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TREES AS THE ROOSTS OF ROSE RINGED PARAKEET IN CENTRAL PUNJAB PAKISTAN

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ABSTRACT

Present paper describes the impact of trees as roosts for the rose-ringed parakeet (*Psittacula krameri* Linn.) in the five districts of Central Punjab, Pakistan. The parakeet has established sufficiently large numbers of communal roosts in some of the predominant trees as the *Salmalia malabarica, Cedrella toona, Dalbergia sissoo, Azadirachta indica, Terminalia arjuna* and others with the suitable ecological conditions. The old and tall trees have occurred here for more than century, offer depressions or hollows. Of these, several after being refined by the parakeets, serve as nests for breeding. Total of six major habitats viz. cropland, villages, roadside plantations, canal sides, city road avenues and the university campus were sampled to determine the overall trees 8769 ± 1.39, cavities 2474 ± 0.97, cavities per tree 10.44 ± 1.78, parakeet nests 528 ± 0.78 and nest percentage proportions 325 ± 1.85 respectively. Significantly, majority of the roosts were closely associated with the economically important food crops viz. wheat, maize, sunflower, sorghum and variety of fruits, therefore, their regular visits to them were frequent to inflict substantial economic losses. The study concludes that although the emphasis to grow more plantations throughout the agro-ecosystems of Central Punjab would prove beneficial; nonetheless population of the parakeets and of the other vertebrate pests would also increase in the ecologically suitable habitats. Therefore, population of such pests should be also estimated accurately and rationalize the strategies the strategies to inhibit the probable depredations on the crops.

Keywords: Roosts, nests, communal; rose-ringed parakeet

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INTRODUCTION

The rose ring parakeet (*Psittacula kremeri* Linn. Scopoli), belongs to order 'Psittaciformes' and is important bird pest species in the Asian sub-continent, parts of Europe and North America (Butler, 2003). The rose-ringed parakeet (*Psittacula krameri*) is most widely distributed in Pakistan. It is also widespread throughout the Indus plain and occurs in summer at Murree hills (914m); nonetheless, it is absent in the large desert habitats and from northern foothill regions (Roberts,1991). The parakeets along with the other birds have increased their roosting in the last several decades due to the suitable ecological conditions (Harms and Eberhard, 2003). The roosts are, therefore, important communal structures which are considered sustainable for multiple years. They are predominantly studded with diurnal movements in and around their roosts and also cause of serious depredations of the food resources to cause economic losses (Khan *et al*., 2011; Ahmad *et al*., 2012 [a, b]).

Considering, the native range of parakeet, it has been largely recorded to roosts in the intermediate timbered habitats, roadside forest plantations, farm cropping patterns and the well-established urban gardens (Strubbe and Mathysen, 2009; Manzoor *et al*., 2020; Yasin *et al*., 2021). An important inhibitory factor for intensive fruit damage and losses to the cultivated crops occur due to the tenacious damage of the parakeets due to their wide feeding niche (Khan and Beg, 1998; Iqbal *et al*., 2001; Paton *et al*., 1992). Considering the ancient history of the sub-continent (Whistler, 1949; Ali and Ripley, 1969; Beg, 1978), canal irrigation system (CIS). In this region before the sub-continent partition, for promotion of agriculture, implicated favorable impacts on the rose ringed parakeet's populations.

Occurrence of nutritious and economically important agriculture crops, fruit orchards and also some indoor food resources offer large feeding niche to the parakeets (Babu and Muthukrishnan, 1987; Sushil and Kumar, 1994; Lambert *et al*., 2010). Moreover, the different trees are largely considered as the parakeet roosts either temporary or permanent (Krause and Ruxton, 2002; Rogers *et al*., 2006). Avian communal roosting is common and also depicts strong impacts to better the phenotypic traits, population dynamics and the mating systems (Cockburn, 2004; Dunbar, 2009; Aplin *et al*., 2015). Thus, the communal roosting of birds generally comprises hundreds of birds and is considered

the diurnal centre of activities for them. In the evening with all the birds returning in varying numbers to their respective roosts transmutes as the nocturnal roost, and birds recapitulate to pass through their night periods harmlessly (Barta and Giraldeiu, 2001).

It is pertinent that while the roost selection occurs by the different birds, they are largely influenced by the self-organization theory (SOT) to inhabit the roost complexities; some communal roost members as leaders and the others as follows for the roost discipline (Camazine *et al*., 2001; Sueur *et al*., 2010). Furthermore, important advantage of bird roosting is to provide thermoregulation in closed environment to all the roost members particularly in the cold weather (Duplessis and Williams, 1994). Avoidance of predatory pressure (Elgar, 1998) is considered significant for the communal roosting of the parakeets. It is ecologically suitable to determine the aggressive parakeets on the existing food sources in the small and large flocks to cause the depredations, and to possibly dispel the birds before their possible damage patterns (Eiserer, 1984). Aggregation of the birds to feed on the existing food crops is considered safe and effortless during the diurnal periods, while some of the left overs safeguard their roosts (Mock *et al*., 1988; Thiolly and Julien, 1998). The communal roosting in the rose ring parakeet is widespread and, therefore, houses fairly large of the parakeets with their siblings or conspecifics in the same roost with the benefit of maximum foraging periods in the daytime (Richnar and Hebb, 1995; Khan *et al*., 2004; Ahmad *et al*., 2012). Present study was, therefore, designed to estimate the proportions of tree cavities in the six major habitats for the overall 44 communal parakeet roosts with the effective conversion in the nests for breeding.

MATERIALS AND METHODS

Investigations were recorded from May, 2019 through April, 2021 in the five canal-irrigated sites viz. Faisalabad (31°27'36"N 73°08'10"E), Hafizabad (32°04'25"N 73°41'20"E), Jhang (31°16'50"N 72°19'53"E), Toba Tek Singh (30°58'22"N 72°28'55"E) and Sheikhupura (31°43'07"N 73°59'04"E) to determine the tree composition, tree height and their diameters at breast height (dbh), for the trees and the occurrence of tree depressions or hollows as tree cavities for the rose-ringed parakeets. The Central Punjab ranges between 155.20 through 206.00 m from the sea surface (Fatima *et al*. 2015). Mean annual climate of this region ranges from (7±4ºC in winter and 35±12ºC for summer), while the fall and spring seasons are relatively cool (25±5ºC) (Nawaz *et al*. 2020; Nawaz *et al*. 2019; Asmat and Athar, 2017). For the present study, all observations were consecutively recorded through direct survey of the 44 communal roosts in Central Punjab, Pakistan for the predominant trees.

Study Sites: The designated sites in this study area comprised small and large communal roosts in the five districts viz. Faisalabad, Jhang, Toba Tek Singh, Hafizabad and Sheikupura. Of the total 44 roosts, two University of Agriculture, Faisalabad and the Jinnah gardens occurred in the Faisalabad city avenues, whereas the other 42 belonged to the four Central Punjab districts. All the parakeet roosts were spaced about 30 km away from Faisalabad city. and alongside three main irrigation canals viz. Jhang branch, the Gogera branch and the Rakh branch respectively. The region of Central Punjab (31.45° N; 73.13° E) is largely agricultural and contributes approximately (26%) for the requirements of Pakistan (Qamar, 2005; Iftikhar *et al*., 2019; Rehman *et al*., 2015). Composition of all habitats comprised varied numbers of the old and tall trees to form the agricultural landscape (Ahmad *et al*., 2012). Different tree species with their diverse diameters at breast height comprised tree hollows in good proportions and were, therefore, regarded as the predominant and co-dominant throughout the 44 sampled communal roosts in Central Punjab, Pakistan.

Bird sampling: The diurnal (sunrise through sunset) observations were made for all the seasons throughout the year. A specific point was selected in all the roosts to assess the bird movement patterns among the dominant and co-dominant trees for the study sites by the 'simple random selection' method (West, 2017). All observations were conducted using the field binocular (Zeiss-Carl 05, 50x700 mm) whenever required for better visualization.

For the present study, the rose ring parakeet (*Psittacula krameri* Linn.) was sampled consecutively for two years among all the roosting sites to determine its relative abundance and proportions of tree cavities. All the sampling was done using the simple random selection (West, 2017). Significantly, not all the occurring cavities turned out to be the parakeet nests; nonetheless, both the breeding pairs after the cautious surveillance, duly approved selected cavities as their nests for the breeding.

Assessment of diameters at breast height: Various trees which existed in the roosts were categorized as 'dominant' and 'co-dominant' and, therefore, comprised sufficient numbers of tree hollows. Therefore, total of 12 such trees on the basis of their diameter at breast heights 'dbh' were carefully assessed using the measuring tape around the tree trunks. This tape was held straight by the two workers and observations were made accurately with multiple repetitions throughout the study sites in the different roosts. In all, trees were differentiated for three classes viz. less than or equal 50cm, 50-70cm and more than 70cm respectively with varying tree depressions in all the roosts.

Statistical Analysis: The data were statistically analyze using the Kolmogrove software, non-parametric tests and

the scatter regression plots (Minitab, 2010) for the results in the present studies.

Figure 1. Map of Central Punjab, Pakistan with the location of study the sites.

RESULTS

The data obtained revealed that all the 44 roosting sites surveyed in the five districts of Central Punjab, Pakistan, 28 were recorded in Faisalabad, seven in Jhang, and only four and two Hafizabad and Sheikhupura (Table 1). Numbers of rose-ringed parakeets were present in good numerical numbers All of them comprised variable trees with three categories of their diameters at breast height categories. Of these, the average tree height was 20 m. Predominantly, of three 'dbhs', majority was of trees was of less or equal to 50cm were recorded. It was evident for all the five major habitats of the five study sites. Coefficient of determination $R^{2,}$ thus depicted higher numerical index, 96% for the five roosting sites. Nonetheless, the other two dbh categories viz. 50-70 cm and greater than 70 cm were of lesser proportions, R^2 =13.61 and -1.61 (Figure 2a).

Similarly, alongside and considering the regression analysis of the Jhang district of tree composition in its respective communal roosts, yet again, highest coefficients of determinations R^2 was 77.2, 30.78 and also 2.00 were recorded for trees with 50 cm diameters, and regarded as the dominant and co-dominants (Figure 2b). For the other three sampled sites viz. Hafizabad, Toba Tek Singh and Sheikhupura, approximately with the similar regression values were recorded (Figure 2c). Assessment of the tree cavity percentage of various roosts strongly suggested that presence of trees cavities seemed were fairly high for the tree diameters (50 cm), while their proportions for the

remaining two 'dbh categories' viz. 50-70cm and more than 70 cm were considered as low and the least due to less numbers of existing trees here y =2.5567x + 3.3064 R^2 = 0.8567. Thus, there appeared significant correlation between the tree cavities to support the rose-ringed parakeet among the dominant and co dominant trees in their varied communal roosts in different sites. Apparently, the more tree hollows among the old and tall trees more than century ago here, were certainly significant factor for the augmented tree cavities for the parakeet nocturnal roosts, depicted strong correlation with the greater proportions of the perceptible parakeet nests. Occurrence of the invaluable roosts among the varied trees not only the rose-ringed parakeets but also for many other cavity-nesting birds in the similar habitations. It was further evident that trees and their hollows seem instrumental for the proportions of cavities and the probable nests to the diversified avian faunal distributions.

Table 1. Location of the rose-ringed parakeet roosts as sampled from different study sites in Central Punjab, Pakistan.

S. No	LOCATION OF ROOSTS		Coordinates	Estimated population
FAISALABAD DISTRICT				
1	Aminpur CRH	On the bank of Jhang branch canal	31°29'32"N 72°51'33"E	500
2	Awagat CRH	On Faisalabad-Jaranwala road, Tehsil Jaranwala	31°20'56"N 73°19'09"E	300
3	Badwala CRH	52 R.B., Branch road, Faisalabad-Shorkot road	31°37'42"N 73°37'19"E	300
4	Burala CRH	Eight km upstream from Chamrail Jhal Bridge, Gogera branch, near Satiana, Tehsil Jaranwala	31°08'35"N 73°16'32"E	1500
5	Farida CRH	On Gogera branch canal, Tehsil Jaranwala	30°40'03"N 72°43'59"E	200
6	Gidderwala CRH	271 R.B., near Dijkot, Tehsil Faisalabad	31°10'37"N 72°54'50"E	200
7	Hathiarwala CRH	On Jaranwala-Khurrianwala road, Tehsil Jaranwala	31°10'37"N 72°54'50"E	200
8	Kanyan CRH	Eight km downstream on Gogera branch canal,Tehsil Jaranwala	31°08'04"N 73°03'50"E	1200
9	Jinnah Gardens, Faisalabad	On the club road, Faisalabad city	31°33'32"N 73°05'06"E	1200
10	Khanuwana CRH	In Khanuwana, on Faisalabad- Samundari road, Tehsil Jaranwala	31°19'31"N 73°24'19"E	800
11	Kot Khuda Yar CRH	On the bank of Jhang branch canal	31°28'40"N 73°04'38"E	300
12	Muhammadwala CRH	229-RB., Muhammadwala, Tehsil Jaranwala	31°22'08"N 73°14'22"E	200
13	Ludianwala CRH	On Jaranwala-Lahore road, Tehsil Jaranwala	31°18'53"N 73°34'35"E	200
14	Miranwala CRH	6 J.B., on the side branch, Faisalabad-Chiniot road	31°26'37"N 73°08'10"E	100
15	Mureedwala CRH	On Mureedwala-Mamoonkanjan road, Tehsil Samundari	30°56'21"N 73°43'38"E	200
16	Munianwala CRH	Mamoonkanjan, Tehsil Samundari	30°49'39"N 73°43'18"E	150
17	Newan CRH	On the bank of Jhang branch canal	31°28'40"N 73°04'38"E	300
18	Narwala CRH	61 J.B., on Faisalabad-Aminpur road	31°27'21"N 72°58'03"E	500
19	Pauliani CRH	On Jaranwala-Khurrianwala road	30°49'56"N 73°27'29"E	100
20	Rodhu Koru	133 J.B., on Faisalabad-Samundari, near Dijkot, Tehsil	31°56'76"N	200

	CRH	Samundari	72°98'58"E	
21	Satiana CRH	One km from main Satiana road, Tehsil Jaranwala	31°12'18"N 73°10'21"E	500
22	Sandianwala CRH	248 R.B., on Faisalabad- Samundari road	30°48'40"N 72°48'35"E	200
23	Terkhani CRH	On Tandlianwala-Kamalia road, Tehsil Samundari	31°03'18"N 73°04'40"E	400
24	Thikriwala CRH	74 J.B., on Faisalabad-Jhang road	31°33'45"N 74°11'02"E	300
25	Univ. of Agri. Faisalabad	Faisalabad University Campus	31°23'49"N 72°59'42"E	2000
26	Jinnah garden	On the club road, Faisalabad city	31°25'32"N 73°05'06"E	1000
27	Ukbana CRH	On the bank of Rakh branch canal, near forest park, Guttwala	31°28'50"N 73°12'39"E	300
28	Khidderwala CRH	On Samudari-Pir Mahal road, Tehsil Jaranwala	31°56'51"N 72°49'44"E	100
HAFIZABAD DISTRICT				
29	Bairanwala CRH	On the bank of Jhang branch canal, Tehsil Pindi Bhattian	32°17'23"N 73°41'15"E	200
30	Mochiwala CRH	On the bank of Rakh branch canal, Tehsil Pindi Bhattian	32°17'24"N 73°41'13"E	200
31	Nanuwana CRH	On the bank of Rakh branch canal, Tehsil Pindi Bhattian	31°57'36"N 73°37'27"E	300
32	Sukheke CRH	On the bank of Rakh branch canal, Tehsil Pindi Bhattian	31°50'17"N 73°29'42"E	400
		JHANG DISTRICT		
33	Bairwala CRH	On Jhang-Chiniot road, Tehsil Chiniot	31°44'17"N 72°35'47"E	200
34	Chimranwali CRH	On Faisalabad-Jhang road	31°44'36"N 72°35'04"E	300
35	Joora CRH	On Bhowana branch canal, Tehsil Chiniot	31°44'21"N 72°35'42"E	400
36	Khairwala CRH	On the bank of Jhang branch	31°18'46"N 72°19'08"E	200
37	Muradwala CRH	In Muradwala on Jhang road	30°53'46"N 71°50'50"E	200
38	Tawan CRH	On the bank of Jhang branch canal	31°16'04"N 72°19'39"E	100
39	Yahkuwala CRH	Chak kot qazi, near Lalian forest plantation	31°16'05"N 72°19'39"E	100
TOBA TEK SINGH				
40	Gojra CRH	On Jhang-Gojra road, Tehsil Gojra	31°09'27"N 72°39'05"E	700
41	Moongi CRH	On Jhang branch, Tehsil Gojra	31°01'17"N 72°42'00"E	400
42	Rajbah Khan Chand	273 J.B., Jhang branch canal, Tehsil Gojra	31°53'59"N 72°48'32"E	100
		SHEKHUPURA		
43	Mudh Balochan CRH	On the bank of Rakh branch canal, Tehsil Safdarabad	31°17'24"N 72°41'15"E	200
44	Salarwala CRH	On the bank of Jhang branch canal, Tehsil Safdarabad	31°48'47"N 72°31'25"E	200

CRH = canal rest house

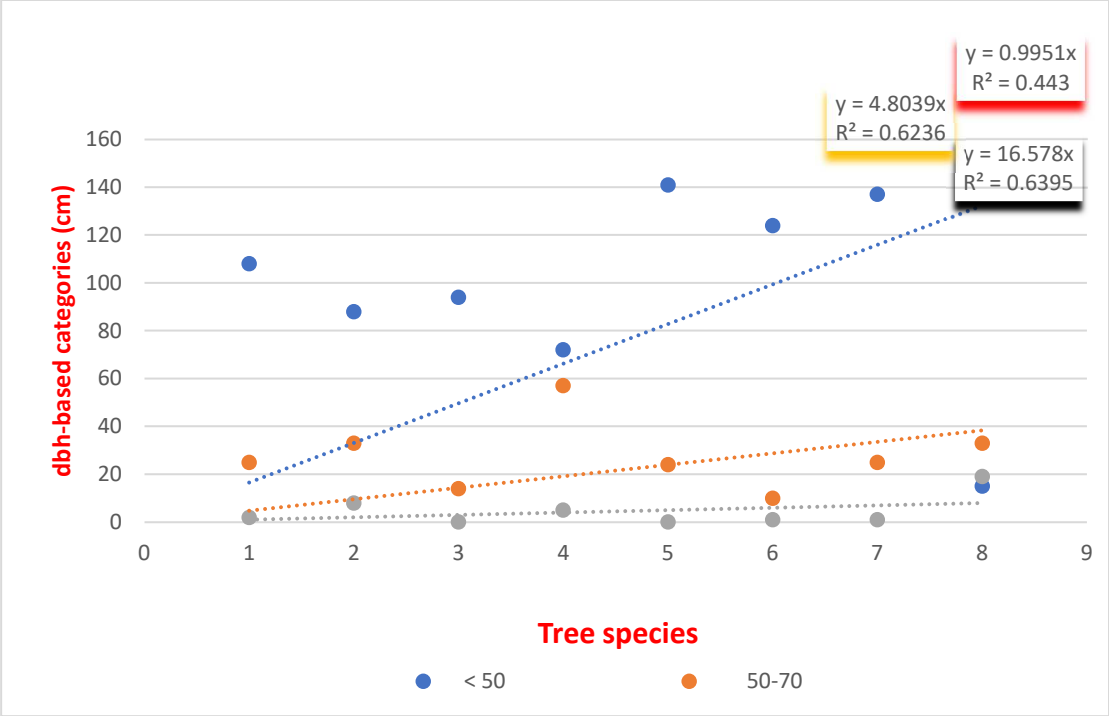

Figure 2a. Interaction between three diameters at breast height (dbh) three segregated categories as recorded for the tree hollows at the two major sites in the urban avenues of Faisalabad viz. University Campus and Jinnah garden with maximum abundance in 50-70 cm.

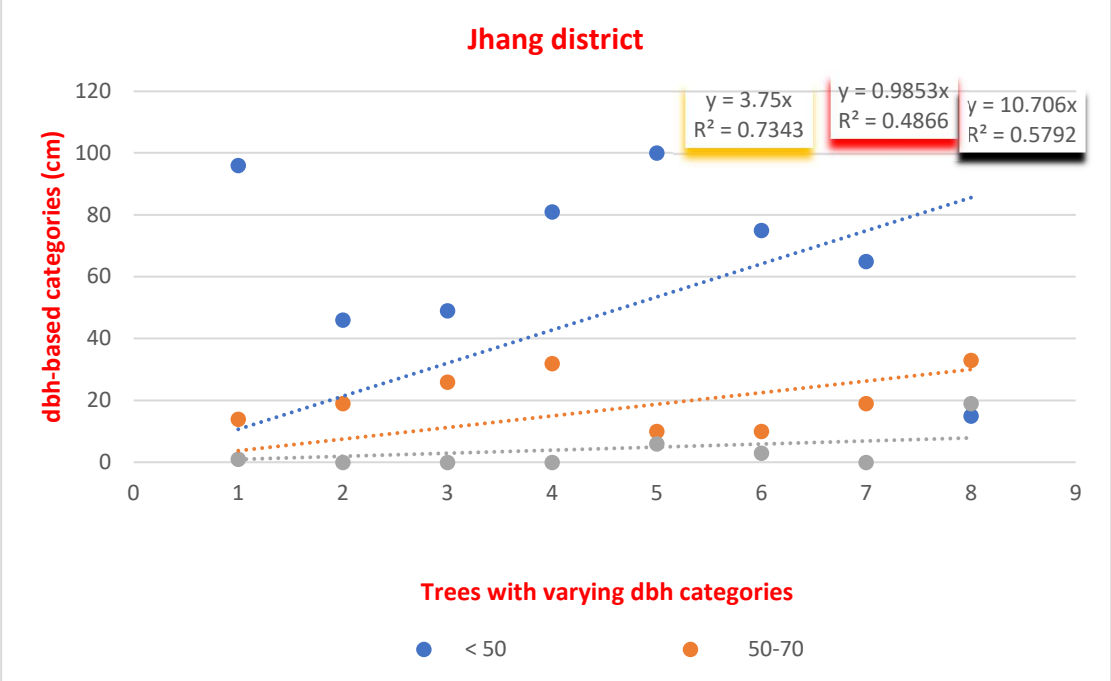

Figure 2b. Correlation indices recorded for the Jhang district in various rose-ringed parakeet roosting sites of three dbh designated classes in relation with the predominant trees. Evidently ≤ 50 cm comprised the major numbers of tree depressions in parakeet roosts.

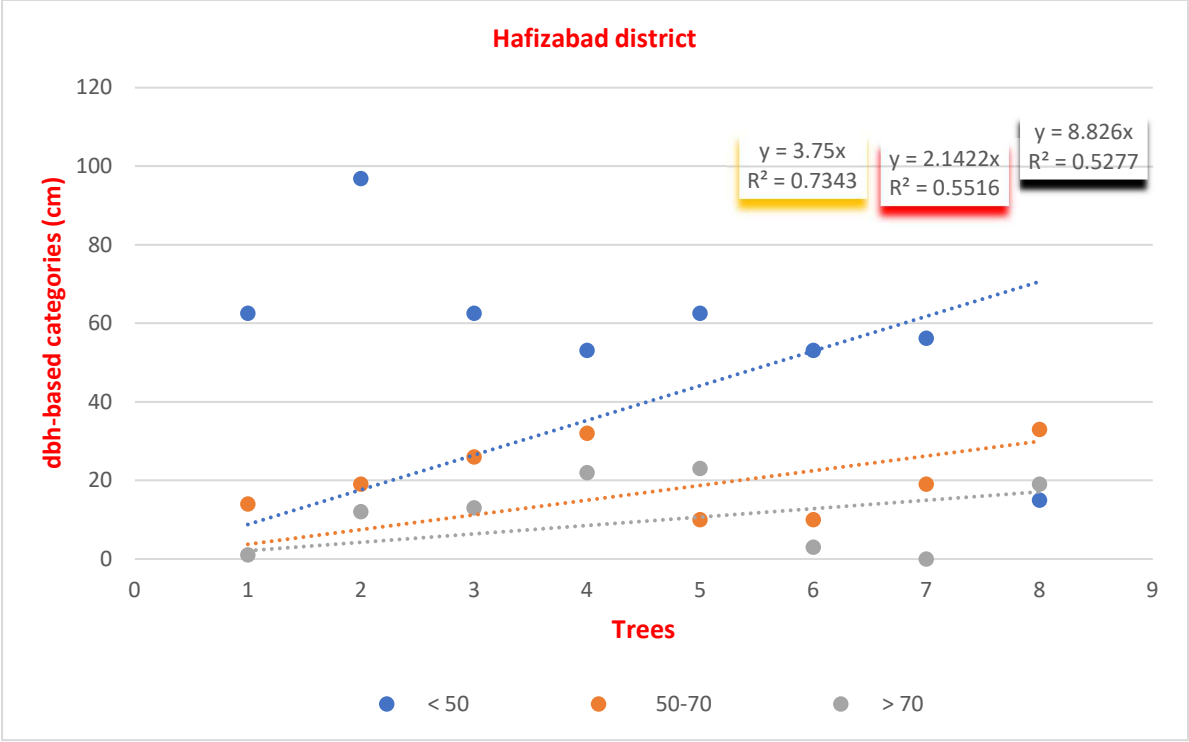

Figure 2c. The figure represents fairly strong regression between trees diameters at tree trunks height versus cavities. As apparent, yet again the tree proportion (50 cm) harboured the maximum tree hollows to correspond with the prospective nests in designated sites of Hafizabad district.

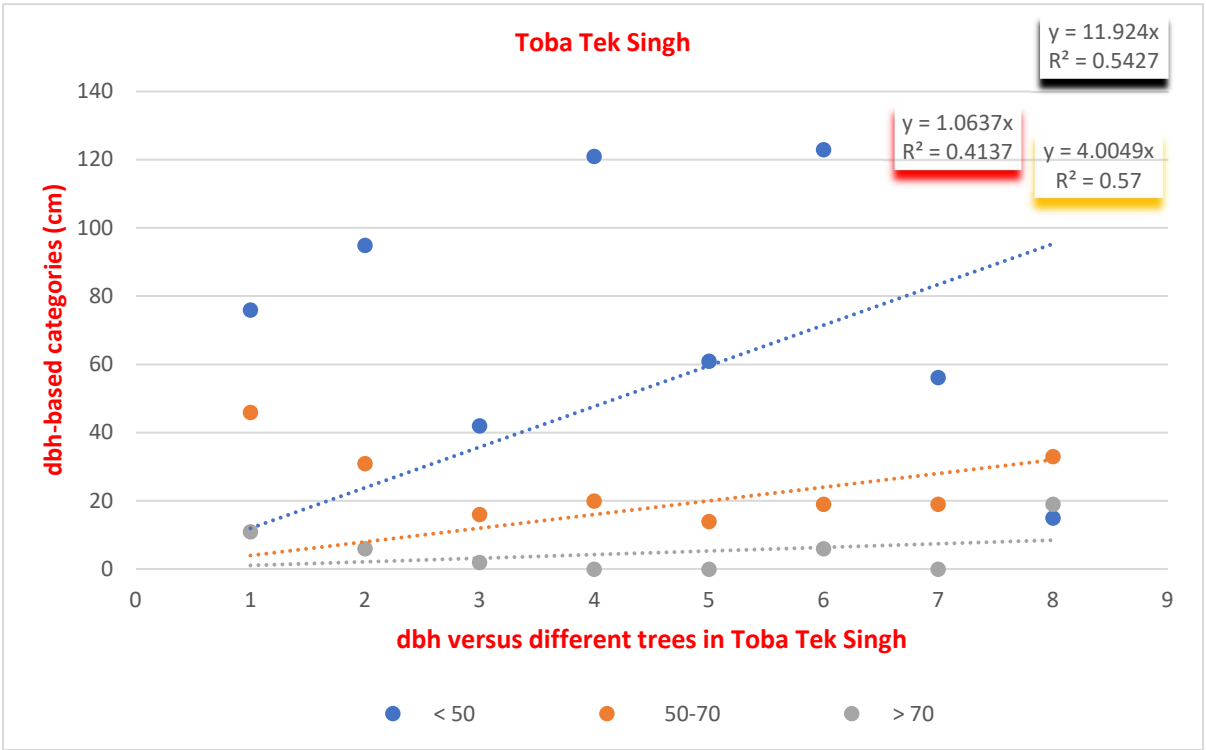

Figure 2d. This figure depicts again the maximum cavities in relation to the tree trunk diameters of ≤50 cm, while their numbers were of intermediate for the dbh 50-70 cm and were almost negligible when exceeded more than 70 cm in the Toba Tek Singh site.

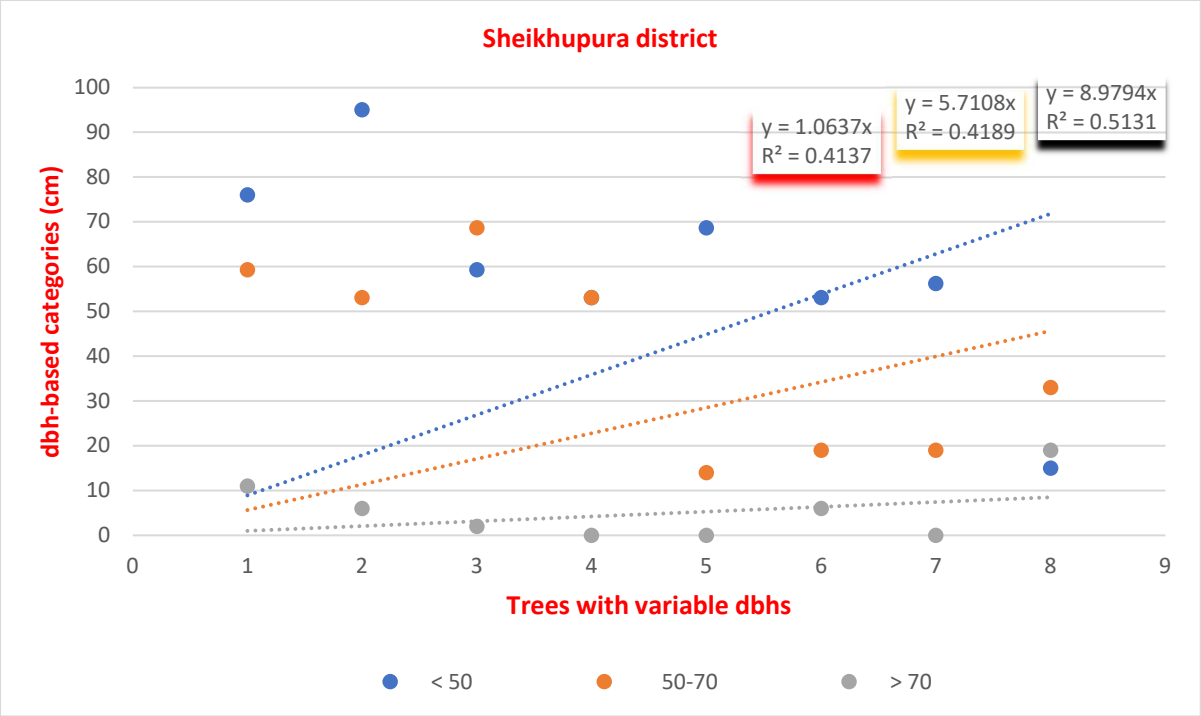

Figure 2e. Representation of the strong correlation of tree species with average diameters of trunks of 50 cm, considered conveniently dominant with large numbers of depressions. Of these, several changed as prospective parakeet nests after surveillance in breeding season in Sheikhupura district.

DISCUSSION

It was apparent in the present results that of the total 44 roosts in the six major habitats viz. croplands, village communities, roadside forest plantations, the city road avenues and University Campus throughout the five districts of Central Punjab, the croplands were the largest spread over more than 1000 acres. They were followed by the village communities of 100 acres, the roadside forest and canal plantations were each 72 acres, the city road avenues comprised 16 acres and that of the sufficiently large University Campus was more than 2500 acres respectively. The copped habitats were more predominant owing to the traditional concept of multiple-cropping systems (MCS) which also occurs today among the farming communities throughout Central Punjab. Of the predominantly 2224 trees, *Dalbergia sisso* was the highest of all the locations and was closely followed by the *Morus alba*. The *Zizyphus* species nonetheless was of the lowest proportions among all the habitats. Numbers of cavities and the productive nest proportions were 184 (0.27) and 16 (0.025) and yet again were of the *Zizyphus* species. Overall the cropland comprised 392 tree cavities and 64 nests (Figure 3a).

Invariably, the proportions of tree cavities were the highest for the differential trees in the all major habitats. Significantly, association recorded for tree cavities and of the parakeet productive nests also was fairly significant depicting the regression equation Y= -0.39 + 0.214 x (R^2 = 99.4%). It indicated that with single increase of tree cavity among of the total habitats resulted in increase 0.214 parakeet nests. Thus, several of the tree depressions are likely to be changed as 'useful nests' for breeding in the spring season. The fact that the communal roosts of the parakeets in the various habitats offered large population index with the occurrence of ample foraging and feeding opportunities to them. Incidentally the multiple- cropping practices continue to occur in various croplands by the farmers provide the food source damage and also the resulting economic losses. As majority of the crops are a viable to them throughout the year and the old and tall trees grown more than multiple decades ago, offer, and the communal roosts of the parakeets. Therefore, over the years, not only the sustainable roosting has existed here, located at short distance from the food crops. (Ali *et al*., 1981., Roberts, 1991; Ahmad *et al*., 2012 [a,b]; Tariq *et al*., 2007). The communal roosts which were surveyed for the five districts in the Central Punjab, Pakistan incorporated the tree diameters at breast height (dbh) for the three categories viz. 50 cm, 50-70 cm and more than 70 cm. Of these, majority of the old and tall trees grown here for more than century ago, comprised predominantly the trees cavities and subsequently the prospective nests.

Invariably, the parakeets left their roosting sites fairly early (about sunrise) and returned late at evening

following their daily diurnal activities viz. foraging, roosting, tussles with other birds and the search for cavities to be altered into suitable nests after the cautious surveillance for breeding behaviour in late April. Present results have also indicated similarities regarding the search for cavities during the fall season to prepare for the successful breeding periods (Sarwar *et al*., 1989, Hussain, 1982., Wang *et al*., 2018). Significantly, with the well-developed audio-visual system for the parakeets, majority of them displayed the impact of the telencephalon in the brain to critically monitor and organize their behavioural actions (Shimizu *et al.,* 2008; 2010). Such cognitive actions, therefore, remain effective to impact the parakeets behavioural displays for their diurnal and nocturnal activities viz. foraging, feeding with emergence of the loud or feeble calls during their roost exists and also returns at the dawn and dusk (Hodos *et al*. 2003; Frost and Sun, 1997; Shimizu *et al*., 2010).

Undoubtedly, the altered ecological conditions presently ecologically prove beneficial to variety of birds to forage in high abundance on the unprotected food resources close to their roosts as of the Eurasian black birds (*Turdus maurula* Linn.) in United States (Fiedler *et al*., 1991; Lindell *et al*., 2013; Elser *et al*., 2019), while the present results of the rose-ringed parakeets among the different habitats of Central Punjab, Pakistan on the economically important crops viz. wheat, maize, sunflower, fodders and various fruit orchards (Ahmad *et al* 2012., Zeeshan *et al.,* 2016).

The parakeets are largely regarded as the social and cavity nesters. The productive breeding pairs prefer to select such nests which are considerably safe from the environmental threats to their nests. The cavities as the depressions in the old and tall trees might not all turn as the productive nests, but only after the surveillance by both the breeding pairs, preferably in the fall season in the woodlands (Mathysen, 2007., Simwat and Sidhu, 1973, Roberts,1977, Butler *et al.* 2003). Palpably, majority of the trees in the present study belonged to the dbh category (50 cm), had the major contribution for the tree cavities as concurrently the productive nests. Seemingly, the present results also suggest close relationship between tree cavities of different with the parakeet nests (Figures 3,4,5). The parakeets remained in active pursuits of the suitable nests almost in all yearly months; nonetheless, it gained impetus during the fall and late winter seasons. Major search for the tree cavities to be subsequently transformed in the prosperous nests occurred well away from the parakeets' communal roosts as were also recorded by (Ahmad, 196; Chaudhry and Beg, 1977; Umer, 2000; Sarwar *et al*., 1989).

Parakeets used the hollows intelligently and refined them to lay the eggs for brooding subsequently. Onset of fledgling stage was highly significant and both the parents offered food to the chicks by the allo-feeding and allo-preening (Ahmad, 1986; Whistler, 1986) for about three to four weeks for the desirable vigour to enable them to make their early aerial movements. Present results apparently suggest that among all the six major habitats for the rose-ringed parakeets, percentage of cavities was fairly high while the selected breeding nests proportion remained low commensurate to the approval by both the breeding partners for the ecological protection (Figure 3 a,b,c,d,e,f).

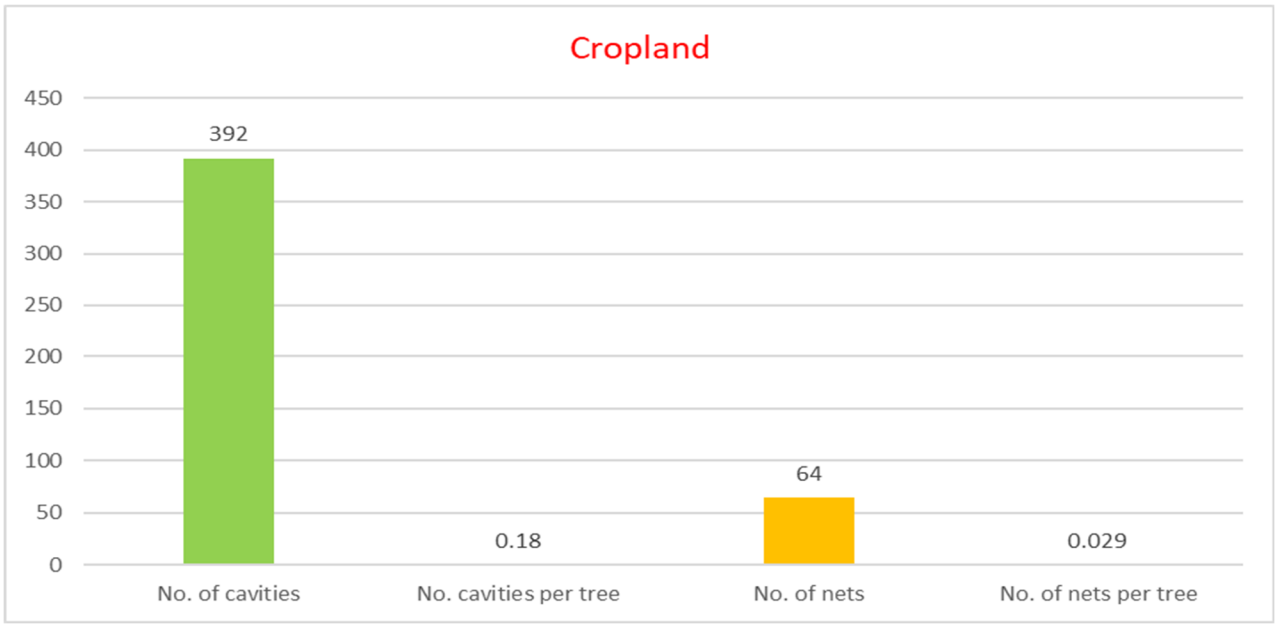

Figure 3a. Occurrence of highest numbers of nests proportions as recorded in the all croplands among the designated study locations in Central Punjab, Pakistan for the rose-ringed parakeet also containing larger nest proportions also.

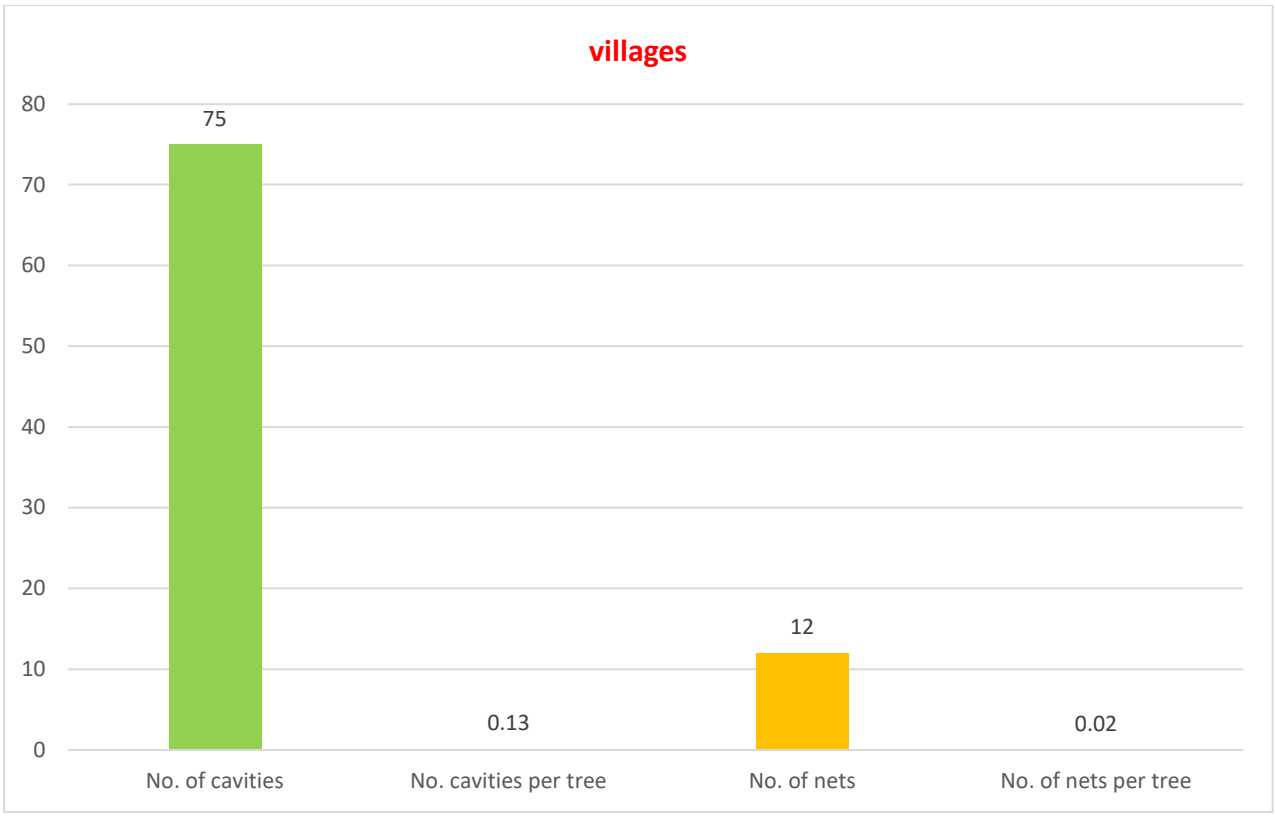

Figure 3b. Representation of tree cavities among three dbh classes in the villages with overwhelming tree cavities of the parakeet in the all study ecologically suitable habitats (Central Punjab).

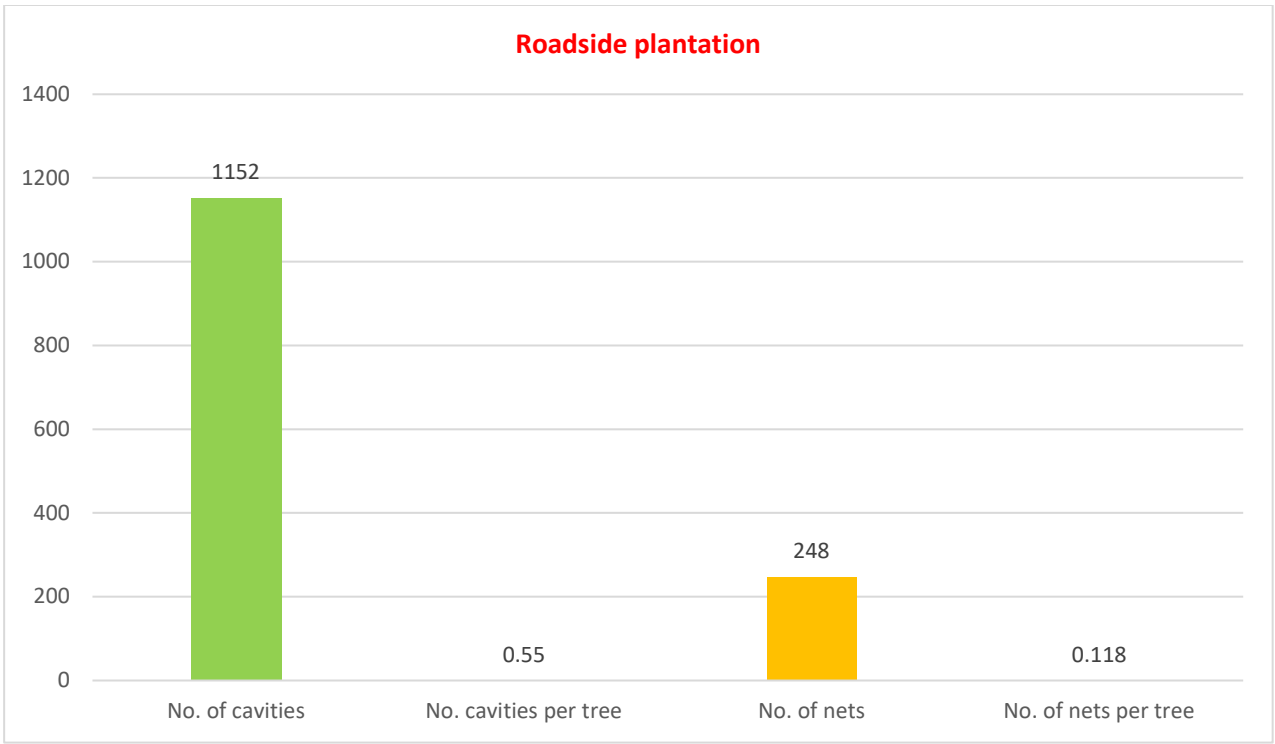

Figure 3c. Occurrence of larger percentage as indicated by the croplands for the sum total localities of five districts. Evidently, the tree hollows were 1192 regarding the road side forest plantations.

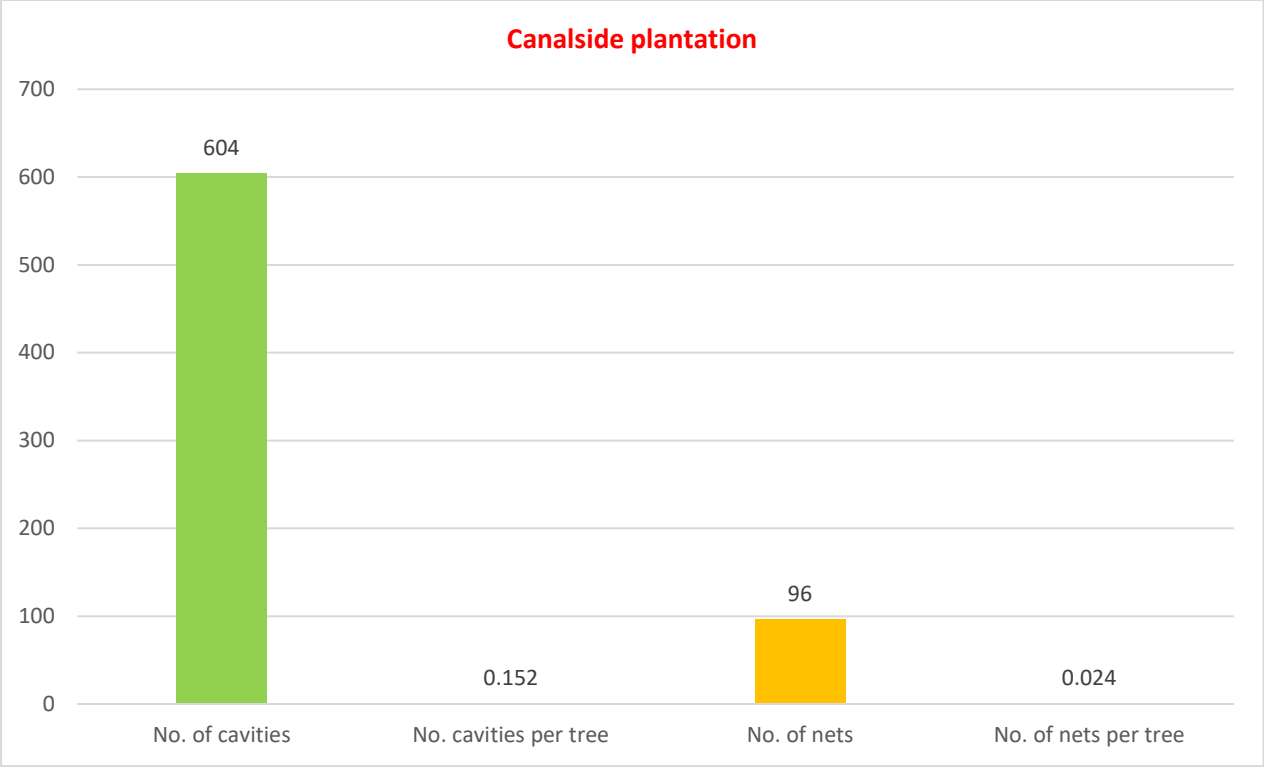

Figure 3d. This figure depicts yet again maximum numbers of tree depressions for the rose-ringed parakeets in the canal-irrigated plantations with good degree of moisture availability to support the bird populations in the five major study habitats.

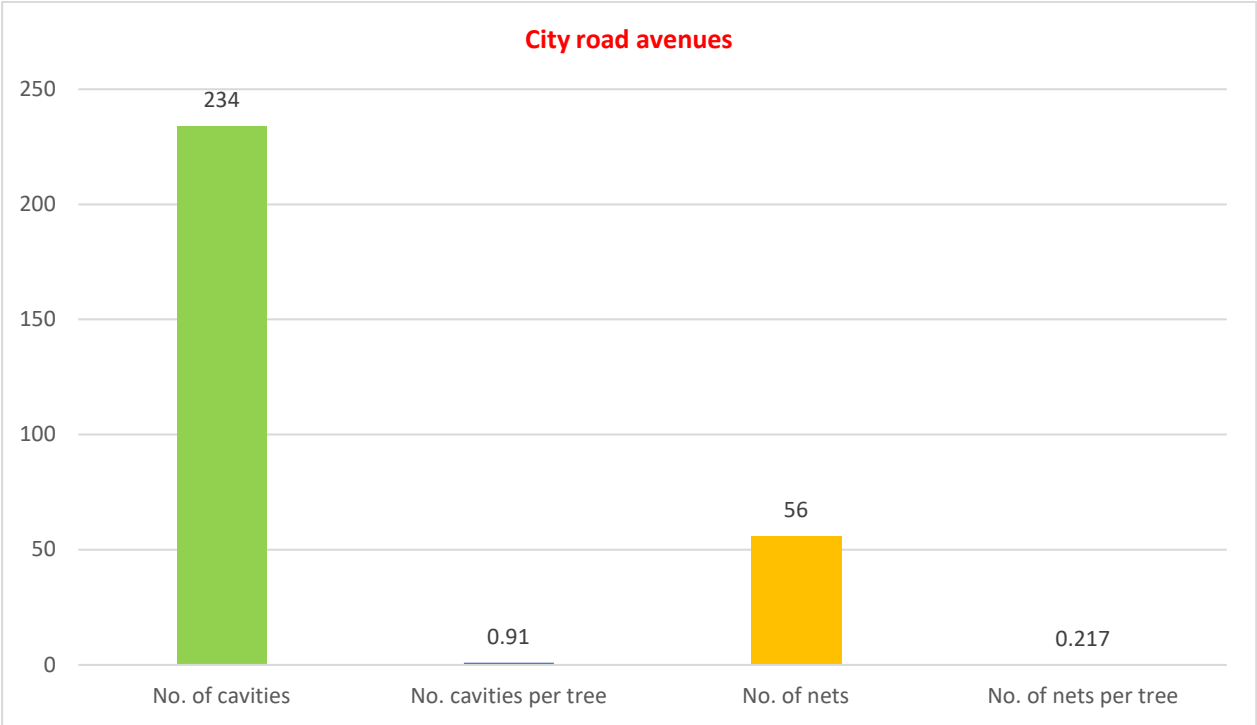

Figure 3e. Considering the city road avenues, once again the tree depressions (234) were recorded highest in percentage and also in commensurate with the productive parakeet nests for breeding in the respective season.

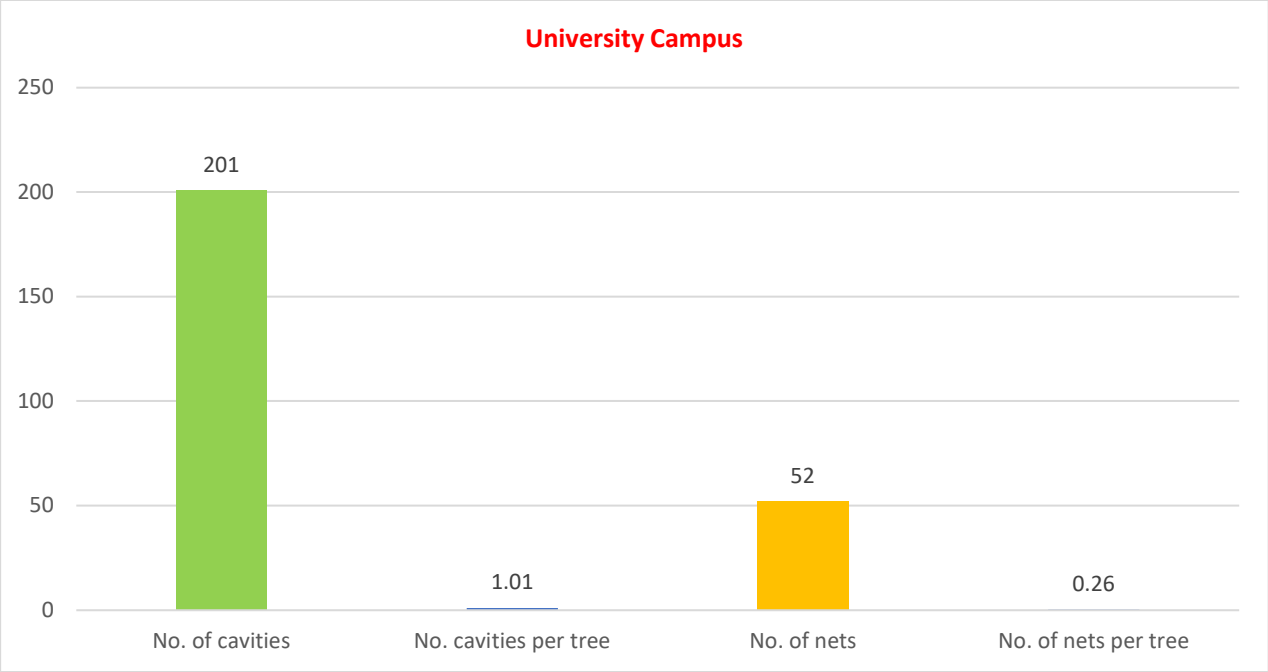

Figure 3f. Percentage composition for the maximum numbers of trees and the accompanying tree hollows within the largest agricultural habitat and plantations to augment the parakeet and other bird's populations in sufficiently large roosts at the University Campus.

Lately, threats to wildlife regarding their sustainability have increased owing to various ecological factors as the urbanization. Importantly, the woodlands, considered as the refuge for majority of the wildlife in their natural ecosystems, portrays depleted picture with varied environmental predicaments in the differential world-wide agro-ecosystems. Moreover, the fast diminishing food resources with the incorporation of unpredictable climate changes, conditions, and requiring the ecologically friendly strategies to bail out of this situation in future.

Conclusions:

1. Thick and light timbered plantations are occupied either as temporary or permanent roosting sites for the parakeets and also for some other birds.
2. Present emphasis on 'grow more trees campaign' would require thoughtful considerations. Several wildlife species regard the plantations as their natural refuge. Of these, many act as the serious pests of agriculture, and likely to deplete food crops and, therefore, cause economic losses.
3. The rapid urbanization and alleviation of the thick and light woodlands to accommodate the human population is seriously jeopardizing the wildlife and weakening the environment sustainability.
4. Asymmetrical climate variations are also leading to the uneven temperatures, precipitation and relative humidity indices in nearly all worldwide habitats. Occurrence of the demise of beneficial wildlife is a perplexing ecological predicament including of the useful birds and seem catastrophic in future also.

Authors contribution: All authors have equally contributed in the present research. Hammad Ahmad Khan designed the experiment, while Waqar Majeed, Sajida Mustafa and Sumaira Shabbir worked in the field, collated and compiled the research data.

Conflict of Interest: It is certified that there is no conflict of interest for this manuscript among all the authors and all the authors have given their consent strongly for the submission of this manuscript in the Pakistan Journal of Agricultural Sciences.

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REFERENCES

Ahmad, A. (1986). Breeding behaviour of common myna and rose-ringed parakeet in Central Punjab.

M.Sc. Thesis, Zoology, Wildlife and Fisheries, Univ. Agriculture, Faisalabad. 42 p.

Ahmad, S., H.A. Khan, M. Javed and K. Rehman (2012). An estimation of rose-ringed parakeet (*Psittacula krameri*) depredations on citrus, guava and mango in orchard fruit farm. Int. J. Agric. And Biol., 14: 149-152.

Ahmad, S., H.A. Khan, M. Javed and K. Rehman (2012). Management of maize and sunflower against the depredations of rose-ringed parakeet (*Psittacula krameri*) using mechanical repellents in an agro-ecosystem. Int. J. Agric. And Biol., 2: 286-290**.**

Ali, S., B.H.K. Rao, M.A. Rao and P.S. Rao (1981). Parakeet damage to maize. J. Bomb. Nat. Hist. Soc., 79: 201-204.

Ali, S. and S.D. Ripley (1968). Handbook of the birds of India and Pakistan: together with those of Nepal, Sikkim, Bhutan and Ceylon. Oxford University Press. UK.

Aplin, L.M., (2015). Experimentally induced innovations lead to persistent culture via conformity in wild birds. Nature, 518: 538-542. doi:10.1038/ nature13998

Asmat, U. and H. Athar. Run-based multi-model inter-annual variability assessment of precipitation and temperature over Pakistan using two IPCC AR4-based AOGCMs. Theor. Appl. Climatol. 127:1-16. DOI 10.1007/s00704-015-1616-6

Babu, R.S. and T.S. Muthukrishnan (1987). Studies on the damage by *Psittacula krameri* (Scopoli) and *Passer domesticus* (Linnaeus) on certain crops. Int. J. Pest Manage., 33:367-369. https://doi.org/10.1080/09670878709371185

Barta, Z. and L.A. Giraldeau (2001). Breeding colonies as information centers: a reappraisal of information-based hypotheses using the producer-scrounger game. Beh. Ecol., 12:121-127. https://doi.org/10.1093/beheco/12.2.121

Beg, M.A. and S.A. Rana (1978). Ecology of the field rat, *Rattus meltada pallidior* in Central Punjab, Pakistan. Pakistan J. Zool., 5: 163-168.

Butler, C.J. (2003). Population biology of the introduced rose-ringed parakeet *Psittacula krameri* in the UK. Ph.D. Dissertation, Dept. Zoology, Univ. Oxford, UK.

Camazine, S., J.L. Denobourg, N.L. Franks, J. Sneyd, G. Theraulaz and E. Bonebeou (2001). Self-organization in biological systems. Princeton, New Jersey, Univ. Press p 288.

Cockburn, A. (2004). Prevalence of different modes of parental care in birds. Proc. Royal Soc. Trans., 274: 1373-1384. doi: 10.1098/rspb.2005.3458

Du Plessis, M. A. and J.B. Williams (1994). Communal cavity roosting in green wood hoopoes: consequences for energy expenditure and the seasonal pattern of mortality. The Auk, 111: 292-299. https://doi.org/10.2307/4088594

Dunbar, R.I. (2009). Darwin and the ghost of Phineas Gage: neuro-evolution and the social brain. Cortex, 45:119–1125. DOI: 10.1016/j.cortex.2009.05.005

Elser, J.L., L. Amber, M.M. Karen, C.P. Tyler, S.R. Kerr and S.A. Schwiff (2019). Economic and livestock health impacts of birds on dairies: evidence from survey in Washington dairies. USDA Wildl. Service, USA. https://doi.org/10.1371/journal.pone.0222398

Eiserer, L.A. (1984). Communal roosting in birds. Bird Behav., 5: 61-80.

Elgar, M.A., (1998). Predator vigilance and group size in mammals and birds: a critical review of the empirical evidence. Biological Review. 64: 13-33. https://doi.org/10.1111/j.1469-185X.1989. tb00636.x

Fatima, T., M.S. Sajid, M.K. Saleemi, Z. Iqbal and R.M. Siddique (2015). Descriptive epidemiology of endo-parasitic fauna in layer birds (*Gallus domesticus*) of Central Punjab, Pakistan. Pakistan J. Agric. Sci., 52: 815-820.

Fiedler, L.A., M.W. Fall, R.L. Bruggers and De Grazio. (1991). Rodent and bird problems in agriculture and their management in developing countries. Proc. 11th Int. Cong. Plant Prot., Manila, Philippines. pp 74-92.

Frost, G.B. and M.I. Sun (1997). Pigeon courtship behaviour in response to live birds and video presentations. 5th Int. Conf. on Neuro-ethology, Ontario, Canada pp 78-95.

Harms, K.E. and J.R. Eberhard (2003). Roosting behavior of the brown-throated parakeet (*Aratinga pertinax*) and roost locations on four southern Caribbean islands. Ornithol. Neotrop., 14:79-89.

Hodos, W., A. Potocki, M.M. Ghim and M. Gaffney. (2003). Temporal modulation of spatial contrast vision in pigeons (*Columba livia*). Vision Res., 43: 761-768. https://doi.org/10.1016/S0042-6989(02)00417-0

Hussain, R.H. (1982). Nesting and food habits of rose-ringed parakeet in Central Punjab. M.Phil. Thesis, Dep. Zool. and Wildl., Univ. Agric., Faisalabad. p 55.

Iftikhar, M., G. A. Khan and J. Hussain (2019). Identification and prioritization of agricultural risks with special context of rice crops in Punjab, Pakistan. Int. J. Agric. Ext., 7: 99-105. DOI: 10.33687/ijae.007.01.2486

Iqbal, M.T., H.A. Khan and M.U.H. Ahmad (2001). Feeding regimens of rose-ringed parakeet (*Psittacula krameri*) on a sunflower field in an agroecosystem in Central Punjab, Pakistan Vet. J., 20: 177-180.

Khan, H.A., S. Ahmad, M. Javed, K. Ahmad and M. Ishaque (2011). Comparative effectiveness of some mechanical repellents for management of rose ringed parakeet (*Psittacula krameri*) in citrus, guava and mango orchards. Int. J. Agric. and Biol., 13: 396-400.

Khan, H.A., M.A. Beg and A.A Khan (2004). Breeding habitats of the rose-ringed parakeet (*Psittacula krameri*) in the cultivations of Central Punjab. Pakistan J. Zool., 36: 133-138.

Krause, J., G.D. Ruxton and G. Ruxton (2002). Living in groups. Oxford University Press. UK.

Lambert, M. S., G. Massei, C.A. Yoder and D.P. Cowan (2010). An evaluation of diazacon as a potential contraceptive in non-native rose-ringed parakeets. J. Wildl. Manage., 74: 573-581. https://doi.org/10.2193/2008-531

Lindell, C.A., J.L. Reid and R.J. Cole (2013). Planting design effects on avian seed dispersers in tropical restoration experiment. Rest. Ecol., 21: 515-522. https://doi.org/10.1111/j.1526-100X.2012.00905.x

Mock, D.W., T.C. Lamey and D.B. Thompson (1988). Falsifiability and the information centre hypothesis. Ornis Scand., 19:231-248. https://doi.org/10.2307/3676564

Manzoor, S., H.A. Khan and M. Hameed (2021). Communal roosting habits of some passerine birds in Central Punjab, Pakistan. Pakistan J. Agric. Sci., 58:143-150. DOI: 10.21162/PAKJAS/21.1084.

Mathysen, E. (2007). Breeding pairs surveillance for selection of nests in woodlands of North America. Int. J. Avian Sci., 7: 277-288.

Nawaz, Z., X. Li, Y. Chen, N. Nawaz, R. Gull and A. Elnashar (2020). Saptio-Temporal characteristics of precipitation and temperature in Punjab, Pakistan. Water, 11: 1916. https://doi.org/10.3390/w11091916

Nawaz, Z., X. Li, Y. Chen, N. Nawaz, R. Gull and A. Elnashar (2019). Temporal and spatial assessment of global precipitation products over the largest agriculture region in Pakistan. Remote, Sens., 12: 3650.

Paton, P.W.C., C.R. Hebb and E. Richnar (1992). Communal roosts and parental care. The Auk, 2: 501-508.

Qamar, M.K. (2005). Modernizing national agricultural systems: A practical guide to the policy makers. United Nations. p 387.

Rehman, A., L. Jingdong, B. Shehzad, A.A. Chandio, I. Hussain, G. Nabi and M.S. Iqbal (2015). Economic perspectives of major field crops of Pakistan: an empirical study. Pac. Sci. Rev., 3: 145-158. https://doi.org/10.1016/j.psrb.2016.09.002

Richnar, H. and P. Hebb (1996). Communal life: honest signaling and recruitment centre hypothesis. Beh. Ecol., 24: 1-45. DOI:10.1093/beheco/7.1.115

Roberts, T.J. (1977). Mammals of Pakistan. Oxford Univ. Press, London, England.

Roberts, T. J. (1991). Birds of Pakistan. Oxford Univ. Press, London. p 728.

Rogers, D.I., P.F. Battley, T. Piersma, J.A. Van-Gils and K.G. Rogers (2006). High-tide habitat choice: insights from modelling roost selection by shorebirds around a tropical bay. Anim. Beh., 72: 563-575. https://doi.org/10.1016/j.anbehav.2005.10.029

Sarwar, M., M.A. Beg, A. A. Khan and D. Shehwar. (1989). Distribution and abundance of tree hollows and parakeet nests in agro-ecosystems of Central Punjab. Pakistan J. Zool., 21: 131-138.

Shimizu, T., T.B. Patton and G. Szaffaranski (2008). Evolution of visual system in reptiles and birds. Encycl. Britt., 2: 1177-1188.

Shimizu, T., T.B. Patton and S.A. Husband (2010). Avian visual behavior and the organization of the telencephalon. Brain Behaviour and Evolution, Encycl. Britt., 4: 588-600. DOI: 10.1159/000314283

Simwat, G.S. and A.S. Sidhu (1973). Nidification behaviour of rose-ringed parakeet in Indian Punjab. Ind. J. Agric. Sci., 43: 648-652.

Strubbe, D. and E. Matthysen (2009). Experimental evidence for nest-site competition between invasive ring-necked parakeets (*Psittacula krameri*) and native nuthatches (*Sitta europaea*). Biol. Cons., 142:1588-1594. https://doi.org/10.1016/j.biocon.2009.02.026

Sueur, J.R., J.E. Hines, J.E. Fallen and K.I. Couzini (2010). Differences in nutrient requirements imply a non-linear emergence of leaders in animal groups. PLOS Comp. Biol., 6: 1000917. https://doi.org/10.1371/journal.pcbi.1000917

Sushil, K. (1994). Seed damage of tree *Terminalia arjuna bedd* by rose-ringed parakeet *Psittacula krameri* (Scopali). Ind. J. For., 17:151-153.

Tariq, M.I., S. Afzal, I. Hussain and N. Sultana (2007). Pesticides exposure in Pakistan: a review. Enviro. Int., 33: 1107-1122. https://doi.org/10.1016/ j.envint.2007.07.012

Thiolly, J.M. and M. Julien. (1998). Flocking behavior of foraging birds in a neo-tropical rain forest and anti-predatory hypothesis. Int. J. Avian Biol., 140: 382-392. https://doi.org/10.1111/j.1474-919X. tb04599.x

Whistler, H. (1949). Popular handbook of Indian birds. Gurney and Jackson Press, London.

Yasin, M., H.A. Khan, W. Majeed, S. Mushtaq, A. Hedfi, S. Maalik, M.B. Ali, S. Mustafa, S. Kanwal and S. Tahreem (2022). Investigation of roost composition of passerine birds in different environmental conditions. Braz. J. Biol., e26335482. https://doi.org/10.1590/1519-6984.263354

Wang, X., F. Kuang, Tan, K and Z. Ma (2018). Population trends, threats and conservation recommendations in China. Avian Res., 9: 118640657.

West, P.W. (2017). Population structure and correlation between auxiliary and target variables may affect precision of estimates in forest inventory. Commun. Stat. Simul. Comput., 6: 4951-4965. https://doi.org/10.1080/03610918.2016.1139128

Zeeshan, M., H.A. Khan, M. Javed and H.A. Farooq (2016). Roosting requirements and habits of rose-ringed parakeet (*Psittacula krameri*) in a canal-irrigated plantation in Central Punjab. J. Entmol. And Zool. Stud., 4: 663-667.