CHAPTER: 2

NESTING ECOLOGY

INTRODUCTION:

Nests of birds have been compared to the mammalian uterus which provides warmth and protection to the developing embryo. Hence, in many species of birds selection of the nest site is often considered as an important determinant of their reproductive success (Coulson, 1968; Ryder and Ryder, 1981; Jackson *et al.*, 1988; Rendell and Robertson, 1989; Li and Martin, 1991; Toumenpuro, 1991; Donazar *et al.*, 1994; 1996). Thus, the nest site selection is an important determinant of the population dynamics of birds. For breeding, habitat selection is also important where the parents can easily get primary requirements such as food (Kushlan 1976; Wilson *et al.,* 2009; Watling *et al.*, 2009, Gamauf *et al.,* 2013). An individual's fecundity and survival is likely to depend upon the choice of nest site which may in turn determine the structure and growth rate of populations, and also the evolution of species (Clark *et al.*, 2004). The poor nest site selection can lead exposure of nest to predation for longer duration when parents are away feeding and hence affect the natural selection of the bird species (Lack, 1954; Ricklefs, 1969; Nillson, 1987).

Knowledge of how individuals disperse and select nest sites remains limited (Walters, 2000). However, the distribution of nesting raptors is

not only influenced by nest site but also by food availability (Newton, 1979). Raptors are reported to settle in areas where food is abundant, which significantly influence the selection of nest sites, minimizing the risks of predation (Simmons and Smith, 1985; Mearns and Newton, 1988) and optimize the thermal environment (Skutch, 1976; Mosher and White, 1976). In reality, the choice of nest site represents a compromise between various factors, for *e.g.* Northern harriers show compromise between wet nest site in close proximity to optimum foraging habitat and their females to a mate with a high food provisioning rate (Simmons and Smith, 1985). Relatively little is known about the breeding biology of raptors in tropical regions. Tropical birds of prey have longer breeding seasons and lower reproductive rates than their temperate counterparts (Mader, 1981). Due to stable climatic conditions they can lay eggs almost at any time of the year (Immalmen, 1971; Mader, 1982). However, tropical species may have breeding seasons that are restricted to either the wet or the dry seasons (Benson *et al.*, 1971; Mader, 1981; 1982). The duration of some of their stages of the breeding cycle (such as incubation and nesting periods) are generally longer (Newton, 1979; Mader, 1982) with reproductive rates and nest success comparatively lower (Lack, 1968; Skutch, 1976) while, survival of fledglings and adults is as high as in temperate areas due to prolonged parental care (Mader, 1982).

Factors such as inclement weather and proximity to feeding places influence species of bird with small body size while larger species are better equipped to tolerate weather oscillations and can make long distance trips in search of food (Collias and Collias, 1984). Further, avian nest studies also show intraspecific variations in reproduction success in relation to nesting substratum. Nests made at the places not easily accessible to predators, such as cliffs, tall trees, thick vegetation, *etc.* have high breeding success (Li and Martin, 1991; Watson, 1992; Kelly, 1993). Further, nest site selection is also closely related to the individual fitness since it influences the probability of raising offspring successfully (Martin, 1988). As nest sites selection is competitive and strong, the choice of less secure places is very common. The individuals with lesser competitive abilities relegate to suboptimal sites (Li and Martin, 1991; Newton, 1991). In a given species, nest site quality varies in space and time at different scales due to different environmental factors affecting reproductive success (Wiens, 1976). Thus, selection of nesting habitat is of prime importance for the fitness of individual birds (Martin, 1988; Boulinier, 1996). Nest site selection of raptors has been studied by Speiser and Bosakowski, (1987) for Northern Goshawks, Redpath *et. al.*, (2001) for Hen harrier, Ontiveros (1999) for Bonelli's Eagle, Krûger (2002) for Common Buzzard, Serrano *et al.* (2004) for Lesser Kestrel,

Orth and Kennedy (2001) for Burrowing owl, Sara and Vittorio (2003) for Egyptian Vultures and Stanevièius, (2004) for Marsh harrier.

However, nesting requirements of the Black Kites is poorly known except brief accounts given by Ali, (1979) and Naoroji, (2007). Hence, nesting ecology of the Black kites was studied to understand the factors affecting selection of nesting habitat and nest tree characteristics and its implications for management of the species for conservation purpose.

MATERIALS AND METHODS:

Study area:

The Breeding season of Black kite is from September to February (Ali, 1979; Mahable and Bastawade, 1984; Naoroji, 2007). In the present study, nesting of Black Kites is investigated in Vadodara city (22° 18'N, 73° 10' E), Gujarat, India from 2009 to 2011. After identification of nests month wise random surveys were conducted from September to February (2009-11) each year to find out active nests (nest with eggs). Once identified the nests were regularly monitored for 2 to 4 days in a week. To study nesting ecology, nest site characteristics like tree species where the nest was built, height of tree, height of nest, canopy cover, sub-branches, trunk diameter at breast height (DBH), number of nests, distance from nearest water body, distance from nearest building (based on Google earth images), are recorded. The percentage of canopy cover is measured with the help of a mirror that has known numbers of grids

marked on it with uniform length and width. For the evaluation of canopy cover the grid mirror was held under the canopy exactly parallel to the ground and the number of grids occupied by the image of the canopy and the grids that were exposed to light having no image of canopy were counted to find out percentage of canopy cover (Paletto and Tosi, 2009). Tree height and Nest height was obtained using scale method and diameter at breast height (DBH) was measured using a standard measuring tape to measure the circumference of a tree and divided by π (3.14). Degree of urbanization and human activities along with differences in habitat composition around each nest tree was noted down.

Statistical analysis:

To analyze the relationship between different nest site characteristics, nest height is correlated with characteristic of the trees studied like canopy cover, height, DBH, distance of the nest from the nearest water body and distance of the nest from the nearest building by using Spearman rank correlation coefficient. Nest site characteristics for successful and unsuccessful nests were analyzed using t-test. Statistical evaluation of the data is carried out using Statistical software package Graph Pad Prism 3.00 and SPSS 7.0. Data values are expressed as mean ± SE and test statistics were considered significant at $P< 0.05$ and $p< 0.01$.

RESULTS:

Total 90 nests of Black Kites are recorded within the study area from 2009 to 2011.Out of these, 83 nests were successful whereas 7 were unsuccessful. As seen in Table1 and Fig.1, majority of nests were found on Neem trees (*Azadiracta indica* 61% of successful nests Plate: 5). The other species of trees used for nesting were Maha neem 13.25% (*Alianthus excelsa* - 12% successful with 2% unsuccessful attempts), Eucalyptus 4.81% (*Eucalyptus sps.* -4% successful nest and 1% unsuccessful nests), three each 3.61% of Gulmohor (*Delonix regia*– successful nests 3%) and Tamarind (*Tamarindus indicus* successful nests 3%), Ashoka 6.2% *(Saraca asoka)* with 6% successful and 2% unsuccessful nests), and one each (1.2%) of Piple (*Ficus religiosa* 1% successful nests and 2% unsuccessful nests) and Bahedo (*Terminalia bellirica*- successful nests 1% Plate:5). The mean tree height, nest height,canopy cover and DBH for Neem trees were 20.9 ± 0.12 m, 15.24 ± 0.32m, 85 ± 0.24 % and 96 ± 0.02cms.respectively. For the other 6 species, the height of nesting trees with successful attempts were 18.89 ± 0.32, 19.81 ± 0.04, 19.72 ± 0.81, 18.28 ± 0.34, 17.67 ± 0.01, 16.98 ± 0.75 and 20.42 ± 0.3m. for Maha neem, Eucalyptus, Gulmohor, Tamarind, Ashoka, Pipal and Bahedo respectively. The mean height at which nests are constructed are 14.02 ±0.21, 16.15 ± 0.09, 15.76 ± 0.9, 14.98 ± 0.2, 13.63 ± 0.12, 13.1 ± 0.24, 14.93 ± 0.5m. respectively. The highest canopy cover is

noted for Tamarind (87 ± 0.23%) while lowest is of Ashoka (58 ± 0.16%) and Eucalyptus (58 ± 0.4%). The highest mean DBH is noted for Tamarind (90 ± 0.02 cms) while lowest is noted for Ashoka (43 ± 0.4 cm).

Out of 83successful nesting trees, 45 nest are located near busy roads,26 near human habitation,8 nests near dumping area whereas only3 nests are found in garden and 1 near Industrial area (Table1, Fig.1). Further, for Neem trees mean distance from nearest water body and from nearest building are 370 ± 2.34 m. and 180 ± 13.21m. respectively, while for other species like Maha neem it is 800 ± 14.32 and 100 ± 4.21m, for Eucalyptus it is 400 ± 12.13; 220 ± 9.19m, for Gulmohor it is 500 ± 10.21 and 200 ± 4.1m, for Tamarind it is 300 ± 8.1 and 300 ± 15.76m, for Ashoka 179 ± 1.02 and 402 ± 12.98 m., for Pipal and Bahedo; 200 and 40 m. and 240 m. and 0 m. respectively as only one tree each are used for nesting.

Characteristics of trees used for nesting by Black kite- *Milvus migrans govinda* in Vadodara city.

As seen in Table 1 the mean height of trees where nesting is successful is 19.08 ± 0.48 m. Their mean height at which nests are constructed is 14.73 ± 0.37 m., the mean difference between tree height and height of nest is 4.23 ± 0.26m., mean canopy cover is 75%, mean DBH of trees is 63.25 ± 6.9 cms., the mean distance from nearest water body is 373 ± 71.93 m. and from nearest building is 180.3 ± 47.07 m.

As seen in table 2 the mean height at which the nesting was successful is 14.23±0.66m., the mean height at which the nest is constructed is 16.62± 1.64m, the mean difference between the tree height and nest height 1.88±2.06 m, the mean canopy cover is 68.5±0.07 %, the mean DBH 52±6.17cm., the mean distance from the nearest water body 394.8 ± 1.44m. and the mean distance from the nearest build is 195.5±78.06. On the other side the mean height at which the nesting was unsuccessful is 11.15 ± 0.61 m., the mean height of the tree is 14.74±1.24m, the mean difference between tree height and height of nest is 2.97 ± 0.9m., mean canopy cover of these trees is 48%, mean DBH of trees 41.75 ± 6.04 cms., the mean distance from nearest water body is 350 ± 120 m. and from nearest building is 190 ± 56.77 m.

In present study, breeding failure was noted in 7 nests. These nests were found on Eucalyptus, Ashoka, Pipal and Maha neem trees. When data of tree species on which both successful and unsuccessful nesting is computed (Table:3) there were significant differences between nest height ($P<0.05$) and percentage of canopy cover ($P<0.05$) of successful and unsuccessful nesting. No significant differences were noted between height of tree ($P>0.05$), DBH of tree ($P>0.05$), distance from nearest water body ($P>0.05$) and distance from nearest building ($P>0.05$).

As noted in Table: 3 highly significant correlation was found between tree height and nest height (0.89, $P<0.1$), tree height and canopy cover

(0.722, $p<0.05$) and, nest height and canopy cover (0.813, $p<0.05$). While DBH, distance from nearest water body and nearest building were non significantly correlated (0.431, 0.487 and 0.559 respectively, $p>0.05$) with each other.

Table: 1 Characteristics of trees used for nesting by Black kite- *Milvus migrans govinda* in Vadodara city.
SN=Successful nest, USN= Unsuccessful ne

		Tree height (m)	Nest height (m)	Difference Between tree and nest height (m)	Canopy cover (%)	DBH (cm)	Distance from nearest water body (m)	Distance from nearest building (m)
Neem tree *Azadiracta indica* **66.26%**	SN=55 61%	20.9±0.12	15.24±0.32	5.66	85±0.24	96±0.02	370±2.34	180 ± 13.21
Mahaneem *Alianthus excelsa* **13.25%**	SN=11 12%	18.89±0.32	14.02±0.21	4.87	78±0.02	50±0.09	800±14.32	100±4.21
	USN=2 2%	15.81±0.01	12.62±0.3	3.19	55±0.21	41±0.12	700±10.34	130±8.0
Eucalyptus *Eucalyptus sps.* **4.81%**	SN=4 4%	19.81±004	16.15±0.09	3.66	58±0.4	70±0.12	400±12.13	220±9.19
	USN=1 1%	15.01	11.21	3.81	45	59	320	200
Gulmohor *Delonix regia* **3.61 %**	SN=3 3%	19.72±0.81	15.76±0.9	3.96	78±0.34	58±0.2	500±10.21	200± 4.1
Tamarind *Tamarindus indica* **3.61 %**	SN=3 3%	18.28±0.34	14.98±0.2	3.3	87±0.23	90±0.02	300±8.10	300± 15.76
Ashoka *Saraca asoka* **6.02 %**	SN=5 6%	17.67±0.01	13.63±0.12	4.04	58±0.16	43±0.4	179±1.02	402 ± 12.98
	USN=2 2%	16.93±1.21	12.23±0.34	4.70	50±0.9	35±0.9	180±4.9	350±9.0
Piple *Ficus religeosa* **1.2%**	SN=1 1%	16.98±0.75	13.1±0.24	3.88	80±0.23	45±0.5	200	40
	USN=2 2%	11.21±0.76	9.53±0.41	2.68	45±0.34	32±0.79	220±3.21	100±4.65
Bahedo *Terminalia bellirica* **SN = 1, 1.2%**	SN=1 1%	20.42±0.3	14.93±0.5	4.49	75±0.01	57±0.8	240	0
Mean	90 (83+7)	19.08 ± 0.48	14.73 ± 0.373	4.23 ± 0.26	74.88 ± 3.93	63.25 ± 6.9	373 ± 71.93	180.3 ± 47.07

Table 2. Nest site characteristics of successful and unsuccessful nests.

Nest site characteristics	Unsuccessful Nest	Successful Nest
Tree height	14.74 ± 1.24	16.62 ± 1.61
Nest height	11.24±0.61	14.23 ±0.66*
Canopy cover	48.75± 2.39	68.50±3.07*
DBH	41.75 ±6.04	52±6.17
Distance from nearest water body	350 ± 120	394 ± 1.44
Distance from nearest building	190±56.77	195. ± 78.06

Table 2. Spearman rank Correlation coefficient between nest height and different characteristics of nesting tree.

Nest site characteristics (N=83)	Nest Height	Canopy cover	DBH	Distance from water body	Distance from nearest building
Height of tree	0.89**	0.722*	0.431	0.487	0.559
Nest Height		0.813*	0.456	0.351	0.510
Canopy cover			0.561	0.510	0.455
DBH				0.461	0.520
Distance from water body					0.623

* P<0.05, ** P<0.01, *** P<0.001

Fig:1 Percentage of trees used for nesting successfully (83 nests) by Black kite-*Milvus migrans govinda* in Vadodara city.

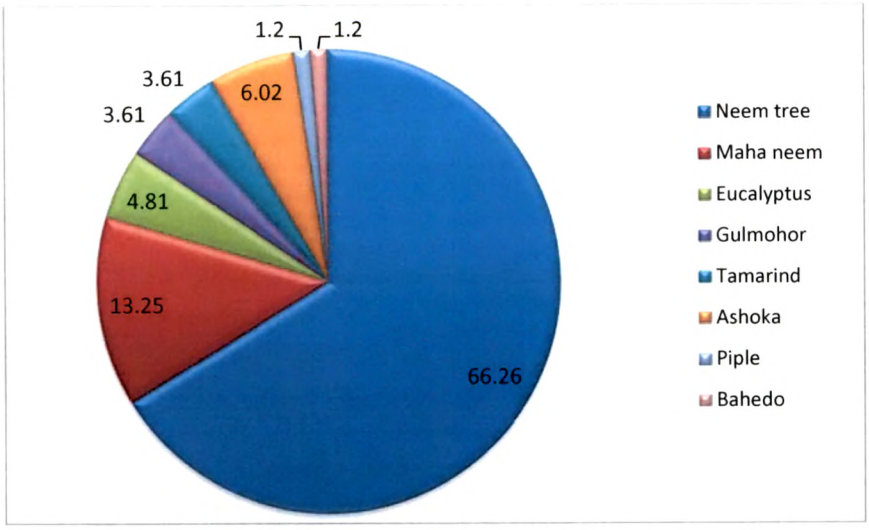
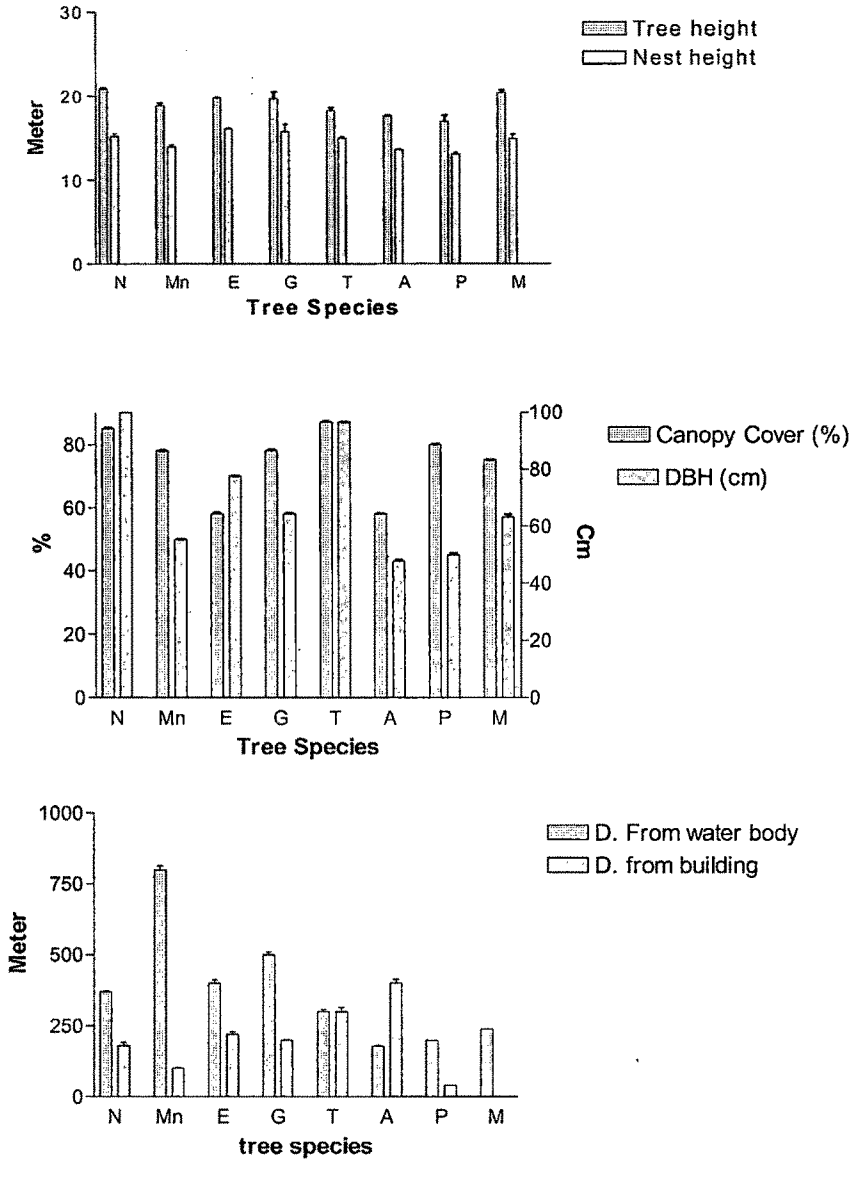


Fig: 2 Tree height, nest height, canopy cover, DBH, distance from nearest water body and distance from nearest building of trees used for nesting of Black kite.



Where, N= Neem tree, Mn=Maha neem tree, E= Eucalyptus tree, G= Gulmohor tree, T= Tamarind tree, A= Ashoka tree, P=Pipal tree, B= Bahedo tree.

Fig 3. **Correlation between Tree height and different characteristics of nesting tree.**

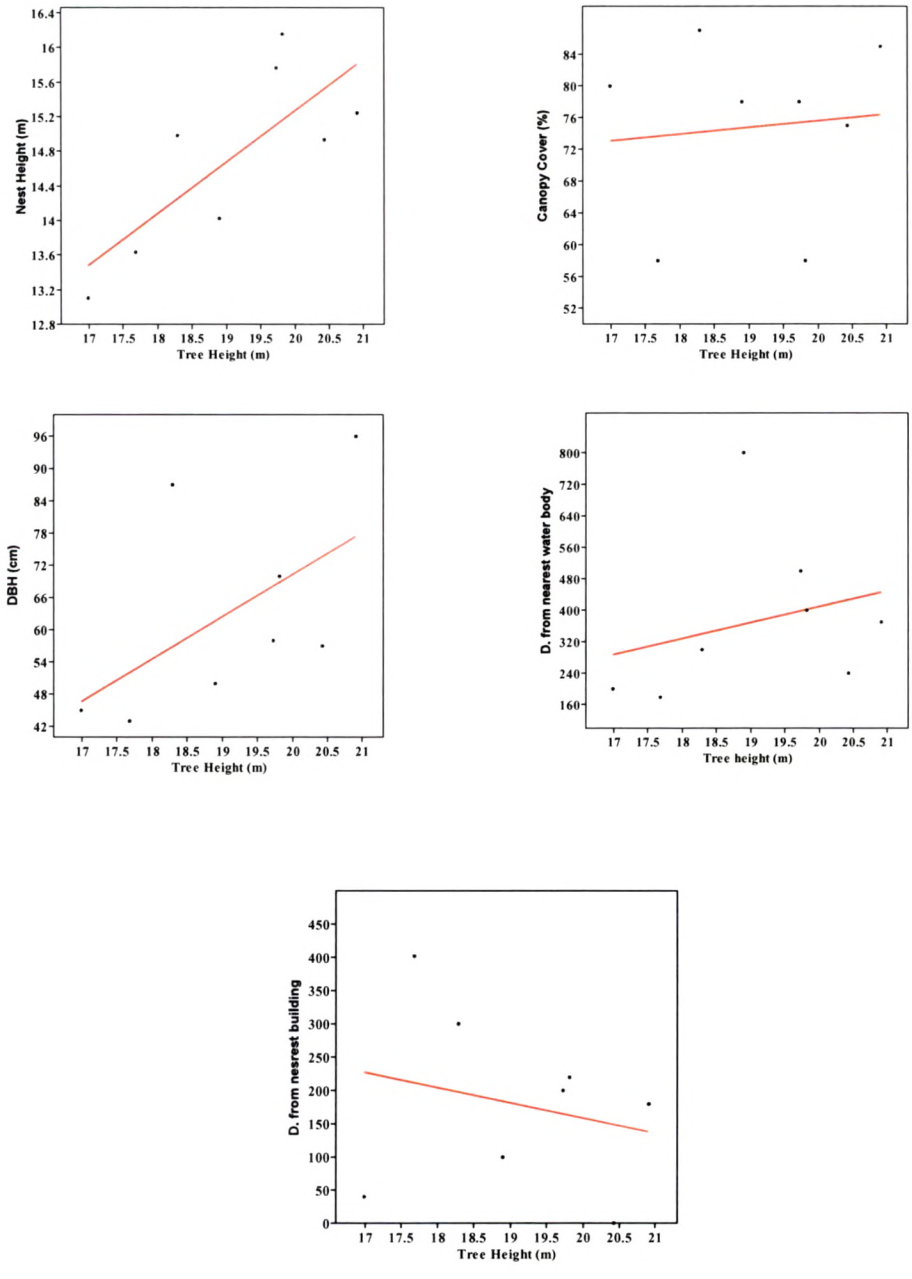
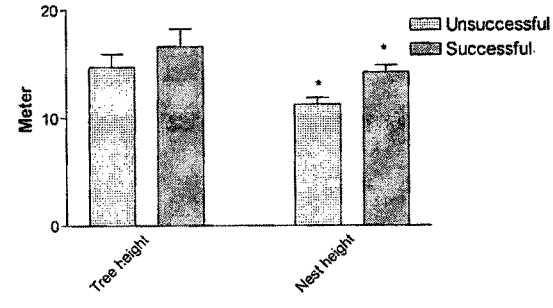
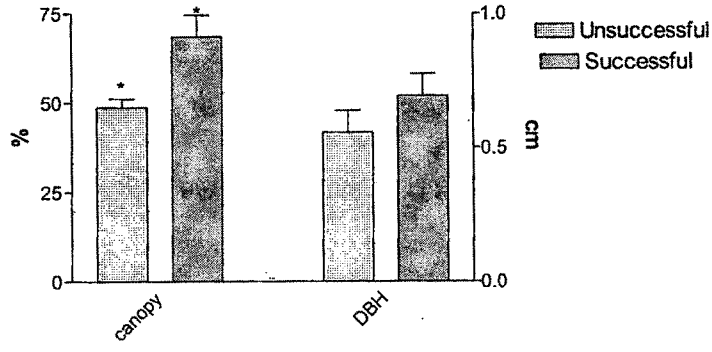
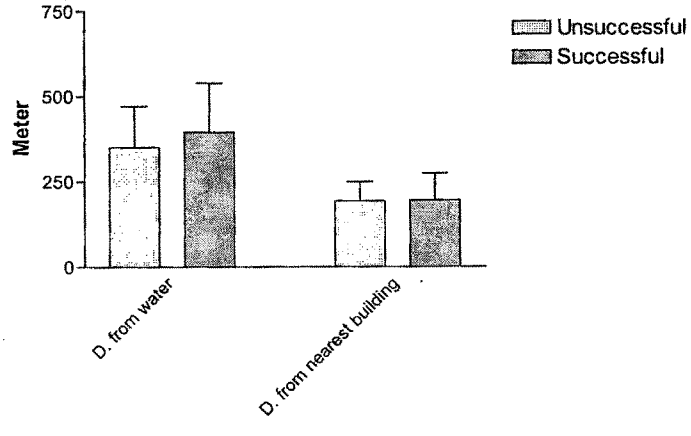


Fig 4. Nest site characteristics of successful and unsuccessful nests.







DISCUSSION:

Identification of the habitat features, that influence reproduction and survival, are essential for the management and long-term viability of bird populations (Davis *et al.*, 2006). As successful nesting is important for later, selection of nesting tree also should be equally important. In the present study it is noted that the Black Kites mainly prefer Neem trees (*Azadiract indica*) for nesting. The reason may be the availability of these trees in large numbers which have suitable height and canopy preferred by these raptors. Neem is the most common tree in the area. Among other trees, Maha Neem (*Alianthus exelsa*) with almost similar canopy covers and height were preferred. They also provide number of crotches to hold the nest properly on the tree. The dense cover of the canopy provides sustained protection by minimizing direct heat loss to the open sky (Morse, 1980) and thermal stress to vulnerable young while provides hide from the predators (Burger and Hahn, 1989) and does not require wing shading provided by parents to their chicks, which considerably reduces energy loss by the parents (Lack, 1968).

However, among these two tree species, 100 % nesting success was noted only on *Azadiracta indica* (55 nests) whereas nesting success for *Alianthus exelsa* is noted to be lower [Successful nest-11 (12%) and Unsuccessful nest-2 (2%)] having comparatively low canopy cover. As noted for Hadada Ibis and Black Ibis (Soni *et.al.*, 2010), Black Kites also

prefer nesting on the upper third of the tree. A positive correlation of tree height and canopy with nest height indicates that canopy cover and height of trees are important for nesting by Black Kites. The height and higher nest elevation provide easy access to leave and to land directly on the nest. Majority of bird species choose their nest site with the consideration of climatic pressures such as wind speed, temperature, sudden and heavy rain pour as well as potential predation including human disturbance (Dhinsa *et al.*, 1989). The position of nest on the sub- branch and its proximity to the trunk minimizes exposure, easy flight pathways and escape. Beside the characteristics of the tree and nest vicinity, consideration of the foraging sites is also equally important. The American White ibis (*Eudocimus albus*) are reported to construct their nesting colony depending on the availability of the foraging habitat (Kushlan, 1976). Similarly, Egyptian Vultures (*Neophron percnopterus*) also build their nests at the site where the food availability is abundant (Olga and Jose, 1989). Thus, distance from foraging habitat is crucial to birds to avoid exposure of chicks for long duration to predation (Plate: 6). Though not measured majority of nests found in the present study were found nearer to either garbage dumps or near poultry or mutton shops where plenty of food is available. Food and water are the basic requirements for any individuals. In the case of Black kites, their nests are nearer to waterbodies too.

Birds with food solitarily show nest solitarily too (Lack, 1968). Like, Common Kestrel (*Falcon tinunculus*) (Bustamante, 1994), Black Kites are also solitary nesters. Further, it is a well known fact that availability of food and nesting sites are limiting factor for bird populations including raptors. However, raptors in urban area are equally opportunistic and acquire either of these limited commodities from human source. Though, not observed in Vadodara, Kites have been observed nesting on power poles or high voltage transmission towers in Ahmedabad. Thus, when trees are not available for nesting they use other resources to overcome availability of a second limited source. Acquisition of such limited commodities has increased the urban population of Kites.

Many bird species are reported to occupy previously used nesting area (Greenwood and Harvey, 1976; Newton, 1979; 1982). These researchers noted that breeding site fidelity is more often observed in the successful individuals than the unsuccessful one. Reuse of old deserted nests and taking over of active nests are recorded for many bird species as a consequence of scarcity of nest sites or nest materials (Dusi, 1968; Burger, 1978a; 1978b). Many species also show nesting associations (Welty and Bapista, 1988). Nesting association of Black Kites with crows was recorded in Vadodara. An association with a predatory species is related to protection from potential predators. Such an association is also

reported in White Ibis (Donazar *et al.*, 1996). Similar observation was recorded at Ahmedabad. It was also noted that the nests used by Vultures were reused by Black Kites (Personal observation). Stealing of nest material was also recorded occasionally by Black Kites as is also reviewed by Welty and Bapista (1988). Old nest is reused by many species like Cattle egret and Little Blue heron (Dusi, 1968) and Buff necked Ibis (Donazar *et al.,* 1996). Likewise, Black Kites often reuse their conspecific or heterospecific deserted nests. By preferring old nests, the kites could save energy required in exploring safer nest sites and by shortening the period of nidification. Frequent flights are required to gather nest material from nearby area to build a nest. Thus, Black Kites have to invest much time and energy to build a new nest. Therefore, reuse of nest involves apparent benefit of time and energy saving by not building a new nest. It is further supported by the fact that pre-laying period is significantly shortened when a pair reuses old nest. If the same pair reuses the site, then it could minimize the cost of territory establishment too (Soni *et al.*, 2010).

Nest predation is the main cause of nest failure in many bird species (Ricklefs, 1969; Martin, 1993) and nest-predation rates have been shown to vary with nest-site characteristics for a wide range of bird species (Ricklefs, 1969; Collias and Collias, 1984; Martin, 1993). In Black Kites, out of 83 nests only 7 nests are not successful. It is also noted that

unsuccessful nests are built on shorter trees which provide lower nest height with a thinner canopy cover and are directly exposed to sunlight. Though the actual reason for nest failure could not be found out in present study, it might be because of selection of inferior nesting sites. Human impact on the environment is one of the major issues in biodiversity conservation (Meffe and Carroll, 1994). As far as an urban adaptor like Black Kite (Rathod, 2009) is concerned, the human presence had no negative influence on its nesting. Distance from nearest building was not correlated with nesting activities as 45 nests were located on busy roads, 26 near building while only 4 in undisturbed area.

In conclusion it may be said that Black Kites *M. m. govinda* prefers nesting in the trees which are tall and have higher canopy cover. The availability of these trees is also important. In Vadodara where large number of old *Azadiracta inidca* with high canopy cover as well as height are present the success of nesting on it is 100%.

Plate 5 Nest of Black Kite (*Milvus migrans govinda*) on Neem

Nest of Black Kite on *Terminalia bellirica*

Plate 6

Young once of Black Kites (*Milvus migrans govinda*)

Juvenile Black Kite (*Milvus migrans govinda)* with Parent