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Original Article

Investigation of roost composition of passerine birds in different environmental conditions

Investigação da composição de poleiros de passeriformes em diferentes condições ambientais

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Abstract

The majority of the birds in different habitats are stressed due to alteration in multiple climate factors contributing to their loss. The present study has been planned to find the roosts composition of passerine birds in different major and sub-habitats of Punjab, Pakistan. In Faisalabad, of the four species, the higher number of exits was almost comparable, while *Passer domesticus* and *Pastor roseus* were more abundant than *Tachycinet bicolor* and *Lanius cristatus*. For the three remaining birds, total exits and returns were 180 for *P. roseus,* 181 for *T. bicolor,* and 179 for *L. cristatus,* respectively. Considering the exits in morning hours, a total of 314, 256, 246 and 210, were recorded from Sheikhupura. In Khanewal, of the four species, the highest exits and returns were that of *P. domesticus* (407; 451), followed by that of the *P. roseus* (273; 336), *T. bicolor* (242; 319) and *L. cristatus* (220; 397). The temperature imposed serious effects on roost exits for the four birds. The varied P-values which were higher (< 0.001***, < 0.001***, 0.002 **, <0.001***) appeared to limit the roost exits for them. Nonetheless, the impact of relative humidity exerted a strong influence on the *T. bicolor* (0.003**). In roosts return, it was seen that roost returns were even likely in warm temperatures and precipitation did not impose seriously on returns, and even in light rainfall. Nonetheless, relative humidity (RH) strongly impacted the sparrow. The *T. bicolor* and *L. cristatus* were adversely affected with the slopes (1.37) and (2.06), indicated with each percentage increase of relative humidity, and slope variations became least.

Keywords: birds, roosts behavior, climate change, effects.

Resumo

A maioria das aves em diferentes habitats está estressada devido à alteração em vários fatores climáticos que contribuem para sua perda. O presente estudo foi planejado para encontrar a composição dos poleiros de aves passeriformes em diferentes, grandes e sub-habitats de Punjab, no Paquistão. Em Faisalabad, das quatro espécies, tem-se que o maior número de saídas foi quase comparável, enquanto que as espécies *Passer domesticus* e *Pastor roseus* foram mais abundantes que *Tachycinet bicolor* e *Lanius cristatus*. Para as três aves restantes, o total de saídas e retornos foi de 180 para *P. roseus*, 181 para *T. bicolor* e 179 para *L. cristatus*, respectivamente. Considerando as saídas nas horas da manhã, um total de 314, 256, 246 e 210 foi registrado de Sheikhupura. Em Khanewal, das quatro espécies, as maiores saídas e retornos foram de *P. domesticus* (407; 451), seguidas de *P. roseus* (273; 336), *T. bicolor* (242; 319) e *L. cristatus* (220; 397). A temperatura impôs sérios efeitos nas saídas dos poleiros para as quatro aves. Os maiores valores de *p* variados (< 0,001***, < 0,001***, 0,002 **, <0,001***) pareceram limitar as saídas de poleiro para os pássaros. No entanto, o impacto da Umidade Relativa (UR) exerceu forte influência sobre o *T. bicolor* (0,003**). Com relação ao retorno dos poleiros, verificou-se que esses retornos eram até prováveis em temperaturas quentes, visto que a precipitação não foi um fator extremamente determinante para os retornos, mesmo em chuvas fracas. No entanto, a UR impactou fortemente o pardal. O *T. bicolor* e *L. cristatus* foram prejudicados com as declividades (1,37) e (2,06), que foram indicadas a cada percentual de aumento de UR, ao passo que as variações de declividade tornaram-se menores.

Palavras-chave: aves, comportamento dos poleiros, alterações climáticas, efeitos.

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1. Introduction

Climate is considered a cumulative term of all the weather components, impacting organisms in different biological systems. Since many decades, continuous human activities have altered the existing climate ultimately increasing the earth's temperature (Stocker et al., 2013). The increasing temperature alters the ecosystems and biomes which severely affects the species (shifts in periodic activities, range, migration, abundance and interaction), including humans. Undeniably, lately, altered temperatures have also severely impacted global biodiversity, resulting in the emergence of environmental changes or stressors (Marzluff, 2001; Walther et al., 2002; Thomas et al., 2004; Pereira et al., 2010). Presently, global biodiversity changes are influenced by climate fluctuations and anthropogenic factors (Jetz et al., 2007). Lately, detailed observations adjudging the effects of climate on the worldwide ecosystems on different organisms have occurred due to shifts of phenology with the biotic interactions. Some plants and animals tolerate the alterations in the few habitats (Root et al., 2003; Menzel et al., 2006; Valladares et al., 2007; Ockendon et al., 2014).

Birds' respond differently to such changes in the three possible ways: a) to monitor such climatic alterations relative to different geographical regions of the world with suitable temperatures, b) to indicate adaptations of birds for the existing ecological conditions and c) to suffer from agonizing conditions in wither to either extinct or perish their population status seriously (Quintero and Wiens, 2013). Several authors have suggested that numerous farmland birds are stressed due to weather modalities and experienced a decline in the past two decades (Reif and Vermouzek, 2019). Most of the research on climate changes lacks the basis to determine the altered bird species abundance. Nonetheless, other factors as precipitation, habitat fragmentation, presence of native species, and relative humidity are also important climate variables to impact birds (Parmesan and Yohe, 2003; Gordo, 2007; Bellard et al., 2012; Szabo et al., 2012).

The majority of the avian fauna in different habitats remain stressed by changing in either a single climate factor like temperature or increased multiple similar factors contributing to their unwanted loss (McCarty, 2001; McLaughlin et al., 2002; Hansen et al., 2006) while many of them suffer drastic declines owing to the weather impact on their biological systems (Wormworth et al., 2012). Perhaps, a few of them trigger useful biological mechanisms and activity indicators, and others would also be seriously jeopardized in the future (Böhning-Gaese and Lemoine, 2004; Crick, 2004; Zuckerberg et al., 2011).

Studies on bird movement patterns provide contrasting results; however, their overall numerical counts and mapping techniques might have varying results (Lee, 2021) for their distribution patterns in the tracking regarding their space and time orientation (Visser et al., 2009; Egevang et al., 2010; Robinson et al., 2010). Broad-scale spatial patterns of biodiversity report bird species' richness and distribution ranges (Orme et al., 2006; Storch et al., 2006), and some indication of the predictable seasonal movements, along with the bird migrations, consecutively and non-consecutively due to climate fluctuations and finally affect the biodiversity (Bauer and Hoye, 2014).

Food availability is a direct environmental cue (Salgado-Ortiz et al., 2009); however, heavy rainfall seems a trivial factor is limiting bird movements in several circumstances (Mezquida and Marone, 2003; Houston, 2013) simultaneously with that the breeding behavior for a variety of ecosystems. Therefore, elevated and dropped air temperatures remain a key factor to impact bird breeding profiles (Scheuerlein and Gwinner, 2002). The present study aimed to assess the roost composition of bird species in their specific habitats. For this purpose, four passerine birds' species were selected to investigate their roost composition.

2. Materials and Methods

2.1. Preliminary survey

For the present study, the duration was 28 months. The first phase comprised from January through April 2017. During this period, observation was recorded on the roost composition and the population estimation of four bird species for three crops viz. wheat, maize and barley. Recordings were made at the four major habitats collaboratively with the available field assistants at each site. They already work on specific habitats for crop maintenance. Observations were recorded per sub-site of each of the major habitats weekly.

2.2. Study sites

The region of Punjab contributes largely to Pakistan's agricultural sector and plays a significant part in Pakistan's economy. Although Pakistan is ranked as a developing country, its economy is increasingly based on the agro-based industry. In this study, the four major habitats (districts) viz. Faisalabad, Toba Tek Singh, Khanewal and Sheikhupura were selected. Three sub-habitats were further designated to ascertain the varied bird behavioural patterns.

2.3. Experimental layout

Effects of differential weather modalities elicited responses from the four passerines viz. *Passer domesticus, Pastor roseus, Tachycineta bicolor,* and *Lanius cristatus* was recorded from October 2017 to September 2019 in the four agriculturally important districts of Central Punjab (Faisalabad, Toba Tek Singh, Sheikhupura, and Khanewal), Pakistan. Observations related to determining the effect of climatic factors on the behaviour of birds continued from 6:00-18:00 hrs with 30 minutes time intervals. The various crops like the wheat (*Triticum aestivum*), maize (*Zea mays*), sugarcane (*Saccharum officinarium*), rice (*Oryza sativa*), sorghum (*Sorghum bicolor*), millet (*Pennisetum glaucum*), cotton (*Gossypium hirsutum*), graminoid leguminoid fodders and barley (*Hordeum vulgare*) are cultivated in good proportions. Concurrently, a variety of fruit crops viz. citrus (*Citrus reticulata*), mango (*Mangifera indica)*, dates (*Phoenix dactylifera*), guava (*Psidium guajava*), watermelon (*Citrullus lanitus*), and jaman (*Eugenia jambolana*) also remain in different seasons. The crops selected to study the roost composition and population abundance of four species of passerines were wheat, maize and barley.

2.4. Roost composition

The observation of bird exits and returns from 6:00 am to 5:00 pm were made. All such observations were continued for seven days consecutively in the three sub-habitats of the four major habitats. The day-long observations were further split into 15-minutes intervals, which were maintained during the length of the study periods. All such visitations of the birds were recorded with critical observations of their movement patterns from a specific point close to their roost and using a field binocular (Zeiss carl 7x50 mm) wherever required for precise observations.

2.5. Statistical analysis

The present study's data was analyzed using the statistical version Minitab (20) and incorporated logistic regression to determine the overall data significance. Similarly, the application of Poisson regression and GLMM (Generalized Linear Mixed Models) was performed regarding the population's point count data and the response variables in the bird populations.

3. Results

3.1. Roost composition of birds in Faisalabad

3.1.1. University of Agriculture, Faisalabad

The roosts' returns did not seem to be of the same magnitude, and their numbers were higher than the morning exits. In mid-day with broader light, the roosts' movements continued for all the designated birds, although their number was reduced. Evidently, towards the end of the day, sufficiently large flocks of all four species return to their respective roosts and prepare for their assemblage (roosts) for passing the night. Of the four species, the higher number of exits was almost comparable, while *P. domesticus* and *P. roseus* were more abundant than *T. bicolor* and *L. cristatus*. For the three remaining birds, total exits and returns were 180 for *P. roseus,* 181 for *Tachycineta bicolor,* and 179 for *Lanius cristatus,* respectively (Figure 1).

3.1.2. The PARS campus

For the 15-minutes time intervals here, it was apparent that the number of species to eject from their roosts remained almost comparable. Nonetheless, even during mid-day and late evening hours, the four species' movement patterns were also recorded in the inhibited proportions. Roost exits became somewhat sluggish by the end of the day, while the returns were more substantial by the late evening hours of all these bird species. Undeniably, the number of birds returning from different directions was more than their exits in the morning hours. In all, there were total exits 321 for *L. cristatus*. However, regarding the roost returns highest proportion was recorded for *P. domesticus* 553, followed by *P. roseus* 389 (Figure 2).

3.1.3. Gutwala forest plantations

Seemingly, as adjudged on the remaining movement patterns of their exits and returns from Gutwala, Wildlife Research Institute in Faisalabad. It was seen that the number of birds existing were nearly comparable throughout the day except *Pastor roseus*. Considering their returns, *P. domesticus* possessed the highest 726 numbers, followed by *P. roseus* 480 (Figure 3).

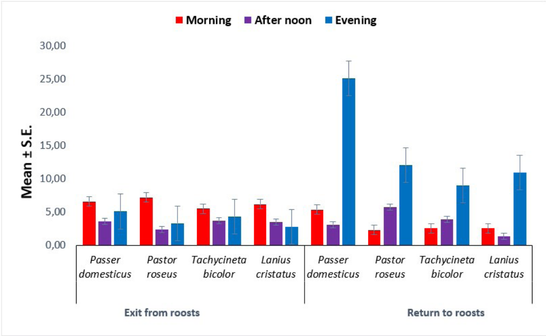

Figure 1. Recordings of four birds in their communal roosts in University Campus, Faisalabad. S.E. = Standard Error.

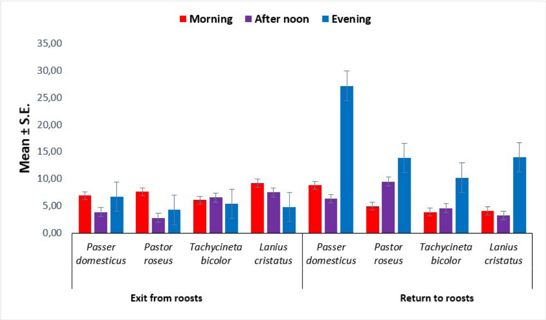

Figure 2. PARS Campus for the roost composition of birds. S.E. = Standard Error.

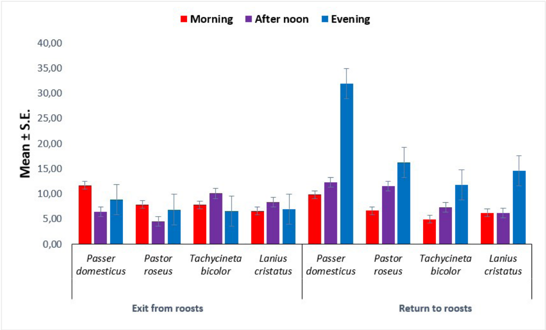

Figure 3. Roost composition of bird species from forest plantations, Gutwala wildlife sanctuary, Faisalabad. S.E. = Standard Error.

3.2. Roost composition of birds in Toba Tek Singh

3.2.1. Toba Tek Singh (UC 286)

Following the previous protocols of same time intervals, bird movements were recorded in their occurring communal roosts. Fluctuations were recorded in the returns, particularly for *P. domesticus* which occurred in significant numbers towards its nocturnal roosts 526. For the remaining three species, not many variations were recorded (Figure 4).

3.2.2. Toba Tek Singh (UC 287)

Considering the UC-287 it was apparent that cumulative birds, which were recorded in the day-long observations, overall bird numbers remained slightly more than UC-286. There were hardly any obstructions for inhibiting the bird depredations and roost movements. Ironically, their numerical numbers were more significant in the evening as compared to the morning (Figure 5).

3.2.3. Toba Tek Singh (UC 288)

The Union Council 288 did not offer major deviations from the earlier localities and was almost comparable in its magnitude and comprised the predominant flocks of house sparrow eliciting early in the morning and returning to their roosts in the evening (Figure 6).

3.3. Sheikhupura District

3.3.1. Lahore road, Sheikhupura

A burst of activity was recorded in all directions from the four closely related bird roosts for the weekly observation. It was evident that very few returns occurred in the early morning hours and that following the earlier bird departures, the return only accelerated towards the closure of the day. Although some roosts activities continued during the different time intervals throughout the day, but none were with the peak foraging or other behavioural displays. In all, relatively small roost exits were recorded in the morning, whereas the number of birds which returned to their roosting sites in the evening was maximum such as that of house Sparrow 437. This discrepancy was because more bird numbers returned to the roosts after the day-long work. The same situation was achieved graphically that the birds returned to their respective roosts were more than the exits in the morning (Figure 7).

3.3.2. City road, Sheikhupura

This sub-habitat in Sheikhupura was relatively small on the city road, which leads to main city premises and other important landmarks. Nonetheless, this road also had some forest plantations where some numbers of all

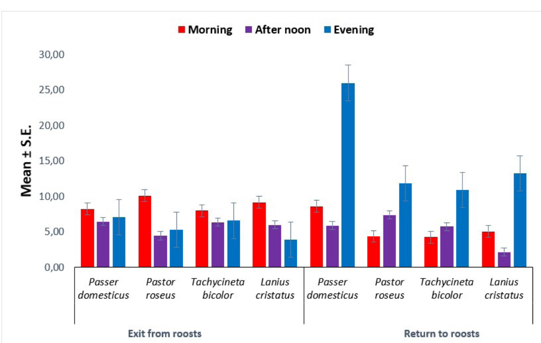

Figure 4. Roost composition of birds in Toba Tek Singh (UC 286). S.E. = Standard Error.

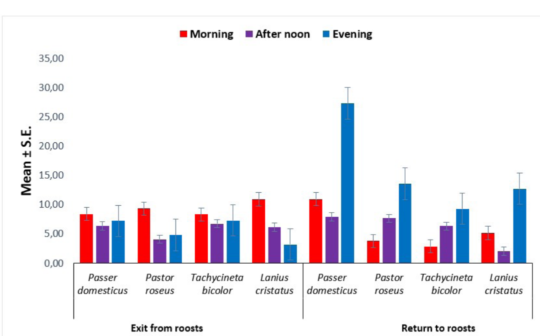

Figure 5. Roost ejects and returns of birds in Toba Tek Singh (UC 287). S.E. = Standard Error.

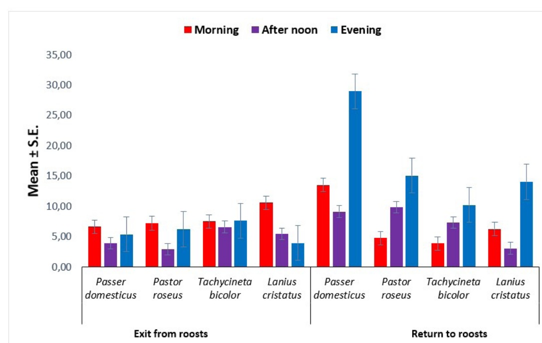

Figure 6. Roost composition of birds in Toba Tek Singh (UC 288). S.E. = Standard Error.

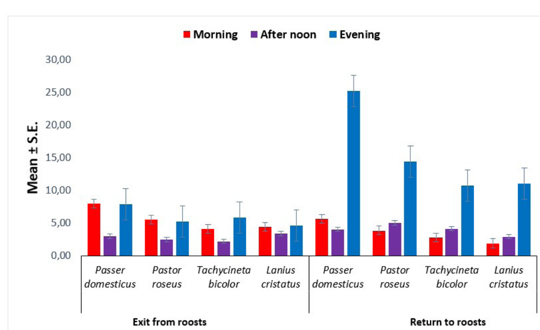

Figure 7. Roost composition of birds in Lahore Road, Sheikhupura. S.E. = Standard Error.

representative members were present. Considering the exits in morning hours, a total of 314, 256, 246 and 210, were recorded. This number was mainly similar. However, the returns to the roost were fairly high, and yet again, 456, 371 and 303 were recorded (Figure 8).

3.3.3. Dirt road, Sheikhupura

This sampled dirt road of Sheikhupura was situated in the thick forest plantations and a mixed number of old and tall trees. Overall, all the four birds' roost exits, and returns did not seem to deviate from the earlier regimens. However, the house sparrow was the most dominant bird, while the others were least in their numerical proportions. As of the previous observations, the returning birds were more than their exits. It might be logical to assume that increased roost flocks occurred to incorporate their conspecifics in return for their communal roosts (Figure 9).

3.4. Khanewal District

3.4.1. Khanewal UC-5

Of the four species, the highest exits and returns were that of *Passer domesticus* (407; 451), followed by that of the *P. roseus* (273; 336), *T. bicolor* (242; 319) and *L. cristatus* (220; 397) as depicted by (Figure 10).

3.4.2. Khanewal UC-6

Ironically, somewhat brief movements (exits and returns) were recorded for the birds. Nonetheless, it was evident that the number of sparrows that reached back the roost in the evening was high (406). The other species' exits, and weekly returns did not seem reasonably high but were of the medium range. It was also apparent that nearly comparable bird movements occurred in their respective roosts (Figure 11).

3.4.3. Khanewal UC-6

Finally, the last sub-habitat (UC-7) also indicated that the house sparrow was a highly abundant bird here than the other three remaining species (Figure 12)

3.5. Roost exits

The temperature imposed serious effects on roost exits for the four birds. The varied P-values which were higher (< 0.001***, < 0.001***, 0.002 **, <0.001***) appeared to limit the roost exits for them. Nonetheless, the impact of relative humidity exerted a strong influence on the *T. bicolor* (0.003**), while for the other three, appeared to be largely negligible. For the generalized mixed effects (modelling), temperature also was statistically significant and largely reduced roost exits activity of all four species,

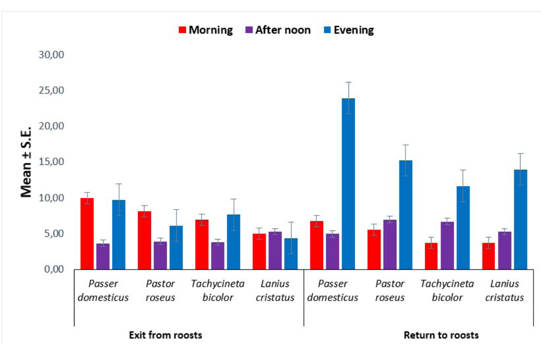

Figure 8. Roosts composition of birds recorded from the city road, Sheikhupura. S.E. = Standard Error.

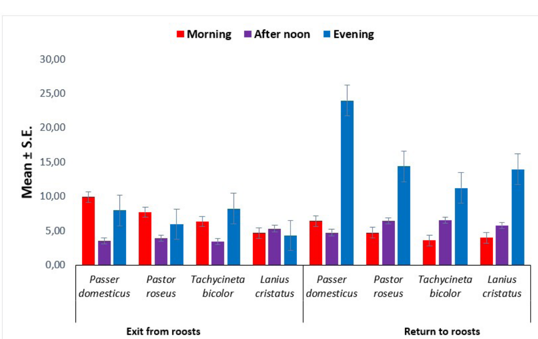

Figure 9. Recordings of birds in their communal roosts in dirt road, Sheikhupura. S.E. = Standard Error.

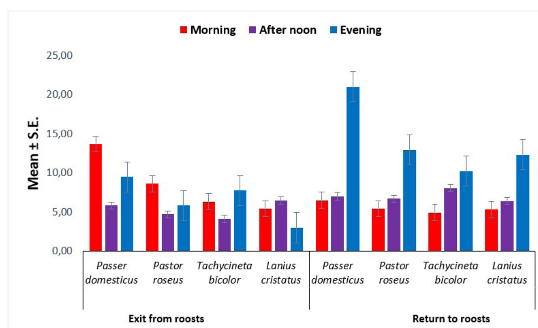

Figure 10. Roost composition in the Khanewal of UC-6. S.E. = Standard Error.

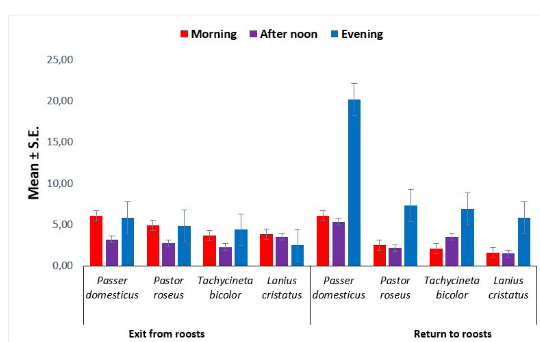

Figure 11. Roost composition in the Khanewal of UC-6. S.E. = Standard Error.

and that with each degree rise, 3.05 (house sparrow), 2.20 (rosy starling), 1.96 (tree swallow), and 2.14 *L. cristatus* indicated less activity. Precipitation indicated no influence on roost exits of three species, but *P. roseus* showed a significantly positive influence of rain (slope 11.56) due to the availability of surplus food, emergence of insects and decreased temperature. The slope was 0.99, which suggests that each percentage increase of relative humidity is 0. 99 birds of *T. bicolor* were seen to avoid leaving the roosts. Overall, the effect size of temperature and humidity is small but still significantly different from zero. However, the humidity effect is on *T. bicolor* shows some slightly positive effect (Table 1).

3.6. Roost returns

It was apparent that the role of temperature remained invariably non-significant regarding the roost returns by the sampled birds. Ironically, with every degree rise, some impacts on all four birds appeared to be (0.11, 1.13, 0.53, and 1.03), respectively. It was also seen that roost returns were even likely in warm temperatures, as reaching the roosts was important to the birds. Precipitation also did not impose seriously on returns, and even in light rainfall or drizzle, birds continued to make comebacks towards their roosting sites without significant variation. Nonetheless, relative humidity (RH) strongly effected the sparrow, brown shrike, rosy starling, and tree swallows. The *T. bicolor* and *L. cristatus* were affected with the slopes (1.37) and (2.06), indicated with increasing relative humidity (Table 2).

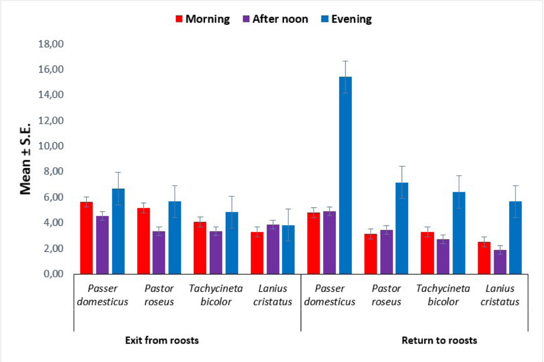

Figure 12. Khanewal: UC 7; Roost composition of the four birds. S.E. = Standard Error.

4. Discussion

Present study data on the roosting behaviour and composition indicated that of all the four major habitats and four birds expressed their roost exits (morning) and returns (evening). Roost composition, therefore, appears important aspect of life history of birds' and roosts are conveniently recognized as the centre of activities throughout the day. In the morning hours, the four birds' viz. *P. domesticus*, *P. roseus*, *T. bicolor,* and *L. cristatus* were recorded for their exits from their roosting sites for foraging. Incidentally, all the four birds occurred in sufficiently large numbers (communal roosts) in the university campus vegetation. As the roost of the sparrow, rosy starling, tree swallows, and brown shrikes were not situated away from food sources (less than a kilometre), their exits from the roosts were fairly pronounced till the broad daylight, after which such movements were slowed down, but not ceasing completely.

Studies conducted by different authors regarding some birds' roosting habits made it evident that no real distinction could be made in the present study regarding all the four birds' roost movements. Although the city of Faisalabad, considered one of the urban locations but in the designated sub-sites, relative disturbance from the other inhibitory agents remained minimal as reported similarly in the communal roost choices (Daoud-Opit

Table 1. Climate variables impacts on roost exits.

Behaviour	Fixed factors	Species	Slope	S.E.	t-value	p-value
Roost exits	Temperature	*P. domesticus*	-3.05	±0.60	-5.08	<0.001***
		P. roseus	-2.20	±0.48	-4.53	<0.001***
		T. bicolor	-1.96	±0.50	-3.91	0.002 **
		L. cristatus	-2.14	± 0.44	-4.86	<0.001***
	Precipitation	*P. domesticus*	36.66	±33.22	1.10	0.27
		P. roseus	11.56	±4.23	2.72	0.007 **
		T. bicolor	-4.007	±22.42	-0.17	0.85
		L. cristatus	-4.66	±11.53	-0.40	0.68
	Humidity	*P. domesticus*	-0.78	± 0.45	-1.73	0.086
		P. roseus	-0.54	±0.33	-1.61	0.11
		T. bicolor	0.99	±0.31	3.13	0.003 **
		L. cristatus	0.20	±0.35	0.57	0.56

: Highly significant; *: Strongly significant; S.E. = Standard Error.

Table 2. Effect of temperature, humidity, and precipitation on roost returns.

Behaviour	Fixed factors	Species	Slope	S.E.	t-value	p-value
Roost returns	Temperature	*P. domesticus*	-0.11	± 0.78	-0.14	0.88
		P. roseus	-1.13	±0.70	-1.60	0.11
		T. bicolor	-0.53	±0.52	-1.01	0.33
		L. cristatus	-1.03	±0.62	-1.65	0.13
	Precipitation	*P. domesticus*	-24.25	±43.61	-0.55	0.57
		P. roseus	-1.08	±6.17	-0.17	0.86
		T. bicolor	19.90	±22.39	0.88	0.37
		L. cristatus	3.40	± 17.25	0.19	0.844
	Humidity	*P. domesticus*	-1.75	± 0.59	-2.96	0.003 **
		P. roseus	-1.30	± 0.49	-2.64	0.009 **
		T. bicolor	-1.37	±0.36	-3.72	<0.001***
		L. cristatus	-2.06	±0.51	-3.98	<0.001***

: Highly significant; *: Strongly significant; S.E. = Standard Error.

and Jones, 2016). Moreover, animals' responses to the urban landscape and ecological conditions appeared to be tricky for their population abundance (Chace and Walsh, 2006; Felton et al., 2009) while some birds appear to thrive in the urban landscape (Sewell and Catterall, 1998; Davis et al., 2012). Tobolka (2011) reported that most of the house and tree sparrow roosts were in the agricultural landscapes, which provided safety; however, no relationship could be developed between climate conditions and roosting. Whenever, the roosts are found close to the food crops, the distance to be travelled by most of the birds remains perilously close and enables them to feed continuously without the drainage of energy (Forshaw, 2010; Narayana et al., 2019). The importance of roosting for some other birds is also reported by (Heisterberg, 1983; Harms and Eberhard, 2003; Gordo, 2006, 2007). They emphasized that although most birds remain active in the diurnal conditions, they also lead to nocturnal roosting.

Undoubtedly, all four birds' roosting habits indicated their accelerated departures in the morning due to the previous night hiatus were perfectly in line with active foraging. Although the movements occurred in sufficient numbers during the entire days of study fauna, their flock size increased while many were making good towards their respective roosts after the day-long activities. Ironically, their numerical counts for 15 minutes intervals suggested the return numbers more than vacated roost. However, it remains uncertain for the increased number, but mostly speculating that some of their conspecifics join them to reach the roost.

Conclusively, the fact that more birds returned to their roosts in the evening hours than the morning exits owes to the fact that while returning in differential flocks' during the evening, many of their conspecifics joined them to reach at their communal roosts, closely located to their nocturnal roosts, considered as part of their communal roosts. Moreover, as the roosts are maintained by birds for successive years. Moreover, communal roosts which are the aggregates of unrelated conspecifics going together to spend diurnal and nocturnal timings in resting conditions is widespread phenomenon among birds', some insects and partially in mammals. They comprise hundreds to thousands of individuals for particular season and also on yearly basis (Eiserer, 1984; Clough and Ladle, 1997). Communal roosts are also taxonomically widely distributed indicating roost dynamics, also with their differences in nightly shifts with regard to traditional locations describing their theoretical and empirical approach of tree swallows driven by combination of the conspecifics roost fidelity (Laughlin et al., 2014).

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