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Occurrence of ear head caterpillar species complex on Kenyan finger millet (*Eleusine coracana* L. Gaertn.) genotypes

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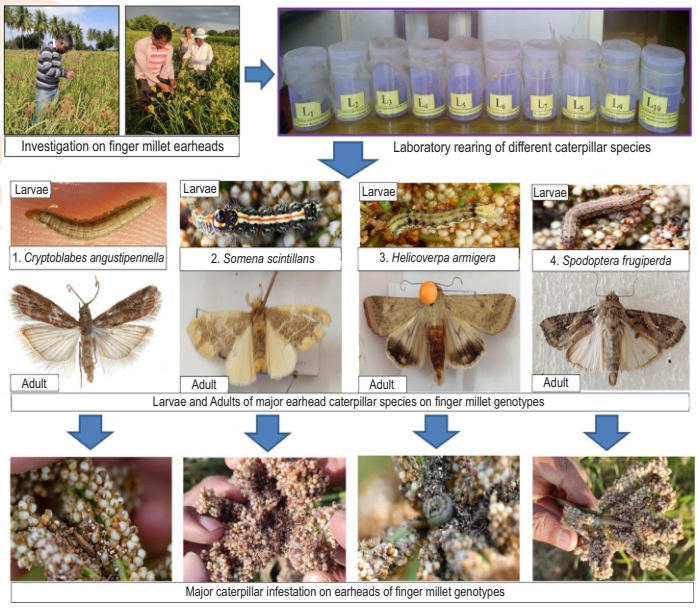
Abstract

Aim: The present study aimed at reporting the occurrence of various ear head caterpillar species on different ear head shape and stage of the panicle in Kenyan finger millet genotypes.

Methodology: A set of 40 Kenyan finger millet genotypes were selected to investigate the occurrence and abundance of ear head caterpillars species complex on different growth stages of ear head.

Results: Among the fifteen ear head caterpillars species recorded on forty Kenyan genotypes, *Cryptoblabes angustipennella* (Hampson) (3.96 larvae/ear head) caused high level of incidence, followed by *Somena scintillans* (Walker) which recorded 2.08 larvae/ear head and the population of *Helicoverpa armigera* (Hubner) & *Spodoptera frugiperda* (J.E. Smith) was 0.61 and 0.56 larvae/ear head, respectively. Further, genotypes with open ear head shape were free from infestation by ear head caterpillars, which were categorized as highly resistance. The semi-compact (1.82 - 2.07 larvae/ear head) ear heads were categorized under moderately resistance scale. Similarly, compact (2.70 - 2.90 larvae/ear head) shape ear heads fell under susceptible category. Whereas, Fist shape (3.74 to 4.68 larvae/ear head) ear heads were recorded under highly susceptible category.

Interpretation: The data on occurrence, species complex and severity can be used for formulating integrated pest management strategies on finger millet.



Key words: *Cryptoblabes angustipennella*, Ear head caterpillars, Finger millet, Kenyan genotypes, *Somena scintillans*, Species complex

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Introduction

Among the millets, after sorghum, Bajra and foxtail millet finger millet holds 4th rank in the world (Upadhyaya *et al.*, 2007). In Africa and Asian countries, finger millet is widely cultivated for food, fodder, nutritional and medicinal value, (Mirza and Marla, 2019), especially in India, Malaysia, Srilanka, Japan China, and major parts of east and Central Africa under both irrigated and rainfed situations. Due to its greater tolerance to biotic and abiotic stresses, adverse climatic conditions compared to other cereals. It is one of the important staple food crops of Southern Karnataka. Karnataka is the leading producer contributing 65 per cent of its area and production in the country, productions are mostly concentrated in the districts of Bengaluru rural, Tumakuru, Chitradurga, Davanagere, Hassan, Kolara, Ramanagara, Chikkamangalore, Chikkaballapura, Chamarajanagara, Mysuru and Mandya (Ashoka and Hallikatti, 1997). This crop has wider adaptability, suitable for growing in all cropping seasons in different parts of the country. The loamy, sandy and alluvial soil with good drainage facility is well suitable for growing crops and can be cultivated in poor to fertile soils throughout the year.

More than 57 insect pests have been reported (Sharma and Davies, 1988) inflicting finger millet crop from germination till harvest. Out of which, shoot fly, *Atherigona miliaceae* (Malloch) (Diptera: Muscidae), pink stem borer, Sesamia inferens (Walker) (Lepidoptera: Noctuidae), white stem borer, *Saluria inficita* (Walker) (Lepidoptera: Noctuidae), red headed hairy caterpillar, *Amsacta albistriga*, (Walker) (Lepidoptera: Erebidae), Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) (Lepidoptera: Erebidae), oriental armyworm, *Mythimna separata*, (Walker) (Lepidoptera: Noctuidae) and sucking pests *viz.,* ragi root aphid, *Tetraneura nigriabdominalis*, (Sasaki) (Homoptera: Pemphigidae) and aphids, *Hysteroneura setariae* (Thomas) (Homoptera: Aphididae) are considered as important candidate species. The crop is mainly infested by two hemipteran bugs during ear formation stage *viz.,* mirid bug (*Calocoris angustatus*) (Lethierry) (Hemiptera: Miridae) and rice gundhi bug, *Leptocorisa acuta* (Thunberg) (Hemiptera: Alydidae) and the information on ear head caterpillar species complex in finger millet is scanty.

Even though several species complex of lepidopteran caterpillars namely *Cryptoblabes angustipennella* Hampson (Lepidoptera: Pyralidae), *Cryptoblabes gnidiella* (Milliere) (Lepidoptera: Pyralidae), *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), *Eublemma silicula* (Swinhoe) (Lepidoptera: Noctuidae), *Stathmopoda theoris* Meyr (Lepidoptera: Stathmopodidae), *Cacoecia epicyrta* Meur (Lepidoptera: Tortricidae), *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) and *Archips micaceana* (Walker) (Lepidoptera: Tortricidae) appearing during ear head stage and feed upon maturing grains leaving empty glumes were found cause higher level of infestation due to changes in climatic conditions (Tarat *et al.,* 2018). Most of the ear head caterpillars of lepidopteran are becoming a major production constraint in all regions of the country, especially in the southern regions of India (Raveendra *et al.,* 2018). In Karnataka, the farmers are facing economic losses due to increased incidence ear head caterpillars *viz., C. angustipennella*, *A. micaceana, Euproctis subnotata* (Walker), *H. armigera* and *S. frugiperda* in finger millet, especially in both rainfed and irrigated situations. Recently, Chikkarugi and Vijayakumar (2022) reported various species of ear head caterpillars on finger millet in the southern parts of Karnataka as these caterpillars damage the crop during ear head stage, thereby reducing the crop yield to economic level. Keeping these things in view, promising Kenyan finger millet genotypes were studied against ear head caterpillar species complex incidence, which will serve as a source of breeding line and which can be exploited in developing the resistant or tolerant varieties to ear head caterpillars.

Materials and Methods

Field experiments on ear head caterpillars of finger millet were carried out at Zonal Agricultural Research Station (ZARS) Vishweshwaraiah Canal (V.C) Farm, Mandya, University of Agricultural Sciences, Bangalore, during *kharif* 2018 and 2019, to investigate the occurrence of different species of ear head caterpillars. A set of 40 Kenyan genotypes namely, EC886311, EC886312, EC886313, EC886314, EC886316, EC886317, EC886318, EC886320, EC886321, EC886323, EC886327, EC886328, EC886329, EC886330, EC886333, EC886335, EC886336, EC886337, EC886338, EC886339, EC886340, EC886341, EC886342, EC886343, EC886344, EC886345, EC886346, EC886347, EC886348, EC886349, EC886350, EC886351, EC886352, EC886353, EC886354, EC886355, EC886356, EC886357, EC886358, EC886359 were procured from All India Co-ordinated Research Project on Small Millets, V. C. Farm, Mandya and used for evaluation.

The Kenyan finger millet genotypes were sown in 3 lines of a 3 meter row length with a spacing of 30 X 10 cm between rows and plants with three replications. Recommended package of practices were followed for establishment of crop from sowing to till harvest. Seven fist ear head shape of finger millet genotypes namely, EC886329, EC886337, EC886336, EC886340, EC886328, EC886342, EC886343 were selected to study the occurrence of ear head caterpillars species complex on different stages of ear head viz., flowering, milky, dough, and grain hardening (maturity). Under each entry, the number of caterpillars of different species occurred were recorded on 20 randomly selected plants and the mean larval population was worked out.

Further, the abundance of ear head caterpillar species on Kenyan finger millet genotypes representing droopy (fingers lax and drooping), open (fingers straight), semi-compact (tops of fingers curved), compact (fingers incurved) and fist-like (fingers very incurved) were recorded at weekly interval from flowering to till harvest of the crop on 20 ear heads randomly. Finally the number of ear head caterpillars per ear head was worked out. The replicated data were subjected to ANOVA (Hosmand, 1988; Gomez and Gomez, 1984) and the means were separated by

Tukey's HSD (Tukey, 1965) for interpretation. Different genotypes were grouped into various resistance categories based on mean larval population per ear head. The outlined by Croxton and Cowden (1964) was followed.

Results and Discussion

Among 40 Kenyan finger millet genotypes examined for diversity of morphological features showed greater variability in ear head shape. Four (10.0%) genotypes had open ear head shape, seventeen (42.5%) genotypes had semi-compact, twelve (30.0%) genotypes had compact and seven (17.5%) genotypes had fist ear head shape (Table 1). Further the genotypes *viz.,* EC886329, EC886337, EC886336, EC886340, EC886328, EC886342, EC886343 bearing fist ear head shape in Kenyan genotypes were selected to investigated the occurrence of various species of lepidopteran caterpillars on different ear head stages (flowering, milky, dough, and grain hardening (maturity) stages).

Statistical significant differences in the mean larval population were noticed among different ear head stages during two years of study. However, flowering stage did not have larval incidence as the fingers were held loosely with each other on the ear head, which, hinders the shelter and food sources for the caterpillars. Subsequently, from flowering to milky stage, a steady increase in the incidence of larval population reached their peak on dough stage. Later, as maturity stage began, significantly reduced the incidence level, as the grain maturity/hardiness and opening of ear heads occurs (Fig. 1). During milky stage, the mean of seven fist ear head shape genotypes recorded 1.13 ± 0.06 and 1.51 ± 0.16 total mean larval populations during kharif 2018 and 2019, respectively, and an average of 1.32 ± 0.10 lepidopteron species complex was found per ear head during milky grain. Among the fifteen species of ear head caterpillars reported, the incidence of *Cryptoblabes angustipennella, Somena scintillans* and *Archips micaceana* were observed during milky stage of the crop. At dough stage of ear head, the incidence almost doubled, *i.e.,* 2.77±0.16 and 2.71±0.15 the mean larval population per ear head was observed during *kharif* 2018 and 2019, respectively. On an average of 2.74 ± 0.14. during this stage all the reported caterpillar species were known to occur on the ear head namely, *Cryptoblabes angustipennella, Somena scintillans, Helicoverpa armigera, Spodoptera frugiperda, Archips micaceana, Cydia* sp., *Nola analis, Pyrausta phoenicealis, Stathmopoda* sp., *Corcyra cephalonica, Euproctis similis, Conogethes punctiferalis, Eublemma* sp., *Mythimna separata* and *Ataboruza* sp. (Table 2). Among fifteen species of ear head caterpillars, *Cryptoblabes angustipennella, Somena scintillans, Helicoverpa armigera* and *Spodoptera frugiperda* were found to be serious. Further, there was a drastic reduced in the mean larval population at maturity (harvesting) stage (0.21 ± 0.03 and 0.22 ± 0.03 during kharif 2018 and 2019, respectively) and an average mean larval population of 0.21 ± 0.03.

Among various lepidopteron species reported, *Cryptoblabes angustipennella, Somena scintillans, Helicoverpa armigera* and *Spodoptera frugiperda, Pyrausta phoenicealis* and *Cydia* sp. were recorded during maturity (harvesting) stage of ear head, as most of these species were polyphagous and known to occur even at grain maturity/hardiness of the ear head, which caused lesser incidence by increased activities of natural enemies as opening of the ear heads proved commencement of

Table 1: Abundance of ear head caterpillar's species complex on Kenyan finger millet genotypes during dough stage

Insect species	Mean larval population per ear head							
	Genotypes (40)							
	0	4	17		12		7	
	Droopy/ Lax type	Open type	Semi-compact type		Compact type		Fist type	
			Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Archips micaceana	0	0	0.022 ± 0.013	0.02 – 0.07	0.085 ± 0.017	0.05 – 0.11	0.246 ± 0.014	0.21 - 0.29
Somena scintillans	0	0	0.565 ± 0.027	0.51 – 0.60	0.580 ± 0.039	0.48 – 0.64	0.939 ± 0.055	0.79 – 1.01
Cryptoblabes angustipennella	0	0	1.120 ± 0.033	1.05 – 1.18	1.136 ± 0.042	1.09 – 1.21	1.701 ± 0.131	1.40 – 1.89
Nola analis	0	0	0.016 ± 0.008	0.01 – 0.03	0.067 ± 0.009	0.06 – 0.09	0.127 ± 0.008	0.12 – 0.14
Cydia sp.	0	0	0.035 ± 0.023	0.02 – 0.09	0.132 ± 0.008	0.12 –0.14	0.200 ± 0.030	0.17 – 0.25
Helicoverpa armigera	0	0	0.067 ± 0.009	0.06 – 0.09	0.215 ± 0.012	0.20 – 0.24	0.330 ± 0.018	0.30 – 0.35
Pyrausta phoenicealis	0	0	0.026 ± 0.008	0.01 – 0.04	0.149 ± 0.012	0.13 – 0.17	0.174 ± 0.015	0.13 – 0.18
Corcyra cephalonica	0	0	0.012 ± 0.005	0.01 – 0.02	0.088 ± 0.012	0.07 – 0.11	0.140 ± 0.007	0.11 – 0.15
Stathmopoda sp	0	0	0.017 ± 0.005	0.01 – 0.03	0.129 ± 0.011	0.11 – 0.15	0.157 ± 0.013	0.13 – 0.18
Spodoptera frugiperda	0	0	0.063 ± 0.008	0.05 – 0.08	0.232 ± 0.014	0.21 – 0.25	0.261 ± 0.015	0.24 – 0.30
Total	**0**	**0**	**1.944 ± 0.061**	**1.82 – 2.07**	**2.812 ± 0.062**	**2.70 – 2.90**	**4.275 ± 0.218**	**3.74 – 4.68**

*Observations from a set of 40 finger millet genotypes under Kenyan genotypes

Table 2: Species of finger millet ear head caterpillars recorded at ZARS, V. C. Farm, Mandya, Karnataka

Common name	Scientific name	Family
Earhead webworm	*Cryptoblabes angustipennella* (Hampson)	Pyralidae
Yellow tail tussock moth	*Somena scintillans* (Walker)	Erebidae
Gram caterpillar	*Helicoverpa armigera* (Hubner)	Noctuidae
Fall armyworm	*Spodoptera frugiperda* (J.E. Smith)	Noctuidae
Soyabean leaf roller	*Archips micaceana* (Walker)	Tortricidae
Cydia moth	*Cydia* sp.	Tortricidae
Tuft moths	*Nola analis* (Wileman and West)	Nolidae
Perilla leaf moth	*Pyrausta phoenicealis* (Walker)	Crambidae
Leaf miner	*Stathmopoda* sp.	Stathmopodidae
Rice moth	*Corcyra cephalonica* (Stainton)	Pyralidae
Yellow tail moth	*Euproctis similis* (Moore)	Erebidae
Castor Shoot and capsule borer	*Conogethes punctiferalis* (Guenee)	Crambidae
Earhead Worm	*Eublemma* sp.	Erebidae
Oriental armyworm	*Mythimna separata* (Walker)	Noctuidae
Makunda Moths	*Ataboruza* sp.	Erebidae

Table 3: Different resistance categories based on mean larval population of ear head caterpillars

Scale range	Classification	Category
< 0.11	< $\bar{X}$-2σ	Highly Resistant
0.12 – 1.30	$\bar{X}$-2σ to $\bar{X}$-σ	Resistant
1.31 – 2.49	$\bar{X}$-σ to $\bar{X}$	Moderately Resistant
2.50 – 3.67	$\bar{X}$ to $\bar{X}$+σ	Susceptible
3.68 – 4.86	$\bar{X}$+σ to $\bar{X}$+2σ	Highly Susceptible

$\bar{X}$ = Mean, σ = Standard Deviation

less sheltered and grain maturity/hardiness manifest lesser acceptance for the ear head caterpillar species (Fig. 1). The results are in conformity with findings of Damasia *et al.* (2020) who reported the occurrence of fall armyworm on finger millet in Gujarat state and Andhra Pradesh. (Venkateswarlu *et al.,* 2018) Suby *et al.* (2020) studied the distribution of fall armyworm. David *et al.* (1962) in past examined 100 ragi ear heads randomly for the infestation of *Cryptoblabe*s sp., *E. silicula*, *H. armigera*, *S. theoris* and *S. cerealella*, in the standing crop at three different stages of ear head *viz.,* flowering, milky and matured stages of the ear head and recorded infestation, which varied 36.0 to 38.0 % and Raveendra *et al.* (2018) noticed finger millet caterpillars during ear head stage.

Similar findings were reported by Srivastava and Singh (1973) on the incidence of ear head webworm, *Cryptoblabes gnidiella* on hybrid sorghum, where in the larvae fed on milky and hard grain stages of ear heads, caused considerable yield loss. Likewise, Mital *et al.* (1980) recorded higher relative abundance of *H. armigera* during the milky stage of sorghum grain and declined as grain maturity began. They also noticed sporadic occurrences of *E. subnotata* and *Celama analis* on the ear head stage of sorghum whereas the occurrence of *Pyrausta panopealis,* a voracious feeder on sweet basil *Ocimum basilicum* resulted in the cent per cent yield loss (Shivakumara *et al.,* 2021). Another species, *Pyrausta phoenicealis* was reported on finger millet as a major ear head caterpillar by Chikkarugi *et al.* (2020)

Further, the severity of infestation by ear head caterpillars on finger millet normally varies with different stages of ear head development as noticed in the present field study. However, no incidence of ear head caterpillars was registered during the flowering stage, meanwhile, the incidence increased steadily during milky stage and peaked during dough stage of the ear head and declined thereafter, drastically towards maturity/grain ripening stage. Further, studies on Kenyan finger millet genotypes having phenotypic diversity *viz.,* open, semi-compact, compact and fist types were evaluated against abundance of ear head caterpillar species. Droopy/lax types of ear head were not found in the Kenyan genotypes and open type of ear head were found in 4 (10.0 %) genotypes namely, EC886311, EC886312, EC886314 and EC886339 which were free off infestation by ear head caterpillars, which fall under highly resistance category by scoring less than $\bar{X}$-2σ (< 0.11 larvae/ear head) (Table 1).

Semi-compact type of ear heads were the most common type, found among the 40 entries in the genotypes accounting 17 (42.5 %) genotypes. It was observed that the semi-compact group wherein the mean larval population varied between 1.82 – 2.07 ($\bar{X}$ = 1.944 ± 0.061) found minimum level of infestation and had

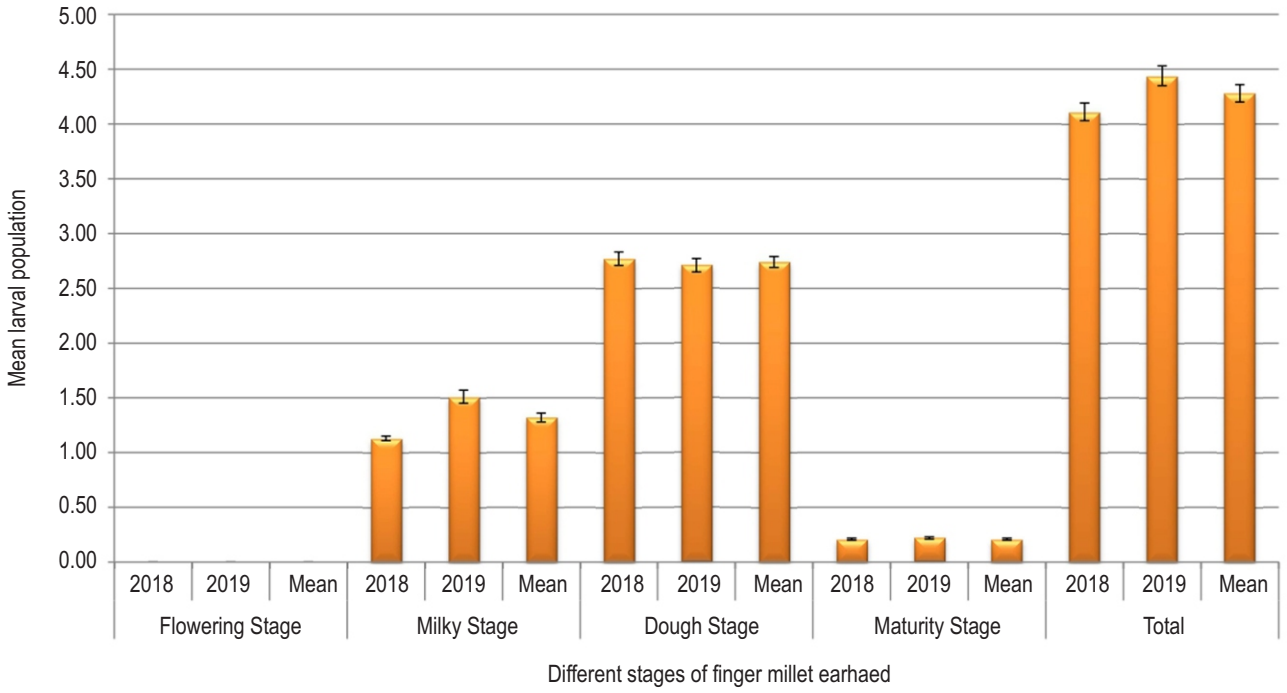

Fig. 1: Occurrence of different earhead caterpillar species on different stages of finger millet genotypes. *Observation recorded from 7 fist earhead finger millet genotypes under Kenyan group.

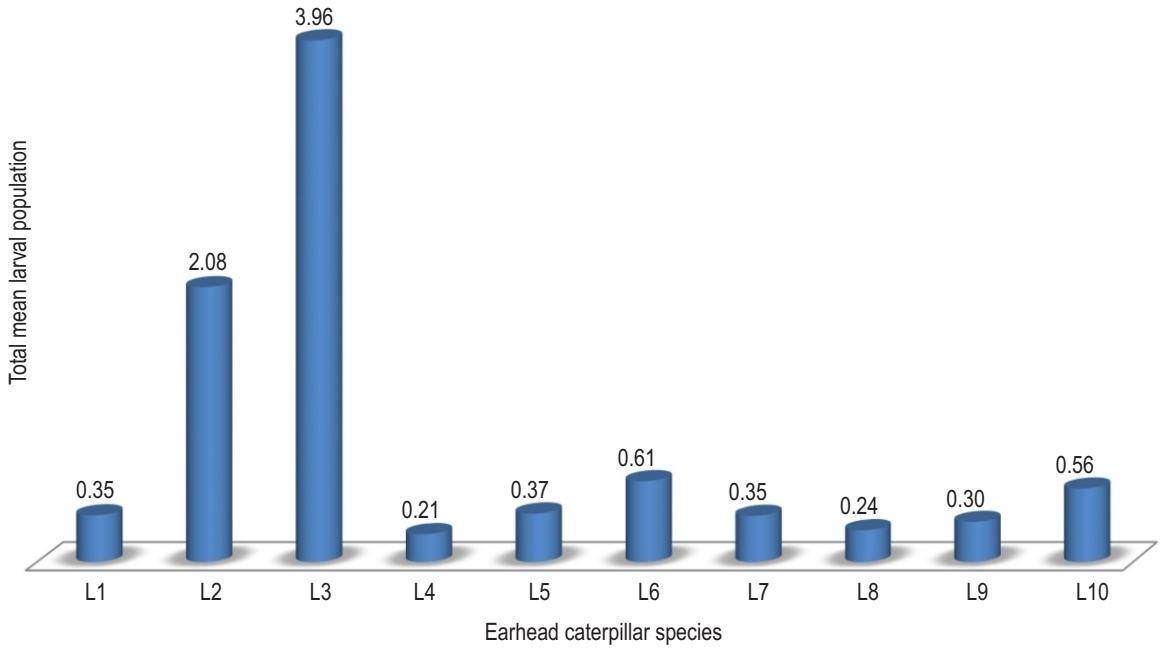

Fig. 2: Occurrence of different lepidopteran earhead caterpillar species complex on finger millet earhead. *Observation recorded from 7 fist earhead finger millet genotypes under Kenyan group; L_1: *Archips micaceana*, L_2: *Somena scintillans*, L_3: *Cryptoblabes angustipennella*, L_4: *Nola analis*, L_5: *Cydia* sp., L_6: *Helicoverpa armigera*, L_7: *Pyrausta phoenicealis*, L_8: *Corcyra cephalonica*, L_9: *Stathmopoda* sp., L_{10}: *Spodoptera frugiperda.*

moderately resistance scale, *i.e.,* 1.31 to 2.49 ($\overline{X}$-σ to $\overline{X}$) larvae/ear head (Table 3). Twelve (30.0 %) genotypes in Kenyan group had compact type of ear heads, which were the second most common earhead type and recorded varied level of mean larval population between 2.70 – 2.90 ($\overline{X}$ = 2.812 ± 0.062) fall under susceptible category *i.e.,* 2.50 to 3.67 ($\overline{X}$ to $\overline{X}$+σ). Whereas, Fist type of ear heads were only seven genotypes (17.5 %) in Kenyan group and were recorded much higher mean larval population ranged between 3.74 to 4.68 ($\overline{X}$ = 4.275 ± 0.218) scaled under highly susceptible category i.e 3.68 to 4.86 ($\overline{X}$+σ to $\overline{X}$+2σ) larvae/ear head (Table 3). The research findings are in conformity with Fletcher (1921) and Chikkarugi *et al.* (2022) who elucidated that tight-fisted or more compact genotypes are generally highly susceptible to attack, as they provide congenial hiding places for the caterpillar within the closed ear head and differential exposer to natural enemies has been suggested as the reason for the resistance conferred by various ear head types of finger millet against their pest.

In addition to this, the ear head types may be giving differential protection to the caterpillars from the physical environment. Montezano *et al.* (2018) reported finger millet was one of the host plants to fall armyworm. Similar studies were carried out by Musthak Ali *et al.* (1987), where they screened 722 different finger millet accessions against ear head caterpillars, They opined that lax and open type of ear heads in finger millet were less prone to attack by ear head caterpillars whereas, compact and fist ear head types were liable for higher infestation. Among the 120 finger millet germplasm lines evaluated by Hedge (1989), droopy and open ear head types were free off infestation by *C. angustipennella* and germplasm lines with semi compact type of ear heads were less vulnerable for the attack. Meanwhile, the majority of the germplasm lines with compact ear heads suffered with higher infestation (>20 per cent). In this study, the level of infestation considered in terms of mean larval number per ear head and per cent of ear head infestation. Paul *et al.* (1980) and Sharma *et al.* (2022) found that loose ear head entries were resistant against *H. armigera* and compact ear head genotypes were highly susceptible and Makwana *et al.* (2017) reported the population dynamics of *H. armigera* in millet. In another study carried out by Balasubramanian *et al.* (1979) wherein, the fewer numbers of earhead bugs, caterpillars and webworms were registered in the open and loose panicles compared to the semi compact and compact types of panicles. In a field study conducted by Mote and Pokharkar (1981) the compact ear heads types of sorghum genotypes *viz.,* CS3541 and SPV-102 were more susceptible to attack by larvae of *S. elongella* and *E. subnotata*.

Among the species complex of various earhead caterpillars studied on forty Kenyan finger millet genotypes, *Cryptoblabes angustipennella* had infected higher level of incidence by recording mean larval population of 3.96 larvae/ear head, followed by *Somena scintillans* recorded 2.08 larvae/ear head and *Helicoverpa armigera* and *Spodoptera frugiperda* recorded 0.61 and 0.56 larvae/earhead, respectively from milky to maturity stage (harvesting) of the crop. The mean larval population of other species ranged between 0.21 to 0.37 larvae/ear head (Fig. 2). The larval mean population recorded less than 0.10 larvae/ear head were not taken into consideration for analysis of data. The present novel study revealed that, ear head caterpillars are the major constraints in finger millet production. In this context, reporting and identification of various species of ear head caterpillars helps to take up prophylactic measures and adaptation and development of various integrated pest management technologies in a holistic approaches to combat menace of ear head caterpillars.

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