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Research Article

Species Composition and Relative Abundance of Stored Maize Insect Pests in Selected Districts of Kellem Wollega and West Wollega Zones of Western Ethiopia

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ABSTRACT

The maize grains samples were collected from six selected districts of two zones of Western Oromia regional state, Ethiopia in April 2022 and July 2022. The main objective of the study was to assess species composition and relative abundance of maize storage insect pests. The study was conducted in 4 selected districts of Kellem Wollega (Sayo, Hawa Galan, Sadi Chanka, and Dalle Sadi) and in 2 selected districts of West Wollega Zone (Ayira and Lalo Asabi). Samples were collected from farmers' storage facilities in each selected district. Each samples consisting of 300 g of maize grain seeds were taken and put in plastic jar of 500 ml. Samples were kept for identification of insect pests, and to estimate grain damage and weight loss using count and weight method. The samples were collected two times in the storage periods, namely 3 months and 6 months from the farmer's storage structures (facilities). Identification was made using combination of insect identification guides by observing under dissecting microscope (20 X). For assessing insect pests' infestations, the main variables were included relative abundance and constance (frequency of occurrence) of species found in samples. Descriptive statistical analysis (mean and percentage) was performed on percent weight loss, grain damage and germination over the storage periods using IBM SPSS Version 25. Four species of order coleoptera in three families and one species of order Lepidoptera in one family were identified and considered as important pests damaging stored maize in the study areas. From all, *Sitophilus zeamais* was the most abundant. It is possible to conclude that there was significant grain damage, weight loss and germination loss due to stored maize insect pests in the study area. Enhancing farmers' knowledge on improvement of existing storage structures and training them on how to handle maize grains is highly recommended.

Keywords: Stored maize; Species composition; Relative abundance; Grain damage

INTRODUCTION

Maize (*Zea mays L.*), is the staple crop with the largest production worldwide, with an estimated of 1026 million tons. This cereal is the basic food in developing countries. In Africa, maize is mainly cultivated by smallholder farmers, who take advantage of corn adaptability, high yields and valuable by-products. However, biotic and abiotic factors cause losses ranging 30%-60% of global yield. Abiotic stress is mainly caused by extreme environmental conditions, which are enhanced by climate change. Biotic stress caused by diseases, weeds, and insects lead to losses of 54% of attainable yield in Africa [1-9]. Post-harvest losses caused by insect pests represent 12%-36% of grain weight worldwide, affecting mainly low-income developing countries, due to poor postharvest management and inappropriate grain storage conditions. Post-harvest maize insect pests include many species from the orders coleoptera and lepidoptera, which are distributed worldwide, causing yield and quality losses of grains and by-products, with important economic repercussions. Species such as *Sitophilus zeamais*, *Prostephanus truncatus*, *Sitotroga cerealella*, *Rhyzopertha dominica* and *Tribolium castaneum* are considered major pests and are a

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serious concern in global agriculture. Insect pests inflict their damage on stored products mainly by direct feeding. Some species feed on the endosperm causing loss of weight and quality, while other species feed on the germ, resulting in poor seed germination and less viability. Thus, due to damage done by insects, grains lose value for marketing, consumption or planting. In addition to direct consumption of the product, insect pests contaminate their feeding media through excretion, moulting, dead bodies and their own existence in the product, which is not commercially desirable. Damage done by insect pests encourages infection with bacterial and fungal diseases through transmission of their spores. The presence of insects also raises the product temperature, due to their feeding activity, resulting in "hot spots". These spots in turn lead to concentrating of humidity within the product, thus stimulating seed deterioration and further fungal activity. Therefore, the objective of this study was to assess species composition and relative abundance of maize storage insect pests in the selected districts of Kellem Wollega and West Wollega Zones [10-16].

MATERIALS AND METHODS

Description of the study area

Maize grain samples were collected from farmers' storage structures (facilities) in four selected districts (Sayo, Hawa Galan, Sadi Chanka and Dalle Sadi) of Kellem Wollega Zone and in 2 selected (Ayira and Lalo Asabi) of West Wollega zones of Western Oromia regional state of Ethiopia.

Kellem Wollega and West Wollega zones are located between 8011'0''N to 9022'30''N and 34038'45''E to 350 46' 45'' E . According to data gathered from national meteorological agency Gambella branch and respective districts, magnitude of temperature, rain fall and elevation of each district mentioned as follows. The elevation of Sayo district ranged from 1300 m to 1827 m above sea level (m.a.s.l). The mean maximum and minimum temperature of this study area is 25.15°C and 13.38°C, respectively and the annual rainfall 700 mm to 1300 mm. Hawa Galan district has an elevation of 700 m.a.s.l to 2200 m.a.s.l and the area has the mean maximum and minimum temperature of 30.84°C and 16.38°C, respectively. The average annual rainfall of this study area is 1,645 mm. Sadi Chanka district has altitudinal range of 1159 m to 1528 m above sea level and has mean temperature of 12°C to 35°C. The annual rain fall of this area is from 700 mm to 2800 mm. Dalle Sadi district has elevation ranging from 1300 m.a.s.l-2000 m.a.s.l and this area also has annual rain fall of 1000 mm to 1300 mm and the temperature varies from 23°C to 34°C. Ayira district has altitudinal range between 1479 m.a.s.l-1754 m.a.s.l, rain fall 1000 mm to 2000 mm and temperature of 10°C to 28°C [17-19]. Lalo Asabi district has elevation of 1500 m.a.s.l-1950 m.a.s.l, rain fall 1230 mm-1800 mm and temperature ranging from 18°Cto 32°C (Figure 1).

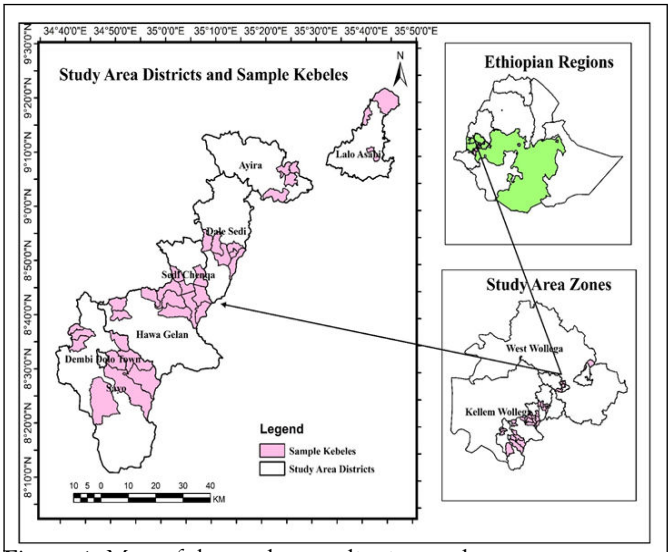

Figure 1: Map of the study area districts and zones.

Sample collection procedures

The survey was conducted when maize grain is in storage for three to six months and infestation and grain damage levels are most likely to be serious. Survey sites (districts and kebeles) were selected based on their maize production status (major maize producing areas) of the zones. Storage facilities from all selected kebeles and districts were visited and samples collected. Selection of sites, storage containers and samples were made in such a way that they are the representative of the district at random. Each samples consisting of 300 g of maize grain seeds were taken and put in plastic jar of 500 ml. The samples obtained from the same storage were mixed together and kept for identification of insect pests, and to estimate grain damage and weight loss using count and weight method. The samples were collected two times in the storage periods, namely 3 months and 6 months from the farmer's storage structures (facilities). The collection was made at April 2022 and July 2022.

Insect pest identification

In the laboratory, at Dambi Dollo university professor Gabisa Ejeta laboratory center, each sample of maize grains was sieved over a 2 mm mesh sieve. Both live and dead insects were removed, counted, identified and grouped according to order, family and species. Identification was made using combination of insect identification guides in and pictures. Dissecting microscope (20 X) was used to observe morphological structures. The samples were re-stored in 0.5 L glass jars and kept under laboratory conditions (27°C ± 3°C and 55%-70% RH) to determine internal infestation. For assessing insect pests' infestations, the main variables were included relative abundance and constance (frequency) of species found in samples as suggested by Bueno and Souza.

The relative abundance of species is expressed by the percentage of individuals of the species in a total number of observed individuals as shown in the following formula:

$$\text{Relative abundance of Species} = \frac{\text{Number of individuals of a species}}{\text{Total number of observed individuals}} x100$$

Constance (frequency) expresses the percentage of species occurrence. It is obtained by the relationship between the number of samples containing the species and the total number of samples. The following formula is expressing this relationship.

$$\text{Constance of Species} = \frac{\text{Number of samples in which the species occurred}}{\text{Total number of samples}} x100$$

Grain damage and weight loss assessment

The percentage of weight loss of maize grains due to insect pests was calculated using a gravimetric or count and weight method as follow:

$$\text{Weight Loss}(\%) = \frac{(Wu * Nd) - (Wd * NU)}{Wu(Nd + NU)} x100$$

Where:

W_u=weight of undamaged grain

N_u=Number of undamaged grain

W_d=Weight of damaged grain

N_d=Number of damaged grain

The percentage of insect damaged seed was then calculated as follows:

$$\text{Insect damaged grain } (\%) = \frac{\text{Number of insect damaged grain}}{\text{Total number of grain}} x100$$

Assessment of germination loss

From each damaged and undamaged grain subsamples, 100 grains were taken randomly and placed in petri-dishes lined with filter paper which were moistened with distilled water of 10 ml and then kept in four replications for about 5 days to 7 days to determine the germination percent at room temperature. Percent germination was calculated following Dubale, et al. method as follow:

$$\text{Germination } (\%) = \frac{\text{Number of germinated seed}}{\text{Number of seed planted}} x100$$

Data analysis

Descriptive statistical analysis (mean and percentage) was performed on percent weight loss, grain damage and germination over the storage periods using IBM SPSS Version 25.

RESULTS

Taxonomic positions, relative abundance and constance of recorded stored maize insect pests

List of insects recorded from stored maize collected from West Wollega and Kellem Wollega Zones are indicated in the Table 1. Four species of order coleoptera in three families and one species of order lepidoptera in one family were identified and considered as important pests damaging stored maize in the study areas (Tables 1-3).

Table 1: Taxonomic rank of recorded insect pests from stored maize in West Wollega and Kellem Wollega zones.

Common name	Scientific name	Order name	Family name
Maize weevil	*Sitophilus zeamais* (Motschulsky)	Coleoptera	Curculionidae
Angoumois grain moth	*Sitotroga cerealella* (Olivier)	Lepidoptera	Gelechiidiae
Rice weevil	*Sitophilus oryzae* (L.)	Coleoptera	Curculionidae
Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera	Tenebrionidae
Rusty grain beetle	*Cryptolestes ferrugineus* (Stephens)	Coleoptera	Cucujidae

Table 2 indicated that the relative abundance and constance (frequency of occurrence in collected samples). Accordingly, the relative abundance of *Sitophilus zeamais* was highest in Sadi Chanka district (95.8%) followed by Hawa Galan, Dalle Sadi, Ayira, Sayo and Lalo Asabi districts. The occurrence of this species per 300 g was 100% in Lalo Asabi, Ayira, Dalle Sadi and Hawa Galan districts and 94.4% in Sayo district. The relative abundance of *Tribolium castaneum* was 23.7% with constance of 94.4 % in Lalo Asabi district followed by 13.3% relative abundance and 59.6% of occurrence in samples in Sayo district.

Similarly, the relative abundance of *Sitotroga cerealella* was highest 28.2% in Lalo Asabi district followed by 11.4% in Sayo district. *Sitophilus oryzae* was also relatively abundant next to *Sitophilus zeamais* in Ayira (26.8%) and Dalle Sadi (20.3%) districts, respectively.

Table 2: Relative abundance and constance of recorded stored maize insect pests during 3 months-6 months of storage period in the study areas.

Insect Pest	Total counted	West Wollega Zone												Kellem Wollega Zone					
		Lalo Asabi		Total counted	Ayira		Total counted	Dalle Sadi		Total counted	Sadi Chanka		Total counted	Hawa Galan		Total counted	Sayo	
		Relat. Abund (%)	% of Constance		Relat. Abund (%)	% of Constance		Relat. Abund (%)	% of Constance		Relat. Abund (%)	% of Constance		Relat. Abund (%)	% of Constance		Relat. Abund (%)	% of Constance
Maize weevil	2003	47.7	100	4310	67.1	100	5206	70.1	100	6333	95.8	100	8212	93.6	100	8300	60.6	94.4
Red flour beetle	996	23.7	94.4	394	6.1	77.7	681	9.2	66.3	255	3.8	54.2	175	2	55.1	1817	13.3	59.6
Rusty grain beetle	16	0.4	62.5				29	0.4	45.8	24	0.4	37.8	16	0.2	38.4	21	0.2	37.7
Angoumois grain moth	1184	28.2	76.3										372	4.2	45	1565	11.4	65.2
Rice weevil				1724	26.8	55	1508	20.3	53.9							1987	14.5	59.2
Total	4199			6428			7424			6612			8775			13690		

Weight loss, grain damage and seed germination

Table 3 revealed that there was significant weight loss, grain damage and germination loss due to insect pest infestation on stored maize grains under farmers' storage facilities in the study areas.

Table 3: Percent weight loss, grain damage and seed germination over storage period of 3 months-6 months in West Wollega and Kellem Wollega zones.

Parameter (in %)	West Wollega Zone		Kellem Wollega Zone			
	Lalo Asabi	Ayira	Dalle Sadi	Sadi Chanka	Hawa Galan	Sayo
Weight loss (Mean ± SEM*)	58.6 ± 3.3	44.5 ± 1.6	54 ± 0.9	57.9 ± 0.8	67.2 ± 0.6	70.1 ± 0.8
Grain damage (Mean ± SEM)	88.3 ± 0.5	88.3 ± 0.3	89.3 ± 0.2	89.4 ± 0.2	89.8 ± 0.2	89.7 ± 0.1
Germination (Mean ± SEM)	44.2 ± 1.6	38.6 ± 1.1	30.9 ± 0.8	30.9 ± 0.8	20.4 ± 0.4	29.6 ± 0.9

*SEM: Standard error of mean

Weight loss: There was significant weight loss due to insect pests in all surveyed study areas. The mean percentage of weight loss due to insect pests under farmers' storage facilities was highest in Sayo district (70.1%) followed by Hawa Galan, Lalo Asabi, Sadi Chanka, Dalle Sadi and Ayira districts 67.2%, 58.6%, 57.9%, 54% and 44.5%, respectively (Table 3).

Grain damage: The mean percentage of grain damage in all assessed districts was between 88.3% and 89.8%.

Germination: The lowest mean percentage of germination of maize grain was recorded from Hawa Galan district (20.4%) and highest mean percent germination was from Lalo Asabi district (44.2%) followed by 38.6%, 30.9%, 30.9% and 29.6% Ayira. Dalle Sadi, Sadi Chanka and Sayo districts, respectively.

DISCUSSION

Taxonomic positions, relative abundance and constance of recorded stored maize insect pests

Four species belonged to three different families of coleopterans and one species belonging to one family of lepidoptera; namely: Curculionidae, Tenebrionidae. Cucujidae and Gelechiidiae, respectively, were recorded in the present study. From all recorded insect pests, maize weevil (*Sitophilus zeamais*) was the most dominant in all surveyed districts of West Wollega and Kellem Wollega zones. Similar study conducted by Abraham indicated that 37 species of arthropods associated with stored maize grain were recorded in the Bako area, western Ethiopia. This author also stated that among all counted arthropods, 79% were the weevils (*Sitophilus spp*). As Sori and Ayana indicated in their report, seventeen arthropod species were recorded on maize grain in Jimma zone, Ethiopia. Among these, maize weevil (*Sitophilus zeamais*), *Sitotroga cereallela*, *Sitophilus oryzae* and *Tribolium confusum*, respectively, were the most dominant and wide spread species in all the area they have surveyed. Mamoon-ur-Rashid, et al., also reported that they have recorded six species belonged to three different orders: Coleoptera, Lepidoptera and Hymenoptera. Of all, the maize weevil (*Sitophilus zeamais*), confused flour beetle (*Tribolium confusum*), angoumois grain moth (*Sitotroga cerealella*), (*Rhizopertha dominica*) and rice weevil (*Sitophilus oryzae*) were the most abundant insect pests species in Dera Ismail Khan and its adjacent Punjab areas. The most frequently occurred insect species per 300 g of sampled maize grain was *Sitophilus zeamais* (94.4 and 100%) followed by *Tribolium castaneum* (between 54.2% and 94.4%), *Sitotroga cerealella* (between 45% and 76.3%), *Cryptolestes ferrugineus* (between 37.7% and 62.5%) and *Sitophilus oryzae* (between 53.9% and 59.2%), respectively. Berhanu reported that *Sitophilus zeamais*, *Sitotroga cerealella*, Sitophilus oryzae, *Tribolium castaneum*, *Tribolium confusum*, *Cryptolestes ferrugineus*, *Cryptolestes pusillus* and *Rhyzopertha dominica*, were found to be the most frequently occurring species per 100 g of sampled maize grain from Silte and Hadiya zones, Ethiopia.

Weight loss, grain damage and seed germination

In the current study, weight loss of maize grain due to insect pest was varied from 44.5% to 70.1% while grain damage was 88.3% to 89.8% in the surveyed districts of West Wollega and Kellem Wollega Zones. Sori and Ayana reported the weight loss that varied from 41% to 80% and grain damage ranged from 54% to 75% between three to six months of storage in Jimma Zone.

The study by Waktole also revealed that there was significant mean percentage of weight loss (63.85%) and grain damage (64.60%) under farmers' storage structures in Jimma zone. The mean percentage germination of maize seeds collected from farmers' storage facilities was varied from 20.4% to 44.2%. According to Emana and Assefa there was reductions in maize seed germination because of insect damage in Sidama zone. The study report by shiferaw also indicated that there was lower maize germination due to relatively higher infestation and grain damage in Eastern Ethiopia.

CONCLUSION

In the present study, five species of arthropods from three orders and four families were recorded from the study area. *Sitophilus zeamais*, *Sitophilus oryzae*, *Tribolium castaneum* and *Cryptolestes ferrugineus* were identified from order coleoptera and *Sitotroga cerealella* from lepidoptera. *Sitophilus zeamais* was the most abundant followed by *Sitophilus oryzae*, *Sitotroga cerealella*, *Tribolium castaneum* and *Cryptolestes ferrugineus*. There was significant grain damage and associated quality loss due to these stored maize insect pests.

RECOMMENDATIONS

Storage insect pests were found to be the most economically important constraints of storing and utilizing maize grains by farmers in West Wollega and Kellem Wollega zones. Therefore, it is important to design and implement safe management strategies to mitigate loss of maize grains due to storage insect pests. Providing timely training for farmers and extension workers is very important. Beside this, it is important to provide farmers with improved maize seeds. In addition, improvement of existing storage facilities, safe handling of maize grains and environmentally sound management practices are urgently needed in the study area. Further study that covers all maize growing area of both zones to evaluate the economic importance and infestation stored maize insect pests for better management option is needed.

DATA AVAILABILITY STATEMENT

Data are available any time on request after publication.

CONSENT FOR PUBLICATION

Authors have seen and approved their consent for publication and declared that no competing interests exist.

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