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Review on biology and management of *Anomis spp.* other than *A. sabulifera* (Lepidoptera: Erebidae)

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Abstract
Generalist semiloopers of the genus *Anomis* are one of the most notorious defoliator pests of different economic crops throughout the world. Numerous studies on biology and management of different *Anomis spp.* have been conducted throughout the world for more than seven decades (1956-2025). Pest fitness is also influenced by the genetic traits specific to the population and different biotic as well as abiotic factors. Now, it is imperative to study the bioecology and alternative management strategy for different *Anomis spp.* including *A. sabulifera* on different crops to predict their outbreaks. This review will obviously support the use of different sustainable management strategies like trap cropping for sustainable production of different economic crops against such generalist semiloopers. Future researches can use this information to formulate proper sustainable IPM against this notorious semiloopers in near future.

Keywords: *Anomis spp.*, management, IPM

Introduction

Insect pests are one of the major constraints in limiting yield potential of different economic crops throughout the world (Schoonhoven *et al.*, 2005) [1]. Worldwide, different economic crops are attacked by ecologically similar complexes of insect pests and their natural enemies (Sadat & Chakraborty, 2019) [50]. Among the pest complex, jute semilooper, *Anomis sabulifera* (Guenée 1852) and cotton semilooper or okra caterpillar, *A. flava* (Fabricius, 1775), *A. flava flava*, *A. impasta A. leona, A. privata, A. commoda, A. mesogona* etc. [Lepidoptera: Erebidae] are the most destructive holo-metabolic insect pests in the South East Asian countries (Khan 1956; Srivastava & Rose 1989; Santos *et al.*, 2012; Suman & Singh 2022; Babu *et al.*, 2025) [26,62,51,66,6]. These sporadic defoliator pests sometimes cause serious damage to various economic crops (Sadat & Chakraborty, 2019; Babu *et al.*, 2021) [50,5]. The life-cycle of the semiloopers, *Anomis spp*., is completed within 24-44 days (Rao & Patel 1973; Neupane 1977; Senapati & Ghosh, 1991; Essien & Odebiyi, 1991) [45,40,54,15]. They completed their life cycle through four metamorphic stages and several generations are completed in a year (Neupane 1977; Essien & Odebiyi, 1991; Babu *et al.*, 2021) [40,15,5]. For management, several strategies like, hand removal of the larvae, ploughing the infested fields after harvest to kill the pupae, dislodge the caterpillars by drawing a rope across the young crop and spraying endosulfan 35 EC or phosalone 35 EC at first appearance of the pest, etc. are recommended. Plant-derived products or commercial products that contain *Bacillus thuringiensis* can be used against young larvae (Singh & Kumar, 2015) [56]. Their natural enemies include tachinid flies and parasitoids like, *Litomastix gopimobani* (Encyrtidae), *Tricholyga sorbillans* and *Sisyropa formosa* (Tachinidae) and few entomopathogenic fungi (Sadat & Chakraborty, 2019) [50]. But unfortunately, management of the notorious pests, *Anomis spp.* by applying broad-spectrum synthetic pesticides or other means injudiciously for even a single pest observation irrespective of pest density or their population growth is practiced often (Carvalho, 2017) [10]. These result in secondary pest outbreak, pest resurgence and development of pesticide resistance (Kim *et al.*, 2005) [27].

The basic information on biology of an insect pest is necessary before deciding any strategy to combat with the pest (Chen *et al.*, 2017) [11]. Host plant quality influences larval growth and development of insect pests which are the key determinant of adult longevity, fertility, fecundity and survivability (Dicke, 2000; Shobana *et al.*,2010; War *et al.*, 2012) [13,55,69].

Morphological and chemical characters of plant surface also serve an important role in insect–plant interactions (Jetter *et al*., 2000) [20]. Even, environmental factors always influence the growth, reproduction, longevity and survival of that population (Schowalter, 2006) [53]. On the other hand, life table is a powerful tool for analysing and understanding the effect of different hosts on feeding, growth, survival and reproduction of an insect pest (Kakde *et al*., 2014) [21]. Biology and population dynamics of the pests are very crucial for their sustainable management (Southwood and Henderson, 2000) [60]. Therefore, understanding the fundamental life history parameters of *Anomis spp.* on their host plants will enhance effective strategies to control these economic pests. Thus, objectives of the present review were to (i) find out the bioecology, host damage by different *Anomis spp.*, (ii) find different management strategies of the pest to suggest alternative strategy for IPM of *Anomis spp.* in the field.

Review of literature

The bioecology and management of the notorious pest, *Anomis spp.* other than, *A. sabulifera* was studied for more than seven decades (1956-2025). Taxonomy, distribution and biology of several semilooper species (*Anomis spp.*) is represented in the table 1-2. Whereas, the damage potential and host range of *Anomis spp.* is presented in table 3. The existing management strategies of *Anomis spp.* is also represented in table 4 with proper citation of existing research till date. Most of the important studies are included in this detail review through literature survey and mentioned bellow accordingly and chronologically:

1. *Anomis flava* (F.) injured cotton over a large area in Hyderabad State in September 1956. The larvae devoured whole leaves, attacked the corolla, ovaries and stamens of the flowers and completely destroyed the calyces of developing bolls. The eggs were deposited on the leaves, and pupation took place in cocoons spun between leaf folds; the egg, larval and pupal stages lasted about 3-4, 15-20 and 9 days, respectively. Mild outbreaks were controlled by hand-picking; against severe ones, spraying with 1-1.25 oz. lead arsenate per gal. or 0.25 per cent. DDT was ineffective, but a spray of endrin at 5 cc. 19.5 per cent. emulsion concentrate per gal. gave complete mortality within six hours when applied at 1.5-2 lb (Khan 1956) [26].
2. *Brachymeria multicolor* (Kieff.) and the new species *B. tibialis*, both reared from *Anomis flava* f. in Madagascar, are described. The former, still bred from a Pierid, has no economic value, while the latter, which attacks many others Noctuids and Pyralids, seems very effective against *Anomis* on cotton (Steffan 1958) [63].
3. *Anomis flava flava* (F.) has caused considerable damage to kenaf [*Hibiscus cannabinus*] in Taiwan since 1964. The larvae feed on the leaves and buds, and heavy infestation reduces top growth. The Noctuid has three generations a year, of which the third is the most injurious. It feeds only on Malvaceae, and in Taiwan its main food-plants are cotton and kenaf. Chemical control presents some difficulty, and other possible remedial measures are discussed (Yu & Tu 1969) [74].
4. An account is given of laboratory and field-plot studies carried out in Gujurat, India, on the biology and control of *Anomis flava* (F.) on okra (*Hibiscus (Abelmoschus) esculentus*). The total life-cycle (from oviposition to the death of the adult) at 28.32 deg C averaged 31.42 days. When the effectiveness of sprays of 0.075% malathion, 0.1% endosulfan, 0.25% DDT, 0.03% dimethoate and 0.15% carbaryl against larval infestations was evaluated in field plots, all the treatments gave at least 94.7% mortality after both 24 and 48 h while carbaryl gave 100% mortality at both times (Rao & Patel 1973) [45].
5. Biology of the cotton semilooper, *Anomis flava* F. was studied in the laboratory. The average number of eggs laid by an individual female was 325.0 when fed on sucrose and 37.50 when fed on water alone. The egg, larval, prepupal and pupal periods were 3-4, 14-20, 2 and 6-8 days respectively. The sex ratio was 1:1. The larvae were parasitized by a hymenopterous parasite, *Meteorus sp.* and the extent of parasitization was as high as 60% during 1974 (Neupane 1977) [40].
6. The distribution of larvae and larval damage of the cotton looper, *Anomis flava* Fabr., during periods of natural attack on cotton in the south-east Queensland region. Major damage was caused to leaves 14–21 days old which were approximately midway through their photosynthetic capacity range and continuing to decline in photosynthetic importance. The data are considered relative to the inclusion of loopers in a complete pest management program currently being developed for cotton in the south-east Queensland region (Bishop *et al*.1978) [9].
7. A severe infestation of *Anomis flava* (F.) was observed on musk mallow (*Hibiscus abelmoschus* (*Abelmoschus moschatus*)), an essential oil crop in India, at Lucknow, Uttar Pradesh, during the rainy season. The intensity of attack decreased as temperatures became lower, and the pest disappeared completely in mid-November (Singh & Manchanda 1980) [57].
8. Characters identified in the laboratory in India for distinguishing male and female pupae of *Anomis flava* (F.) are described. Differences were found in the sternal areas of the 8th and 9th abdominal segments (Singh *et al*.1981) [58].
9. The effectiveness of a nuclear polyhedrosis virus against the cotton pest *Anomis flava* (F.) was determined in laboratory and field tests in Hubei Province, China, in 1979-80. In the laboratory, the mortality of 1st-3rd-instar larvae infected with doses ranging from 1×10^5 to 5×10^6 polyhedral inclusion bodies (PIBs)/ml was 89.4-100%, peak mortality occurring 5-6 days after infection. In the field, doses ranging from 6×10^5 to 3×10^6 PIBs/ml gave 80-96.7% mortality, peak mortality occurring 8-10 days after spray application. The data indicated that the virus had potential as a control agent for the pest (Liang *et al*.1981) [34].
10. A single spray application of *Bacillus thuringiensis* and chlordimeform (chlorphenamidine) at 350 g/ha provided adequate control of a larval population of *Anomis flava* (F.) that built up in the unsprayed crop. Eggs of *A. flava* were not parasitised by *Trichogramma* (Twine & Lloyd,1982) [67].
11. Information is given on the taxonomy, morphology and biology of *Anomis flava flava* (F.) on cotton in the Philippines, which appears to be recorded for the 1st time in that country and to be well distributed throughout the cotton-growing areas of the islands. The

eggs were laid singly on the lower surface of the leaves and had an incubation period of 2-3 days. The larval stage usually lasted 11 days and included 5-6 instars, and the pupal stage lasted 6-11 days (Ferino *et al*. 1982) [17].

12. The population dynamics of *Anomis flava flava* (F.) on cotton were studied in the Philippines in the 1978-79 and 1979-80 crop seasons. The heaviest mortality occurred during the larval and pupal stages. Larval disappearance was attributed to predation by *Eumenes* spp. and appeared density-dependant. Egg and pupal mortality from parasitism (by *Trichogramma* sp. and *Brachymeria obscurata* (Wlk.), respectively) was also directly related to population size, while egg infertility and larval parasitism were inversely related to it. Population growth was inhibited by high temperatures and favoured by rainfall. Seed cotton yield was signficantly reduced only at pest densities of 6-8 larvae/plant or at damage rates involving at least 60% defoliation (Ferino *et al*.1982) [16].
13. A field trial was carried out in Punjab, India, to determine the effectiveness of synthetic pyrethroids against *Anomis flava* on cotton. The compounds tested were fenvalerate, permethrin, cypermethrin, flucythrinate, fenpropathrin and fluvalinate all at 50 and 100 g a.i./ha, and deltamethrin at 10 and 20 g a.i./ha. Carbaryl at 1250 g a.i./ha was used for comparison. Large numbers of larvae were collected from treated fields within 1 h of spraying. Three groups of 15 larvae each were reared on treated food and another 3 groups on untreated food. Larvae were also collected from unsprayed fields and reared on treated food with 1-, 3- or 7-day-old spray deposits. Larval mortality was recorded after 72 h, and that of treated larvae fed on treated food ranged from 51% for fluvalinate to 100% for carbaryl (Dhawan *et al*.1985) [12].
14. Fruit-piercing moth, *Anomis fructusterebrans* is compared with those of other species in this genus and their significance as pests in fruit orchards is compared. The piercing mouth parts are compared with those of other *Anomis* and their significance as pests in fruit orchards is discussed (Banziger H. 1986) [7].
15. The taxonomy of 8 species of the genus *Anomis* from India, including *A. mesogona, A. flava* and *A. sabulifera* and one new species is discussed. The male and female genitalia of these species are described and a key to species of this genus is provided (Srivastava & Rose 1989) [62].
16. Dead larvae of the noctuid *Anomis flava* collected in Shanxi, China, were found to be infected with a granulosis virus, which is described. The virus was highly infective to *A. flava* and the pyralid *Ostrinia furnacalis*, producing 98-100% mortality in 3- and 6-day-old larvae of *A. flava*. The virus was designated An-03 Gv in the B subgroup, *Baculovirus*, Baculoviridae. In field trials, the preparation produced 75-85% control of *A. flava* (Yin *et al*.1991) [73].
17. In laboratory experiments at 21-29°C and 71-90% RH, larvae of *Anomis flava* which were reared in groups on okras generally passed through 5 instars, whereas about 22% of individually reared larvae passed through 6 instars. The life cycle from egg to adult emergence ranged from 20 to 33 days. The oviposition period lasted 12 days and daily oviposition reached a peak on the 7th day. The average number of eggs laid per female was 476 with a viability of 78%. Longevity of males was 26 days and of females 19 days on average. (Essien and Odebiyi 1991) [15].
18. *Apanteles anomidis* is an important natural enemy of the cotton pest *Anomis flava*. It has one generation per year in Yuanjing County, Hunan, China. A mated female laid 109.2 eggs in 9.2 2nd-instar larvae and preferred to oviposit in 1st- to 3rd-instar larvae of the host. Methods of protecting *Apanteles anomidis* are discussed (Xiong *et al*.1994) [71].
19. A study was conducted in Burkina Faso from 1991 to 1994 on the parasitoids associated with the following lepidopterous pests of cotton including *Anomis flava* (F.). Thirty-nine primary parasitoid species and ten secondary parasitoid species were collected. An unidentified Tachinidae on*A. flava* and *Metopius discolor* Tosquinet (Ichneumonidae) on *S. littoralis*. (Streito and Nibouche1997) [64].
20. *Rhynocoris kumarii* Ambrose and Livingstone (Heteroptera: Reduviidae) is documented as an important predator of several pests of agricultural crops in South India. An attempt was made to evaluate the biocontrol potential of *R. kumurii* against the gram pod borer, *Helicoverpa armigera* (Hubner) and the cotton semi-looper, *Anomis flava* (Fabricius) in okra field cages (Ambrose 2000) [1].
21. Spatial distribution pattern of larvae of *Anomis f1ava* (Fabricius) was studied on mungbean [*Vigna radiata* (L.) Wilczek], urdbean [*Vigna mungo* (L.) Hepper] and cowpea [*Vigna unguiculta* (L.) Walp.] during kharif seasons of 1992 and 1993. About 50% time the values of various indices were less or close to random distribution and rest ~f the values revealed aggregated behaviour (Rathore & Tiwari 2002) [46].
22. The semilooper, *Anomis flava* Fab is a foliage feeding lepidopteran insect, often found occurring in the cotton ecosystem during the first 60–75 days of sowing. Its occurrence overlaps or just precedes the incidence of Helicoverpa armigera. This study reports the impact of mechanical wounding or of prior herbivory by semilooper larvae on cotton host-plant resistance to H. armigera. (Kranthi *et al*. 2003) [29].
23. An outbreak of *A. flava* on cotton was observed during August-September 2001 around Umerkote, Orissa, India. As many as 10-12 larvae per plant were recorded during mid-August. However, the population of *A. flava* declined sharply and disappeared by the end of October. The rapid decline in larval population during mid-October (17.5-35.5% mortality) was attributed to *N. rileyi*, which was isolated from the dead larvae (Mohapatra & Sahu 2004) [38].
24. Pathogenicity of entomopathogenic nematde, Steinernema carpocapsae Pocheon strain (ScP) was evaluated against different larval stages (2nd, 3-4th and 5th) of *Anomis commoda* and *Anomis mesogona* (Lepidoptera: Noctuidae) in petri dish and pot. The LC50 values were increased in proportion to larval stage of *A. commoda* and *A. mesogona*. LC50 value of ScP against 2nd instar of *A. commoda* and *A. mesogona* was 9.7 and 4.5, respectively (Kim *et al*. 2005) [27].

25. The lesser cotton leafworm, *Anomis impasta* (Guenée) (Lepidoptera, Noctuidae) in cotton. Anomis impasta (Guenée) is a species that shows remarkable morphological and behavioral similarities with the cotton leafworm *Alabama argillacea* (Hübner). The similarities with *A. argillacea*, as discussed in this study, can be one of the reasons for low reference to *A. impasta* in the field. Therefore, the information provided here will allow researchers and growers to distinguish these two cotton defoliators (Santos *et al*. 2012) [51].
26. The study on the major insect pest community of *Hibiscus syriacus*. There were three orders, seven families, and thirteen species of insects harmful to *H. syriacus*. *Anomis privata* appeared at a rate of 0.05 per tree during the first week of May and continuously occurred from the fourth week of June to the fourth week of October. Its occurrence was most frequent at 2.30 per tree during the third week of September (Kim *et al*.2013) [28].
27. Invasive tropical Noctuidae pest species collected in Israel included *Spodoptera mauritia* (Boisduval), *Trichoplusia vittata* (Wallengren), *Anomis flava (*Fabricius), *Anomis sabulifera* (Guenée), *Earias vittella* (Fabricius), *Earias biplaga* Walker, and *Earias cupreoviridis* (Walker). Possible reasons for this type of distribution are discussed. Several common parasitoid species – *Elasmus flabellatus* (Fonscolombe), *Elasmus nudus* (Nees) and *Elasmus viridiceps* Thomson (Hymenoptera: Eulophidae), with potential as biological control agents for tropical noctuids, are detected in Israel (Kravchenko *et al*. 2014) [30].
28. The present investigation was carried out to evaluate the parasitoids (*Trichogramma raoi*, *T. chilonis*), predator (*Chrysoperla cornea*) and biopesticides i.e. botanicals (neem based Gronim) / mocrobials (*Bacillus thuringensis* and *Beauveria bassiana*) against five major insect pests *viz*. *Polytela gloriosae*, *Anomis flava*, *Earias vitella*, *Dysdercus cingulatus* and *Aphis gossypi* of important target species of medicinal plants- *Abelmoschus moschatus*, *Gloriosa superba* and *Withania somnifera* in forest nursery, Tropical Forest Research Institute, Jabalpur and Delakhari west Chhindwara forest division, Madhya Pradesh (India). The results revealed that *Bacillus thuringensis* 1% followed by neem-based pesticide (Gronim) 1% was found to be most effective against all defoliators (Meshram *et al*.2015) [36].
29. Recent field survey in the last 3 years at the Cocoa Research Institute of Nigeria (CRIN) showed that eight out of ten Lepidopteran caterpillars is *Anomis Leona* Schaus (Lepidoptera: Noctuidae). Some life cycle parameters of *A. leona* were investigated in the laboratory inside a growth chamber at an ambient temperature of 27 ± 3 °C and 70–80% relative humidity. The insect undergoes holometabolous development. The insect completed its life cycle in 26.3 days (range 24–30 days) from the egg stage (Maroof *et al*. 2020) [35].
30. Muskdana, *Abelmoschus moschatus* (L.) is a medicinal cum minor vegetable crop in India. The knowledge of insect pests infesting the crop is especially important for its sustainable management. But the information on the pest complex of this crop is very scanty, particularly from the Northern part of West Bengal. Therefore, field experiments were explored to document the biodiversity of insect pest complexes of muskdana in Pundibari, West Bengal for two seasons in the year 2021 and 2022 respectively to document the pest situations throughout the crop growth period. The present study reports nearly twelve species of insect pests that occurred on muskdana. The foliage feeders like leaf folder, *Helcystogramma hibisci*, and leaf roller, *Sylepta derogata* caused noticeable damage to the foliage by occurring in large populations from the early vegetative to maturity stage of the crop, while cotton semi looper, *Anomis flava* was observed sporadically with a moderate population (Rani *et al*. 2022) [43].
31. Cocoa is an important foreign exchange earner and a major source of income for several households in Ghana. In 2018, a larval outbreak on cocoa pods was reported in Ghana. The outbreak was mainly caused by larvae of *Anomis leona* (~96% infestation of cocoa trees in some communities) with extensive feeding damage (chewing channels/tunnels) on the pericarp of pods. Field populations of *A. leona* larvae from districts in the Central region subjected to bifenthrin were susceptible at the recommended field rate (0.0245%) for mirids after 48 h of exposure under laboratory conditions. The insecticide induced a median lethal concentration (LC50) of ≤0.0061% and ≤0.0018% on A. leona larvae from Jukwa and Twifo Praso in the Central region at 24 and 48 h of exposure, respectively. Field application of bifenthrin was able to suppress infestation. The findings show that Anomis larvae were responsible for the outbreak, inducing extensive damage on pods (Avicor *et al*.2022) [3].
32. The effect of two rearing cages, a wicker-framed muslin cage and a wooden cage on longevity of adult *Anomis leona* Schus (Lepidoptera: Noctuidae) was investigated in Entomology laboratory of the Cocoa Research Institute of Nigeria (CRIN), Ibadan at an ambient temperature of 27 ± 3 °C and 70–80% relative humidity. The adult insect was fed on 10% commercial sugar solution, a formulation required for its gonads maturation. The results showed that the adult *A. leona* reared in wicker-framed muslin cage lived significantly longer with mean value of 16.2 days and 13.3 days than the adult insect in the wooden cage with mean value of 5.2 and 6.8 days. Virgin and mated males and females of *A. leona* reared in a wicker-framed muslin cage and fed on 10% commercial sugar solution lived significantly longer than virgin and mated males and females of *A. leona* fed on ordinary distilled water (Idoko & Maroof 2022) [19].

Discussion

Different insect pests are the major constraints in limiting yield potential of different economic crops throughout the world (Schowalter, 2006) [53]. The poor productivity of these crops in India has been attributed to many factors but among them insect pests' infestation is a major limiting factor (Kumar *et al*., 2024) [31]. Among the insect pest different semiloopers, *Anomis spp.* and other Lepidoptera species are common foliage feeders (Rahman & Khan, 2012; Babu *et al*., 2025) [6, 42]. The protection of these crops against pest damage is important in optimizing their yield (Kumar *et al*., 2024) [31]. The deployment of improved cultivars and adoption of cultural practices, including fertilizers, can increase yield. However, these inputs can be expensive or unavailable in some areas of their production (Yadav *et al*., 2010) [72]. Insects always look for a true and healthy host plant for proper nutrition, oviposition for their neonates (Dicke 2000) [13]. Whereas, plants have evolved a regulatory mechanism to maintain a balance between growth and defence responses (Wu & Baldwin 2009) [70]. Whereas, herbivore also use some volatiles for host finding and oviposition (Kessler & Baldwin 2001, 2002; Roy, 2025) [24,48]. The basic information on population growth of an insect pest in respect to host phytoconstituents is necessary before combating with the pest (Awmack & Leather 2002) [4]. Pest population growth is regulated by host phytoconstituents and both are highly dynamic in nature (War *et al*., 2012; Kamar *et al*., 2025) [69,23]. The complex mixture of defensive chemicals in many plants may provide effects in defense against a range of pests (Bernays & Chapman 2000) [8]. Modern agriculture includes integrated crop management (ICM) as well as integrated pest management (IPM) for ecofriendly, sustainable and smart agriculture (Subedi *et al*., 2019) [65]. Trap cropping by habitat manipulation is an attractive remedy for biological control by natural enemies over artificial bio-control or other conventional means of pest control through vegetative diversification (Midega *et al*., 2011; Holden *et al*., 2012) [37,18]. Moreover, different trap crops can release different volatiles which can attract and enhance the foraging efficacy of natural enemies in an agro-ecosystem (Rhino *et al*., 2016) [47]. Considerable research has been conducted on different trap crops to develop improved pest management strategies for substantial reduction in pesticides uses throughout the world (Srinivasan *et al*., 2008) [61]. This review will obviously support the use of different sustainable management strategies like trap cropping for sustainable production of different economic crops against such generalist semiloopers in near future.

Conclusion

Numerous studies on biology and management of different Anomis spp. have been condicted throughout the world for more than seven decades. Pest fitness is also influenced by the genetic traits specific to the population and different biotic as well as abiotic factors. Now, it is imperative to study the bioecology and alternative management strategy for different *Anomis spp.* including *A. sabulifera* on different crops to predict their outbreaks. Future researches can use this information to formulate proper sustainable IPM against this notorious semiloopers in near future.

Statements and Declarations

Competing Interests: The authors declare that there is no competing interest other than publication of this paper.

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