<u>A Study of Resource Selection by Black Kites (*Milvus migrans*) in the Urban Landscape of National Capital Region, India</u>

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BY

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Certificate

This is to certify that **Mr. Nishant Kumar** has carried out an original research titled ***"A Study of Resource Selection by Black Kites in the Urban Landscape of National Capital Region, India"*** in partial fulfilment of Master's Degree in Wildlife Science from Saurashtra University, Rajkot. The study was carried out under our supervision from December 2012 to June 2013. We hereby certify that this work has not been submitted for any other degree to any other university.

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- Nishant Kumar.

Summary

Black Kites are the scavenger and predator raptors of the old world. In India they are synanthropic and perform the ecological role of city scavengers. Abundance and distribution of these birds suffers change due to rapid infrastructural changes in the developing cities which likely limit or change spatial layout of the available habitat and food. Many cities in the old world (London, Cape Verde, Istanbul) have experienced decline in the population of *Milvus* kites owing to rapid urbanization. Indian sub-continent almost lost its main scavenger, white backed vultures, in the last century. After this loss; existence of black kites, the most abundant raptor of the old world proves very vital.

On these lines I carried carry out this dissertation from December 2012 to April 2013. This study focused on **a)** estimating the abundance of Black Kites on the Ghazipur dump site and the abundance of nesting pairs in National Capital Region (NCR), **b)** evaluating factors influencing nesting habitat selection combined with a broad understanding of its foraging habits and **c)** estimating nest survivorship in the urban landscape. I studied these parameters at selective study sites in NCR by intensive counts of birds at Ghazipur and breeding pairs at nest sites across eight study sites. Nests were searched intensively at each site while I tried to develop and test a new method to count the kites on the Ghazipur dump. Data from 116 nests and nest sites covariates were used to model nest survivorship under Known Fate scheme in Programme MARK.

For my first objective, I estimated the current abundance of nesting pairs of Black Kites at 7 study sites. It ranged from 4 pairs / km^2 in Sagarpur to 67 pairs / km^2 in North Campus area. Nesting kites were selective while choosing a nest site, as evident by significant partial correlation between nest density, food index and green cover. The sites at the best trade-off between green cover and food availability had the highest nest densities. While developing a new methodology, I estimated around 2400 kites on the Ghazipur dump. Through behavioural observations and broad examination of regurgitated pellets, I could confirm scavenging as well as predacious nature of Black Kites. The overall probability of a nest to produce a viable fledgling was 0.45. The nest survivorship was stage specific and varied with pre-laying, incubation or nestling stage. The lower survival probability (0.60) at pre-laying stage is likely because of surplus nest formation at sites with good foraging opportunities. Understanding the importance of kites in urban ecology, further studies using individually marked kites will reveal vital details of their behavioural and physiological adaptations. If future long term studies are conclusive enough, we may establish Black Kites as an umbrella species of urban ecology.

1. Introduction

Increasing rate of global urbanization and awareness has created new interests for the urban biodiversity (Magle *et. al*.2012). Although urbanization in general tends to reduce species richness at a place, in a context, it is not true for certain plants and animals (Luck *et. al* 2011). Amongst these, the Black Kite (*Milvus migrans),* a medium sized accipitrid, is the most common scavenging and predacious raptor of the old world. It lives amidst human habitation in India; thriving on dump sites (Ferguson-Lees and Christie 2001).

Black Kites and congeneric Red Kites belong to the family *Milvinae* or old world kites. *Milvinae* kites evolved in the Miocene Epoch in Tertiary Period of Cenozoic Era, 25 million years ago. Species belonging to the genus *Milvus* and *Haliastur*, in this family, are known to be notorious scavengers (Grossman *et al.* 1964). Kites have featured in literature over the world, depicting their ecological relationships with human since centuries (Gotch 1981, Table 1). The dependency of Old world kites on the human refuse has a regulatory effect on their abundance and distribution. The urban infrastructure changes to promote better waste management towards improvement of hygiene ultimately reduce or clumps the scattered food resources (Schreiber *et al.* 2000).

Table 1: Summary of the relationship of kites and human beings as mentioned in old literature (Source- Grossman *et al.* 1964)

Bird	Time period	Text	Remarks
Red Kite	Before Christ	*Republic by* Plato	Kites termed temple thieves
Red Kite	Henry VI	Shakespeare's poems	Snatchers of kills of other raptors
Red Kite		• Shakespeare's *Julius Ceaser* • *Hamlet*	I. 'Kite' used to define a person's black character. II. Commonly called 'Puttock'.
Brahminy Kite and Black Kite.	BC	• Sanskrit (Shiv Purana) • Battle records of Ancient India	I. Br. Kite signified good omens and the Bl. Kite the bad ones. II. First scavengers to arrive during battles.
Brahminy Kite	BC	Ancient bird Classification, source: Dave (1985)	The fishing eagles, greater adjutant stork, common heron, Br. Kite were classified together as *jalpars* or water birds.

The abundance and distribution of these birds is currently suffering declines (Sergio and Boto 1999) and shrinkage due to rapid infrastructural changes in the developing cities, which likely limit or change the spatial layout of the available habitat and food sources (Ferguson-Lees and Christie 2001). Many cities in the old world (London, Cape Verde, Istanbul) have experienced historical declines in the population of *Milvus* kites owing to rapid changes in their landscape (Ferguson-Lees and Christie 2001, Grossman *et al.* 1964, Parry and Putman 1979, Schreiber *et al.* 2000).

It is noticeable that abiotic, biotic and cultural components of an urban landscape produce a great diversity of habitats ranging from near natural to completely artificial. These habitats are characterized by small patch size of vegetation, varied ownership, unexpected juxtaposition, intensive human management, abrupt change in structure and high anthropogenic interference (Bookhout 1996). In the above context Delhi, the capital of India, has undergone rapid urban development since the country's independence (Mehta 2011).

Development in Delhi has changed the availability and accessibility of resources for the urban fauna. Kite distribution and abundance has likely responded to the changed spatial distribution of habitat and food sources within the city. I gathered it from a questionnaire survey circulated among old age citizens in June 2012 as a part of reconnaissance for this thesis. It holds even more importance after Indian sub-continent has almost lost its primary scavenger, white backed vultures, since 1990s from most of its distribution range (Pain *et al.* 2008; Prakash *et al.* 2003).

The existence of Indian Black Kites, the *govinda* sub-species, as the secondary scavenger proves vital. Therefore, it is important to understand the behavioral characteristics that allow kites to adapt to a highly urban landscape, nest amidst human habitation and forage on dump refuse. Black kites have most likely acquired a portion of the niche recently vacated by vultures in the Indian Sub-Continent, while they may also limit rodent pests within the city, with potential beneficial effect on human health-risks (Malhotra 2007).

In this thesis, I report the results of a 5 month study on Black Kite population in the state of Delhi and its adjoining areas in India called National Capital region (hereafter referred to as NCR). The aim of this study was to provide quantitative data on Black Kite abundance, nest site selection and nest survivorship. The intensive study was conducted at 8 study sites distributed in NCR.

1.1. Literature Review

Long term monitoring of Black Kites in Europe since last 40 years makes it the most intensively monitored-studied raptor population in the world. Researchers there monitor more than 500 pairs each year, have ringed 7000 individuals, trapped about 2000 birds and have satellite-GPS tagged more than 100 birds till date (Pers comm, Sergio F. 2013). These studies report the importance of marsh, riverine area, open woodland and wooded cliffs associated with water bodies as favoured habitat for the kites (Hille 2000; Sergio *et al.* 2003a, b; Schreiber *et al.* 2000). Kites also adjust in urban territories, agricultural areas and grasslands with adequate nesting facilities. They have rarely been reported to nest on the buildings (Ferguson-Lees and Christie 2001). Their extended adaptation to nest amidst human settlement in the India and Africa highlights their ecological plasticity (Ferguson-Lees and Christie 2001, Schreiber *et al.* 2000).

In contrast to other raptors, the breeding and non-breeding segments in the Black Kite population do not share much of their habits and habitats (Blanco 1994, 1997; Newton 1979). This aspect of breeding biology with respect to the intersections between the floaters and breeding conspecifics has been little studied in raptors while it is known to have a potential influence on their population dynamics (Newton 1979). Floaters roost in the woodland area near the dump sites and are exclusive consumers of refuse and seldom take wild prey whereas the breeders which are largely predators sporadically visit the dumpsites (Blanco 1997). In Italy Sergio and Boto (1999) identified 307 items of prey through the analysis of regurgitated pellets and prey remains. Fishes constituted 62% of diet against 28% from avian sources. All vertebrate classes were represented in the diet with some occasional invertebrate prey.

Black kites in Europe, against the resident Red Kites, are trans-Saharan migrants from Africa and breed in relatively natural setup (Schreiber *et al.* 2000, Sergio and Boto 1999, 2003a, b, Vinuela 1999). The diet of both *Milvus* kites is highly influenced by their habitats. (Schreiber *et al.* 2000, Sergio *et al.* 2003a, Vinuela 1999). However, Black Kites are comparatively less specific and utilize even unstable food sources. In Europe, this enables Black Kites to successfully raise more fledglings than their conspecifics (Vinuela 1999). It is noticeable that even though they show greater opportunism in utilization of both prey and human refuse, their breeding success was found much lower against Asian or African populations (Sergio and Boto 1999).

Comparatively less studied Indian Black kites, which are residents, form the largest and the densest population than any raptor for its distribution range. Raptor reference sources have mentioned them to be the most successful birds of prey, based on their opportunistic utilization of garbage at the dumpsites (Ferguson-Lees and Christie 2001; Grossman *et al.* 1964; Veiga *et al.* 1990; del Hoyo *et al.* 1994). Aquatic prey base in Indian sub-continent is mostly harvested by the Brahminy Kite, *Haliastur indus* (Ferguson-Lees and Christie 2001; Grossman *et al.* 1964). In Afro-Asia the adaptability of these birds to forage amidst human establishment has made it the greatest menace at the airports. Satheesan (1996) found Black Kites to be responsible for 21% of all Indian air hazards. It is a result of unplanned management of the airport areas as many of these are associated with dumpsites (Satheesan 1996; Owino 2004).

There are several reports based on anecdotal observations on Black Kites in India in volumes of *Journal* of Bombay Natural History Society (1892, 1906, 1910, 1911, 1912, 1916, 1921, 1926, 1938, 1950, 1968, 1972, 1982, 1985, 1986, 1989, 1990 and 1991) emphasizing their natural history. From these sources, we know the sporadic predacious behavior of kites. They have been reported to prey on the birds of the size of common kingfisher and rodents. Ali (1926) and D'Abreu (1911) reported their breeding behavior for the first time through keen observations. Many birds start the nest building activity, one or two months before the normal season (Ali 1926). This phenomenon was also observed in Delhi during the present study. Mahabal and Bastawade (1985) studied communal roosting behavior of these birds in Pune city. They reported the seasonal fluctuation in the birds on the roosts. These roosting places were found both permanent as well as temporary over time.

However, apart from Galushin (1971), no other concrete quantitative attempt, reporting their abundance and distribution in a landscape has been made. Desai and Malhotra (1979) studied their breeding behavior at Delhi Zoological Park, monitoring nesting success for 60 nests in the area. At Delhi Zoo, average hatching success (55%) was found way below other studies (Sergio and Boto 1999). Malhotra (2007) also mentioned large congregation of non-breeding Black Kites inside the park area. Apart from scavenging on garbage, Malhotra (2007) also established the importance of rodents and fishes in the diet and published his thesis in the form of a book titled “Tigers of the sky: Black Kite” with nest monitoring and chick growth data. It will be important to compare growth patterns of chicks over a gap of 30 years.

Evidences of impacts of habitat modifications on *Milvus* kite population

London

London is amongst those cities which foremost saw industrialization. This resulted in major infrastructural and landscape related stochastic ties (http://www.picturesofengland.com). For European kites, Red Kites are comparatively better adapted to withstand human presence and were street cleaners (Grossman *et al.* 1964; Schreiber *et al.* 2000). Post 16th century, the evolution of London as the major economic hub led to increased hygiene maintenance through better solid waste management which negatively impacted these birds. The impact was either directly through shortage of food, persecution or indirectly through the chemical treatment of the dumpsites (Schrieber *et al.* 2000; Hille 2000). The climate of London does not support vultures as scavengers (http://save- vultures.org/save_speciesguide.html). Thus, understanding the necessity of Red Kites in their ecosystem, Royal Society for Protection of Birds, London (RSPB) initiated their reintroduction programme in open areas which came to effect in 1989 (http://www.rspb.org.uk/wildlife/birdguide/name/r/redkite/)

Cape Verde

Cape Verde, an island group, is 500 kilometres off the western coast of Senegal. The island had a mixed population of Red and Black Kites till it suffered a heavy decline in the last three decades (Brown 1976, Johnson *et al.* 2005; Hille 2000). With the changing urban face, the fate of kites of this island closely followed London by 2000. Hille (2000) also reported a simultaneous decrease in the number of other carrion feeders which are Egyptian Vulture, Cape Verde Buzzard and raven in Cape Verde.

Delhi

Delhi, as the national capital of a new democratic state has undergone rapid development. (http://books.google.co.in/books?id=aqqAAAAAMAAJ&q=urbanization#search_anchor, http://esa.un.org/unpd/wup/Maps/maps_1970_2011.htm). Through a time sustaining immigration, human population and random settlements shot up exponentially with decreased public sanitation (Mehta 2011). Under National Urban Sanitation Policy, small or large dumps from the middle of the city were closed and covered. In addition, new dump areas were allocated on the outskirts (www.urbanindia.nic.in/programme/uwss/NUSP, indiasanitationportal.org.Ghaziabad_CSP, http://talkdelhi.com/delhi/delhi-the-garbage-capital/). The population of Black Kites, utilizing these temporary resources, has responded in terms of changing distribution patterns. This is reflected more evidently in reduced sighting of the common flocks of birds in many parts of the city as reported by the old aged residents during my questionnaire survey. Study of Galushin (1971), where he noted 2400 nesting pairs of Black Kites in 150 km^2 of city is a baseline data to compare any changes in the abundance of breeding birds in Delhi. According to his study, 83% of the total monitored raptor nesting pairs were Black Kites. However, their distribution had notable unevenness with 50-80 nesting pairs per km^2 in old Delhi against 16 pairs per km^2 in New Delhi area.

1.2. Objectives

Following were main objectives of this study-

Objective 1: To estimate the abundance and distribution of Black Kites in the urban landscape of National Capital Region, India.

a. Abundance of nesting pairs in the study sites.
b. Abundance of kites at foraging sites.

Objective 2: To evaluate factors influencing nesting habitat selection

Objective 3: To assess the nesting success of Black Kites across different ecological settings in National Capital Region, India.

2. Study Area

I conducted the study in NCR and covered 1500 km^2, most of which falls in the state of Delhi. It included eight intensive study sites, each of 3 km^2, distributed along the increasing scale of urbanization based on collective account of vegetation cover, built up area and human population levels. The scaling has been discussed in detail in the method section. These sites were selected on the basis of Mehta (2011) to represent the maximum variation of land use land cover (Table 2, Figure 1).

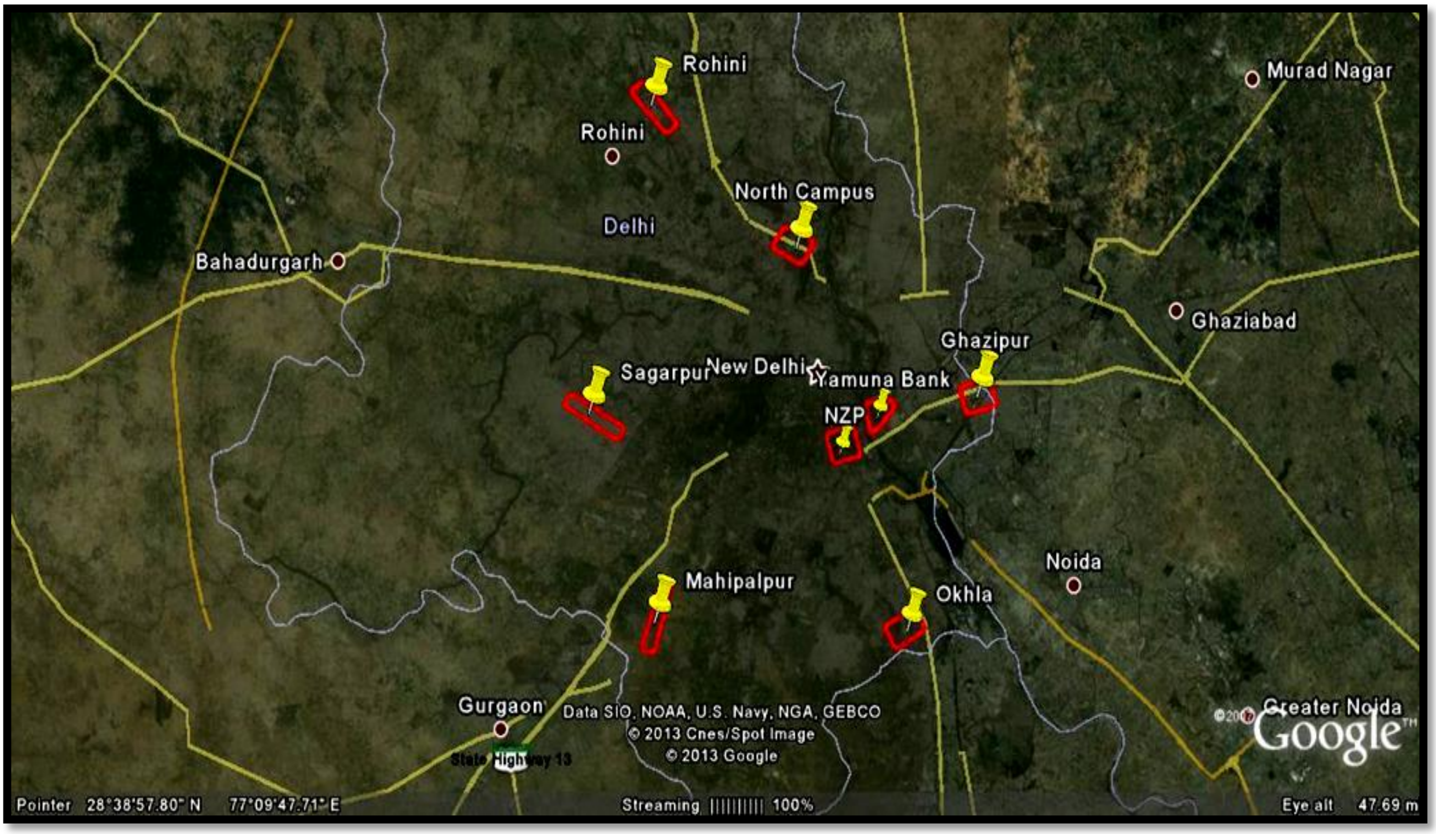


Figure 1: Eight intensive study sites, marked on the Google Earth Map of National Capital Region (NCR).

A. Mahipalpur: is near Indira Gandhi International airport in the south-west of Delhi. It comprises of thorny forest of *Prosopis juliflora*. The land is primarily rocky with almost no human habitation (Figure 2).

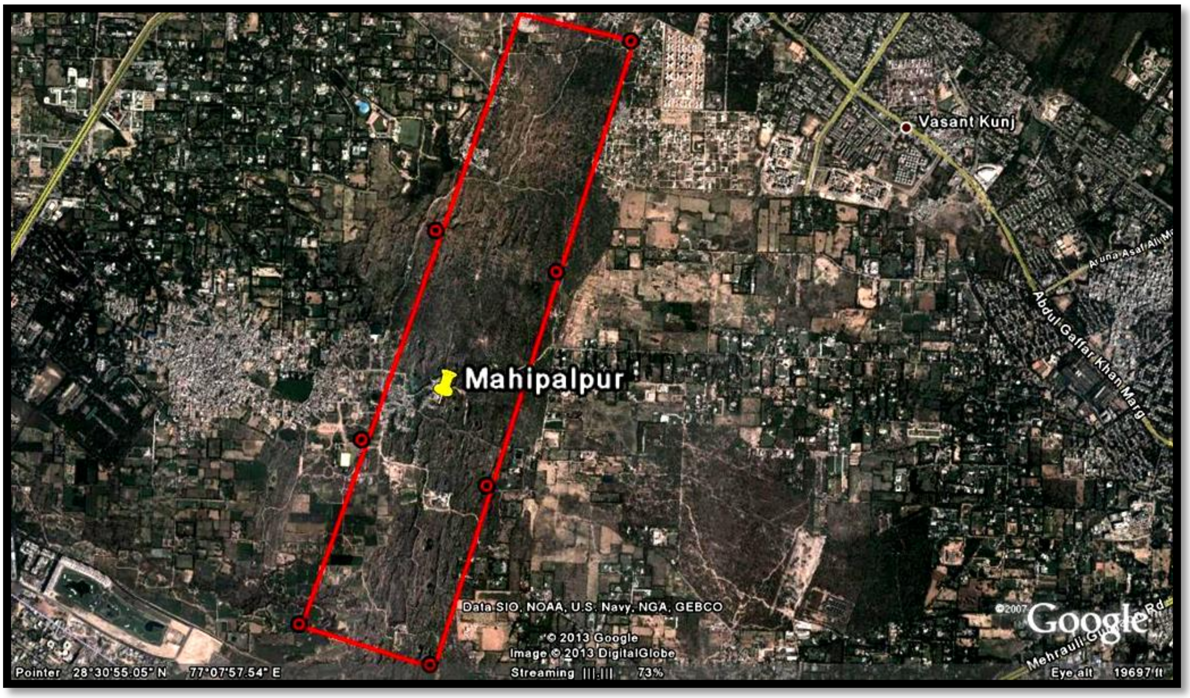


Figure 2: Mahipalpur area study site with its boundary in red.

B. Yamuna Bank: in Eastern Delhi, this area holds plantation of Eucalyptus with adjoining agricultural patches in the river floodplains and few settlements (Figure 3).

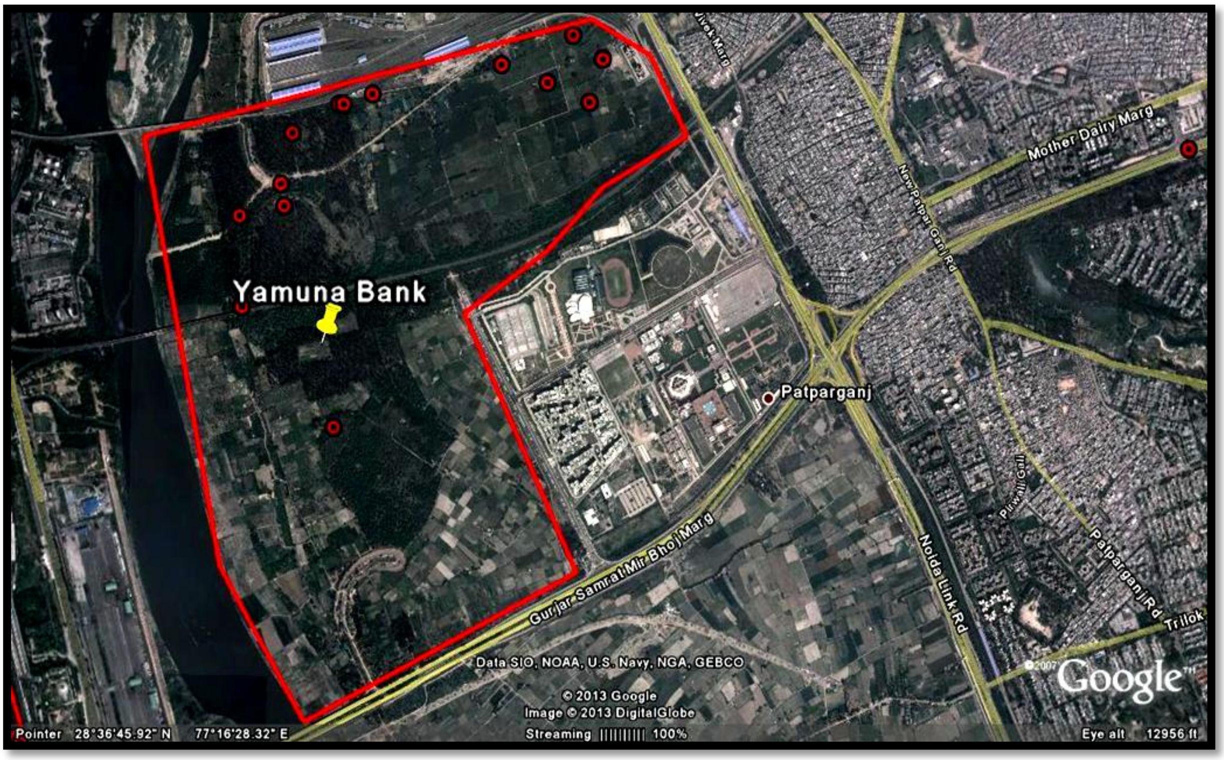


Figure 3: Yamuna Bank study site with its boundary in red and nest locations as red dots.

C. National Zoological Park (NZP): is semi-forested protected area in the heart of the city beside river Yamuna with modern settlements (Figure 4).

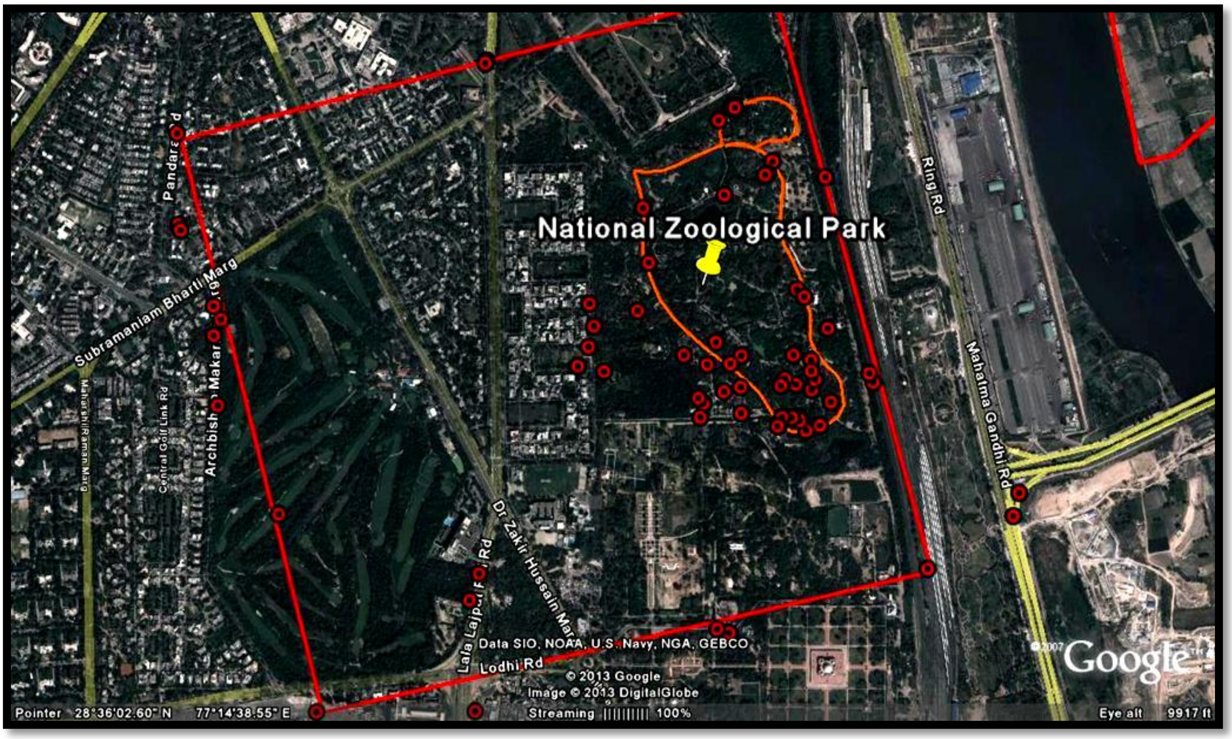


Figure 4: NZP study site with its boundary in red and nest locations as red dots.

D. Rohini: in north- western part of Delhi has wide open agricultural fields, fruit orchards and Eucalyptus plantations with no settlements (Figure 5).

Figure 5: Rohini study site with its boundary in red and nest locations as red dots.

E. North Campus of University of Delhi: is an area with mixed blend of greenery and modern built up space (Figure 6).

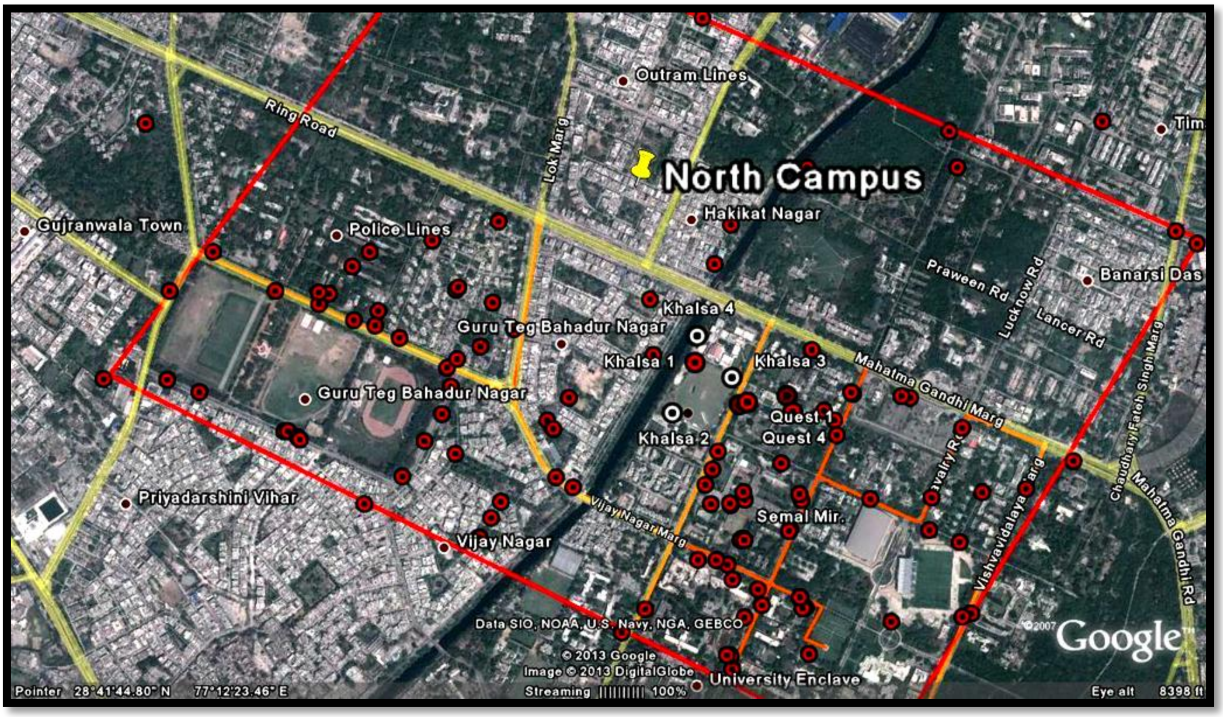


Figure 6: North campus study site with its boundary in red and nest locations as red dots.

F. Okhla: This site in extreme south has a passive landfill site where kites used to congregate in past. There is a good stretch of open land combined with human settlement and patch of *Prosopis juliflora* (Figure 7).

Figure 7: Okhla study site with its boundary in red and nest locations as red dots.

G. Ghazipur: is in the extreme east of the city with an active mega-dump. I selected this site, keeping the dump at the focal centre, to understand the response of kites to super abundance of food. The huge congregation of kites at this place is discussed in numerous raptor literatures (Brown 1976, Ferguson-Lees and Christie 2001, Malhotra 2007 and Newton 1979) (Figure 8).

Figure 8: Ghazipur study site at centre with its boundary in red and nest locations as red dots.

H. Sagarpur-Uttam Nagar stretch: in west Delhi is semi-urban with unplanned architecture. The houses are densely set side by side. This leaves very little or no green space. However, poor waste management provides foraging opportunities to the kites (Figure 9).

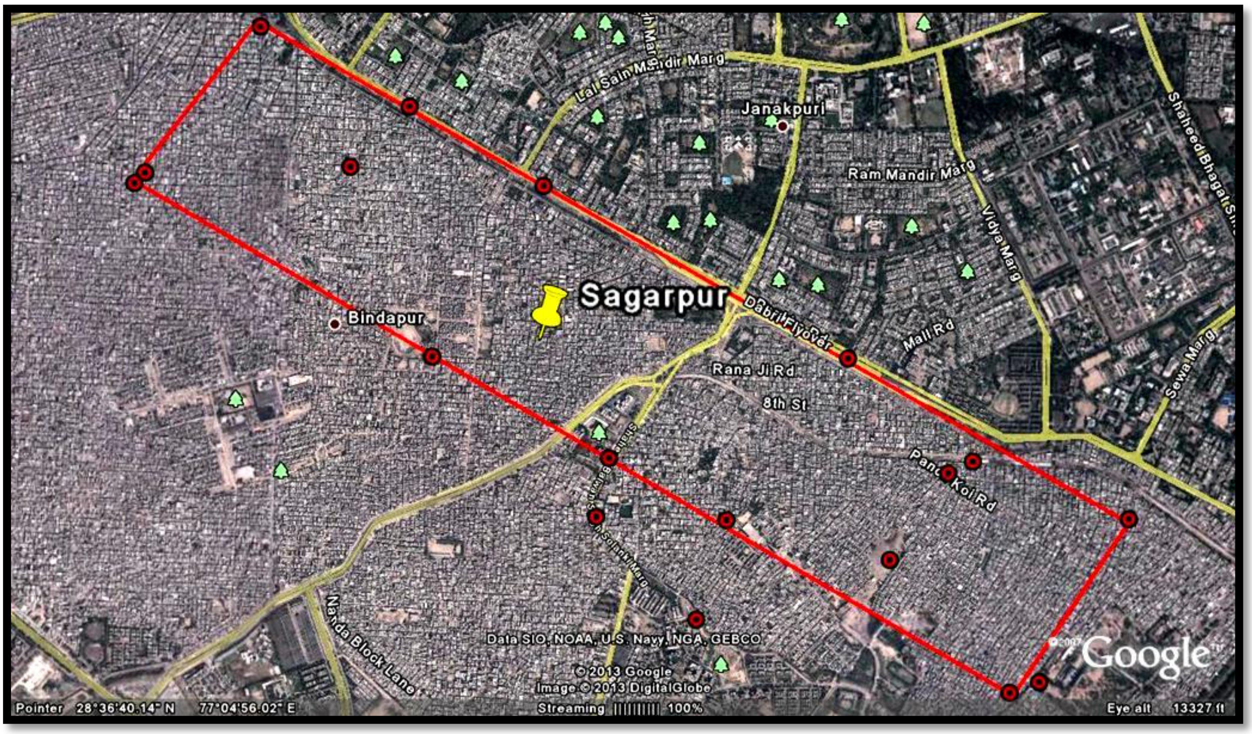


Figure 9: Sagarpur study site with its boundary in red and nest locations as red dots.

NCR falls in the semi-arid zone with 60 cm of annual rains, mainly in the two months of monsoon. The capital city lies at the farthest eroded *Aravali* ranges at an altitude of 200 odd meters. Being in the Northern belt, it experiences both temperature extremes (touching 47° C in summer to less than 1° C in winter) (Krishen 2006). Vegetation of Delhi falls in typical Northern Tropical Thorn Forest category (Champion & Seth 1968). (*Prosopis* spp., *Acacia* spp.) and few patches of dry Monsoon forests (Krishen 2006). The prominent vegetation is comprised by Acacias such as *A. nilotica, A. leucophloea, A. catechu, A. modesta, Butea monosperma*, *Cassia fistula, Salvadora persica*, *Anogeissus latifolia* with abundant *Prosopis juliflora* (http://www.delhi.gov.in). The trees around human establishment are of *Sygizium* spp., Neem (*Azadiracta indica),* Arjun (*Terminalia arjuna), Eucalyptus* spp. *and Ficus* spp. from the plantation movements in the city planning over the years (Champion & Seth 1968, Krishen 2006).

3. Methods

3.1. Black Kite nest counts

My field work spanned from December 2012 to April 2013 after I did few reconnaissance surveys between June 2012 and December 2012. This tenure encompassed the major breeding activity of the Black Kites in NCR (Ali and Ripley 1968; Malhotra 2007). At each study site I chose a representative polygon of 3 km^2, homogenous in terms of landscape features. Later, I subdivided each study sites into smaller grids of 1 km^2 to put uniform effort while doing nest search. Here, I involved a team of 15 trained volunteers to do grid wise nest search on pre determined paths for all study sites initially for one month. I was not able to cover the full 3 km^2 of most of the study sites due to involvement of private property permission issue and inaccessibility. Therefore, while computing the nest density for each study site, only the net sampled area value was used.

The landscape features for each of these sites was not uniform. In order to validate accuracy of total count of nests and to find out the probability of non-detection, I did fixed-width road transect to locate nests in a Mark-Recapture framework (Cooch & White 2013). I used two different teams, each comprising four members, including one trained person to identify the kite nests. Such nests are quite different from common urban birds nest in terms of the gross size and thickness of long twigs used (Figure 10). Both teams were unaware of the nest locations. I sent the first team to locate and mark the nests found along pre-designed paths for which the total number of nests was already known from the intensive search. The second team was sent on the same path to try and recapture the nests marked earlier.

Figure 10: Typical nest of a Black Kite showing gross structure, size and thickness of twigs.

This exercise was performed at three selected sites, namely North Campus, NZP and Rohini with high, medium and low nest density respectively. For data analysis, with the total count already known, the nests reported by Team 'A' were taken as marked nest while the ones reported by Team 'B' were taken as recaptured nests. This exercise generated a single event mark-recapture data of nest detection along a path. I analysed the data under closed capture framework in the Programme MARK (Cooch & White 2013).

3.2.Abundance of kites at Ghazipur dump site

Black Kites congregate in thousands at the mega landfill sites of NCR to forage opportunistically on garbage produced by residents of Delhi and the slaughter houses located in the vicinity. It is almost impossible to visually estimate the number of these birds on the dump, either through total counts or through the common estimation methods. These birds, apart from hovering over the dump are also seen foraging on the garbage. Therefore, to estimate the total number of birds at a time, one also needs to compute the number of birds sitting on the dump.

To come up with the minimum number of kites on a dump, I tried a new method of photograph based count of the birds present on Ghazipur dump. The number of kites on the dump does not remain uniform throughout the day. It undergoes through major fluctuations as the day progresses. I determined the time of maximum congregation in a day through repeated photo shoots of the dump from a fixed vantage point at every hour between 0500 hours and 1830 hours.

Analysis of these photographs in software ImageJ (http://rsbweb.nih.gov/ij/) gave the period of maximum congregation between 1530 and 1700 hours (Figure 11). This was also cross verified with the workers on the dump site. This software is not able to count the kites sitting on the dump which are to be counted manually in a photograph. Therefore, I tried to obtain an average proportion of kites sitting on the dump to the kites in flight. It was to be used to estimate the kites sitting on the dump with the knowledge of kites in flight through the analysis of panoramic shot from the top of the dump.

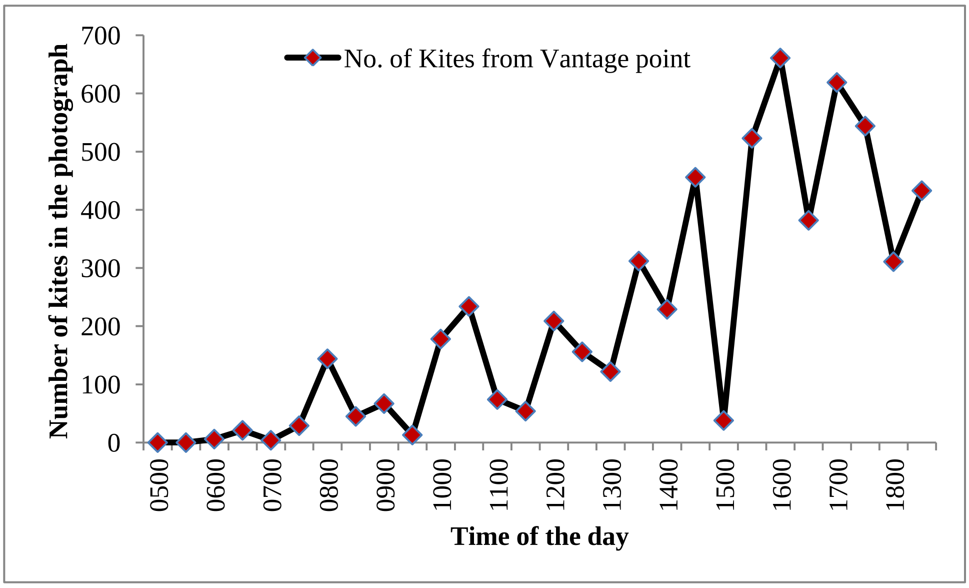


Figure 11: Count of the kites found over the dump in photo shots taken from a vantage point. The photographs clicked between 0500 hrs and 1830 hours were analysed in software ImageJ.

Using above clue, I stationed 10 persons, each with a camera, at uniform systematic locations on full face of the dump around 1600 hours on 15th February 2013 (Figure 12). Each person first clicked the kites sitting on the dump followed by tilting the camera upwards to shoot the kites in flight (Figure 13). This was followed by a 60˚ turn and repeating the earlier step with no overlap with previous frame. The said person continued this till he completed shooting all kites in his 360˚ view through 5 replicates of first step. In the end, kites flying over his head were captured with an overhead shot. Thus, at an average, 6 clicks of kites sitting on the dump and 7 clicks of the kites in flight completed the shooting of kites available for a person from a given point on dump. Other nine persons also followed the same at their respective points. Their activity was synchronized for each point using cellular phones to avoid double counts of birds as they change locations within minutes.

Simultaneously, I captured seven panoramic 360° views of all birds in flight between 1530 hours and 1700 hours from the top of the dump (Figure 14). I obtained the proportion of kites sitting on the dump to the kites in flight for each of these points. Using these values, I came up with an average proportion for whole dump. I used freely available java based software ImageJ (http://rsbweb.nih.gov/ij/) to count the number of kites in flight in a photograph. The use of this software use was validated by analysing different photographs through manual counts of kites. In all the photographs, the kites sitting on the dump were counted manually.

Figure 12: A view of the Ghazipur dump around 1600 hrs in evening during breeding season to show congregation of the Black Kites.

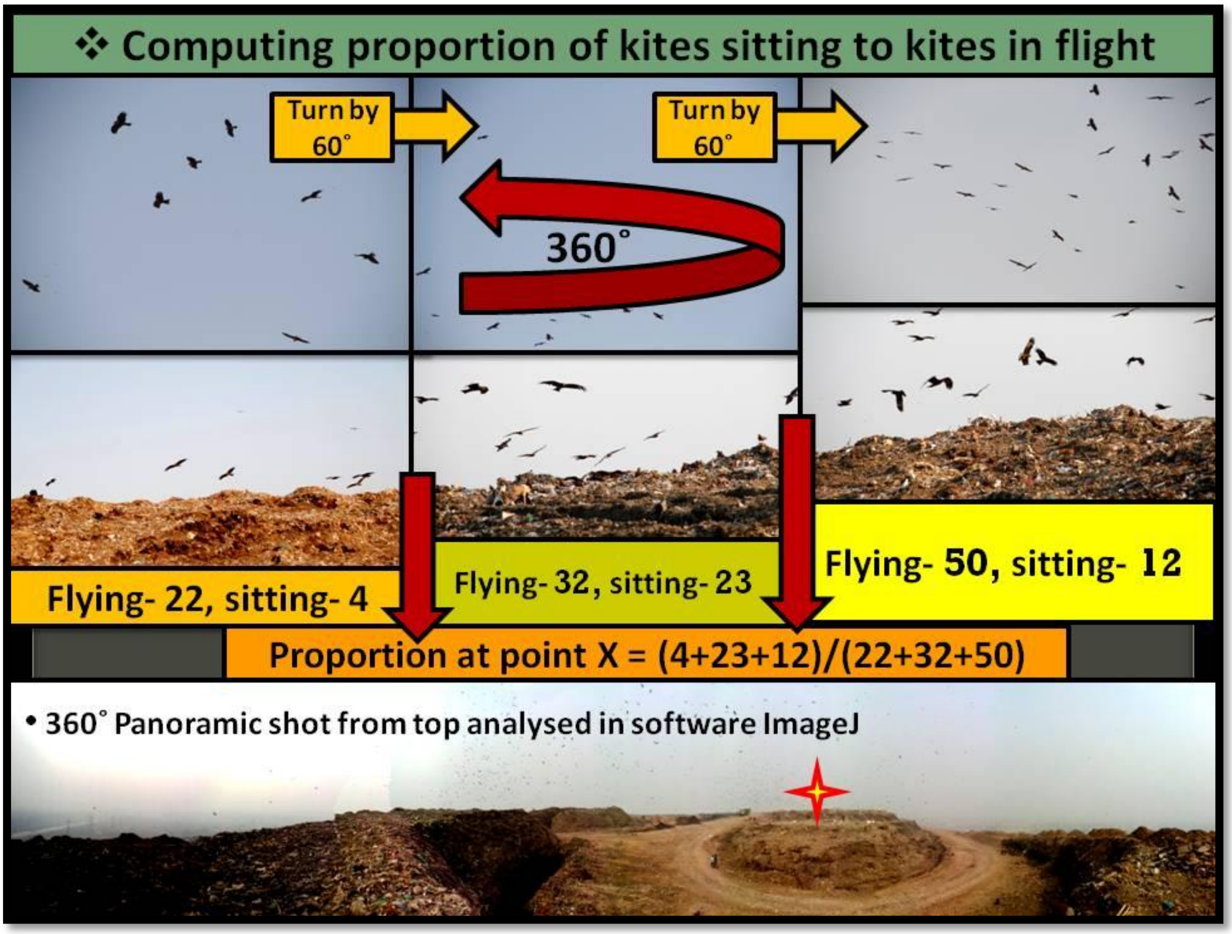


Figure 13: The photograph shooting scheme to count the kites at Ghazipur.

Figure 14: Panoramic 360˚ shot from the top of the Ghazipur dump analysed in software ImageJ to estimate kites in flight.

3.3. Nesting habitat selection

In order to evaluate the factors which regulate the nesting behaviour, I estimated the availability of green cover, built up area and food, specific for each study site. The landscape variables, proportional green cover and built up area were obtained using latest Google Earth imagery of the study area. It was done by subdividing each study site into smaller grids of 25 hectare. This divided each study site into 12 grids of 25 hectare blocks which is quite close to the median as well as mode of kite territories in the study sites (Table 3). For NCR, I assumed foraging radius of breeding birds at 300 m because of the easy food availability and regular vigilant presence of parent birds during the nest checks. It is unlike the European sub species foraging radius of one kilometre (Sergio *et al.* 2003a).

Further, I used smaller grids of Google Earth which subdivided each 25 hectare grid into 30 smaller grids (Figure 15). I assigned each of the 30 Google Earth grids a status of either built up, green, open or mixed after visually judging percent extent of each category. The built up or green status was assigned only when the percent extent of each category was more than 60. Mixed status was for the percent extent of built up or green from 40 to 60 while open was used for areas which were fallow.

Later, the mixed category grids were equally distributed to built up and green categories. Therefore, from total 360 Google earth grids for each study site, I obtained the percent built up and green space on their built up or green status (Table 2).

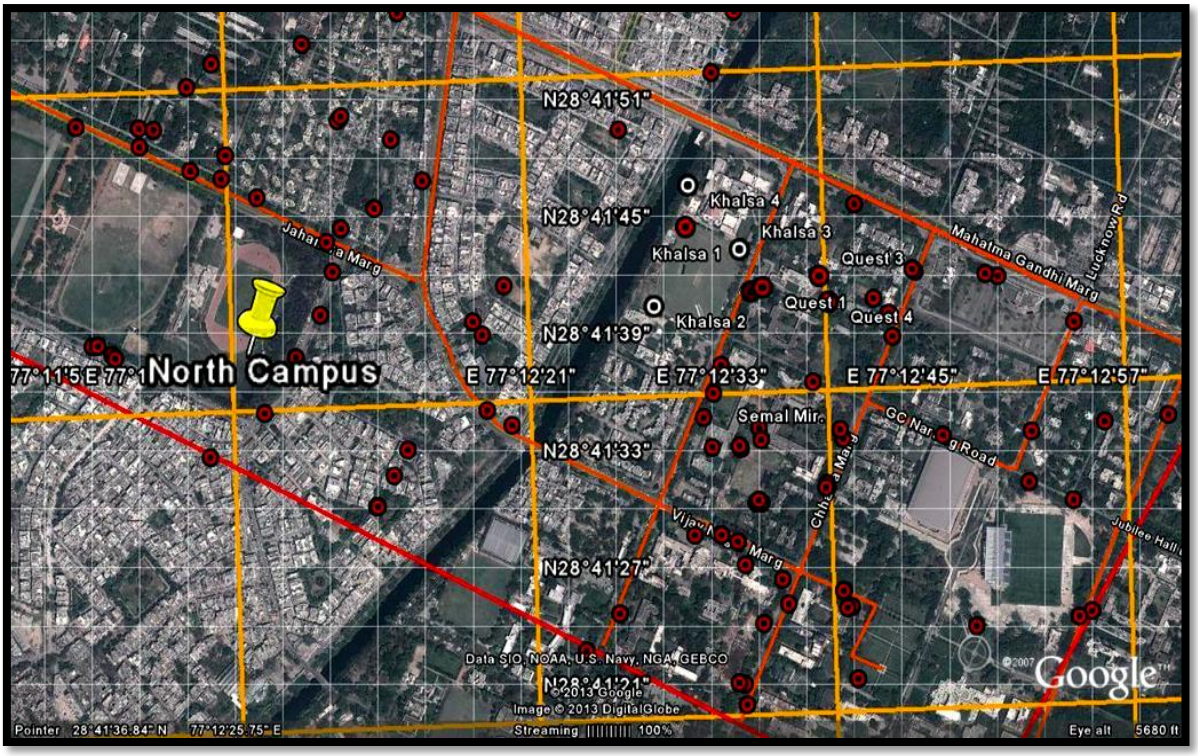


Figure 15: Division of each study area into 12 yellow grids of 25 hectares each. Further, each yellow grid was subdivided into 30 smaller grids using Google Earth grid view.

During the field work, I could not quantify the availability of the food for Black Kites. Therefore, on the basis of repeated visits to each study site, I logically developed the Food Index under the following framework: {(**built up area proportion) x (waste disposal rank) + Presence of open dump rank}**. Waste disposal level was given index value ranging from 0 to 2, allotted on the basis of regularity of clearance of garbage from colony based small dumps in each study area. Study areas with no dumps received a score of zero. The areas with most irregular or no disposal of garbage from the colony based dumps received a score of two. The built up proportion was taken analogous to the population level in a study area. Therefore, poor waste disposal areas with high built up proportion most likely interact to give best foraging opportunities to the kites. To this value, I added the index value of direct food availability (in terms of large dump site, left over from slaughter houses) which ranged from 0 to 2 on the increasing scale. Thus, study areas with the poor waste disposal mechanism, high built up area and with good availability of the direct food were the best foraging areas for the kites (Table 2).

To understand the relationship between the nest densities, proportional green cover and food index in a study area, I performed partial correlation between the nest density and the food index, keeping the value of green cover constant. Partial correlation was decided after the bi-variate correlation between the green cover and food index.

Table 2: Land use land cover specifics of 8 intensive study sites in NCR (with proportional green cover and logical derivation of Food Index for each site).

Study area	**Waste disposal regularity 'a'(0 =no waste, 1 =high / 2= low)**	**Proportional Built-up area 'b'**	**Food indirect '(a*b)'**	**Direct food availability index 'c' (0 = absence/ 1= moderate/ 2= high)**	**Food Index (a*b + c)**	**Proportional Green Cover**
Mahipalpur	0	0	0	0	0	0.91
Yamuna Bank	2	0.08	0.16	1	1.16	0.42
Delhi Zoo (NZP)	1	0.41	0.41	2	2.41	0.67
Rohini	0	0	0	1	1	0.17
North Campus	1	0.52	0.52	2	2.52	0.54
Okhla	2	0.62	1.24	1	2.24	0.38
Ghazipur	2	0.6	1.2	2	2.20	0.13
Sagarpur	2	0.98	1.96	1	2.96	0

a: The index of regularity of waste disposal from a study area. 0= no waste present, 1= regular waste removal, 2= irregular removal of waste

a*b: indirect index of food which gives the quantum of interaction between the built up area (analogous to population) and waste removal regularity. The high built up area and irregular waste disposal shall generate high amount of food.

c: Direct food availability index to represent the direct sources of food which were regularly seen in a particular area, like large dumps, slaughter house waste

3.4. Monitoring nesting success

I monitored all 150 reported nests for their contents at a gap of 5 to 10 days. New nests, as and when reported, entered monitoring protocol at all stages of maturity i.e. pre-laying, under incubation and nestling. The criterion for nesting success was successful fledging of at least one nestling by the parents (Sergio and Boto 1999). I used an 8 meter long telescopic metal rod mounted with a mirror and small spy video camera on its top to collect the data on nesting success on subsequent visits to the nests (Figure 16).

Figure 16: Volunteers using telescopic rod to monitor a kite nest using the mirror mounted on top to instantly view the contents and a small camera attached on top to record the video footage.

In order to minimize any disturbance to the chicks, I collected field data on the important nest site covariates (nesting tree species, nest height, nesting tree height, nest area canopy, nesting tree canopy, nesting tree GBH, central or peripheral position of nest in the tree canopy and study site) after majority of the chicks fledged. The nest height was measured using a laser range finder. Tree height was ascertained applying Pythagoras theorem using range finder. The nesting tree canopy was measured through standard protocol of using a spherical forest densitometer (http://www.cdpr.ca.gov/docs/emon/pubs/sops/fsot00201.pdf). Nesting area canopy was measured within the 12 m radial area of the nesting tree (Sergio *et al.* 2003a).

The continuous scale data of the nesting tree canopy cover and the nesting area canopy cover was transformed to categorical data to incorporate the interaction of these two different covariates while modelling the nest survivorship. For nesting area canopy cover, all the data points with canopy cover from 0 to 25 % were categorized ‘0’, data points with canopy value of 26 to 50% were categorized ‘1’ and the points with canopy value more than 50% were categorized ‘2’. For nesting tree canopy cover, values ranging from 0 to 33% were categorized 0.3; points falling within 33 to 66% were categorized 0.6 while the points with canopy value more than 66% were categorized 0.9. The canopy covariate was represented as (nesting area canopy category) × (nesting tree canopy category) to contain maximum information in least possible number of parameters. This transformation was done under the assumption that nesting area canopy has greater impact on the nest survivorship than nesting tree canopy.

Likewise, I also combined the tree species categories on the basis of similarity of their structure with respect to supporting a kite nest. All the nesting trees were assigned to following groups *Eucalyptus*, *Ficus* spp., Keekar, Neem + Jamun, Tower and Others. For each nest, I made dummy covariates for the specific tree species group and central / peripheral position of the nest in a tree in 1, 0 frameworks. The study sites were also combined according to habitat similarity as following categories: Sagarpur, North Campus, NZP, Ghazipur + Okhla, Mahipalpur and Yamuna Bank + Rohini. They were used in modelling nest survivorship in 1, 0 framework as well. All re-categorization was done to represent maximum information through least number of parameters, leading to higher fitness of the models during analysis.

The nest survivorship data was analysed using Known Fate scheme in Prog. MARK (Cooch & White 2013) which estimates the interval specific and overall survival index of a nest under log likelihood framework. The programme works under assumption that encounter probability of a nest is 1.0. The resultant nest survivorship (Cooch & White 2013) estimate is very close to the classic Mayfield estimator (http://www.dodpif.org/kiwa/kw-papers/1961%20Mayfield.%20Nesting%20Success%20Calculated.(Wilson%20Bulletin).pdf. The estimated parameter signifies the chance that the nest will survive from one interval of nest check to the other. As new nests entered the analysis scheme at different stages of construction and maturity, only those 116 nests which were monitored since nest building stage were put into analysis. The Known fate data was arranged in a staggered stage specific pattern of pre-laying stage, incubation stage and nestling stage.

Pre-laying stage was defined as the period between first day on field and the last day an egg was laid in a nest (first 84 days of field work). The nests which did not bear eggs post this stage were taken as failed nests. The incubation stage was defined as the time taken by the last laid egg to successfully hatch (85^{th} to 119^{th} day of field work). All the nests under incubation with no resultant hatchling post this period were taken as failed nests. The nestling stage was defined as the approximate time taken by the youngest nestling to fledge out (50 days from the 120^{th} day on the field).

Thus, I modelled the nest survivorship in Programme MARK using the encounter history of 116 nests along with their nesting covariates. I began with the null model which assumes the nest survivorship to be uniform throughout the season, with no incorporation of covariates. The null model was used as datum to further model nest survivorship (Appendix II) using various sets of covariates. This ultimately helped in deciding those specific nesting site covariates which significantly influence nest survivorship.

Collection of regurgitated pellet and prey remains of kites

I also collected the regurgitated pellets during each nest check from the nesting and communal roosting sites for further examination in laboratory. Regurgitated pellets are compact balls, around 2 – 2.5 cm in diameter, of undigested remains of the prey consumed by the kites. They provide a reliable means to assess diet consumed by the birds (Malhotra 2007, Sergio and Boto 1999). Based on Sergio and Boto (1999), I bagged these pellets separately for each nesting and roosting site in tagged plastic bags. In case of large roosting sites where I encountered heap of pellets, I bagged all pellets falling within five randomly drawn 50 cm radius circles. Whenever possible, I also collected the prey remains (body parts, scales, bones, feathers) from inside and below the nest to better understand their diet (Figure 17).

Figure 17: Clockwise from top left: 1. Systematic collection of regurgitated pellets at communal roosting site 2. & 4. Scan sampling of Black Kites foraging on the dump 3. A kite’s nest with chicks and prey remains (pigeon).

3. Results

Nest density

I could find a total of 244 nests in all the 8 study sites. I collected data from 150 nests across 7 study sites chosen at random (Table 3). No nests were found in Mahipalpur area. Nest substrates were quite variable for the 150 nests under regular monitoring. Of these, 23.3 % were on *Eucalyptus*, 17.3% on *Ficus* spp., 12.6% on Keekar *(Prosopis* spp.), 16% on Neem & Jamun, 11.3% on pylons & towers and rest on other tree species.

Total nest counts on specific paths for three study sites, where I employed double observer Mark Recapture, were within the 95% CI of the Prog. MARK estimate of nest counts (Table 4, Figure 18). The densities of kite nests for 8 study sites varied from 0 nests / km^2 at Mahipalpur to 67 nests / km^2 at North Campus (Table 3). I found nest densities to be correlated with the Food index, once the effect of proportional green cover was controlled for 8 study sites ($\alpha = 0.1$, partial $r = 0.636$, $p = 0.06$) (Figure 19). There was non-significant negative correlation between Food Index and proportional green cover ($\alpha = 0.1$, $r = -0.45$, $p = 0.14$) for 8 study sites.

Table 3: Number of nests, net area sampled for nest search, nest density and number of nests used for data collection on nesting success

Area	Total No. of Nests	Net Area Sampled (km^2)	Nest Density (Nests / km^2)	Number of nests used for nest survivorship data
Mahipalpur	0	2.03	0	0
Sagarpur	9	2.08	4.33	9
Rohini	13	2.70	4.81	13
Yamuna Bank	15	3.00	5.00	7
Okhla	15	2.60	5.73	8
Ghazipur	16	2.18	7.34	6
NZP	70	2.65	26.42	46
North Campus	106	1.58	67.09	59

Table 4: Comparison between double observer based Mark-Recapture estimate and actual nest count along fixed paths in three study sites

Study Area	Mark-Recapture estimate	LCL (95%)	UCL (95%)	Total nest count on path
NZP	30.66	30.09	34.75	31.00
Rohini	7.16	7.02	9.58	8.00
North Campus	41.91	41.15	46.51	41.00

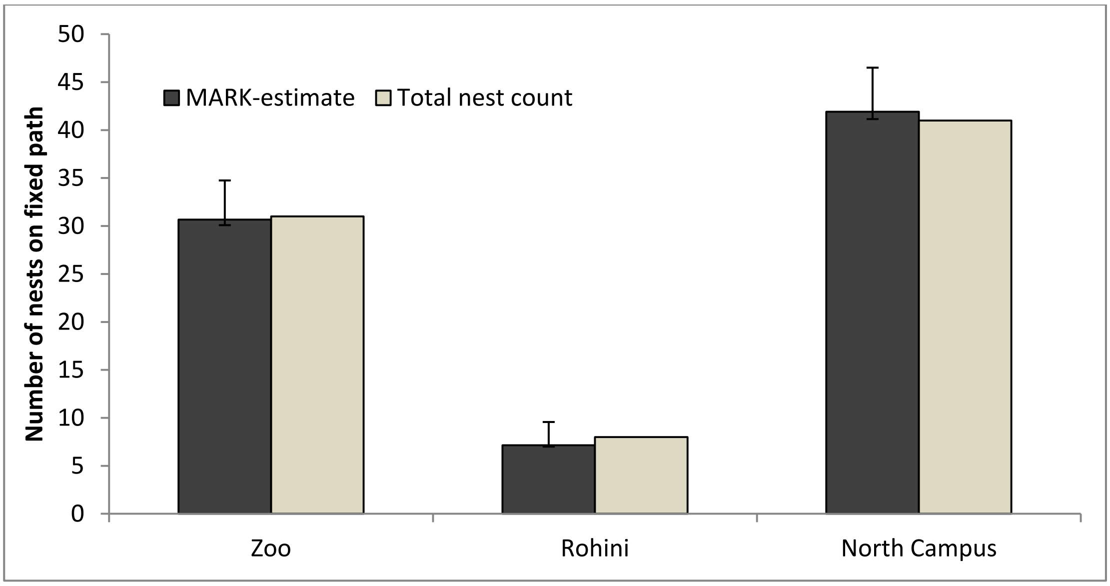


Figure 18: Comparison between estimated numbers of nests using Prog. MARK and total nest counts on fixed paths in three study sites to show the accuracy obtained through one month intensive nest search.

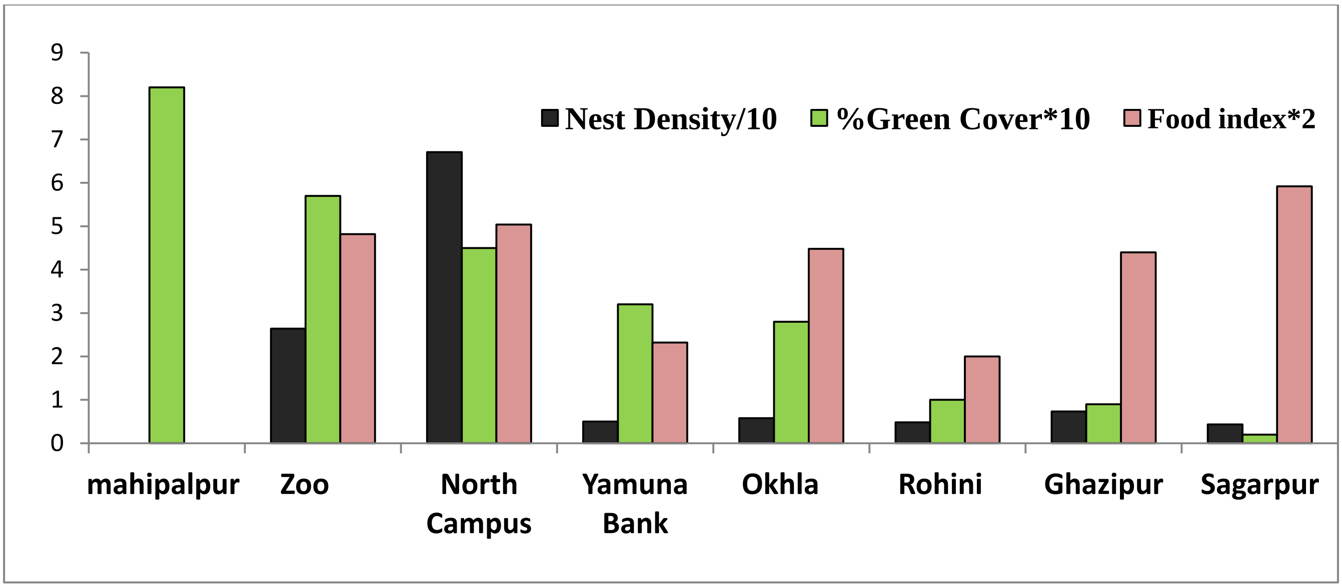


Figure 19: Comparison of trade off between proportional green cover and food index which accounts for variation in the nest density across study sites (scales adjusted for comparison of three parameters)

Abundance of kites at Ghazipur dump site

I estimated the proportion of kites in flight to those sitting over the dump site at Ghazipur by photographing the 360˚ view from 10 uniformly chosen positions. A total of 2,121 kites in flight were estimated analysing the 360˚ panoramic shot taken from the top of the dump (Figure 14). I used average proportion (0.118, S.E. = 0.036) of the kites sitting on dump to the kites flying over at 10 different locations to correct this estimate of total kites. Thus, with 250 (95% CI = 75) sitting birds, the total kites on the dump were estimated to be 2,371 (95% CI = 75).

Nesting success

Average clutch size in NCR was 2.1. Height of the nests on natural substrates ranged from 5.7 to 19 meters while on towers and pylons it ranged from 8 to 42 m. The Sagarpur area lacked mature trees but had good foraging opportunities. It eventually resulted in utilization of towers as nesting substrates. The artificial structures, like towers, pylons, were highly utilized in the areas where green cover was low. Moreover, at North Campus, with the highest nest density, kites only used 5% artificial substrates. This signifies their preference for the natural substrates. The differences in the proportional nesting success (direct estimation on the basis of release of one fledgling) on the natural and artificial substrates is summarised in Table 5 and compared in Appendix II.

Table 5: Direct estimation of breeding success on the basis of successful fledging of one chick from a nest to compare the fate of a nest on natural and artificial substrate (towers and electric poles).

Study Area	No. of nests	Nests on trees (% nests)	Success % on trees (only for nests monitored)	Nests on artificial structure (% nests)	Success % on artificial structure (only for nests monitored)
Mahipalpur	**0**	**-**	**-**	**-**	**-**
Yamuna Bank	**15**	**15 (100)**	**83.3**	**0 (0)**	
Delhi Zoo (NZP)	**70**	**70 (100)**	**43.5**	**0 (0)**	
Rohini	**13**	**13 (100)**	**53.8**	**0 (0)**	
North Campus	**106**	**100 (94.3)**	**45.3**	**6 (5.7)**	**33**
Okhla	**15**	**10 (77)**	**40**	**5 (33)**	**40**
Ghazipur	**16**	**13 (81.3)**	**50**	**3 (18.7)**	**-**
Sagarpur	**9**	**2 (32.2)**	**50**	**7 (77.8)**	**14**
Total	**244**	**223 (91.4)**	**45.9**	**21 (8.6)**	**27.8**

Under Known Fate scheme, the interval specific nesting success was found non- uniform across the different stages of the nesting event during the study period. The null model assuming uniform survival for the duration of the study was not selected. Models with stage specific survival had lower AICc values (Table 6). The incorporation of canopy cover and species of trees used for nesting increased the performance of stage specific model and such models were best selected on the basis of delta AICc values (Table 6). The impact of the canopy on the nest survivorship is exponential with the value of beta coefficient of Logit-link function at 0.56 (Appendix II).

The top four models were equally fit and did not differ in terms of their AICc scores. Thus, I averaged the estimates of each to predict the stage specific nesting success. The overall survival probability for a nest under construction to be able to successfully release a fledgling was estimated by multiplying the stage specific nest survivorships, i.e. 0.60 × 0.84 × 0.90 at 0.45 (Table 7) .

Table 6: Summary of the selected models to estimate the survival parameters for the Black Kite nests in NCR (December 2012- April 2013), using Prog. MARK. Data from 116 nests was used for this analysis.

Model	AICc	Delta AICc	AICc Weights	Num. Par	Deviance
S (Stage) x (C.Cover)	**480.12**	**0**	**0.37**	**4**	**472.08**
S (Stage) x (Imp Spp.)	**480.65**	**0.52**	**0.28**	**5**	**470.59**
S (Stage) x (Imp Spp. +C.Cover+ Imp area + Nest ht)	**481.35**	**1.23**	**0.2**	**11**	**459.09**
S (Stage) x (C.Cover + Position)	**482.12**	**2**	**0.14**	**5**	**472.06**
S (Stage)	**487.4**	**7.28**	**0.01**	**3**	**481.38**
S(.)	**528.7**	**48.58**	**0**	**1**	**526.7**

Table 7: Results of the nest survivorship estimated by averaging the estimates of top four models (Table 5) on the basis of delta AICc cut off.

Nesting Stage	Interval (average 7 day) specific survival Estimate (n)	LCL (95%)	UCL (95%)	Stage survival estimate (avg. no. of intervals = y) n^
Pre-laying	**0.88**	0.85	0.90	**0.60** (LCL: 0.52 UCL: 068; **y = 4**)
Incubation	**0.96**	0.92	0.98	**0.84** (LCL: 0.68, UCL: 0.93, **y = 5**)
Nestling	**0.98**	0.95	0.99	**0.90** (LCL: 0.62, UCL: 0.98, **y = 9**)
Probability of a nest to successfully pass all Stages = 0.60 × 0.84 × 0.90 = 0.45				

Diet of Black Kites

In the absence of the reference samples (Sergio and Boto 1999), the pellets of Black Kites could not be analysed to detail. However, the gross examination of the pellets and the prey remains gave important information regarding the difference in the diet spectrum of the breeding and non-breeding roosting birds (Table 8, Figure 20). In future, as I built up the reference samples of my own for the Indian Black Kites, these regurgitated pellets can then be thoroughly analysed.

Table 8: Diet of breeding and non-breeding Black Kites in NCR, ascertained from direct observations and rapid analysis of regurgitated pellets and prey remains which were sourced from the nesting sites and the communal roosting sites respectively.

Diet Source	**Nesting kites' pellets and prey remains + predation events**	**Non- Breeding roosting birds pellets and prey remains**
Birds	Pigeon, Domestic Fowl, Collared Dove, Indian Roller, Moor-hen.	Domestic Fowl
Others	Rodents, Lizards, Frogs, Fishes, Squirrel, red meat chunks	Mammalian bones and large fish skin sourced from slaughter house

Figure 20: Prey remains from a nest at NZP (Left: Red meat and Right: partially eaten fish commonly found in NZP moats).

4. Discussion and Conclusion

Black Kite nest densities are highly uneven for the eight study sites. This shows the selectivity of the breeding Black Kites for nesting areas (Sergio *et al.* 2003a). The high use of *Eucalyptus* for nesting is likely justified by high relative availability of this species at all the sites. Both extremes of habitat suitability in terms of green cover (Mahipalpur) and Food availability (Ghazipur) were not favoured for nesting. While the scarce food could be the reason of absence of nests at Mahipalpur, presence of few trees and competition for space from the roosting non-breeders likely limits the nesting opportunity. The Black Kites exhibiting high densities at 67 nests / km^2 in North Campus and at 26 nests / km^2 in NZP is at the best trade off between the Food index and proportional green cover (Figure 19).

Comparison of current nest densities with the records from 1970 shows remarkable fluctuations. The nest density at North Campus, which falls in the old Delhi zone, has remained quite same since Galushin (1971) studied them to be 50-80 nests / km^2. However, they have decreased significantly from 16 nests / km^2 to 4 nests / km^2 in rest of the study sites falling in New Delhi, the new built up, region. From the survey done by Malhotra in 2003, where he reported nest densities at 4 nests /km^2, kites in NZP area have shown recovery at the current density of 26 nests / km^2. The nest density during his earlier study was 25 nests / km^2 (Desai and Malhotra 1979, Malhotra 2007, http://www.hindu.com/2007/04/18). This can be attributed to loss of mature old trees from the city which appears to have forced Black Kites to overuse left over green refugia. Thus, even when the green cover shows increasing trend from last few decades due to plantation drives (http://www.delhi.gov.in), there has been considerable loss of mature trees to various constructions (Malhotra 2007).

Even though the nesting densities and the nesting success estimates are encouraging in the North Campus and NZP, the decreased in nest density in the remaining study areas raises caution. According to my questionnaire survey and field observations during this study, Black Kites as an opportunistic species (Sergio and Boto 1999) is increasingly becoming tolerant towards humans. This has serious implications in disease spillage from dump sites to humans in case of increasing use of human habitation for roosting and nesting. Future studies focusing on behavioral characteristics that facilitate adaptation to an urban environment, e.g. by comparing the fleeing distances from humans of birds living in different scenarios of proximity to humans will allow us to better understand their changing distribution patterns.

I tried and developed a new method to estimate the huge congregation of the kites on the dump site. Through this photo based count, I estimated the number of Black Kites on the dump to be 2,371. This is a point estimate during the period of their maximum congregation on dump in a day. Due to the lack of time and man-power, I could not replicate this effort. The preliminary estimate has yielded positive results. Although, the estimated number looks below the expectation, the exercise will surely be helpful in future to better design the photo capturing strategy. Availability of good quality cameras with each team member will also enhance the accuracy of the results.

Raptors of the size of kites consume about 100 g of food daily (www.birdcare.asn.au). Thus, at a point they are removing about 250 kg of dead and decaying garbage from the dump. The number of kites at the dump site is most likely to turn over several times in a span of the day which will eventually increase the free scavenging service by these birds by several folds. The availability of kites as city scavenger is of vital importance (Blanco 1997) as they dispose of the decaying carcasses and other dump, which could otherwise rot and lead to spread of diseases. In future, to quantify the ecological service of the kites, it will be necessary to tag many individuals, both away and at the dump. Individually marked kites will reveal their turnover number through the day. Specified studies focussing on their foraging behaviour on the dump will also give better insights in case they show fluctuations in number in future.

Black Kites in NCR show a wide range of foraging habits. In addition to being scavengers on the dump sites and streets, these birds have an important niche in the urban ecosystem as predators (Malhotra 2007). During this study, I observed them preying on rodents, squirrels, , fishes, insects, amphibians, reptiles and birds of the size of pigeon or smaller (Malhotra 2007, Ferguson-Lees and Christie 2001). In field I often found chunks of red meat, most likely from a nearby slaughter house, weighing 50-200 gram in most of the active nests. On the dump sites they feed on carcass and gross gulp chicken feathers; a by-product of meat dressing.

On a broad examination, I found high representation of chicken feathers in the regurgitated pellets of the non-breeding roosting kites. The pellets and prey remains of the breeding birds collected from the nesting territory have mixed representation from the predated and the scavenged food. It was also supported from the fresh kills I recovered from the nests and through observations of direct event of predation by me and people residing near nesting territory. The occurrence of such prey in the nests increased once most eggs hatched after mid-February 2013. Although the analysis of pellets gives a good insight to what the birds eat, it is mostly the representation of the undigested remains (Sergio and Boto 1999). In NCR where kites forage on carcasses and chunks of meat, studies trying to understand their foraging behaviour solely through the pellets will be highly biased.

Modelling of stage specific nest survivorship with constant impact of canopy cover had the lowest score of AICc. However, this model did not differ much from the other top three models, based on their delta AICc values (Table 7). Thus, better fitness of smaller model is likely explained by the representation of 67% of the total nests only from North Campus and NZP study areas. Both study sites have high mean canopy cover (Appendix II) and most nests found there were on the important nesting tree species. Canopy is important as it shields the eggs under incubation and the growing chicks from extreme weather of NCR, apart from providing protection from potential predators. According to the present and earlier studies, *Milvus* kites choose trees which provide stable nesting platform and have good canopy cover as well (Desai and Malhotra 1979, Newton *et al.* 1981, Sergio and Boto 1999, Sergio *et al.* 2003a).

According to the current study, the breeding success of the Black Kites in NCR is 72% starting from the incubation stage. It is higher than the 55% breeding success found in Italy but lower than the values from Spain and Germany and similar to the estimates from Japan (Sergio and Boto 1999). Nests on artificial structures were comparatively more exposed and all which failed (73%) could not reach incubation stage. Comparatively exposed nests face far greater destruction threat from the avian predators like crows, other Black Kites, rhesus macaque, and humans (Malhotra 2007, Sergio and Boto 1999). This can be attributed to large areas under poor sanitary conditions and ill management of solid waste, providing ample foraging opportunities for breeding kites.

However, Indian Black Kites dwell in the cities at extremely high densities. The limitation of green cover for nesting and roosting birds likely puts an upper cap to their overall breeding success. Therefore, just the ample availability of food does not make all the occupied nesting sites equally suitable. It is signified by overall low success probability ($p = 0.60$) of a nest to reach incubation stage. Newton *et al.* (1981) have reported the probability of a nest to reach incubation stage for Red Kites in Wales. It ranged from 0.46 to 0.63 in a span of 30 years.

In case of raptors, young adults do practice nesting (Brown and Amadon 1968, Newton 1979) while best territories are occupied by more experienced birds (Sergio and Vincenzo 2005). Black Kites, along with other raptors, show site fidelity in terms of utilizing previous nest substrate as base of a new nest or using same tree for nesting in successive years (Malhotra 2007). Thus, after the initial moderate survival rate of nests in the pre-laying stage, there is a considerable increase in the survival value of nests which reach the incubation stage. The value increases even more once the selective nests enter the nestling stage. Regarding raptors in general, only the best (e.g. oldest) individuals make it to the end of reproduction. Therefore, the percentage of high-performers progressively increases through the consecutive breeding stages through time (Newton 1979).

In future, it is necessary to understand the impact of urban ecosystem on kites by linking individual quality and status (breeder .vs. floater) with movement behavior through satellite telemetry (Tanferna *et al.* 2012). This shall be dealt with the final objective of studying how potential resources (food, refuse from garbage dumps, nest-sites, and partners) and threats (human interference, predators, and contaminants) shape the adaptation of a species to a highly urban landscape through telemetry.

Studying the relationship of distribution, density, breeding success and survival of individually marked kites shall enable us to better understand the impact of urban landscape structure and resource distribution, such as garbage dumps. Examination of the eco-physiological and eco-toxicological consequences of urban life (Bird *et al.* 1996) (e.g. by studying the Corticosterone-stress levels and pathogens of birds using the garbage dumps to different degrees: heavy metals from feathers, pesticides from egg shell and egg shell thinning) will provide insight to know the impact of garbage consumption on these birds (Tenan *et al.* 2012). Moreover, it will also be necessary in judging their role as potential carriers of diseases from such dumps.

Apart from emphasizing their importance in the ecosystem as scavengers and predators, Sergio *et al.* (2003a, b) have successfully advocated the use of Black Kites in Europe as valid conservation model species. In India, the concept of urban ecosystem and urban wildlife remains neglected. Black Kites, being an urban scavenger and top trophic level species, provide important ecological service to mankind. Kites in India are also very tolerant to human intervention, as found during my nest inspections.

This enables them to be a good model for experimental ecology with respect to nest condition manipulations. These birds also occur at high densities which make them a valid model species to test ecological hypothesis with higher precision and accuracy. Eventually, studies validating above ideas will establish Black Kites as an umbrella species for urban ecology (Bird *et al*. 1996, Luck *et al.* 2011, Magle *et al.* 2012).

REFERENCES

Ali S 1926 Mating habits of the Common Kite Milvus migrans govinda, Journal of the Bombay Natural History Society, **31**:2: 524 - 526.

Ali S and Dillon R Â 1978 No. 132. Black Kite (Milvus migrans migrans) (Boddaert), Handbook of the Birds of India and Pakistan; Oxford University Press, New Delhi, Volume **1** (Divers to Hawks): 226.

Bookhout T A 2006 Research and Management Techniques for Wildlife and Habitats ; Wildlife Society

Bird D, Varland D and Negro J 1996 Raptors in Human Landscapes: Adaptations to built and cultivated environments; Raptor Research Foundation; Academic Press, San Diego

Brown L H and Amadon D 1968 Eagles, hawks and falcons of the world; - Academic Press, New York.

Blanco G 1994 Seasonal abundance of Black Kites associated with rubbish dump of Madrid, Spain; Journal of Raptor Research; **28**(4):242-245

Blanco G 1997 Role of refuse as food for Migrant, Floater and Breeding Black Kites (*Milvus migrans*); Journal of Raptor Research; **31** (1):71-76

Brown L 1976 Birds of Prey: their biology and ecology; Hamlyn – New York

Carter I, McQuaid M, Snell N and Stevens P 1999 The Red Kite (*Milvus milvus*) reintroduction project: Modelling the impact of translocationg kite young within England ; Journal of Raptor Research; **33** (3) :251-254

Champion, H G and Seth S K 1968. A Revised Survey of the Forest Types of India. Manager of Publications, Government of India, New Delhi.

Cooch E and Gary White G 2013 Programme MARK, A Gentle Introduction, 8th Edition

D'Abreu E A 1911 Nesting habits of the Common Pariah Kite (Milvus govinda*),* Journal of the Bombay Natural History Society, **20**:3: 854.

Dave K N 1985 Birds in Sanskrit Literature; Motilal Banarsidas, Delhi del Hoyo J, Elliot A and Saragatat J 1994 Handbook of the Birds of the world **(Vol. 2)**; Birdlife International. Lynx Edicions; Barcelona

Desai J H and Malhotra A K 1979 Breeding biology of the Pariah Kite Milvus migrans at Delhi Zoological Park, Ibis, **121**: 320 - 325.

Ferguson-Lees J and Christie D A 2001 Raptors of the world; Houghton Miffin Company; New York

Galuschin V M 1971 A huge urban population of Birds of prey in Delhi India; Ibis; Volume **113**, Issue 4, page 522

Gotch A F 1981 Birds- Their Latin names explained; Blandford Press; Poole Dorset

Grossman M L, Hamlet J and Grossman S 1964 Birds of Prey of the world; Bonanza Books, New York

Hille S and Thiollay J M 2000 The imminent extinction of the Kites *Milvus milvus fasciicauda* and *Milvus m. migrans* on the Cape Verde Islands; Bird Conservation International; **10**:361–369

Johnson J A, Watson R T and Mindell D P 2005 Prioritizing species conservation: does the Cape Verde kite exist? Proc. R. Soc. B, **272**, 1365-1371

Krebs C J 2009 Ecology: The experimental analysis of distribution and abundance; Benjamin Cumnings; New York

Krishen P 2006 Trees of Delhi, A field Guide. D K Publishers Delhi

Larraz D S 1999 Dumps for dead livestock and the conservation of wintering Red Kites; Journal of Raptor Research; **33** (4):338-340

Luck G W, Davidson P, Boxall D and Smallbone L 2011 Relations between Urban Bird and Plant Communities and Human Well-Being and Connection to Nature Conservation Biology, Volume **25**, No. 4, 816–826

Magle S B , Hunt V M, Vernona M and Crooks K R 2012 Urban wildlife research: Past, present, and future, Biological Conservation **155** (2012) 23–32

Mahabal A and Bastawade D B 1985 Population ecology and communal roosting behaviour of Pariah Kite Milvus migrans govinda in Pune (Maharashtra), Journal of the Bombay Natural History Society, **82**: 337.

Malhotra A K 2007 Tiger of sky-Pariah Kite, PhD thesis, Shilalekh Publishers, Delhi.

Mehta R L 2011 Land Use Land Cover Change detection in Delhi, M.Sc. Dissertation, Delhi University.

Newton I 1979 Population ecology of raptors; Berhamsted, UK: Poyser

Owino A, Biwott N and Amutete G 2004 Bird strike incidents involving Kenya Airways flights at three Kenyan airports, 1991–2001; African Journal of Ecology; **42**, 122–128

Pain D J *et al.* 2008 The race to prevent the extinction of South Asian Vultures; Birdlife Conservation. Int.2 **18**:S30-S48

Parry G and Putman R 1979 Birds of Prey; Simon & Schuster, New York

Perrins C M, Lebreton J-D and Hirons G J M 1994 Bird Population Studies (Relevance to Conservation and Management) : Newton I 1988 Population limitation in Birds of Prey: a comparative approach ; Oxford Ornithology Series, Oxford university Press

Prakash V *et al.* 2003 Catastrophic collapse of Indian White backed (*Gyps bengalensis*) and Long billed (*Gyps indicus*) vulture population; Biological Conservation. **109**: 381-390

Satheesan S M 1996 Raptors associated with Airports and Aircrafts; Raptors in Human landscapes; Academic press limited

Schreiber A, Stubbe M and Stubbe A 2000 Red kite (*Milvus milvus*) and black kite (*M. migrans*): minute genetic interspecies distance of two raptors breeding in a mixed community (Falconiformes: Accipitridae); Biological Joumal of the Linnean Society; **69**: 351-365

Sergio F and Boto A 1999 Nest dispersion, diet and breeding success of Black Kites (*Milvus migrans*) in Italian Pre-Alps; Journal of Raptor Research; **33**(3):207-217

Sergio F, Pedrini P and Marchesi L 2003a Reconciling the dichotomy between single species and ecosystem conservation: black kites (*Milvus migrans*) and eutrophication in pre-Alpine lakes; Biological Conservation **110**: 101–111

Sergio F, Pedrini P and Marchesi L 2003b Adaptive selection of foraging and nesting habitat by black kites (*Milvus migrans*) and its implications for conservation: a multi-scale approach; Biological Conservation **112**: 351–362

Sergio F and Vincenzo P 2005 Public information and territory establishment in a loosely colonial raptor; Ecology; vol. **86**, n2, pp. 340-346

Tanferna A, López-Jiménez L, Blas J, Hiraldo F and Sergio F 2012 Different Location Sampling Frequencies by Satellite Tags Yield Different Estimates of Migration Performance: Pooling Data Requires a Common Protocol. PLoS ONE **7**(11): e49659

Tenan S, Adrover J, Mun˜oz Navarro A, Sergio F, Tavecchia G (2012) Demographic Consequences of Poison-Related Mortality in a Threatened Bird of Prey. PLoS ONE **7**(11): e49187

Veiga J P and Hiraldo F 1990 Food habits and the survival and growth of nestlings in two sympatric kites (*Milvus milvus* and *Milvus migrans*); Holarctic Ecology **13**: 62-71. Copenhagen

Vinuela J 1999 Sibling aggression, hatching asynchrony, and nestling mortaity in the Black Kite (Milvus migrans), Behavioral Ecology and Sociobiology, **45** .

Vinuela J and Sunyer C 1992 Nest orientation and hatching success of Black Kites Milvus migrans in Spain, Ibis, **134**

- **Web Sources**

(http://www.hindu.com/2007/04/18/stories/2007041809150200.htm) accessed on 2nd April 2013

(http://books.google.co.in/books?id=aqqAAAAAMAAJ&q=urbanization#search_anchor) accessed on 2nd April 2013

(www.urbanindia.nic.in/programme/uwss/NUSP) accessed on 2nd April 2013

(indiasanitationportal.org.Ghaziabad_CSP) accessed on 2nd April 2013

(http://blogs.thehindu.com/delhi/?p=15940) accessed on 2nd April 2013

(http://www.dodpif.org/kiwa/kwpapers/1961%20Mayfield.%20Nesting%20Success%20Calculated...(Wilson%20Bulletin).pdf) accessed on 2nd April 2013

(http://esa.un.org/unpd/wup/Maps/maps_1970_2011.htm) accessed on 30th March 2013

(http://books.google.co.in/books?id=gSupaU3vVacC&pg=PA249&hl=en#v=onepage&q&f=false) accessed on 30th March 2012

(http://www.rspb.org.uk/wildlife/birdguide/name/r/redkite/) accessed on 28th March 2013

(http://save-vultures.org/save_speciesguide.html) accessed on 28th March 2013

(http://talkdelhi.com/delhi/delhi-the-garbage-capital/) accessed on 20th January 2013

(http://www.delhi.gov.in) accessed on 20th January 2013

(http://rsbweb.nih.gov/ij/) accessed on 28th March 2013

(http://www.cdpr.ca.gov/docs/emon/pubs/sops/fsot00201.pdf) accessed on 28th March 2013

(www.birdcare.asn.au) accessed on 28th March 2013

Appendix I: Data collection photographs from the field work.

Appendix II :

1. **Nest survivorship estimation Models selected on the basis of delta AICc values.**

S (.) : 7 day specific Survival (ISS) is same over all for all the nests;

S(Stage) : ISS= function of (Stage of nest maturity).;

S{(Stage) x (C. Cover + Position)}: Stage specific ISS(SISS) = f'n (canopy cover + position).;

S{(Stage) x (Imp spp. + C. Cover + Imp area + Nest ht)}: SISS = f'n (canopy cover + imp. study area + imp. nesting tree spp. + nest height);

S{(Stage) x (Imp Spp.)}: SISS = f'n (imp. tree spp.);

S{(Stage) x (C. Cover)}: SISS = f'n (canopy cover)

2. **Table depicting the percent nesting tree canopy cover and nesting area canopy cover. Towers and Pylons were not given any value.**

Study Area Code	Nesting tree CC	Nesting area CC
/*Sagarpur.Light pole*/	.	.
/*S.Eukalyptus*/	25	13
/*S.Tower*/	.	.
/*S.School Eukalyptus*/	.	.
/*S.Tower 1*/	23	12
/*S.Tower 2*/	.	.
/*S.New tower (MTNL)*/	.	.
/*S.Ele Pole*/	.	.
/*Ghazipur.1*/	14	12
/*G.2*/	32	22
/*G.3*/	48	24
/*G.4*/	23	18
/*G.5*/	24	21
/*G.6*/	18	16
/*G.7*/	35	26
/*Okhla.Pole*/	79	46
/*O.Park*/	76	21
/*O.Peepal*/	34	32
/*O.Reliance Tower*/	.	.
/*O.Tower*/	56	44
/*O.Tower 2*/	.	.
/*O.DTC 1*/	.	.
/*O.DTC 2*/	.	.
/*O.DTC 3*/	59	54

/*Zoo.Opp LTM*/	54	33
/*Z.Opp Chimp*/	65	58
/*Z.Opp. Aviary*/	68	72
/*Z.Aviary*/	24	27
/*Z.Red JF*/	74	54
/*Z.Calvert*/	52	29
/*Z.Croc.*/	12	10
/*Z.New Croc.*/	48	39
/*Z.Hornbill*/	41	39
/*Z.Lion*/	66	36
/*Z.Water Tank*/	63	33
/*Z.Elp bk*/	68	66
/*Z.Staff Gate*/	71	61
/*Z.Staff Q. Peepal*/	66	36
/*Z.Staff Q. Keekar1*/	43	32
/*Z.Staff Q. Keekar2*/	46	51
/*Z.Fig opp. Water*/	77	51
/*Z.Peepal (mukesh)*/	67	59
/*Z.Krishna*/	82	68
/*Z.Chandan*/	37	49
/*Z.Eukalyptus*/	39	42
/*Z.Civet*/	67	39.4
/*Z.Sunder Nagar*/	85	77
/*Z.C-4*/	57	41
/*Z.Lion retiring cell*/	64	35
/*Z.Behind lion*/	62	47
/*Z.Opp. Deer */	55	59
/*Z.Dead Kite*/	61	59
/*Z.C4- Gate*/	19	15
/*Z.Bamboo*/	46	43
/*Z.In front Elp*/	81	75
/*Z.New Sheesham (Lion)*/	44	34
/*Z.Adj. Hornbill nest*/	73	61
/*Z.Dir. Garden*/	53	32
/*Z.Adj. Croc*/	48	43
/*Z.Black Buck*/	67	54
/*Z.Gibbon 1*/	37	33
/*Z.Gibbon 2*/	88	74
/*Z.Adj. Euka*/	66	43
/*Z.Adj. LTM*/	44	31
/*Z.Beside hornbill*/	61	58
/*Z.Pandey Keekar*/	56	45
/*Z.Vet. Euc*/	41	38
/*Z.C 4 Back*/	48	42

/*Z.Wild ass*/	74	44
/*Z.Above Croc.*/	58	46
/*R.1ST*/	29	11
/*Rohini.2ND*/	27	21
/*R.3rd*/	25	22
/*R.4th*/	23	25
/*R.5th*/	44	34
/*R.6th*/	32	12
/*R.7th*/	22	12
/*R.8th*/	24	20
/*R.9th*/	19	16
/*R.10th*/	42	25
/*R.11th*/	18	11
/*R.12th*/	28	13
/*Yamuna.13th*/	29	17
/*Y.Peepal*/	90.3	67
/*Y.Shisham*/	66	16
/*Y.new SHEESHAM*/	59	46
/*Y.Semur*/	76	34
/*Y.Eukalyptus*/	34	23
/*Y.Stable*/	83	54
/*Y.Ynst 1*/	36	21
/*North Campus.8*/	71	54
/*N.9*/	96	67
/*N.26*/	85	73
/*N.27*/	92	54
/*N.28*/	51	36
/*N.Twin Nest*/	83	77
/*N.30*/	67	62
/*N.31*/	.	.
/*N.34*/	42	37
/*N.Dept. Of Zoology*/	87	75
/*N.36*/	73	62
/*N.37*/	75	66
/*N.38*/	83	64
/*N.39*/	80	69
/*N.41*/	72	68
/*N.48*/	41	39
/*N.54*/	69	42
/*N.55*/	75	53
/*N.56*/	59	38
/*N.57*/	89	74
/*N.58*/	79	63
/*N.59*/	86	65

/*N.70*/	64	54
/*N.71*/	82	56
/*N.72*/	82	56
/*N.73*/	12	10
/*N.74*/	64	54
/*N.75*/	42	56
/*N.76*/	46	57
/*N.77*/	81	61
/*N.78*/	44	32
/*N.79*/	34	29
/*N.80*/	46	31
/*N.81*/	57	47
/*N.82*/	59	43
/*N.83*/	23	19
/*N.84*/	56	53
/*N.85*/	82	55
/*N.86*/	56	39
/*N.87*/	72	65
/*N.88*/	64	52
/*N.89*/	77	42
/*N.Opp. Twin Nest*/	65	54
/*N.Opp. Patel chest rest*/	69	70
/*N.Int. Guest house*/	71	49
/*N.NDPL*/	56	41
/*N.VV 1*/	63	57
/*N.VV 2*/	63	45
/*N.Veer haq. Pole*/	.	.
/*N.Meghdoot*/	54	46
/*N.Khalsa 1*/	.	.
/*N.Khalsa 2*/	.	.
/*N.Khalsa 3*/	.	.
/*N.Khalsa 4*/	.	.
/*N.Khalsa 5*/	66	53
/*N.Quest 1*/	65	44
/*N.Quest 2*/	73	64
/*N.Quest 3*/	79	56
/*N.Vijay School*/	83	77

3. Z-test to compare two proportions of nesting success (release of one fledging from a nest) on natural and artificial substrates

Analysed: Tue Jun 25, 2013 @ 17:55 using online source: http://epitools.ausvet.com.au

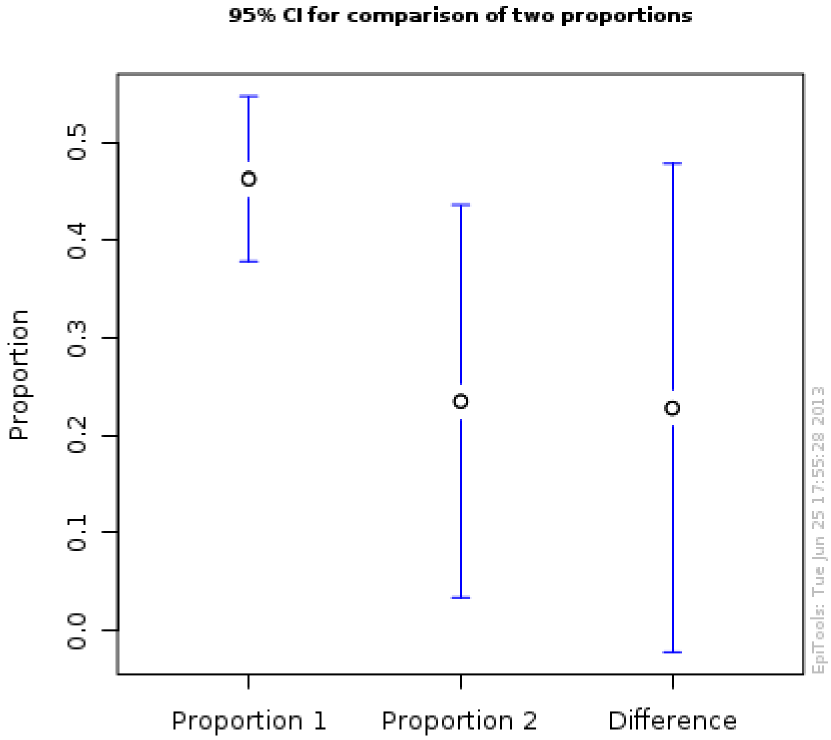
Inputs

	Sample 1(trees)	Sample 2(towers)
Sample Proportion	0.463	0.235
Sample size	134	17
Significance level	0.05	
1- or 2-tailed test	2-tailed	

Results

	Sample 1 (trees)	Sample 2 (towers)	Difference
Sample proportion	0.463	0.235	0.228
95% CI (asymptotic)	0.3786 - 0.5474	0.0334 - 0.4366	-0.0223 - 0.4783
z-value	1.8		
P-value	0.0742		
Interpretation	Not significant, accept null hypothesis that sample proportions are equal		
n by pi	n * pi <=5, test inappropriate		

CI plot of proportion 1 **(trees) , Proportion 2 (towers) and their difference.**



4. Program MARK - Survival Rate Estimation with Capture-Recapture (nest survival encounter) Data output.

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\- -

This version was compiled by GCC version 4.8.0 20120422 (experimental) using the options

-m64 -mtune=generic -march=x86-64 -mthreads -O2 -fimplicit-none -fbounds-check -funroll-loops -ftree-vectorize -fopenmp.

This problem will use 4 of 4 possible threads.

```
INPUT --- proc title KF_Final_Analysis;

  CPU Time in seconds for last procedure was 0.00


INPUT --- proc chmatrix occasions=169 groups=1 etype=Known icovar=14
INPUT --- ICMeans NoHist hist=300;

INPUT ---    glabel(1)=Group 1;

INPUT ---    time interval 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
INPUT ---    1 1 1 1 1 1      1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
INPUT ---    1 1 1 1 1 1 1 1 1 1 1 1 1      1 1 1 1 1 1 1 1 1 1 1 1 1 1
INPUT ---    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1      1 1 1 1 1 1 1
INPUT ---    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
INPUT ---    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
INPUT ---    1 1 1 1      1 1 1 1;

INPUT ---       icovariates Nest_Ht Na.Nt_R Position Euc. Peep_Ficus
INPUT ---    Keekar Neem_Jam Tower       Other_Spp Sagarpur Ghz_Okh
INPUT ---    Zoo_Nst North_Camp YB_Rohini;

   Number of unique encounter histories read was 112.

   Number of individual covariates read was 14.
   Time interval lengths are all equal to 1.

   Data type number is 4
   Data type is Known Fate

  CPU Time in seconds for last procedure was 0.02
```

```
 INPUT --- proc estimate link=Logit varest=2ndPart ;


 INPUT --- model={S(Stage) x (C.Cover};
SQUARE

 INPUT ---    group=1 S rows=1 cols=169 Square;
 INPUT ---             1  1  1  1  1  1  1  1  1  1  1  1  1
 INPUT ---       1  1  1  1  1       1  1  1  1  1  1  1  1
 INPUT ---      1  1  1  1  1  1  1  1  1  1       1  1  1  1
 INPUT ---       1  1  1  1  1  1  1  1  1  1  1  1  1  1
 INPUT ---         1  1  1  1  1  1  1  1  1  1  1  1  1  1
 INPUT ---      1  1  1  1       1  1  1  1  1  1  1  1  1  1
 INPUT ---       1  1  2  2  2  2  2  2       2  2  2  2  2
 INPUT ---      2  2  2  2  2  2  2  2  2  2  2  2  2       2
 INPUT ---       2  2  2  2  2  2  2  2  2  2  3  3  3  3  3
 INPUT ---       3  3       3  3  3  3  3  3  3  3  3  3  3
 INPUT ---      3  3  3  3  3  3  3       3  3  3  3  3  3  3
 INPUT ---       3  3  3  3  3  3  3  3  3  3  3       3  3
 INPUT ---      3  3  3  3  3;

 INPUT ---    design matrix constraints=3 covariates=4;
 INPUT ---            1 0 0 Na.Nt_R;
 INPUT ---            0 1 0 Na.Nt_R;
 INPUT ---            0 0 1 Na.Nt_R;

 INPUT ---    blabel(1)=;
```

INPUT --- blabel(2)=;

INPUT --- blabel(3)=;

INPUT --- blabel(4)=;

INPUT --- rlabel(1)=S;

INPUT --- rlabel(2)=S;

INPUT --- rlabel(3)=S;

Link Function Used is LOGIT

Variance Estimation Procedure Used is 2ndPart

-2logL(saturated) = -0.0000000

Program MARK - Survival Rate Estimation with Capture-Recapture Data

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KF_Final_Analysis

- -

Effective Sample Size = 1027

Number of function evaluations was 27 for 4 parameters.

Time for numerical optimization was 0.09 seconds.

-2logL {S(Stage) x (C.Cover} = 472.08393

Penalty {S(Stage) x (C.Cover} = -0.0000000

Gradient {S(Stage) x (C.Cover}:

0.2220550E-05-0.1449277E-05 0.1172064E-05 0.2829843E-05

S Vector {S(Stage) x (C.Cover}:

63.90109 10.15820 5.013449 3.288746

Time to compute number of parameters was 0.03 seconds.

Threshold = 0.1000000E-06 Condition index = 0.5146619E-01

Conditioned S Vector {S(Stage) x (C.Cover}:

1.000000 0.1589675 0.7845639E-01 0.5146619E-01

Number of Estimated Parameters {S(Stage) x (C.Cover} = 4

DEVIANCE {S(Stage) x (C.Cover} = 472.08393

DEVIANCE Degrees of Freedom {S(Stage) x (C.Cover} = 108

c-hat {S(Stage) x (C.Cover} = 4.3711475

AIC {S(Stage) x (C.Cover} = 480.08393

AICc {S(Stage) x (C.Cover} = 480.12307

BIC {S(Stage) x (C.Cover} = 499.82152

Pearson Chisquare {S(Stage) x (C.Cover} = 2121.5018

LOGIT Link Function Parameters of {S(Stage) x (C.Cover}

			95% Confidence Interval	
Parameter	Beta	Standard Error	Lower	Upper
1:	1.5598805	0.1865263	1.1942890	1.9254721
2:	2.9221913	0.4380093	2.0636931	3.7806895
3:	3.8498551	0.5241023	2.8226147	4.8770956
4:	0.5603960	0.1894561	0.1890622	0.9317299

Real Function Parameters of {S(Stage) x (C.Cover}

Program MARK - Survival Rate Estimation with Capture-Recapture Data

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KF_Final_Analysis

- -

Following estimates based on unstandardized individual covariate values:

Variable Value

--------- -------------

NEST_HT	11.984821
NA.NT_R	0.7875000
POSITION	0.5714286
EUC.	0.2321429
PEEP_FICUS	0.1875000
KEEKAR	0.0982143
NEEM_JAM	0.1696429
TOWER	0.1339286
OTHER_SPP	0.0446429
SAGARPUR	0.0803571
GHZ_OKH	0.1160714
ZOO_NST	0.2589286
NORTH_CAMP	0.4285714
YB_ROHINI	0.1160714

			95% Confidence Interval	
Parameter	Estimate	Standard Error	Lower	Upper
1:S	0.8809222	0.0143564	0.8497890	0.9063141
2:S	0.9665442	0.0134569	0.9274287	0.9849195
3:S	0.9864959	0.0067107	0.9645603	0.9949258

Estimates of Derived Parameters

Survival Estimates of {S(Stage) x (C.Cover} for the duration of the study = (0.8809222^4)*(0.9665442^5)*(0.9864959^9) = 0.449