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Research Paper

First Report of the Larger Grain Borer, *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) from Stored Maize in Ethiopia

Sisay Girma Abebe, Ofgaa Djirata Dako*

Department of Applied Biology, Adama Science and Technology University, Adama, P.O. Box 1888, Ethiopia

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Abstract

In Ethiopia, over nine million farmers produce maize on about 14% of the total land area. It serves as food and feed. Various arthropod pests destroy maize in traditional storage. Larger grain borer (LGB), Prostephanus truncatus (Horn) is a devastating storage pest that constrain stored maize in Eastern Africa and beyond. This study was aimed at surveying whether the LGB has been infesting stored maize in southern Ethiopia or not. Community based cross sectional survey was conducted in four purposively selected kebeles in Baka Dawula Ari District in South Omo Zone of South Nations, Nationalities and Peoples Regional State. A total of three maize cobs were picked from each type of storage structure in three replications from every study Kebele. Then, the cobs were taken to the Laboratory of Entomology and Vertebrate Zoology of Arba Minch Plant Health Clinic and the pest species were identified by the use of binocular microscope. A total of 11 species of arthropod pests were identified from the stored maize. P. truncatus was found to be one of the most severely damaging of stored maize. This pest was recorded infesting maize grain in Ethiopia for the first time by this study. It is concluded that LGB has already entered into Ethiopia, it has already been established and it is devastating stored maize. Immediate integrated control of the LGB shall be implemented. A survey of countrywide geographical distribution of the LGB shall be held in order to design large-scale management practices of the pest.

1. Introduction

Cereal crops in general and maize (*Zea mays* L.) in particular play a significant role as a food in human nutrition (Bucklin et al., 2019). Maize ranks third, coming next to wheat and rice in the global cereal production (Swai et al., 2015). Its current global production covers several hundred millions of hectares, of which the shares of Africa, mainly the Sub-Saharan Africa, Asia and the South America, are incomparably maximal (Cairns et al., 2021; Erenstein et al., 2022). In Ethiopia, maize occupies a significant position in production, productivity and area coverage among the cereal crops (CSA, 2021). It is one of the major cereal crops in Ethiopia whose grains serve as food, and straws as a feed for domestic animals, for firewood and, in some lowland areas for the construction of temporary fences and other simple homestead structures (Waktole, 2014). According to Tsedeke et al. (2015), in Ethiopia, well over nine million farmers produce maize on about 14% of the total land area which is an indication that the crop is of paramount significance in the resilience food security. Maize production in Ethiopia is at a small scale level for family consumption and local markets, in general; however, very few medium-sized business oriented farms are emerging nowadays.

The maize producing communities store maize for various obvious reasons. Maize grain is stored to secure

*Corresponding author, e-mail: *ofgaa.djirata@astu.edu.et*

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food availability for the non-harvest season, to wait for a better marketing time, or to keep the seed for sowing in the next planting season. Smallholder farmers in most instances store their maize in traditional storage structures. Maize is stored, on average, for 10 – 12 months in a traditional storage in most of the African countries (Nukenine, 2010). The practice of keeping maize in traditional storage for later use is not without a challenge as for most other cereal crops. Many factors, such as adverse weather conditions, types of storage facilities, unwise storage practices, and the grain storage pests separately or in combination constrain keeping the maize grain in traditional storages (Suleiman et al., 2015; Berhanu and Emana, 2018). Rodents, birds, arthropod pests and fungi are among the biological factors associated with qualitative and quantitative losses of stored maize.

Among the pests that constrain maize grain in storage, some members of the two insect orders, the Coleoptera and the Lepidoptera, are the most prevalent and devastating. The maize weevil (*Sitophilus zeamais*), the larger grain borer (*Prostephanus truncatus*), the angoumois grain moth (*Sitotroga cereallela*) and the lesser grain weevil (*Sitophilus oryzae*) being the most common postharvest pests of maize in Africa, the grain loss due to these pests accounts to about 30% with a conservative estimate (Abraham and Basedow, 2004; Bekele et al., 2011; Abass et al., 2014; Suleiman and Rosentrater, 2015; Likhayo et al., 2018). Likewise, *Sitophilus zeamais*, *Sitotroga cerealella*, *Ephestia cautella*, *Plodia interpunctella*, *Tribolium* spp. and *Cryptolestes* spp. were reported to constrain maize grain in traditional storage in all maize growing areas in Ethiopia (Abraham, 1996; Abraham, 2008; Girma et al., 2011).

The Larger Grain Borer (LGB), *Prostephanus truncatus* (Horn) was believed to have been introduced into Africa accidentally from Central America in 1970s, but its presence was confirmed only in 1981 in Tanzania (Golob et al., 1985; Tadele et al., 2011). Thus, Tanzania was the first focal country from where the pest spread across Eastern Africa and beyond. Following its record in Tanzania, the spread of LGB to Kenya, Burundi, Rwanda, Malawi, Mozambique, Namibia, Zambia, and South Africa was confirmed at different periods in time (Africa soil health consortium, 2014; Midega et al., 2016). The occurrence of the pest has been reported from East to Central Africa, Southern Africa and Western Africa in that order, with its introduction to western Africa to have been relatively recent (Muatinnte et al., 2014). Gueye et al. (2008) confirmed that LGB was recorded in Senegal only in 2007 for the first time. The entry into western Africa of the LGB was believed to be independent of that of the Tanzanian route (Africa soil health consortium, 2014).

The Larger Grain Borer established in Africa and became a devastating pest that caused a yield loss of about 40 and 100% to stored maize and cassava chips, respectively (Muatinnte et al., 2014; Quellhorst et al., 2021). Reports indicated that the LGB is a polyphagous pest which feeds on numerous varieties of crops including cowpea, groundnuts, wheat, haricot beans, and cowpea, of which maize is the major host for the pest (Shires, 1977, as cited in Abraham et al., 2012). Despite its wide distribution in the East African countries, the LGB has not been reported infesting any crop in storage in Ethiopia so far, including in the Southern Ethiopian regions which share boarders with Kenya. In Ethiopia, LGB was recorded from only pheromone traps deployed at localities closer to the Kenyan border in 2009 (Abraham et al., 2012). The state of facts that LGB has not been recorded infesting any crop in Ethiopia is incongruous with its establishment, spread and attainment of a key pest status in almost all of the Sub-Saharan African countries. There were frequent and consistent surveys of the LGB by plant protection professional in Southern Ethiopia but the pest has not been recorded from storage crops prior to this study (personal communication with an expert from Arba Minch Plant Health Clinic). Therefore, this investigation has been initiated with the aim of surveying the occurrence of the LGB in Southern Ethiopia.

2. Materials and Methods

2.1. Description of the study area

The study was conducted in the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS), South Omo Zone, Baka Dawula Ari District. The district is geographically located between 5° 46' 0" and 5°54' 30" N and 36° 27' 0" and 36° 40' 30" E. It is one of the potential maize producing districts in the administrative zone. The altitude of Baka Dawula Ari District ranges from 800 to 3000 m above sea level. The site of the field survey gets a bimodal rainfall pattern with a shorter rainy season from March – May and the longest rainy season from August to November. The long-term mean annual rainfall is 1342.03 mm and the maximum and minimum monthly average temperatures of the study area are 27.61 and 16.3 °C, respectively (Biruk et al., 2018). Four administrative Kebeles (smallest administrative unit); namely Bako, Kaysa, Bayitsemal, and Giste, were considered for this study and the survey was conducted from January 01, 2023 up to March 31, 2023. The study Kebeles lay over different altitudinal ranges above the sea level; specifically, Bako from 2232 to 2339 m, Giste from 1342 to 1451 m, Kaysa from 1446 to 1488 m and Bayitsemal from 1331 to 1439 m. The main source of income of the communities in these kebeles is agriculture, of which maize production is the major.

2.2. Study design and sampling techniques

A community-based cross-sectional survey was used to select the households for this study. From a total of 3,715 maize producing households in the kebeles considered, 84 households having abundant numbers and sizes of storage structures were purposively selected (personal communication with Woreda Agricultural Development Offices). In the meantime, the numbers allocated to the kebeles were proportional to the total maize-farming households of each Kebele. Accordingly, 53, 14, 9 and 8 households were addressed from Bayitsemal, Kaysa, Giste and Bako kebeles, respectively.

To collect the pest samples from the stored maize, a total of three maize cobs were taken from the different types of storage structure, in three replications from every study Kebele. The maize cobs were collected from the bottom, middle, and upper parts of the *Gotera* (traditional storage analogous to silo but much smaller in size and volume), and from the middle and both end sides for the hanging over smoke and hanging without smoke. The collected maize cobs from each storage method were placed in separate plastic jars, labelled, and taken to the Laboratory of Entomology and Vertebrate Zoology of Arba Minch Plant Health Clinic for identification of the pests**.** In the laboratory, a total of three hundred grams of maize grains were shelled from each sample and the grains were sieved through a 3 mm sieve and later a 4.5 mm sieve to separate the pests from the maize grains and the flour produced by the pests. Following the sieving, the grains were inspected by hand lens, and the pests that remained in the damaged maize grains were removed and included in the sample. The pests were preserved in a 75 % alcohol, observed under a binocular microscope and identified with the aid of identification keys and coloured plates (Rees, 2007; Hagstrum and Subramanyam, 2009) and numbers of populations of each species were counted and recorded.

2.3. Data analysis

Microsoft Office Excel was used to summarize and present the species composition, relative abundance, and the frequency of occurrence of the insect pests inflicting the stored maize in the study kebeles. Accordingly, the count of individuals in each species relative to the total number of individuals in all the species was considered as a relative abundance of each species from the following formula:

$$Relative\ abundance\ of\ a\ species = \frac{Number\ of\ individuals\ of\ the\ species}{Total\ number\ of\ observed\ individuals} * 100$$

Frequency of species occurrence was calculated from:

$$Frequency\ of\ occurence = \frac{No\ of\ samples\ in\ which\ species\ occurred}{Total\ number\ of\ samples} * 100$$

3. Results

It was found that maize grains were stored in *Goteras* (*Riqa*), hanged over smoke and hanged without smoke. The *Goteras* were used in various forms; namely, walls made of bamboo, wooden poles with thatched grass roof and corrugated metal roof whose walls were either plastered or unplastered. In all cases, maize grains were stored unshelled from the cobs. A total of 10 species of insects categorized under the two orders, Coleoptera and Lepidoptera, and one acarine pest were recorded from the stored maize examined (Table 1).

Table 1: Categories of pests identified from stored maize in the study area

Order	Family	Common name	Scientific name
Coleoptera	Bostrichidae	Larger grain borer	*Prostephanus truncates*
	Bostrichidae	Lesser grain borer	*Rhyzopertha dominica*
	Curculionidae	Maize weevil	*Sitophilus zeamais*
	Curculionidae	Rice weevil	*Sitophilus oryzae*
	Curculionidae	Granary weevil	*Sitophilus granaries*
	Tenebrionidae	Rust red flour beetle	*Tribolium castaneum*
	Tenebrionidae	Confused flour beetle	*Tribolium confusum*
	Silvanidae	Saw toothed grain beetle	*Oryzaephilus surinamensis*
	Nitidulidae	Corn sap beetle	*Carpophilus dimidiatus*
Lepidoptera	Gelechiidiae	Angoumois grain moth	*Sitotroga cerealella*
Acarina	Acaridae	Grain or flour mite	*Acarus siro*

Nine of the 10 insect species identified were the coleopteran, among which the larger grain borer (LGB) *Prostephanus truncates* was found. In this study, the larger grain borer (LGB) *Prostephanus truncatus* (*Coleoptera: Bostrichidae*) was recorded infesting the maize grain in the storages for the first time (Figure 1).

The large grain borer was found to have bored through a cob with intact husk, breaks the maize grain upon consuming it until the whole grain was turned into flour (Figure 2).

The relative abundance of P. truncates population was found to be at the second level being preceded by only S. zeamais and its frequency of occurrence was after S. zeamais and S. oryzae in a descending order (Table 2).

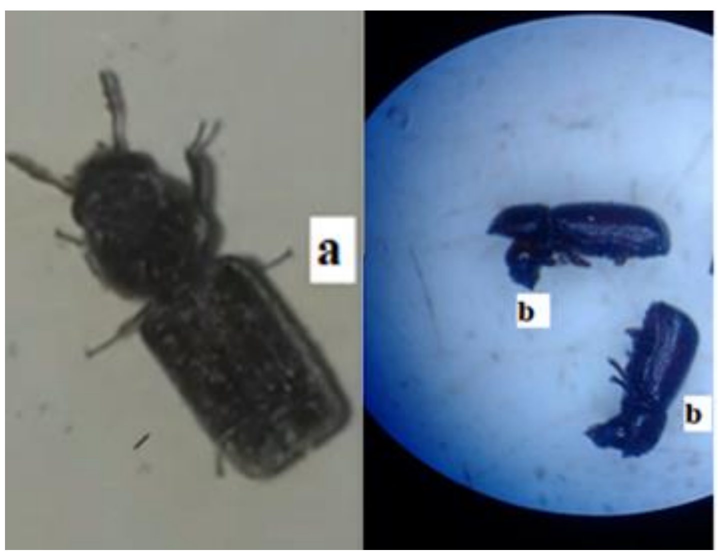

Figure 1: *Prostephanus truncatus* photos taken through eyepieces of the binocular microscope, (a) dorsal position and (b) rear positions

Figure 2: The damages posed by LGB on maize in storage

Table 2: Population size, relative abundance and frequency of occurrence of the pests associated to the stored maize

Pest species	Total number of adult collected	Relative abundance (%)	Frequency(%) of occurrence
Prostephanus truncatus	2439	34.15	75.00
Rhyzopertha dominica	722	10.10	75.00
Sitophilus zeamais	2608	36.51	91.60
Sitophilus oryzae	368	5.15	79.50
Sitophilus granaries	189	2.65	41.60
Tribolium castaneum	298	4.17	72.20
Tribolium confusum	213	2.98	75.00
Oryzaephilus surinamensis	75	1.05	50.00
Sitotroga cerealella	213	2.98	66.60
Carpophilus dimidiatus	9	0.13	8.30
Acarus siro	9	0.13	5.50

4. Discussions

Maize grains were stored unshelled from the cobs. The major insect pests found severely damaging the crop were members of the order Coleoptera with only one representative each from Lepidoptera and Acarine pest. *Prostephanus truncatus*, which is commonly known as the Large Grain Borer (LGB), was recorded by this study for the first time infesting storage products in Ethiopia. The LGB was found piercing the intact husk of the maize cob and making holes through the maize grain by which most parts of the grains were changed completely into maize dust. This finding is in agreement with the studies which depicted that the LGB is a major storage pest that caused the loss of more than half of stored maize in various African countries (Abass *et al*., 2014; Midega *et al*., 2016). Almost all of the pests recorded in this study have been frequently reported from stored maize and other field crops from Ethiopia by various area experts except for the LGB (Abraham and Basedow, 2004; Abraham et al., 2012; Ararso and Berhanu, 2020; Tsehaynew and Berhanu, 2020).

On the other hand, the presence of the LGB was confirmed in 2009 from pheromone traps deployed in Ethiopia at localities closer to the Kenyan border, but it was reported that the pest was not recorded from any crop. It is questionable to accept that the LGB which was introduced in 1981 into the Eastern Africa and soon established and spread throughout the region and beyond didn't enter into Ethiopia up to recent years. Rather, there might be lack of thorough investigation or there might be error in the identification of the insect. Gueye et al. (2008) underlined that the record of the LGB in Senegal relatively later than other western African countries might not indicate its real absence but probably because sufficient investigation was not done till its first record in 2007. The probable route of entry of the LGB to Southern Ethiopia is from the Kenyan side and the period might be much earlier to this record. If the introduction of the LGB to Ethiopia took place long ago but remained unrecorded from stored crops by researchers and crop protection departments, it might have been well established and might have already spread to other maize producing regions of Ethiopia. Finally, introduction of *Prostephanus truncatus* into Ethiopia as a new storage pest and that it established and began to destruct the maize grain will pose a new and serious challenge to the agricultural sector.

5. Conclusion and Recommendations

Maize was stored in traditional storage facilities, the grains unshelled and the husks kept intact in the study area. *Gotera* was the dominant storage structure of maize cobs in the study area. Arthropod pests, mainly the coleopteran were the dominant pests of stored maize. *Prostephanus truncatus* has entered into Ethiopia and has already begun to have aggressively devastated the stored maize grains. The frequency of occurrence of the LGB recorded in this study indicated that its population abundance reached an alarming level.

Larger grain borer is a catastrophic pest newly introduced to Ethiopia. However, it is not new to science. Therefore, its control methods shall be shared from the countries which have already experienced the pest infestation and be implemented in Ethiopia. Countrywide awareness creation and training shall be given to the agricultural sector workers and maize farmers on the biology, phenology, and feeding behaviour of the large grain borer as soon as possible.

A survey on the geographical distribution of the larger grain borer shall be held as soon as possible in order to design large-scale management strategies to control the pest before it is too late.

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