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Research Article

INSECT BIODIVERSITY AND ASSESSMENT OF POST-HARVEST GRAIN LOSSES IN STORED COWPEA (*Vigna aunguiculata* L.)

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Abstract

Insect pests cause huge economic losses to stored grain cereals and pulses in tropical and subtropical areas around the globe. The level of damage and losses caused by different insect pests varies depending upon the infesting species, type of food materials, duration of storage and structures. The information about the diversity of infesting species, their dispersal and abundance are key for devising effective pest management techniques against storage insect pests. The present study aimed to collect information on the distribution, relative abundance and biodiversity of major insect pests of stored cowpeas in Dera Ismail Khan (Khyber Pakhtunkhwa) and its adjoining Punjab province areas of Pakistan. The areas selected for biodiversity studies were Paniala, Mankera, Bhakkar, Paharpur, Kulachi, Ramak, Dera Ismail Khan, Darya Khan, Notak and Behal. A vast survey of godowns was conducted to find out the population dynamics of insect pests of stored cowpeas and to explore the % grains damage and weight losses in the mentioned areas. For the collection of samples, a spear sampler was used to collect 500-gram samples from the top, middle and bottom portions of the bags. Samples were preserved in plastic containers and after 30 days, were sieved out with the help of a 2mm mesh sieve to remove different types of dead and alive insects. A total of five species representing two distinct orders i.e., Coleoptera and Lepidoptera. Coleopterans are *Callosobruchus maculatus*, *Tribolium castaneum*, *Oryzaephilus surinamensis*, *Trogoderma granarium* belonged to four families including Chrysomelidae, Tenebrionidae, Silvanidae, Dermestidae and Lepidopteron are *Sitotroga cerealella* belonging to family Gelechidae. The most abundant species among all the recorded insect pests of cowpea was *C. maculatus* (53.60%) followed by *T. castaneum* (18.60%), *S. cerealella* (16.97%), *O. surinamensis* (6.49%) and *T. granarium* (04.34%). The maximum infestation (26.98%) and weight loss (28.91%) of cowpea was recorded in Darya Khan followed by Dera Ismail Khan (22.70% and 26.33%), whereas; minimum % infestation and weight losses were recorded in Bhakkar (16.91% and 17.14%) area showing significant differences between the surveyed areas. The *C. maculatus* is the most abundant specie of the stored cowpea grains in the surveyed areas and needs management tactics to minimize the post-harvest grains losses. The population of *C. maculatus* starts to build up during the month of March (23.30ºC and 56.25% RH) and reaches at peak in May (35.32ºC and 68.88% RH). Special measures should be taken during these months to minimize the infestation and losses caused by *C. maculatus*.

Keywords: Cowpea, Damage, Storage, infestation, insect pests, C. maculatus
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1. INTRODUCTION

Cowpea (Vigna unguiculata L.) is an annual herbaceous legume crop and a source of food for mankind and livestock. Cowpeas are sometimes referred to as poor's meat due to the high nutritional value present in the leaves and seeds (Hamid et al., 2016). In drier regions of the world, it is a necessary component of cropping patterns (Fatokun et al., 2002). The color of the cowpeas may vary due to the coat covering the grains. It may be red, brown, white or green and smooth or wrinkled in shape. Cowpea is also grown as intercrop or in rotation with other cereal crops like maize, rice and sweet sorghum. All parts of the plant are used as food i.e., the green leaves, stem, green pods and dry seeds. Cowpeas seeds contain multi-nutritional elements viz. proteins, carbohydrates (sugar, dietary fiber), fats, vitamins, minerals and water (Goncalves et al., 2016).

In Pakistan, Chitral, Kohistan, Shangla, Bunner, Dir, Swat, Malakand, Thal Kohistan, Barawal, Dir and Bamboret valley in Chitral are the main cowpea growing areas where high quality cowpeas are produced having soft skin and good taste (Khan et al., 2010).

Cowpeas are stored for many purposes including maintenance of supply throughout the year, for gaining high prices during off-season and times of scarcity and for planting seeds at the next cropping season. The level of damage and losses caused by different insect pests during storage varies depending upon the infesting species, type of food materials, duration of storage and structures. A loss above 5% is regarded as an economic loss (Lale and Ofuya, 2001). The information about the insect pest diversity, distribution and abundance is vital for devising effective pest management plans against storage insect pests (Lale, 2002).

Approximately 1000 species of insect pests have been reported to cause damage to stored grain products in different regions around the globe (Jamwal et al., 2022). About 600 coleopteran species, causes damage to food commodities in stores (Rajendran and Sriranjini, 2008). Around the globe, almost 10% of post-harvest grain losses have been documented during storage conditions (Shankar and Abrol, 2012). A variety of insect pests have been reported to attack stored cowpea i.e. Callosobruchus maculatus, Sitophilus zeamais Motsch., Sitotroga cerealella Olivier and Tribolium castaneum Herbst in Nigeria (Suleiman, 2016). The production of cowpea is greatly affected by insect pests and diseases resulting in huge economic losses. This crop is attacked by insect pests both under field (flowering and post-lowering) and stored conditions (Jackai and Daoust, 1986). The losses caused by various insect pests to cowpea are a major threat to food security (Ofuya, 2001). It was reported that losses may often range between 40 to 100% in unprotected cowpea grains (Akinkurolere et al., 2006). The stored grain insects not only cause quantitative losses, but they also cause qualitative losses The presence of insects or their body parts in the stored grains (wings, legs, molting, etc.) is considered undesirable.

It has been recorded in Bangladesh that fifty (50) species of insect pests are considered notorious for causing substantial loss of food grains (Ahad, 2003). In the Jammu and Kashmir area of India, 16 different pests representing two orders i.e., Coleoptera (81.25%) and Lepidoptera (18.75%) were recorded under storage conditions from human dwellings during 2017-2018 (Jamwal et al., 2022). In Cameroon, the insect pests caused complete damage during 8-10 months storage in unprotected conditions (Ngamo, 2000). In Africa, the stored grain losses caused by insect pests were estimated at 49% (Olembo, 2000). Out of these species C. maculatus is the major pests (Ahad, 2003; Bhalla et al. 2008; Sharma et al., 2016; Gupta et al., 2016). The cowpea beetle C. maculatus is a cosmopolitan pest from field to store (Caswel, 1981). It causes significant qualitative and quantitative losses by

making holes in the seed which results in weight loss, decrease in market value and germination potential (Oluwafemi, 2012). It has been reported to cause up to 100% grain loss during storage, leading to severe economic losses (Umeozor, 2005). In West Africa, C. maculatus is considered as the key pest responsible for causing economical losses during storage conditions (Sanon et al., 2017).

There is a lack of information about the pest diversity, infestation and post-harvest losses caused to stored cowpeas in different areas of Pakistan. The tropical climate of Pakistan displays favourable conditions for the development and survival of a range of insect pests throughout the year. The present study aimed to find out the distribution, relative abundance and spectrum of major insect pests of stored cowpea in Dera Ismail Khan and its adjoining Punjab province areas for assessment of post-harvest losses. By using this information, sustainable pest management strategies may be designed to minimize the infestation and losses caused by insect pests during storage conditions.

2. Materials and Methods

2.1. Proposed place of work and facilities

This experiment was conducted at Laboratory of Entomology, Faculty of Agriculture, Gomal University Dera Ismail Khan (Latitude: 31.8188°N, Longitude: 70.8971°E).

2.2. Plan of work and methodology adopted

A vast survey of godowns, of studied areas, was conducted to investigate the population dynamics of insect pests of stored cowpea and to find out the percent grain damage and weight losses in Dera Ismail Khan and its adjoining Punjab province areas. The samples were collected fortnightly from 10 different locations in selected areas. The locations selected were Paniyala (70°58'45.29"E), Mankera (71°26'9.00"E), Bhakkar (71° 5'30.27"E), Paharpur (70°58'45.29"E), Kulachi (70°27'50.18"E), Ramak (70°41'24.97"E), Dera Ismail Khan (70°54'1.28"E), Darya Khan (71° 6'42.93"E), Notak (71° 3'2.55"E) and Behal (71° 0'45.03"E).

For the collection of samples, a spear sampler was used to collect 500-gram samples from the top, middle and bottom portions of the bags (Hall et al., 2000). All the collected samples were brought to the Laboratory of Entomology Department, Gomal University Dera Ismail Khan and preserved in plastic containers after due tagging according to their site of collection to avoid mixing of grains and were incubated for 30 days at constant conditions of 35 ± 2ºC and 65 ±5% RH. After 30 days, samples were sieved out with the help of a 2mm mesh sieve to remove dead and alive insects. The adult insects were identified by using standard keys.

2.3. Parameters/variables studied

The collected samples were brought to the laboratory and 20-gram cowpeas seeds were isolated from collected specimens and placed in separate containers in an incubator maintained at 35 ± 2ºC and 65 ±5% R.H. for an incubation period of two months to calculate percent infestation and weight loss. After the incubation period, the damaged and undamaged grains were separated. The data on the damage indices was recorded and grains were divided into damaged (those having holes) and undamaged grains (without holes). A grain having at least a perforation made by the emergence of an adult insect was considered a damaged grain. The damaged and undamaged cowpea grains were separated with the help of a magnifying glass. The percentage infestation and damage were calculated with the help of the following formula:

% Weight loss = ((UNd - DNu) /U (Nd-Nu) x 100

“Und” stands for Weight of undamaged grains

“Nd” stands for the number of damage grains

“D” stands for the weight of damaged grains

“Nu” stands for the number of undamaged grains

% Infestation=(Damaged grains in a container/ Total grains in a container)×100

2.4. Statistical Analysis

The pest infestations and weight loss data were analyzed using one-way analysis of variance (ANOVA) and means were separated by F-test at α = 0.05 using computer software (SPSS ver. 13).

3. RESULTS AND DISCUSSION

3.1. Population dynamics of post-harvest insect pests of cowpea crop

The data presented in Fig-1 show infestation of post-harvest insect pests associated with stored cowpea in all the surveyed locations with different infestation levels during November 2017 to October 2018. The minimum infestation was recorded during the extreme cold months of January and February, 2018. As the season progressed, the population of insect pests started to build up during the month of March (23.30º C and 56.25% RH) and reached at peak in the month of May (35.32º C and 68.88% RH). During the course of the study, it was noted that a population decline was observed in the month of June and July suggesting that high temperature (40-42 ºC) and low humidity (30-38%) negatively affected the biology of insect pests of stored cowpea. The population again started to build up during the month of August, 2018 (Fig-1).

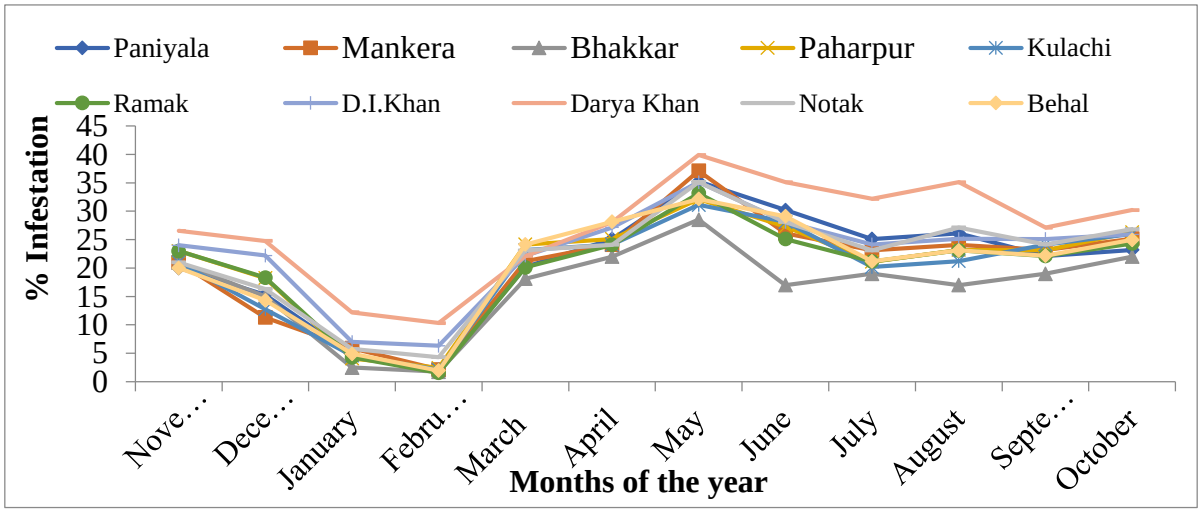


Fig-1: Percent infestation of various insect pests of stored cowpea during November 2017 to October-2018

Among the locations, the maximum % infestation (26.98%) and weight losses (28.91%) were recorded in Darya Khan followed by Dera Ismail Khan (22.70% and 26.33%), Notak (21.59% and 24.19%), Paharpur (20.85% and 24.09%), Paniyala (20.75% and 22.51%), Behal (20.52% and 21.66%), Mankera (20.38% and 21.03%), Ramak (20.03% and 20.90%) and Kulachi (19.88% and 20.01%), while minimum % infestation and weight loss was recorded in Bhakkar (16.91% and 17.14%) showing significant variations among the surveyed localities.

Sori and Ayana (2012) also reported 64.50% and 41 to 80% grain damage and weight losses caused by stored grain pests after three to six months storage.

Overall, maximum infestation of insect pests was found in Punjab Areas and minimum infestation was recorded in Dera Ismail Khan (KPK) areas. These results are in contrast with the findings of Rashid et al., 2016; they reported that Dera Ismail khan (KPK) and its adjoining areas had a higher pest population while minimum was recorded from Punjab and its surrounding areas. The reason behind this may be difference of host. The differences in infestation and losses caused in the surveyed areas are due to the reason that in Punjab province the farmers are storing the commodities for longer durations whereas; in Dera Ismail Khan (KP) the commodities were stored for shorter periods and on a small scale.

It is evident from the present findings that the temperature and humidity affect the biology of the insect pests of cowpea. Our findings confirm the previous results which found that the standard temperature for post-harvest storage insect pests of cowpea ranges between 30-35ºC with a relative humidity of 65% (Ahmady et al., 2016, Beck and Blumper, 2011 and Verma et al., 2018).

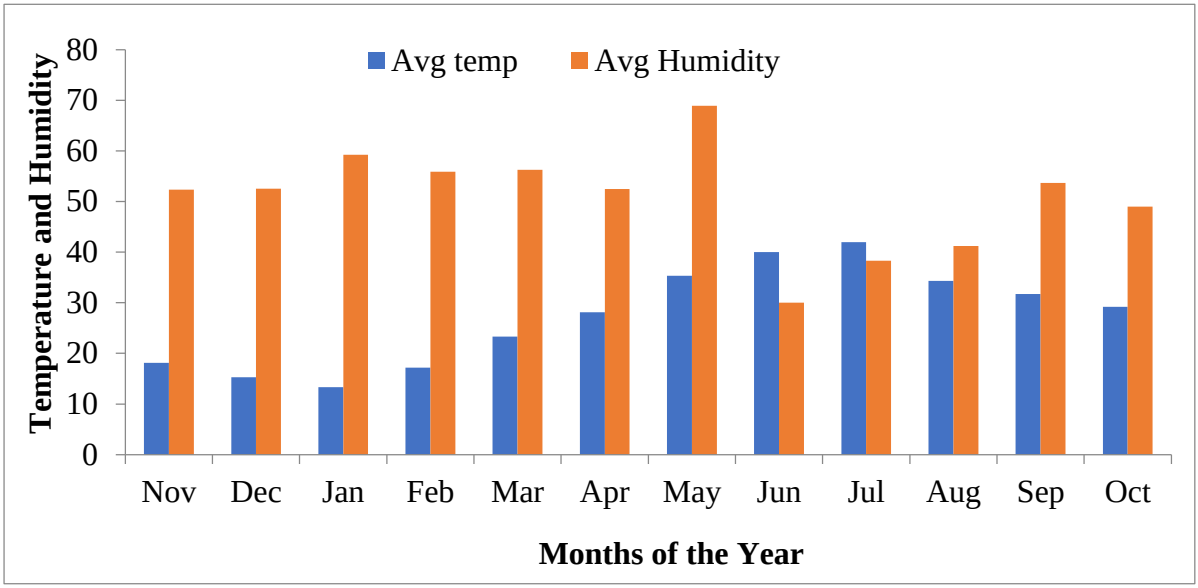


Fig-2: Average temperature (ºC) and relative humidity (%RH) from November 2017 to October 2018 of Dera Ismail Khan

that a total of five species belonging to two distinct orders i.e., Coleoptera and Lepidoptera. Coleopterans are Callosobruchus maculatus (pulse beetle), Tribolium castaneum (red flour beetle), Oryzaephilus surinamensis (sawtoothed beetle), Trogoderma granarium (khappra beetle) belonged to the families Chrysomelidae, Tenebrionidae, Silvanidae, Dermestidae and Lepidopteron are

Table-1: Percent infestation and weight loss of cowpea grains (120 grams) at various locations of Dera Ismail Khan and its adjoining Punjab area

Location	% Infestation	% Weight loss of sample
Darya Khan	26.98 a	28.91 a
Dera Ismail Khan	22.70 b	26.33 b
Notak	21.59 bc	24.19 c
Paharpur	20.85 cd	24.09 c
Paniyala	20.75 d	22.51 d
Behal	20.52 d	21.66 de
Mankera	20.38 d	21.03 ef
Ramak	20.03 d	20.90 ef
Kulachi	19.88 d	20.01 f
Bhakkar	16.91 e	17.14 g
LSD Value	1.07	1.09

3.1.1. Biodiversity and relative abundance of insect pests associated with stored cowpea

Current study was conducted to explore the various insect pests causing damage to stored cowpea in Dera Ismail khan and its adjoining Punjab areas. Table-2 revealed

Sitotroga cerealella (angoumois moth) belonged to family Gelechidae. The most abundant specie among all the recorded insect pests of cowpea was C. maculatus (53.60%) followed by T. castaneum (18.60 S. cerealella (16.97%), O. surinamensis (6.49%) and T. granarium (04.34%). Sori

and Ayana (2012) also reported the biodiversity of insect pests associated with stored grains. They explored seventeen arthropods, thirteen Coleopterans, three Lepidopterans and one Acarina on stored maize.

The survey conducted to find out the biodiversity of insect pests of stored pulses during a six-month storage period. The lifecycle of the C. maculatus was studied by Oke and Akintunde (2013). They also confirmed that the best suitable temperature for the growth and development of C. maculatus may range 30-35 ºC and humidity is 70-90% R.H.

Table-2 Average relative abundance of insect pests of stored cowpea in Dera Ismail khan and its adjoining Punjab province areas

Common Name	Scientific Name	Family	Relative Abundance
Pulse beetle	*Callosobruchus maculatus*	Chrysomelidae	53.60%
Red flour beetle	*Tribolium castaneum*	Tenebrionidae	18.60%
Angoumois moth	*Sitotroga cerealella*	Gelechidae	16.97%
Sawtoothed beetle	*Oryzaephilus surinamensis*	Silvanidae	6.49%
Khapra beetle	*Trogoderma granarium*	Dermestidae	04.34%

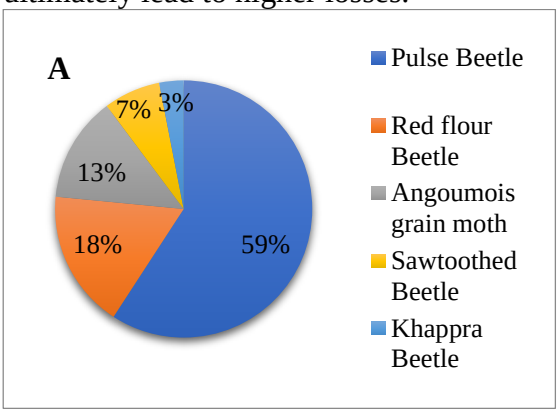
in Hyderabad Karnataka region by Harish et al., 2018 also revealed that Callosobruchus analis L., C. maculatus F., C. chinensis L. and T. castaneum H. are the major stored pulses insects. As both the areas are situated in tropical zones so the insect biodiversity was found almost similar. The same results were also obtained by Caswel et al. (1981) they concluded that Callosobruchus maculatus is the widespread specie, ranked as the major devastative pest of stored cowpea in Nigeria. The perforation of seed cause qualitative and quantitative losses, which ultimately results in the loss of weight, market value and germination of cowpea seeds (Oluwafemi, 2012).

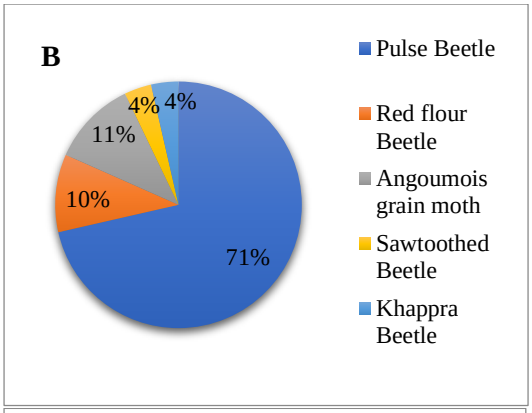
Callosobruchus maculatus is a predominant pest of stored cowpea grains as noticed by Srinivasan et al. (2008) during a survey conducted in Dharwad district of Karnataka. The same was recorded by the Hampanna et al. (2006) from Raichur district of Karnataka. Raoul and Léonard (2013) documented that C. maculatus was the most notorious pest infesting mainly cowpeas s (34.92 bruchids/g of seed) under storage condition in Central Africa.

Credland and wright (1990) reported that Callosobruchus maculatus causes 60-100% losses either its qualitative or quantitative

3.2. Location-wise insect pests' status and their relative abundance of stored cowpea at Dera Ismail Khan and its adjoining Punjab areas

Location-wise data depicts that in Darya Khan the population of pulse beetle (59.18%) was higher which is followed by red flour beetle (17.35%), angoumois grain moth (13.27%), sawtoothed beetle (7.14%) and Khapra beetle (3.06%). The percent infestation caused by coleopterans was found higher i.e., 86.73% while lepidopterans caused minimum i.e. 13.27%. This higher infestation is due to the inappropriate storage condition of the cowpea grains. Jha et al. (2015) have reported that improper storage practices ultimately lead to higher losses.




B
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Sawtoothed Beetle
Khappra Beetle
71%
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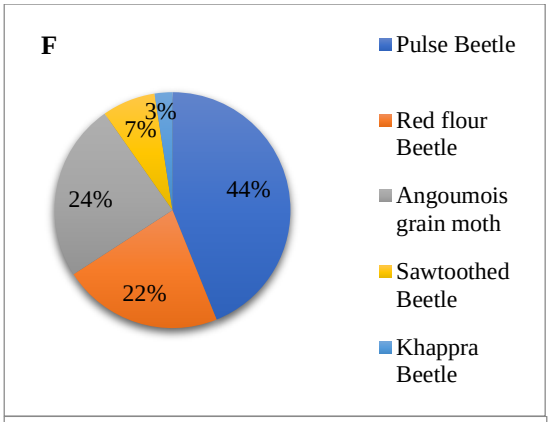
4%


F
Pulse Beetle
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Sawtoothed Beetle
Khappra Beetle
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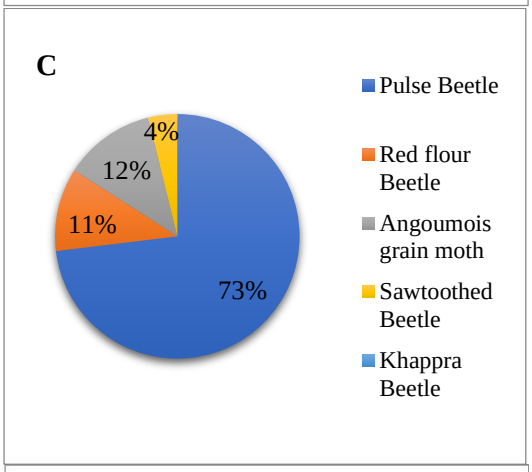
3%


C
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Khappra Beetle
73%
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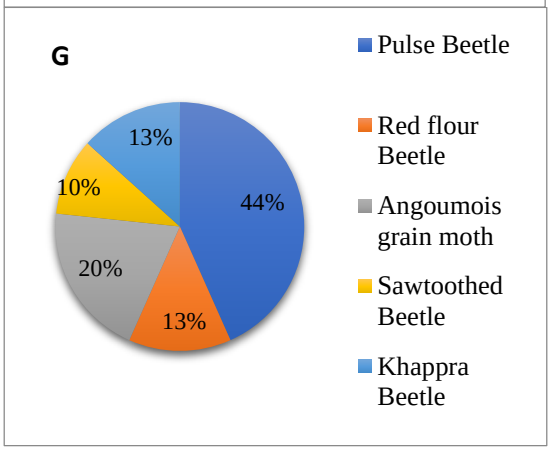
12%
4%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Sawtoothed Beetle
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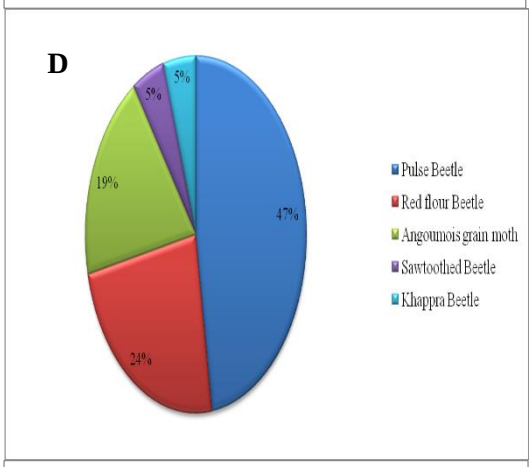
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Khappra Beetle
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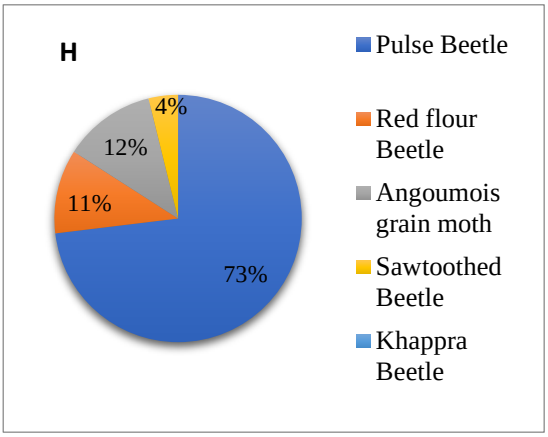
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73%
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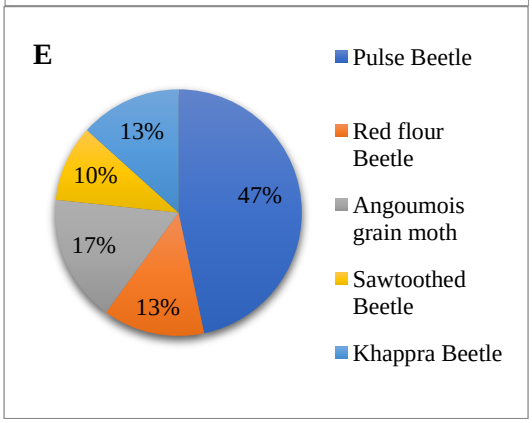
E
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Sawtoothed Beetle
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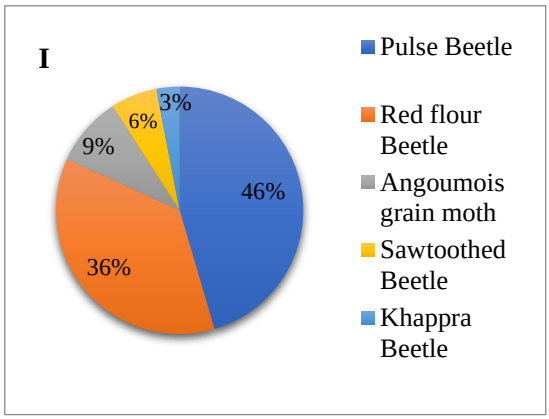
13%


I
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Red flour Beetle
Angoumois grain moth
Sawtoothed Beetle
Khappra Beetle
46%
36%
9%
6%
3%

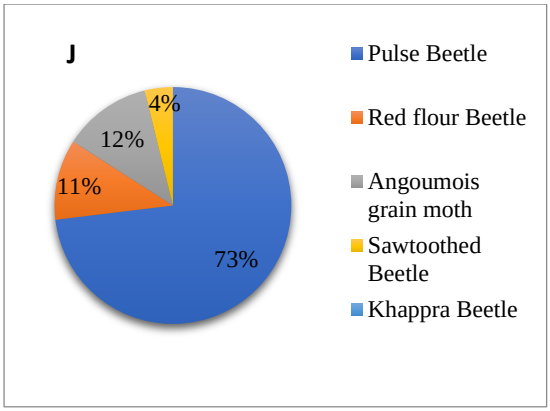

Fig-3 Insect biodiversity of stored cowpea: A-Darya khan, B-D.I.Khan, C-Notak, D-Paniyala, E-Paharpur, F-Behal, G-Mankera, H-Ramak, I-Kulachi, J-Bhakkar.

The relative abundance data of Dera Ismail Khan exhibits that the pulse beetle population (71.43%) remained at its peak while other pests red flour beetle (10.21%), Angoumois grain moth (11.20%), sawtoothed beetle (3.56%) and Khapra beetle (3.60%). The data collected from Notak area represents that the pulse beetle population (73.08%) followed by the red flour beetle (11.00%), Angoumois grain moth (12.08%), sawtoothed beetle (3.84%) and the zero population of Khapra beetle was recorded (0.0%). In Paniyala, five insects were recorded, among them, pulse beetle (47.62%) was highest as compared to all other insects i.e. red flour beetle (23.81%) Angoumois grain moth (19.05%) sawtoothed beetle (4.76%) and Khapra beetle (4.76%). In Paharpur the pulse beetle population was highest i.e. 46.67% while others were lowest i.e. red flour beetle (13.33%) Angoumois grain moth (16.67%) sawtoothed beetle (10.0%) and Khapra beetle (13.33%).

Five different species belonging to two different were recorded from Behal. The maximum was pulse beetle (43.90%) while other insects were recorded minimum i.e. red flour beetle (21.95%) Angoumois grain moth (24.39%) sawtoothed beetle (7.32%) and Khapra beetle (2.44%). The data recorded from Mankera area exhibits that's the pulse beetle population (43.33%) was stand maximum compared to other insects; red flour beetle (13.33%) Angoumois grain moth (20.0%) sawtoothed beetle (10.0%) and Khapra beetle (13.33%).

Four species were recorded form Ramak area pulse beetle (48.15%), red flour beetle (18.52%), Angoumois grain moth (25.93%) and sawtoothed beetle (7.41%). Kulachi area also indicates five different species i.e., pulse beetle (45.45%), red flour beetle (36.36%), Angoumois grain moth (9.09%), sawtoothed beetle (6.06%) and Khapra beetle (3.03%) respectively. From Bhakkar area the highest population of pulse beetle (57.14%) was recorded as compared to others i.e., red flour beetle (19.05%), Angoumois grain moth (19.05%) and sawtoothed beetle (4.76%).

Overall, it was concluded from all studied/surveyed areas that coleopterans were found higher in percentage i.e. 83.49% while lepidopteran was found minimum i.e. 16.51%. The same study was also conducted by zulaikha et al., 2018 on rice to find out the abundance and diversity of insect pests. They concluded that four main species i.e., Oryzaephilus surinamensis (97%), Tribolium castaneum (0.88%), Sitophilus oryzae (0.02%) and Cadra cautella (1.56%) which are responsible for qualitative and quantitative losses.

4. Conclusion

The *C. maculatus* is the most abundant specie of the stored cowpea grains in the surveyed areas and needs management tactics to minimize the post-harvest grains losses. *C. maculatus* is a notorious pest of stored cowpea grains. Its population starts to build up in the month of March (23.30ºC and 56.25% RH) and reaches at peak in the month of May (35.32ºC and 68.88% RH). Pest management measures should be taken during these months to minimize the losses caused by *C. maculatus*. The result of this study will aid in designing pest management strategies for stored grain insect pests. In the future, studies focusing on the insect biodiversity in different climatic zones around the globe are needed.

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