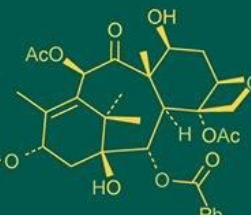
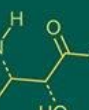
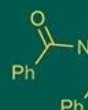


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Occurrence of stem borer (*Aeolesthes sarta* Solsky) in different apple cultivars grown in different elevations of Kashmir valley

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Abstract

Stem borer, *Aeolesthes sarta* (Solsky) is a major threat to apple cultivation in Kashmir valley. Larvae cause structural damage by boring into the host trees and interrupt the flow of water and nutrients, resulting in the loss of several branches and eventually, the entire tree. In case of severe infestation, decline of the canopy takes place and the entire tree dries out within 2 to 3 years. Apple production is drastically reduced in such affected orchard. In order to understand the prevalence of *A. sarta*, we assessed the response of different commercial apple cultivars across three elevations-karewas, higher belts and low-lying areas. Tree age and the vertical position of infestation on the trunk were also considered. The results of the present study indicated that almost all cultivars were susceptible, but the extent of damage varied noticeably. Apple cultivars viz., American Apiroque and Red Delicious were the most affected, whereas White Dotted Red, Benoni and Cox Orange Pippin experienced much lower infestation across locations. More vulnerable were the older trees, while the least damage was noticed in younger trees. The upper stratum of the tree trunk, where the scaffold limbs emerge, were severely infested by stem borer in comparison to middle and lower strata of the trunk. Infestation was highest in the Karewas, followed by higher belts, with low-lying areas showing the least impact. These findings provide clear evidence of cultivar-specific susceptibility to stem borer and emphasise the need for resistant cultivars, timely monitoring, especially in ageing orchards as well as region-based management strategies to reduce stem borer losses in apple plantations.

Keywords: *Aeolesthes sarta*, cultivars, Kashmir, stem borer, karewas, pest severity

1. Introduction

Apple (*Malus domestica* Borkh.) is one of the most important temperate fruit crops of Kashmir Valley, contributing significantly to the region's economy and livelihood security [1, 2]. The valley offers highly favourable agro-climatic conditions for apple cultivation, and over the years, the crop has expanded both in area and productivity [3]. However, apple orchards are increasingly threatened by a complex of insect pests, which adversely affect fruit quality, yield, tree growth and orchard longevity [4, 5]. A noticeable shift has been observed in pest pressure, with several wood-boring insects of forest origin expanding their host range and invading apple orchards. Among them, the stem borer *Aeolesthes sarta* (Solsky) (Coleoptera: Cerambycidae) is a highly destructive polyphagous stem borer that attacks a variety of broad leaved trees including apple and has emerged as a serious pest of apple [6]. The larvae bore into the main stem and major branches, feed on internal tissue due to which transportation of water and nutrients are disrupted, leading to canopy decline, leaf drying, and, over time, the death of both young and mature trees [7]. Infestation is often visible as holes in the trunk, frass (wood dust), and crisscross galleries under the bark. In severe cases, entire apple tree populations are significantly affected, with damage rates varying between 30-40% in some regions [8]. The cryptic nature of *A. sarta* infestation makes early detection difficult, as larval feeding occurs deep within the woody tissues. External symptoms such as frass extrusion, sap oozing, and exit holes often appear only after substantial internal damage has occurred [7, 8]. Moreover, the prolonged larval period and overlapping generations further complicate effective management of this pest.

More than 7500 apple cultivars are known worldwide and out of which approximately 113 cultivars are found in Kashmir [9]. Apple cultivars are known to differ in their susceptibility towards insect pests because of genetic, morphological, and phenological traits that affect insect preference and performance [10, 11]. Assessment of pest susceptibility differences in various apple cultivars is therefore significant for the pest management strategies in apple orchards planted with mixed-cultivars. Kashmir Valley encompasses diverse topographical zones, including low-lying areas, karewas, and higher belts, each characterised by distinct climatic and ecological conditions. In addition to cultivars, the elevation where the orchard is located has also an impact on the severity of insect pest infestation [12, 13, 14].

Hence, the present investigation was undertaken to assess infestation severity of *Aeolesthes sarta* in different apple cultivars, varying in age groups, tree trunk strata and grown in different elevations in Kashmir valley.

2. Materials and Methods

Surveys were conducted during the active infestation period of *A. sarta* in apple orchards falling in the three districts of North Kashmir, India, at three distinct elevation zones, namely low-lying areas, Karewas, and higher belts. The orchards within each elevation zone were selected randomly. Infested apple trees of different cultivars were selected randomly for assessment. The study included nine commonly grown apple cultivars: Shimla Delicious, American Apiroque, Red Delicious, Golden Delicious, American Jolly Flower, Benoni, Cox's Orange Pipin, Royal Mishri and White Dotted Red. Selected trees were categorised into three age groups; 0-15 years, 15-30 years and > 30 years. For assessing the vertical distribution of infestation, each apple tree was divided into three equal trunk strata: Lower stratum (basal portion of the trunk near ground level), Middle stratum (central portion of the trunk), and Upper stratum (region wherein the scaffold limbs emerge). The number of holes was used as an indicator of infestation intensity. The severity of *A. sarta* infestation was assessed by a scale mentioned below [15]:

0 = No hole (Healthy)

1 = 1.0 to 2.0 holes (Low infestation)

2 = 2.1 to 3.0 holes (Moderate infestation)

3 = 3.1 to 4.0 holes (High infestation)

4 = 4.1 to 5.0 holes (Severe infestation)

5 = more than 5.0 holes (Extremely severe infestation)

The mean per cent pest severity (PPS) was calculated as:

$$PPS = \frac{\sum \text{pest severity ratings from 1 to } n}{N \times 5} \times 100$$

Where

Σ = summation

n = Total severity ratings

N = Number of replications

5 = Maximum grade value

2.1 Statistical Analysis: Descriptive statistics including mean, standard deviation, coefficient of variation (CV %), minimum, maximum, and confidence intervals (lower and upper limits) were calculated to summarize the variability

among cultivars, age group, and trunk strata at each elevation level.

3. Results and Discussion

The attack of *A. sarta* was found on almost all commercially grown apple cultivars with significant variations, indicating differential susceptibility to the pest under Kashmir conditions. The severity of pest attack was highest in the cultivar, American Apiroque followed by Delicious, whereas infestation was comparatively lower in White Dotted Red, Benoni and Cox Orange Pippin across all the three elevations used in the study (Table 1). The rest of the cultivars showed intermediate level of infestation. Differences in apple cultivar susceptibility to any pest may arise from plant traits that affect pest preference, feeding, and survival, many of which are genetically controlled [16, 17]. The resistance or susceptibility to borers is mainly driven by wood structure and defensive chemistry of the stems/branches [18, 19]. The more lignified wood with richer phenolic defences was found to make walnut cultivars less attractive and harder to bore, while soft, nutrient-rich tissue encouraged infestation [18, 15] studied the infestation of *A. sarta* on apple trees and recorded highest severity (23.23%) on the trunk and scaffold limbs of apple cultivar, Red Delicious and the lowest (6.47%) on American Apiroque.

In the present study, trees of all age groups were found susceptible to infestation with *A. sarta*, however infestation level was consistently lowest in younger trees across all elevations and cultivars (Table 1, 2 & 3). Older trees (>30 years) were severely infested as compared to middle-aged (15-30 years) and younger trees (0-15 years). The results confirm the reports that stem borers attack host trees irrespective of age; pest severity increase with the increase in tree age across all cultivars and elevations [12]. The old aged trees tend to become more vulnerable because, with age, their vigour gradually declines and the bark becomes thicker and often cracked, creating ideal sites for the beetles to lay eggs and larvae to settle. Additionally, these trees are exposed to pests for a longer time that increased the chances of repeated attacks. The adults of *A. sarta* are poor fliers, and often reinfest the same host plants from which they emerge. Consequently, infestation tends to accumulate and intensify with increasing tree age. Our findings also align with the observations of other workers who reported age-dependent incidence of the coffee stem borer, *Xylotrechus quadripes*, with significantly higher infestation in older coffee trees as compared to younger ones [20].

While assessing the entire tree trunk, it was observed that highest infestation was on upper stratum followed by middle and lower stratum across all the cultivars, age groups, and elevations (Table 1, 2 & 3). The orchards located in karewas were found highly infested with *A. sarta* followed by higher belts, whereas infestation level was lowest in low-lying areas. Karewa soils are young, low in organic matter, and hold very little moisture. Apple trees growing in these areas receive intense sunlight and often experience drought-like conditions, which could explain the higher *A. sarta* infestation recorded there. Such stressed environments may weaken trees, making them more attractive or vulnerable to stem borers. Sun-exposed stem and branch surfaces of cherry cultivars in Kullu, India were preferred sites for oviposition by the flat-headed borer, *Sphenoptera lafertei* [21].

Table 1: Mean percent pest severity of stem borer, *Aeolesthes sarta* across cultivars, age groups, and trunk strata of apple trees in higher belts of North Kashmir.

Cultivar	Age (Years)								
	0-15			15-30			>30		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
American Apirouge	6.46	4.61	2.51	25.88	18.48	10.59	29.10	25.96	19.46
Delicious	5.28	3.20	2.04	20.56	15.15	8.15	25.37	19.88	17.70
White Dotted Red	1.81	1.59	0.52	7.47	6.07	2.05	10.07	8.13	2.27
Golden Delicious	2.96	1.59	1.08	14.03	9.48	5.80	18.62	15.79	7.87
Benoni	1.77	1.24	0.56	8.80	5.48	2.56	12.70	8.79	2.82
American Jolly Flower	3.17	1.77	1.19	16.57	9.81	5.57	19.45	13.59	8.82
Cox's Orange Pipin	1.79	1.18	0.46	8.79	5.74	1.97	11.59	8.07	2.13
Shimla Delicious	3.05	1.55	1.07	14.25	8.48	6.04	19.54	13.79	6.91
Royal Mishri	2.87	1.65	1.18	13.80	10.46	4.87	16.70	12.90	7.89
Mean	3.24	2.04	1.18	14.46	9.91	5.29	18.13	14.10	8.43
Standard Deviation	1.6	1.13	0.69	5.97	4.40	2.88	6.28	5.90	6.32
Minimum	1.77	1.18	0.46	7.47	5.48	1.97	10.07	8.07	2.13
Maximum	6.46	4.61	2.51	25.88	18.48	10.59	29.10	25.96	19.46
Lower limit (CI: 95%)	1.99	1.17	0.64	9.87	6.52	3.08	13.30	9.56	3.57
Upper limit (CI: 95%)	4.49	2.91	1.71	19.06	13.29	7.50	22.96	18.64	13.29
CV (%)	50.09	55.35	59.12	41.33	44.46	54.42	34.67	41.87	74.98

Table 2: Mean percent pest severity of stem borer, *Aeolesthes sarta* across cultivars, age groups, and trunk strata of apple trees in Karewas of North Kashmir.

Cultivar	Age (Years)								
	0-15			15-30			>30		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
American Apirouge	8.59	6.13	4.20	29.90	24.37	11.45	32.59	30.14	24.49
Delicious	6.90	4.20	2.05	22.27	18.87	9.14	28.04	26.59	22.87
White Dotted Red	1.87	1.18	0.47	9.18	8.11	2.90	11.86	9.36	3.10
Golden Delicious	4.34	2.60	1.55	19.88	10.53	6.96	15.92	13.17	9.97
Benoni	1.91	1.61	0.54	10.87	10.47	4.13	10.25	8.13	4.17
American Jolly Flower	4.70	2.81	1.53	20.57	15.48	7.04	26.15	23.37	10.10
Cox's Orange Pipin	1.87	1.13	0.47	11.18	8.47	3.88	9.37	13.58	3.17
Shimla Delicious	3.77	2.59	1.56	18.89	13.59	8.79	16.59	21.21	8.76
Royal Mishri	4.88	2.87	1.59	16.90	14.17	7.47	15.48	22.76	9.76
Mean	4.32	2.79	1.55	17.74	13.79	6.86	18.47	18.70	10.71
Standard Deviation	2.33	1.58	1.15	6.58	5.28	2.79	8.39	7.85	7.91
Minimum	1.87	1.13	0.47	9.18	8.11	2.90	9.37	8.13	3.10
Maximum	8.59	6.13	4.20	29.90	24.37	11.45	32.59	30.14	24.49
Lower limit (CI: 95%)	2.52	1.58	0.67	12.68	9.73	4.72	12.03	12.67	4.63
Upper limit (CI: 95%)	6.11	4.01	2.44	22.80	17.84	9.01	24.92	24.74	16.79
CV (%)	54.00	56.56	74.30	37.10	38.30	40.70	45.41	41.99	73.87

Table 3: Mean percent pest severity of stem borer, *Aeolesthes sarta* across cultivars, age groups, and trunk strata of apple trees in low lying areas of North Kashmir.

Cultivar	Age (Years)								
	0-15			15-30			>30		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
American Apirouge	3.43	2.72	1.44	20.86	14.24	8.26	24.37	21.75	11.59
Delicious	2.17	1.78	1.04	14.25	9.59	4.37	18.26	16.01	6.59
White Dotted Red	0.17	0.14	0.09	4.88	3.18	1.49	6.08	4.47	2.89
Golden Delicious	1.53	1.19	0.91	10.87	7.79	2.98	12.66	10.79	4.13
Benoni	0.14	0.12	0.06	5.29	2.88	1.18	6.13	4.94	3.37
American Jolly Flower	1.47	0.72	0.47	9.17	6.26	3.14	8.56	6.48	4.24
Cox's Orange Pipin	0.47	0.16	0.05	5.57	2.09	1.52	9.77	7.92	2.99
Shimla Delicious	1.51	0.51	0.67	9.45	7.70	2.77	10.19	9.64	3.88
Royal Mishri	1.55	1.18	0.87	8.80	5.74	2.86	8.46	7.61	4.78
Mean	1.38	0.95	0.62	9.91	6.61	3.18	11.61	9.96	4.94
Standard Deviation	1.05	0.88	0.49	5.09	3.82	2.16	6.06	5.63	2.73
Minimum	0.14	0.12	0.05	4.88	2.09	1.18	6.08	4.47	2.89
Maximum	3.43	2.72	1.44	20.86	14.24	8.26	24.37	21.75	11.59
Lower limit (CI: 95%)	0.58	0.27	0.24	5.99	3.67	1.52	6.96	5.63	2.84
Upper limit (CI: 95%)	2.19	1.62	1.00	13.82	9.55	4.83	16.27	14.29	7.04
CV (%)	75.54	92.70	79.23	51.37	57.77	67.87	52.16	56.53	55.29

4. Conclusion

In the present investigation, the stem borer, *A. sarta* was found capable of infesting all common cultivars of apple, though not with the same intensity. Apple trees grown in Karewas and old aged trees were highly infested with *A. sarta*. Among the cultivars, American Apiroque and Delicious were the most affected while the least damage was observed in White Dotted Red, Benoni and Cox Orange Pippin, suggesting that they may possess traits that make them less favorable to the pest. Hence, the outcome of the studies may prove helpful while making strategies for the successful management of *A. sarta* in apple growing areas of Kashmir valley.

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