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Incidence of stem borer, *Celosterna scabrator* Fab. (Cerambycidae: Coleoptera) on three grape varieties

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Abstract
Grapevine encounters group of pests. Among them, the stem borer *Celosterna scabrator* Fab. (Cerambycidae: Coleoptera) causes severe damage to grape. A fixed plot and roving survey were conducted during 2017-18 in three districts of Karnataka (India) to study the variations in the level of incidence of *C. scabrator* on three varieties of grapes namely Thompson seedless, Manikchaman and Sonaka. Non-significant difference was recorded between three varieties of grape with respect to the population of adults and twig damage per vine. Significant difference was recorded during fixed plot surveys between three varieties with respect to mean percent exit holes and live holes and total mean percent incidence. Highest total mean percent incidence was recorded in Thompson seedless (86.30) followed by Manik chaman (64.40) and Sonaka (56.60). Similarly, during roving surveys, Thompson seedless recorded maximum total mean percent incidence (38.70) followed by Manikchaman (28.20) and Sonaka (24.90).

Keywords: Grape varieties, stem borer, exit holes, live holes, incidence level

Introduction
Grape is cultivated commercially and mainly classified into table grapes and wine grapes. Most popular and economically important table varieties of grapes are Thomson seedless with its clones like Tas-A-Ganesh, ManikChaman, Sonaka and 2-A. The wine varieties are Chardonnay, Muscat, Sauvignon Blanc, Cabernet Sauvignon, Shiraz, Viognier and Zinfandel (Anon, 2010) [1].

In state Karnataka, Vijayapura ranked first with an area and production of 10,652 ha and 211.64 MT respectively (Anon, 2018) [2]. Among the different species of insect pests attacking grape vine, the wood borer *Celosterna scabrator* Fab. is becoming a major pest in the recent past. Studies revealed mean yield loss 3475.75 kg per acre from borer-affected vines. **(**Sunitha *et al.*, 2017) [3].

Females make ovipositional injury and both females and males scrape the green matter from tender twigs and shoots and gnaw the shoots resulting in wilting beyond that point .While emerging out they cut circular holes from inside tree on trunks and branches of tree. The grubs after hatching make their way into the tree by making a small entry hole and make extensive tunneling in both the directions from the entry holes, affecting the translocation of the nutrients. The leaves turn yellow, later turn brown and drop. The borer affected vines become weak and give very low berry yield **(**Sunitha, 2018) [4].

C. scabrator severely infected Black champa and Black choraicon with 30.08 percent and 28.70 percent respectively (Mani *et al*., 2008) [5]. There was less than one per cent infestation in ninety seven varieties, which were categorized into tolerant, less susceptible, moderately susceptible or highly susceptible (Mani *et al*., 2014) [6]. Tempranillo variety was highly susceptible to *Xylotrechus arvicola* (Olivier) than Prietopicudo variety (Rodriguez *et al.*, 2017) [7]. Host plant qualities are important parameters for the choice of infestation site by cerambycid beetles, because they affect the development of the offspring (Rice, 1995) [8]. The recognition of host and plant in cerambycid beetles is driven through the chemical cues which originate from the plants. (Allison *et al*., 2004) [9]. In Northern Karnataka, Thompson seedless, Manikchaman and Sonaka are the predominant varieties. Much of the work has not been done on the preference of *C. scabrator* towards the three varieties of grape. So the present study was undertaken during 2017-18 in three districts of Karnataka (India) to study the infestation levels of *C. scabrator* on three varieties of grape.

Materials and Methods

Fixed plot and Roving surveys were conducted from June (2018) to April (2019) in the grape orchards of Vijayapura, Bagalkote and Belagavi districts of Karnataka (India) respectively. Fixed plot survey was conducted in the grapevine orchards of Vijayapura district. Observations were recorded at monthly intervals (first fortnight of every month) on three grape varieties *i.e*., Thomson seedless, Manikchaman and Sonaka from the grape orchards of Vijayapura district. Under each variety, ten grape orchards were selected and from each grape orchard, hundred vines were randomly selected. Observations were recorded on number of *C. scabrator* beetles per vine, (Fig 1), number of twigs damaged by *C. scabrator* beetles per vine. (Fig 2). Similarly hundred vines were examined for the presence of live holes by adopting frass indexing method (Goodwin *et al*., 1994) [10] (Fig 3) and expressed as per cent live holes. Observations were also recorded on exit holes cut by emerging adults of the grape stem borer *C. scabrator* during the previous season (Fig 4) which is also an indication of incidence levels of *C. scabrator* on different varieties. Further, mean per cent live and exit holes were calculated. The mean per cent exit and live holes were added to compute total mean per cent incidence for each variety.

While to measure the tunnel length made by the feeding grub of *C. scabrator*, 35 grape vines with live holes from each variety were sampled and vines were split opened to measure the tunnel length during the last week of April with a measuring tape and length was expressed in cm. (Fig 5)

Wherein during roving survey observations were recorded three times from the grape orchards of Thomson seedless, Manikchaman and Sonaka varietites from three districts *viz*.,Vijayapura, Bagalkote and Belagavi. Under each variety, ten different grapevine orchards were selected during each visit from each taluk and from each grape variety, hundred vines were examined for the presence of live holes by adopting frass indexing method (Goodwin *et al*., 1994) [10] and expressed as per cent live holes. Observations were also recorded on exit holes cut by emerging adults of the grape stem borer *C. scabrator* during the previous season which is also an indication of incidence levels of *C. scabrator* on different varieties. Further, mean per cent live and exit holes were calculated. The mean per cent exit and live holes were added to compute total mean per cent incidence for each variety.

Frass indexing method

Each selected vine was examined for the external sign of *C. scabrator* larval infestation, which is the presence of fresh frass or sawdust extruded from the bored tunnels out which often collects around the entry hole and at the base of the vine (Goodwin *et al*., 1994) [10].

Mean was calculated for the number of adults per vine, number of twigs damaged per vine, tunnel length of grubs, per cent exit holes, live holes and total holes. The one-way ANOVA was performed for comparison of adult population and twig damage between three varieties of grape with SPSS 16.0 for windows software.

Fig 1: *C. scabrator* beetles on grape vine

Fig 2: Twig damage by *C. scabrator* beetles

Fig 3: Grape vine with live hole extruding frass

Fig 4: Exit hole cut by *C. scabrator* beetle

Fig 5: Tunnel made by *C. scabrator* beetles

Results and Discussion

The observations were recorded during fixed plot survey at grape orchards of Vijayapura between June 2018 to April 2019 on population of beetles of *C. scabrator* on three varieties of grapes. The beetles started emerging during the first week of August on all the three varieties. Mean number of beetles per vine showed a non- significant difference (*P*= > 0.05) between Thompson seedless (0.88) and Manikchaman (0.45) varieties (F=1.07 and *P*=0.32). Similarly, non-significant difference was also observed between Manikchaman (0.45) and Sonaka (0.25) varieties (F=0.84 and *P*=0.37) and between Thompson seedless (0.88) and Sonaka (0.25) varieties (F=2.47 and *P*=0.13). Though the statistical analysis showed non-significant results highest mean population was recorded on Thompson seedless followed by Manikchaman and Sonaka (Table 1). Again mean number of twigs damaged showed a non-significant difference (*P*=> 0.05) between Thompson seedless (1.08) and Manikchaman (0.41) varieties (F=1.96 and *P*=0.18). Similarly, non-significant difference was also observed between Manikchaman (0.41) and Sonaka (0.40) varieties (F= 0.01 and *P*=0.94) and between Thompson seedless (1.08) and Sonaka (0.40) varieties (F=2.07and *P*=0.17). The number of twigs damaged per vine showed similar trend as that of the population of beetles per vine (Table 2). No incidence was recorded between June to August month on all the three grape varieties.

The observations recorded on number of live holes by adopting frass indexing method indicated that Thompson seedless recorded highest mean per cent live holes (41.80) followed by Manikchaman (23.20) and minimum mean per cent incidence was recorded on Sonaka (18.10). Similarly, Thompson seedless variety recorded the highest mean per cent exit holes (44.50) followed by the Manikchaman variety (41.20) and lowest mean per cent exit holes were recorded on Sonaka variety (38.50). Total mean per cent incidence (Live holes+Exit holes) was highest in Thompson seedless (86.30) followed by the Manikchaman (64.40) and lowest total mean per cent incidence was recorded in Sonaka (56.60) variety (Table 3).

Results of roving survey conducted in three districts namely Vijayapura, Bagalkoteand Belagavi revealed that mean numberof exit holes (14.62), live holes (22.63) and total mean per cent incidence (38.70) are highest on Thomson seedless variety followed by Manikchaman (12.70, 15.47 and 28.20 % respectively) and Sonaka variety (11.97, 12.98 and 24.90 %respectively) (Table 4).

Significant difference was observed between three varieties with respect to tunnel length made by the *C. scabrator* grubs. The mean tunnel length was highest in Thompson seedless (101.11 cm) followed by Manikchaman (80.28 cm) and lowest tunnel length was observed in Sonaka variety (74.11 cm) (Table 5).

Table 1: Population of *Celosterna scabrator* beeetles Fab. on three grape varieties

Number of beetles/vine			
***Month of observation**	**Thompson seedless**	**Manik chaman**	**Sonaka**
June	0.00	0.00	0.00
July	0.00	0.00	0.00
August	0.80	1.20	0.70
September	1.90	0.90	0.40
October	3.20	1.40	1.10
November	2.50	0.65	0.30
December	0.40	0.30	0.00
January	0.00	0.00	0.00
February	0.00	0.00	0.00
March	0.00	0.00	0.00
April	0.00	0.00	0.00
Total	8.80	4.45	2.50
Mean	0.88	0.45	0.25
SD ±	1.21	0.55	0.38
Variance	1.46	0.31	0.15
Varieties	Test statistic F value (0.05)	Table F value	*P* value (0.05)
Thompson seedless x Manikchaman	1.07	4.41	0.32
Manikchaman x Sonaka	0.84	4.41	0.37
Thompson seedless x Sonaka	2.47	4.41	0.13

N = 10 and n = 100 (N = Number of orchards, n = Number of vines/orchard), *First fortnight

Table 2: Number of twigs damaged by *Celosterna scabrator* fab beetles on three varieties of grapes

Number of twigs damaged/vine			
***Month of observation**	**Thompson seedless**	**Manik chaman**	**Sonaka**
June	0.00	0.00	0.00
July	0.00	0.00	0.00
August	1.20	0.95	1.20
September	2.70	1.25	0.95
October	4.10	1.60	1.45
November	3.10	0.40	0.75
December	0.80	0.35	0.00
January	0.00	0.00	0.00
February	0.00	0.00	0.00
March	0.00	0.00	0.00
April	0.00	0.00	0.00
Total	11.90	4.55	4.35
Mean	1.08	0.41	0.40
SD ±	1.55	0.54	0.59
Variance	2.40	0.30	0.35
Varieties	Test statistic F value (0.05)	Table F value	*P* value (0.05)
Thompson seedless x Manikchaman	1.96	4.41	0.18
Manikchaman x Sonaka	0.01	4.41	0.94
Thompson seedless x Sonaka	2.07	4.41	0.17

N = 10 and n = 100 (N= Number of orchards, n = Number of vines/orchard), * First fortnight

Table 3: Percent vine incidence of *Celosterna scabrator* fab on three varieties of grape (Fixed plot survey)

Mean percent incidence			
***Month of observation**	**Thompson seedless**	**Manikchaman**	**Sonaka**
Live holes (2018-19)			
June	0.00	0.00	0.00
July	0.00	0.00	0.00
August	0.00	0.00	0.00
September	17.40	16.50	12.70
October	25.10	17.80	13.60
November	27.20	19.80	14.50
December	29.50	21.60	16.00
January	31.70	21.90	17.10
February	41.80	23.00	17.60
March	41.80	23.20	17.90
April	41.80	23.20	18.10
Exit holes (2017-2018)			
June to April	44.50	41.20	38.50
Total incidence	86.30	64.40	56.60

N = 10 and n = 100 (N = Number of orchards, n = Number of vines/orchard), * First fortnight

Table 4: Percent vine incidence of *Celosterna scabrator* fab on three varieties of grape (Roving plot survey)

Districts	**Taluks**	***Thompson seedless**			***Manikchaman**			***Sonaka**		
		% exit holes	**% live holes**	**Total % incidence**	**% exit holes**	**% live holes**	**Total % incidence**	**% exit holes**	**% live holes**	**Total % incidence**
Vijayapura	Vijayapura	39.37	52.00	91.40	13.65	20.97	34.60	12.86	16.89	29.80
	Indi	15.08	25.69	40.80	12.85	17.64	30.50	11.63	12.82	24.40
	B. Bagewadi	13.38	23.95	37.30	11.02	13.23	24.30	11.47	12.46	23.90
	Muddebihal	11.24	16.20	27.40	10.52	10.50	21.00	10.33	10.50	20.80
	Sindagi	11.23	17.74	29.00	12.12	14.19	26.30	11.15	12.03	23.20
District mean		18.06	27.12	45.18	12.03	15.31	27.34	11.49	12.94	24.42
Bagalkote	Bagalkote	10.50	16.28	26.80	11.01	12.05	23.10	10.30	10.46	20.80
	Hunagund	11.29	16.26	27.60	10.71	11.77	22.50	10.89	11.08	22.00
	Jamakandi	12.92	17.79	30.70	13.19	15.72	28.90	10.99	10.77	21.80
District mean		11.57	16.78	28.37	11.64	13.18	24.83	10.73	10.77	21.53
Belagavi	Athani	17.45	26.46	43.90	17.45	22.19	39.60	12.39	13.40	25.80
	Gokak	13.10	28.61	41.70	16.86	21.36	38.20	17.48	20.46	37.90
	Ramadurga	12.17	16.92	29.10	10.33	10.58	20.90	12.17	11.92	24.10
District mean		14.24	24.00	38.23	14.88	18.04	32.90	14.01	15.26	29.27
Overall mean		14.62	22.63	38.70	12.70	15.47	28.20	11.97	12.98	24.90

Table 5: Tunnel length of *Celosterna scabrator* Fab. grubs on three varieties of grape

S. No.	Length of the tunnel (cm)		
	Thompson seedless	**Manikchaman**	**Sonaka**
1	95.50	87.40	80.10
2	98.50	79.60	82.40
3	104.60	84.60	76.40
4	105.60	84.20	79.40
5	87.60	69.40	67.40
6	108.70	78.60	76.40
7	94.60	87.40	72.40
8	109.40	69.50	86.40
9	106.30	81.30	64.70
10	112.70	86.40	74.60
11	96.50	70.60	74.10
12	102.50	81.40	67.40
13	109.40	79.40	69.80
14	102.30	88.70	76.40
15	92.50	89.60	64.50
16	90.20	78.40	67.50
17	111.40	79.50	73.60
18	109.40	66.50	66.10
19	94.60	86.20	80.60
20	98.70	80.30	74.10
21	90.10	76.40	70.30
22	112.60	81.20	71.60
23	88.40	89.40	64.30
24	99.10	69.40	66.40
25	111.70	84.60	76.40
26	98.70	81.20	66.20
27	97.40	68.70	64.20
28	109.40	80.40	74.10
29	105.20	88.40	76.40
30	99.40	84.60	86.40
31	103.40	67.40	79.40
32	109.40	87.40	81.60
33	98.60	86.30	79.40
34	95.30	74.30	82.50
35	88.90	81.20	80.50
Mean	101.11	80.28	74.11
SD ±	7.54	6.84	6.47
Variance	56.92	46.86	41.84
Varieties	Test statistic Z value(0.05)	Table Z Value	P value (0.05)
TS x MCH	12.13	1.95	0.00
MCH x S	3.79	1.95	0.00
TS x S	16.03	1.95	0.00

TS – Thompson seedless, MCH - Manik chaman, S - Sonaka

The present studies indicated that *C. scabrator* has differential preference towards the varieties of grape. Thompson seedless was highly preferred followed by Manik chaman and Sonaka. The results of present investigation are in line with the Anonymous (1976) [11] who reported that, infestation by the *C. scabrator* was severe in Black champa and Black choraicon with 30.08 percent and 28.70 percent infestation respectively. Anonymous (1979) [12] classified ninety seven varieties as tolerant with less than one per cent infestation such as Gulabi and Bangalore purple, Black round, Buck and Sweet, Phakandi, Salt Creek, Convent large black, Flame muscat, Isabella, President, Teror, Jaishee, Lungluenga and Madras field court. Ocete and Lopez (1999) [13] reported that *Xylotrechus arvicola* (Olivier) (Cerambycidae: Coleoptera) infested the majority of sampled grape vines older than 15 years in La Rioja vineyards (North eastern Spain), where Tempranillo is the traditional cultivar and shows the highest infestation. Similarly, present findings are also comparable with that of Ocete *et al*. (2002) [14] who reported that Cabernet Sauvignon (13 years old) has the highest infestation rate, *i.e*., more than 90 percent, indicating its high susceptibility to the insect and this variety is followed by Macabeo with 27.5 percent infestation rate by the cerambycid wood borer. The results corroborate with Ocete*et al.* (2008) [15] who revealed an increasing number of attacks of the generalist xylophagous insect *X. arvicola* are being recorded in Spanish grape vineyards and further reported that *X. arvicola* is affecting vineyards of four years and on occasion forcing the removal of 15-year-old vineyards. Rodriguez *et al.* (2017) [7] also reported that Tempranillo variety is more susceptible to *X. arvicola* than Prietopicudo variety. The investigations are in line with the studies conducted by Sunitha (2018) [3] who reported that, 90.00 percent of the grape vines affected by *C. scabrator* in one of the study areas *i.e*., Vijayapura (Karnataka, India) belong to Thompson seedless variety and one and two years old vine orchards recorded significantly lowest mean live tunnels (8.30 ± 2.86 and11.15 ± 5.75 respectively).

The differences in the level of incidence of *C. scabrator* on three varieties can be attributed to the variations in the morphological characters of the varieties (Kulkarni, 2012) [16] and spectrum of volatiles released by the three varieties. The overall quality of a plant as a host for insects have been cited as possible causes of variation in herbivore population dynamics by Rausher (1989) [17]. Zangerl (1990) [18] reported that plant characters such as trichome density, leaf toughness, nutrient and secondary chemical contents have been shown to affect insect feeding preference, performance characters such as growth, survival and fecundity. Similarly, plant quality is defined here by the performance of herbivores on the plant, with herbivores having higher fitness on higher quality plants. Overall plant quality for a particular herbivore is likely to be affected by many specific plant-quality characters, such as alkaloid content or trichome density. It has been suggested that stress imposed by the abiotic environment can change plant quality (Louda and Collinge, 1992) [19], and perhaps lead to outbreaks of herbivores such as forest insects and mites (Reeve *et al*., 1995) [20]. Rice (1995) [8] reported that host qualities such as branch diameter, age, height, vigour and nutritional value are important parameters for the choice of infestation site by cerambycid beetles, because they affect the development of the offspring. Similarly, the plant traits strongly affect not only the success of individual, but also characters that may influence growth rates, and thus long-term population dynamics as reported by Underwood and Rausher (2000) [21]. Allison *et al*. (2004) [9] reported that the signaling molecules play a very important role in the life history of the cerambycids. Adults feeding on inflorescence and from leaf and trunk of larval hosts usually get attracted towards the plant volatiles.

The present investigations are also discussed in the light of cerambycid beetles attacking other fruits. Chatterjee (2003) [22] conducted the field studies on varietal preference and management of Citrus shoot borer, *Oberea posticata* (Gall) (Cerambycidae: Coleoptera) in Darjeeling district of West Bengal, India and revealed that *Citrus jambhiri* was the most preferred host with a maximum (23.33 %) shoot damage followed by *C. reticulata, C. limonia* and *C. sinensis.* Similarly Reddy *et al*. (2015) [23] reported that mango varieties 'Alphonso', 'Langra' and 'Jehangir' being the most susceptible (25–50 % damage) and 'Himayuddin' and 'Banganapalli' being the least susceptible to the stem borer.

Conclusion

Celosterna scabrator Fab. (Cerambycidae: Coleoptera) is emerging as a major pest in grape growing regions of the country, especially Maharashtra and Karnataka states. Pest not only causes significant yield loss but also death of grapevines. The present study was aimed at studying the variations in incidence levels of *C. scabrator* on three grape varieties and results indicated Thompson seedless variety suffers more damage compared to Manik chaman and Sonaka varieties. Owing to the hazards caused by the insecticides, there is always a need to explore alternate pest management strategies. Further studies in this line are required involving chemical ecology of *C. scabrator*

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