The Species Composition and Relative Abundance of Insect Pests of Stored Faba Bean in Farta District of South Gondar Zone of North Western Ethiopia

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Abstract: Faba bean contributes to meet the basic dietary needs of millions of people and animals around the world, including Ethiopia, pertaining to its high protein, carbohydrate, dietary fibers and micronutrients. Nevertheless, insect pests have been reported to cause significant loss of it under traditional farmers' storages. Accordingly, survey involving sampling of stored faba bean from a total of 162 farmers stores selected in nested design was conducted from 4, September 2019 – 15, May 2020 in six major faba bean producing peasant associations of Farta District. Accordingly, a total of 10 species of insect pests viz *Acanthoscelides obtectus*, *Callosobruchus* sp.*, Callosobruchus chinensis, Zabrotes subfasciatus, Callosobruchus maculutus, Bruchus* sp. and *Bruchidius* sp. were recorded from stored faba bean of the study area. 90% of which was belonging to order Coleoptera with in two families i.e., Bruchidae and Nitidulidae, while one species (10%) was from order Psocoptera of the family Liposcelididae. In terms of their relative abundance the species were in the following order *Acanthoscelides obtectus* > *Callosobruchus sp.* > *Callosobruchus chinensis* > *Zabrotes subfasciatus* > *Callosobruchus maculutus* > *Carpophilus sp.* > *C. dimidatus* > *Liposcelis sp.* > *Bruchus sp.* > *Bruchidius sp.* Accordingly, the presence of great infestation of the faba bean grain by pests was suggested. As a result, the traditional practices used by farmers were ineffective for satisfactory protection of the stored faba bean grains. Therefore, designing effective management strategies against insect pests of stored faba bean in the study area is urgently needed.

Keywords: Insect pests, relative abundance, species composition, stored faba bean.

1. INTRODUCTION

Faba bean (*Vicia faba* L.), are among the oldest crops grown in the world [1-3]. It is the third most important grain legume after soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) in area coverage and production [2, 3]. It contributes to meet the basic dietary needs of millions of people and animals around the world, including Ethiopia due to its high content of proteins, carbohydrates, dietary fibers and micronutrients [4].

In Ethiopia, pulses are vital crops next to cereals, as they are cheap sources of protein and play a modest role in export market. These legumes include faba bean or broad bean (*Vicia faba*), haricot bean or common bean (*Phaseolus vulgaris*), field pea (*Pisum sativum*), chickpea (*Cicer ariethenum*), grass pea (*Lathyrus sativus*), lentil (*Lens culinaris*) and soybean (*Glycine max*) [5].

However, rural farmers of the study area, in particular and Ethiopia, in general have been facing the most serious grain loss problem, including faba bean under their traditional storage facilities mainly due to insect pests [6-11]. Faba bean has been grown in a wide range of environments in Ethiopia and subjected to attack by various insect pest species [5]. The reason behind such serious attack of faba bean and other grains in storage in Ethiopia has been reported to be the use poor traditional storage facilities by farmers and shortage of storage technologies that allows insect pests, fungi and other vertebrate pests to easily infest and reproduce on grain [11, 12].

Consequently, while mentioning the extent of the storage problem, farmers frequently reported that they have been almost equally sharing their stored food grains such as faba bean with post-harvest pests, primarily of insect pests, followed by fungi [8, 10, 13]. This situation has been forcing the farmers to sale their produce immediately after harvest when market price is very low to buy later at expensive price and consequently, leads them to fail under poverty trap [6, 8, 10, 11, 14].

Accordingly, these losses have great impact in food security, income as well as prosperity of resource poor farmers in Ethiopia. As a result, there is urgent need to maintain quantity as well as quality of grains, including faba bean to reduce such significant loses and increase food security as well as income of resource poor farmers in the study area. Consequently, determining the species composition and relative abundance of the insect pests is the first and vital step towards the search of solution to such grain loss

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problems by farmers. Therefore, this study has assessed and determined the species composition and relative abundance of insect pests of stored faba bean in Farta District of South Gondar Zone of North Western Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in Farta Woreda (district), which is located in south Gonder zone of the Amhara Regional State (ARS) of Northern Ethiopia. Farta district lies between 11^0 32' to 12^0 03' latitude and 37^0 31' to 38^0 43' longitude [15]. It is one of the 105 districts in the Amhara Regional state of Ethiopia, bordering Debre Tabor, the capital of South Gondar Zone.

2.2. The Study Period and Design

The study was conducted between 4, September 2019 – 15, May 2020 in six major faba bean producing kebeles (peasant associations or PAs) of Farta woreda (district). The PAs are namely Weybila-Selamko, Buro-kantona, Abaregay, Kanat, Werkien and Eyesus.

From each kebele, about three sub-localities were randomly selected and from each sub-locality, three villages were selected at random with the assistance of the Ministry of Agriculture (MOA) sub-kebele staff using a nested design as adopted by earlier researchers [8, 9, 11, 16]. From each village, three farmers' storages were selected randomly. Kebeles was selected purposively based on abundance of faba bean production, such that all kebeles growing faba bean utmost were selected for the survey, while villages and representative farmers storages were selected randomly.

2.3. Determination of the Species Composition and Relative Abundance of Insect Pests of Faba Bean

One kg of faba bean grain was taken from a total of 162 stores (three storages from each village of the six kebeles, i.e. 6 kebeles x 3 localities x 3 villages x 3 stores = 162 stores totally), selected randomly in the aforementioned manner. Samples were taken from top, sides, center and bottom of the different storage structures using different sampling tools such as sampling spear and human hands after mixing them thoroughly. Each sample at each sampling date from different storage methods at each villages of the sampling site was collected in sampling bag, labeled with necessary information and brought to insect science laboratory of Debre Tabor University for identification of insect pests [11]. The sample grains were collected three times from farmer's storages of each village in the middle of 3^{rd}, 4^{th} and 5^{th} month's storage period, during which the stored faba bean grains were likely to be more infested by insect pests than in the beginning of storage periods.

Then each sample at each sampling date from different storage methods at each villages of the sampling site were sub sampled to come up with the slandered of 100g sub sample for identification of pests. Sieves of different size (mm) were used for separating the adult insects from the sub sample grains. Live and dead insects from sub samples of the different farmer's traditional methods of each villages of each kebeles were collected and immediately preserved in 100 ml capacity bottles and kept for further identification. The sub sampled grains was also putted in 1 L glass jars and kept under laboratory conditions (27 ± 3 °C and 55 - 70% RH) to determine species from internal infestation [11]. The procedures and keys of the books related with stored product insect pests and other arthropods by different authors [17-22] were used for identification purpose.

Then after, insects were sorted according to their orders, families and species, and counted for each subsample grains from each of different farmer's traditional storage methods from each PAs, in each case noting the number. The average of the sum total of species of insect pests collected from sub-sampled grains from all of the farmer's traditional storage methods over three sampling periods were used to determine the abundance and relative abundance of insect pests. The abundance and relative abundance of insect pests were determined as suggested by Bueno [23].

Accordingly, abundance refers to the total number individuals of a species divided by the total number of samples (in this case the total kilograms of grain sampled) and it is expressed by the following formula:

Abundance of species = Total number of individuals of species **/** Total number of samples

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

Relative Abundance of species = (Number of individuals of a species **/** Total number of observed individuals) x 100

2.4. Data Analysis

The data collected from the grain sample survey were managed and analyzed using Microsoft Excels software version 2010 and Statistical Program for Social Sciences (SPSS) software version 2016. Descriptive statistics (mean, frequency and percentage) were used for compiling, summarizing and computing data on abundance and relative abundance of insect pests of stored faba bean. Appropriate statistical method, one way analysis of variance (ANOVA) was used for calculating mean abundance and mean percent relative abundance of insect pests identified from stored faba bean sample grains of the study area. Significant differences between means were separated by Turkey's honestly significant difference (THSD) test at 95% confidence level.

3. RESULTS

3.1. The Species Composition of Insect Pests Associated to Stored Faba Bean Grains in Farta District

The species composition of insect pests identified in sampled grain collected from stored faba bean of farmers traditional storages of the study area are indicated in Table **1**. Accordingly, in the current sample survey, a total of 10 species of insect pests such as *Acanthoscelides obtectus, Callosobruchus* sp.*, Callosobruchus chinensis, Zabrotes subfasciatus, Callosobruchus muculutus, Bruchus* sp. and *Bruchidius* sp.*,* were identified from stored faba bean samples collected from representative farmer's storages of the study area. Of which, nine species (90%) were belonging to order Coleoptera with in two families such as Bruchidae and Nitidulidae, while, one species (10%) was from order Psocoptera of the family Liposcelididae. Besides, among insect pests identified in sampled grain collected from stored faba bean of farmer's traditional storages of the study area, seven spices; *Acanthoscelides obtectus, Callosobruchus* sp., *Callosobruchus chinensis, Callosobruchus muculutus*, *Zabrotes subfasciatus*, *Bruchus* sp. and *Bruchidius* sp.*,* were primary pests. But, three species; *Carpophilus* sp.*, C. dimidatus* and *Liposcelis* sp. were mold feeders in terms of pest type (Table **1**).

3.2. Relative Abundance of Insect Pests of Stored Faba Bean Grains in Farta District

Among the insect pests identified from farmers' traditional storage methods of faba bean, five species*; Acanthoscelides obtectus, Callosobruchus* sp., *Callosobruchus chinensis, Zabrotes subfasciatus* and *Callosobruchus muculutus,* respectively were found to be the most abundant relatively as they appeared between 26.36 and 12.65 individuals on average per 100 g of sampled grains (Figure **1**). They were also found to be the most prevalent as they occurred in the range between 427 and 205 individuals of each species per 100 g of the sampled grains (Figure **2**).

Next to the aforementioned five species, *Carpophilus* sp. and *C. dimidatus* were found to be the other abundant and predominant species as they appeared in 6.85 and 6.05 average number of individual each, respectively per 100 g of sampled grains (Figure **1**) and as they occurred in 111 & 98 individual species each, respectively on 100 g of the sampled grains (Figure **2**). However, *Liposcelis* sp. *Bruchus* sp. and *Bruchidius* sp., were found to be least abundant and least prevalent as they occurred in 2.22,

Table 1: The species Compositions of Insect Pests Identified in Stored Faba Beans of the Study Area

Insect pests recorded	Common name	Order	Families	Pest type
Callosobruchus sp.	Cow pea beetle	Coleoptera	Bruchidae	Primary
Callosobruchus chinensis	Adzuki bean weevil	Coleoptera	Bruchidae	Primary
Callosobruchus maculatus	Cowpea weevil	Coleoptera	Bruchidae	Primary
Zabrotes subfasciatus	Mexican bean weevil	Coleoptera	Bruchidae	Primary
Acanthoscelides obtectus	Common bean weevil	Coleoptera	Bruchidae	Primary
Carpophilus sp.	Sap beetles	Coleoptera	Nitidulidae	Mold feeder
Carpophilus dimidatus	Corn sap beetle	Coleoptera	Nitidulidae	Mold feeder
Liposcelis sp.	Book lice	Psocoptera	Liposcelididae	Mold feeder
Bruchus sp.	Pea weevil	Coleoptera	Bruchidae	Primary
Bruchidius sp.	Bruchid beetles	Coleoptera	Bruchidae	Primary

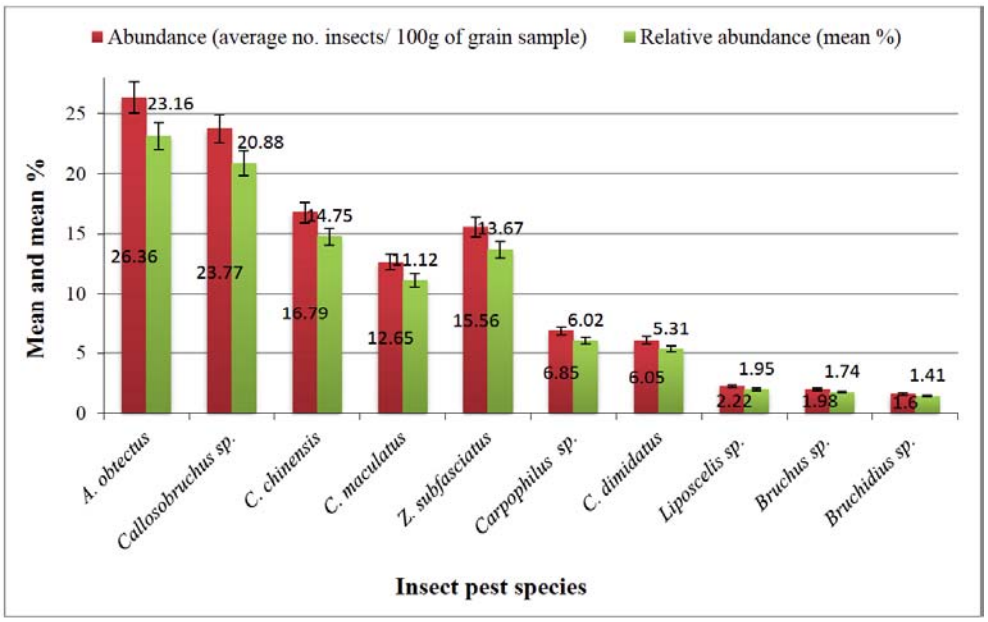

Figure 1: Relative abundance and prevalence of insect pests associated to stored faba beans in the Study Areas. Data labels inside the bars represent abundance, while those at outside end of the bar represent relative abundance, no. = number.

Means with different colors followed by different error bar (M ± SE) are significantly different; $p < 0.05\%$ using Turkey's studentized range test.

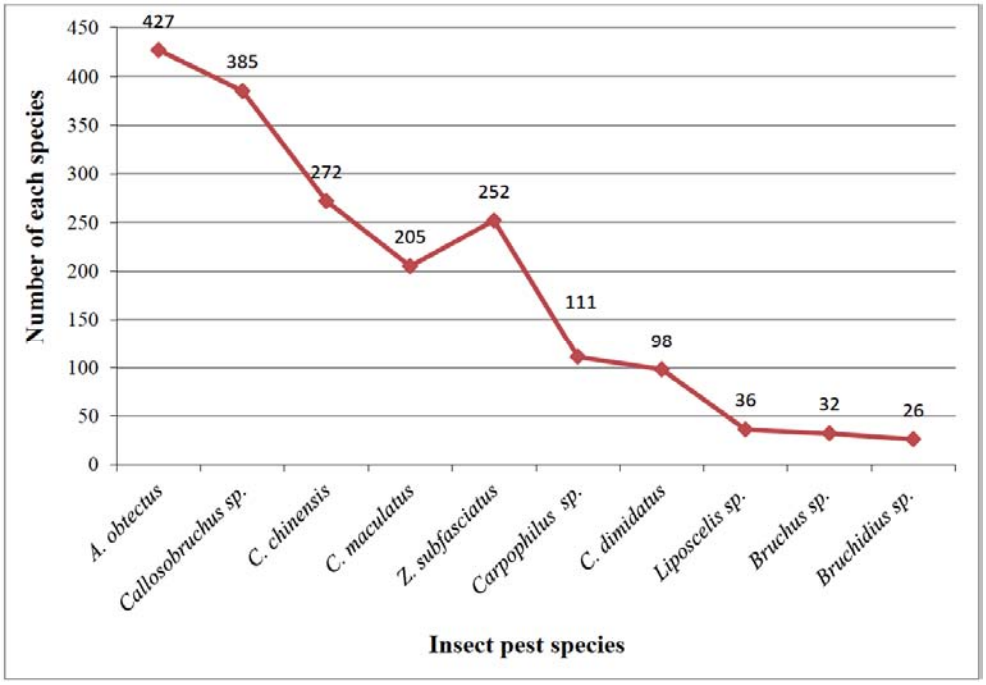

Figure 2: Number of insect pest species collected from stored faba bean sample of the study area (Total N = 1844), *N = number.*

1.98 and 1.60 individuals on average, respectively per 100 g of the sampled grains (Figure **1**) and as they appeared in 36, 32 and 26 individual each, respectively per 100 g of sampled grain (Figure **2**).

Accordingly, among ten species of insect pests identified from stored faba bean grain samples collected from the study area, five species (*Acanthoscelides obtectus, Callosobruchus* sp., *Callosobruchus chinensis, Zabrotes subfasciatus* and *Callosobruchus muculutus*) were the most abundant and predominant relatively that contributed to considerable attack of the stored faba bean in the study

area. However, two species (*Carpophilus* sp. and *C. dimidatus*) were moderately prevalent (abundant) relatively, while three species (*Liposcelis* sp. *Bruchus* sp. and *Bruchidius* sp.) were less prevalent and non-predominant. In other words, the ten species recorded from stored faba bean samples were found to be in the following order in terms of their relative abundance; *(Acanthoscelides obtectus* > *Callosobruchus* sp. > *Callosobruchus chinensis* > *Zabrotes subfasciatus* > *Callosobruchus maculutus* > *Carpophilus* sp. > *C. dimidatus* > *Liposcelis* sp. > *Bruchus* sp. > *Bruchidius* sp.) (Figures **1** & **2**).

4. DISCUSSION

Most of the species (90%) identified and recorded in the present study were from the order of Coleoptera (beetles). This finding suggests great importance of beetles in grain storages. It was also reported that pests that devastate stored grains, including faba bean are beetles [24, 25]. Among insect pests identified in sampled grain collected from stored faba bean of farmers' traditional storages of the study area in the present study, seven spices; *Acanthoscelides obtectus*, *Callosobruchus* sp*., Callosobruchus chinensis*, *Zabrotes subfasciatus*, *Callosobruchus maculutus*, *Bruchus* sp. and *Bruchidius* sp*.,* were primary feeders, while three species; *Carpophilus* sp., *C. dimidatus* and *Liposcelis* sp., were mold feeders which is accordingly to the feeding behavior and biology of these pests. In similar manner, it was reported that insect pests associated with stored grain can be divided into three major groups (primary, secondary and mold feeders) based on their importance, biology, and feeding behavior [11, 26, 27].

The relative abundance of the ten species of insect pests recorded from stored faba bean samples and their categorization accordingly in the following order; *Acanthoscelides obtectus* > *Callosobruchus* sp. > *Callosobruchus chinensis* > *Zabrotes subfasciatus* > *Callosobruchus maculutus* > *Carpophilus* sp. > *C. dimidatus* > *Liposcelis* sp. > *Bruchus* sp. > *Bruchidius* sp. in the present survey is in accordance with earlier reports [17-22] in which the former five species were indicated to be abundant pests of stored grains, especially pulses, including faba bean worldwide, followed by *Carpophilus* sp. and *C. dimidatus*. Besides, accordingly to the finding of the current study, *Bruchus* sp. and *Bruchidius* sp. were also shown to be pests of stored pulses, including faba bean worldwide [17-22]. Similarly, it was also shown that the most important pests of stored beans and other legumes are *Zabrotes subfasciatus, Acanthoscelides obtectus, Cullosobruchus chinensis* and *Cullosobruchus maculutus* [5, 28]. Furthermore, Umbuyeyi and Rukazambuga [29] also indicated that bean grain weight losses reached to 38% due to *A. obtectus, C. chinensis* and *Z. subfasciatus.*

5. CONCLUSIONS AND RECOMMENDATIONS

In the current study, it was possible to record a total of ten species of insect pests such as Acanthoscelides obtectus, Callosobruchus sp., Callosobruchus chinensis, Zabrotes subfasciatus, Callosobruchus maculutus, Bruchus sp. and Bruchidius sp., from stored faba bean samples collected from representative farmer's storages of the study area. Besides, the majority (90%) of the pests recorded were confirmed to be beetles than moths. Furthermore, majority (70%) of the identified pests were found to be primary pests than mold feeders (30%) in terms of pest type. The presence of mold feeder in the current study also suggests that the stored faba bean grains were highly infested and were out of conditions under some of the farmer's traditional storages. Accordingly, presence of great infestation, attack and the associated loss of the aba bean grain due to pests to which farmers have invested their knowledge, energy, time and money were suggested under farmer's traditional storage structures of the study area.

As a result, the traditional practices used by farmers were ineffective for satisfactory protection of their stored faba bean grains from insect pests after 3 months of storage. Therefore designing effective management strategies against insect pests of faba bean in the study area is promptly needed. In addition, improving the existing farmer's traditional storage structures and other traditional practices used by farmers is also unquestionable. Besides, provision of training to farmers and extension workers on safe handling of grains and management of insect pests of stored faba bean under farmer's traditional storage conditions are also needed by any concerned bodies. Moreover, the identification of stored faba bean pests of the study area was done using morphometric in the present survey, thus further identification using molecular techniques need to be done for better confirmation of them.

CONSENT FOR PUBLICATION

Not applicable.

APPENDIX

Partial views of pictures of insect pests recorded from stored faba bean grains of farmer's storages of the study area

Liposcelis sp. *C. dimidatus* *Callosobruchus* sp. *Callosobruchus* sp. *Callosobruchus* sp.

Callosobruchus chinensis *C. chinensis* *C. chinensis* *C. chinensis*

(Females, the former two; left and males with distinctive antennae, the latter two; right)

Callosobruchus sp. *Zabrotes subfasciatus* *Z. subfasciatus*

(*Z. subfasciatus* Adult- *g*lobular with long legs and antennae, elytra patterned and do not fully cover abdomen, spines at tip of tibia on hind leg)

Callosobruchus maculatus *C. maculatus* *C. maculatus* *C. maculatus*

(Adult globular with long legs and antennae, elytra patterned)

Acanthoscelides obtectus

Bruchus sp.

Bruchidius sp.

(*A. obtectus* adult: Elytra patterned and do not fully cover abdomen; adult have long antennae, patterned elytra and exposed final segments of abdomen, spines on lower edge of femur of hind leg).

(*Bruchus* sp adult; side of thorax with spine, larger relatively and *Bruchidius* sp. adult; head capsule narrow relative to width of pronotum, small relatively).

CONFLICTS OF INTEREST

The author declare that there is no conflicts of interest

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