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Food and Foraging Niches of Carnivorous Bird Species in Orchards: Implications for their Conservation

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ABSTRACT

The present study was carried out to assess food and foraging niches of carnivorous bird species in mixed fruit orchard selecting two transects I and II at Punjab Agricultural University campus from March 2015 to February 2016. There were observed 12 and 11 carnivorous bird species out of total 52 and 38 bird species recorded in transect I and II respectively. Habitat features (hedgerows, un-cemented water channel), irrigation schedules and fruit developmental stages seemed to determine the bird composition, especially carnivorous bird species in mixed fruit orchard.

Keywords: carnivorous birds, conservation measures, foraging behaviour, orchard

Birds are the principle elements in an agricultural ecosystem to maintain the ecological balance (Haslem and Bennett, 2008). Birds are considered to be bio indicators of healthy ecosystems (Slabbekoorn and Ripmeester, 2008). Orchard systems contain high plant diversity and perennial multi-strata designs that provide wealthy resources and habitats to birds and other beneficial organisms (Simon *et al*., 2010). Orchard plantation and their pattern contribute to plant diversity within the agricultural areas and also provide resources for animal communities (Boller *et al*., 2004). Workers had reported that the presence of natural enemies like predatory birds and insectivorous birds help in pest control of fruit pests such as mites, aphids, leaf miners and psyllids by natural enemies (Saunders *et al*., 2016). Perennial habitats of orchards with complex structures provide refuge and food for 112 species of birds (Mellink *et al*., 2017). The present study was designed to observe the food and foraging behaviour of carnivorous bird species in mixed fruit orchard so as to address the conservation of "Birds of Prey" in agricultural landscape of Punjab state.

MATERIALS AND METHODS

Line transect method was followed to record bird data by selecting transect I and transect II of mixed fruit orchard in Punjab Agricultural University Ludhiana from March 2015 to February 2016 (Verner, 1985).

Transect I was of 300 m in length and 50 m in width. Different species of citrus trees covered the 80% area of one side of transect. Maximum rows (14 rows of 12 trees each) were of Orange fruit trees along with two rows of guava, three rows of kinnows, two rows of sweet lime and two rows of ber (Table 1). On the other side of transect were seasonal vegetable crop fields.

The transect II was of 150 m in length and 50 m width on either side of central line. On the one side of transect, 30% area was under grape vines and rest was under poly houses for banana. There were present hedgerows consisting of Dhek, Tun, Putranjiva and Eucalyptus trees on one side of transect (Table 1). On other side, there were buildings (office, staffrooms and Tubewell house) two Green houses for Papaya and water channel.

Birds inhabiting/ foraging in all the study areas were counted by employing line transect method during dawn and dusk (Verner, 1985). The vegetation was carefully scanned using binocular. Identification of birds inhabiting the study areas was done on the basis of visual observations

Table 1: Tree diversity in transect I and transect II

Trees	Scientific name	Approx. tree height (In ft)	
Fruit Trees		**Transect I**	**Transect II**
Mango	*Mangifera indica*	50'- 60'	—
Orange	*Citrus sinensis*	10'- 12'	—
Lemon	*Citrus lemon*	10'- 12'	—
Sweet Lime	*Citrus limetta*	10'- 12'	—
Kinnow	*Citrus reticulata blanco*	10'- 12'	—
Guava	*Psidium guajava*	15'- 18'	—
Pear	*Pyrus communis*	12'- 18'	—
Ber	*Ziziphus mauritiana*	15'- 18'	—
Grapes	*Vitis vinifera*	—	6'- 7'
Banana	*Musa acuminate*	—	8'- 10'
Papaya	*Carica papaya*	—	8'- 10'
Other tree species			
Eucalyptus	*Eucalyptus globulus*	70'- 85'	80'- 85'
Poplar	*Populus deltoids*	—	40'- 50'
Tun	*Toona ciliate*	—	70'- 80'
Putranjiva	*Putranjiva raxburghii*	—	40'- 50'
Dhek	*Melia azedarch*	—	18'- 20'

described by Ali (2002). The different bird species were analysed with Shannon-Wiener Index. Species wise relative abundance from the said transects was compared with Mann-Whitney U test.

RESULTS AND DISCUSSION

A total of 52 and 38 bird species were recorded in transect I and transect II during one year from March 2015 to February 2016 respectively (Table 2). Bird species observed belonged to 13 orders namely Passeriformes, Ciconiiformes, Coraciiformes, Cuculiformes, Columbiformes, Galliformes, Psittaciformes, Strigiformes, Piciformes, Upupiformes, Charadariiformes, Bucerotiformes and Gruiformes. Orders Charadariiformes and Bucerotiformes were observed only in transect I and Gruiformes only in transect II. Passeriformes, Ciconiiformes, Columbiformes, Cuculiformes and Galliformes were found to constitute 63.49%, 9.18%, 4.51%, 1.56% and 0.88% respectively in transect I. Order Passeriformes (56.61% relative abundance) followed by Psittaciformes (17.38%) and Ciconiiformes (17.05%) were the abundant orders in transect II.

In transect I, trophic levels namely insectivorous (30), carnivorous (12), omnivorous (5), granivorous (2), frugivorous (2) and nectarivorous (1) were recorded. Insectivorous and carnivorous bird species have cumulative abundance 43.05% which showed the presence of abundant and diverse insect food. In transect II, 17 insectivorous, 11 carnivorous, four omnivorous, three frugivorous, two granivorous and one nectarivorous bird species were recorded. Twelve carnivorous bird species (11.40%) and eleven carnivorous species (18.34%) were categorized into two groups in transect I and II respectively (Table 3).

Statistical method of Mann- Whitney U test has shown no significant difference between the relative abundance of total bird species and dominance of carnivorous species in transect I and transect II (Table 2,3).

White-breasted Kingfisher

White-breasted Kingfisher was noted 0.37% and 0.09% in transect I and transect II respectively. It perched on the electric wires (15-20ft); fed on invertebrates (flies, grasshoppers, worms in transect I) and on amphibians (frogs and tadpoles in transect II). Naher and Sarker (2014) had mentioned the feeding habits and recorded 16 species of food items in their feeding.

Table 2: Bird community characteristics in transect 1 and transect II from March 2015 to February 2016

Month	Mar 15		April 15		May 15		June 15		July 15		Aug 15		Sept 15		Oct 15		Nov 15		Dec 15		Jan 16		Feb 16		Relative Abundance (%)		Trophic group
Transect	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
Bird species																											
Ashy Prinia	1.65	—	3.46	—	—	—	—	1.70	—	—	0.79	—	1.40	—	0.42	—	2.27	—	2.80	—	0.92	—	—	—	1.14	0.14	I
Asian Koel	—	—	—	1.25	—	—	—	—	—	0.74		1.70	—	—	—	—	—	—	—	—	—	—	—	—	—	0.30	F/I
Asian Pied Starling	—	—	3.46	3.75	2.26	1.31	1.16	—	—	—	1.58	0.85	—	—	—	—	—	—	0.8	—	—	—	—	—	0.77	0.49	I/F
Black—crowned Night—heron	—	—	—	—	—	—	—	—	—	0.74	—	—	—	0.74	—	—	—	—	—	—	—	—	—	—	—	0.12	I/SI
Black Drongo	—	—	2.47	7.50	2.64	3.94	1.16	5.98	0.93	9.62	1.18	2.56	0.46	3.70	2.10	—	1.13	—	0.40	0.92	1.85	—	1.28	2.85	1.30	3.08	I
Black Ibis	1.65	—	—	—	0.75	—	—	—	—	—	0.39	—	1.40	—	—	—	—	—	—	—	—	—	1.8	—	0.49	—	I/G
Black Kite	1.65	9.09	1.48	5.00	1.88	6.57	0.58	—	3.27	—	0.79	—	4.20	—	—	2.94	2.65	6.97	2.40	2.77	1.38	3.41	1.03	2.28	1.77	3.25	I/SV
Black Redstart	—	—	—	—	—	—	—	—	—	—	—	—	0.46	—	—	—	1.13	—	0.8	—	—	—	0.51	—	0.24	—	I
Black—shouldered Kite	—	—	—	—	—	—	—	—	—	—	—	—	0.46	—	—	—	0.37	—	—	—	—	—	—	—	0.06	—	I/SV
Blue Rock Pigeon	—	5.68	—	—	—	—	1.16	—	—	—	—	—	—	—	1.26	4.9	0.75	—	—	—	—	—	—	—	0.26	0.88	G
Brown—headed Barbet	—	—	—	—	—	—	—	—	—	0.74	—	—	—	—	—	—	—	—	—	—	—	—	—	2.85	—	0.29	I/F
Cattle Egret	6.61	14.77	3.96	1.25	6.79	6.57	2.32	0.85	0.46	2.22	8.30	3.41	2.80	11.11	11.81	7.84	10.6	3.48	1.20	—	4.16	34.18	—	57.71	4.91	11.94	I/SI
Common Babbler	5.78	1.13	5.44	3.75	2.64	—	2.32	—	1.89	—	3.55	—	2.33	5.18	5.99	—	7.19	—	3.20	3.70	7.40	—	—	4.57	3.97	1.52	I/F
Common Golden—backed Woodpecker	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.37	—	—	—	—	—	—	—	0.03	—	I
Common Hoopoe	1.65	1.13	2.9	—	1.13	—	0.58	—	0.93	3.70	1.58	1.70	0.46	2.22	0.42	—	—	—	—	—	—	—	—	—	0.80	0.72	I
Common Lesser Whitethroat	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.25	—	0.02	—	I/F
Common Myna	15.70	13.63	11.38	13.75	12.07	13.15	3.48	40.17	4.20	22.96	5.92	5.98	7.47	11.85	8.01	19.6	3.40	10.46	6.00	15.74	7.87	11.96	7.47	6.85	7.74	15.50	I/F/P/SI

(Cont...)

Common Swallow	—	3.40	—	—	—	—	—	—	—	—	—	—	—	5.92	—	—	—	—	—	—	—	—	—	—	0.77	I
Common Tailorbird	—	1.13	—	—	—	—	—	—	—	—	—	—	—	—	0.84	0.98	—	—	1.20	—	1.38	—	1.80	—	0.43	0.17	I/P
Eurasian Collared—dove	2.47	—	2.47	—	—	—	4.06	—	1.89	—	17.11	1.7	1.40	2.96	8.01	1.96	4.54	2.32	4.40	1.85	1.38	2.56	3.35	—	4.25	1.11	G
Franklin's Prinia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.2	—	—	—	—	—	0.10	—	I
Great Tit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.77	—	—	—	0.23	—	I/SI
Greater Coucal	4.13	—	1.98	—	1.13	—	1.16	0.85	0.46	—	0.39	—	—	—	0.42	—	2.27	—	1.60	—	2.31	—	2.06	—	1.49	0.07	I/SI/SV
Grey Francolin	—	—	—	—	—	—	—	0.85	—	—	—	—	1.86	—	5.48	—	—	—	2.00	—	—	—	0.51	—	0.82	0.07	G/I/SI/SV
Grey Wagtail	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.92	—	0.77	—	0.14	—	I/F
House Crow	23.14	34.09	22.27	35.00	20.00	28.94	12.20	22.22	9.81	26.66	16.20	27.35	22.42	28.88	8.86	25.49	20.07	54.65	19.2	28.70	23.14	17.94	24.22	18.85	18.46	29.06	I/F/G/SV
House Sparrow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.8	—	—	—	1.28	—	0.17	—	G/I
Indian Chat	—	—	0.99	1.25	1.13	—	—	—	—	0.74	—	—	—	—	—	—	—	—	0.8	—	—	—	—	—	0.24	0.16	I
Indian Grey Hornbill	—	—	0.99	—	—	—	—	—	0.46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.12	—	F/I
Indian Peafowl	—	4.54	—	—	—	—	—	—	—	1.48	0.39	1.7	—	—	—	—	—	—	0.4	1.85	—	0.85	—	—	0.06	0.86	G/P/I/SV
Indian Pond—heron	—	—	—	—	—	—	—	—	—	0.74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.06	I/SV
Indian Robin	—	—	—	—	—	—	—	—	—	0.74	—	—	—	—	0.42	—	—	—	—	—	—	—	—	—	0.03	0.06	I
Indian Roller	—	—	—	—	—	—	—	—	—	—	—	—	0.46	—	—	0.98	0.75	—	—	—	—	—	0.25	1.14	0.12	0.17	I
Indian Treepie	—	2.27	—	—	—	2.63	—	0.85	—	2.22	—	1.7	0.46	0.74	0.42	—	0.75	—	—	0.92	—	—	0.51	—	0.17	0.94	I/SV
Jungle Babbler	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.84	—	—	—	—	—	—	—	—	—	0.07	—	I/F
Oriental Magpie—robin	0.82	—	0.49	—	—	—	—	—	0.46	—	—	—	—	—	0.42	—	0.37	—	1.20	—	1.38	—	1.03	—	0.51	—	I
Oriental White—eye	—		—		—		—		—		—		—		—		—		—		1.38		—		0.11	—	I/N
Paddyfield Pipit	—	1.13	0.49	—	0.37	—	0.58	—	—	—	0.79	—	—	—	0.84	—	—	—	0.40	—	0.46	—	—	—	0.32	0.09	I/P
Pied Bushchat	—	—	0.49	—	0.75	—	—	—	1.40	—	—	—	—	—	—	—	—	—	0.40	—	—	—	0.77	0.57	0.31	0.04	I

(Cont...)

Pied Crested Cuckoo	—	—	—	—	—	—	0.46	—	0.39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.07	—	I
Plain Prinia	3.30	—	0.99		—		—		—		—		—		0.84		0.75		2.00		0.92		—		0.73	—	I
Purple Sunbird	2.47	1.13	5.44	1.25	0.75	2.63	0.58	0.85	2.33	2.22	1.58	0.85	0.46	—	—	—	—	1.16	2.40	—	—	—	1.03	—	1.42	0.84	N
Red—vented Bulbul	9.09	—	8.41	1.25	7.92	—	15.11	11.11	4.67	1.48	10.67	0.85	7.47	—	15.18	1.96	3.78	—	8.40	—	4.16	2.56	4.12	—	8.24	1.60	I/P/F
Red—wattled Lapwing	4.13	—	—	2.50	2.26	5.26	—	2.56	0.46	2.96	4.74	2.56	2.33	1.48	3.37	—	—	—	0.80	—	2.77	—	1.28	1.14	1.84	1.53	I/SI
Rofous—fronted Prinia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.68	—	1.13	—	0.80	—	0.92	—	0.51	—	0.42	—	I
Rose—ringed Parakeet	14.04	1.13	8.41	22.5	15.47	25.00	4.65	5.98	8.87	13.33	14.62	13.67	33.17	22.22	21.94	32.35	31.81	9.30	18.00	43.51	19.44	19.65	12.37	—	16.89	17.38	F/P/G
Rosy Starling	—	—	—	—	—	—	—	—	0.46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.03	—	F/G/N/I
Small bee—eater	—	4.54	3.96	—	5.28	3.94	1.74	2.56	3.27	4.44	2.76	10.25	5.14	—	—	—	—	—	—	—	—	6.83	5.15	—	2.27	2.71	I
Spotted Munia	—	—	0.99	—	2.64	—	2.90	—	2.8	—	3.95	—	—	—	—	—	—	—	4.80	—	1.85	—	13.14	—	2.75	—	I/G
Spotted Owlet	—	—	—	—	—	—	—	—	—	—	—	—	—	0.74	—	—	0.37	—	—	—	—	—	—	—	0.37	0.06	I/SV
Stone—curlew	—	—	—	—	0.37	—	—	—	0.93	—	1.58	—	0.46	—	—	—	—	—	—	—	—	—	—	—	0.27	—	I/SI
Tawny Eagle	—	1.13	—	—	—	—	—	—	—	—	—	—	1.40	0.74	—	—	—	—	—	—	—	—	—	—	0.11	0.15	I/SV
White—breasted Kingfisher	1.65	—	0.49	—	0.37	—	—	—	—	—	—	—	0.46	—	—	—	0.37	—	—	—	0.92	—	0.25	1.14	0.37	0.09	I/SV
White—breasted Waterhen	—	—	—	—	—	—	—	—	—	0.74	—	0.85	—	—	—	—	—	—	—	—	—	—	—	—	—	0.13	I/SI/P
White—browed Fantail—flycatcher	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.51	—	0.04	—	I
White—throated Munia	—	—	6.43	—	11.32	—	43.02	3.41	49.06	—	9.88	—	—	—	—	—	—	—	11.2	—	10.18	—	11.59	—	12.72	1.87	I/G
Wire— tailed Swallow	—	—	—	—	—	—	1.16	—	—	—	0.79	9.40	0.93	1.48	0.42	—	3.03	11.62	—	—	—	—	—	—	0.52	1.87	I

(Cont...)

Yellow-legged Green-pigeon	—	—	—	—	—	—	—	—	—	1.48	—	12.82	—	—	—	0.98	—	—	—	—	—	—	—	—	—	1.27	F
Yellow Wagtail	—	—	—	—	—	—	—	—	0.46	—	—	—	—	—	—	—	—	—	0.40	—	—	—	1.03	—	0.15	—	I/SI
Species Richness	17	16	24	13	22	11	19	14	23	20	24	18	24	15	23	11	23	8	29	9	23	9	28	11			
Species Diversity	2.40	2.14	2.69	1.93	2.51	1.98	2.02	1.85	2.02	2.24	2.65	2.32	2.23	2.09	2.45	1.77	2.27	1.47	2.69	1.46	2.52	1.77	2.54	1.42			
Species Evenness	0.84	0.77	0.84	0.75	0.81	0.82	0.68	0.70	0.64	0.74	0.83	0.80	0.70	0.77	0.78	0.73	0.72	0.71	0.81	0.66	0.80	0.80	0.76	0.89			

G— grains, F— fruits, I— insects, P— plants, SI— small invertebrates, SV— small vertebrates, N— nectar

Z— 0.294 (NS)

Z is the coefficient of Mann— Whitney U test

NS— Difference is non significant

Table 3: Difference between the dominance of carnivorous species in both transect

	Carnivorous species	**Transect I** (Relative abundance %)	**Transect II** (Relative abundance %)
Insects/ Vertebrates (I/V)	White-breasted Kingfisher	0.37	0.09
	Black Kite	1.77	3.25
	Black-crowned Night-heron	—	0.12
	Spotted Owlet	0.03	0.06
	Greater Coucal	1.49	0.07
	Tawny Eagle	0.11	0.15
	Black-shouldered Kite	0.06	—
	Cattle Egret	4.91	11.94
	Indian Pond-heron	—	0.06
Insects/ Invertebrates (I/IV)	Stone-curlew	0.27	—
	Indian Treepie	0.17	0.94
	Yellow wagtail	0.15	—
	Red-wattled Lapwing	1.84	1.53
	Great Tit	0.23	—
	White-breasted Waterhen	—	0.13
	Total	11.40	18.34

Z- 0.585 (NS), Z is the coefficient of Mann- Whitney U test

NS- Difference is non significant

Cattle Egret

Cattle Egret, was noted having 4.91%, 11.94% relative abundance in transect I and transect II respectively. During ploughing and watering; they foraged (5-6 min), alternatively settled down on fruit trees and then on the ground in symmetrical pattern. Workers had discussed seasonal changes affecting the feeding behaviour and its conservation in agro-ecosystem (Abdullah *et al*., 2017).

Black Kite

Relative abundance (%) was found to be 1.77%, 3.25% in transect I and transect II respectively. Black Kite was found hovering over the orchard in circular movements to locate the prey (rodents, snakes and flying insects) and perching on the Eucalyptus and Poplar trees. Sharma and Soni (2017) had mentioned the seven kinds of feeding behaviour of Black Kite in 12 different microhabitats.

Black-crowned Night-heron

Black-crowned Night-heron was observed only in transect II. It preferred Tun trees for perching, nesting and roosting during day time. Feeding activity on aquatic insects, frogs along water channel and in the open ploughed field was recorded. Erwin *et al*. (1991) had mentioned about the individual feeding trips of black-crowned Night-heron.

Indian Pond-heron

Relative abundance (%) of Indian Pond-heron was found to be 0.06% in transect II. It foraged on ground along with Cattle Egrets; food items were aquatic insects, worms, flies, bees and tadpoles. Roshnath (2014) had mentioned it as solitary ground feeder and also discussed its scavenging behaviour.

Spotted Owlet

Relative abundance (%) was noted 0.03%, 0.06% in transects I and transect II respectively. It was observed hunting on insects and invertebrates from the soil enriched with compost in transect I; found as efficient hunter of rats in transect II. Paunikar *et al*. (2015) also discussed the feeding of Spotted Owlet on beetles, small mammals and rodents.

Tawny Eagle

Relative abundance of Tawny Eagle was found to be 0.11% and 0.15% in transect I and transect II respectively. Flocks of Tawny Eagle and Black Kite were recorded hovering over orchard to prey on active bird nests and rodents; perching on large Eucalyptus and Poplar trees. Wichmann *et al.* (2004) also stated that Tawny Eagle's food mainly depends on small mammals, insects, reptiles and amphibians.

Stone Curlew

Stone Curlew was observed only in transect I; it preferred citrus plantation for food (insects, arthropods and lizards), shelter and hiding space in their shrubby foliage. Karavaev (1998) had mentioned the feeding activities upon small and large insects to feed their chicks.

Black-shouldered Kite

Black-shouldered Kite (0.06%) was observed only in transect I. It used vintage points both electric wires and eucalyptus trees to locate the prey in the citrus and guava plantations. Jaksic *et al*. (1987) also discussed that time allocated to hunting flight decreased during spring and increase during summer season.

Indian Treepie

Indian Treepie was noted 0.17%, 0.94% in transect I and transect II respectively; fed upon insects, grasshoppers and small reptiles. Basheer and Thomas (2012) had also mentioned it as bio-control agent because of its unique techniques of prey catching.

Greater Coucal

Relative abundance (%) of Greater Coucal was found to be 1.47% , 0.07% in transect I and transect II respectively. It was observed hopping on branch to branch and noticed scrabbling in vegetation to forage on insects, lizards, rodents and other vertebrates. Narayana *et al*., (2013) had mentioned foraging and also stated its feeding on the Common Myna.

Yellow Wagtail

Yellow Wagtail was recorded with 0.15% of relative abundance in transect I. Observations showed probing in undergrowth of fruit trees to feed on insects, worms and invertebrates. Kirby *et al*., (2012) had mentioned that they used to prefer places with high manure heaps.

Red-wattled Lapwing

Relative abundance (%) of Red-wattled Lapwing was noted 1.84% and 1.53% in transect I and transect II respectively. It foraged in flocks on insects, worms and invertebrates in mud puddles. Narwade and Fartade (2008) had stated the use of riverbeds for nesting to have more prey availability in wet soil.

Great Tit

Great Tit was recorded 0.23% in transect I; observed devouring on bees, flies and beetles under citrus plantations in the accumulation of dry fallen leaves under the tree canopy. Pagani-Núñez and Senar (2013) had discussed the feeding behaviour of parent Great Tit to their youngones.

White-breasted Waterhen

White-breasted Waterhen was noted with relative abundance of 0.13% in transect II. Observations of feeding activity had revealed that they probed the wet soil of water channel and along with bank vegetation of shrubs and weeds looking for the aquatic insects, small tadpoles and other invertebrates. Akhtar *et al*., (2013) had also mentioned the feeding and foraging activity on insects, frogs and tadpoles.

In transect I, highest number of species (52 species) had been recorded which has indicated the good agronomic practices and safe pesticides were being used. The complex relationships between the activities of multiple species having different feeding habits seem to be related to fruit tree diversity.

Relative abundance (18.34%) of carnivorous bird species was found to be more dominant in transect II. Water channels had additive effect in inviting water dependent species. Presence of official buildings caused the human disturbance which might affect the bird community. Carnivorous bird species were observed roosting and perching on hedgerows of Eucalyptus and Poplar trees had a definitive role as biological control agents.

McKenzie and Whittingham (2009) had mentioned lack of pesticides and non crop habitats have effect on farmland birds. Saunders *et al*. (2016) had pointed out the costs and benefits of the activity of multiple avian species in different fruit crops. Workers had mentioned that insectivorous bird species predated on insect pests in orchards and reduced the insect damage to the fruits providing biological control (Peisley *et al*., 2016). Sam *et al*. (2015) discussed that the differential predation rates on different types of prey items in fruit orchards. Workers had recorded fourteen carnivorous bird species in agroecosystem at different phenological stages of Wheat and Rice in Punjab (Kler and Parshad, 2011). Kaur *et al*. (2018) had recorded water dependent bird species near pond and mentioned that it depended upon the high tree diversity and absence of weeds. Luck *et al*. (2013) also noted the variability in flock size of birds in different seasons. Wiacek and Polak (2008) had stated the influence of surroundings on the bird community and also mentioned that mixed-species orchards offered food resources for number of small birds. Sidhu and Kler (2017) had inferred that the fruit tree diversity supported more avian richness and is of paramount importance for bird conservation efforts.

CONCLUSION

Fruit tree types (both semi deciduous and evergreen species) and habitat features (Eucalyptus, Poplar as hedgerows) could help in attracting the carnivorous bird species for nesting, perching and roosting purposes to mixed fruit orchards. Presence of un-cemented water channel and irrigation schedules of different fruit crops might impact the availability of animal food for aerial foragers, ground foragers, mud probers and wet soil waders.

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