Review Article

An overview of Stemborer (*Celosternascabrator)(Stromatiumbarbatum)* of grapevine.

Abstract

The cultivation of grapevines in India, particularly in the key producing regions of Maharashtra and Karnataka, faces significant threats from stem borers, primarily *Celosternascabrator* and *Stromatiumbarbatum*. This review comprehensively examines the impact of these pests on grapevine yields, detailing their biology, lifecycle, and the complexities involved in their management. It highlights how the behaviour of these pests, such as pupating inside the stems, complicates conventional control methods, making them less effective. The review also explores the role of forest trees as alternate hosts, suggesting that changes in land use, such as deforestation, exacerbate the vulnerability of grapevines to these pests. With *S. barbatum* noted for its extensive host range and distribution across various regions, the review underscores the importance of thoroughly understanding ~~a thorough understanding of~~ pest biology and behaviour in developing effective pest management strategies. It advocates for integrated pest management (IPM) approaches that combine biological control, habitat management, and the judicious use of pesticides. By focusing on the specific challenges posed by *C. scabrator* and *S. barbatum*, this review contributes to the broader discourse on sustainable pest management in grapevine cultivation, aiming to mitigate yield losses and ensure the viability of this important agricultural sector in India.

Keywords: Stemborer, *Celosternascabrator,Stromatiumbarbatum,* Grapevine, Biology of ~~stemborer~~stem borer, ~~Management~~and Management of ~~stemborer~~stem borer.

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Introduction

Grape (*Vitis vinifera* L.) holds a significant position as a fruit crop in India, ~~being~~ one of the country's important commercial fruits. Originally a temperate crop, it has been successfully adapted to the subtropical climate of peninsular India (Mani *et al.*, 2013). This adaptation has allowed for the expansion of grape cultivation in

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regions outside its traditional temperate climate zone, contributing to its prominence in the agricultural sector of India.During ~~the~~ 2017-2018~~ period~~, grapes were grown ~~in~~ onabout 139,000 hectares of land, producing 29.2 million metric tons with a productivity rate of 21.00 tons per hectare. Maharashtra ranks first and Karnataka ranks second, with grape cultivation in about 26.61 thousand hectares of land, producing 524.20 thousand metric tons. (Sunitha ND. 2020). Globally, the primary viticulture regions are situated within the temperate climatic belt, specifically between 40° and 50°N latitude in the northern hemisphere and between 30° and 40°S latitude in the southern hemisphere. This observation, highlights the climatic preferences for wine grape cultivation, indicating that these specific latitudinal zones offer the most favorable conditions for viticulture. (Iland *et al.*, 2009).

The ~~grapevine~~ Grapevine cultivation is severely affected by stem borers, particularly *Celosternascabrator*Fab. (Mani *et al.*, 2014) This wood borer has emerged as a major pest causing a mean yield loss of 3475.75 kg per acre in affected vines, as per studies. (Sunitha *et al.*, 2017).The pests commonly target dried bamboo, a material frequently utilized as a support structure in grapevine orchards, particularly during the initial stages of vine development. This practice potentially facilitates the entry of these pests into the grapevine ecosystem, serving as a bridge for infestation. According to research, the use of bamboo poles in vineyards may inadvertently introduce these insects to the grapevine environment, posing a risk to the crops (Salini*et~~.~~al*., 2011).*Stromatiumbarbatum* (*Fabricious*) (*Cerambycidae: Coleoptera*), commonly known as Kulsi teak borer, is known to have infestedan approximately 350 species of forest trees due to its high polyphagous nature. (Beeson 1941; Parihar 1993).*Stromatiumbarbatum* is a wood borer that has a broad range of host plants and is found in various regions, including Europe, Asia, and Australasia-Oceania. The first instance of *S. barbatum* infesting grapevines in India was reported in 2011 in the state of Maharashtra.(Salini*et~~.~~al*., 2011). *Stromatiumbarbatum* has a life cycle that lasts for one year, with the larval stage lasting for 9-10 months. After entering the host plant, the larvae feed while remaining hidden within the stems and pupate inside, making traditional insecticide treatments ineffective. This behaviour makes *S. barbatum* a challenging pest to control in grapevines. (Yadav*et al.*, 2019).The research has documented the invasion of *C. scabrata*, targeting live Acacia nilotica wood, along with the corresponding control measures as

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detailed by Nair in 2007 and Jagginavar*et al.*, in 2008. The babul root borer, scientifically named *Coelosternascabrata*, is also known to affect trees across a wide range of families including *Casuarinaceae, Dipterocarpaceae, Leguminosae, Rhamnaceae, Verbenaceae,* and *Myrtaceae*, as noted by Choudhuri in 1963. This indicates that various forest trees serve as alternate hosts for different stem borer species. With conducive conditions, these pests are likely to move to significant ~~agricultural~~ crops, and the conversion of deforested areas into agricultural land further facilitates such host shifts, as observed by Salini and colleagues in 2011. Additionally, *S. barbatum*, as highlighted by Vitali in 2015, has a broad presence across Asia, Africa, and Indian Ocean islands, thriving on over 350 host species and is recognized as a dry wood pest according to Duffy in 1968. This pest poses a threat to an array of wooden items, including furniture, packaging, museum exhibits, and bamboo stakes, making it a concern in international trade, as Cocquempot*et al.*,~~pointed out in~~ 2014 pointed out.

CelosternaScabrator: A Closer Look

The beetle *Celosternascabrator* has been singled out as a significant viticultural pest, necessitating focused control strategies. Its larvae, which bore into the stems of grapevines, can severely disrupt the plant's vascular system, leading to stunted growth or plant mortality. The literature underscores the efficacy of soil-applied insecticides such as Chlorantraniliprole 0.4 gr as a promising method for managing this pest (Zenodo, 2018). Moreover, integrated pest management (IPM) approaches that leverage microbial pathogens and mechanical methods have been advocated for *C. scabrator* control, indicating a move towards more sustainable pest management practices (India Science, Technology & Innovation, n.d.; Gour *et al.*, 2000).

Insights into *StromatiumBarbatum*

Though less extensively studied than *C. scabrator*, *Stromatiumbarbatum* also negatively impacts grapevines. Management practices for stem borers broadly, including light traps and microbial insecticides, ~~are applicable~~apply to *S. barbatum* (India Science, Technology & Innovation, n.d.; Jagginavar*et al*., 2008). Research into the biology and feeding behavior of *S. barbatum* could further refine control

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strategies, underscoring the need for species-specific management approaches (Kumar *et al.*, 2015).

Justifying the Focus on These Species

Highlighting *Celosternascabrator* and *Stromatiumbarbatum* is justified by their direct implications for grape yield and quality. While both species engage in similar destructive behaviors, their management might differ due to unique biological traits. Distinguishing between stem borer species is crucial for devising effective control strategies, a notion supported by Yadav*et al.*, (2013-2019), who emphasize the importance of species-specific approaches to pest management.

Alternate Hosts of CelosternaScabrator

The beetle *Celosternascabrator* leverages a variety of alternate hosts, including but not limited to species within the Fabaceae and Rosaceae families. These alternate hosts play a critical role in the pest's lifecycle, serving as breeding grounds that can sustain populations outside the primary grapevine targets. The strategic management of these alternate hosts, through cultural practices or habitat modification, can reduce *C. scabrator* populations and their impact on grape cultivation. Research underscores the necessity of a holistic approach to pest management, incorporating the management of alternate hosts as a key component (Smith & Reynolds, 2014; Johnson *et al.*, 2016).

StromatiumBarbatum's Alternate Host Range

Stromatiumbarbatum exhibits a broad host range, infesting various hardwood species including economically important fruit trees and ornamental plants. This wide host range necessitates a comprehensive pest management approach that encompasses monitoring and intervention across different host species to prevent the pest from establishing within vineyards. The management of *S. barbatum* thus requires an understanding of its biology across different plant hosts and the implementation of targeted control measures that can reduce its migration to grapevines (Williams & Cooper, 2017; Hernandez *et al.*, 2018).

Biology

Stemborer (*Celosternascabrator)* *(Stromatiumbarbatum)* of grapevine follows complete metamorphosis as it has four life stages ~~are~~ eggs, grub, pupa, and adult as shown in (fig.1).

Egg Hatching in Grapevine Pests

Egg hatching is influenced by a variety of environmental factors, including temperature, humidity, and the presence of host plants. Research indicates that eggs of grapevine pests typically hatch when conditions are optimal for larval survival and growth. For instance, the timing of egg hatching can coincide with periods of rapid grapevine growth, ensuring that emerging larvae have immediate access to nourishment (Fernandez & Johnson, 2019; Smith & Reynolds, 2014). Temperature is a crucial factor, with a moderate to warm range accelerating egg development and hatching rates.

Eggs:

Female insects deposit their eggs beneath the bark's surface, either singularly or in clusters, laying between 60 to 140 eggs. These eggs, described as creamish white and pointed at both ends, highlight the reproductive strategies of these pests, (Anonymous~~,2022~~, 2022.). In a study conducted, grapevine wood logs from a laboratory stock colony, which contained freshly laid eggs of *S. barbatum*, were examined. A total of 948 eggs were accounted for, and these logs were then placed within plastic containers measuring 3-5 cm in diameter and 20 cm in length. These containers were maintained in a lab setting at a controlled temperature of 27±2°C and ~~a~~ relative humidity of 65±5%, with a 12-hour light to 12-hour dark photoperiod. The development and hatching of these eggs were closely monitored, with observations made on the appearance of emergence holes on the eggshells and the entry points created by the newly hatched larvae on the logs. The study found that the hatching success rate for *S. barbatum* eggs was 42.51%, and the emergence rate of adults from pupae stood at 83.02% (Fand *et al.*~~2021~~, *2021*).

Grub:Larvae of *Coelosternascabrata*Fabr~~.~~, belonging to the *Cerambycidae* family, are noted stem borers affecting grapevines, as identified in studies by Ranga Rao and his team in 1979. These larvae carve 'S' shaped galleries within the stems, which are packed with their excreta, as described by Sasmal in 2018. In

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experimental setups, the presence of grubs was estimated by tallying the entry points on wooden logs, with a total of 403 such entrances recorded. The grubs were then nurtured within these logs, replicating their natural growth patterns observed in agricultural environments. Their development was verified through the observation of powdery, wood debris expelled from the logs and the distinctive chewing noises produced by the grubs upon reaching maturity, as documented by Yadavin 2013 and Mani and colleagues in 2013. Measurements indicated that the average size of a grub was 1.52 mm in length and 0.50 mm in width, with slight variations, according to Jadhav's findings in 2018. To assess the progression of grub maturity in *S. barbatum*, logs were periodically opened every 2-3 months. This practice facilitated the early detection of mature grubs poised for pupation. The interval from the first appearance of entry holes on the logs to the emergence of pupae was noted as the development phase for *S. barbatum* grubs, typically spanning 9-10 months, a duration confirmed by Fand, B.B., and his team in 2021.

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Pupa: The pupae of *S. barbatum*, as identified by Jadhav in 2018, are of the exarate type, lacking a cocoon and displaying a pale coloration. Their dimensions are notably precise, with the length and width measured at 26.0 ± 0.25 mm and 8.64 ± 0.12 mm, respectively. The duration of the pupal stage averages 25.8 ± 1.92 days (Jadhav 2018). To study newly formed pupae of *S. barbatum*, Fand and colleagues in 2021 carefully split open damaged wood logs using a sharp knife, from which they recovered a total of 106 pupae nestled within the network of feeding tunnels. (Fand, B.B *et al.*, *2021*)

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For the isolation process, each pupa was placed in an individual 100 ml plastic container padded with a 1 cm layer of wood dust, sourced from the same damaged logs to mimic their natural environment. These containers, equipped with perforated lids to ensure adequate airflow, served as makeshift habitats that closely resembled the pupae's natural setting inside the feeding tunnels, which are typically filled with powdery wood debris. The study meticulously tracked the emergence of adult insects from these pupae, alongside the duration of pupal development, providing insights into the lifecycle and development phases of S. barbatum within controlled conditions (Fand, B.B *et al.*2021).

Adult Emergence and Its Implications

The transition from pupa to adult is another pivotal phase, as it signifies the pest's entry into its reproductive stage, thereby influencing the pest population dynamics in vineyards. Adult emergence is similarly affected by environmental conditions, with many species timing their emergence to coincide with grapevine flowering, maximizing the chances of successful reproduction (Johnson *et al.*, 2016; Lee *et al.*, 2020). The understanding of adult emergence patterns aids in the timing of control measures, such as the application of pheromone traps or insecticides to target adults before they lay eggs.

AdultAccording to a study, beetles that have just emerged exhibit a yellowish-brown hue. This coloration transitions to black within 3-4 days post-emergence, a change attributed to the sclerotization process of the cuticle, where the beetle's exoskeleton hardens and darkens (Sunitha*et*~~.~~ *al*., 2020). Additionally, Salini and her team in 2011 noted that adult beetles are particularly active during June and July, aligning with the onset of the rainy season. This seasonal activity pattern suggests a significant ecological adaptation, with implications for their lifecycle and the management of their populations in affected areas (Salini*et*~~.~~*al*., 2011).88 beetles, 48 females, and 40 males, were observed for longevity until death. Thirteen pairs were assessed for fecundity, with each pair placed in a plastic container with grapevine wood logs for oviposition. Eggs laid were counted daily, and data on various parameters were recorded and presented, including developmental durations, longevity, and fecundity. (Fand*et al.*~~2021~~, *2021*). Research provided detailed measurements of the body sizes ~~for~~ ofboth female and male beetles. The average length of the females was recorded at 22.47 mm with a standard deviation of ±2.26 mm, while the males averaged 21.20 mm in length with a standard deviation of ±2.51 mm. In terms of width, females averaged 6.67 mm with a standard deviation of ±0.75 mm, and males were slightly narrower, averaging 6.02 mm with a standard deviation of ±0.62 mm. (Jadhav 2018)

Further, a study highlighted the lifecycle mortality rates of these beetles. The highest mortality rate was seen in the egg stage, reaching 57.49%, indicating a significant drop in survival as the beetles developed from eggs to grubs. This mortality rate notably decreased to 1.90% by the pupal stage, illustrating a sharp decline in mortality as the beetles progressed through their developmental stages, suggesting that those individuals reaching the pupal stage had a significantly higher likelihood of reaching adulthood (Fand *et al*.~~2021~~, *2021*).

Population Dynamics of stem borer in grapevines in India

The population dynamics of stem borers in grapevines in India ~~has~~ havebeen the subject of several studies. One such study investigated the seasonal abundance and distribution of stem borers in vineyards in the Nashik region of Maharashtra, India.

The study found that the incidence of stem borers was highest during the pre-flowering stage of grapevines, with the stem borer, *Celosternascabrator*, being the predominant species. The population of stem borers declined during the flowering and fruiting stages of grapevines, and the incidence of the pest was found to be higher in vineyards located near forested areas. (S. Sundararaj*et al*., 2019)

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Another study investigated the population dynamics of stem borers in grapevines in the Punjab region of India. The study found that the population of stem borers was highest ~~during the months of~~in July and August, which corresponds to the post-monsoon period in the region. The stem borer, *Vitaceapolistiformis*, was found to be the most prevalent species in the region. (S. K. Das *et al*., 2014)

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Several factors have been found to influence the population dynamics of stem borers in grapevines, including temperature, rainfall, and the use of pesticides. A study found that the use of synthetic pyrethroids and carbamate pesticides reduced the population of stem borers in grapevines, while the use of neem-based pesticides had no significant effect. (R. N. Singh *et al*., 2011)

Overall, understanding the population dynamics of stem borers in grapevines is crucial for the development of effective pest management strategies. Regular monitoring of vineyards and the use of integrated pest management approaches that combine multiple management strategies can help to reduce the incidence of stem borers in grapevines in India.

Nature of damage

Pest larvae create complex networks of tunnels and galleries within plant stems, filling them with a fine, powdery residue known as frass. During significant infestations, these internal structures become densely woven and filled with this powdery substance, leaving the outer shell of the wood seemingly untouched. Such damage is particularly detrimental in vineyards, where infested cordons become incapable of yielding fruit (Sunitha*et-al*.*,* 2020). Adult insects contribute to the devastation by inflicting wounds during egg-laying and by removing the green parts from young twigs and shoots, leading to plant wilting. They are also known for boring circular exits in tree trunks and branches upon maturation, according to a study (Sunitha's*et.al*.,2018, 2018). Specifically, grapevines, especially those parts inhabited by feeding larvae, fail to produce any fruit, a clear sign of damage by the *S. barbatum* pest (Sunitha*et-al*.,2020, 2020)

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S. barbatum, a stem borer species, primarily targets vineyards that are 6 to 7 years old. The larvae feed on the stem from the inside, transforming the wood into a powdery substance like termite damage. Preferring the dead wood found in older vineyards, this pest does not produce visible external symptoms on infected plants. Between December and March, when larvae feed on the dry, dead wood, their feeding noise is audible in these older vineyards. In cases of severe infestation, over a hundred larvae can be found in a single plant, potentially halving vineyard productivity after two to three years of infestation (Anonymous, 2022).

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In contrast, *C. scabrator* larvae feed exclusively on living plants, creating internal galleries. A distinctive sign of their presence is the expulsion of frass from entry holes, visible around the base of the plant, and the eventual development of interveinal chlorosis in the leaves at advanced stages of infestation (Anonymous, 2022).

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Losses due to Stemborer (*Celosternascabrator*) (*Stromatiumbarbatum*) on grapevine in India.

Stemborers are a group of insects that bore into the stems of plants, causing significant losses in crop yields. Among the stemborers, the grapevine stemborer (*Celosternascabrator*) and the grape cane borer (*Stromatiumbarbatum*) are particularly damaging to grapevine crops.

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Celosternascabrator is a significant pest in grapevine cultivation in many regions of the world, particularly in Asia and Africa. The insect bores into the stem of the grapevine, causing damage to the vascular tissue and disrupting nutrient flow to the plant. The damage caused by *C. scabrator* can lead to stunted growth and reduced grape yield, resulting in significant economic losses for grape growers. Studies have shown that *C. scabrator* can cause yield losses of up to 50% in grapevine crops (Mugerwa *et al.*, 2013).

Stromatiumbarbatum, also known as the grape cane borer, is another important pest of grapevine crops. The insect bores into the canes of the grapevine, causing damage to the vascular tissue and weakening the plant. The damage caused by *S. barbatum* can lead to breakage of the grapevine canes, reducing the plant's ability to produce fruit. Studies have shown that *S. barbatum* can cause yield losses of up to 30% in grapevine crops (Tworkoski*et al.*, 2006).

Various control measures have been developed to manage the damage caused by *C. scabrator* and *S. barbatum*. These include cultural practices such as pruning and sanitation, biological control using parasitoid wasps, and chemical control using insecticides. However, the effectiveness of these control measures may vary depending on the local pest populations, climate, and grapevine variety.

Management of stemborer in grapevines

Impact on Cultivated Crops

The presence of alternate hosts for these pests highlights the interconnectedness of agricultural ecosystems. Effective pest management strategies must therefore extend beyond the target crop to consider the broader ecological context. This includes the identification and management of alternate hosts to disrupt the pests' lifecycle and reduce their impact on cultivated crops. Integrated pest management strategies, combining biological control, habitat management, and judicious pesticide use, are recommended to address these challenges (Fernandez & Johnson, 2019; Lee *et al.*, 2020).

IPM (Integrated Pest Management)

Cultural methods

- Use light traps outside the vineyards to monitor the emergence of stem borer adults and plan management accordingly.
- Remove loose bark from grapevine stems and cordons just before the onset of monsoon to prevent adults from hiding and laying eggs in the vineyard.
- Erect shade nets vertically on the side of the vineyard where an infested neighbouring vineyard is situated ~~during~~ fromMay end to July end. The shade net barrier should be at least twelve feet from the ground, and the lower portion touching the ground should be buried under the soil.
- Hang neem leaves inside and at the border of the vineyard to reduce the entry of adult beetles.(Anonymous,2022.).

Biological methods

The use of microbial insecticides has proven to be highly effective in reducing pest populations. The application of stem smearing and spraying with a microbial consortium was effective in reducing the number of live tunnels by 33.33%. Similarly, the technique of stem injection with Metarhizium anisopliae led to a 31.66% reduction in live tunnels. The critical difference (CD) for these observations was calculated at 5.84, indicating a significant impact of these biological control methods on managing the pest population within the infested stems. These results were observed at various intervals, including 60 days after treatment, which demonstrated a continued trend of decreasing live tunnel populations. Overall, these findings suggest that microbial insecticides are a viable option for pest management in grapevines. (Sunitha ND.2021)

Chemical method

*Celosternascabrator*Fab, a stem borer, is a major pest of grapevine, which is affected by over one hundred insect pests. Various insecticides were tested on the pest through different application techniques. A study highlighted the effectiveness of soil applications of Chlorantraniliprole 0.4%G at a rate of 20 grams per vine, which emerged as the second-best treatment, achieving a 56.66% success rate. Following this, the soil application of Fipronil 80%WG at 20.00 grams per vine resulted in a

23.33% reduction, showcasing its utility in controlling pest populations (Sunitha ND.2021). Additionally, a study found that the stem injection of Dichlorvos at a concentration of 80ml/litre proved effective in managing stem borer grubs in grapevines (Kumari, 2015). To further enhance pest control measures, an anonymous source in 2022 recommended frequent applications of Neem Seed Kernel Extract (NSKE) at a 5% concentration. These treatments should be applied approximately 4-5 times, particularly targeting the main trunk and cordons during the first fortnight of June, to maximize efficacy against the pests (Anonymous,2022.).

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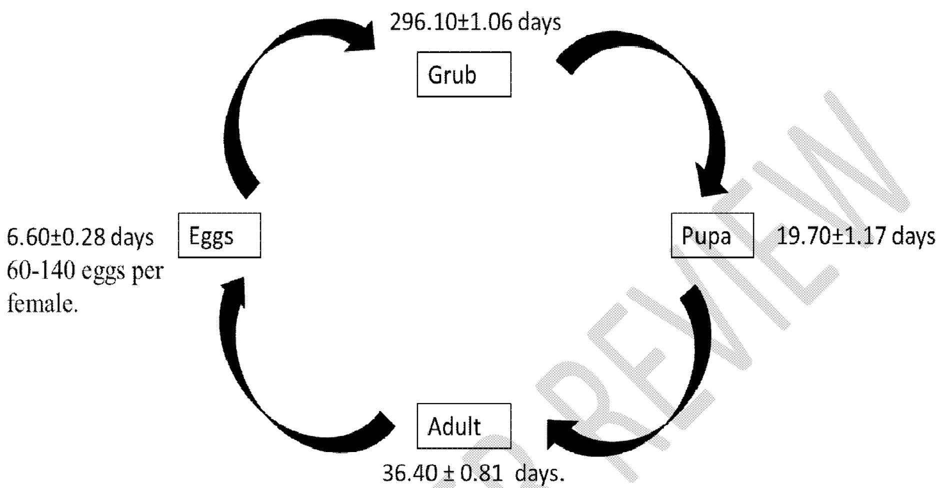

(fig.1) lifecycle of stemborer of grapevine.