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RESEARCH ARTICLE

Four Insectivorous Birds in Search of Foraging Niche in and Around an Agricultural Ecosystem of Nalgonda District of Telangana, India

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Study Area: Sherpally, Nalgonda District, Telangana

Coordinates: : 16°.74934N 78°.86753E

Key words: Perch types, Perching height, Foraging height, Foraging substrates and Feeding methods

Abstract

Foraging niche of Small Green Bee-eater *Merops orientalis*, Indian Roller *Coracias benghalensis*, Common Myna *Acridotheres tristis* and Black Drongo *Dicrurus macrocercus* was studied in and around agricultural landscapes of Sherpally, Nalgonda District of Telangana, India. Data on perch types, perching height, foraging height, foraging substrates types and foraging methods were transformed into percent use. Small Green Bee-eater predominantly perched on electric power lines (67.21%), Common Myna used plants (75.44%) as a substrate and gleaning was the common feeding technique used by all the birds with height of 0-3m, Indian Roller fed mostly at 3-6m (30.91%). Black Drongo and Indian Roller had the highest niche overlap ($O=0.96$) for perch types while the lowest overlap was observed for small Green Bee-eater and Common Myna ($O=0.34$) in the foraging substrate.

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Introduction

Foraging ecology of birds explain the population composition, source use and contest or co-existence in a rigorous environment (Recher & Davis, 2002). The feeding techniques in a bird community be explain a manner; species find food, verity of food employ, which foraging substrates use in different heights at which different species feed (MacNally, 1994). In species associations and population structure is needful to study on the niche-overlap in their exploitation of space for food or other activities (Litvaitis, 2000). The incidence of overlap amongst potential competitors may be used to evaluate the degree of availabilities partitioning on the niche proportions considered (Gokula & Vijayan, 2000). Utilizations partitioning to the resources reduces the result of competition by falling the amount of overlap between the competing species (Wiens, 1989). Several bird species are naturally search for food at different heights with selection of various substrates and they apply different methods to obtain food, with compression of other species show varying degrees of specialization (Somasundaram & Vijayan, 2008). Such specialists, when unable to adapt to changes at mostly on the range cause by human activities in their environment, will become endangered or extinct (Vijayan & Gokula, 2006). A selection of habitats in birds has attributes that influence their hunting success, such as perch height, perch availability, floral density and prey visibility. It is usually assumed that a perched bird scans a circular area and that the search area increases with perch height (Ali et al., 2010).

Foraging behavior helps to evaluate communities within and among habitats (Recher & Davis, 1998; Gokula & Vijayan, 2000; Ali et al., 2010). Studies of niche segregation have shown a separation in foraging behaviour of a few closely related species (Gokula & Vijayan 2000; Somasundaram & Vijayan, 2008; Ali et al., 2010; Laxmi Narayana et al., 2014). Study on the foraging behaviour of birds in and around an agro-ecosystem of India is limited (Dhindsa & Saini, 1994; Parasharya et al., 1994). Insectivorous birds play a significant role in insect pest control in the agricultural crops. Thus insectivorous birds need to be encouraged in the agro-ecosystem by use of appropriate management practices and also to assess the health of the ecosystem and management needs for the conservation of species and ecosystems (Lawton, 1996; Loyn, 2002; Laxmi Narayana et al., 2011, 2014). Hence, the present study was designed to study foraging niche separation with special reference to selection of perch types, perching height, foraging height, foraging substrates, foraging methods and niche overlap among the Small Green Bee-eater *Merops orientalis*, Indian Roller *Coracias benghalensis*, Common Myna *Acridotheres tristis*, and Black Drongo *Dicrurus macrocercus* in and around the agricultural landscapes of Sherpally region, Nalgonda District, Telangana, India.

Materials and Methods:

Study area: The present study was carried out in and around the agricultural ecosystem of Sherpally, Nalgonda District, Telangana from December 2010 to March 2011. The climate of Nalgonda is generally hot and dry with temperatures rising up to 43-45°C during May and dropping to 8-12°C in December. The main crops grown in the district are paddy, jowar, bajra, ground nut, red gram, green gram, castor and sugar cane in an area about 150,000 acres.

Increased irrigation facilities give a boost to agricultural activity in the district. Out of a total of 1,423,423 ha land utilization in the district; more than 50% is cultivable land. The terrain of the district is suitable for irrigation development. The predominant tree species found in the study area are *Borassus flabellifer*, *Ficus benghalensis*, *Azadirachta indica*, *Holoptilia integrifolia* and *Acacia nilotica*. Important shrub species are *Prosopis juliflora*, *Jatropha glandulifera* and *Vitex nigundo*. Plantations of *Casuarina equisetifolia*, *Tectona grandis* and *Bamboosa arundinacea* are also found in the study area.

Field study techniques: the birds foraging behaviour was noted in the studied area regularly at morning from 6:00 hr to 9:00 hr and at evening from 15:00 hr to 18:00 hr. It was done by using 7X50 binocular. Parameters taken into account were:

- perch type: electric power lines, trees, shrubs and ground
- perching height: height at which the bird was perched while feeding was grouped into 0-3m, 3-6m, 6-9m and 9-12m
- foraging height: 0-3m, 3-6m, 6-9m and 9-12m
- foraging substrate: the material from which food is taken by the birds - classified into air, plants and ground
- foraging method: the attack maneuver is a method on how the food items are captured and are classified into aerial feeding - a bird flew into air to catch flying prey; gleaning - a stationary food item is picked from its substrate by a standing or hopping bird, and ground feeding - the bird picked prey from the ground (Bell & Ford, 1990; Hutto 1990; Asokan, 1995; Gokula, 2001).

The heights were visually estimated. Methodology forwarded by Ali *et al.*, (2010) was adapted to study utilization of perch related variables and variations on foraging behaviour. Further percent use of different foraging variables were used for various statistical analysis.

Mammalian prey items (skulls and mandibles) were identified up to species level following the key by Talmale & Pradhan (2009). Invertebrate prey items were identified on the basis of undigested pieces such as heads, mandibles, wings and legs (Triplehorn & Norman, 2005; Arrow, 1931).

Statistical analysis: the BIODIVERSITY-PRO version 2.0 software was used for the statistical analysis. The specialty of different foraging variables was analyzed using Shannon-Weiner index (Shannon & Weiner, 1949): $H' = -\sum P_i (\ln P_i)$, where H' = Shannon-Weiner Index, and P_i =

the proportion of the each species in the sample. The niche overlap values between the foraging variables of birds were calculated by Pianka's index (Pianka, 1973): $O = \frac{p_{xa} p_{ya}}{\sqrt{p_{xa}^2 p_{ya}^2}}$, where, p_{xa} = proportion of use of 'a' th resource by species 'x' and p_{ya} = proportion of use of 'a' th resource by species 'y'. Two multivariate analyses were performed on the data. Similarity matrix was done by using Bray-Curristis single link analysis (Species X variables) following Euclidean distance coefficients. Correspondence analysis is a technique similar to Pearson's correlation analysis, but it is effective in plotting the numerical data and detecting similarities between the rows and columns of a data matrix (Miles, 1990).

Results and Discussion:

Foraging observations: we recorded total 384 foraging observations of Indian Roller (*Coracias benghalensis*), 303 of Black Drongo (*Dicrurus macrocercus*), 265 of Common Myna (*Acridotheres tristis*) and 298 of Small Green Bee-eater (*Merops orientalis*) in the studied area. Among the perch types, we found Small Green Bee-eater (67.21%), Black Drongo (57.63%) and Indian Roller (43.75%) perched predominantly on electric power lines but Common Myna (19.15%) used mostly ground. The Indian Roller mostly used trees (40.63%) and Small Green Bee-eater (18.03%) shrubs (Table 1; Fig.- 1). The perching and foraging heights were seen to be varied from 0m to 12m. In general, a perching height of 0-3m seemed to have been preferred by all bird species. The Indian Roller (30.91%) and Small Green Bee-eater (29.03%) fed predominantly at 3-6m respectively. The Small Green Bee-eater and Common Myna forage mostly at a height of 0-3m (66.67%) (Table 2; Fig.- 2, 3). The Common Myna (75.44%) preferred plant as a foraging substrate (trees, shrubs and herbs) to find insect prey while Small Green Bee-eaters (59.38%) used air and Common Mynas used ground as their foraging substrates (Table 3; Fig.- 4). Foraging by gleaning was relatively higher for Indian Roller (80%) and Common Myna (78.95%). The Small Green Bee-eater (72.58%) foraged mainly by aerial feeding (Table 4; Fig.- 5).

Foraging niche overlap: the extent of overlap, with respect to foraging proportions, namely type of perch, perching height, foraging height, foraging substrate and foraging methods differed among species. Mean niche overlap between species showed that only few had very high (>0.9% i.e. 90%) overlap with other species (Table 5; Fig.- 6, 7).

Black Drongo and Indian Roller had the highest overlap (0.96) for perch types while the Small Green Bee-eater and Indian Roller, Small Green Bee-eater and Common Myna were having similar overlap (0.86). The niche overlap of perching height was highest between Black Drongo and Small Green Bee-eater (0.92) while the lowest was between Indian Roller and Common Myna (0.56) and similarly between Black Drongo and Common Myna and Small Green Bee-eater and Common Myna (0.9). The highest niche overlap in foraging height was between Indian Roller and Common Myna (0.93); and between Small Green Bee-eater and Indian Roller and Small Green Bee-eater and Common Myna (0.92) while the lowest niche overlap (0.85) was found between Black Drongo and Small Green Bee-eater. The highest overlap was found in foraging substrates between Small Green Bee-eater and Indian Roller (0.92) while the lowest was found between Small Green Bee-eater and Common Myna (0.52)

Cluster diagram using Bray-curists single link analysis (Between Groups) representing-

Figure -1: the grouping of birds based on perching types

Figure -2: the grouping of birds based on perching heights (m)

Figure -3: the grouping of birds on foraging heights (m)

Figure -4: the grouping of birds based on foraging substrates

Figure -5: the grouping of birds based on foraging methods.

Figure -6: the grouping of birds based on perch type, perching height, foraging height, substrate and method.

Figure -7: Correspondence plot of between species based on foraging variables (perch type, perching height, foraging height, substrate and method). Ellipses indicate groups of bird species that were significantly showing variations ($p < 0.01$) for any parameter according to a Pearson's correlation analysis**Table 1: Various perch types used by four insectivorous birds**

Perch type	Black Drongo	Common Myna	Small Bee-eater	Indian Roller
Electric power line	34* (57.63%)	38* (40.43%)	41* (67.21%)	28* (43.75%)
Trees	19* (32.20%)	27* (28.72%)	9* (14.75%)	26* (40.63%)
Shrub	6* (10.17%)	11* (11.70%)	11* (18.03%)	9* (14.06%)
Ground	0*	18* (19.15%)	0*	1* (1.56)
H'	0.40	0.56	0.37	0.46

*Number of observations, H' = Shannon-Weiner Index

Table 2: Various perching and foraging heights used by four insectivorous birds

Perching height (m) / Foraging height (m)	Black Drongo	Common Myna	Small Bee-eater	Indian Roller
0-3 / 0-3	23* (37.70%) / 24* (39.34%)	36* (63.16%) / 38* (66.67%)	24* (38.71%) / 54* (66.67%)	7* (12.73%) / 38* (69.09%)
3-6 / 3-6	17* (27.87%) / 16* (26.23%)	8* (14.04%) / 14* (24.56%)	18* (29.03%) / 4* (4.94%)	17* (30.91%) / 4* (7.27%)
6-9 / 6-9	16* (26.23%) / 14* (22.95%)	12* (21.05%) / 2* (3.51%)	16* (25.81%) / 4* (4.94%)	25* (45.45%) / 12* (21.82%)
9-12 / 9-12	5* (8.20%) / 7* (11.48%)	1* (1.75%) / 3* (5.26%)	4* (6.45%) / 19* (23.46%)	6* (10.91%) / 1* (1.82%)
H' / H'	0.55 / 0.59	0.58 / 0.52	0.59 / 0.51	0.54 / 0.42

*Number of observations, H'= Shannon-Weiner Index

Table 3: Various foraging substrates used by four insectivorous birds

Foraging substrates	Black Drongo	Common Myna	Small Bee-eater	Indian Roller
Air	13* (21.31%)	0	19* (59.38%)	21* (38.18%)
Plant	30* (49.18%)	43* (75.44%)	12* (37.50%)	29* (52.73)
Ground	18* (29.51%)	14* (24.56%)	1* (3.13%)	5* (9.09%)
H'	0.45	0.24	0.34	0.40

*Number of observations, H'= Shannon-Weiner Index

Table 4: Various foraging substrates used by four insectivorous birds

Foraging methods	Black Drongo	Common Myna	Small Bee-eater	Indian Roller
Ariel Feeding	30* (49.18%)	0	45* (72.58%)	11* (20%)
Gleaning	18* (29.51%)	45* (78.95%)	17* (27.42%)	44* (80%)
Ground feeding	13* (21.31%)	12* (21.05%)	0	0
H'	0.45	0.24	0.34	0.40

*Number of observations, H'= Shannon-Weiner Index

Table 5: Niche overlap values (O= Pianka's index) among the four insectivorous birds

Bird species	Perch type	Perching heights	Foraging heights	Foraging substrates	Foraging method
Black Drongo X Common Myna	0.92	0.9	0.88	0.91	0.55
Black Drongo X Small Bee-eater	0.95	<u>0.92</u>	0.85	0.74	0.92
Black Drongo X Roller	<u>0.96</u>	0.57	0.91	0.91	0.66
Small Bee-eater X Roller	0.86	0.8	0.92	<u>0.92</u>	0.56
Small Bee-eater X Common Myna	0.86	0.9	0.92	0.52	0.34
Roller X Common Myna	0.93	0.56	<u>0.93</u>	0.8	<u>0.93</u>

Highest niche overlap values are underlined

(high niche overlap (>0.9% i.e. 90%) and low niche overlap (<0.3 % i.e. 30%)

and in foraging methods highest overlap was found between Indian Roller and Common Myna (0.93) and lowest between Small Green Bee-eater and Common Myna (0.34).

The present study revealed the difference of perch types among four insectivorous bird species in the study area. Small Bee-eater, Black Drongo and Indian Roller use electric power lines which is a common feature in the study area especially around the agricultural habitats and our result correlated Ali *et al.*, (2010). Lammers & Collopy (2007) stated that over-head utility power lines are widely used for perching due to their importance for various activities, such as prey detection, hunting, vigilance, resting etc. The other dominant perch sites used by birds in the study area are trees and shrubs. Small Bee-eater, Black Drongo and Indian Roller are sit-and-wait predators and utilize perches mainly to locate the prey for attack and hunting (Brookers *et al.*, 1990). Several other factors also influences the preference of perch type which are species abundance, availability and type of prey in a particular habitat, morphological and behaviour characteristics of the bird species etc. (Ali *et al.*, 2010). In our study, Common myna were seen to prefer perched height 0-3m as they are commonly ground foragers. The Indian Roller perched at 3-9m height for locating the prey which was also noted by previous workers (Sivakumaran & Theyagesan, 2003; Ali *et al.*, 2010). Small Bee-eater naturally perched at 3-12m, highest category to scan in an area. Black drongo's average category perching height was 3-9m, it can perch frequently at same place for hunting of prey insects. In general insectivorous birds are height generalists which depend on vegetation structure, plant species composition, prey abundance / distribution, and interspecies competition. It altogether affects the foraging height selection of birds (Robinson & Holmes, 1984; Brookers *et al.*, 1990). Gleaning is foraging method suitable for capturing slow moving insect (Adamik & Kornan, 2004), in our study in Indian Roller and Common Myna it was mostly noted, Nevertheless, Small Bee-eater, Black Drongo foraged mostly by aerial feeding and Common Myna used ground feeding, indicating that these species adopted a foraging technique. Small Bee-eater having of a long bill which is suitable for capturing and confidently grasping aerial insects, having of small bill, Common Myna is a gleaner, prefers ground for ground feeding technique, such forging technique of birds also changes according to their habitat (Murakami, 2002).

Ali *et al.*, (2010) stated that the distribution, abundance, and quality of food may influence the extent of foraging niche overlap. Highest niche overlap was recorded between Black Drongo Vs Indian Roller (perch type), Black Drongo Vs Small Green Bee-eater (perching heights), Indian Roller Vs Common Myna (foraging height), Small Green Bee-eater Vs Indian Roller (foraging substrate) and Indian Roller Vs Common Myna (foraging method). The high and low niche overlap values revealed by these species could be attributed to the bird assemblages, availability of food resources and inter-specific competition in the habitat and high quality food and different populations in respective habitats of study area (Gokula & Vijayan, 2000; Joshi & Shrivastava, 2012). Laxmi Narayana *et al.*, (2013) already reported the variations in the niche overlap in relation to different crops / habitats of bird assemblages from Nalgonda District of Andhra Pradesh

Conclusion:

In general foraging behaviour of birds depends on many factors, such as time of day, season, temperature, weather, availability of prey, breeding season and predator presence (Gokula & Vijayan, 2007). In this paper we had not discussed food items or prey of these insectivorous birds. Study is required on diet preference for better understanding of their guilds. The study suggests beneficial impacts on implementation of IPM (Integrated pest management). It is beneficial for agriculturalists to install T-shaped structure for perches within farmlands at different heights providing perch for the insectivore avifauna. IPM conceptualises Ornithology as one of the potential component within the crops like Cotton, Red gram in the *Helicovera* population. The important thrust area is to identify the beneficial specific birds, which help in the control of particular insects and rodent pests; and to develop methods to encourage them to derive maximum benefits from their activities.

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References:

- Adamik P. & Kornan M. (2004): Foraging ecology of two bark foraging passerine birds in an old-growth temperate forest. *Ornis Fennica*, 81: 13-22.
- Ali A.M.S., Asokan S., Manikannan R. & Nithyanandam T.G. (2010): Foraging behavior of selected birds in Cauvery Delta region of Nagapattinam District, Tamil Nadu, India - A preliminary study. *J.Threatened Taxa*, 2(2):690-694.
- Arrow G.J. (1931): **The Fauna of British India including Ceylon and Burma, Coleoptera: Lamellicornia (Coprinae). III**, Taylor&Francis, London, 428pp.
- Asokan S. (1995): **Ecology of the Small Green Bee-eater, *Merops orientalis* Latham 1801 with special reference to its population, feeding and breeding in Mayiladuthurai, Tamil Nadu, South India**. Ph.D. Thesis, Bharathidasan University, Thiruchirappalli.
- Bell H.L. & Ford H.A. (1990): The influence of food shortage on inter-specific niche overlap and foraging behaviour of three species of Australian warblers (Acanthizid). *Stud. Avian Biol.*, 13: 381-388.
- Brookers M.G., Braithwaite R.W. & Estbergs J.A. (1990): Foraging ecology of some insectivorous and nectarivorous species of birds in forests and woodlands of the wet-dry tropics of Australia. *Emu*, 90: 215-230.
- Dhindsa M.S. & Saini H.K. (1994): Agricultural ornithology: an Indian perspective. *J. Biosc.*, 19: 391-402.
- Gokula V. & Vijayan L. (2000): Foraging pattern of birds during the breeding season in thorn forest of Mudumalai wildlife sanctuary, Tamil Nadu, South India. *Tropic. Ecol.*, 41: 195-208.
- Gokula V. (2001): Foraging patterns of birds in the thorn of Mudumalai Wildlife Sanctuary, Southern India. *J. South Asian Nat. Hist.*, 5: 143-153.
- Gokula V. & Vijayan L. (2007): Foraging strategies of birds in partitioning of food resources in dry deciduous forest of Mudumalai Wildlife Sanctuary, Tamil Nadu, India. *J. Scientific Transac. Environ. Technovation*, 1(1): 36-42.
- Hutto R.L. (1990): Measuring the availability of food resources. *Stud. Avian Biol.*, 13: 20-28.
- Laxmi Narayana B., Pandiyan J. & Vasudeva Rao V. (2011): Checklist of avifauna in the agricultural ecosystem of Sherpally, Nalgonda District, Andhra Pradesh, South India. *Newslet. Birdwatch.*, 51(1):8-12.

- Laxmi Narayana B., Vasudeva Rao V. & Venkateswara Reddy V. (2014): Foraging behaviour of Black drongo (*Dicrurus macrocercus*) in Nalgonda district of Andhra Pradesh, India. *The Bioscan*, 9(2):467-471.
- Laxmi Narayana B., Vasudeva Rao V. & Pandiyan J. (2013): Avifaunal assemblages in relation to different croplands/habitats of Nalgonda District, Andhra Pradesh, India. *Int. J. Life Sci. Biotech. Pharma Res.*, 2(3): 212-224.
- Lammers W. & Collopy M.W. (2007): Effectiveness of avian predator perch deterrents on electric transmission Lines. *J. Wildlife Manag.*, 71(8): 2752-2758.
- Lawton J.H. (1996): Population abundances, geographic ranges, and conservation, 1994 Whitherby Lecture. *Bird Study*, 43:3-19.
- Litvaitis J.A. (2000): Investigating food habits of terrestrial vertebrates. In L Boitani, TK Fuller, eds.: **Research techniques in animal ecology. Controversies and consequences**. Columbia Univ. Press, New York, USA, pp. 165-190.
- Loyn R.H. (2002): Patterns of ecological segregation among forest and woodland birds in south-eastern Australia. *Ornithol. Sci.*, 1: 7-27.
- MacNally R. (1994): Habitat specific guild structure of forest birds in southeastern Australia: a regional scale perspective. *J. Animal Ecol.*, 63:988-1001.
- Miles D.B. (1990): A comparison of three multivariate techniques for the analysis of avian foraging data. *Stud. Avian Biol.*, 13:295-308.
- Murakami M. (2002): Foraging mode shifts of four insectivorous bird species under temporally varying resource distribution in a Japanese deciduous forest. *Ornithol. Sci.*, 1: 6369.
- Parasharya B.M., Dodia J.F., Mathew K.L. & Yadav D.N. (1994): Natural regulation of white grub (*Holotricha* sp. Scarabidae) by birds in agro-ecosystem. *J. Biosc.*, 19: 381-390.
- Pianka E.R. (1973): The structure of lizard communities. *Ann. Rev. Ecol. Sys.*, 4:53-74.
- Recher H.F. & Davis W.E. (1998): The foraging profile of a Wandoo woodland avifauna in early spring. *Australian J. Ecol.*, 23:514-527.
- Recher H.F. & Davis W.E. (2002): Foraging profile of a Salmon Gum woodland avifauna in Western Australia. *J. Royal Soc. Western Austr.*, 85: 103-111.
- Robinsons K. & Holmes R.T. (1984). Foraging behaviour of forest birds: the relationships among search tactics, diet and habitat structure. *Ecology*, 63:1918-1931.
- Shannon C.E. & Weiner W. (1949): **The Mathematical theory of Communication**. University of Illinois Press, Urbana.
- Sivakumaran N. & Thiyagesan K. (2003): Population, diurnal activity patterns and feeding ecology of the Indian Roller *Coracias benghalensis*. *Zoos' Print Journal*, 18(5):1091-1095.
- Somasundaram S. & Vijayan L. (2008): Foraging Behaviour and Guild Structure of Birds in the Montane Wet Temperate Forest of the Palni Hills, South India. *Podoces*, 3:79-91.
- Talmale S.S. & Pradhan M.S. (2009): Identification of some small mammal species through owl pellet analysis. *Records of the Zoological Survey of India, Occasional Paper No- 294*:1-44.
- Vijayan L. & Gokula V. (2006): Human Impact on the Bird Communities in the Western Ghats. In: Proc. of the Chinese Acad. Sciences, Proc. of the 23rd International Ornithological Congress, Beijing 2002. Symposium paper. *Acta Zoologica Sinica*, 52:692-696.
- Wiens J.A. (1989): **Ecology of Bird Communities** - Vols. 1 & 2. Cambridge: Cambridge University Press.