

**A COMPARATIVE STUDY OF THE COMPOSITION, ABUNDANCE
AND LARVAL PARASITISM OF INSECT PESTS IN FRESHLY
HARVESTED COBS FROM IRRIGATED AND RAINFED MAIZE IN
SAMARU, ZARIA, NIGERIA**

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SUMMARY

Cob infestation, insect species composition, lepidopterous larval pest density and larval parasitism rates were assessed in freshly harvested cobs from irrigated and rainfed maize in Samaru, Zaria, Nigeria. Maize cob sampling was conducted at three commercial sales points at weekly intervals over eight months. Infested cobs were collected and kept in the laboratory for observations till adult insect emergence. Data were analyzed using Shannon Diversity Index (H') and Kruskal-Wallis test (H). Mean percentage cob infestation was significantly higher in cobs from rainfed (40%) than irrigated maize (32%). On the contrary, mean percentage number of damaged grains was significantly higher in cobs from irrigated (74%) than rainfed (16%) maize. Four species (*Spodoptera frugiperda* (J. E. Smith), *Ephestia rectivittella* Ragonot, *Pococera africalis* Hampson and *Agromyza verdensis* Spencer) and two species (*S. frugiperda* and *E. rectivittella*) were respectively recorded as dominant insect pests in cobs from rainfed and irrigated maize. Insect diversity was significantly higher in cobs from rainfed (4.2) than irrigated maize (1.1). Lepidopterous larval density per cob was significantly higher in cobs from rainfed (3.9) than irrigated

maize (1.2). Nonetheless, the mean abundance of adult moths (*S. frugiperda* (2.5/5.1), *E. rectivittella* (1.0/3.2) and *Eldana saccharina* Walker (1.0/1.5) did not vary per species in cobs from both rainfed and irrigated maize. Three parasitoid species including *Gronotoma* sp., an unidentified diptera and Eupelmidae were recovered in cobs from rainfed maize. The mean abundance of adult parasitoids and larval parasitism rates were similar in cobs from both rainfed and irrigated maize. In conclusion, maize cob infestation is moderate to high across seasons. *Spodoptera frugiperda* and *E. rectivittella* are the dominant pest species attacking cobs from both irrigated and rainfed maize. Larval parasitism rates are too low and insufficient to manage lepidopterous larval pests in these maize cobs.

Keywords: Maize cobs, insect diversity, lepidopterous, larval density, *Spodoptera frugiperda*, parasitism rates

Worldwide, maize devastation is often orchestrated by a few major pests. Reported key pests of maize in Africa are lepidopterous species, and depending on the region can either be the African stem borer, *Busseola fusca* Fuller (Lepidoptera: Noctuidae), the Spotted stem borer, *Chilo partellus* Swinehoe (Lepidoptera: Pyralidae), the Coastal stem borer, *Chilo orichalcociliellus* (Strand) (Lepidoptera: Crambidae), the Pink stem borer, *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) or the African boll worm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) (7, 8, 19, 22). Some of the pests including *B. fusca*, *S. calamistis*, the Fall armyworm, *Spodoptera frugiperda*

(J. E. Smith) (Lepidoptera: Noctuidae) and *H. armigera* destructively feed on maize leaves and/or tunnel through the stem, and at maturity may also feed on the silk/ear and developing kernels (22).

The feeding and tunneling activities of these larval pests can have severe consequences on maize production, if control measures are not applied effectively, especially during dry years. *Spodoptera frugiperda*, a native to tropical and subtropical regions of the Americas, is the most recent invasive pest on the African continent that has already spread to at least 30 countries including Nigeria, and continues to spread on the continent (16, 17, 21, 23). Solely, this

pest is responsible for leaf, silk and tassel damage levels of between 25% and 50% and grain yield reduction of 58% (13, 24). Infestation during the mid- to late-whorl stage of maize development has severe consequences on crop yield (19), especially in West and Central Africa where the larvae are more damaging to maize than other *Spodoptera* spp. (20). This pest can breed continuously in the tropics and can have four to six generations yearly. The moth is interestingly capable of pupating in the kernels of maize cobs (12). Its rapid spread in Africa is attributed to the moth's strong flight capacity, whereby, a single female can migrate over 500 km before settling to oviposit (12, 15). Amongst the endemic species, *B. fusca* diapauses during the dry season, whereas *S. calamistis* does not diapause all year in West Africa (8, 19). In spite of the different patterns of attack and sustenance of these lepidopterous larval pests, there is hardly empirical data on larval pest complex and their activities in maize cobs at any point between harvest and consumption or storage. Moreover, cataloguing the assemblage of fauna associated with maize in different regions and localities remains crucial. So as to give better understanding of the maize agroecosystem or future ecological imbalances as can be occasioned by several factors such as

intense pesticides misuse or irreversible climatic changes.

In Zaria, Nigeria, freshly harvested maize cobs are regularly supplied, in 50 kg polypropylene bags, at various commercial sales points almost year-round for consumption as cooked or roast corn. The cobs are largely supplied from fields situated in and around the same locality and also other localities in the Guinea Savannah regions of the country. The cobs harvested from irrigated maize are supplied during the dry season, whereas cobs harvested from rainfed maize are supplied during the rainy season. Some of these cobs are often encountered infested with lepidopterous larvae. This study assessed the composition and diversity of insect species associated with maize cobs from irrigated and rainfed maize, and also the lepidopterous larval pest density and parasitism rate in maize cobs supplied in Samaru, Zaria.

MATERIALS AND METHODS

Maize cob inspection was conducted over eight months in 2018 at three commercial maize cob sales points in Samaru. The sales points were located at the Samaru Campus main gate (the Ahmadu Bello University (ABU), Zaria), Dogon It'che junction and Samaru market. Weekly visit, at least once, was made to each of the sales points. In all, 51 visits were

made over 16 weeks between late-February and early-June to sample cobs harvested from irrigated maize. Likewise, 54 visits were made over 17 weeks between mid-June and early-October to sample cobs harvested from rainfed maize. At each sales point, one 50 kg polypropylene bag of freshly harvested maize cobs was checked for larval infestations. Each infested maize cob was collected and kept separately in a ventilated plastic jar for daily observation till adult emergence (27), under ambient conditions in an Entomology laboratory, Department of Crop Protection, ABU Zaria. Data on the number of cobs, cob infestation rate, number of damaged grains per cob, weight/length/radius of cobs, lepidopterous larval density, weight of larval/prepupal/pupal stages, adult pest/parasitoid abundance and larval parasitism were subjected to Kruskal-Wallis test to estimate differences in relation to cob type, irrigated and rainfed maize. The STATISTIX 10.0 statistical software was used for the analysis. Statistical significance was set at 0.05. The dominance of species recovered was determined as the percentage of individuals of a given taxon compared to the individuals of all taxa found (14), with classification as dominant (>5%), influent (2-5%)

or recedent (<2%) species. The Shannon Diversity Index (H'), which takes into account the number of species (richness) and their relative abundance (equitability), was used to compute species diversity in maize cobs (29):

$$H' = \sum P_i \ln P_i$$

where i is the species, P_i is the proportional abundance of the i^{th} species, and \ln is the natural logarithm. t -test, with $P \leq 0.05$, was performed to examine differences in species diversity in relation to cob type.

RESULTS

The mean number of cobs and percentage cob infestation per bag were significantly higher in cobs from rainfed than irrigated maize ($H = 21.4$; $df = 184$; $P = 0.0001$ and $H = 19.5$; $df = 184$; $P = 0.0001$, respectively) (Table 1). The mean number of damaged grains and damaged portions per cob were respectively significantly lower ($H = 41.7$; $df = 184$; $P = 0.0001$) and higher ($H = 8.46$; $df = 184$; $P = 0.0041$) in cobs from rainfed than irrigated maize. The mean weight and length of cobs observed were significantly higher in cobs from rainfed than irrigated maize ($H = 14.6$; $df = 184$; $P = 0.0000$ and $H =$

Table 1: Number of cobs and infestation rate per bag, and percentage cob damage, cob weight and size in relation to cob type, irrigated and rainfed maize (mean \pm SE)

Cob type	Maize cob						
	Per bag		Per cob				
	No. cobs	Infestation (%)	Damaged grains (%)	No. damaged portions	Weight (g)	Length (cm)	Radius (cm)
Irrigated maize	170.17 \pm 7.7a	32.2 \pm 6.4a	74.11 \pm 5.0a	1.00 \pm 0.01a	65.09 \pm 1.5a	13.31 \pm 0.19a	4.20 \pm 0.0
Rainfed maize	188.33 \pm 1.9b	40.01 \pm 1.2b	15.56 \pm 0.5b	1.41 \pm 0.03b	100.80 \pm 3.6b	13.74 \pm 0.1b	4.56 \pm 0.1

4.31; df = 184; $P = 0.0002$, respectively). However, the mean radius of cobs observed was similar in both cob types ($H = 0.5$; df = 184; $P = 0.5737$). At 8% to 41% composition (Table 2), four species including *S. frugiperda*, *Ephestia reactivittella* Ragonot, *Pococera africalis* Hampson and *Agromyza verdensis* Spencer were dominant pests in cobs from rainfed maize. At 2% to 5% composition, four other species including *Pyroderces* sp., *Eldana saccharina* Walker, *Anatrichus erinaceus* Loew, and *Mycodrosophila* sp. were influent species in the same cob type. While eight other species including *Sesamia calamistis* Hampson, *Salebria* sp., *Plodia interpunctella* Hübner, *Dichomeris* sp., *Anarsia arachniota* Meyrick, *Pectinophora gossypiella* (Saunders), *Zaprionus ghesquierei* Collart and

Mycodrosophila nigerrima Lamb. were recedent species in the same cob type, each having a composition below 2%. At 86% and 9% composition, *S. frugiperda* and *E. reactivittella* were respectively the dominant pest species in cobs from irrigated maize. The composition and diversity of the three parasitoid species (*Gronotoma* sp., Unidentified diptera and Eupelmidae) recovered were not computed as these species were restricted to one cob type (from rainfed maize) and had less than seven individuals. The Shannon diversity index of pest species found was significantly higher in cobs from rainfed than irrigated maize ($t = 9.35$, $P < 0.001$) (Table 3, Plate 1). The mean number of lepidopterous larvae recovered and their density per cob were significantly higher in cobs from rainfed than irrigated maize

Table 2: Species composition (%) of insect pests and their parasitoid in cobs from irrigated and rainfed maize

Pests	Species composition (%)		Parasitoids	Species composition (%)	
	Rainfed Maize	Irrigated maize		Rainfed maize	Irrigated maize
<i>Spodoptera frugiperda</i> (J. E. Smith)	41	86	<i>Gronotoma</i> sp.	NC	
<i>Ephestia rectivittella</i> Ragonot	16	9	Unidentified diptera	NC	
<i>Pococera africalis</i> Hampson	14		Eupelmidae	NC	
<i>Agromyza verdensis</i> Spencer	8				
<i>Pyroderces</i> sp.	5				
<i>Eldana saccharina</i> Walker	4	5			
<i>Anatrichus erinaceus</i> Loew	2				
<i>Mycodrosophila</i> sp.	2				
<i>Sesamia calamistis</i> Hampson	1				
<i>Salebria</i> sp.	1				
<i>Plodia interpunctella</i> Hübner	1				
<i>Dichomeris</i> sp.	1				
<i>Anarsia arachniota</i> Meyrick	1				
<i>Pectinophora gossypiella</i> (Saunders)	1				
<i>Zaprionus ghesquierei</i> Collart	1				
<i>Mycodrosophila nigerrima</i> Lamb.	1				

NC = not computed

Table 3: Species diversity of pests and their parasitoids in cobs from irrigated and rainfed maize

Indices/Statistics	Pest species		Parasitoid species	
	Rainfed maize	Irrigated maize	Rainfed maize	Irrigated maize
Species richness (S)	16	3	3	
No. individuals (N)	208	45	6	
Shannon evenness index (<i>E</i>)	0.85	0.37	NC	
Shannon diversity index (<i>H'</i>)	4.2	1.1	NC	
<i>t</i> -value	9.35			
<i>P</i> -value	P<0.001			

NC = not computed



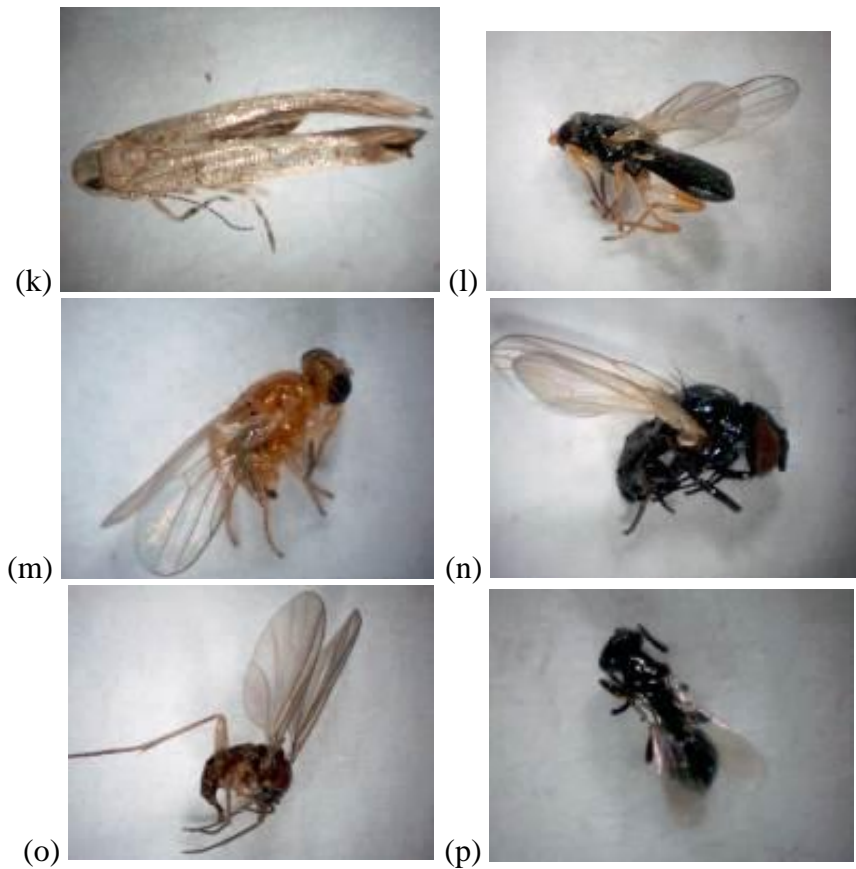


Plate 1: Showing (a and b) larval feeding activity on harvested maize cobs and (c) the prepupal stage of *S. frugiperda*; some adult insect pests and parasitoid species recovered including (d) *S. frugiperda*, (e) *S. calamistis*, (f) *E. saccharina*, (g) *E. rectivittella*, (h) *P. interpunctella*, (i) *P. africalis*, (j) *Salebria* sp., (k) *Pyroderces* sp., (l) *A. erinaceus*, (m) *Z. ghesquierei*, (n) *A. verdensis*, (o) *M. nigerrima* and (p) *Gronotoma* sp.

($H = 31.5$; $df = 184$; $P = 0.0001$ and $H = 11.1$; $df = 184$; $P = 0.0001$, respectively) (Table 4). The mean weight of larval ($H = 0.07$; $df = 184$; $P = 0.7931$), prepupal ($H = 0.07$; $df = 184$; $P = 0.5642$) and pupal ($H = 0.07$; $df = 184$; $P = 0.9912$) stages of lepidopterous pests in cobs from both rainfed and irrigated maize were not significantly different. *Spodoptera frugiperda*, *E. reactivitella* and *E. saccharina* attacked cobs from both irrigated and rainfed maize. The mean

adult abundance of these pests, from the former to the latter, were significantly similar in both cob types ($H = 0.47$; $df = 184$; $P = 0.8220$, $H = 1.33$; $df = 184$; $P = 0.3125$ and $H = 0.78$; $df = 184$; $P = 0.5933$, respectively). The mean number of adult parasitoids ($H = 3.51$; $df = 184$; $P = 0.3719$) and larval parasitism rates ($H = 2.03$; $df = 184$; $P = 0.1120$) did not vary significantly in cobs from rainfed and irrigated maize (Table 5).

Table 4: Lepidopterous larval pest abundance and density, and weight of the developmental stages in cobs from irrigated and rainfed maize (mean \pm SE)

Cob type	Larva		Weight (g) per			Adult moth abundance			
	No.	Density per cob	Larva	Prepupa	Pupa	<i>S. frugiperda</i>	<i>E. saccharina</i>	<i>E. rectivittella</i>	Other spp.
Imz	13.83 \pm 2.02 a	1.25 \pm 0.1a	0.3541 \pm 0.0 2	0.3112 \pm 0.0 3	0.1804 \pm 0.0 3	2.5 \pm 0.8	1.0 \pm 0.0	1.0 \pm 0.0	
Rm _z	36.09 \pm 0.6b	3.93 \pm 0.1 b	0.3587 \pm 0.0 6	0.2858 \pm 0.0 6	0.1842 \pm 0.0 4	5.1 \pm 0.9	1.5 \pm 0.2	3.25 \pm 0.5	11.94 \pm 0. 8

Imz = Irrigated maize; Rm_z = Rainfed maize

Means per column followed by different letters are significantly different at $P \leq 0.05$.

Table 5: Number of adult parasitoids and larval parasitism rates of lepidopterous pests in cobs from irrigated and rainfed maize (mean \pm SE)

Cob type	No. adult parasitoids	Larval parasitism (%)
Irrigated maize	0.0 \pm 0.0	0.0 \pm 0.0
Rainfed maize	1.7 \pm 0.3	1.6 \pm 0.1

DISCUSSION

Analyzed data shows that maize cobs are sufficiently supplied from irrigated and rainfed maize for consumption in this locality almost all year. However, the maize cobs were observed to have moderate to high (32% to 40%) infestation rates across seasons. The extent of grain damage is particularly high (74%) in cobs from irrigated maize, where *S. frugiperda* is a dominant pest. Even in cobs from rainfed maize, with much lower extent of grain damage, *S. frugiperda* remains the predominant pest. Clearly, bigger cobs, in terms of weight and length, from rainfed maize did not yield higher extents of grain damage. The abundance of adult *S. frugiperda*, *E. rectivittella* and *E. saccharina* per cob types was similar. Yet, the authors suspect that larval density at species level (not pooled) might have varied between cob types in at least *S. frugiperda*. Unfortunately, species separation at

different larval stages was somewhat difficult owing to insufficient details on larval features of most African and some exotic lepidopterous pest (34). Also, if assessed on species basis, the larval, prepupal and pupal weights of these lepidopterous pests might vary with cob type in at least some species. Irrespective of these, *S. frugiperda* actively thrives in irrigated maize cobs during the dry season. Moreover, the pest can breed continuously in the tropics (having four to six generations yearly) and is capable of pupating in maize cob kernels (12). Altogether, these results raise questions on the role of maize cobs in spreading (in terms of distance transported as traded commodity and the speed of movement) this exotic pest across localities or regions on the African continent. Contrary to the believe that *S. frugiperda* spread rapidly in Africa through strong moth flight capacity (12, 15), it is possible that the moth is

largely transported via infested maize cobs almost year-round to far greater distances (intra- and inter-state/border locations) and at very great speeds. Further studies should establish this in sub-Saharan Africa where uncountable informal crossings/routes sustain constant movement of people and food commodities between border towns or countries throughout the continent.

Results on species diversity shows that the richness and relative abundance of pest species is greater in cobs from rainfed maize. Two-thirds (11 species) of these pests are lepidopterous species, of which three (*S. frugiperda*, *E. rectivittella* and *P. africalis* as mentioned earlier) are dominant pests in these cobs. At 8% (relatively low) species composition, the fourth/sole dominant dipteran species (*A. verdensis*), can be said to be marginally dominant. Several *Agromyza* spp. have been reported on a wide variety of cereals such as barley, oats, rye, wheat and maize, but mostly as leaf miners and of little economic importance (36). To our knowledge, this is the first report associating all the recovered (16) insect species as pests of maize cobs across seasons in this locality, and perhaps in Nigeria. Evidence shows that only three lepidopterous species including *S. frugiperda*, *E. rectivittella* and *E. saccharina* are common pests in cobs from both

irrigated and rainfed maize. The reasons for this are unclear to us. Except for the four dominant species stated earlier, on different cob types, most of the species found are influent or recedent, and therefore are minor to negligible pests. *Sesamia calamistis*, *E. saccharina*, *P. gossypiella* and *P. interpunctella* are expectedly influent or recedent species in maize cobs as they are major pests of other crops on the continent. *Sesamia calamistis* has been reported to predominate in sorghum cultivated in parts of the Guinea Savannah region of Nigeria (1, 2, 4). Nevertheless, the non-recovery of a single specimen of *S. calamistis* in cobs from irrigated maize provides evidence to support the argument by Bosque-Perez (8), which states that *S. calamistis* has no resting stage throughout the year in Nigeria, but is scarce on crops during the dry season as it's feeding is restricted to mature grasses such as *Pennisetum purpureum*, *Setaria* spp. and *Rottboellia exaltata*. Although sugarcane is the major crop host of *E. saccharina*, the pest also attacks other cereals including maize, sorghum or rice and wild hosts including wild grasses (Poaceae, e.g., Guinea grass, *Panicum maximum*), wetland sedges (Cyperaceae, e.g., papyrus, *Cyperus papyrus*), *rushes* (Juncaceae) and typha (Typhaceae) (5, 41). *Pectinophora gossypiella* is not only a serious pest of cotton in all the

cotton-growing areas of the world, but also importantly attacks hibiscus, okra and other malvaceous plants (10). *Plodia interpunctella* is reported by Mbata and Osuji (30) to be a serious pest of stored groundnut in Nigeria. Although the moth feeds mainly on flours/meals, it also attacks some pulses or whole cereals, dried fruits, nuts and other processed foods. Hence, its field recovery is not surprising, since the females can deposit eggs on crops in the field or in storage and at any point in between (33). More still, this pest might be much more abundant in more favorable cooler-highland areas of the Guinea Savannah region (36). *Ephestia* spp. larvae spin silken tunnels into and feed on a variety of stored food products (40). On this basis, *E. reactivitella* can be considered a field-to-store pest of stored maize grains in this locality. Our results coupled with the report by King and Saunders (25) indicates that *Pococera* spp. are minor to negligible pests of maize in both tropical and temperate environments, feeding not just on maize tassel but also on maize silk or kernels. *Anatrichus erinaceus* is a reported shootfly pest of sorghum in Samaru (3). Results provided in that study and ours suggest that *A. erinaceus* might be common on cereals in this locality, but is particularly a minor pest of both sorghum and maize. *Pyroderces* spp., *Mycodrosophila* spp., and *Zaprionus*

spp. largely seem to be non-economically important scavengers or general feeders encountered on maize cobs consumed in this locality (18, 31, 32, 34, 42). *Anarsia arachniota*, *Salebria* spp. and *Dichomeris* spp. are mainly minor lepidopterous larval pests that feed on various host plant parts such as twigs, shoots and leaves (6, 9, 16, 26, 28).

The none recovery of *H. armigera* on maize cobs in this study was not surprising, since it is an occasional pest of maize in some parts of Africa (11). This polyphagous pest likely sustains its populations through the dry and rainy seasons within the Guinea Savannah region in irrigated or cultivated major crop hosts including tomato, okra, *Brassica* spp., *Capsicum* spp. or *Solanum* spp. and wild hosts like *Acalypha* spp., *Amaranthus spinosus*, *Amaranthus* spp. *Brassica* spp., *Ricinus communis*, *Rumex* spp., *Sesbania* spp., *Solanum* spp. and *Xanthium* spp. (38, 39). Moreover, *H. armigera* is attacked by a large number of parasitoids, predators and entomopathogens that might keep its field populations low (11).

Low richness (≤ 3) and abundance (≤ 2) of parasitoids solely in rainfed maize cobs suggest that these natural enemies are scarce across seasons in their associated lepidopterous larval hosts. Very low (≤ 2) field parasitism

rates indicate insignificant contributions of larval parasitoids towards managing larval pest populations in freshly harvested maize cobs in this locality.

CONCLUSION

Present results show that cobs from irrigated and rainfed maize, supplied almost year-round in this locality, have moderate to high infestation levels. These cobs are attacked to a great extent by lepidopterous larval pests, of which, *S. frugiperda* and *E. rectivittella* are dominant pests in both cob types. These results suggest that: (1) traded/transported maize cobs can be an important means of *S. frugiperda* dispersal, over farther distances and at greater speeds than is currently being projected, and that (2) a sizeable proportion of maize grain infestation by *E. rectivittella* commences in the field during both

rainy and dry seasons. A higher diversity of insect species was recorded in cobs from rainfed maize, but most of them are minor to negligible pests. Extremely low parasitoid richness and parasitism rates in rainfed maize cobs depicts negligible parasitoid impact against lepidopterous larval pests in maize cobs consumed in this locality.

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