The Pharma Innovation Journal 2023; 12(3): 3094-3097

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 3094-3097

www.thepharmajournal.com
Received: 07-12-2022
Accepted: 10-01-2023

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Key mortality factors and field life-tables of hairy caterpillars infesting *rabi* sorghum in Maharashtra region of India

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Abstract
The present study examines the mortality in three different species of hairy caterpillars infesting the sorghum. The mortality in early and late instar larvae of *Orgyia* sp. infesting *rabi* sorghum was observed to be 16.64 and 20.00 per cent, respectively due to NPV during first generation while, the mortality in late instar larvae of *S. scintillans* infesting *rabi* sorghum was observed to be 20.00 per cent due to unknown reasons. While, in early instar larval stage and pupal stage mortality was not observed. In the case of *O. mendosa* the mortality in early instar larvae infesting rabi sorghum was observed to be 40.00 per cent due to NPV. The total 'K' for first generation of *Orgyia* sp., *S. scintillans* and *O. mendosa* was 0.476, 0.397 and 0.560, respectively.

Keywords: Mortality, unknown reasons, early instar, late instar, NPV, generations

Introduction
Sorghum (*Sorghum bicolour* (L.) Moench) an ancient crop belonging to the family Poaceae is a warm-climate cereal of African origin, which was first cultivated in the region of Ethiopia or Chad and spread to India by 4000 years (Rosentrater & Evers, 2018) [14] Sorghum is a C4 plant that can tolerate adverse climatic conditions so this species is also known as "the camel among crops" and " the sugarcane of the desert" due to its ability to withstand desert climatic conditions with wide adaptation from temperate to tropical climates, under rainfed and irrigated conditions (Srinivas Rao *et al*., 2013) [16].
As a global food ingredient, sorghum is a versatile crop cultivated in more than 109 countries over 40.07 million ha producing 57.89 million tonnes of grains with a average productivity of 1444.6 kg per ha (FAOSTAT, 2020) [5]. In India, the area under sorghum crop is 4.09 million ha with the production of 3.47 million tonnes and the average yield of 849 kg per ha (FAOSTAT, 2020) [5]. Sorghum is ravaged by a number of insect pests *viz*., shoot fly (*Atherigona soccata* Rondani), stem borers (*Chilo partellus* Swinhoe and *Sesamia inferens* Walker), armyworms (*Mythimna separata* Walker and *Spodoptera frugiperda* J.E. Smith), aphids (*Melanaphis sacchari* Zehntner and *Rhopalosiphum maidis* Fitch), midge (*Contarinia sorghicola* Coquillett), head caterpillars (*Helicoverpa armigera* Hubner), hairy caterpillars (*Orgyia* sp., *Olene mendosa* Hubner and *Somena scintillans* Walker), shoot bugs (*Peregrinus maidis* Ashmead) and green stink bug (*Nezara viridula* (Linnaeus) in Maharashtra. In sorghum fields, more than 35 per cent crops losses are reported due to insect pests estimated at $580 million in India (Reddy & Zehr, 2004) [13].

Materials and Methods
The non-replicated field experiment comprising forty-eight quadrats each of 2.70 x 3.00 sq. m size was laid to investigate the field life-tables and population dynamics of major insect pests of *rabi* sorghum at the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (MS) during *rabi* season, 2020-2021. The popular sorghum variety Parbhani Moti was sown at the spacing of 45 x 15 cm in 48 quadrats with all recommended package of practices recommended by VNMKV, Parbhani (Anonymous, 2018) [1] in *rabi* season. The field experiment was conducted under pesticide free conditions.
The sampling of eggs, early and late instar larvae and pupae of the Hairy caterpillars was done from the randomly selected quadrats on the basis of development of pests in the laboratory reared culture.

At each observation, three quadrats of sorghum were carefully examined twice in a week for the number of eggs, larvae and pupae of target pests. The field collected eggs, larvae and pupae were brought to the laboratory carefully and reared on respective sorghum plant parts. This was referred to as a field culture. The food was changed as and when required. The culture was reared till adult emergence.

The observations were made on the egg, larval and pupal parasitism as well as mortality because of unknown reasons and entomopathogens in early and late larval instars and pupal stage as well.

Preparation of life-tables

The column headings proposed by Morris and Miller (1954) [10] and Harcourt (1969) [8] were used in the life-tables during the present study.

X = The age interval of egg, larva, pupa and adult

l_x = The number surviving at the beginning of stage noted in „x‟ column

d_x = The number dying within the age interval stated in 'x' column.

d_xF = The mortality factor responsible for 'dx‟

$100q_x$ = Percentage mortality

S_x = Survival rate within the age mentioned in 'x‟ column

The trend index was simply ‘lx’ for the early instar larvae in the next generation expressed as a ratio of the previous generation. The trend index can be calculated with the help of the formula N2 / N1 where N2 is equal to the population of early instar larvae in the next generation and N1 is equal to the population of early instar larvae in the previous generation.

The generation survival was an index of population trend without the effect of fecundity and adult mortality; it was calculated with the formula N3/ N1- where N3 is equal to the population of adults in a generation and N1 is equal to population of early instar larvae in the same generation. A separate budget table was prepared for each generation of Hairy caterpillars to find out the key factors responsible for the fluctuations in the population trend of Hairy caterpillars on sorghum. The method of study of key factors analysis was developed by (Varley & Gradwell, 1963; 1965) [17] was used to detect the density relationship of mortality factors. By using this method, the killing power (K) of such mortality factors or group of mortality factors in each age group was estimated as the difference between the logarithms of population density of the killing power of ‘k’s.

Results and Discussion

Key mortality factors of *Orgyia* sp.

The mortality in early and late instar larvae of *Orgyia* sp. infesting *rabi* sorghum was observed to be 16.64 and 20.00 per cent, respectively due to NPV during first generation. The pupal mortality was not noticed. The trend index and generation survival was 0 and 0.66, respectively during first generation. (Table-1).The maximum generation mortality of *Orgyia* sp. during first generation was noticed from late instar larval stage (k=0.096). The total ‘K’ for first generation was 0.476. (Table-2).

The results of present investigation are in compliance with findings of Hall and Buss (2020) [7] who exhibited that *Orgyia* caterpillars were found to be infected by NPV (*Baculovirus*) and cytoplasmic polyhedrosis viruses (*Cypovirus*). FPNA (2020) described that *Orgyia pseudotsugata* (McDunnough) was dramatically reduced due to NPV infection. Shylesha *et al*. (2012) [15] exhibited that NPV was found to be effective in bringing down the pest populations of *Orgyia antique*. Frankenhuyzen *et al*. (2002) [6] illustrated that singly embedded NPV was responsible for collapse of larval populations of *Orgyia leucostigma* Fitch. Dahlsten *et al*. (1977) [3] stated that the low levels of NPV infection were noticed in populations of *O. pseudotsugata*.

Key mortality factors of *Somena scintillans* (Walker)

The mortality in late instar larvae of *S. scintillans* infesting *rabi* sorghum was observed to be 20.00 per cent due to unknown reasons. While, in early instar larval stage and pupal stage mortality was not observed. The trend index and generation survival was 0 and 0.80, respectively during first generation. (Table-3).The maximum generation mortality of *S. scintillans* during first generation was noticed from late instar larval stage (k=0.096). The total ‘K’ for first generation was 0.397. (Table-4).

The more or less comparable results were obtained by Hussain *et al.* (2019) [9] who revealed that *Euproctis chrysorrhoea* (L.) was found to be infected with NPV on apricot trees in Ladakh. Dhembare (2018) [4] evidenced that unknown reasons were found to be key mortality factor during early larval, late larval and pupal stages of *Euproctis* sp.

Key mortality factors of *Olene mendosa* (Hubner)

The mortality in early instar larvae of *O. mendosa* infesting *rabi* sorghum was observed to be 40.00 per cent due to NPV. While, in late instar larval stage and pupal stage mortality was not noticed. The trend index and generation survival was 0 and 0.60, respectively during first generation. (Table-5). The maximum generation mortality of *O. mendosa* during first generation was evidenced from early instar larval stage (k=0.259). The total ‘K’ for first generation was 0.560. (Table- 6).

The results of present investigation are in agreement with findings of ICAR-NRCB (2016) [11] who documented that most of *Olene mendosa* larvae were killed by NPV like disease on banana. NRCP (2012) [12] reported that and one hymenopteran parasitoid, *Brachymeria* sp. was emerged from *O. mendosa* infesting on pomegranate. Cantre (1987) [2] reviewed that Tachinidae was principal parasitoid of *O. mendosa* attacking many agricultural and horticultural crops in Australia.

Table 1: Key mortality factors for first generation of *Orgyia* sp. on rabi sorghum

Age interval	Numberalive / ha at the beginning of x	Factors responsible for d_x	Number dying during x	dx as % of l_x	Survival rate at age X
X	l_x	d_xF	d_x	$100q_x$	S_x
Larval population					
Early instar larvae (N_1)	2,469	NPV	411	16.64	0.83
Late instar Larvae	2,058	NPV	411	20.00	0.80
Pupae	1,647	-	-	-	1.00
Moths	1,647	Sex 50% Females	-	-	-
Females x 2 (N_3)	823	(Reproducing females=823)	-	-	-
Trend index (N_2/N_1)	0 / 2,469	-	0	-	-
Generation survival (N_3/N_1)	1,647 2,469	-	0.66	-	-

Table 2: Budget of *Orgyia sp* on *rabi* sorghum for first generation

Age interval	Number / ha	Log No./ ha	'k' values
Early instar larvae After mortality due to unknown reasons	2,469	3.3925	-
Late instar larvae After mortality due to NPV	2,058	3.3134	0.079
Pupae After mortality due to	1,647	3.2166	0.096
Moths	1,647	3.2166	0.000
Reproducing females	823	2.9153	0.301
K=0.476			

Table 3: Key mortality factors for first generation of *S. scintillans* on *rabi* sorghum

Age interval	Number alive / ha at the beginning of x	Factors responsible for dx	Number dying during x	dx as % of lx	Survival rate at age X
X	Lx	dxF	Dx	100qx	Sx
Larval population					
Early instar larvae (N1)	2,057	-	0	0.00	1.00
Late instar Larvae	2,057	Unknown reasons	411	20.00	0.80
Pupae	1,646	-	0	0.00	1.00
Moths	1,646	Sex 50% Females	-	-	-
Females x 2 (N3)	823	(Reproducing females=823)	-	-	-
Trend index (N2/N1)	0 / 2,057	-	0	-	-
Generation survival (N3/N1)	1,646 2,057	-	0.80	-	-

Table 4: Budget of *S. scintillans* on *rabi* sorghum for first generation

Age interval	Number / ha	Log No./ ha	'k' values
Early instar larvae After mortality due to	2,057	3.3132	-
Late instar larvae After mortality due to unknown reasons	2,057	3.3132	0
Pupae After mortality due to	1,646	3.2164	0.096
Moths	1,646	3.2164	0.000
Reproducing females	823	2.9153	0.301
K=0.397			

Table 5: Key mortality factors for first generation of *O. mendosa* on *rabi* sorghum

Age interval	Number alive / ha at the beginning of x	Factors responsible for d_x	Number dying during x	dx as % of l_x	Survival rate at age X
X	l_x	d_xF	d_x	$100q_x$	S_x
Larval population					
Early instar larvae (N_1)	2,057	NPV	823	40.00	0.59

Late instar Larvae	1,234	-	-	-	1.00
Pupae	1,234	-	-	-	1.00
Moths	1,234	Sex 50% Females		-	-
Females x 2 (N_3)	617	(Reproducing females=823)		-	-
Trend index (N_2/N_1)	0 2,057	-	0	-	-
Generation survival (N_3/N_1)	1,234 2,057	-	0.60	-	-

Table 6: Budget of *O. mendosa* on *rabi* sorghum for first generation

Age interval	Number / ha	Log No./ ha	'k' values
Early instar larvae After mortality due to NPV	2,057	3.3132	-
Late instar larvae After mortality due to	1,234	3.0913	0.259
Pupae After mortality due to	1,234	3.0913	0
Moths	1,234	3.0913	0
Reproducing females	617	2.7902	0.301
K=0.560			

Conclusions

The above discussed study concluded that the various factors are responsible for the fluctuations in the population and generation of various species of hairy caterpillars infesting the *rabi* sorghum at different stages of life. The various unknown and biological factors are causing mortality in the early and late larval stages during the different generations of hairy caterpillars in the field condition in *rabi* season. The total 'K' for first generation of *Orgyia* sp., *S. scintillans* and *O. mendosa* was 0.476, 0.397 and 0.560, respectively. The field life table is considered as a effective tool for the developing the IPM modules and also helpful in the recognition and identification of the various natural enemies associated with crop pests.

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