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Habitat characteristics dependent population and distribution of Indian Peafowl, *Pavo cristatus* (Galliformes: Phasianidae) in Punjab

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Abstract
The present study was carried out to estimate the habitat characteristics dependent population and distribution of Indian Peafowl of Punjab Agricultural University campus, Ludhiana considered as location 1, Village Baranhara (district Ludhiana) as location 2, village Gharuan (district Ropar) as location 3 and village Rauni (district Patiala) as location 4 from January 2016 to December 2016. A total 1655, 426, 370 and 107 individuals of Indian Peafowl were recorded at location 1, location 2, location 3 and location 4 respectively. The observation showed that female count was higher at location 1 and 3 and lesser at location 2 and 4. Overall population density of Indian Peafowl was 16.29, 9.40, 8.39 and 7.46 (Indian Peafowl/Km) at location 1, location 2, location 3 and location 4 respectively. The observations showed variation in the population of Indian Peafowl at all selected transects which seemed to be dependent on the availability of food items, roosting sites, ground cover for breeding and protection purposes.

Keywords: Indian Peafowl, distribution, density, habitat, population

1. Introduction
Indian Peafowl (*Pavo cristatus*) is one of the large, colorful pheasants known for their iridescent tails. The population of Indian Peafowl is facing a severe threat due to habitat destruction, poaching, and contamination of its food source, even though it is protected under Schedule 1 of the Wild Life (Protection) Act, 1972 [15]. Indian Peafowl are among most sensitive bird living nearby human population and may be used as sign of environment values [2]. Ramesh and McGowan had mentioned about difficulties faced in the population studies of Indian Peafowl [13]. Kler had stated less abundance of Indian Peafowl ranging from 2.00 to 5.00 percent of total bird abundance in agricultural habitats of six districts of Punjab state [11]. Indian Peafowl was observed less in bird community structure inhabiting wheat-rice dominated agro ecosystem of Punjab, it occupied omnivorous food guild and was ground forager [12]. Sohi and Kler studied on the behavioral aspects of nesting, foraging and roosting of avian fauna in changed landscape of villages and suggested that such studies are required for different bird species inhabiting agro ecosystem of Punjab [18]. Rameshkumar had stated that lack of detailed information on abundance and distribution of Indian Peafowl in Tamil Nadu [14]. Keeping this in view, present work was planned in three districts of Punjab on the population and distribution of Indian Peafowl.

2. Materials and methods
The population of Indian Peafowl was estimated by the line transect method using distance sampling [6, 8].The field sampling was carried out from January 2016 to December 2016. During this period the population of Indian Peafowl was monitored in four different habitats by selecting two transects each *viz*., Punjab Agricultural University Campus (PAU Campus) i.e. Location 1, village Baranhara (District Ludhiana) Location 2, village Gharuan (District Ropar) Location 3 and village Rauni (District Patiala) Location 4. The university is situated in the Ludhiana city towards west and lies at latitude of 30 54` 147 N and longitude of 075 47`642 E and 244 m above mean sea level. The campus has a large stretch of agricultural fields spread in an area of more than 550 hectares. The village Baranhara is a medium size village located in Ludhiana West of Ludhiana district and lies at latitude of 30 93` 56 N and longitude of 075 77` 49 E.

Gharuan is a large village located in Kharar Tehsil of Mohali district, Punjab, India. The latitude 30.7728° N and longitude 76.5575° E are the geocoordinate of the Gharuan (district). Rauni is a village panchayat located in the Patiala district of Punjab state, India. The latitude 30.5987° N and longitude 76.0885° E are the geocoordinate of the Rauni. Each location was further divided into two transects viz; location 1 comprised of transect I and II, location 2 divided into transect III and IV, location 3 consisted of transect V and VI, location 4 comprised of transect VII and VIII. Data was taken thrice a week at each selected transect. According to Jerath, months were categorized into three different seasons i.e. summer (April to June), rainy (July to September) and winter (October to March) [10]. Seasonal sex wise abundance was noted. Seasonal changes in population and density of Indian Peafowl was also calculated. The study area comprised of eight transects.

Transect I: It comprised of transect (1 Km) selected in enclosed three acres area having indigenous trees and shrubs.

Transect II: Selected transect (0.5 Km) was in cultivated area having indigenous trees, fruit trees and exotic trees.

Transect III: Transect (0.5 Km) was located on outskirts of village having few houses adjoining to uncultivated land.

Transect IV: The selected transect (1 Km) was on inner road of village having 16 farm houses.

Transect V: Transect (1 Km) was selected in crop fields.

Transect VI: Selected transect (0.5 Km) was situated on inner residential roads of village.

Transect VII: Transect (0.71 Km) was selected in agricultural fields having variety of crops.

Transect VIII: Transect length of 0.5 Km was selected in uncultivated area.

2.1 Statistical Analysis

The data on seasonal sex wise abundance of Indian Peafowl was subjected to Chi square test by using software SPSS. One way Analysis of Variance (ANOVA) with post hoc test was applied on the mean monthly population of Indian Peafowl by using software SPSS. Spearman rank correlation analysis was carried to compare the population numbers of Indian Peafowl by using software SPSS (Standard version 20.0).

3. Results and Discussion

The population of Indian peafowl was found to vary in all the eight different transects of selected habitat throughout the year. During the present study, female count was higher at location 1 and 3 and lesser at location 2 and 4. Females were noted moving / foraging along with chicks in rainy season that might be possible reason for female biased ratio in that season.

Table 1: Seasonal sex wise abundance of Indian peafowl

Sex	Summer				Rainy				Winter			
Locations→	1	2	3	4	1	2	3	4	1	2	3	4
Male	200	70	36	18	198	62	32	15	389	88	75	28
Female	235	40	57	8	201	45	58	7	395	98	95	20
Juveniles	10	8	7	3	12	7	4	4	15	8	6	4
Overall	445	118	100	29	411	114	94	26	799	194	176	52
Sex Ratio	1.17:1	0.57:1	1.58:1	0.44:1	1.01:1	0.72:1	1.81:1	0.46:1	1.01:1	1.11:1	1.26:1	0.71:1

Statistical analysis showed a significant relationship in summer (Pearson Chi-Square value= 19.212^{a}, df=3) and rainy season (Pearson Chi-Square value= 13.118^{a}, df=3). Furthermore, no significant relationship was found in winter season (Pearson Chi-Square value= 3.612^{a}, df=3) (Table 1).

Table 2: Average flock size per observation of Indian peafowl

Study Areas	Transect I	Transect II	Transect III	Transect IV	Transect V	Transect VI	Transect VII	Transect VIII
January	4.71±0.23^{a}	2.88±0.16^{b}	2.22±0.22^{b}	1.77±0.14^{b}	2.12±0.22^{b}	1.50±0.17^{b}	1.66±0.33^{b}	1.66±0.33^{b}
February	4.23±0.20^{a}	2.94±0.13^{ab}	1.88±0.26^{b}	1.44±0.17 ^{B}	2.12±0.29 ^{B}	1.87±0.21^{b}	1.66±0.33^{b}	1.33±0.33^{b}
March	5.05±0.18^{a}	3.27±0.13^{b}	2.44±0.29^{bc}	2.11±0.20^{bc}	2.50±0.26^{bc}	2.12±0.27^{bc}	2.33±0.33^{bc}	1.66±0.33^{c}
April	5.05±0.22^{a}	3.38±0.18^{b}	2.33±0.16^{bc}	2.11±0.20 ^{C}	2.62±0.32^{bc}	1.75±0.15^{c}	2.00±0.00	1.66±0.33^{c}
May	5.27±0.32^{a}	2.88±0.17^{b}	2.44±0.17^{bc}	1.77±0.22^{bc}	2.12±0.12^{bc}	1.75±0.15^{bc}	2.00±0.57^{bc}	1.33±0.33^{c}
June	4.83±0.24^{a}	2.88±0.16^{b}	2.33±0.16^{bc}	2.11±0.20^{bcd}	2.37±0.18^{bc}	1.87±0.11^{bcd}	1.66±0.33^{cd}	1.00±0.00^{d}
July	4.50±0.20^{a}	3.16±0.18^{b}	2.11±0.20^{bc}	1.88±0.20^{c}	2.12±0.22^{bc}	1.50±0.17^{c}	1.66±0.33^{c}	1.33±0.33^{c}
August	4.77±0.27^{a}	3.38±0.14^{b}	2.33±0.16^{bcd}	2.00±0.2^{cd}	2.75±0.31^{bc}	1.87±0.27^{cd}	2.00±0.00^{cd}	1.33±0.33^{d}
September	4.65±0.20^{a}	2.76±0.13^{b}	2.44±0.17^{bc}	1.88±0.20^{bc}	2.00±0.26^{bc}	1.50±0.17^{bc}	1.33±0.33^{bc}	1.00±0.00^{c}
October	4.22±0.15^{a}	2.72±0.64^{b}	2.11±0.26^{bc}	1.44±0.17^{c}	1.87±0.12^{bc}	1.37±0.17^{c}	1.33±0.33^{c}	1.33±0.33^{c}
November	4.50±0.20^{a}	3.11±0.73^{b}	1.77±0.14^{c}	1.44±0.17^{c}	1.75±0.16^{c}	1.62±0.17^{c}	1.00±0.00^{c}	1.00±0.00^{c}
December	4.58±0.15^{a}	3.35±0.19^{a}	1.66±0.16^{b}	1.22±0.14^{b}	1.62±0.18 ^{B}	1.50±0.17^{b}	1.33±0.33^{b}	1.00±0.00 ^{B}
Total	56.45±2.61	36.77±2.99	26.11±2.40	21.22±2.28	26.00±2.69	20.26±3.24	20.00±3.24	15.66±2.66

Mean values within a column with the same letter are not significantly different (ANOVA at 5% level of significance)

Maximum flock size of Indian Peafowl was observed in transect I followed by transect II, III, V, IV, VI, VII and VIII respectively. However, statistical analysis was found to be significant between all selected transects (Table 2). The variation in the population of Indian Peafowl seemed due to the availability of sufficient food items, roosting sites, good ground cover for breeding and protection purposes in selected transects.

Table 3: Seasonal changes in average population number and density of Indian peafowl

Locations	Transects	Summer Season		Rainy Season		Winter Season		Annual		Location Wise	
		Average population number	Indian peafowl/ Km	Average population number	Indian peafowl/ Km	Average population number	Indian peafowl/ Km	Average population number	Total No. of Indian peafowl/Km	Average population number	Average Density (Indian peafowl/Km)
Location 1	Transect I	5.05	5.05	4.64	4.64	4.54	4.54	4.74	14.23	3.90	16.29
	Transect II	3.04	6.08	3.10	6.20	3.04	6.08	3.06	18.36		
Location 2	Transect III	2.36	4.72	2.29	4.58	2.01	4.02	2.22	13.32	2.02	9.40
	Transect IV	1.99	1.99	1.92	1.92	1.57	1.57	1.83	5.48		
Location 3	Transect V	2.37	2.37	2.29	2.29	1.99	1.99	2.22	6.65	1.95	8.39
	Transect VI	1.79	3.58	1.62	3.24	1.66	3.32	1.69	10.14		
Location 4	Transect VII	1.88	2.74	1.66	2.33	1.55	2.18	1.70	7.16	1.49	7.46
	Transect VIII	1.33	2.66	1.22	2.44	1.33	2.66	1.29	7.76		

Our study revealed that average population number of Indian Peafowl was higher in transect I followed by transect II in all seasons. It may be attributed to the ideal habitat consisting of open field areas for foraging purposes and tree plantations utilized for roosting purposes. Average population number was less in transect VI as compared to transect IV of both residential areas. It might be due to the presence of large houses with cattle sheds and less number of inhabitants in transect IV which seemed to be preferred by Indian Peafowl over transect VI having habitat structure with more number of houses and population.(Table 3). Data taken in cultivated areas showed less average population number in transect VII as compared to III and V. It might be due to less tree diversity in transect VII. The average population number was higher in summer season > rainy season > winter season in transect I, II, III, IV, V, VI and VII.

The Indian Peafowl density was recorded highest in transect I and II of location 1 as it had crop fields, orchard and most importantly being located within the PAU campus. Location 1 consisted of maximum tree diversity, rich canopy cover and little human disturbance which sustained the high population of Indian Peafowl. The interaction with farm workers bought out that they knew the National bird status of Indian Peafowl and did not let anyone disturb their roosting sites. It was further noticed that both transects had thick shrub cover which was being utilized by peahens for their breeding grounds. Both transect provided sites for roosting, foraging and breeding to Indian Peafowl because of already explained factors. Predation by cats and dogs was observed less in transect I of location 1 as compared to other locations (Table 3).

Observations had shown that transect III and V in cultivated areas had moderate population density of Indian Peafowl which was comparable to transect IV and VI which were in residential area. The common factor seemed to be the less tree diversity and its number along with higher human disturbance at transects IV and VI (Table 3). Similarly, it was also found that Transect VII and VIII of location 4 had least population density as compared to all the selected transects. Study had revealed that transect VII had less tree diversity with limited roosting sites and having more predation risk. Transect VIII had shrubs and wild plants which provided lesser foraging and roosting sites which was evident in its less population density (Table 3).

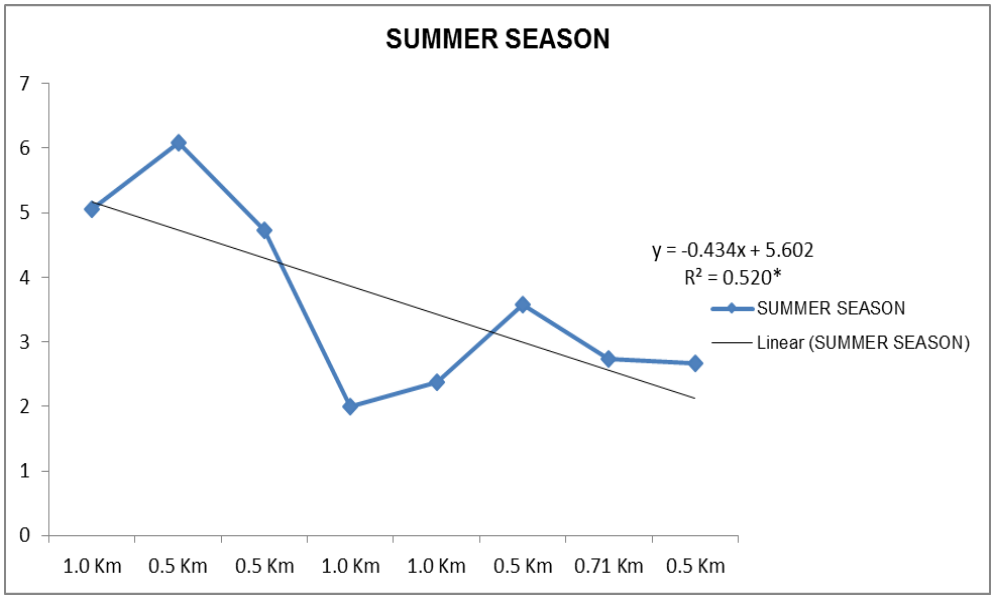

Fig I (a)

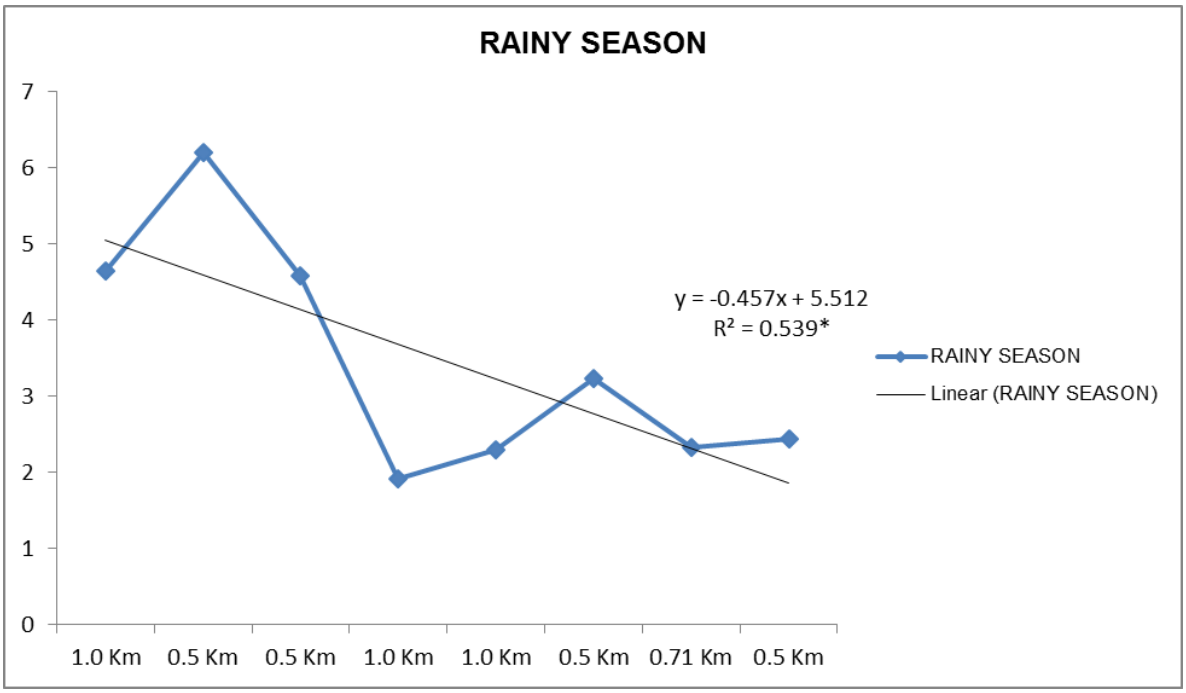

Fig I (b)

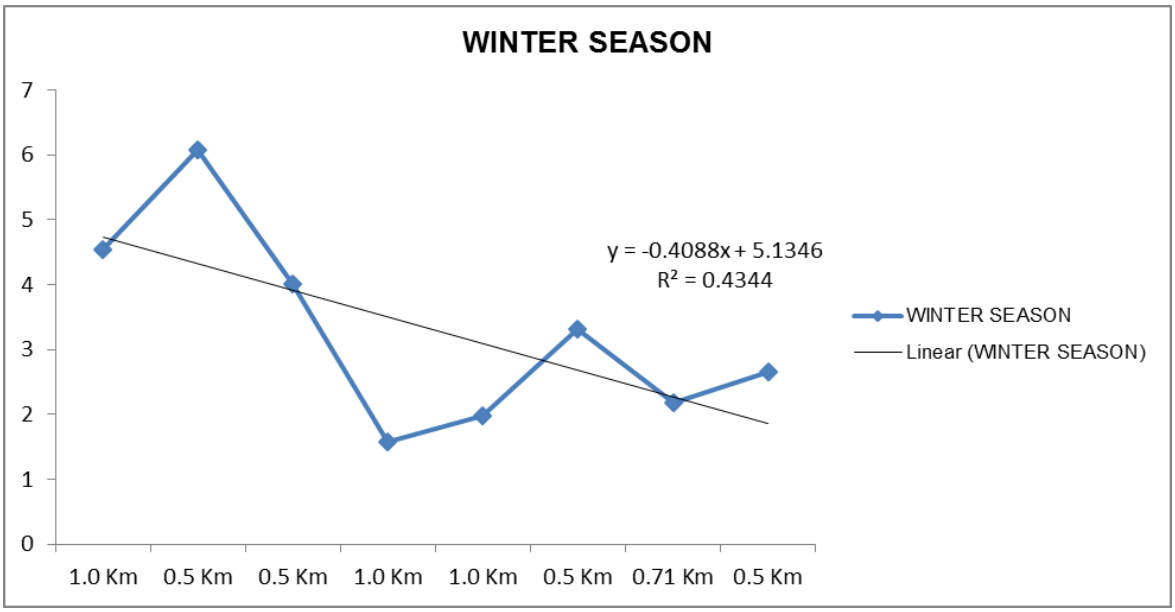

Fig I (c)

Fig 1 (a, b, c): Correlation between population density and transect length during different seasons.

Variation in population density is explained by transect length in which R^2 is equal to 0.52 (52%), 0.53 (53%) and 0.43 (43%) during summer, rainy and winter seasons respectively (Fig I a, b, c).

Table 4: Results of Spearman rank correlation analysis of Indian peafowl at selected locations

	Locations →	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Spearman's rho	Transects	Transect I Transect II	Transect III Transect IV	Transect V Transect VI	Transect VII Transect VIII
	Correlation Coefficient	0.545	0.732**	0.711**	0.710**
	N	12	12	12	12

** Correlation is significant at the 0.01 level of significance (2-tailed)

Correlation between population number of Indian Peafowl was found significant at 1% level of significance between transects of Location 2, Location 3, and Location 4. However, no significant relationship was found between transect I and transect II of Location 1 (Table 4).

Southwood reported that Indian Peafowl utilized thorny shrubs, grassy areas and trees foraging purposes that can provide food such as seed and fruits; grass seeds, and faunal diet whereas cultivated trees and concrete areas were strongly avoided as in accordance with our study [19]. It was further

suggested that Indian Peafowl preferred a varied vegetative structural diversity when foraging for invertebrates.

Brickle reported that areas near the human habitations did not support much population of Indian Peafowl. It was further stated that the presence of water source was essential for the species and greatly influenced population density of Indian Peafowl [5]. Thus, areas with high human interference and absence of water source had low population of Indian Peafowl. Dodia suggested that high tree density favored the survival rate of Indian Peafowl as roosting on trees with high canopy reduced risk from predators like cats, dogs, mongoose etc [9]. Anwar recorded a low population of Indian Peafowl in cultivated areas probably due to disturbance by human activities and livestock grazing which was in accordance with our study [3].

Comparative bird diversity studied by Sidhu and Kler at multifruit crop orchard and two fruit crop orchard had showed 45 and 30 bird species respectively [16]. It was reported that three bird species of order galliformes including Indian Peafowl, Black francolin and Grey francolin had shown preference for foraging among understory vegetation of shrubs and weeds at multifruit crop orchard. Sidhu and Kler had reported bird community comprising of 37 bird species in guava orchard out of which ground foragers like Indian Peafowl, Red jungle fowl, Black francolin and Grey francolin had lesser population abundance [17].

Subramanian *et al.* reported that very low degree of correlation was found in the population of Indian Peafowl in summer, rainy and winter season [20]. Rameshkumar *et al.* stated that abundance of Indian Peafowl was recorded more in scrub jungle in Mudumalai Wildlife sanctuary [15]. The study revealed that the rare sightings of Indian Peafowl in Southern sub-tropical hill forest area might be due to high altitude and sparse availability of shrubs and bushes. It was also reported that densities of Indian Peafowl were highest in the summer season.

In present study, females were observed in open areas because of awareness among persons working at location 1; there was least human presence at location 3 which favored females coming out. Females seemed to be taking lesser risk to move out in open areas at location 2 and 4 as these locations had high human disturbance. Anwar *et al.* revealed that male Peafowl came to open areas for dust bathing, display and feeding in early morning and late evening hours so they got easily sighted [3]. It seemed to be the case at location 2 and 4. Occasionally females were also sighted along with males, but in very low numbers, as females were mostly found in forest habitat and present data reflected lesser female count. The given observations could be correlated with the low female population number at location 2 and 4. Different workers, reported that Indian Peafowl preferred the cultivated area which is in accordance with our study [1, 4].

4. Conclusions

In conclusion, our study indicated that sex ratio i.e. female: male and maximum population density was found at location 1 due to the habitat characteristics having combinatorial factors such tree diversity, high canopy cover, foraging sites and human awareness. Furthermore, it was observed that a variation was found between population density and selected transects in summer and rainy season. Similarly, a significant correlation was observed between transects having different habitat features except at location 1. This might be due to the habitat features of cultivated and residential areas at other locations that affected their abundance and population density. The population status of Indian Peafowl can be improved by selecting and protecting specific sub habitats having desired characteristics in Punjab state. The present study recommends that the conservation can be undertaking in specific areas fulfilling habitat requirements.

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