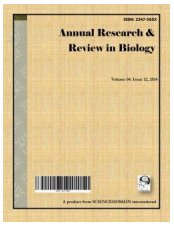

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Roosting Behaviour of Black-winged Kite (*Elanus caeruleus*) Inhabiting the Arid Zone of Rajasthan

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Authors' contributions

This work was carried out in collaboration between both authors. Author MLM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MLM and KCS managed the analyses of the study. Authors MLM and KCS managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The word "Roost" means "a sleeping house of fowls". The roosting ecology of Black-winged kite was studied from January 2012 to December 2014 in rural and urban areas of Churu city and rural areas of Ratangarh of Churu district, Rajasthan, India (Lat 29˚ N, Long 75˚ E and 286 Msl). The aim of this study was to find out the factors like the roost site selection, tree preference for roosting and roosting hours of Black-winged kite to help in long term management and conservation of this bird. During this period, 29 roosting sites were studied out of which 24 (82.76%) roosting sites were located in rural areas while 5 (17.24%) roosting sites were located in urban areas. Temporary and permanent roosting sites were mostly located near agriculture farm houses and sand dunes. Twelve species of trees were available for roosting out of which only one species of trees was mostly preferred for roosting, namely Khejari (*Prosopis cineraria*). It prefers Khejari (*Prosopis cineraria*) tree due to its height, canopy and diameter at breast height (DBH). The waking and sleeping calls were also recorded during this study period. The average waking calls were made at 06:11 hr SD±0.50 hr (n=12) and average sleeping calls were made at 18:54 SD±0.04 hr (n=12) in summer season. It

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roosts early in the winter and late in the summer and rainy season because the duration of the day time is longer than the winter.

Keywords: Roosting; black-winged kite; Rajasthan; India; Khejari (Prosopis cineraria).

1. INTRODUCTION

A bird's perching or roosting place is its roost. The word "Roost" is derived from the German meaning; "a sleeping house of fowls" [1]. Aggregations of roosting individuals are common in primates [2], bats [3,4], and birds [5]. Avian communal roosting is thought to confer benefits in terms of decreased predation risk, and increased foraging efficiency [5,6] but the results are still controversial [7]. A greater knowledge of the ecological correlates of communal roosting could help unravel issues about the origin and maintenance of the trail in birds. Roosting is the activity of birds to settle for taking rest or sleeping at night. Some nocturnal birds may however rest during day time. Some birds are solitary in nature as they stroll singularly for food and also roost singularly, e.g. woodpeckers and other whole nesters. However, the phenomenon of singular roosting is not common, as it may be less advantageous to these birds [8].

The roosting behaviour of various avian species has been studied all over the world. Some of these investigations include: Study on starling's roosts by [9,10] worked on roosting in the swallow; and [11] studied roosts in the Australian harrier. [12] collected much data on the behaviour of birds prior to their occupation of communal roosts and hypothesized roosting behaviour to have a function of regulation of population size in relation to local food supply. Roosting sites also play a significant role in population regulation in birds [13].

Communal roosting behaviour implies many ecological and evolutionary consequences in birds [5,14-16]. Intra and interspecific interactions at a mixed roost of Ciconiiformes in Mexico have been described [17]. Observations of communal roosts of the Black-winged kite focusing on competition for perch site selection was considered to execute during the present study. [18] studied the roosting behaviour and its relationship to the number of Pariah kite at Kolhapur, India. Following corollary study, the number of roost sites occupied by the Black-winged kite during different climatic season were noted and discussed. [19] found that natural entrainment by photoperiod, and that the entrained organisms integrate more or less over the light intensities in both parts of a light cycle.

To find out the factors inducing the roost site selection, tree preference for roosting and roosting hours a study was done of the Black-winged kite from January 2012 to December 2014 in Churu district of arid zone of Rajasthan (India). Therefore, the objective of this study was to determine these factors on the temporal behaviour of the Black-winged kite roost. Because the adaptive significance of roosts yet to be resolved [20-23]. Basic patterns in roosting behaviour should provide essential information enabling understanding of the general functions of communal roosting of the Black-winged kite may help in long term management and conservation of this bird. Therefore, the roosting mechanism was studied in details during present study.

2. MATERIALS AND METHODS

The roosting ecology of Black-winged kite (*Elanus caeruleus*) was studied during January 2012 to December 2014 in rural and urban areas of Churu city and rural areas of Ratangarh city (Churu district) of Rajasthan, India (Lat 29˚ N, Long 75˚ E and 286 Msl).

In the study area, a total of 29 roosts sites were identified and divided into subareas; urban and rural, depending upon the location of roosts, in or at the outskirt areas of the Churu city and outskirt areas of Ratangarh city. Further roost was classified at temporary or permanent, depending upon seasonal or perpetual presence of the Black-winged kite respectively throughout the study area.

From four roosting sites of the different localities, at least 10 Black-winged kites were selected to study the roosting behaviour. These selected roosts sites were visited once a month for 36 months from January 2012 to December 2014 in the morning from 5:00 AM to 8:00 AM to estimate the peak departure time, and in the evening from 4:00 PM to 8:00 PM to estimate the peak arrival time of the Black-winged kite. Sunset and sunrise timing were collected from the metrological department to determine relationship between periods of sunlight with the peak arrival as well departure timings of the Black-winged kite.

The proximity of foraging ground and a terrestrial habitat to the roosts were recorded after estimating the availabilities of habitats at temporary and permanent roosts. All the trees and objects in 100 meter radius of each roost were counted, identified up to the species level, and measured. This work was performed at the approachable roosts to find out preference for the trees in relation to all characteristics. The diameter at breast height (DBH) of all available trees were measured with the help of meter tape by measuring the circumference in feet. Height of all available trees and object were measured using on ebony level, and recorded in feet. The canopy covers of all available trees were measured from 4 different sides to obtain on average diameter.

The Juvenile Black-winged kites are apparently less skilled in finding roosts during late evening after sunset. Therefore; number of birds arriving before and after sunset were recorded at already marked 2 roosts were classified according to adult and Juvenile birds to Justify the fact whether Juveniles can search roost after sunset or not. The Black-winged kite Juvenile considered his body features as an overall darker brown but liberally mottled and streaked.

The timings of sleeping and waking calls at roosts were recorded to determine the resting hours during different climatic seasons. Further, the student's t-test was applied to determine the significance of the variation in resting hours depending upon the length of day during different seasons. To assess the social rituals of mornings, the average time between the first call and sunrise period was compared to the time of first call and the start of departure from the roosts by applying student's t-test. And the correlation between waking calls and sunrise timing were also analyzed.

The Black-winged kites were observed with naked eyes as well as with the help of 10 X 50 Olympus binocular photographs were taken with the help of Nikon P-510 camera.

3. RESULTS

3.1 Classification of Roosts Sites

Out of total 29 roosts sites, 19 (65.52%) were found temporary whereas 10 (34.48%) were permanent (Table 1). Further, it was recorded that out of total 19 temporary roosts, 14 (73.68%) were located in rural area and 5 (26.32%) in the urban area. Among permanent roosts it was found that out of 10 roosts, 10 (100%) were located in rural area and 0 (0.0%) in the urban areas. There were 24 (82.76%) roosting site located in rural areas and 5 (17.24%) in the urban areas. The ratio of temporary and permanent roosts was 1.40:1 in rural area. Among 5 urban roosts, 5 (100%) were temporary in nature while permanent roost sites were entirely absent in urban area. Roosting trees were also used for nesting by this Black-winged kite. In rural area 91.67% roosts were selected for breeding, where as in urban areas roosts were not selected form breeding.

3.2 Factor Inducing the Selection of Roosts

Distance of the foraging grounds, availability of agriculture farm houses were the important factors in the site selection of roosts. Tables 2 and 3 show immediate locations of the 5 classified microhabitats around temporary and permanent roosts within 1 km. radius. There were an average 3.05 SD±0.71 foraging grounds located nearby temporary roosts, and 3.7 SD± 0.48 nearby permanent roosts of the 19 temporary roosts, 11(57.89%) roosts were located near the feeding habitat, 7(36.84%) within 1000-2000M and 01 (5.26%) beyond 2000 m from foraging grounds (Table 4). Among 19 temporary roost, 13 (68.42%) roosts were located near the aquatic habitat, 04(21.05%) within 1000-2000M and 02 (10.53%) beyond 2000M from the habitat. Among the 10 permanent roosts, 8 (80%) were located near the feeding habitats, 1(10%) within 1000-2000 M and 1(10%) beyond the 2000 m from these habitats (Table 4). Among these 10 permanent roosts, 7(70%) roosts were located near an aquatic habitat and 2(20%) within 1000-2000m and 1(10%) beyond 2000 m from aquatic habitat (Table 4). Temporary and permanent roosts sites were preferably near agriculture farm houses and sand dunes and grazing fields (Tables 2, 3).

3.3 Roost Trees

Total 432 trees belonging to 12 species were recorded as roosting trees. Khejari *Prosopis cineraria* (43.29%), Rohida *Tecomella undulate* (23.61%) and Keekar *Acacia nilotica* (17.59%) were the principal roosting trees comprising 84.49%. Only 15.51% roost trees belonged to 9 species. There number was 67 trees belonged to 9 species. There number was 67 trees only (Table 5).

Table 1. Location of temporary and permanent roosts at urban and rural areas. And record of those sites used for breeding as well (Percentage in parenthesis)

Roost site	Rural area	Urban area	Total roosts
Temporary	14 (58.33)	5 (100)	19 (65.52)
Permanent	10 (41.67)	00 (00)	10 (34.48)
Total roosts	24	5	29
Roosts selected for breeding	22 (91.67)	00 (00)	22 (75.86)

Table 2. Feeding habitats recorded around 1 km radius of temporary roost of Black-winged kite

Roost site	Location	AFH	SD	FA	GF	GYA	Total sites
Shri Ganesh Temple	Depalsar	*	*		*		3
Meera ji Temple	Khariya	*	*		*		3
Birbal Ram's Farm	Khariya	*	*		*		3
Joranath ji Temple	Gorisar	*	*		*		3
Koalth (Hanif's Farm)	Gorisar	*	*	*	*		4
Shukra Nath ji ki Bari	Gorisar	*	*		*		3
Govt. Primary School	Daudsar	*	*		*		3
Sohan Ram's Farm	Malpur	*	*		*		3
Karni Mata Temple	Malpur	*					1
Muslim Graveyard	Jaleu	*	*			*	3
Thakrana	Jaleu	*	*	*	*		4
Govt. Primary School (Mata Temple)	Sehla	*	*	*	*		4
Jambhoji Gaushala	Satara	*	*		*		3
Hanuman's Farm	Satara	*	*		*		3
Nath Ji Dhora	Churu	*	*	*	*		4
RIICO Area	Churu		*	*			2
Pankha Kabristan	Churu		*	*		*	3
Sethani Johara	Churu	*	*	*			3
Narmada Park	Churu	*	*	*			3
Total		17	18	8	13	2	$\bar{X}$=3.05 SD±0.71 Range: 1-4

Asterisk (*) indicate number of available feeding habitats.
$\bar{X}$ indicates average number of available feeding habitats. SD± indicates standard deviation.
AFH= Agriculture farm house, SD = Sand dunes, FA = Forest area, GF = Grazing field, GYA = Graveyard area.

Table 3. Feeding habitats recorded around 1 km radius of permanent roost of Black-winged kite

Roost site	Location	AFH	SD	FA	GF	GYA	Total sites
Govt. Secondary School	Khariya	*	*	*	*		4
Sukha Ram's Farm	Khariya	*	*		*		3
Surjana Johara	Khariya	*	*	*	*		4
Lalani Johara (Railway Puliya)	Khariya	*	*		*		3
Ranana Johara	Gorisar	*	*	*	*		4
Mohan Ram's Farm	Gorisar	*	*	*	*		4
Nirani Johara	Gorisar	*	*	*	*		4
CJRM School	Gajsar	*	*	*	*		4
Choudhary Farm	Jaleu	*	*		*		3
Nath Ji Ki Jhopari	Satara	*	*	*	*		4
TOTAL		10	10	7	10	00	$\bar{X}$=3.7 SD±0.48 Range: 3-4

Asterisk (*) indicate number of available feeding habitats.
$\bar{X}$ indicates average number of available feeding habitats. SD± indicates standard deviation.
AFH= Agriculture farm house, SD = Sand dunes, FA = Forest area, GF = Grazing field, GYA = Graveyard area.

Twenty-nine (6.71%) trees belonging to 2 species were more preferred for roosting by the Black-winged kite. Distribution and reference of 12 tree species at the 29 roost sites may be seen in the Fig. 1. Names and average heights of the available and preferred trees are graphically presented in Fig. 2 and tabulated in the Table 5. Table 6 represents the available trees at various roosts sites, preferred trees for roosting and tree heights. Table 7 shows the highest preference for roosting to those sites which were having tree frequency in the range of 5-10 and least preference for those sites which were having tree frequency 1-5. Among total 29 roost sites 4 (13.79%) roost sites were having tree frequency in the range of 1-5, 12 (41.38%) in the range of 5-10, 5 (17.24%) in the range of 10-15 and 8 (27.59%) were in the range of >15.

3.4 Factors Influencing the Selection of Roost Trees

The Black-winged kite selected live and unbroken canopies of the tall tree to roost. Though height was one of the consideration for roosting but only tall trees of Khejari and Rohida with good canopy selected for roosting (Tables 5, 6). Thus, a combination of height, canopy and DBH influenced the roosting of the Black-winged kite on trees (Table 8).

3.5 Waking and Sleeping Calls

The waking calls were normally recorded during dawn and the sleeping calls during dusks. In the summer, average waking calls were made at 06:11 hr SD± 0.50 hr (N=12) and average sleeping calls were recorded at 18:54 hr SD± 0.04 hr (N=12). During the monsoon season, average waking calls were made at 06:10 hr SD± 0.01 hr SD± 0.08 (N=12). And during winter season, average waking calls were made at 06:21 hr SD±0.03 (N=12) and average last calls during the late evening were recorded at 18:37 hr SD± 0.06 hr (N=12). (Table 9)

The difference between timing of calls made during summer and monsoon seasons were non-significant ($t=0.44$, $df=22$, $p<0.05$). While there was a significant difference between the timing of calls made in monsoon and winter seasons ($t=-11.93$, $df=22$, $p<0.05$). The difference in the timing of calls made in the summer and winter seasons were also significant ($t=-6.17$, $df=22$, $p<0.05$). (Table 9)

Table 4. Location of temporary and permanent roosts from feeding and aquatic habitats. Distance of the sites presented in meter (m)

Percentage in parenthesis

Habitat	Location of 19 temporary roosts (m)			Location of 10 permanent roosts (m)		
	< 1000	1000-2000	> 2000	< 1000	1000-2000	> 2000
Feeding	11 (57.89)	07 (36.84)	01 (5.26)	8 (80)	01 (10)	01 (10)
Aquatic	13 (68.42)	04 (21.05)	02 (10.53)	7 (70)	02 (20)	01 (10)

Table 5. Record of available and preferred roosting trees and average height of each species. Observations were recorded in feet (ft) and presented as mean ($\bar{X}$) and range (R)

Common name of tree	Number of tree available	Number of tree preferred	Average height of available tree (ft)	Average height of preferred tree (ft)
Khejari	187	28	$\bar{X}$=26.17 R=18.35-33.96	$\bar{X}$=25.33 R=21.16-28.90
Rohida	102	1	$\bar{X}$=28.64 R=16.79-32.52	$\bar{X}$=26.48
Keekar	76	0	$\bar{X}$=22.11 R=14.56-26.86	
Talee(Sisham)	22	0	$\bar{X}$=25.27 R=15.76-30.73	
Neem	27	0	$\bar{X}$=23.68 R=16.76-32.34	
Peepal	7	0	$\bar{X}$=26.07 R=20.11-32.67	
Sirash/Saresh	1	0	$\bar{X}$=20.64	
Bargad	1	0	$\bar{X}$=22.57	
Vilayati babool	1	0	$\bar{X}$=26.48	
Shapheda	2	0	$\bar{X}$=31.19 R=27.67-34.71	
Jaal	2	0	$\bar{X}$=21.64 R=17.16-26.12	
Ardu	4	0	$\bar{X}$=31.44 R=28.40-35.22	
Total	**432**	**29**		

Table 6. Record of available and preferred roosting trees at different roosting sites. Roost site in italics indicate permanent roosting site

Roost site	Location	Available tree	Preferred tree for roosting	Tree height
Shri Ganesh Temple	Depalsar	Kh,R,Ke,N.J	Kh	27.43
Govt. Secondary School	Khariya	Kh,R,Ke,A	Kh	23.29
Meera Ji Temple	Khariya	Kh,R,Ke,T,N,P	R	26.48
Sukha Ram's Farm	Khariya	Kh,R,Ke	Kh	23.13
Surjana Johara	Khariya	Kh,R,Ke,N	Kh	26.77
Birbal Ram's Farm	Khariya	Kh,R,Ke,N,A	Kh	22.83
Lalani Johara (Railway puliya)	Khariya	Kh,R,Ke,N	Kh	22.90
Joranath Ji Temple	Gorisar	Kh,R,Ke,N,P	Kh	23.49
Ranana Johara	Gorisar	Kh,R,Ke,T,N,P,A	Kh	28.31
Mohan Ram's Farm	Gorisar	Kh,R,Ke	Kh	25.79
Kolath (Hanif's Farm)	Gorisar	Kh,R,Ke,J	Kh	23.13
Nirani Johara	Gorisar	Kh,R,Ke,T,N	Kh	26.31
Shukranath Ji Ki Bari	Gorisar	Kh,R,Ke,T,N,P,Vb	Kh	27.79
Govt. Primary Shool	Daudsar	Kh,R,Ke,N	Kh	21.16
Sohan Ram's Farm	Malpur	Kh,R,Ke	Kh	23.29
Karni Mata Temple	Malpur	Kh,R,Ke,T,N,P,A	Kh	28.61
Muslim Graveyard	Jaleu	Kh,R,Ke,N	Kh	25.03
Choudhary Farm	Jaleu	Kh,R,Ke,T,N	Kh	21.69
Thakrana	Jaleu	Kh,R,Ke	Kh	27.59
Govt. Primary School (Mata Temple)	Sehla	Kh,R,Ke,T,N,P	Kh	26.12
Jambhoji Gaushala	Satara	Kh,R,Ke,T,N	Kh	28.90
Nath Ji Ki Jhopari	Satara	Kh,R,Ke,T,N	Kh	22.31
Hanuman's Farm	Satara	Kh,R,Ke	Kh	28.15
CJRM School	Gajsar	Kh,R,Ke	Kh	26.18
Nath Ji Dhora	Churu	Kh,R,Ke,T,N,P,S,B	Kh	26.84
RIICO Area	Churu	Kh,Ke,N.P.Sh	Kh	22.64
Pankha Kabristan	Churu	Kh,R,Ke,N,P,B,Sh	Kh	25.23
Sethani Johara	Churu	Kh,R,Ke,N,A	Kh	26.61
Narmada Park	Churu	Kh,R,Ke,T,N,P,	Kh	27.66

Kh=Khejari, R=Rohida, Ke=Keekar, T=Talee/Sisham, N=Neem, P=Peepal, S=Sirash, B=Bargad, V=Vilayati babool, Sh=Shapheda, J=Jaal, A=Ardu

3.6 Factors Affecting Communal Roosting

The communal roosting of the Black-winged kite inhabiting arid zone of Rajasthan was mainly affected by the photo period. The bird roosts early in the winter and late in the summer and rainy season when the span of the day is longer than the winter weather conditions measured as ambient temperature, wind speed and cumulative daily precipitation had no effect on arrival times at the pre-roost and the roost. Likewise, moon light did not affect roosting times.

4. DISCUSSION

Our result shows that the Black-winged kite roosts both in rural and in urban areas but mostly roosts in rural area of arid zone of Rajasthan. The reason of its roosting in these areas is availability of feeding ground viz agriculture farm and grazing fields [24-26]. And these areas are mostly found in the rural areas.

In arid zone of Rajasthan, the Khejari trees are found in more density in rural area, which facilitated this Black-winged kite to select and roosts on Khejari tree. Black-winged kite also use Rohida tree for roosting which are also present in rural areas. These trees are full of canopy which provides proper shelter during roosting. So, Black-winged kite use these trees for roosting and nesting throughout their range [27].

Black-winged kite mainly feed in agricultural areas all over the world and their permanent roosts are located near these areas [28]. Black-winged kite adapted to forage in the agricultural areas in the arid zone of Rajasthan.

Roosts in not a simple assemblage of individuals, but rather evolved as a predator avoidance [29]

and information center [30]. Selection of roost sites and roost tree is therefore, largely based on the availability of the roosts with reference to predator avoidance and acting as information centers. Characteristics and availability of the tree species are also the reasons of selecting a particular tree [31]. Trees like Sisham (*Delbergia sisso*), and Jaal (*Salvadora persica*) lack a dense canopy pattern. They cannot provide protection against climate and potential predators, henceforth not preferred for roost. Whereas, the trees with denser canopy such as Khejari (*Prosopis cineraria*) and Rohida (*Tecomella undulata*) were preferred as they provide shade, and cover and hence minimizing predation and energy loss. Khejari is preferred more in comparison to Rohida because of slightly short height and characteristics pattern of leaves. Moreover, canopy of Khejari tree is denser than the Rohida tree. Some species, such as Sapheda (*Eucalyptus alba*) and Vilayati babool (*Prosopis Juliflora*) are fairly tall but they are architecturally inappropriate for the Black-winged kite to perch. Preference of the Black-winged kite to the Khejari trees with dense foliage seems reasonable as the foliage minimize radiation heat loss to clear skies [32]. Similar studies have been reported by [33] and [34] on Spotted owl (*Strix occidentalis*) and in Torresian crow *(Corvus orru)* respectively. The importance of canopy density has been previously shown by [35] for rural roost and also in urban roosts of House crow, *Corvus splendens* [36] and Common myna *Acridotheres tristis* [37]. Though predation could not be observed during the roosting of Black-winged kite, but the bird take care while roost on the tree. Taking care during roosting from conceivable predator is reported in birds [30]. Choice of the roosting tree does not depend on imprinting [38], or early experience [39] in birds, so also in Black-winged kite the selection of roosting tree depends on structural characteristics and the availability of the suitable species.

Vocalization of birds is the consequential gesture in their social development. Because birds are the only animals other than human beings that can make sounds they were not born to make [40]. Birds in the plains and forest are very regular in their roosting timings. A longer time difference between the first call and sunrise period shows their chronological sense to call before an actual beginning of the first call and sunrise period show their chronological sense to call before an actual beginning of the day. Shorter time difference between the first call and the departure of the Black-winged kite from the roost shows its ability to save day duration for the diurnal activities.

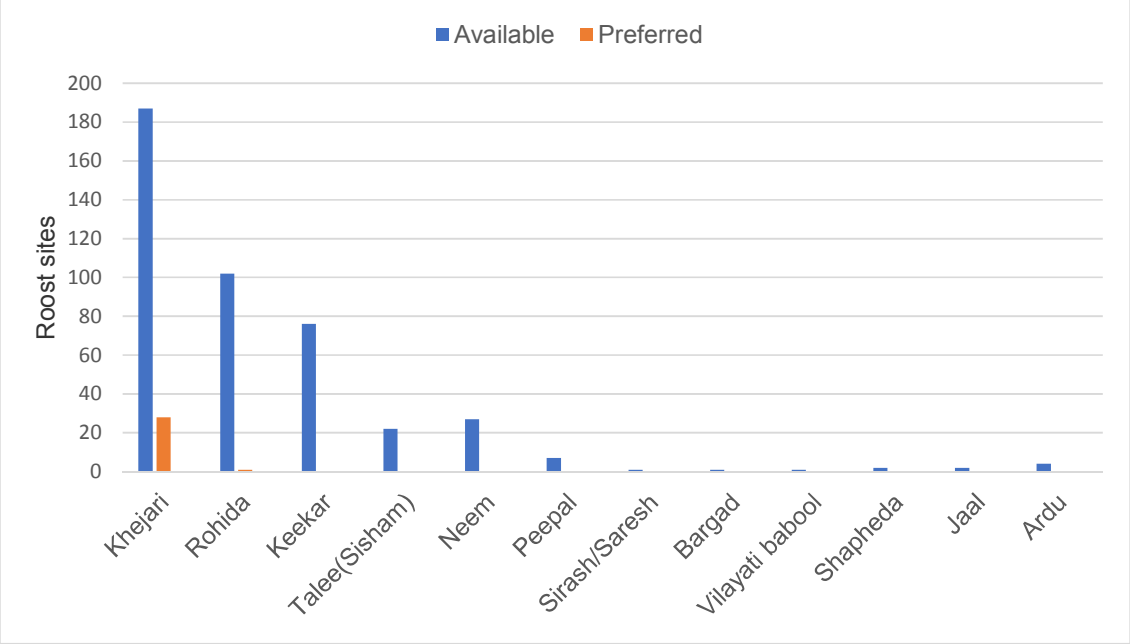

Fig. 1. Distribution of available tree species and the preference for roosting by the Black-winged kite at 29 sites

Table 7. Density of potential roost trees recorded in 100 m radius. Asterisk (*) indicates tree frequency

Percentage in parenthesis

Roost site	Location	Tree frequency			
		1-5	5-10	10-15	>15
Shri Ganesh Temple	Depalsar	*			
Govt. Secondary School	Khariya		*		
Meera Ji Temple	Khariya	*			
Sukha Ram's Farm	Khariya		*		
Surjana Johara	Khariya				*
Birbal Ram's Farm	Khariya		*		
Lalani Johara (Railway puliya)	Khariya		*		
Joranath Ji Temple	Gorisar	*			
Ranana Johara	Gorisar				*
Mohan Ram's Farm	Gorisar		*		
Kolath (Hanif's Farm)	Gorisar				*
Nirani Johara	Gorisar			*	
Shukranath Ji Ki Bari	Gorisar		*		
Govt. Primary Shool	Daudsar		*		
Sohan Ram's Farm	Malpur		*		
Karni Mata Temple	Malpur				*
Muslim Graveyard	Jaleu			*	
Choudhary Farm	Jaleu		*		
Thakrana	Jaleu	*			
Govt. Primary School (Mata Temple)	Sehla			*	
Jambhoji Gaushala	Satara		*		
Nath Ji Ki Jhopari	Satara				*
Hanuman's Farm	Satara			*	
CJRM School	Gajsar		*		
Nath Ji Dhora	Churu				*
RIICO Area	Churu				*
Pankha Kabristan	Churu				*
Sethani Johara	Churu		*		
Narmada Park	Churu			*	
Total sites: 29		**4 (13.79)**	**12 (41.38)**	**5 (17.24)**	**8 (27.59)**

Table 8. Average values of height, canopy cover, and diameter at breast height (DBH) of the available and preferred roost trees.

Tree characteristics	Available trees (N= 432)	Preferred trees (N= 29)	Student's t-test
Height (ft)	$\bar{X}$= 25.49 SD±2.65	$\bar{X}$= 25.91 SD±1.04	t= 0.847 df= 459 p<0.05 (NS)
Canopy cover (ft)	$\bar{X}$= 19.87 SD±2.20	$\bar{X}$= 18.35 SD±1.03	t= -3.689 df= 459 p<0.05
DBH (ft)	$\bar{X}$= 1.86 SD±0.83	$\bar{X}$= 1.21 SD±0.35	t= -4.182 df= 459 p<0.05

Measurements were recorded in feet (ft) and represented as mean ±SD; Two tailed student's t-test performed to compare the mean characteristics between available and preferred trees. N= Number of trees

Calls of the birds made during down and dusk, are considered as vocal information exchanges. But sometimes they are not made in the down and dusk and hence make the vocal information exchanges controversial [41]. However, louder vocalization noticed at the larger aggregation of the birds could apparently be seen as a technique to attract other individuals to share the roost.

Table 9. Record of average time of waking and sleeping calls at Surjana Johara roost site during summer, monsoon, winter seasons

Seasons	Waking call	Sleeping call	Student's t-test		
Summer (N=12)	06:11 hr SD±0.50 hr	18:54 hr SD±0.04 hr	(S-M)	(M-W)	(S-W)
Monsoon (N=12)	06:10 hr SD±0.01 hr	19:06 hr SD±0.08 hr	t= 0.44 df=22	t= -11.93 df=22	t= -6.17 df=22
Winter (N=12)	06:21 hr SD±0.03 hr	18:37 hr SD±0.06 hr	p<0.05(NS)	p<0.05	p<0.05

Data represented as the mean ±SD; S= Summer, M= Monsoon, W= Winter

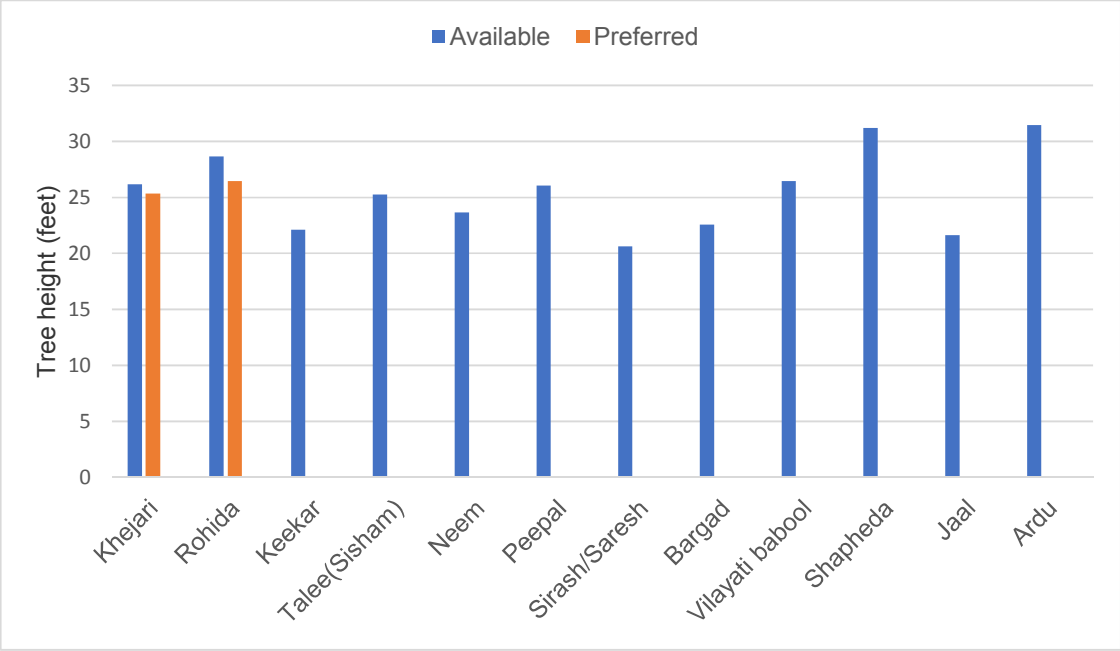

Fig. 2. Average height of available and preferred roost tree species at 29 sites

The Black-winged kite feeds in unevenly distributed habitats of the arid zone and roosts communally on the trees near to theses habitats. The adaptive significance of communal roosting includes better anti predation response of the bird easy food findings [30]. According to [30] species feeding in an unevenly distributed food supply tend to roost communally. The social attraction among the members also increases at the communal roosts [8]. The number of communal roosts of the Black-winged kite was less in winter as the number of the bird decline due to shortage of food in the arid zone, while the number of these roosts increases in summer and rainy season because the bird gathers for breeding and prey availability also increase.

Our results indicate that arrival of communally roosting Black-winged kite at the roost were exclusively determined by day length and cloud cover. This is an agreement with the general view on circadian rhythms in birds, assumed to be primarily governed by photoperiod and light intensity [42,43]. Moonlight does not provide additional illumination to delay roosting times of the Black-winged kite.

5. CONCLUSION

The Black-winged kite mostly roosts in rural areas due to availability of food in agriculture farm houses and grazing fields. It mostly prefers Khejari (*Prosopis cineraria*) tree for its roosting due to its dense canopy, height and its leaves pattern. After first call, it immediately departs and thus save much time for diurnal activities. It roosts early in winter than summer and rainy season. Its roosting is determined by length of the day and cloud cover. Moonlight does not delay its roosting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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