	+	+	+	Bhat *et al*. (2005), Sreedevi *et al.* (2017a)
111.	*Anomala rugosa* Arrow,	+	-	+	Sreedevi *et al.* (2017a)
112.	*Anomala siliguria* Arrow	-	-	+	Chandra *et al.* (2012)
113.	*Anomala stoliczkae* Sharp	+	-	+	Chandra (2005), Chandra *et al.* (2012)
114.	*Anomala tristis* Arrow	-	-	+	Sreedevi *et al.* (2017a)
115.	*Anomala varicolor* (Gyll.)	+	-	+	Chandel *et al.*(1994a), Sreedevi *et al.* (2017a)
116.	*Anomala variivestis* Arrow	+	-	-	Chandel *et al*. (2022)
117.	*Anomala versicolor* (Mulsant)	+	-	-	Kumar *et al*. (1996)
118.	*Anomala versutus* Harold	+	-	-	Tiwari *et al*. (1991)
119.	*Anomola dimidiata* (Hope)	+	-	+	Sreedevi *et al.* (2017a)
120.	*Anomala xanthonota* Arrow	+	-	+	Chandra (2005), Kumar *et al.* (2019)
121.	*Anomala xanthoptera* (Blanch.)	+	-	+	Chandra (2005), Mishra and Singh (1996)
122.	*Ischnopopillia moorei* Kraatz	+	-	-	Chandra (2005)
123.	*Mimela fulgidivittata* Blanch.	+	-	+	Sreedevi *et al.* (2017a), Chandra (2005)
124.	*Mimela horsfieldi* Hope	-	-	+	Chandra *et al.* (2012)
125.	*Mimela passerinii* Hope	+	+	+	Chandra *et al.* (2012), Chandel *et al*.(1994a)
126.	*Mimela pectoralis* Blanch.	+	-	-	Sreedevi *et al.* (2017a)

127.	*Pachyrhinadoretus frontatus* (Burm.)	+	-	+	Chandra (2005), Singh *et al*. (2003)
128.	*Popillia clypealis* Ohaus	+	-	-	Chandra (2005)
129.	*Popillia complanata* Newman	-	-	+	Sharma and Bisht (2012)
130.	*Popillia cupricollis* Hope	+	+	+	Sreedevi *et al.* (2017a), Chandra *et al.* (2012)
131.	*Popillia cyanea* Hope	+	+	+	Thakur *et al*. (1996), Chandra *et al.* (2012)
132.	*Popillia gemma* Newman	+	-	-	Kashyap and Adlakha (1971)
133.	*Popillia laevicollis* Kraatz	-	-	+	Chandra *et al.* (2012)
134.	*Popillia lucida* Newman	+	-	+	Chandra *et al.* (2012), Srivastava e*t al*. (2009)
135.	*Popillia maclellandi* Hope	+	-	+	Sreedevi *et al.* (2017a), Kumar *et al.* (2007)
136.	*Popillia marginicollis*	+	-	-	Sreedevi *et al.* (2017a)
137.	*Popillia nasuta* Newman	+	-	+	Sreedevi *et al.* (2017a), Chandra *et al.* (2012)
138.	*Popillia pilosa* Arrow	+	-	+	Chandra *et al.* (2012), Chandra (2005)
139.	*Popillia simlana* Arrow	+	-	-	Chandra (2005)
140.	*Popillia sulcata* Redt.	-	-	+	Chandra *et al.* (2012)
141.	*Popillia virescens* Hope	+	-	-	Sreedevi *et al.* (2017a)
142.	*Rhinyptia meridionalis* Arrow	-	-	+	Chandra *et al.* (2012)
143.	*Trichanomala fimbriata* (Newm.)	-	-	+	Chandra *et al.* (2012)
144.	*Tropiorhynchus orientalis* (Newm.)	+	-	-	Chandra (2005)
Subfamily: Dynastinae					
145.	*Alissonotum bindulum* (Fairmaire)	+	-	-	Chandra (2005)
146.	*Alissonotum piceum* (Fab.)	+	-	-	Sreedevi *et al.* (2017)
147.	*Alissonotum simile* Arrow	+	-	-	Chandra (2005)
148.	*Heteronychus annulatus* Bates	+	-	+	Chandra (2005)
149.	*Heterorychus lioderes* Redt.	+	-	+	Chandra *et al.* (2012), Sreedevi *et al.* (2017)
150.	*Heterorychus robustus* Arrow	+	-	-	Kumar *et al.* 2005
151.	*Eophileurus perforatus* Arrow	+	-	-	Chandra (2005)
152.	*Eophileurus planatus* (Wiedemann)	-	-	+	Chandra *et al.* (2012)
153.	*Oryctes nasicornis* (Linn.)	+	+	+	Bhat *et al*. (2005), Chandra *et al.* (2012), Uniyal and Mathur (1998)
154.	*Pentodon bengalensis* Arrow	-	-	+	Singh *et al*. (2003)
155.	*Pentodon bispinifrons* Reitter	+	-	-	Chandel *et al.* (1994a)
156.	*Phyllognathus dionysius* (Fab.)	+	-	+	Chandel *et al.* (1994a), Chandra *et al.* (2012)
157.	*Xylotrupes gideon* (Fab.)	+	-	+	Chandel *et al.* (1994a), Chandra (2005)
158.	*Xylotrupes meridionalis meridionalis* Prell	-	-	+	Sreedevi *et al.* (2017a)
Subfamily: Cetoniinae					
159.	*Anatona castanoptera* (Burm.)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
160.	*Anatona stillata* (Newmann)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
161.	*Anthracophora crucifera* (Olivier)	-	-	+	Chandra *et al.* (2012)

162.	*Anthracophora dalmanni* (Hope)	-	-	+	Chandra *et al.* (2012)
163.	*Cetonia bensoni* (Westwood)	-	-	+	Chandra *et al.* (2012)
164.	*Cetonia rhododendri* Gestro	-	-	+	Chandra *et al.* (2012)
165.	*Chiloloba acuta* (Wiedemann)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
166.	*Clinteria klugi* (Hope)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
167.	*Clinteria spilota* (Hope)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
168.	*Glycyphana horsfieldi* (Hope)	+	-	-	Chandra (2005)
169.	*Heterorrhina mutabilis* (Hope)	-	-	+	Chandra *et al.* (2012)
170.	*Heterorrhina nigritarsis* (Hope)	+	-	-	Chandel (2020), Chandra *et al.* (2012)
171.	*Heterorrhina porphyretica* Westwood	+	-	-	Chandra (2005)
172.	*Jumnos royeli* (Hope)	+	-	-	Chandra (2005)
173.	*Jumnos ruckeri* Saunders	+	-	+	Chandra *et al.* (2012), Chandra (2005)
174.	*Macronota quadrilineata* Hope	+	-	-	Sharma *et al.* (1969)
175.	*Oxycetonia albopunctata* (Fab.)	-	-	+	Chandra *et al.* (2012)
176.	*Oxycetonia bicolor* (Fab.)	+	-	+	Chandra (2005), Kumar *et al.* (2019)
177.	*Oxycetonia jucunda* Foldermann	+	-	+	Chandra *et al.* (2012), Chandra (2005)
178.	*Oxycetonia versicolor* Fab.	+	-	+	Kumar *et al.* (2019), Chandra (2005)
179.	*Protaetia alboguttata* (Vigors)	+	-	+	Chandra *et al.* (2012), Chandra *et al.* (2012a)
180.	*Protaetia coenosa* (Westwood)	+	-	+	Chandra *et al.* (2012), Chandra (2005)
181.	*Protaetia confusa* (Gory & Percheron)	-	-	+	Chandra *et al.* (2012)
182.	*Protaetia impavida* (Janson)	+	-	-	Pathania *et al.* (2015)
183.	*Protaetia neglecta* (Hope)	+	+	+	Kumar *et al.* (2019), Bhat *et al.* (2005), Chandra (2005)
184.	*Protaetia speciosa* (Adams)	-	+	-	Altaf *et al.* (2019)
185.	*Rhomborrhina glaberrima* (Westwood)	-	-	+	Chandra *et al.* (2012)
186.	*Thaumastopeus pullus* (Billberg)	+	-	-	Chandra (2005)
187.	*Torynorrhina opalina* (Hope)	+	-	+	Chandra *et al.* (2012), Chandra (2005)

(+) Present; (-) Absent; HP- Himachal Pradesh; J&K- Jammu and Kashmir; UK-Uttarakhand

Distribution of scarabaeid beetles in north-western Himalaya

Chandra (2005) reported that the zones of distribution of various species are limited to narrow belts in higher altitudes, while at lower altitudes or plains; the species show wide range of distributions. A total of 187 species representing 49 genera belonging to subfamilies Melolonthinae, Rutelinae, Dynastinae and Cetoniinae have been reported from north-western Himalaya by various workers (Table 1). Scarab fauna of Himachal Pradesh is most abundant with 146 species, followed by 112 species reported from Uttarakhand. In Jammu & Kashmir, only 19 species have been reported. Out of the total reported species, 37.43 per cent of the scarab fauna (70 species) are reported exclusively from Himachal Pradesh, while 19.78 per cent of the total species (37 species) are found exclusively in Uttarakhand. In Jammu & Kashmir, only two species (1.06 %) seems to be unique. There are 14 species (7.48 %) which are of common occurrence in Himachal Pradesh, Jammu & Kashmir and Uttarakhand. These species include *Brahmina coriacea* (Hope), *Hilyotrogus holosericeus* Redt., *Holotrichia longipennis* Blanch, *Holotrichia problematica* Brenske, *Melolontha furcicauda* Ancey, *Melolontha indica* Hope, *Schizonycha ruficollis* (Fab.), *Maladera insanabilis* (Brenske), *Anomala rufiventris* Kollar and Redt., *Mimela passerini* Hope, *Popillia cupricollis* Hope, *Popillia cyanea* Hope, *Oryctes nasicornis* (Linn.) and *Protaetia neglecta* (Hope). In Himachal Pradesh and Uttarakhand, the similarity between species is to the tune of 32.08 per cent (60 species). There are two species *viz.*, *Brahmina poonensis* Frey and *Melolontha melolontha* (Linn.)

which are found in Himachal Pradesh and Jammu & Kashmir, but absent in Uttarakhand.

Nature of injury and economic importance

The scarab beetles are placed in one general group called "Pleurosticts" on the basis of their feeding on living tissue, however, there exists a great diversity in their feeding habits (Chandel *et al.*, 2021). Adults of Melolonthinae and Rutelinae devour plant tissue, especially leaves, flowers or young plants. In contrast, adults of Dynastinae usually attack stems or roots of plants in their search for liquid nourishment. Adults of Cetoniinae are also largely liquid feeders, but feed above ground, preferring nectar or sap or the juices of ripening fruits and vegetables. Some species feed on pollens. There are species in each of the subfamilies Melolonthinae, Rutelinae and Dynastinae which do not feed at all during the adult stage (Ritcher, 1958).

Beeson (1921) reported *B. coriacea* on pear and apples in north-western Himlaya. Later this species was recorded as a pest of *Quarcus* and *Rubus* (Beeson 1941). Pruthi and Batra (1960) reported *B. coriacea* beetles feeding on leaves of apple, peach, plum, fig and grapevine in Kullu valley of Himachal Pradesh. Haq (1962) reported *Lachnosterna* (=*Holotrichia*) *longipennis* beetles as an important defoliator of apple, walnut, cherry and strawberry in hilly districts of Uttar Pradesh. Sharma and Bhalla (1964) reported *Clinteria spilota* Arrow defoliating apple plants as well as growing apple fruits during June in Kotgarh. *M. passerinii*, *Oxycetonia jucunda* Faldermann, *P. neglecta*, *Autoserica* sp., *H. longipennis*, *B. coriacea*, *Brahmina crinicollis* (Redt.), *Microtrichia* sp., *Adoretus epipleuralis* Arrow, *Anomala dimidiata* (Hope), *Anomala flavipes* Arrow, *Anomala lineatopennis* Blanch. and *A. rufiventris* were recorded feeding on apple, apricot, peach, plum and other store fruits in Himachal Pradesh during June-July, However, *Heteronychus lioderes* Redt. was found to damage paddy by adult beetles in Khepu-khakhar area. At Kwagdhar in Sirmaur district, *A. flavipes, A. lineatopennis, A rufiventris, H. holosericeus*, *H. longipennis, B. coriacea* and *Macronota quadrilineata* (= 4-*lineata*) Hope have been recorded causing damage to leaves of apple, peach, plum, apricot and pear. At lower elevation, where stone fruits mature early, even fruits are also attacked (Sharma *et al.*, 1969; Chowdhuri and Verma, 1979).

Sharma *et al.* (1971) recorded *B. coriacea, H. longipennis, A. flavipes, A. lineatopennis, A. rufiventris* and *H. holosericeus* causing damage to fruits and foliage of apple, pear, plum, cherry, peach and apricot during May and June at Kwagdhar. Kashyap and Adlakha (1971) reported *Popillia gemma* Krautz as minor pest of soybean feeding on foliage during July-August in Kangra valley (Bhalla and Pawar, 1977). In Chaubattia area of Uttarakhand, *Anomala versutus* (Harold), *A. dimidiata, Anomala polita* Blanch., *A, lineatopennis, Anomala rugosa* Arrow, *A rufiventris, H. holosericeus, Popillia complanata* Newman, *Popillia cyanea* Hope, *B. coriacea, H. longipennis, M. furcicauda, M inidca* and *Xylotrupes gideon* (Linn.) were recorded to feed actively on peach, plum apricot, pear, rose and walnut from April-August (Gupta *et al*., 1977). In Kumaon hills of Uttar Pradesh, *Brahmina* sp. *H. longipennis, Melolontha* sp., *A. versutus, Anomola* sp. and *Serica* sp. were found to defoliate apple, apricot, walnut and cherry (Joshi and Joshi, 1980). Shah (1983) recorded *Anomala nainitalii* as a new species of defoliating beetle collected from a shrub in Nainital. Garg *et al*. (1983) found more than 15 species of scarabaeid beetles attacking fruit and forest trees in Uttar Pradesh. *A. dimidiata* var. *barbata* Burm. and *Holotrichia seticollis* (Moser) being the most abundant ones. Shah (1986) observed serious attack of *Heteronychus lioderes* (Fab.) in low lying irrigated as well as unirrigated rice fields in Uttarakhand.

Shah and Garg (1985) recorded *H. seticollis*, *Lepidoata* sp., *Anomala xanthoptera* Blanch., *Mimela fulgidivitta* Blanch., *Oxycetonia* sp. and *Clintera spilota* (Hope) feeding on apricot, peach, plum, apple and other temperate fruits in Kumaon hills of Uttarakhand. Sharma and Tara (1985) reported *S. rifucollis, M. insanabilis, Lepidioata bimaculata* (Saunders) and *Holotrichia* sp. as important pests of mulberries in Jammu region of Jammu & Kashmir. Chandra (1992) observed damage of *P. cyanea* on rose and other wild flowers during day time in Almora. Among cetoniid beetles, *Torynorrhina opalina* (Hope) and *Jumnos ruckeri* Saunders were found in large numbers clinging to the trunks of popular trees in Almora. *Protaetia alboguttata* (Vigors), *O. jucunda* and *C. spilota* were observed feeding on wild and ornamental flowers at Kalesar forest in Himachal

Pradesh. *Popillia pilosa* Arrow was observed feeding on lawn plantation at Chail in Himachal Pradesh. In Chamba district of Himachal Pradesh, a rutelinid beetle, *P. cyanea* was observed to cause extensive damage during July-August. The beetles caused damage to flowers, buds and newly formed pods of rajmash (Thakur *et al.,* 1996). Chandel *et al.* (1997) collected 21 species of scarab beetles on apple, pear, plum and apricot at Solan. *B. coriacea* was the most predominant species constituting 42.50-51.70 per cent of total beetle catch.

Mishra (2001) recorded severe beetle defoliation in poplar, oak, *bhimal, toon, khirak* and *Rhododendron* in Uttarakhand. Chandel *et al*. (1994) observed more than 40 per cent defoliation by different species of beetles in stone fruits and olive in mid hills of Himachal Pradesh. *M. furcicauda* beetles were recorded feeding on walnut in Kashmir valley (Anonymous, 2004). Bhagat and Kashyap (1999) reported wild rose to be the most preferred host of *B. coriacea* in Shimla. The beetles of *Clinteria* sp. have been observed attacking apple fruits in Himachal Pradesh (Bhagat and Kashyap, 1998). According to Chandel *et al*. (2010) the beetles of *B. coriacea* exhibited distinct preference for a specific host in a particular locality. The beetles preferred apricot at Nauni, *Polygonum* at Fagu, *Indigofera* at Kheradhar and walnut at Shillaroo. *H. longipennis* beetles were observed on *toon* at Palampur. *M. insanabilis* beetles were collected on trees of *Grewia optiva* in large numbers at Bajaura. *Lepidioata stigma* (Fab.) beetles settled on *Delbergia sisoo* Roxb, trees for mating in Kheri area of Hamirpur district. Ratcliff and Ahmed (2010) have reported the presence of *P. cyanea, Oryctes elegans* Prell, *Clintera confinis pseudoconfinis* Schürhoff,, *Gametis jucunda* (Falderman) and *Clinteria klugii* Hope in northen Pakistan. In upper Himalaya of Jammu & Kashmir, flower eating beetle, *P. alboguttata* was found associated with rainfed maize at intermediate zone of Jammu & Kashmir (Ahad *et al.*, 2011).

The economic importance of chafers is primarily due to feeding activity of third instar grubs. In many parts of north-western Himalaya, larvae of Melolonthinae cause extensive damage to the roots of grasses, legumes, small fruits plants, shrubs and trees. Grubs prefer to feed on fibrous roots for normal growth and the crops with tap root system suffer more as compared to adventitious root system (Yadava and Vijayvergia, 2000). In general, the underground parts of all plants are subjected to grub feeding. The symptom of injury caused by root pruning by grubs is varying degrees of wilting, yellowing, browning and eventually plant death. In crops like potato, ginger, turmeric and colocasia, large holes are made in the tubers and rhizomes, rendering them unfit for marketing. Almost all crops grown during *kharif* season are damaged though extent of loss varies from area to area (Mehta *et al.* 2010). Shah and Garg (1985) recorded more than 50 per cent damage in paddy from Uttarakhand. White grubs also damage wheat and millets (Mishra and Singh, 1997). Mishra (2001) observed more than 70 per cent plant mortality in barnyard millet due to white grubs in Gharwal region of Uttarakhand. In potato, the avoidable losses due to white grubs were recorded to the tune of 76.03 per cent in Uttarakhand (Anonymous, 1991). The grubs of *H. longipennis* have been reported to cause more than 60 per cent plant mortality in soybean in Gwaldham (Mishra, 2001).

White grubs are responsible for causing 40-90 per cent losses in potato in endemic areas situated in higher hills of Uttarakhand, Himachal Pradesh and Jammu & Kashmir (Chandel *et al.,* 2015). Chandel *et al.* (2015a) have reported 20-50 per cent infestation of white grubs in potato tubers from Shimla, Sirmaur, Mandi, Kullu, Chamba and Kangra districts of Himachal Pradesh. Chandel *et al.,* (2009) reported up to 30 per cent white grub infestation in various forest nurseries in Himachal Pradesh. In 2004, 48.7 per cent white grub infestation has been observed in poplar nurseries at Solan (Sharma, 2000). In paddy crop, on an average 22.42 and 16.40 per cent damage due to white grubs has been reported in Kullu and Mandi districts of Himachal Pradesh, respectively (Kumar *et al.,* 2005).

In maize, grubs are reported to cause 28.53 and 36.58 per cent plant damage in Mandi and Kullu districts, respectively (Kumar *et al.,* 2005). *H. lioderes* has been reported as an important pest of maize in Mandi, Kullu, Solan and Kangra district of Himachal Pradesh. The beetles generally attack the growing plants by making holes in the stem just beneath the soil level. P. *dionysius* attack maize in Kullu and Solan districts. The grubs attack growing seedlings of maize, cutting through the roots, thus killing the plants. However, *Lepidiota stigma* has been observed to cause more than 50 per cent plant damage in river bed areas of Hamirpur, Mandi and Kangra (Mehta and Chandel, 2007). In Sangla valley, white grubs are reported to cause 8-10 per cent plant mortality in *rajmash* (Sood *et al.,* 2007) and about 20 per cent plant mortality in off season peas (Mehta and Chandel, 2006). The grubs of *Melolontha* sp. also attacked wheat in Kinnaur district (Chandel *et al.,* 2015). The ginger crop in different areas has been reported to be damaged by the grubs to the tune of 6-26 per cent (Misra, 1992; Mehta and Chandel, 2007). In Chuhar valley, upto 30 per cent plants in off season cabbage and 15-20 per cent plants of rajmash are damaged by grubs of *Polyphylla sikkimensis* Brenske. In Palampur area, about 5 per cent plants of cabbage/ cauliflower in main season crop during October-November are reported to be attacked by grubs of *H. longipennis*. In Paprola area of Kangra district, okra plants were found to be damaged by *H. longipennis* grubs, and the incidence was recorded to be 5.0 per cent. In Solan district 10-20 per cent seedlings of capsicum and tomato are killed by the grubs of *Phyllognathus dionysius* Redt. In Kashmir, the infestation of *B. poonensis*, *Maladera* sp., *Anomala* sp. and *Adoretus* sp. has been reported in maize and potato (Anonymous, 2004).

Biology of white grubs in north western Himalaya

Most species of white grubs complete their life cycle in one year. Some species like *M. indica, P. sikkimensis* and *L. stigma* are expected to require 2-3 years to complete their development. In species with two years life cycle, the larvae seldom cause damage in first year; it is during the second year that most damage is caused to plants by the larvae. All scarabaeids undergo three larval stages and spend more than half of life time as larva (Ritcher, 1958); as such it is the larval stage which is encountered more often. Among Indian white grubs, the biology of *B. coriacea*, *H. longipennis, H. sikkimensis* (Fab.)*, A. dimidiata* and *A. lineatopennis* has been studied by various workers.

Chandel *et al*. (1995) studied the biology of *B. coriacea* in mid hills of Himachal Pradesh. Emergence of *B. coriacea* begins in first week of April in mid hills with peak activity in mid June. In Shimla hills, *B. coriacea* constitutes 90 per cent of the total population, and peak emergence takes place in mid June (Chandel *et al.,* 2003). Chandel *et al.* (2008) reported that almost all grubs of *B. coriacea* moult into third instar by the end of September. Fully-fed grubs construct earthen cells and remain in earthen cells for 176-241 days (Chandel *et al*., 1995). Formation of pupae begins in April (Chandel *et al*., 2003). *H. longipennis* constitutes 55.8 per cent of total scarab population in Garhwal region of Uttarakhand (Sushil *et al*., 2006), and nearly 10 per cent in Himachal Pradesh (Mehta *et al*. 2010). The peak beetle emergence takes place during June-July (Gupta *et al*., 1977). The biology of *H. longipennis* has been studied in Uttarakhand (Haq, 1962; Shah and Shah, 1990) and Himachal Pradesh (Pathania *et al.,* 2016). Third instar grubs occupy 216-228 days and fully-fed third instar grubs move downward for overwriting. Haq (1962) reported that third instar grubs of *H. longipennis* are present at a depth of 2-3 inches up to the middle of November and then they migrate deep into the soil up to a maximum of 10 inches, and remain there till the end of February. Total larval period varies from 294-323 days. Pupae are formed in April, and adult emergence starts by the end of May (Mishra, 2001).

In case of *A. lineatopennis,* the duration of third instar grubs ranges from 202-223 days and overwriting takes place deep into the soil in hard earthen cells. The hibernating grubs become active with the rise in temperature and pupa are formed in April (Mishra, 2001). Adults have been recorded to feed on apple, peach and apricot (Musthak Ali, 2001). In Uttarakhand, *A. lineatopennis* completed a generation in about 320 days (Mishra 2001). The adults of *A. dimidiata* are highly phototactic and get attracted to light in large numbers. *A. dimidiata* constitutes 27.6 per cent of total beetle population in Uttarakhand (Sushil *et al*., 2006), whereas in Himachal Pradesh, its relative proportion is about 10 per cent (Chandel *et al*., 1997). The biology of *A. dimidiata* has been studied in Uttarakhand by Mishra (2001) and in Himachal Pradesh by Pathania (2014). The beetles of *A. dimidiata* emerge from the soil in the beginning of June and adults feed on apple, walnut, plum, apricot, peach, *uttish*, *toon*, poplar, *bhimal, hisalu* and *gulbahar* (Mushtak Ali, 2001). For *P.*

dionysius, adult emergence has been reported in May in Himachal Pradesh (Mehta *et al*., 2008). The grubs of *P. dionysius* inflict damage to potato and maize in sub tropical mid hill zone of Himachal Pradesh. The larvae feed during July, August and September. They then pupate, the pupal period being eight days only. The beetles rest in the soil till May, when they become active, burrow out, fly, mate, and lay eggs.

H. seticollis is an important species in the hilly tracts of Uttarakhand (Yadava and Sharma, 1995). The grubs cause heavy damage to all rainy season crops. The beetle emergence may start in the month of May and can be observed till the end of August. Fully-fed third instar grubs transform into pupae in the beginning of October at a depth of 30-50 cm inside earthen cells. Pupal period ranges from 15-20 days. The adults remain in the soil until their emergence, which is triggered by pre- monsoon rains during May. There is a single generation in a year (Yadava and Sharma, 1995). Rana *et al.* (2022) reported that emergence of *P. sikkimensis* begins in second week of July and peak activity occurs during August. Duration of the third larval instar has been reported to vary between 574 - 594 days, and has a biennial life cycle in high hills of Himachal Pradesh. Similarly in case of *M cuprescens*, *M. furcicauda* and *M. indica*, the biennial life cycle has been studied. The duration of third instar ranges from 325-329 days in *M cuprescens*, 299 - 311 days in *M. furcicauda* and 310 - 312 days in *M. indica* (Rana *et al.,* 2022a)

Management strategies

The adults and grubs cause different types of damage; therefore integration of mechanical with chemical control in combination with cultural practices is most effective against the white grubs (Singh *et al.*, 2002). Adults are mobile, therefore controlling one life stage will not necessarily preclude the problems caused by the other (Misra and Chandel, 2003).

Adult Management: The beetles are nocturnal and congregate on preferred hosts for feeding at night. Adult beetle collection can be done by shaking the twigs of their preferred host plants after 8:30 PM. The beetles exhibit distinct preference for certain host in a particular locality. Adult host plant as an attractant has been successfully used while collecting adults as a measure of control (Chandel *et al.,* 2015). The collected beetles can be destroyed by burning or dipping them in kerosinized water (Yadava and Sharma, 1995). Adults can also be killed conveniently by spraying host trees with effective insecticides (Misra and Chandla, 1989; Mishra and Singh, 1991). Koranga *et al.* (2022) reported dimethoate, indoxacarb, flubendiamide, and spinosad to be highly effective and best choice for specific control of *B. coriacea* in its endemic areas in Himachal Pradesh. Host plants may be sprayed within a week time after the first showers in late May. Light trap, though a tool for population monitoring could be used in reducing the population at least for strongly phototactic species like *A. dimidiata* (Mishra, 2001).

Management of grubs: Several workers suggest insecticide application in soil before sowing, or as seed treatment (Misra and Chandla, 1989; Mishra and Singh, 1994; Singh *et al.,* 1999; Mishra, 2001; Chandel and Mehta, 2005). Recent studies conducted on potato in Shimla hills revealed that clothianidin 50WDG applied preventively at earthing up in June to be quite effective at very low dose (120g a.i./ ha) than conventional recommended insecticides (Chandel *et al.,* 2015). In rajmash, soil application of quinalphos (800 g ai/ ha) and seed treatment with imidacloprid (4 ml/ kg) were highly effective (Sood *et al.*, 2007). In Uttarakhand, the grubs of *A. dimidiata* in millet are effectively managed by application of chlorpyriphos @4.0 L/ha (Mishra 2001). Similarly in soybean, seed treatment with chlorpyriphos (25 ml/kg) resulted in complete protection against grubs of *A. dimidiata* without any adverse effect on germination. In Sangla valley of Himachal Pradesh, seed treatment of peas with chlorpyriphos and quinalphos (@ 4 ml/ kg) provided significant protection of pea seedlings against different species of white grubs. Although, neonicotenoids like thiamethoxam and imidacloprid were also effective, but proved economically less viable due to their higher cost (Mehta and Chandel, 2007). Similarly, in *rajmash*, soil application of quinalphos (800 g ai./ha) and seed treatment with imidacloprid (4 ml/ kg) were highly effective resulting in 61.60 and 57.88 per cent reduction in plant mortality (Sood *et al*., 2007). Rana *et al.* (2021) treated *rajmash* seeds before sowing with different insecticides, and revealed that plants from chlorantraniliprole 18.5 SC (2.5 ml/ kg seed) treated seeds registered least mortality (20.0 %), followed by chlorpyriphos 20 EC @ 5 ml/ kg seed (21.67 %) at 10 days after sowing. Fields having a history of white grub attack should be tilled several times in April - May or in September. Tilling or discing soil macerates grubs and exposes them to their predators. The most critical period in the dynamics of white grub infestation lies between August and September, and timely harvest before September can avoid huge losses in summer potato (Chandel *et al.,* 2015).

Potential of biocontrol agents against white grubs: White grubs are naturally infected by various entomopathogens which include fungi, bacteria and nematodes. Entomopathogenic fungi offer great potential and members of genera *Beauveria* and *Metarhizium* are widely used against white grubs. In north western Himalaya, good control of white grubs in potato and turf grass had been achieved with entomopathogenic fungi. Mohi-ud-Din *et al.* (2006) reported complete mortality of white grubs attacking golf course in Srinagar in 20-24 days with *B. bassiana, B. brongniartii* and *M. anisopliae*. Among entomopathogenic nematodes, *H. indica* and *H. bacteriophora* are effective against potato white grubs. Gupta *et al.* (1992) reported that young grubs of *B. coriacea* are more sensitive than the older ones, and *H. bacteriophora* was more effective than *Neoaplectana bibionis*. Inoculum level of 40 dauer larvae/ cm^2 produced 60 and 50 per cent mortality in second instar larvae of *B. coriacea* with *H. bacteriophora* and *N. bibionis*, respectively. Against third instar larvae, 200 dauer larvae/cm^2 resulted in maximum kill of 54.5 and 45.5 per cent with *H. bacteriophora* and *N. bibionis,* after three weeks of treatment. Hussaini *et al.* (2005) applied talc-based formulations of *H. indica* PDBC EN 13.3, *H. bacteriophora*, *S. carpocapsae* PDBC EN 11 and *S. abbasi* PDBC EN 3.1 @ 5 X 10^9 IJs/ ha in a heavily infested golf course with 40-50 grubs/ m^2. *S. carpocapsae* and *S. abbasi* caused 30-40 per cent mortality, whereas for *H. indica* and *H. bacteriophora*, it was 20-25 per cent, 10 days after nematode application. They also observed 39.6-55.7 per cent mortality of white grubs in turf grass in Srinagar with talc-based formulation of *H. indica*, *H. bacteriophora*, *S. carpocapsae*, and *S. abbasi*. Chandel *et al.* (2018) reported 48.75 -55.38 per cent reduction in tuber damage when *Galleria mellonella* cadavers infected with *H. indica* were directly applied in the soil. Recently, *Bacillus cereus* has been isolated from atrophied pupae of *A. dimidiata* from Almora and its strain WGPSB-2 has been able to cause 92 and 67 per cent mortality in second instar larvae of *A. dimidiata* and *H. seticollis,* respectively in Uttarakhand (Selvakumar *et al*., 2007). The EPNs are compatible with chemical insecticides, fungicides, acaricides, and other entomopathogens. Some insecticides, such as imidacloprid and clothianidin are synergistic with EPNs and, therefore can be applied with other pesticides (Chandel *et al.,* 2018). Several species of predatory birds prey upon both grubs and adult beetles. Amongst the avian predators, Indian myna (*Acridotheres tristis* L.) and jungle crow, *Corvus macrorhynchos* are major predators feeding on white grubs at the time of ploughing (Singh *et al*., 2003a). Spotted owlet (*Athene brama*) settles on walnut tree during night and preys upon beetles (Mishra, 2001).

Conclusion

In India, maximum diversity of white grubs exists in north-western Himalaya. The known number of species may increase many folds if all habitats in the region are extensively surveyed. In Jammu & Kashmir, only few species have been reported, but it is not an indicator of low diversity. Probably the survey work has not been carried out extensively in this part of north western Himalaya. The problem of white grubs is becoming more severe every year, and they are spreading to areas where they had not been recorded as a pest earlier. Not only this, but there are records, where the population of these beetles have reached to a pest level and they have become serious pest of crops. The present review revealed that at least 20 species are economic pest either in adult or grub stage in north-western Himalaya. The remaining 90 per cent of the species have not been listed as pests, but might play a crucial role in the local biodiversity. Their biological study could explain what role they play in the local ecology. The changing patterns in population dynamics of different species of white grubs and their varied host preferences invite immediate attention for recognizing the management strategies. Therefore, it is suggested that suitable management approaches be devised and tested against these pests.

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