`Assessment of Avian Pest Diversity and Guava Fruit Damage in Orchards of District Gujranwala, Pakistan

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ABSTRACT

Demand for fruits and vegetables in export and local markets are increasing with population explosion. Pakistan is producing around 33 and 29 types of fruits and vegetables, respectively, around the year. Guava (biennial fruit) is one of the most delicious fruits widely cultivated across Pakistan. However, its yield is reduced due to avian pests, which occasionally visit the orchards. Mostly, scaring methods are exercised to reduce fruit damage. To evaluate the fruit (guava) damage due to avian pests, three different localities (Lamba Wali/Site I, Kot Shahan/Site II, and Mansoora/Site III) were selected in District Gujranwala, Pakistan. Sites I and II were controlled (scaring methods were not applied), while Site III was treated as an experimental site (scaring methods were applied). Results indicated that the most abundant bird species observed at Site III were House Crow (*Corvus splendens*) and House Sparrow (*Passer domesticus*). Overall, 25.67% of visitors were omnivores, followed by 16% of carnivores and frugivores. During the months of May and June, the highest fruit yield was observed at site III, about 1379kg and 1407 kg, respectively, while 33kg and 30kg less fruit damage was observed in a similar fashion when compared with sites 1 and II. It is concluded that scaring and mechanical methods are more powerful tools used in reducing fruit (especially guava) damage.

Keywords: **Guava fruit orchards, damage assessment, relative abundance and diversity of birds, fruit yield**.

INTRODUCTION

Guava (*Psidium guajava*) is a biennial widely cultivated fruit in the subcontinent, including Pakistan (Sidhu and Kler, 2018; Ullah et al., 2012). It belongs to the family Myrtaceae and the genus Psidium. In the food industry, it is used in various products (jams, fruit paste, jellies, etc.) due to its tasty and sweet flavor (Parvez et al., 2018). It is found in different varieties; pink guava is enriched by lycopene and antioxidants (which help in protection from ultraviolet radiation) when compared to other fruits (Naaz, 2018). Common guava is known as the poor man's fruit or the apple of tropical fruits that provide plenty of ascorbic acid, folic acid, vitamin K, and phosphorus (Devi et al., 2022).

Birds belong to the phylum Chordate, a sub-phylum vertebrate with cosmopolitan distribution. These are considered as farmer's friend as they eradicate fruit and crop-damaging insects. On the other side, some themselves harm these crops and are considered pests (Issa and Bakhshawngi, 2018). Mostly, both insect and bird pests are involved in the reduction of fruit yield and quality (texture, nutrition) (Arora et al., 2023). It is reported that only fungivore bird species are significantly involved in the damage to fruit orchards (Menezes et al., 2016). Almost 40% of guava fruit damage in Pakistan is due to a very common bird known as the "Rose-Ringed Parakeet" (*Psittacula krameri),* because guava is its most preferred fruit (either ripened or unripened) to visit. In addition to this, house sparrows (*Passer domesticus*) are also observed in guava orchards (Khan et al., 2006; Dulera and Nayi, 2022). The red-vented bulbul (*Pycnonotus cafer), which* belongs to the family Pycnonotidae, is present in the river Indus plains and some areas of Province Sind and Baluchistan (observed in fields, parks, and orchards) (Zohaib et al., 2021).

There are four known sub-species of the rose-ringed parakeet, i.e. *P.k. borealis, P. k. manillensis, P. k. krameri, and P. k. parvirostris.* The two afore mentioned are abundantly present in Southeast Asia and responsible for large-scale fruit crop damage (Khan et al., 2013). Most of the guava fruit damage is reported in the rainy season as more birds visit the orchards (Sharma et al., 2020). Therefore, it is necessary to protect the fruits from these bird pests to boost the economy of the country (Dulera and Nayi, 2022). Different techniques (scarecrows, kites, nets, etc.) are used to protect the fruit orchard from flocks of birds (Marcon et al., 2021). Currently, some modern techniques (aerial vehicles that may include drones) are also used (Wang et al., 2019).

District Gujranwala is a hub of various bird' species due to the canal bank (Upper Chenab Canal) forest (covering an area of almost 8km). The bird's species reported in this area are black kite, house crow, Indian Pond heron, house sparrow, red-vented bulbul, etc. (Noreen and Sultan, 2021). The present study was designed to find out the fruit damage, relative abundance of birds' pests, and effectiveness of commonly used scaring techniques in different regions (guava orchards) of District Gujranwala, Punjab, Pakistan.

MATERIALS AND METHODS

1.1 *Sampling sites and their grouping:*

Three different sampling sites named Lamba Wali (32°23'98.53" N 74°19'85.14" E), kot Shahan (32°22'57.08" N 74°16'84.16" E), and Mansoora (32°22'77.17" N 74°15'09.69" E) were designated as sites I, II, and III, respectively, from District Gujranwala (Fig. 1). They were selected during the ripening phase (April 2022 to June 2022) of guava fruit (*Psidium guajava*). Sampling sites I and II were control sites (without scaring techniques), while site III was treated as an experimental site (subjected to scaring techniques to repel the avian species). Four plots were selected at selected sampling sites, i.e., drum (Plot 1), recorded tape (Plot 2), scarecrows (Plot 3), and non-management technique (Plot 4). Data from different sites was compared to calculate the fruit damage percentage between the control and experimental sites.

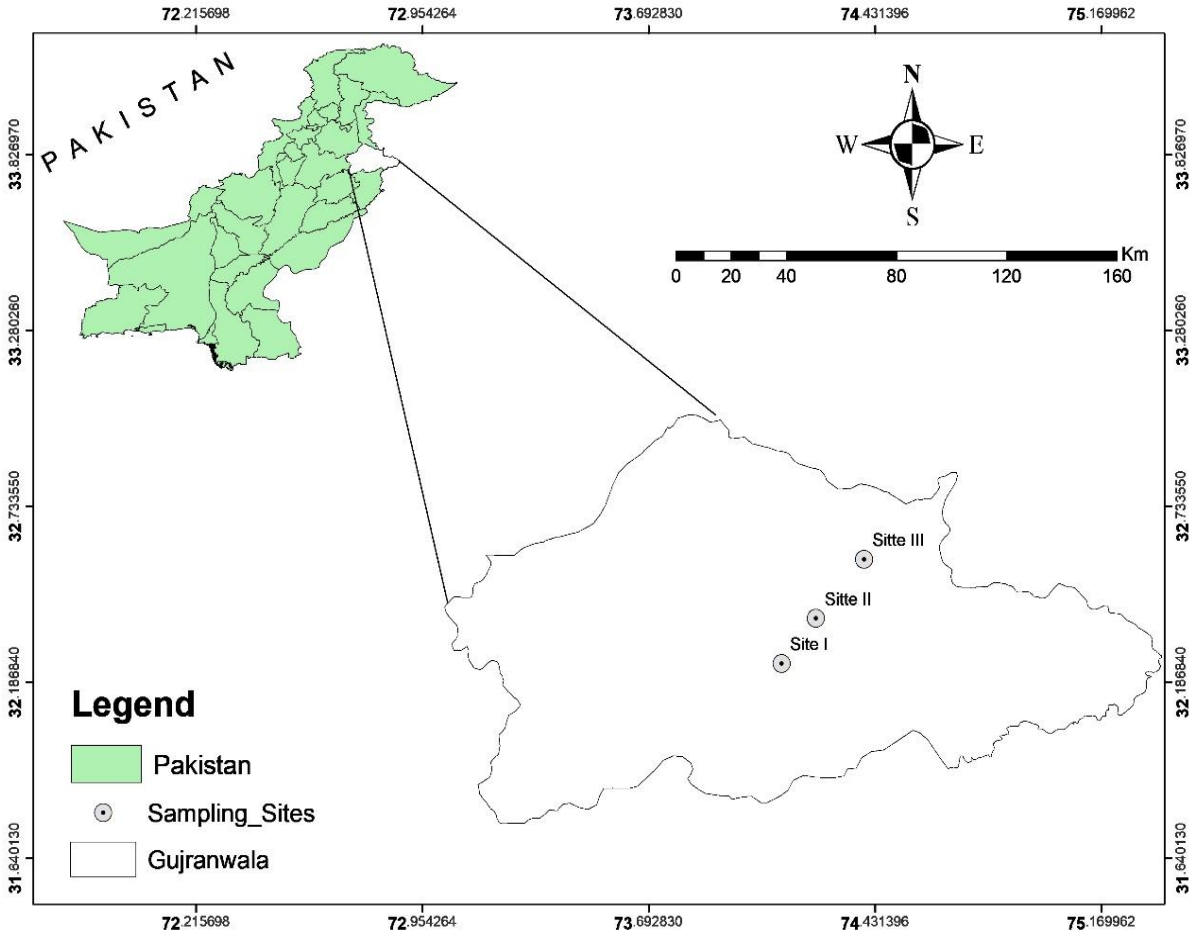

Figure 1. Pictographic presentation of Guava orchards i.e. Site I (Lamba Wali), Site II (Kot Shahan) and Site III (Mansoora) in District Gujranwala, Pakistan.

1.2 *Methodology*

The line transect method was used to count the bird's pest foraging below the canopy or perching above the branches of 20 plants in guava orchards (Tiwari et al., 2021). The selected sites were visited weekly (twice a day) for two months (morning 8:00 a.m. to 10:00 a.m. and evening 4:00 p.m. to 6:00 p.m., which is the maximum foraging time). The total number of birds was counted through the point count method, while binoculars and field guides were also used for their identification. At each site, 20 plants were selected randomly (10 for May and 10 for June) to find the fruit yield (fruit weight, tree, and location) and fruit damage percentage (through an underlying formula) (Arora et al., 2023).

$$Damage\ (\%) = \frac{No.of\ \ damaged\ fruits}{Total\ No.of\ examined\ fruits\ (Fruits\ yield)} \times 100$$

Species Richness was calculated by the evaluation of total number of species at concerned sampling site while the Relative abundance through the underlying formula:

$$Relative\ Abundance\ (\%) = \frac{No.of\ individuals\ of\ a\ species}{Total\ No.of\ individuals} \times 100$$

Number of individuals = n and total number of birds/individuals = N.

Diversity of the bird species (visited the orchards) was calculated through the following indices:

$$(1)\ Simpson\ Index(D) = \frac{1-\ \Sigma n(n-1)}{N(N-1)}$$

n= total number of the individuals of a particular species and N= total number of individuals of all species.

$$(2)\ Shannon\ Weiner\ Diversity\ Index(H') = \Sigma Pi\ ln\ ln\ (Pi)\ \times -1$$

H'= Diversity Index, Pi = proportion of species i relative to the total number of species and ln Pi = natural logarithm of proportion.

1.3 *Statistical Analysis*

All the observed data was analysed through the statistical software SPSS (Statistical Package for the Social Sciences), version 21. The data was subjected to a one-way ANOVA (analysis of variance) to estimate the variance (in the three concerned sites) along with an independent T-test (0.05 significance level) (to compare different locations) (Issa and Bakhshawngi, 2018).

Results and Discussion

2.1 Relative abundance

According to diversity indices, the most abundant bird species were House Sparrow (*Passer domesticus*) (R.A.=13.91), House Crow (*Corvus splendens),* Bank Myna (*Acridotheres gingianus*) (R.A.=12.17), Common Myna (*Acridotheres tristis),* and Red-Vented Bulbul (*Pycnonotus cafer*) (R.A.=6.09) at sites I, II, and III, respectively.

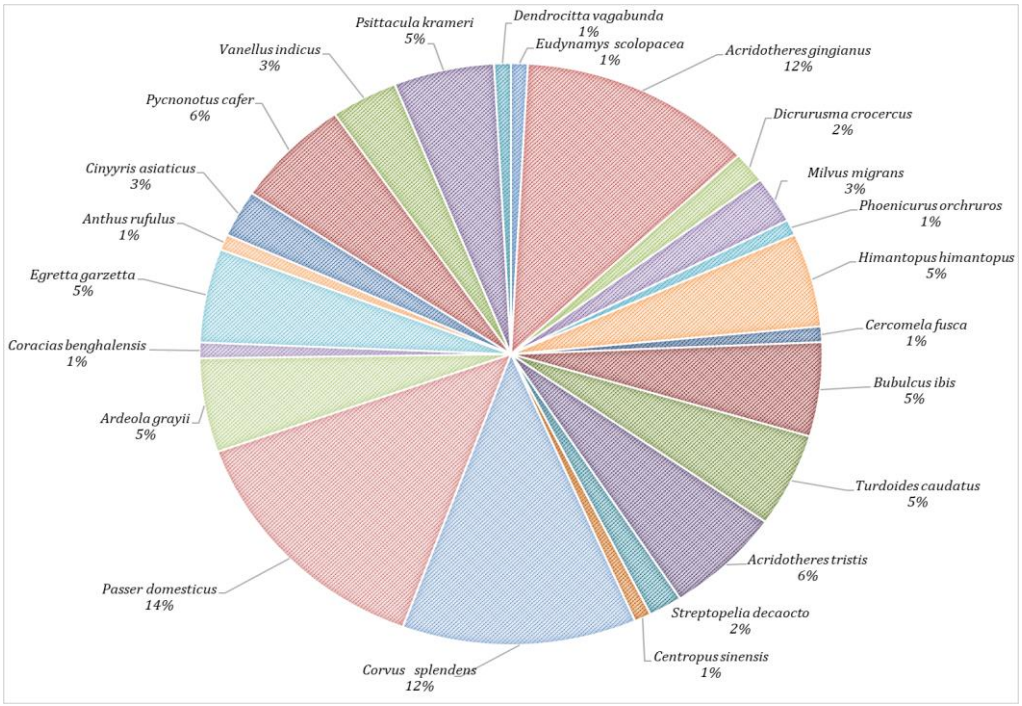

Figure 2. Relative abundance of bird species at Site I (Control site)

The maximum bird count (115 individuals belonging to 23 bird species) was recorded during May and June at site I. The relative abundance of each species (at all sampling sites) is recorded in Figure 2. While the most abundant species observed at location II (Kot Shahan) was House Crow (*Corvus splendens*) with a relative abundance of 14.71, followed by House Sparrow (*Passer domesticus*) (R.A. 11.76), Indian Pond Heron (*Ardeola grayii*), Bank Myna (*Acridotheres gingianus),* each with a relative abundance of 7.84, and Red-Vented Bulbul (*Pycnonotus cafer*) (R.A. 6.86). A total of 102 bird individuals belonging to 21 species were observed (Figure 3).

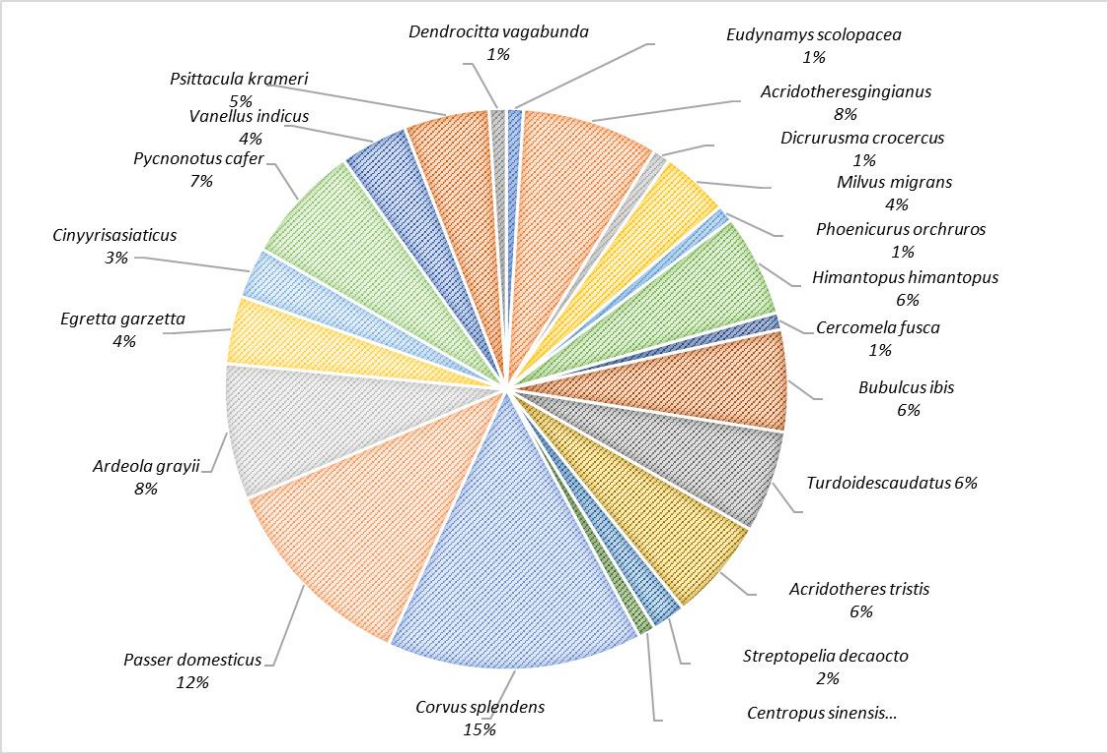

Figure 3. Relative abundance of bird species at Site II (Kot Shahan) (Control site)

While abundant bird species at Site III (Mansoora) were House Crow (*Corvus splendens*) and House Sparrow (*Passer domesticus*) with a relative abundance of 25, followed by Red Vented Bulbul (*Pycnonotus cafer*), Rose Ringed Parakeet (*Psittacula krameri*), Cattle Egret (*Bubulcus ibis),* and Common Myna (*Pycnonotus cafer*) with a relative abundance of 12.5. Six bird species with a total number of eight individuals were recorded during the months of May and June at Site III (Figure 4).

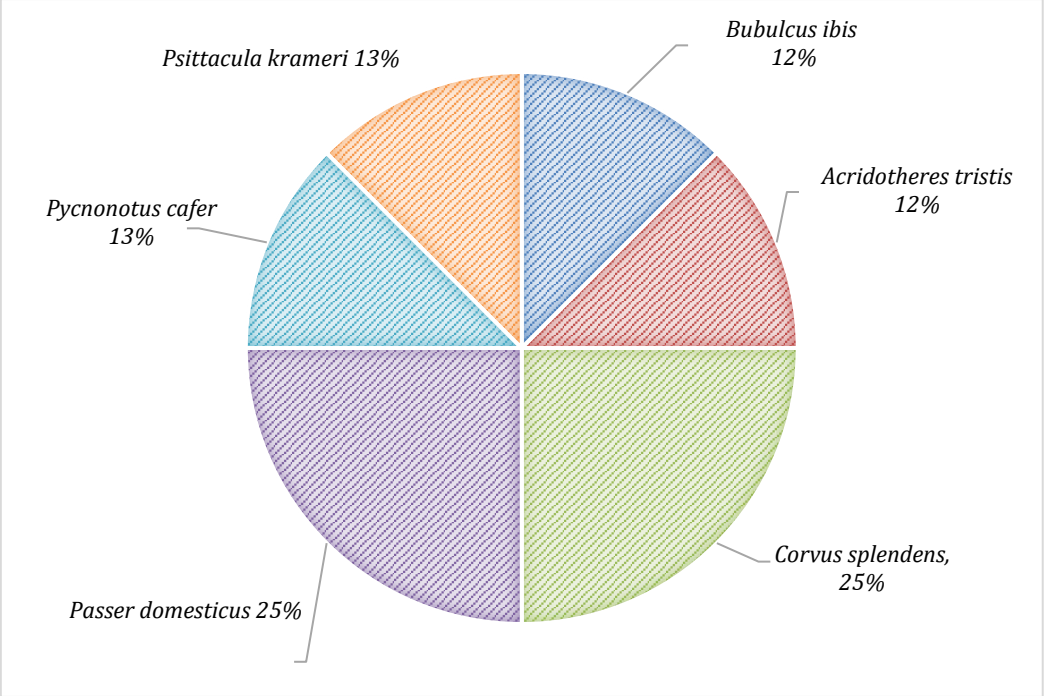

Figure 4. Relative abundance of bird species at Site III (Mansoora)

Bird species that visited the sampling sites were different in number (morning and evening) throughout the study period. At site I, 32 species were observed (20 in the morning and 12 in the evening), while 32 species visited site II (16 in the morning and the same in the evening). Most of the bird species observed at both sites were of the family Ardeidae (3 species), followed by Corvidae, Cuculidae, Musicapidae, and Sturnidae (2 species each), with each other remaining with only 1 species. At site III, family Corvidae was recorded with 2 species, followed by Ardeidae, Psittaculidae, Pycnonotidae, and Sturnidae (1 species each). However, the same number of bird species (6) visited this site in the morning and evening (Table 1).

Table 1. Visit of bird species at control and experimental sampling sites.

S. No	Species		S I		S II		S III	
	Common Name	Scientific Name	M	E	M	E	M	E
1	Asian Koel	*Eudynamys scolopacea*	1	0	1	0	0	0
2	Bank Myna	*Acridotheres gingianus*	0	1	0	1	0	0
3	Black Drongo	*Dicrurus macrocercus*	1	1	1	1	0	0
4	Black Kite	*Milvus migrans*	0	1	1	1	0	0
5	Black Redstart	*Phoenicuru orchruros*	1	1	0	1	0	0
6	Black Winged Stilt	*Himantopus himantopus*	1	1	1	1	0	0
7	Brown Rock Chat	*Cercomela fusca*	0	1	0	1	0	0
8	Cattle Egret	*Bubulcus ibis*	1	1	1	1	1	1
9	Common Babbler	*Turdoides caudatus*	1	0	1	0	0	0
10	Common Myna	*Acridotheres tristis*	1	1	1	1	1	1
11	Eurasian Collared Dove	*Streptopelia decaocto*	1	0	1	1	0	0
12	Greater Coucal	*Centropus sinensis*	1	0	0	1	0	0
13	House Crow	*Corvus splendens*	1	1	1	1	1	1

14	House Sparrow	*Passer domesticus*	1	1	1	1	1	1
15	Indian Pond Heron	*Ardeola grayii*	1	0	1	0	0	0
16	Indian Roller	*Coracias benghalensis*	1	0	0	0	0	0
17	Little Egret	*Egretta garzetta*	1	0	1	1	0	0
18	Paddy fieldPipit	*Anthus rufulus*	1	0	0	0	0	0
19	Purple Sunbird	*Cinyyris asiaticus*	1	0	0	1	0	0
20	Red Vented Bulbul	*Pycnonotus cafer*	1	1	1	1	1	1
21	Red Wattled Lapwing	*Vanellus indicus*	1	0	1	0	0	0
22	Rose Ringed Parakeet	*Psittacula krameri*	1	1	1	1	1	1
23	Rufous Treepie	*Dendrocitta vagabunda*	1	0	1	0	0	0

***S= Site, M=Morning, E= Evening, 1= Specie visited & 0= Specie not visited**

At Site I, most numbers of the bird species observed belong to the order Passeriformes (12 species) followed by Pelecaniformes (3 species), and Charadriiformes (2 species) While the remaining orders carry only 1 species (Figure 2). At location II, most of the bird species were from the orders Passeriformes (11 species), Passeriformes and Charadriiformes contained 3 and 2 species respectively while 1 remaining order had only one species (**Figure 2**). Bird species observed at site III belong to the order Passeriformes (4 species) followed by Pelecaniformes and Psittaciformes (1 species) (Figure 5).

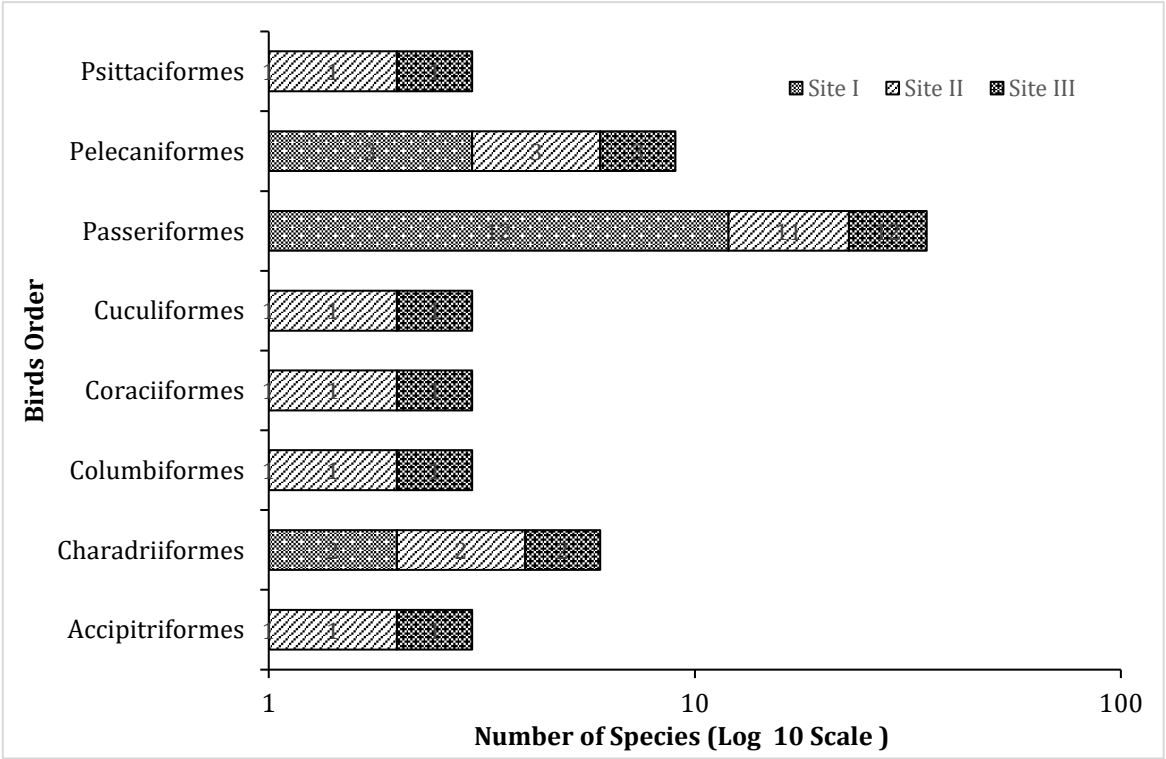

Figure 5: Order wise record of bird species at site I, II and III.

Simpson and Shannon Wiener Index values from site I were 0.93 and 2.59, respectively, whereas 0.93 and 2.77 in similar fashion from site II (Table 2) showed higher avian diversity (site II has a higher diversity than site I) at both control sites. Site III was observed to have lower avian diversity, with Simpson and Shannon Wiener index values of 0.92 and 1.73, respectively (Shannon Weiner index values range from 1.5 (lowest diversity) to 3.5 (highest diversity).

Table 2. Avian diversity indices at control and sample sites.

S. No.	Site	Simpson Index	Shannon Weiner Index
1	I (Control site)	0.93	2.59
2	II (Control site)	0.93	2.77
3	III (Sampling site)	0.92	1.73

***Simpson index =0-1 (lowest 0, highest 1), Shannon Wiener Index=1.5-3.5 (lowest 1.5, highest 3.5)**

3.2 Seasonal occurrence and feeding guild

At site I, 78% of the visited avian species were summer breeders, and 22% were Year-Round residents. 44%, 26%, and 18% were recorded as omnivores, carnivores, and insectivores, respectively, while frugivores, granivores, and nectarivores were observed at 4%. The most abundant observed family and order were Ardeidae and Passeriformes, respectively (Table 3).

Table 3. Seasonal occurrence and feeding guild of bird species at site I (Control site),

Sr. No.	Scientific Name	Occurrence	Feeding Guild	Family	Order
1	*Eudynamys scolopacea*	SB	O	Cuculidae	Cuculiformes
2	*Acridotheres gingianus*	YRR	O	Sturnidae	Passeriformes
3	*Dicrurus macrocercus*	YRR	I	Dicruridae	Passeriformes
4	*Milvus migrans*	YRR	C	Accipitridae	Accipitriformes
5	*Phoenicurus orchruros*	YRR	I	Muscicapidae	Passeriformes
6	*Himantopus himantopus*	SB	C	Recurvirostridae	Charadriiformes
7	*Cercomela fusca*	SB	I	Muscicapidae	Passeriformes
8	*Bubulcus ibis*	YRR	C	Ardeidae	Pelecaniformes
9	*Turdoides caudatus*	YRR	O	Leiothrichidae	Passeriformes
10	*Acridotheres tristis*	YRR	O	Sturnidae	Passeriformes
11	*Streptopelia decaocto*	YRR	G	Columbidae	Columbiformes
12	*Centropus sinensis*	YRR	O	Cuculidae	Cuculiformes
13	*Corvus splendens*	SB	O	Corvidae	Passeriformes
14	*Passer domesticus*	YRR	O	Passeridae	Passeriformes
15	*Ardeola grayii*	YRR	C	Ardeidae	Pelecaniformes
16	*Coracias benghalensis*	YRR	C	Coraciidae	Coraciiformes
17	*Egretta garzetta*	YRR	C	Ardeidae	Pelecaniformes
18	*Anthus rufulus*	YRR	I	Motacillidae	Passeriformes
19	*Cinyyris asiaticus*	SB	N	Nectariniidae	Passeriformes
20	*Pycnonotus cafer*	YRR	O	Pycnonotidae	Passeriformes
21	*Vanellus indicus*	YRR	O	Charadriidae	Charadriiformes
22	*Psittacula krameri*	YRR	F	Psittaculidae	Psittaciformes
23	*Dendrocitta vagabunda*	YRR	O	Corvidae	Passeriformes

***YRR=Year-Round Resident, SB=Summer Breeder, O=Omnivore, C=carnivore, I=insectivore, N= nectarivores, F=frugivores, G=granivores**

Among all 76% and 24% of the bird species recorded at site II were summer breeders and Year-Round residents, respectively. Among them, 47% were omnivores, 24% were carnivores, 14% were insectivores, and 5% were frugivores, granivores, and nectarivores. Most of the species belonged to the family Corvidae and the order Passeriformes (Table 4).

Table 4. Seasonal occurrence and feeding guild of bird species at Site II (Control site)

Sr. No.	Scientific Name	Occurrence	Feeding Guild	Family	Order
1	*Eudynamys scolopacea*	SB	O	Cuculidae	Cuculiformes
2	*Acridotheres gingianus*	YRR	O	Sturnidae	Passeriformes
3	*Dicrurus macrocercus*	YRR	I	Dicruridae	Passeriformes
4	*Milvus migrans*	YRR	C	Accipitridae	Accipitriformes
5	*Phoenicurus orchruros*	YRR	I	Muscicapidae	Passeriformes
6	*Himantopus himantopus*	SB	C	Recurvirostridae	Charadriiformes
7	*Cercomelafusca*	SB	I	Muscicapidae	Passeriformes
8	*Bubulcus ibis*	YRR	C	Ardeidae	Pelecaniformes
9	*Turdoides caudatus*	YRR	O	Leiothrichidae	Passeriformes
10	*Acridotheres tristis*	YRR	O	Sturnidae	Passeriformes
11	*Streptopelia decaocto*	YRR	G	Columbidae	Columbiformes
12	*Centropus sinensis*	YRR	O	Cuculidae	Cuculiformes
13	*Corvus splendens*	SB	O	Corvidae	Passeriformes
14	*Passerd omesticus*	YRR	O	Passeridae	Passeriformes
15	*Ardeola grayii*	YRR	C	Ardeidae	Pelecaniformes
16	*Egretta garzetta*	YRR	C	Ardeidae	Pelecaniformes
17	*Cinyyris asiaticus*	SB	N	Nectariniidae	Passeriformes
18	*Pycnonotus cafer*	YRR	O	Pycnonotidae	Passeriformes
19	*Vanellus indicus*	YRR	O	Charadriidae	Charadriiformes
20	*Psittacula krameri*	YRR	F	Psittaculidae	Psittaciformes
21	*Dendrocitta vagabunda*	YRR	O	Corvidae	Passeriformes

***YRR=Year-Round Resident, SB=Summer Breeder, O=Omnivore, C=carnivore, I=insectivore, N= nectarivores, F=frugivores, G=granivores**

At site III, 83% and 17% of the bird species were summer breeders and Year-Round Resident respectively. 67% of them were omnivores, 16% were carnivores, and 16% were frugivore species. Family Corvidae and order Passeriformes were most abundant (Table 5).

Table 5. Seasonal occurrence and feeding guild of bird species at Site III

Sr. NO	Scientific Name	Occurrence	Feeding Guild	Family	Order
1	*Bubulcus ibis*	YRR	Carnivore	Ardeidae	Pelecanformes
2	*Acridotheres tristis*	YRR	Omnivore	Sturnidae	Passeriformes
3	*Corvus splendens*	SB	Omnivore	Corvidae	Passeriformes
4	*Passer domesticus*	YRR	Omnivore	Corvidae	Passeriformes
5	*Pycnonotus cafer*	YRR	Omnivore	Pycnonotidae	Passeriformes
6	*Psittacula krameri*	YRR	Frugivore	Psittaculidae	Psittaciformes

***YRR=Year-Round Resident, SB=Summer Breeder, O=Omnivore, C=carnivore, I=insectivore, N= nectarivores, F=frugivores, G=granivores**

3.3 Highest yield and Accumulative damage

Fruit damage due to avian pests was observed at 12.19% at site I, followed by 11.04% at site II. The lowest damage was observed at site III (2.26%) (Figs. 6 and 7). However, the highest fruit yield (2786 kg) was recorded at site III, followed by site II (2591kg) and site I (2576kg). The fruit yield at both control sites was similar. The highest fruit yield (1379kg and 1407kg) and the lowest damage (33kg and 30kg) were observed in the months of May (Table 6) and June (Table 7) in similar fashion.

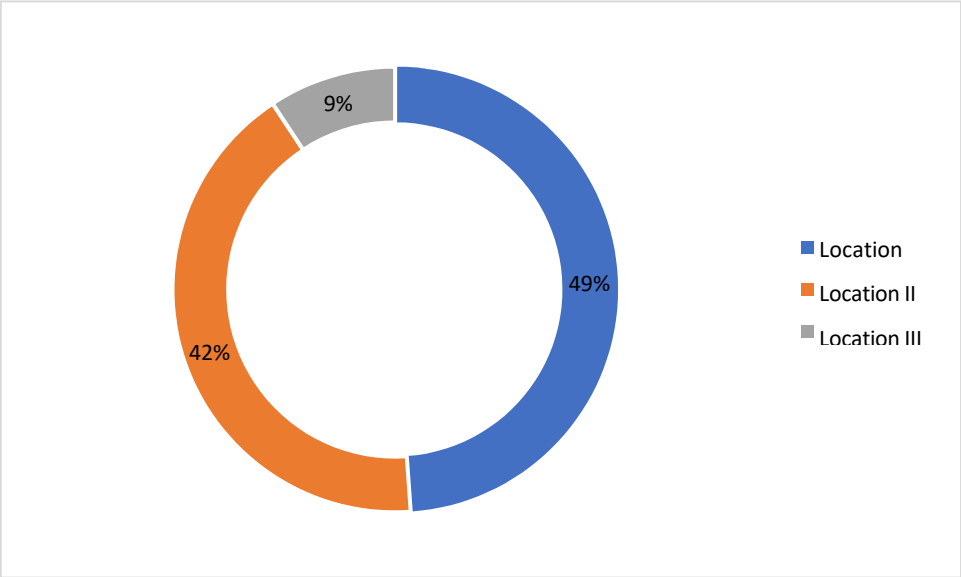

Figure 6. Pictographic presentation of fruit damage (%) during the month of May

Table 6. Fruit damage and its yield (%) during the month of May.

S.T	Site I (Control site)		Site II (Control site)		Site III (Sampling site)	
	F.D (g)	F. Y (kg)	F.D (g)	F. Y (kg)	F.D (g)	F. Y (kg)
1	20	123	15	113	5	130
2	18	121	13	121	3	135
3	14	131	15	127	3	141
4	16	126	11	125	2	139
5	20	128	15	135	5	130
6	14	129	14	123	4	145
7	18	133	13	137	2	141
8	13	128	15	128	4	136
9	16	122	12	139	3	139
10	11	130	16	143	2	143
T.D&T.Y (Kg)	**160**	**1271**	**139**	**1291**	**33**	**1379**
D. P	**12.59%**		**10.77%**		**2.39%**	

***S.T= Samples Tree, F.D- Fruit Damage, F.Y= Fruit Yield, T.D= Total Damage, T.Y= Total Yield & D.P= Damage Percentage**

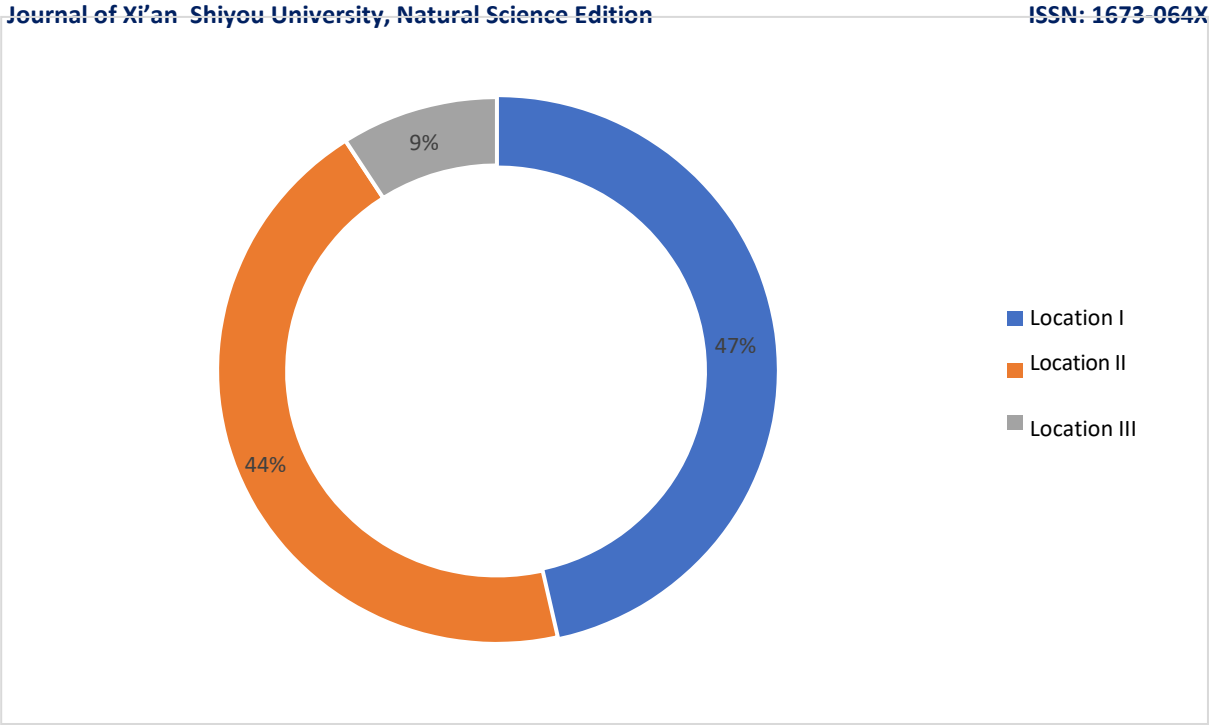

Figure 7. Pictographic presentation of fruit damage (%) during the month of June

Table 7. Fruit damage and its yield (%) during the month of June

S.T	Site I (Control site)		Site II (Control site)		Site III (Sampling site)	
	F.D (g)	F. Y (kg)	F.D (g)	F. Y (kg)	F.D (g)	F. Y (kg)
1	12	123	17	131	3	141
2	14	127	14	134	5	145
3	15	131	18	137	3	139
4	11	135	13	123	2	139
5	12	136	15	126	2	132
6	16	129	16	125	1	136
7	17	121	14	131	2	141
8	20	131	15	123	3	145
9	16	136	13	129	4	143
10	21	136	12	141	5	146
T.D&T.Y (Kg)	154	1305	147	1300	30	1407
D. P	11.80%		11.26%		2.31%	

***S.T= Samples Tree, F.D- Fruit Damage, F.Y= Fruit Yield, T.D= Total Damage, T.Y= Total Yield & D.P= Damage Percentage**

Analysis of variance (Duncan and Tukey tests) for fruit damage showed a statistically significant difference between Site I and III and Site II and III (0.05>0.000). However, a non-significant difference was observed for damage at Sites I and II (0.05), while a significant difference for fruit damage was observed at Site III at p = 0.05 (Table 8).

Table 8. Variance analysis of fruit damage at study sites through ANOVA.

	Groups	N	a	b	c
TukeyB[a]	Location III	20	3.15[a]		
	Location II	20		14.3[b]	
	Location I	20		15.7[b]	
Duncan[a]	Location III	20	3.15[a]		
	Location II	20		14.3[b]	
	Location I	20		15.7[b]	

Any statistically significant difference was not recorded for guava fruit damage through a t-test between control sites locations I and II ($p<0.088$), while between sites I, /II and III, a statistically significant difference ($p>0.000$) was observed through an independent t-test (Table 09).

Table 09. Pair comparison for fruit damage through independent t-test (p=0.05).

Sr. No.	Comparison	N	Mean	Significance.
1	Location I	20	15.7	**0.088**
	Location II	20	14.3	
2	Location I	20	15.7	**0.000**
	Location III	20	3.15	
3	Location II	20	14.3	**0.000**
	Location III	20	3.15	

Discussion

In Pakistan, many fruits are cultivated on larger scales in orchards. However, the yield of these fruits has been reduced due to bird pests. One of the major responsible bird species is the rose-ringed parakeet (Iqbal et al., 2001; Khan et al., 2011), which belongs to the granivorous and frugivorous species (Mentil et al., 2018). Varieties of crops are damaged due to avian pests worldwide. In various continents of the world, i.e., Asia, Africa, and America, severe damage to crops has been reported due to avian pests (Enos et al., 2021). Zohaib et al. (2021) reported 18**%** of red-vented bulbul among avian pests in guava orchards in district Okara. The results of the present study are in line with the previous one (the presence of red-vented bulbuls in the guava orchard). In fact, this bird was reported to be present in a relatively high percentage, as it belongs to the omnivore group as compared to other groups (herbivores, carnivores, etc.).

Rehman et al. reported that most of the species who visited the guava fruit orchard in 2019 were insectivores and omnivorous in District Faisalabad. Current findings evaluated the trend of field guilds (Sites I, II, and III) and found that the most abundant avian pest species belonged to omnivores (44%, 47%, and 67%) followed by carnivores (24%, 26%, and 16%) in the same fashion. The use of some mechanical repellent against the birds (the rose-ringed parakeet) at various fruit orchards proved to be effective during a study at a farmland in the University of Agriculture, Faisalabad. However, the study used different mechanical repellents like high-frequency sound players, frightening kites, helical balloons, wind-powered hawk eye rotators, etc. (Khan et al., 2013). The effectiveness of using such a mechanical repellent against avian species depends on the installation methods. In addition to this, these devices must also be cost-effective (Manzoor et al., 2013).

In Gujranwala district, common myna is the most abundant species, followed by house crows (Noreen and Sultan, 2021). This is the reason that the same species is observed in guava orchards. Different studies conducted in Indian Punjab at the Punjab Agricultural University orchard reported various bird species such as parakeets, mynas, house crows, etc. (Chakravarty and Sandhu, 2004; Arora et al., 2023). Similar avian species have also been reported in current studies. Although the countries are different, the reason for reporting the same species might be that both regions are adjacent to each other. This study will provide basic information and tools regarding the enhancement of fruit yield in a tremendously increasing population. Further studies are recommended with the use of more mechanical scaring devices, i.e., netting, ribbons, high-frequency sound players, etc. However, this study might be an alarm for farmers or gardeners against avian pests to enhance their economic capacity.

CONCLUSION:

It is concluded that the yield of guava fruit is being affected due to the presence of avian pests in the guava fruit orchards. However, scaring method techniques (scare crows, drums, and recorded tapes) significantly increased the percentage yield and decreased the fruit damage (site III) when compared to other sites where no scaring techniques were employed.

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CONFLICT OF INTEREST:

The authors have declared that no conflict of interest exists.

REFERENCES

Arora, S., Kaur Kler, T., Kaur, G. and Kaur, N. (2023). Depredatory Bird Damage Assessment and Its Management Techniques in Guava. *Erwerbs-Obstbau*, pp.1-5.

Chakravarty, S. and Sandhu, J.S. (2004). Avian Community of Orchard and its Surrounding Eucalyptus Windbreak in Punjab Agricultural University Campus, Punjab. *Environment Management*, p.133.

Devi, S., & Yadav, N. R. (2022). Role of explants collecting seasons and sterilization process on in vitro regeneration of guava: A technology hurdle.

Dulera, J.G. & Nayi, A. H. (2022). Assessment of Rose-ringed Parakeet (Psittacula krameri) Depredations to Guava Fruits. *Pharm Innov 11*(7):2825–2829.

Enos, J.K., Ward, M.P. & Hauber, M.E. (2021). A review of the scientific evidence on the impact of biologically salient frightening devices to protect crops from avian pests. *Crop Protection*, *148*, p.105734.

Iqbal M.T., H.A. Khan and M.H. Ahmad, 2001. Feeding regimens of the rose-ringed parakeet on a brassica and sunflower in an agroecosystem in Central Punjab, Pakistan. Pakistan Vet. J., 4: 111–115

Issa, M. A., & El-Bakhshawngi, M. I. A. (2018). An estimation of bird damages onsome field, vegetable and fruit crops at sharkia governorate, Egypt. *ZagazigJournal of Agricultural Research*, *45*(4), 1273-1281.

Khan, H. A., Anwar N,& Perveen S. (2006) Abundance of Rose ringed parakeet (*Psittacula krameri*) and house sparrow (*Passer domesticus*) on guava and sunflower farmlands in an agro- ecosystem in Faisalabad Pakistan. *J. Agri. and Social Sciences*, 2:125-12.

Khan, H.A., Ahmad, S., Javed, M., Ahmad, K. and Ishaque, M. (2011). Comparative effectiveness of some mechanical repellents for management of rose ringed parakeet (Psittacula krameri) in citrus, guava and mango orchards. *International Journal of Agriculture and Biology*, *13*(3).

Khan, H.A., Javed, M., Tahir, A. and Kanwal, M. (2013). Limiting the rose-ringed parakeet (*Psittacula krameri*) damage on guava (*Psidium guajava*) and mango (*Mangifera indica*) with an ultrasonic sound player in a farmland of Faisalabad, Pakistan. *African Journal of Agricultural Research*, *8*(49), pp.6608-6614.

Manzoor, S., Khan, H.A. and Javed, M., 2013. Inhibiting damage of watermelon (*Citrulus lanatus*) against some bird pests in an orchard of Faisalabad, Pakistan. *Journal of Animal and Plant Sciences*, *23*, pp.464-468.

Marcon, P., Janousek, J., Pokorny, J., Novotny, J., Hutova, E.V., Sirůčkova, A., Cap, M., Lázničková, J., Kadlec, R., Raichl, P. and Dohnal, P. (2021). A system using artificial intelligence to detect and scare bird flocks in the protection of ripening fruit. *Sensors*, *21*(12), p.4244.

Menezes I, Cazetta E, Morante-Filho JC, Deborah F (2016) Forest cover and bird diversity: drivers of fruit consumption in forest interiors in the Atlantic forest of southern Bahia, Brazil. *Trop. Conserv. Sci.*, 9(1):549–562.

Mentil, L., Battisti, C. and Carpaneto, G.M., 2018. The impact of Psittacula krameri (Scopoli, 1769) on orchards: first quantitative evidence for Southern Europe. *Belgian Journal of Zoology*, *148*(2).

Naaz, S. (2018). Amazing Benefits Of Guava (Amrood) For Skin, Hair, And Health.Stylecraze.(http://www.stylecraze.com/articles/amazing-benefits-of-guava-for-skin-hair-andhealth/#gref).

Noreen, Z. and Sultan, K. (2022). Habitat Preferences of Birds in Relation to Exotic Trees in Canal Bank Forests Gujranwala, Pakistan. *Pakistan Journal of Zoology*, *54*(4).

Parvez, G. M., Shakib, U., Khokon, M., &Sanzia, M. (2018). A short review on anutritional fruit:guava.*OpenAccess: Toxicology andResearch,1*,1-8.

Sharma RR, Nagaraja A, Goswami AK, Thakre M, Kumar R, Varghese E. (2020) Influence of on-the-tree fruit bagging on biotic stresses and postharvest quality of rainy-season crop of 'Allahabad Safeda' guava (*Psidium guajava L.*). *Crop Prot.*, 135:105216.

Sidhu, S.K. and Kler, T.K. (2018). Avian composition and damage assessment in guava fruit crop at Ludhiana, Punjab. *Journal of Entomology and Zoology Studies*, *6*, pp.2422-2426.

Ullah, F., Badshah, H., Alam, K., Khan, A., Zeb, Q., & Mashwani, M. A. (2012). Evaluation of various insecticides as lure toxicants for fruit fly management in Guava Orchards. *Sarhad Journal of Agriculture*, 28(4), 617-620.

Wang, Z.; Griffin, A.S.; Lucas, A.; Wong, K.C. (2019). Psychological Warfare in Vineyard:

Using Drones and Bird Psychology to Control Bird Damage to Wine Grapes. *Crop Prot.* 120, 163–170.

Zohaib, M., Ansari, M.S., Rakha, B.A. and Akhter, A. (2021). Nesting and Breeding Success of Red-vented Bulbul (Pycnonotus cafer) in Orchards, Parks and Agricultural Fields in Renala Khurd, District Okara, Punjab. *Pakistan. Pakistan Journal of Zoology*, pp.1-7.