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Bionomics, Damage Dynamics, and Resilient Management Approaches for Spotted Pod Borer [*Maruca vitrata* (Geyer)] - An Emerging Threat to Indian Pulses

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ABSTRACT

The maruca pod borer (*Maruca vitrata*) is recognized as a highly destructive arthropod, inflicting harsh damage on a broad spectrum of pulse crops and leading to substantial economic losses. As it can thrive on a diverse range of hosts and adaptability, it remains a persistent pest throughout the year under varying agro-climatic conditions. This insect attacks multiple plant parts, including leaves, flowers, and pods. Its seasonal occurrence

varies across crops and growing seasons; however, larval infestation typically peaks during the flowering and pod formation stages. Females oviposit flattened, scale-like eggs on floral buds, blossoms, foliage, leaf axils, developing pods, and apical shoots. The caterpillars are translucent, bearing distinct dark-brown markings on across all body segments. The caterpillar period extends for about 11–21 days, whereas the complete life span ranges from 27 to 36 daylights, varying with the host plant. Adoption of cultural methods such as mixed cropping, properly timed weed control, optimum sowing period, and appropriate plant spacing has been shown to reduce its incidence in crops like cowpea. Botanical insecticides, including neem-based formulations including neem kernel extract (NSKE) and neem oil besides bio-pesticides like Bacillus thuringiensis, have exhibited distinct degrees of effectiveness across grain legumes Similarly, the effectiveness of insecticides belonging to various chemical classes against this pest has been well documented.

INTRODUCTION

In India, the major pulse crops cultivated include chickpea, arhar, black lentil, mung bean, field bean, and horse gram. Among the various factors that hinder pulse production, insect pests serve a crucial role in reducing yield and productivity. Key pests affecting pulses are gram pod borer, spotted pod borer, plume moth, leafhoppers, whiteflies, and aphids. These pests cause extensive damage, resulting in considerable economic losses. Among them, the maruca pod borer, ranks among the most destructive arthropods, infesting crops primarily from the flowering stage onward. The maruca pod borer, *M. vitrata* Fabricius (Lepidoptera: Crambidae), is recognized as a significant arthropod of food legumes across tropical Asia and sub-Saharan Africa, with additional occurrences reported in the Americas, Australia, and Pacific regions (Sharma, 1998). This species was first documented on beans in Indonesia by Dietz (1914) and subsequently formally documented by Hubner. with subsequent publications by Geyer. This pest is particularly harmful during critical crop growth stages, such as flowering and pod development, where it feeds on essential plant parts including flower buds, blossoms, and pods. Its destructive nature makes it a serious constraint to achieving optimum grain legume productivity.

DISTRIBUTION

The Maruca pod borer (*Maruca vitrata*) is a highly destructive arthropod of edible legumes in tropical and subtropical regions, owing to its extensive spectrum of host species and significant harm prospective. Its geographical distribution covers multiple continents, including Asia, Africa, Australia, and the Americas. In the South Asian region, it stands out as a key pest of arhar, with documented occurrences in Bangladesh (Das & Islam, 1985), Thailand (Buranapanichpan & Napompeth, 1982), India (Sharma, 1998).

HOST RANGE

In India, *M. vitrata* is a significant pest infesting a variety of legume crops, including cowpea, arhar, black lentil, mung bean, field bean, and soybean. During the off-season, when primary host plants are unavailable, the pest sustains itself on alternative hosts such as wild leguminous shrubs, trees, and certain weed species. Commonly infested plants include arhar, cowpea, lima bean, and *Pueraria phaseoloides*. Ramasubramanian and Sundara Babu (1988, 1989) documented caterpillar growth indices of 4.14 on arhar, 4.63 on lobia, and 5.17 on hyacinth bean. The larvae infest up to 39 host species, the majority of which are members of the Leguminaceae family (Atachi & Djihou, 1994). The pest is prevalent across all legume-growing regions of India.

BIONOMICS

In India, comprehensive investigations on the biological characteristics of the maruca pod borer in pigeon pea were conducted by Vishakantaiah and Jagadeesh Babu (1980) and later by Lalasangi (1988).

Egg: Eggs are flat, slightly elongate, pale yellowish, translucent with faint reticulate sculpturing on thin and delicate chorion (Vishakantaiah & Jagadeesh Babu, 1980). Eggs are glued to the under surface of leaves, shoot apex and floral buds. According to Naveen *et al.* (2009), newly deposited eggs are milky white, ovate, and compressed along the dorsoventral axis. The fecundity of female moths and the egg incubation period differ depending on the host plant. A peak count of 140 eggs has been documented on lobia, whereas Vishakantaiah and Jagadeesh Babu (1980) recognized between 5 and 15 egg clusters on arhar, with hatching occurring in approximately 3.3 days.

Larva: Mature caterpillars are 17–20 mm long, with a semi-transparent body exhibiting a pair of dark brown markings on each segment, although the prominence of these markings differs depending on the host plant, and some caterpillar may be entirely unmarked. Caterpillar development occurs through five successive instars. The caterpillar head capsule exhibits a color range from light to dark brown, and the prothoracic plate is dark brown with a dorsal division. Spotting tends to fade prior to pupation. Larvae are nocturnal feeders, active mainly during the evening, and exhibit photonegative behaviour (Singh & Taylor, 1978). The larval duration has been reported as approximately 12.7 daylights (Vishakantaiah & Jagadeesh Babu, 1980) and 16.4 daylights (Jackai & Singh, 1983) on pigeon pea. In Southern India, the total caterpillar period on lobia is around 10 days; however, Ramasubramanian & Sundarababu (1988) showed caterpillar durations of 13.9 daylights on lobia, 13.3 daylights on arhar, and 12.9 daylights on hyacinth bean.

Pupa: The pupae are obtect, brown in colour, and enclosed within a thin, gauze-like cocoon. On average, each pupa is approximately 12.5 mm in dimension and 3.0 mm in girth. The length of the pupal stage is variable depending on the host plant. On pigeon pea, it lasts about 8–10 days (Vishakantaiah & Jagadeesh Babu, 1980), whereas Jackai & Singh (1983) reported pupal periods of 11.6 days on sunhemp, 11.1 daylights on arhar, and 5.6 daylights on lobia. Further, Ramasubramanian & Sundarababu (1988) observed the shortest length of pupation is 6.4 daylights on arhar, 6.9 days on black eyed pea, and a similar period on hyacinth bean (7.5 days).

Adult: Adult moths are moderate-sized, with dusky-brown forewings featuring a crescent-shaped, white spot bordered in black near the distal close of the cell. From just below the costa, a noticeable semi-transparent band with dark edges extends past the cell. Ramasubramanian & Sundarababu (1988) reported that adult endurance ranged from 5.9 to 8.6 days on cowpea, 6.1 to 8.5 days on pigeon pea, and 6.1 to 10.0 days on lablab. On pigeon pea, the entire life cycle was reported to last about 27 daylights (Vishakantaiah & Jagadeesh Babu, 1980), while the average lifespan duration was 30.2 daylights for males and 32.6 daylights for females.

SEASONAL OCCURRENCE

The activity of *Maruca vitrata* (formerly *M. testulalis*) shows distinct seasonal patterns across different regions of India. According to Lalasangi (1988), peak infestation occurs during July, August, and October. Light trap observations at ICRISAT, Hyderabad monitoring revealed two separate peaks in population, the first in September and the second spanning early November to mid-December (Srivastava *et al.,* 1992). At Hisar, the ultimate activity was recorded between mid-September and mid-October, while in Dholi, Bihar, the pest incidence ranged from mid-autumn month to late November, with the highest population towards the end of November. Similarly, at Pantnagar, infestation began in early September, reaching its peak in mid-October (Bajpai *et al.,* 1995) on pigeon pea. In Karnataka, on field bean, pest activity extended spanning the latter half of September through the first half of February, with the highest prevalence occurring from late November to early December (Thejaswi *et al.,* 2008). Gopali *et al.,* (2008) further documented a bimodal pattern on pigeon pea in Karnataka, with an initial peak during mid-October subsequently showing a second peak in December.

INFESTATION POTENTIAL

In pigeon pea, the annual economic losses attributed to *M. vitrata* have been assessed at approximately USD 30 million. Yield reductions due to spotted pod borer infestation in Madhya

Pradesh have been reported to range between 35% and 40% (Bindra, 1968). Larval feeding can result in about 10% damage to flowers and 25–40% damage to pods in pigeon pea. In cowpea, yield losses of 20–60% have been documented. Studies conducted in Bangalore revealed infestation levels in pigeon pea varying from 9% to as high as 84% (Vishakantaiah & Jagadeesh Babu, 1980). Outbreaks triggered by delayed sowing combined with prolonged dry spells have occasionally led to near-total loss of flower buds and pods in pigeon pea crops in Karnataka (Giraddi *et al.,* 2000). Overall, the annual loss induced by Maruca in India are projected to reach about USD 30 million (Saxena *et al.,* 2002).

MODE OF INJURY

Adult moths show a preference for laying eggs on young and tender plant parts, including floral buds, blossoms, shoot apex, and newly emerged pods (Taylor, 1963). Upon shading, the early instar caterpillars (1st to 3rd) primarily attack apical shoots and floral buds, whereas later instars (4th and 5th) cause significant injury to exposed florals and developing pods. The caterpillars usually consume from within a weblike cluster of plants, buds, florals, and pods, which offers protection against natural enemies and reduces the effectiveness of insecticides. Mature larvae are highly active and move extensively, feeding on blossoms and afresh opened pods, leading to potential damage during the crop's reproductive phase. In black gram, young larvae bore into stems through leaf axils, inducing wilting (Goud & Vastrad, 1992). In pigeon pea, the caterpillar initially damages leave by rolling and webbing them, later shifting to buds, flowers, and pods during the flowering and pod development stages, which they bind together with silk for feeding. Preference studies indicate that third-instar caterpillars favour pods over blossoms and leaves, while newly hatched caterpillar show a greater preference for flowers compared to pods and leaves (Sharma, 1998).

ECONOMIC INJURY LEVELS

Ganapathy (1996) reported that the economic injury level on pigeon pea is 3.0 caterpillar per plant, and when *M. testulalis* and *Exelastis atomosa* occur together, a combined threshold of two pairs per plant at 50% flowering stage is recommended.

SUSTAINABLE MANAGEMENT APPROACHES

Cultural management strategies: Damage to cowpea caused by *M. vitrata* can be significantly reduced through cultural practices for example, intercropping, timely weeding, appropriate planting stretch, and maintaining proper plant density. Sowing cowpea at a spacing of 30 × 20 cm or 60 × 20 cm at the onset of rains helps minimize infestation by *M. vitrata* along with other significant insect arthropods. Wider spacing of 1.0 –1.5 m has also been shown to lower pod borer incidence (Asiwe *et al.,* 2005). Intercropping with sorghum and practicing deep plowing during summer can reduce pod borer populations by up to 85%, thereby improving the productivity of legume fields. In addition, maintaining bird perching sites in fields has been observed to enhance natural pest control. At low pest densities, regular monitoring and manual removal of *M. vitrata* eggs and larvae are considered more effective and sustainable compared to the reliance on synthetic insecticides.

Sex pheromone trapping strategies: In recent years, sex pheromones have emerged as an effective tool for managing *M. vitrata* abundance, and pheromone traps have been shown to be an effective supplementary method for controlling pest populations. Numerous studies have been undertaken on the identification and application of sex pheromones in legume pod borer management. Among the identified compounds, the pheromone blend is primarily composed of (E, E)-10,12-hexadecadienal, with (E, E)-10,12-hexadecadienol and (E)-10-hexadecenal acting as minor constituents (Kar *et al.,* 2007; Schlager *et al.,* 2012). Other compounds, including (E)-10-hexadecenol and (Z, Z, Z, Z, Z)-3,6,9,12,15-tricosapentaene, have been shown to improve trap efficiency. Field observations demonstrated that large numbers of moths in light traps set during pigeon pea cropping occasionally collected over 1,500 months in one dark seasons in Kano, Nigeria, highlighting the potential of combining pheromone-based trapping with other integrated pest management strategies to effectively reduce *M. vitrata* damage (Zakari *et al.,* 2019).

Botanical pest management strategies: Neem-based formulations have shown considerable effectiveness against the legume pod borer, although their efficacy is generally lower than that of certain synthetic insecticides. Singh *et al.,* (1985) reported that neem seed powder and NSKE were efficacious, but NSKE was less potent compared to fenvalerate and monocrotophos. Similarly, Bhat *et al.,* (1988) observed that was the second most efficacious treatment after monocrotophos. for managing pod borers on lobia. Ramasubramanian & Babu (1991) reported a notable decrease in flower damage in lablab after foliar applications of NSKE. Shambulingappa (1994) further validated the efficacy of NSKE and neem oil in controlling pod borers on arhar. Later, Durairaj (1999) reported that NSKE at 5% concentration effectively suppressed lepidopteran insects in pigeon pea. Ganapathy (1996) also exhibited that NSKE (5%) and neem oil (3%) significantly reduced caterpillar populations (1.0 and 1.3 per plant), floral harm (7.7% and 10.4%), webbing incidence (1.6 and 1.5 per plant), and injury to pods (6.6% and 7.8%).

Bio-based pest management strategies: According to Mohapatra & Srivastava (2002), Biobit, a Bacillus thuringiensis formulation, applied to the foliage at 1000 g a.i./ha, effectually managed *M. vitrata* in arhar. Similarly, Chandrayudu *et al.,* (2008) demonstrated that a commercial Bt formulation at 0.0025% significantly reduced pod injury caused by the maruca pod borer in lobia. Sunitha *et al.* (2008) documented Bt at a concentration of 6.7×10^{11} and Metarhizium anisopliae at 1×10^{6} were abstemiously useful against M. *vitrata* in pigeon pea under field conditions at Hyderabad. Further, Sreekanth & MahaLakshmi (2012) observed that the lowest florescence injury (4.74%) occurred in plots received sequential use of spinosad 45% SC (73 g a.i./ha) as a foliar application, Bacillus thuringiensis at 1.5 kg/ha (10.52%), and Beauveria bassiana SC at 300 mg/L (14.15%), resulting in significant control of the pest. These treatments resulted in reductions over control of 80.9%, 57.6%, and 42.9%, respectively, compared to 24.79% damage in untreated plots.

Synthetic insecticidal compounds: Lakshmi *et al.,* (2002) documented those dual foliar applications of chlorpyrifos at 0.05%, administered ten days apart, significantly reduced the caterpillar abundance of *M. vitrata* on black lentil by 48.86%. Similarly, they observed a notable decrease in cowpea pod injury caused by the maruca pod borer when treated with a combination of chlorpyriphos and DDVP at 2.5 + 1 ml per liter. In arhar, Malathi (2007) found that applying chlorpyriphos 20 EC at 2.5 ml per liter during the 50% flowering stage resulted in the highest reduction (67.98%) in *M. vitrata* population. Novaluron 10 EC at 1.0 ml per liter also showed good efficacy. Further, Rao *et al.,* (2007) documented that spinosad 45 EC at 0.4 ml per liter and indoxacarb 14.5 EC at 0.4 ml per liter resulted the least pod injury in arhar. According to Shivaraju (2009), applications of thiodicarb 75 WP (562.5 g a.i./ha) and flubendiamide 480 SC (48 g a.i./ha) demonstrated high efficacy, followed by indoxacarb 14.5 SC at 75 g a.i./ha in black gram. Additionally, MahaLakshmi *et al.* (2012) indicated that flubendiamide at 0.2 ml per liter, thiodicarb at 1.5 g per liter, and emamectin benzoate at 0.4 g per liter provided effective control of the maruca pod borer in black gram. Moreover, Coragen 20% SC at 20 g a.i./ha has been suggested as a substitute for conventional insecticides for suppression of the legume pod borer (MahaLakshmi *et al.,* 2013).

CONCLUSION

Most of the research on the bionomics, damage patterns, and sustainable management of *Maruca vitrata* has focused primarily on pigeon pea, with limited studies on cowpea. However, similar investigations are required on other major pulse crops like mung bean and urd bean. Comprehensive information on seasonal occurrence, as well as the determination of Economic Threshold Levels (ETLs) is still lacking for many pulse crops. Although several predators and parasitoids of *M. vitrata* have been documented in other countries, data on their occurrence and role in India remain scarce and need detailed exploration. While numerous studies have assessed chemical insecticides and botanicals, research on the use of biopesticides in India is very limited. Further investigations are necessary to determine the efficacy of biopesticides, pheromone-based strategies, biorational approaches and the feasibility of techniques such as intercropping, border cropping, and the employing trap crops as part of cohesive suppression of the spotted pod borer.

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