A study on the co-existence mechanisms among the six sympatric species of Drongo (Dicruridae: Aves) in the tourism zone of BRT Tiger Reserve

Draft Final Report

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Karnataka Biodiversity Board

&

Conservator of Forests,

Biligiri Ranganathaswamy Temple Tiger Reserve

By

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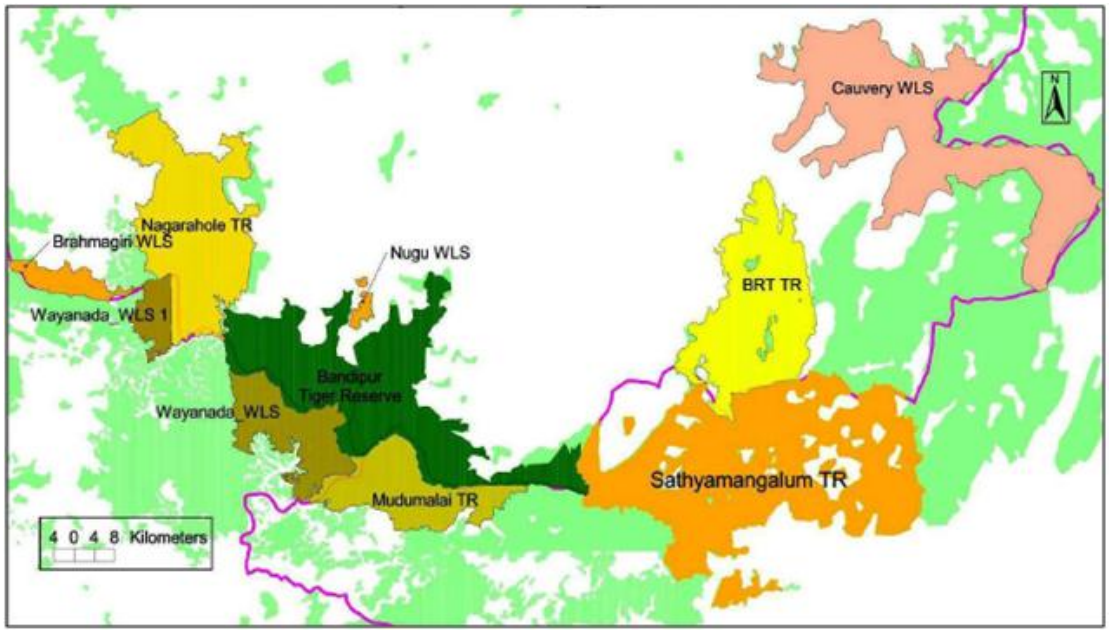
CHAPTER 1: INTRODUCTION

1.1 About the Study Area – Tourism Zone of the BRT Tiger Reserve

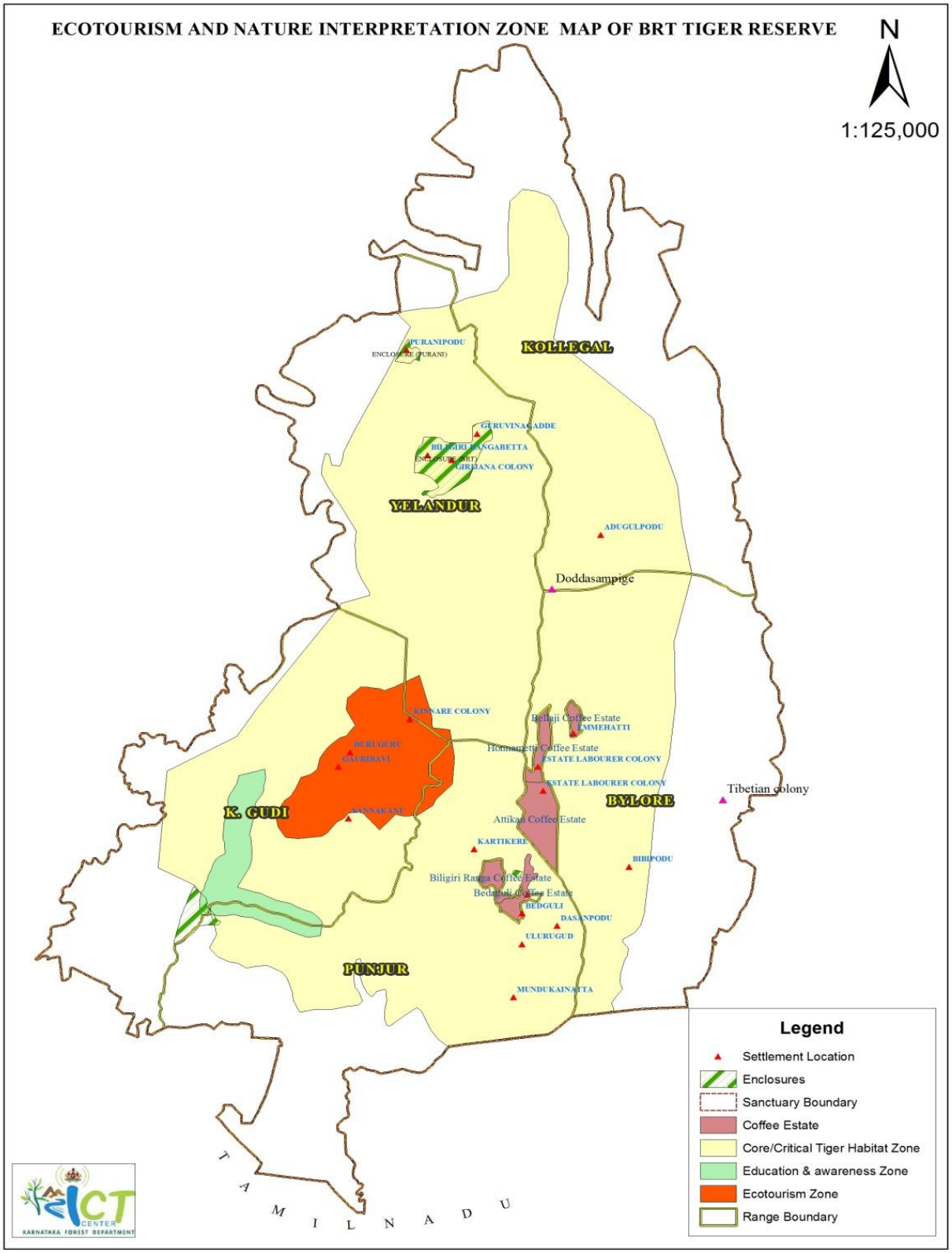
The Biligirirangan Hills, commonly called B R Hills, is a hill range situated in South-Eastern Karnataka, at its border with Tamil Nadu. The site was declared a Tiger Reserve in December 2010, known as Biligiri Ranganathaswamy Temple Tiger Reserve. The sanctuary derives its name Biligiri from the white rock face that constitutes the major hill crowned with the temple of Lord Rangaswamy, or from the white mist and the silver clouds that cover these hills for a greater part of the year.



Map 1 - Landscape map of BRT Tiger Reserve.

1.1.1 Location:

The hills are in the Yelandur and Kollegal Taluks of Chamarajanagar District of Karnataka. The hills are contiguous with the Sathyamangalam Wildlife Sanctuary to the South. Biogeographically, the sanctuary is unique. It is located between 11° and 12° N and the ridges of the hills run in the north-south direction. It is a projection of the Western Ghats in a north-easterly direction and meets the splintered hills of the Eastern Ghats at 78° E. This unique extension of Western Ghats constitutes a live bridge between the Eastern and Western Ghats with the sanctuary located almost in the middle of this bridge.



Map 2 – The study area, the tourism zone of BRT Tiger Reserve.

1.1.2 Climate and Vegetation:

The sanctuary, around 35 km long North-South and around 15 km wide East-West is spread over an area of 574 km², with a wide variation in mean temperature (9 °C to 16 °C minimum and 20 °C to 38 °C maximum) and annual rainfall (600 mm at the base and 3000 mm at the top of the hills). The hill ranges, within the sanctuary rise as high as 1200 m above the basal plateau of 600 m and run North-South in two ridges. The wide range of climatic conditions along with the altitude variations within the small area of the sanctuary have translated it into a highly heterogeneous mosaic of habitats such that we find almost all major forest vegetation types – scrub, deciduous, riparian, evergreen, sholas and grasslands.

According to Champion and Seth's classification (1968), the major forests of the area can be broadly classified into the following sub-types:

1. Tropical Evergreen Forests
2. Southern Tropical Semi-evergreen Forests
3. South Indian Moist Deciduous Forest
4. Southern Tropical Dry Deciduous Forests
5. Montane Wet Temperate Forests

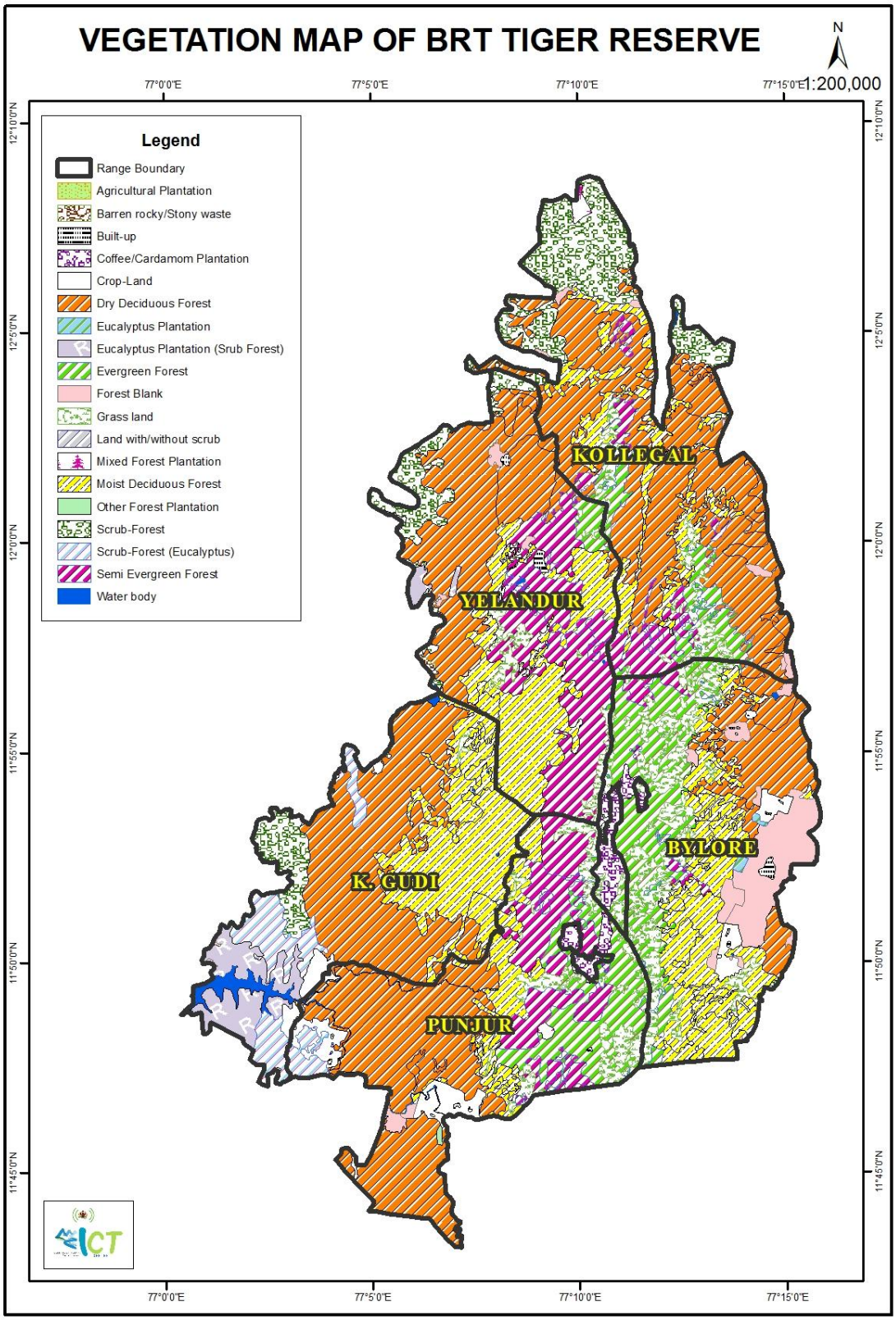
The forests range from scrub forests at lower elevations, degraded by over-use, to the tall deciduous forests typical of the ecoregion, to stunted shola forests and montane grasslands at the highest elevations, which exceed 1800 meters. The scrub vegetation type of forest is a home for *Adina cordifolia*, *Zizyphus* spp., *Emblica officinalis*, *Chloroxylon* spp. and *Acacia* spp. The moist deciduous part includes *Terminalia paniculata*, *Terminalia tomentosa*, *Terminalia bellerica*. The semi-evergreen part includes *Kydia calycina*, *Michelia champaca*, *Syzigium cuminii*. The rare variety plants like *Lillium nilagiricance* and *Remusatea vivipara* grown in this area. The Soliga tribals are accustomed to use more than 300 herbs for the treatment of various ailments.

All these types of vegetation form a very good habitat in terms of shelter and food availability. Tree savannas, shrub savannas and woodland savannas are major habitat for wild animals in terms of grass and leaf fodder availability. During pinch period, animals augment their nutrition through fruits and barks.

1.1.3 Values of the Reserve:

1.1.3.1 Ecological Value –

Entire protected area along with adjoining areas of Sathyamangalam and Mudumalai tiger reserves, Kollegal Wildlife Sanctuary and Cauvery Wildlife Sanctuary forms a unique chunk of biogeographical zone which acts as a live bridge between the Western Ghats and the Eastern Ghats.

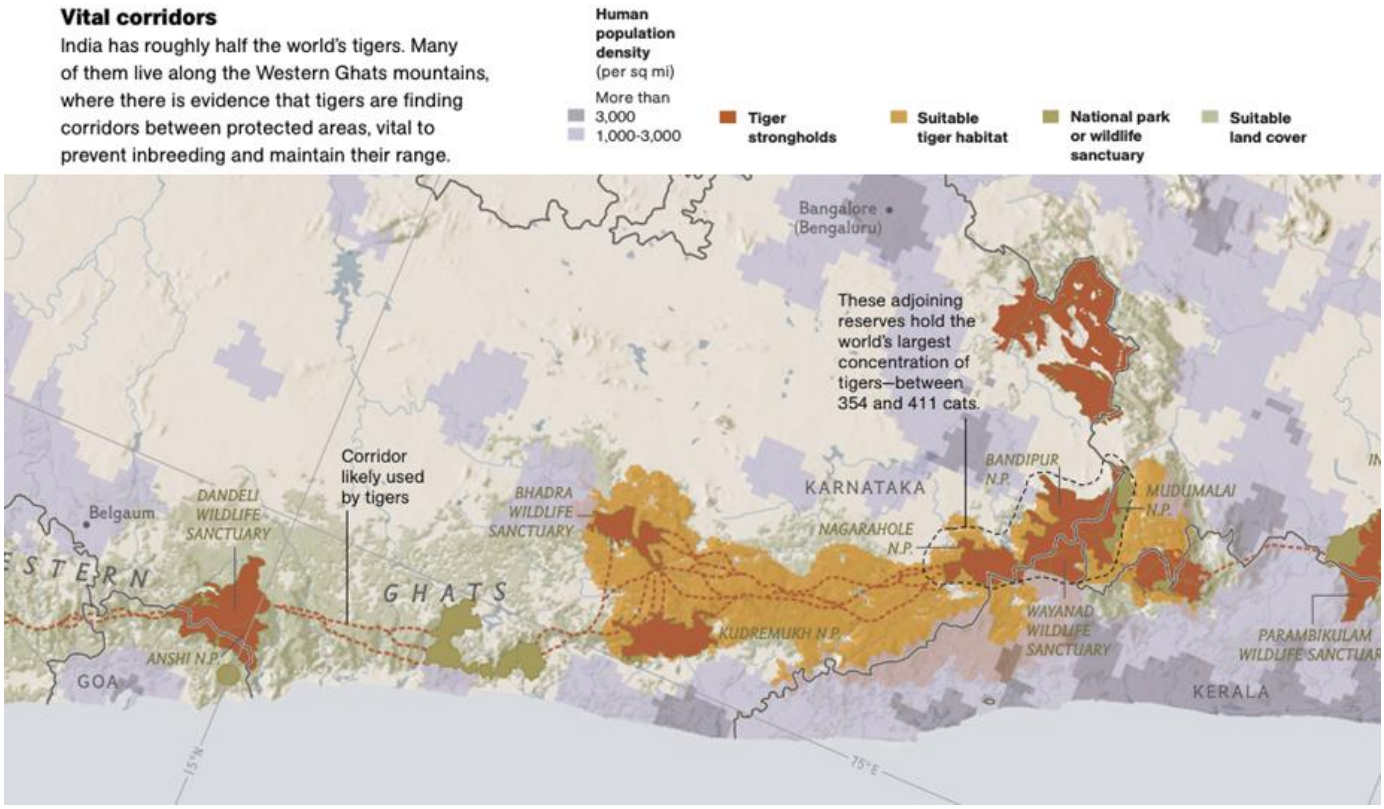


Map 3 – Different vegetation types of BRT Tiger Reserve.

Since the hills range links the Western Ghats and the Eastern Ghats, they allow animals to move between the Ghats and facilitate gene flow between populations of species in these areas. Thus, this sanctuary serves as an important biological bridge for the biota of the entire Deccan plateau. The biota of BRT sanctuary is predominantly of Western Ghats in nature, with significant proportion of Eastern elements as well.

The landscape complex around the BRT Tiger Reserve has tiger occupancy in 11,100 km^2 with an estimated tiger population of about 382 (354 - 411) tigers, constituting the single largest tiger population in the world (Jhala, Qureshi, Gopal, & Sinha, 2011). Connection to wider tiger landscape together with good biomass density makes the BRT tiger reserve a potential habitat to support a good tiger population.

The most conspicuous mammals in the BR Hills are the herds of wild Elephants (*Elephas maximus*). The forests are well known for Gaurs (*Bos gaurus*), the largest bovines. It is a good place for small and large mammals. There are about 26 species of mammals recorded in the sanctuary. The other mammals include Sambar (*Rusa unicolor*), Chital (*Axis axis*), the shy Barking Deer (*Muntiacus muntjac*), which are quite common here, and the rare Four-Horned Antelope (*Tetracerus quadricornis*). Carnivores include Tigers (*Panthera tigris*), Leopards (*Panthera pardus*), Asiatic Wild Dogs (*Cuon alpines*), many lesser cats, civets and Sloth Bears (*Melursus ursinus*). Around 280 species of birds have been recorded in the reserve. The reserve harbors a good diversity of butterflies, insects, spiders, amphibians and snakes. A recently discovered species is a Microhylid frog (*Microhyla sholigari*), named after Soligas.



Map 4 – The tiger landscape of which BRT is an integral part.

1.1.3.2 Economic Value –

The Soligas collect a limited amount of honey, Indian Gooseberry (Phyllanthus emblica) fruits and lichens from the forest. The honey is processed with help of the Forest Department and sold at various outlets. The ecotourism services provided by the Forest Department, Jungle Lodges & Resorts (a government undertaking), and some private homestays also contribute to local economy. In addition to that, the Soligas have been using various species of plants for medicinal purposes.

1.1.3.3 People & Cultural Value –

For hundreds of years, this region has been the home for the semi-nomadic Soliga tribe. The forest regions of Yelandur, Chamarajanagar and Kollegal, including the hilly tracts and foothills of Biligirirangan and Male Mahadeshwara in the southern part of Karnataka, are inhabited by nearly twenty thousand Soliga tribal people. The Soligas inhabiting this range were nature worshippers originally.

The hills are famous for the temple of Lord Ranganatha or Lord Venkatesha which is situated on the highest peak of the hill range, on the 'white cliff' which gives the hill its name. The local form of the deity is called Biligiriranga and is depicted in a unique standing position. The local tribes present a large pair of slippers measuring 1-foot (0.30 m) and 9 inches, made up of skin, to the Ranganathaswamy once in two years.

There is another point of holy reverence in the forests of the reserve. It is a gigantic Champak (*Michelia champaca*) known as "Doddasampige". It is stands to the east of the riverbank, of the river Bhargavi (a tributary of the Cauvery). It is said to be around 600-800 years old, and measures about 43 m in height and about 20 m in girth. The tree is compared to Lord Shiva, who is having a braid. The "Doddasampige" has been the God of the Soligas, who perform fire dance surrounding the tree on the eve of Maha Shivarathri festival. The tree bears usual flowers of both reddish and yellowish color during April. On the east side of the platform there are more than 100 lingams, which are worshipped. This tree symbolizes the tribals' relation with nature. (Biligiriranga Hills, n.d.)

The tourism area in is Kyathadevarayana Gudi range of the reserve, with a mixed forest, consisting of trees from dry deciduous and moist deciduous habitats, with many riparian patches. It is an area of about 13 sq km.

1.2 Background of the Project

There has always been a debate about the importance of interspecific competition in structuring animal communities. To study how the animal species deal with this competition, and as a result, coexist, niche studies started, and then, became popular in 1970-80s. Alatalo, 1982 says that because of weak data from many of those studies, many scientists had started doubting the role of competition in structuring animal communities, and that the study on Tits provided strong evidence for the existence of such competition. The interest in competition and co-existence comes from presence of a number of similar, but different species in bird communities all over the world.

A similar situation prevails in the Tourism Zone of BRT Tiger Reserve. The guild of insectivores consists of different families of birds, ranging from Flycatchers to Drongos to Barbets. The presence of Drongo family (Dicruridae) is marked by presence of six species, one of them, Ashy Drongo *Dicrurus leucophaeus*, being a winter migratory. This raises questions about the competition in these six species, their coexistence and the adjustments that they make to avoid the competition for resources with others.

The project aimed to study the dynamics related to the above questions.

1.3 Objectives/Deliverables of the Project

The objectives of the project were to –

i. To study the presence of migratory Ashy Drongo with respect to that of the resident Drongo species.
ii. To understand the activity patterns of different species of Drongos.
iii. To study the inter-specific interactions within the six Drongo species.
iv. To study the association of Drongo species with other birds.
v. To study the spatial use patterns of the six Drongo species.

1.4 Duration of the Project

The project work spanned a period of two years. Data collection started in Nov 2013 and continued till May 2015.

CHAPTER 2: INTRODUCTION TO THE TARGET SPECIES & THEIR BEHAVIORAL ASPECTS

2.1 The Family (*Dicruridae*)

The birds belonging to this family are medium-sized, passerine birds, called Drongos. They are mainly arboreal and insectivorous. Usually solitary, they can be found in flocks at good food sources. They are bold and aggressive, especially for protecting their nesting territories. The nests are cup-shaped, made of twigs, grasses, and cobwebs, usually between in horizontal forks at end of branches. They are known to be good mimics.

2.2 The Species

2.2.1 Black Drongo (*Dicrurus macrocercus*):

It is a glossy black bird, with a deeply forked tail. It can be identified by shiny blue-black throat and breast, and white rictal spot. Usually found in open cultivation near villages and suburbs, it swoops down or launches sallies for insects from exposed look-out posts. A number of them collect at forest fires or grassland fires. It is aggressive and fearless, and will attack much larger birds that enter their nesting territory (Ali, Asokan, Manikannan, & Nithiyanandam, 2010). It is found throughout much of the subcontinent, except parts of North West, North East and Himalayas.

2.2.2 Ashy Drongo (*Dicrurus leucophaeus*):

It is essentially a forest bird, which uses tree tops. It can be identified by dark grey throat, breast and flanks. It has more deeply forked tail than Black Drongo and has a striking red iris. It is found in open broadleaved and coniferous forests in breeding season and in well wooded areas in winter. It breeds in Himalayas, and migrates to most of the Southern peninsula in winters.

2.2.3 Bronzed Drongo (*Dicrurus aeneus*):

It is a small, forest dwelling bird. It differs from both of above mentioned species by smaller size, spangled crown, nape, mantle and breast, and less deeply forked tail. It is a regular member of mixed hunting parties. It is found in broadleaved evergreen and moist deciduous forests, and also in coffee and rubber plantations. It is found from Himalayan foothills in Northern Uttar Pradesh towards East till Arunachal Pradesh, and South through the hills of NE India and Bangladesh, and in Eastern and Western Ghats.

2.2.4 Grater Racket-tailed Drongo (*Dicrurus paradiseus*):

It is a large forest dwelling Drongo, with long tail-rackets (webbed only on one side of shaft). The tail-streamers and rackets can be broken, and tail can be almost square ended when in mould. It has a conspicuous backward-curving crest on forehead. It is quite sociable, and is a regular member of mixed hunting parties. It is known for its mimicking capability, as it can mimic upto 40 different sounds, including some of the mammals. Usually found in broadleaved forests and bamboo jungles, it occurs

widely thoughout peninsula - from South Gujarat and North-East Haryana east through South Nepal to North-East India and Bangladesh, and then south through the subcontinent.

2.2.5 Spangled Drongo (*Dicrurus hottentottus*):

It is a large, stocky, forest dwelling Drongo, having a hair-like crest, a broad tail with shallow, outward- and upward-twisted fork, and a long down-curved bill, a metallic spangling on crown, sides of neck, throat and breast, and highly glossed tail and wings. It feeds mainly flower nectar, but preys upon insects also. IT is found in broadleaved evergreen and moist deciduous forests, from Himalayan foothills in Punjab towards East to Arunachal Pradesh, south through hills of North-East India and Bangladesh, and Eastern and Western Ghats.

2.2.6 White-bellied Drongo (*Dicrurus caerulescens*):

It is a medium-sized bird, having brownish-grey throat and breast, no glossy sheen, and white belly and undertail-coverts. The tail is short, with a shallow fork. It is commonly found in association with Bronzed Drongo. It is highly crepuscular. Commonly found in clearings and edges of light forest, well-wooded country, gardens, tea and rubber plantations, it is distributed from East Haryana and South Gujarat east through South Nepal to West Bengal and south through the subcontinent. (Grimmett, Inskipp, & Inskipp, 1998) (Ali & Ripley, 2001)

All the above mentioned species of Dongos have been said to be feeding on nectar by (Ali & Ripley, 2001).

2.3 Some Behavioral Aspects

2.3.1 Mimicry and Kleptoparasitism

Drongos use mimicry and are also found to be kleptoparasites.

According to (Chu, 2001), studies have found that Phainopeplas (*Phainopepla nitens*) recruit other bird species to mob predators by mimicking calls, and that Racket-tailed Drongos (*Dicrurus paradiseus*) form foraging partnerships with species attracted by their mimetic vocalizations (Goodale & Kotagama, 2008). Another function of vocal mimicry is indicated in its use by Cuckoos whose chicks mimic the begging calls of host species, thus allowing them to evade rejection by host parents (Langmore, Hunt, & Kilner, 2003). (Flower, 2011)

(Ridley & Raihani, 2006) investigated the response of cooperatively breeding pied babblers (*Turdoides bicolor*) to the Drongo (*Dicrurus adsimilis*), an avian kleptoparasite that regularly follows pied babbler groups, often giving alarm calls to alert the group to predators but also occasionally giving false alarm calls in order to steal food items.

(Ridley, Child, & Bell, 2007) studied the interspecific audience effect on the alarm-calling behaviour of the kleptoparasitic Fork-tailed drongo (*Dicrurus adsimilis*). When foraging solitarily, drongos regularly alarm at aerial predators, but rarely alarm at terrestrial predators. In contrast, when drongos are

following terrestrially foraging pied babblers (*Turdoides bicolor*) for kleptoparasitic opportunities, they consistently give alarm calls to both aerial and terrestrial predators.

2.3.2 Association

Drongos are quite often found in association with various bird species.

(Veena & Lokesha, 1993) studied mixed flocks of Common Myna (*Acridotherus tristis*) and Jungle Myna (*Acridotherus fuscus*) foraging in pure and mixed flocks of various sizes in fallow lands. These flocks were often found associated with drongos that foraged individually on the insects herded out by the movements of the flocking myna.

Greater Racket-tailed Drongo (*Dicrurus paradiseus*) has been found in flocks with Greater Yellownaped Woodpecker (*Picus flavinucha*) (Bates, 1952) *,* and the Black Drongo (*Dicrurus macrocercus*) has been found to be frequently associated with Common Mynas (*Acridotheres tristis*) in India. (Dewar, 1904). (King & Rappole, 2001)

(Styring & Ickes, 2001) discussed the association of Drongos with Woodpeckers, Malkohas, arboreal Squirrels, and Leafbirds.

(Oommen & Shanker, 2010) illustrated an unusual foraging association between an endemic foliage gleaning tupaid, Nicobar Treeshrew (*Tupaia nicobarica*) and two species of birds; one an insectivorous commensal, Greater Racket-tailed Drongo (*Dicrurus paradiseus*) and the other a diurnal raptor and potential predator, Sparrowhawks (*Accipiter* spp.).

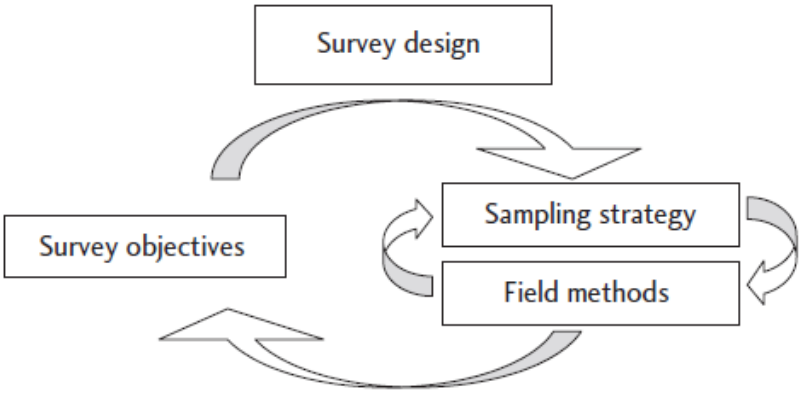
(Sathischandra, Kudavidanage, Goodale, & Kotagama, 2007) noticed many instances when Drongos perched beneath other species caught insects that fell from above, and when Drongos adjusted the perching height depending on whether they were near an Orange-billed Babbler (*Turdoides rufescens)* or an Ashy-headed Laughingthrush (*Garrulax cinereifrons*). In all, Drongos foraged three times more often in flocks than outside them (Sathischandra S. H., Kudavidanage, Kotagama, & Goodale, 2007) .

CHAPTER 3: STUDYING THE BEHAVIORAL ASPECTS

3.1 Relative Density

There are various methodologies to study bird densities.

(Gregory, Gibbons, & Donald, 2004) suggested that although survey design can be seen as a linear process, there should be a strong feedback loop in which the sampling strategies and feedback loops operating in survey design between the survey objectives, sampling strategy, and field methods.



The following parameters were considered when making choice for the adequate methodology –

3.1.1 Relative and Absolute Estimates

The methods should be selected based on whether we need absolute results or relative results. Since one of the objectives of the study is to compare the densities of various Drongo species, when Ashy Drongo is present to when Ashy Drongo is absent, the estimate can be seen to be relative. But, absolute estimates over two different seasons need to be found, and then compared. For density estimates, point counts and line transects over same point, or lines, respectively, need to be carried out.

3.1.2 Point counts and Line transects

Point counts involve walking to, and usually marking, a particular spot, and then recording all bird contacts for a pre-determined period (often 5 to 10 minutes) before moving on to the next point. Line transects involve the observer continually walking and recording all contacts either side of the track walked.

Point counts concentrate fully on the birds and habitats without having to watch where you walk. They provide more time to identify contacts, and one is more likely to detect the cryptic and skulking species.

On the other hand, line transects help one to cover ground more quickly and record more birds, with less chance of double counting. It is good for more mobile, and more conspicuous species and also those which ‘flush’ easily. Also, errors in distance estimation are less serious than for point counts. For targeting a few species which are relatively easy to identify but which may be mobile and occur at low densities, line transects are undoubtedly better.

For Drongos, line transects should be used.

(Ali, Asokan, Manikannan, & Nithiyanandam, 2010) also used line transect explained by (Gaston, 1975) for studying population density of Black Drongo (*Dicrurus macrocercus*) at Cauvery Delta, Tamil Nadu.

But, lack of straight roots, dense Lantana, and availability of only curved paths are the difficulties in using straight line transects in the study area. Cutting straight line transects through dense forest would have been time consuming. Hence, the concept of curved transects was used.

(Hiby & Krishna, 2001) explained that the lack of random design, not the lack of straightness, is the real problem. Curvature of the track poses no serious theoretical or practical problems provided a substantial proportion of detections occur within the radius of curvature. The fact that detection distances are generally short in scrub and forested habitats and that there is a natural tendency for paths and trails to avoid sharp turns suggests that, in terms of curvature, most would be suitable as transects.

Curved transects, of length 500 m, satisfying the conditions in (Hiby & Krishna, 2001) were noted, most of them on the safari routes and the road passing through the area. To represent habitats less found along the noted routes, viz, riparian, Eucalyptus plantation and hill top, 4 routes were selected. Then, the remaining 16 routes were selected, by starting from a random route and selecting every adequate curved path after a minimum distance of 500 m from the earlier selected path.

The distances were estimated using a Bushnell Yardage rangefinder.

3.1.3 Time of Day and Weather Conditions

The time of the day should correspond to the time of peak activity levels of the selected species. For Drongos, the intervals selected were - morning 0700 hours to 1000 hours, and evening 1500 hours to 1800 hours.

Adverse weather conditions such as low cloud, high winds, rainfall and even very high temperatures can affect results by directly affecting bird activity, or by reducing the chances of actually seeing or hearing the birds, or by reducing the attention levels towards counting. (Bibby, Jones, & Marsden, 1998)

In order to reduce error, sampling was carried out under adequate weather only.

3.1.4 Data Collection

- Transects were traversed for a minimum of 15 times each, around half in the morning time and rest in evening. A total of 347 repetitions were done over all the 20 transects.
- 2 or more individuals were recorded as a group, or a cluster of individuals, only if they were seen interacting, or reacting to the others' presence, or if they were within 2 m of each other till 20 m, and within 5 m of each other after 20 m, till 50 m.
- Double counting was avoided by noting the direction of flying birds.

- The following format was used to collect the data:

Transect No.	Repetition No.	Time Block	Drongo Spp	Number	Prependicular Distance

- The number of total sightings of the different species and the number of times when they were in groups is in the table below:

Species of Drongo	Number of Total Sightings	Number of Group Sightings
Ashy Drongo	172	45
Bronzed Drongo	134	33
White-bellied Drongo	55	2
Greater Racket-tailed Drongo	27	3
Spangled Drongo	1	0
Black Drongo	3	0

3.1.5 Estimations Using DISTANCE software

3.1.5.1 Assumptions –

There are four basic assumptions of distance sampling that should be adhered to if an unbiased density estimate is to be obtained:

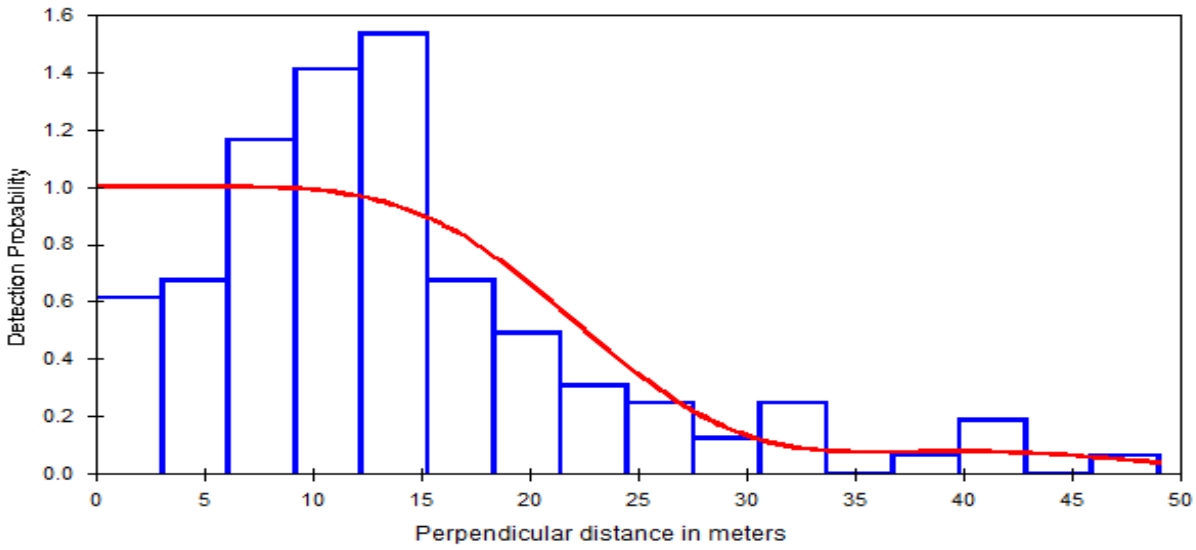
- the transects placement is representative with respect the bird density;
- birds directly on the line or at each point are always detected;
- birds are detected at their initial location prior to any movement;
- distances should be accurately measured. (Bibby, Jones, & Marsden, 1998)

3.1.5.2 Results

The models of the DISTANCE programme were fitted to the distribution of the perpendicular distance data obtained through transects for each species. The model with the lowest Akaike Information Criterion (AIC value); Half normal with cosine adjustments was chosen as the best model.

i. Ashy Drongo

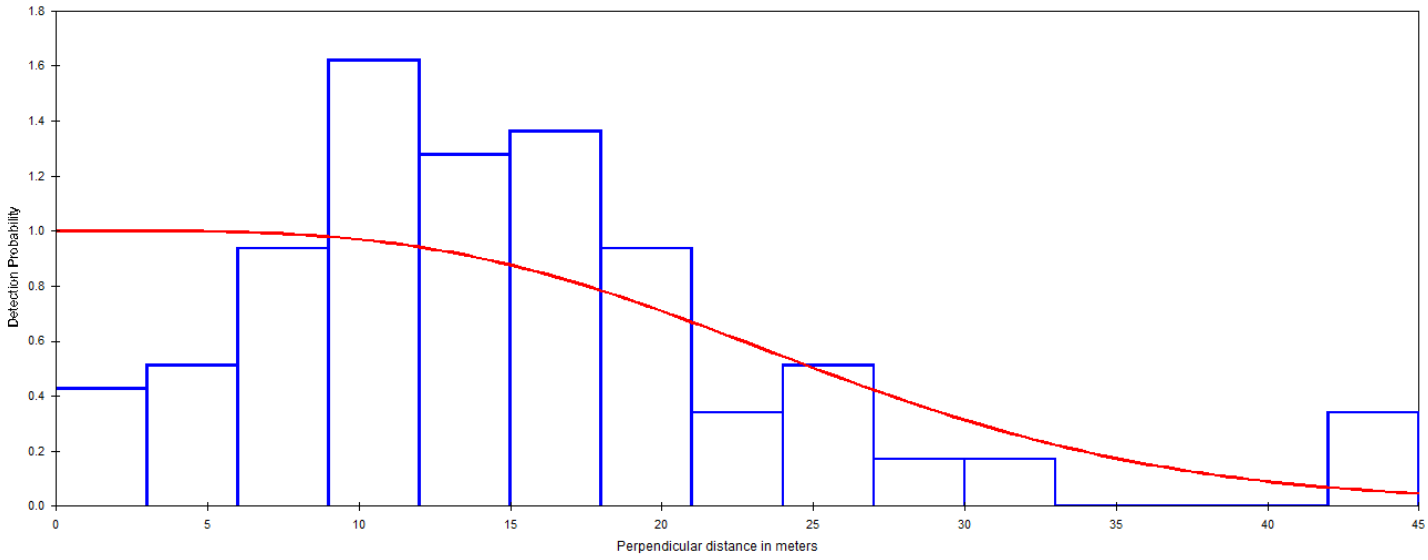
The visibility profile of the chosen model is shown in the plot given below.



The density of Ashy Drongos was estimated to be as 21.276 per sq km with 95% confidence interval from 13.683 – 33.082.

ii. Bronzed Drongo

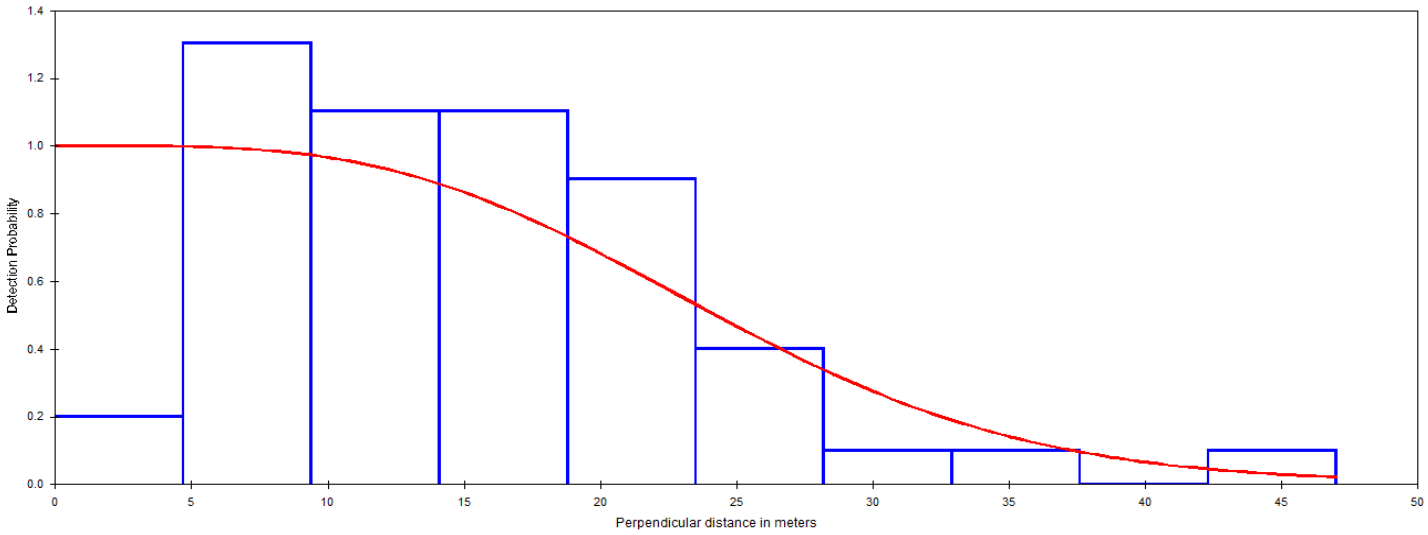
The visibility profile of the chosen model is shown in the plot given below.



The density of Bronzed Drongos was estimated to be as 15.633 per sq km with 95% confidence interval from 9.9987 – 24.443.

iii. White-bellied Drongo

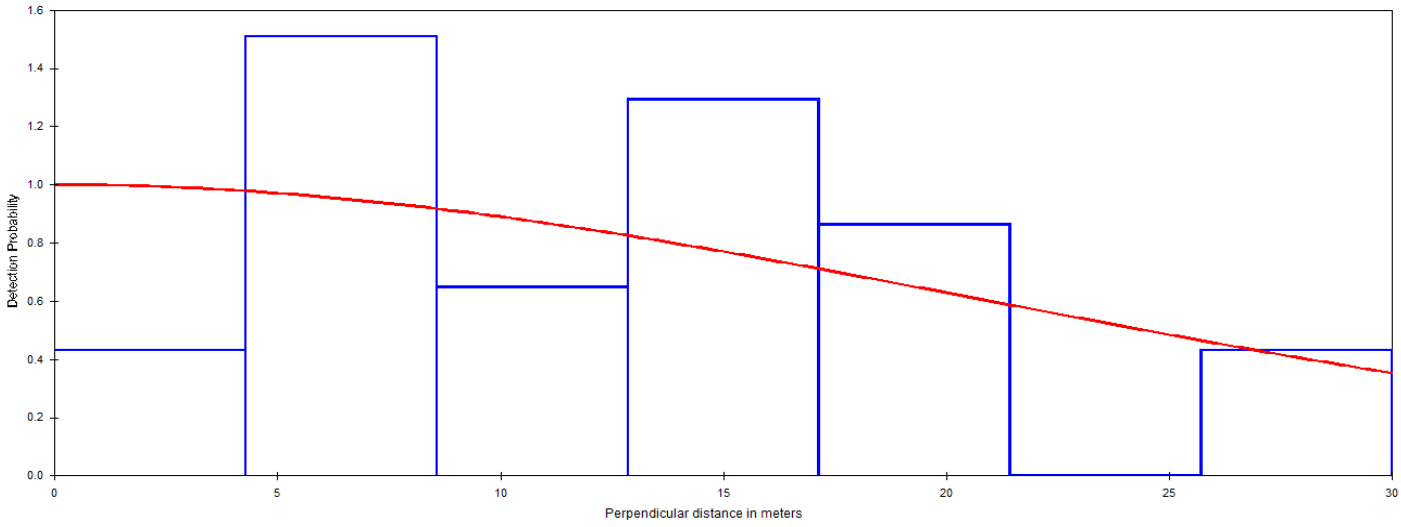
The visibility profile of the chosen model is shown in the plot given below.



The density of White-bellied Drongos was estimated to be as 6.4018 per sq km with 95% confidence interval from 3.7093 – 11.049.

iv. Greater Racket-tailed Drongo

The visibility profile of the chosen model is shown in the plot given below.



The density of Greater Racket-tailed Drongos was estimated to be as 3.5739 per sq km with 95% confidence interval from 2.0482 – 6.2360.

Summary

The densities of the various species of Drongos, not for Spangled Drongo and Black Drongo due to very low individual numbers, as calculated using the data from the transects and DISTANCE software are given below:

Species of Drongo	Density per sq km (Estimate)	Density per sq km (Range with 95 % Confidence Interval)
Ashy Drongo	21.276	13.683 - 33.082
Bronzed Drongo	15.633	9.9987 - 24.443
White-bellied Drongo	6.4018	3.7093 - 11.049
Greater Racket-tailed Drongo	3.5739	2.0482 - 6.2360

The data shows that Ashy Drongo is more dominant in numbers, although it is a migratory species.

3.2 Activity Pattern

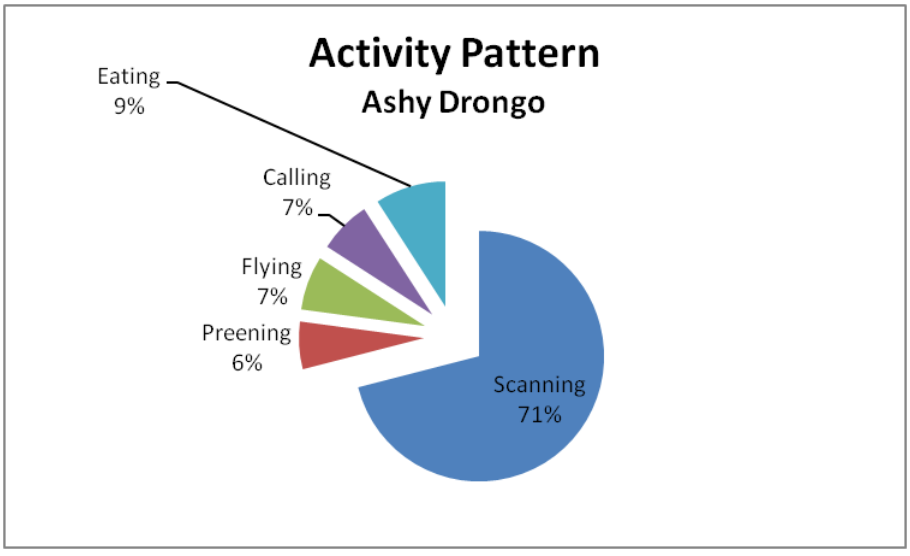
Ali, Asokan, Manikannan, & Nithiyanandam, 2010 used focal animal sampling by Altmann, 1974 for studying diurnal-activity patterns of Black Drongo (*Dicrurus macrocercus*) at Cauvery Delta, Tamil Nadu, India. Altmann, 1974 used the term Focal-Animal Sampling to refer to any sampling method in which (i) all occurrences of specified interactions of an individual, or specified group of individuals, are recorded during each sample period, and (ii) a record is made of the length of each sample period and, for each focal individual, the amount of time during the sample that it is actually in view. Once chosen, a focal individual is followed to whatever extent possible during each of his sample periods.

The Drongos were observed using focal sampling, after categorizing their activities. Around 25 hours of such data had been collected in the following format:

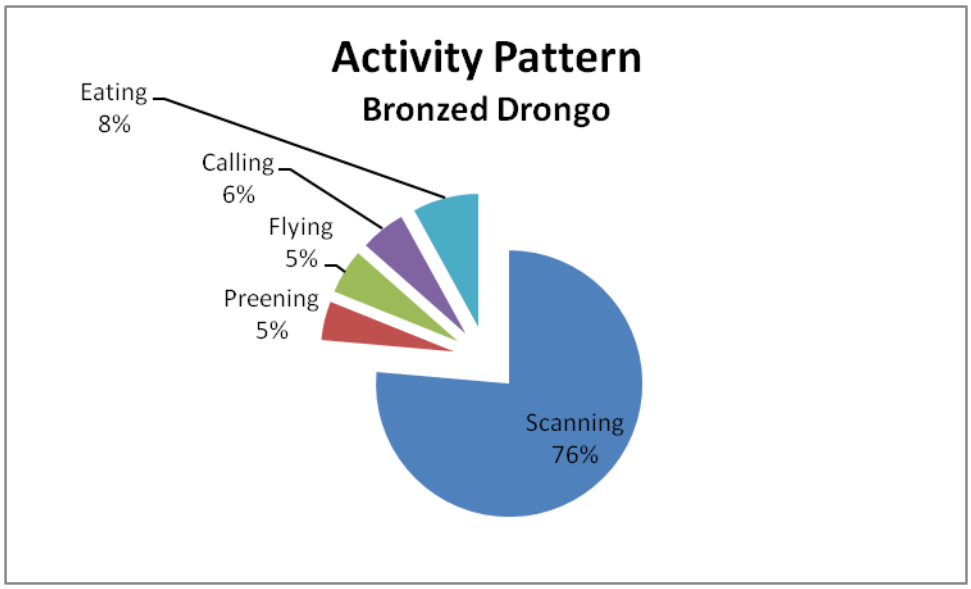
Time Block	Drongo Spp	Activity	From (s)	To (s)	Time Period

3.2.1 Results

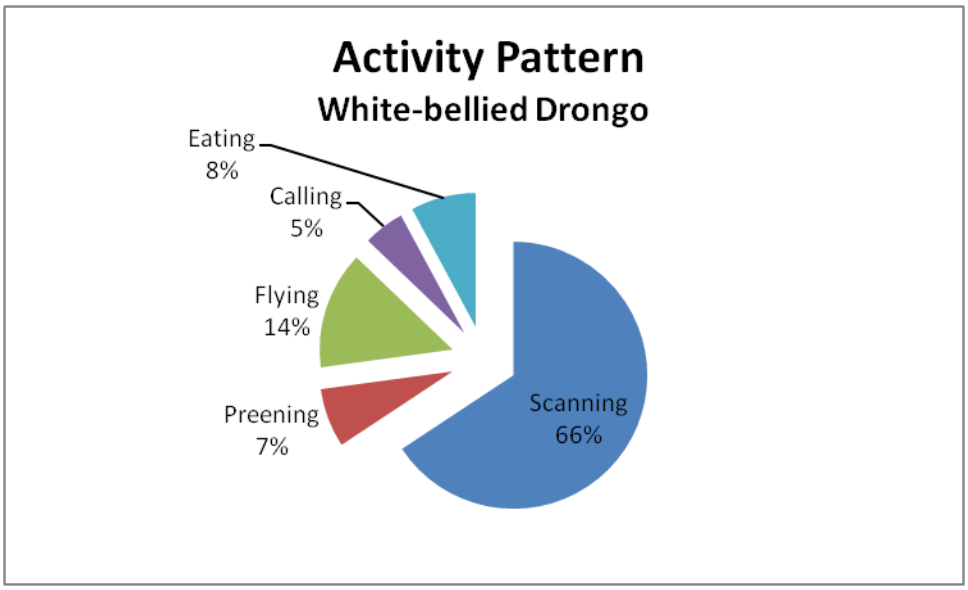
i. Ashy Drongo



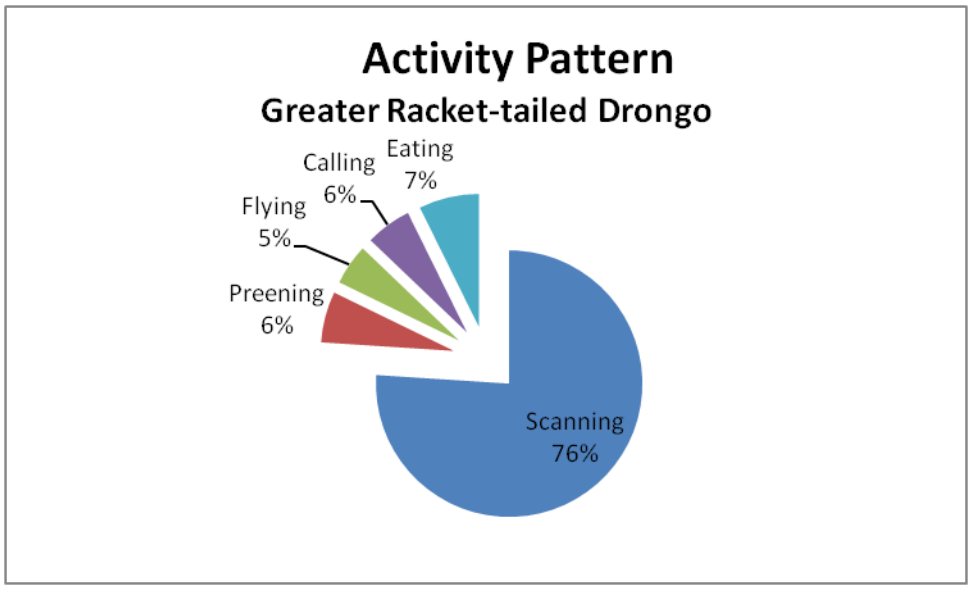
ii. Bronzed Drongo



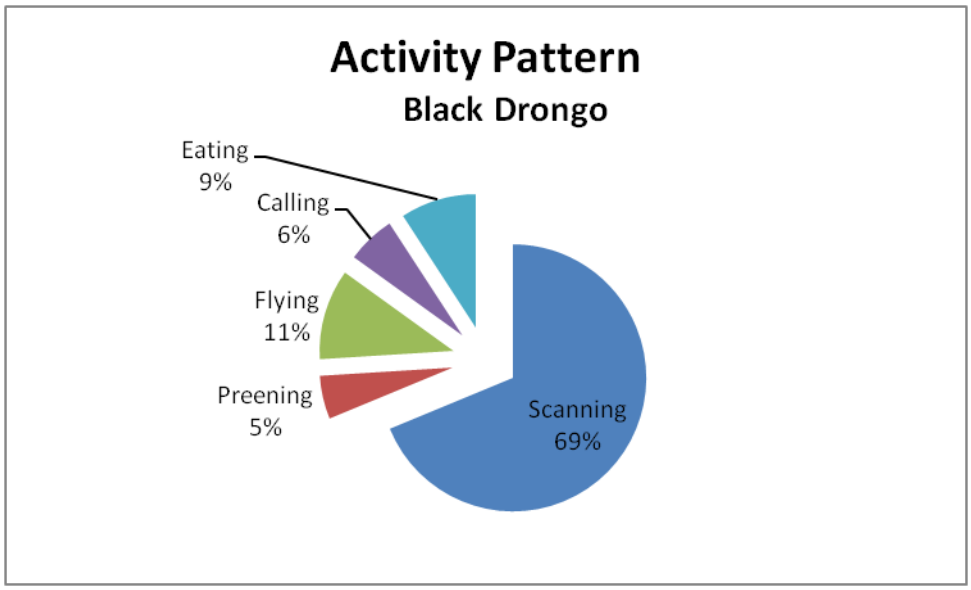
iii. White-bellied Drongo



iv. Greater Racket-tailed Drongo



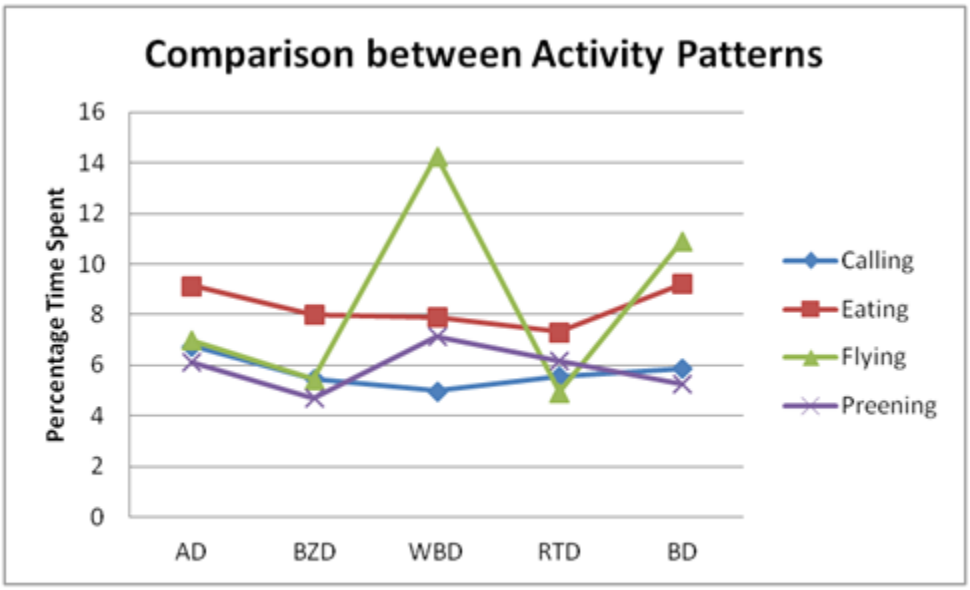
v. Black Drongo



vi. Spangled Drongo

Due to very low sightings of Spangled Drongo, significant data could not be collected for Spangled Drongo.

vii. Comparison between Activity Patterns



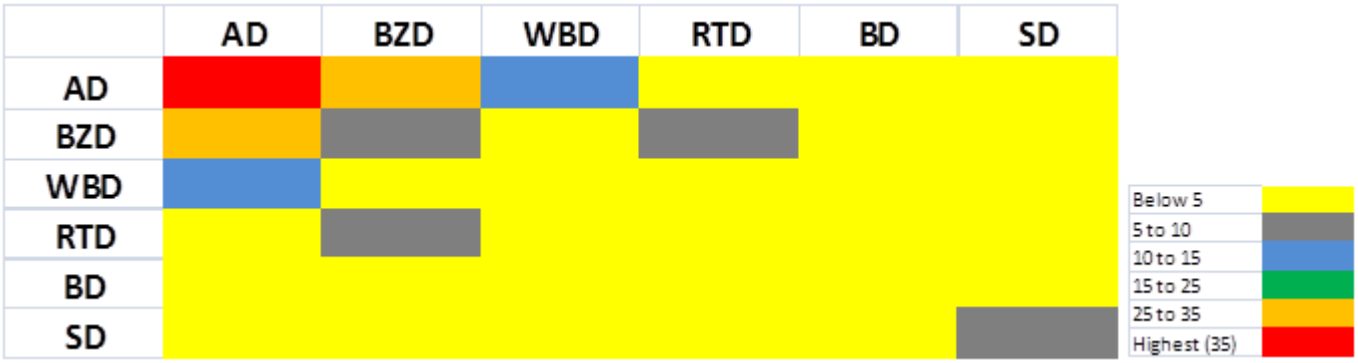
	71	76	66	76	69	Scanning

This shows that there is no significant difference between activity patterns of Ashy Drongo, Bronzed Drongo and Greater Racket-tailed Drongo.

A significant difference exists between the group mentioned above and the group containing White-bellied Drongo and Black Drongo. While the first group invests more time in scanning, the second group invests that time in flying. This may point to more number of sallies or tries by the second group, and to more conservative approach by the first group.

3.3 Inter-specific Interactions between different species of Drongo

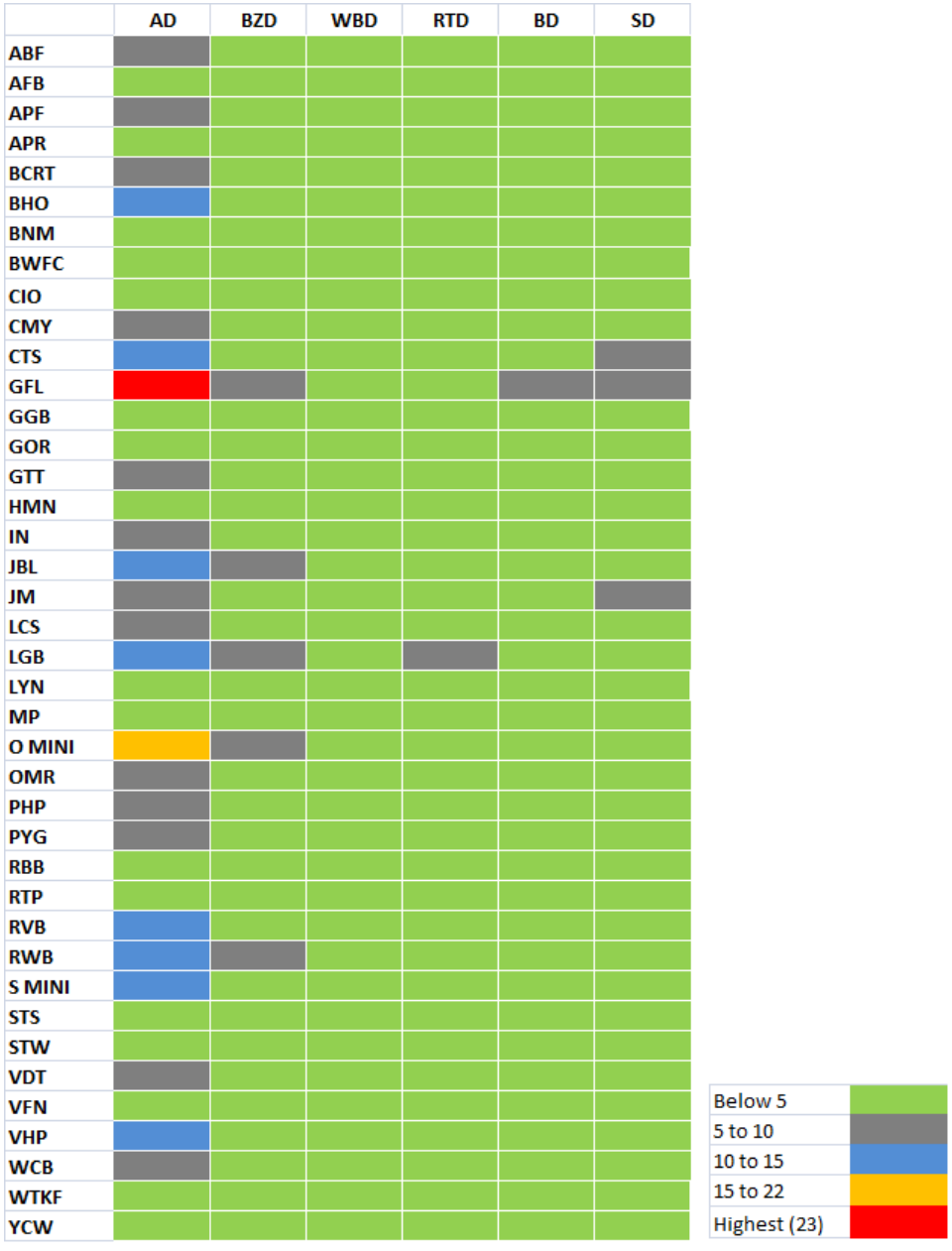
The frequency of the inter-specific interactions between the six species of Drongos is as given in the following graphic:



Ashy Drongo, followed by Bronzed Drongo, was the most social species. Most of the groups formed by Ashy Drongos would have multiple Ashy Drongos, and Bronzed Drongos would also be present quite often. White-bellied Drongo was also found more often with Ashy Drongo than with others. Racket-tailed Drongo was found more with Bronzed Drongo, while Spangled Drongos would mostly be in groups of their own. Black Drongo was the least social of all the six species of Drongos, probably because of their occasional presence and low numbers in the area.

3.4 Association of Drongos with birds from other Genera

The association of Drongos with other birds can be judged by their frequency of interactions as given below:



The names for species given in the above table are:

ABF	Asian Brown Flycatcher (*Muscicapa dauurica*)	**GOR**	Indian Golden Oriole (*Oriolus (oriolus) kundoo*)
AFB	Asian Fairy Bluebird (*Irena puella*)	**GTT**	Great Tit (*Porus major*)
APF	Asian Paradise Flycatcher (*Terpsiphone paradisi*)	**HMN**	Lesser Hill Myna (*Gracula (religiosa) indica*)
APR	Ashy Prinia (*Prinia socialis*)	**IN**	Indian Nuthatch (*Sitta castanea*)
BCRT	Blue-capped Roack Thrush (*Monticola cinclorhynchus*)	**JBL**	Jungle Babbler (*Turdoides striata*)
BHO	Black-hooded Oriole (*Oriolus xantharnus*)	**JM**	Jungle Myna (*Acridotheres fuscus*)
BNM	Black-naped Monarch (*Hypothymis azurea*)	**LCS**	Large Cuckooshrike (*Coracina macei*)
BWFC	Bar-winged Flycatcher Shrike (*Hemipus picatus*)	**LGB**	Lesser Goldenback (*Dinopium benghafense*)
CIO	Common Iora (*Aegithina tiphia*)	**LYN**	Lesser Yellownape (*Picus chlorolophus*)
CMY	Common Myna (*Acridotheres tristis*)	**MP**	Malabar Parakeet (*Psittacula columboides*)
CTS	Chestnut-tailed Starling (*Sturnia mafabarica*)	**O MINI**	Orange Minivet (*Pericrocotus flammeus*)
GFL	Golden-fronted Leafbird (*Chloropsis aurifrons*)	**OMR**	Oriental Magpie Robin (*Copsychus saularis*)
GGB	Greater Goldenback (*Chrysocolaptes lucidus*)	**PHP**	Plum-headed Parakeet (*Psittacula cyanocephala*)

PYG	Brown-capped Pygmy Woodpecker (*Dendrocopos nanus*)
RBB	Rufous Babbler (*Turdoides subrufa*)
RTP	Rufous Treepie (*Dendrocitta vagabunda*)
RVB	Red-vented Bulbul (*Pycnono tuscafer*)
RWB	Red-whiskered Bulbul (*Pycnonotus jocosus*)
S MINI	Small Minivet (*Pericrocotus cinnamomeus*)
STS	Southern (Madras) Tree Shrew (*Anathana ellioti*)
STW	Streak-throated Woodpecker (*Picus xanthopygaeus*)
VDT	Verditer Flycatcher (*Eurnyias thalassinus*)
VFN	Velvet-fronted Nuthatch (*Sitta frontalis*)
VHP	Vernal Hanging Parrot (*Loriculus vernalis*)
WCB	White-cheeked Barbet (*Megalaima viridis*)
WTKF	White-throated Kingfisher (*Halcyon smyrnensis*)
YCW	Yellow-crowned Woodpecker (*Dendrocopos mahrattensis*)

Ashy Drongo was found to be associated most frequently with Golden-fronted Leafbird, followed by Orange Minivet, followed by a group of birds including Black-hooded Oriole, Chestnut-tailed Starling, Jungle Babbler, Lesser Goldenback, Red-vented Bulbul, Red-whiskered Bulbul, Small Minivet and Vernal Hanging Parrot.

Bronzed Drongo was found to be associated often with Golden-fronted Leafbird, Jungle Babbler, Lesser Goldenback, Orange Minivet and Red-whiskered Bulbul.

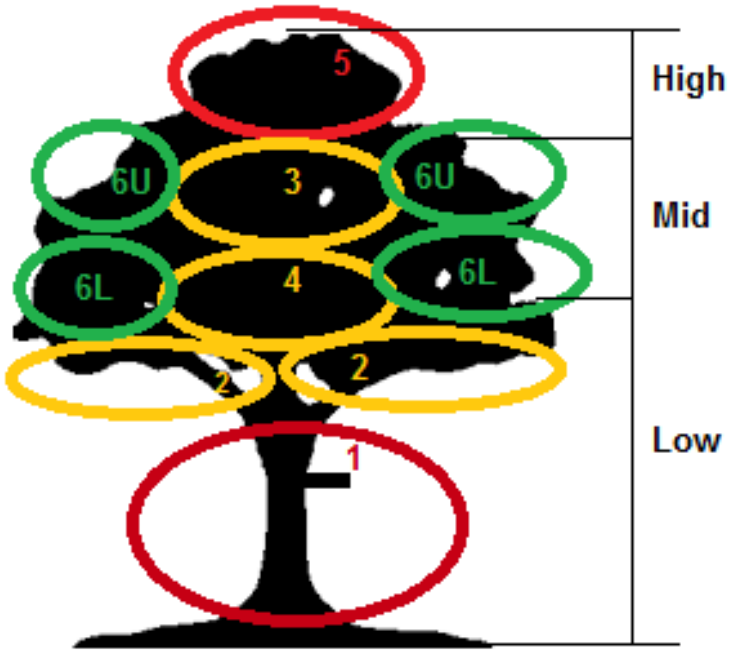
The instances of White-bellied Drongo being with other birds were fairly equally distributed over the species mentioned above, but not associated with any bird significantly.

Racket-tailed Drongo was found to be associated more with Lesser Goldenback, Black Drongo with Golden-fronted Leafbird and Spangled Drongo with Chestnut-tailed Starling, Golden-fronted Leafbird and Jungle Myna.

Out of all the 40 species listed above, Golden-fronted Leafbird, followed by Lesser Goldenback, were associated with more Drongo species.

3.5 Spatial Niche

For understanding the spatial niche, canopy was stratified as given below:



The colored circles were used to stratify tree canopy, while the approximate scale on left was used to stratify overall canopy. The instances of presence of Drongos were noted.

The frequencies of instances of presence of Drongos in these strata are given below:

	1	2	3	4	5	6L	6U
AD	0.066667	0.083333	0.116667	0.116667	0.2	0.183333	0.233333
BzD	0.1	0.25	0.1	0.2	0	0.25	0.1
WBD	0.352941	0.352941	0	0.117647	0.117647	0.058824	0
RTD	0.142857	0.214286	0	0.357143	0.071429	0.214286	0
BD	0.307692	0.230769	0.076923	0.230769	0	0.153846	0
SD	0	0.117647	0.352941	0.117647	0.294118	0.058824	0.058824

0 to 7%	
8% to 15%	
16 to 23%	
24% to 31%	
32 to 36%	

Ashy Drongo uses more of the upper portion and the sides of the canopy. Bronzed Drongo uses more of the lower leafy zone of the tree canopy. The lower canopy is used the most by White-bellied Drongo, closely followed by Black Drongo. The Greater Racket-tailed Drongo follows a pattern similar to Bronzed Drongo, and keeps to lower leafy zone of the canopy. The sightings of Spangled Drongo were less, and always on flowering trees; and the presence would have certainly been affected by the availability of nectar in the flowers.

	Low	Mid	High
AD	0.247423	0.381443	0.371134
BzD	0.431818	0.477273	0.090909
WBD	0.551724	0.275862	0.172414
RTD	0.411765	0.411765	0.176471
BD	0.608696	0.347826	0.043478
SD	0.235294	0.352941	0.411765

4% to 15%	
16% to 27%	
28% to 39%	
40% to 51%	
52% to 61%	

In the overall canopy, the Ashy Drongo covers higher and middle zone more, the Bronzed Drongo and the Racket Railed Drongos cover middle and lower more. The White-bellied Drongo and Black Drongo cover lower zone more, while the Spangled Drongo follows the pattern of Ashy Drongo, with more coverage of higher zone.

3.6 Conclusion

The co-existence of these 6 species of Drongos might be feasible because of the difference in canopy usage, activity pattern and in association with other species, as has been found in this study.

PLATES

Ashy Drongo on a high, open perch

A Black Drongo chasing a conspecific

A Bronzed Drongo perching near water

A White-bellied Drongo on an open perch

A Greater Racket-tailed Drongo

Some of the birds that join food search with Drongos: Top, left – Asian Brown Flycatcher; Top, right – Jungle Babblers; Bottom, left – Orange Minivet (Male); Bottom, right – Lesser Yellownape.

APPENDIX A: BIBLIOGRAPHY / RESOURCES ON THE INTERNET

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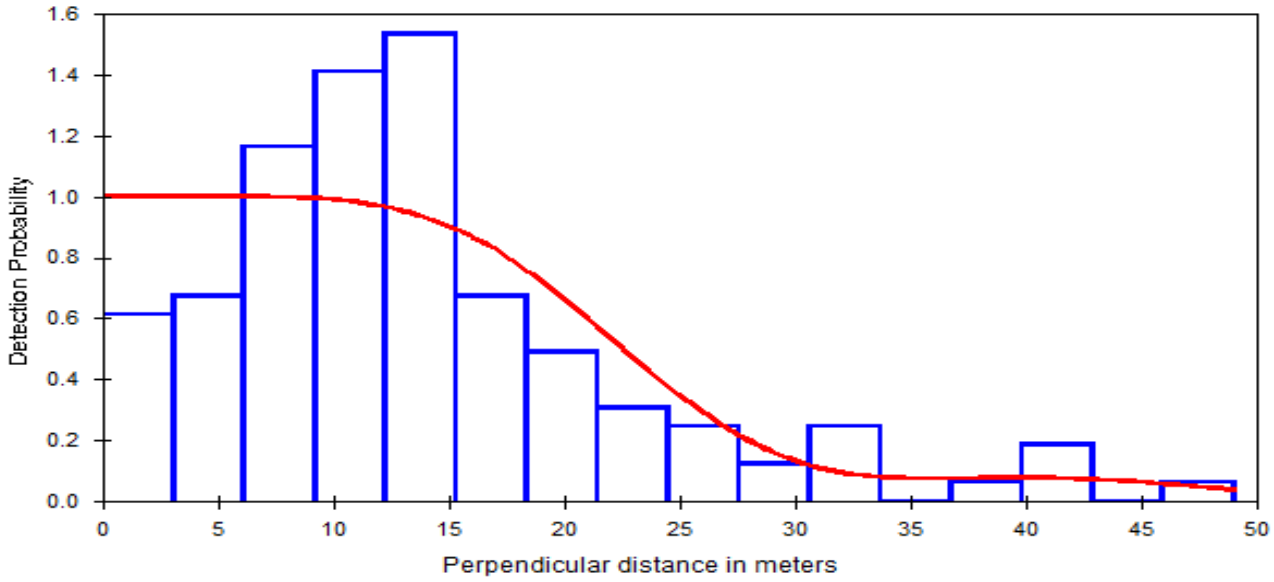
ANNEXURES

Annexure 1: DISTANCE Analysis Results for Ashy Drongo

Detection Fct/Global/Plot: Detection Probability



Detection Fct/Global/Chi-sq GOF Test

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	3.06	10	16.30	2.434
2	3.06	6.12	11	16.30	1.723
3	6.12	9.19	19	16.27	0.456
4	9.19	12.2	23	16.05	3.006
5	12.2	15.3	25	15.27	6.197
6	15.3	18.4	11	13.57	0.488
7	18.4	21.4	8	10.92	0.781
8	21.4	24.5	5	7.76	0.981
9	24.5	27.6	4	4.81	0.136
10	27.6	30.6	2	2.68	0.172
11	30.6	33.7	4	1.56	3.808
12	33.7	36.8	0	1.22	1.222
13	36.8	39.8	1	1.23	0.042
14	39.8	42.9	3	1.22	2.599
15	42.9	45.9	0	1.06	1.058
16	45.9	49.0	1	0.78	0.063

Total Chi-square value = 25.1642 Degrees of Freedom = 11.00

Probability of a greater chi-square value, P = 0.00863

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	3.06	10	16.30	2.434
2	3.06	6.12	11	16.30	1.723
3	6.12	9.19	19	16.27	0.456
4	9.19	12.2	23	16.05	3.006
5	12.2	15.3	25	15.27	6.197
6	15.3	18.4	11	13.57	0.488
7	18.4	21.4	8	10.92	0.781
8	21.4	24.5	5	7.76	0.981
9	24.5	27.6	4	4.81	0.136
10	27.6	30.6	2	2.68	0.172
11	30.6	33.7	4	1.56	3.808
12	33.7	36.8	0	1.22	1.222
13	36.8	39.8	1	1.23	0.042
14	39.8	49.0	4	3.06	0.292

Total Chi-square value = 21.7351 Degrees of Freedom = 9.00

Probability of a greater chi-square value, P = 0.00976

Density Estimates/Global

Effort : 173.5000
samples : 347
Width : 49.00000
observations: 127

Model 4
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Cosine adjustments of order(s) : 2, 3, 4

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
DS	15.338	3.4425	22.44	9.9055	23.749
E(S)	1.3872	0.44321E-01	3.20	1.3022	1.4777
D	21.276	4.8235	22.67	13.683	33.082
N	298.00	67.560	22.67	192.00	463.00

Measurement Units

Density: Numbers/Sq. kilometers

ESW: meters

Component Percentages of Var(D)

Detection probability : 76.7

Encounter rate : 21.4

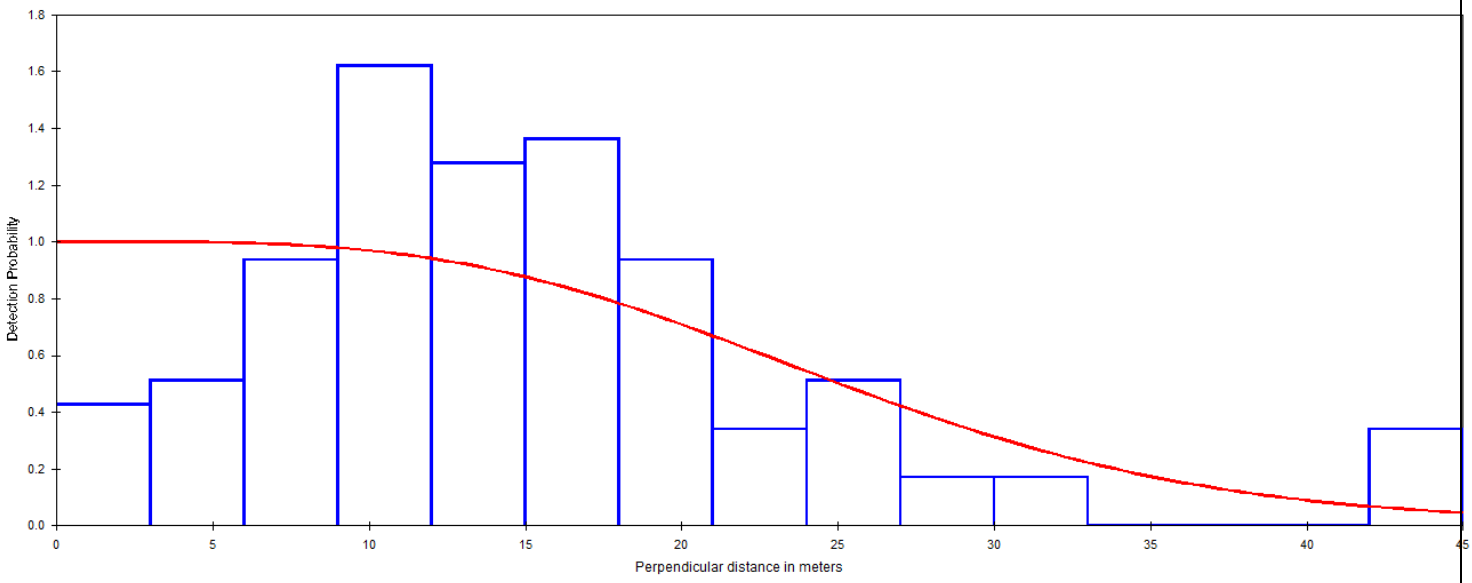
Cluster size : 2.0

Estimation Summary – Density & Abundance

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
DS	15.338	22.44	195.67	9.9055	23.749
D	21.276	22.67	203.55	13.683	33.082
N	298.00	22.67	203.55	192.00	463.00

Annexure 2: DISTANCE Analysis Results for Bronzed Drongo

Detection Fct/Global/Plot: Detection Probability



Detection Fct/Global/Chi-sq GOF Test

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	3.00	5	11.74	3.869
2	3.00	6.00	6	11.72	2.792
3	6.00	9.00	11	11.61	0.032
4	9.00	12.0	19	11.31	5.233
5	12.0	15.0	15	10.71	1.721
6	15.0	18.0	16	9.77	3.967
7	18.0	21.0	11	8.55	0.705
8	21.0	24.0	4	7.13	1.375
9	24.0	27.0	6	5.67	0.019
10	27.0	30.0	2	4.31	1.235
11	30.0	33.0	2	3.13	0.408
12	33.0	36.0	0	2.19	2.194
13	36.0	39.0	0	1.49	1.494
14	39.0	42.0	0	1.00	1.000
15	42.0	45.0	4	0.66	16.772

Total Chi-square value = 42.8156 Degrees of Freedom = 12.00

Probability of a greater chi-square value, P = 0.00002

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	3.00	5	11.74	3.869
2	3.00	6.00	6	11.72	2.792
3	6.00	9.00	11	11.61	0.032
4	9.00	12.0	19	11.31	5.233
5	12.0	15.0	15	10.71	1.721
6	15.0	18.0	16	9.77	3.967
7	18.0	21.0	11	8.55	0.705
8	21.0	24.0	4	7.13	1.375
9	24.0	27.0	6	5.67	0.019
10	27.0	30.0	2	4.31	1.235
11	30.0	33.0	2	3.13	0.408
12	33.0	36.0	0	2.19	2.194
13	36.0	45.0	4	3.16	0.225

Total Chi-square value = 23.7744 Degrees of Freedom = 10.00

Probability of a greater chi-square value, P = 0.00822

Density Estimates/Global

Effort : 173.5000
samples : 347
Width : 45.00000
observations: 101

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Cosine adjustments of order(s) : 2

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval
DS	11.277	2.5603	22.70	7.2476 17.548
E(S)	1.3863	0.47823E-01	3.45	1.2946 1.4844
D	15.633	3.5900	22.96	9.9987 24.443
N	219.00	50.291	22.96	140.00 342.00

Measurement Units

Density: Numbers/Sq. kilometers

ESW: meters

Component Percentages of Var(D)

Detection probability : 67.6

Encounter rate : 30.1

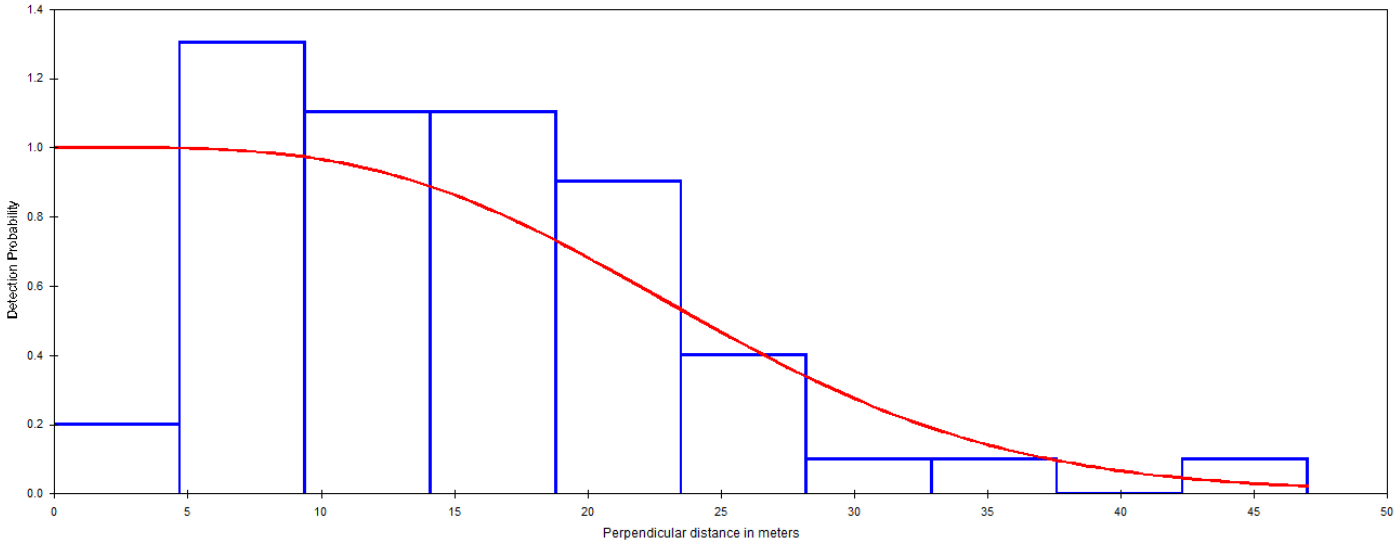
Cluster size : 2.3

Estimation Summary – Density & Abundance

	Estimate	%CV	df	95% Confidence Interval
Half-normal/Cosine				
DS	11.277	22.70	195.76	7.2476 17.548
D	15.633	22.96	204.69	9.9987 24.443
N	219.00	22.96	204.69	140.00 342.00

Annexure 3: DISTANCE Analysis Results for White-bellied Drongo

Detection Fct/Global/Plot: Detection Probability



Detection Fct/Global/Chi-sq GOF Test

Cell i	Cut Points	Observed Values	Expected Values	Chi-square Values
1	0.000	4.70	2	9.98	6.378
2	4.70	9.40	13	9.87	0.989
3	9.40	14.1	11	9.35	0.289
4	14.1	18.8	11	8.14	1.003
5	18.8	23.5	9	6.32	1.132
6	23.5	28.2	4	4.32	0.024
7	28.2	32.9	1	2.60	0.986
8	32.9	37.6	1	1.39	0.112
9	37.6	42.3	0	0.69	0.685
10	42.3	47.0	1	0.32	1.432

Total Chi-square value = 13.0303 Degrees of Freedom = 7.00

Probability of a greater chi-square value, P = 0.07137

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	4.70	2	9.98	6.378
2	4.70	9.40	13	9.87	0.989
3	9.40	14.1	11	9.35	0.289
4	14.1	18.8	11	8.14	1.003
5	18.8	23.5	9	6.32	1.132
6	23.5	28.2	4	4.32	0.024
7	28.2	32.9	1	2.60	0.986
8	32.9	47.0	2	2.40	0.067

Total Chi-square value = 10.8685 Degrees of Freedom = 5.00

Probability of a greater chi-square value, P = 0.05405

Density Estimates/Global

Effort : 173.5000
samples : 347
Width : 47.00000
observations: 53

Model 2
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
Cosine adjustments of order(s) : 2

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
DS	6.1194	1.7100	27.94	3.5496	10.550
E(S)	1.0462	0.19692E-01	1.88	1.0074	1.0864
D	6.4018	1.7930	28.01	3.7093	11.049
N	90.000	25.206	28.01	52.000	155.00

Measurement Units

Density: Numbers/Sq. kilometers
ESW: meters

Component Percentages of Var(D)

Detection probability : 73.6

Encounter rate : 25.9

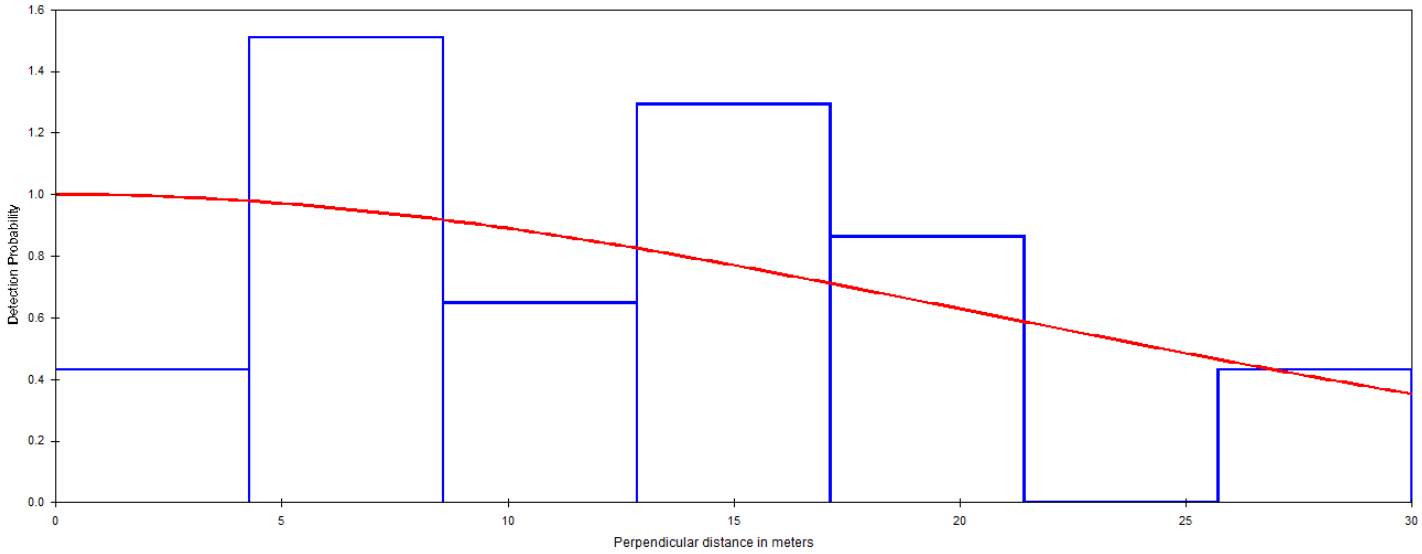
Cluster size : 0.5

Estimation Summary – Density & Abundance

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
DS	6.1194	27.94	91.51	3.5496	10.550
D	6.4018	28.01	92.34	3.7093	11.049
N	90.000	28.01	92.34	52.000	155.00

Annexure 4: DISTANCE Analysis Results for Greater Racket-tailed Drongo

Detection Fct/Global/Plot: Detection Probability



Detection Fct/Global/Chi-sq GOF Test

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	4.29	2	4.61	1.474
2	4.29	8.57	7	4.41	1.514
3	8.57	12.9	3	4.06	0.275
4	12.9	17.1	6	3.57	1.649
5	17.1	21.4	4	3.02	0.321
6	21.4	25.7	0	2.44	2.441
7	25.7	30.0	2	1.89	0.006

Total Chi-square value = 7.6801 Degrees of Freedom = 5.00

Probability of a greater chi-square value, P = 0.17477

The program has limited capability for pooling. The user should judge the necessity for pooling and if necessary, do pooling by hand.

Goodness of Fit Testing with some Pooling

Cell i	Cut Points		Observed Values	Expected Values	Chi-square Values
1	0.000	4.29	2	4.61	1.474
2	4.29	8.57	7	4.41	1.514
3	8.57	12.9	3	4.06	0.275
4	12.9	17.1	6	3.57	1.649
5	17.1	21.4	4	3.02	0.321
6	21.4	30.0	2	4.33	1.257

Total Chi-square value = 6.4905 Degrees of Freedom = 4.00

Probability of a greater chi-square value, P = 0.16539

Density Estimates/Global

Effort : 173.5000
samples : 347
Width : 30.00000
observations: 24

Model 1
Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95% Percent Confidence Interval	
DS	3.1188	0.87644	28.10	1.8026	5.3962
E(S)	1.1459	0.59553E-01	5.20	1.0289	1.2762
D	3.5739	1.0213	28.58	2.0482	6.2360
N	50.000	14.289	28.58	29.000	87.000

Measurement Units

Density: Numbers/Sq. kilometers
ESW: meters

Component Percentages of Var(D)

Detection probability : 49.1

Encounter rate : 47.6

Cluster size : 3.3

Estimation Summary – Density & Abundance

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
DS	3.1188	28.10	84.06	1.8026	5.3962
D	3.5739	28.58	89.51	2.0482	6.2360
N	50.000	28.58	89.51	29.000	87.000