Asian Journal of Conservation Biology, July 2020. Vol. 9 No. 1, pp. 143-150 AJCB: FP0132
ISSN 2278-7666 ©TCRP Foundation 2020

Influence of urbanization on roost selection of Asiatic Lesser Yellow bat, *Scotophilus kuhlii* (Leach, 1821) in Uttar Pradesh, India

Shani Kumar Bhartiy* and Vadamalai Elangovan

Department of Zoology, Babasaheb Bhimaro Ambedkar University, Lucknow-226025, India

(Received: May 04, 2020; Revised: June 12, 2020 ; Accepted: July 05, 2020)

ABSTRACT

Urbanization in Uttar Pradesh has replaced many pre-existing natural habitats with artificial, human-populous environments. Nevertheless, some bat species have persisted in urban habitats, the overall abundance and diversity of bats within them is low. Therefore, we examined urbanization factors that influence roosting of bats such as house density, abandoned buildings, obstruction, lighting, roost height, water and vegetative resource distance in three different habitats such as urban, suburban and rural areas of Uttar Pradesh. We compared among the factors with colony size of *S. kuhlii* in the urban, suburban and rural. In this study, it was observed that house density, roost height, obstruction and distance of water and vegetative resource negative effect on the colony size or roost selection of *S kuhlii* in among the habitats. While in number of insect, abandoned building, number of street light pole and age of building shown positive correlation in among habitats except age of building in rural. Showed significantly different between colony size and factors in urban, suburban and rural ($p < 0.05$) except roost height. The present study signifies preference of intermediate level of urbanization by *S. kuhlii*.

Key words: Conservation, Microclimate, Obstruction, Roost selection, Urban ecology, Urbanization factors

INTRODUCTION

Urbanization is anthropogenic pressure which gradually change vegetative lands into settlements (Grimm *et al.,* 2008) such kind of changes supports too few species and also harmful impact on some species (McKinney, 2002; Shochat *et al.,* 2006). Moderate level of urbanization including suburban areas, there excess amount of foods were available at roosting sites (Blair & Launer, 1997) which supports heterogeneity biodiversity (Mooney, 2011). As compare to urban, suburban and rural area supports higher biodiversity (Merotto & Francis, 2017).
Many studies reported that lower biodiversity in urban environments of different organism such as insects (Blair & Launer, 1997), amphibians (Scheffers & Paszkowski, 2012), birds (Marzluff, 2001) and few mammals (Villasenor *et al.*, 2014). Urban areas also play some profound effect such as additional stress (Isaksson, 2010), increased infection and parasitism rates (Giraudeau *et al.,* 2014).

Bats make a significant contribution to mammalian species richness and biomass in the tropics. The roost structure is one of the most important features of a bat's environment, and the selections made by bats with respect to the type and location of roost sites are likely to have a decisive impact on their survival and fitness (Vonhof & Barclay, 1997).

Many factors such as; water resource, lighting, food availability, house density, vegetation and abstraction in urban, suburban and in rural influence change in behaviours for choosing roosts of bats (Altringham, 1996). High housing density areas support low bat species richness while low-density housing areas have been support high bat richness (Threlfall *et al.,* 2011). Bats may avoid sound pollution environments, presumably because the noise affects their ability to effectively forage, communicate and spatially orient themselves (Mackey & Barclay, 1989; Schaub *et al.,* 2008; Arnett *et al.,* 2013). Bats may also avoid noisy areas for roost sites to reduce disruption during torpor or hibernation (Thomas, 1995; Luo *et al.,* 2014).

Microclimate is an important factor in only of buildings roost (Racey & Swift, 1981; Hamilton & Barclay, 1994). Many authors reported that water resource and lightings are vital for bats (Furlonger *et al.,* 1987; Gehrt & Chelsvig, 2003; Kurta & Teramino, 1992). Availability of water and roost temperature increased the reproductive success of female insectivorous bats (Adam & Hayes, 2008) which directly impact on bats population. Higher light intensity may reduce the foraging success of bats and most of bats distracts their traveling routs (Downs *et al.,* 2003; Stone *et al.,* 2012). Few report suggested that insectivorous bats mostly forage near the high density of insect that found near the white light lamps (Furlonger *et al.,* 1987). In rural areas lighting also play important role on some bats by attracting insect as food resources (Fenton *et al.,* 1983; Rydell, 1992; Van Langevelde *et al.,* 2011). *Lasiurus cinereus*, *L. borealis* roost among the foliage of trees, whereas *Lasionycteris noctivagans* roosts in cavities of tree bark (Kunz & Lumsden, 2003). Removing of tree for urban development, which simultaneously also damage roosting sites, which is opportunistic site for roosting in urban (Duchamp & Swihart, 2008; Dixon, 2012).

Anthropogenic destruction was main factor, which leads to loss of foraging as well as roosting site as a result decline in bats population (Mickleburgh *et al.,* 2002). Several kinds of disturbance in urban habitats may reduce the bats abundance and diversity where (Russell *et al.,* 2009; Kitzes & Merenlender, 2014).

*Corresponding Author's E-mail: shanikumarbhartiy@gmail.com

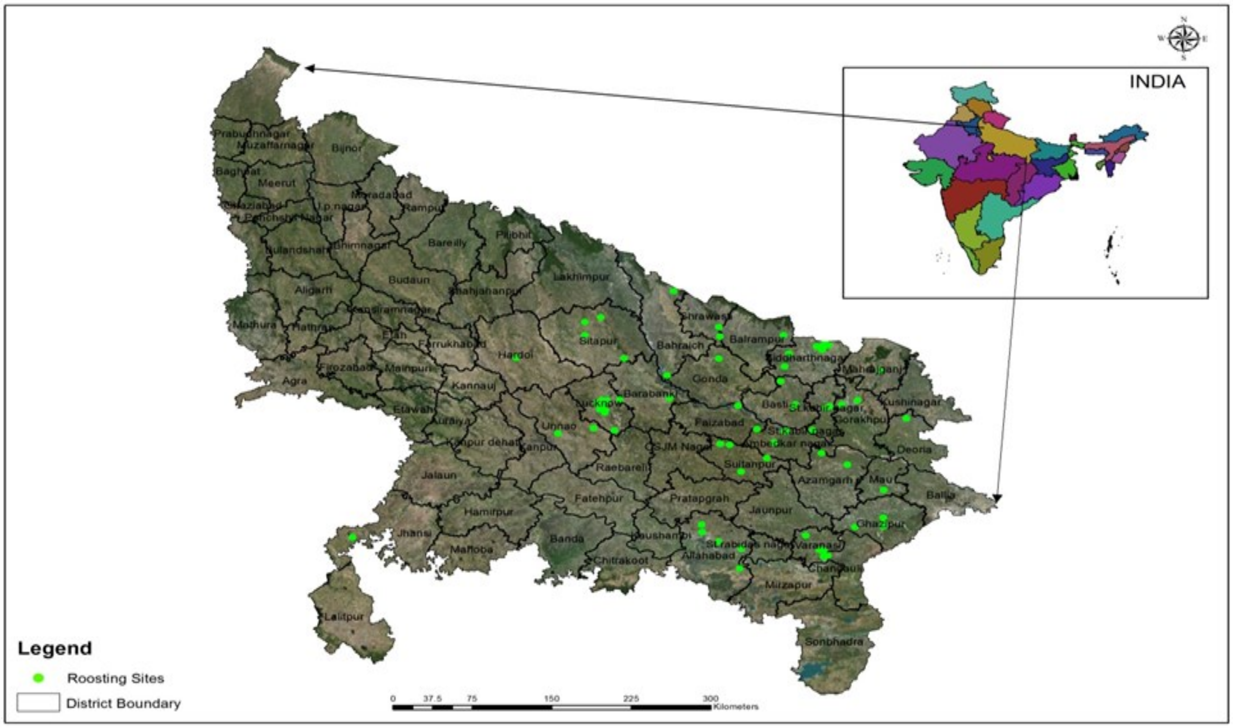

Figure 1. Map of the study area (Uttar Pradesh). The roosting site was marked as a solid circle with the help of G.P.S.

Earlier studies reported that *Scotophilus dinganii* and *Scotophilus mhenhanii* always occupied two different roosts, where *S. dinganii* often occupied in building while *S. mhlanganii* always in trees (Jacobs & Robert, 2009). *S.viridis* and *S. dinganii* both species selected their similar roosts types of tree species and size (Monadjem *et al.,* 2010). *S.leucogaster* select tree roost based on the larger trunk (Fenton *et. al.,* 1998). *Scotophilus kuhlii* is a highly gregarious bat that thrives in anthropogenically altered habitats readily roosting in man-made structures (Nuratiqah *et al.,* 2017).

Asiatic lesser yellow house bat is frequently found in both the rural and urban areas in association with human (Elangovan and Kumar 2018). Bats spend over half their lives in several kinds of roost structure in different environment (Kunz, 1982). These roost structures such as caves, rock crevices, tree cavities, foliage and man-made structures (Kunz & Fenton, 2003).

Uttar Pradesh located in the northern part of India. It is the most populous state including 199,812,341 (Census 2011), where around 72.2% of the total population of the state lives in rural areas. Villasenor *et al.,* (2014) was reported that species richness decline with higher level of urbanization while Blewett *et al.,* (2005) was reported the in moderate level of urbanization increases the species richness. Thus, we predicted that *S. kuhlii* is known as house bat therefore it's should select roost near more house density. Therefore, our aim in this study was to the influences of house density, roost height, insect's abundance, light source, abstraction, abandoned building distance of adjacent water and vegetation resources, age of building and story of building on roost selection of *S. kuhlii* in urban, suburban and rural.

MATERIALS AND METHODS

Study area

The field surveys were carried out at 23 different districts in Uttar Pradesh (26°50'48.16"N, 80° 56'46.17"E), India from August 2015 to December 2018 (Figure 1). Roost search were made by visual observation of bats guano beneath at the roost and by acoustic surveydistricts in Uttar Pradesh (26°50'48.16"N, 80° 56'46.17"E) India from August 2015 to December 2018 (Figure 1). Roost search were made by visual observation of bats guano beneath at the roost and by acoustic survey (Peterson D230, bat detector). The whole study was divided in to three habitats based on the level of urbanization (Mostly house density and agriculture lands) such as urban, suburban and rural. In urban, (> 30 dwellings $0.1km^2$ and agriculture lands > 5 km away from roosting sites); in suburban, (>20 to < 30 dwellings $0.1km^2$and agriculture land < 5 km away from roosting sites) and rural, (< 20 dwellings $0.1km^2$ and agriculture land 200 m away from roosting sites). To estimate of the house density, light, abandoned building and type of abstraction, we used line transect method within 250 m^2 from roosting site. The water resource and vegetative areas adjacent to roost sites were measured within one km by mobile phone GPS tracker. The whole distance in this study was measured by mobile phone GPS tracker. The roost abstractions have been classified into; fire (set on fire of roost by a human), renovation (roost building) and constructions (roost building) based on the observed by local people information. Lightings were classified into: high mast light, white-street light and Yellow Street light were observed based on the height of pole and lighting colour. The roost building height was measured by a metal scale and the clinometer was used wherever possible. Building age was measured (because bats often prefer old building) by two methods first one construction date on the building and second by local people information. Abandoned buildings were classified in plasters building (both sides in/out) and non-plaster building (both side in/out). The Insect was collected surrounding street lights (High mast light, white street light, and yellow street light) within one km^2 by insect hoop net (r =10cm). We have separated insect types based on phenotype characters such as colour antenna, and legs, but not identified insects order. Beside collected insect had compared with colony size in urban, suburban and rural. Temperature and humidity were measured by probe inserting thermo-hygrometer (HTC-103CTH). All line transects were surveyed on foot following Villasenor *et al.,* (2014).

Statistical analysis

We determined to relationship between independent variable such as roost height, house density, insect abundance, street lamp post, abandoned building, numbers of obstruction, distance to adjacent water and vegetation source, building ages and number of stories with dependent variable colony size of *S. kuhlii* using Multiple Linear Regression (MLR) (SPSS, 21) because data was non-parametric. Krushkal Wallish H test (KW) using to determine to compared between colony size of *S. kuhlii* and habitats. Furthermore, Mann-Whitney U was using to determine to compare between colony size and plaster and non-plaster abandoned building. All graphs were made using GraphPad Prism software (Ver. 5).

RESULTS

A total of 82 roosts were observed from three different habitats including urban, suburban and rural sites. Highest numbers of roosts were found in suburban (n = 45) followed by urban (n = 23) and in rural (n = 14). Whereas the percentage of roosts was following, Suburban (54.87%) was significantly selected above all other habitat categories, followed by urban (28.04%) and rural (17.07%). Multiple linear regression (MLR) showed negative effect with colony size on roost height (r = -0.745) and distance from adjacent water source (r = -0.343) in urban followed by house density (r = -0.804), no. of obstruction (r =-0.881) and distance from adjacent vegetative sources(r=-0.261) in suburban (Table 1). While insects abundance (types of insect) (r = 0.643) and age of building (r = 0.237) in urban followed by abandoned buildings (no. of abandoned building) (r = 0.876) in rural and street light pole(r = 0.848) in suburban showed positive effect on colony size (Table 1). Whereas Kruskal Wallish H test (KW) showed significantly different among the habitats such as urban suburban and rural at $p< 0.05$ level of significant except roost height (H =3.216, p = 0.2) (Table 1).

Whereas insects abundance were significantly higher around the high mast light than white-street light, had significantly more than yellow street light in among the habitat (Figure. 4), KW test showed significant differences between insect abundance and colony size , and respectively (Table 1) in three different habitats such as urban, suburban and in rural.

Obstruction were one of the important factors that play a very important role in roost selection that effect of *S. kuhlii* for roosting. The height of roosts was highest in the fire-sensitive building (Set of fire on roosts by a human) in suburban and rural in three different habitats while roost heights were height in renovation urban whereas KW showed significant different between height

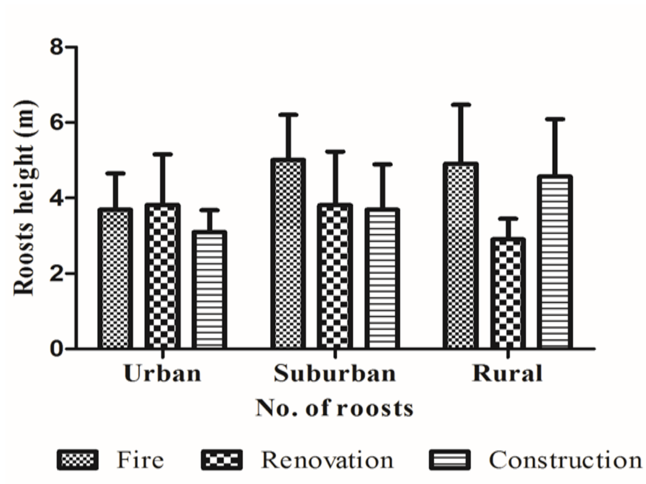

Figure 2. Roost height preferred by *S. kuhlii* in types of obstruction in three different habitats.

Table 1. The effect of urbanization factors on roost selection and colony size of *S. kuhlii* in different habitats. The values of roost characteristics are given as mean ± SD. MLR and Kruskal Wallis H test significant at the 0.05 level.

Variable	Urban	Suburban	Rural	H	P
	Mean ± SD(r)	**Mean ± SD(r)**	**Mean ± SD(r)**		
Roost height(m)	3.67 ± 1.09 (-0.745)	4.15 ± 1.36 (-0.103)	3.97 ± 1.47 (-0.744)	3.216	0.2
House density(m)	38.15 ± 14.00 (-0.759)	25.55 ± 2.85 (-0.804)	18.70 ± 4.70 (-0.016)	37.576	0.001
No. of insect	8.60 ± 4.44 (0.643)	12.48 ± 4.58 (0.621)	15.42 ± 6.99 (0.462)	11.34	0.003
No. of light pole	17.74 ± 3.15 (0.563)	10.17 ± 3.22 (0.848)	5.5 ± 2.27 (0.761)	51.194	0.001
No. of abandoned building	9.56 ± 4.23 (0.591)	13 ± 4.16 (0.862)	12.28 ± 3.70 (0.876)	8.514	0.01
No. of obstruction	14.08 ± 9.17 (-0.473)	7.97 ± 3.37 (-0.881)	6.07 ± 3.97 (-0.693)	8.441	0.001
Distance from adjacent water source (km)	1.48 ± 1.43 (-0.343)	0.34 ±0.22 (-0.143)	0.30 ± 0.22 (-0.138)	19.824	0.001
Distance from vegetation sources(km)	0.26 ± 0.18 (-0.124)	0.29 ± 0.25 (-0.267)	0.27 ± 0.20 (-0.000)	26.719	0.001
Age of building	52.96 ± 42.94 (0.231)	57.62 ± 36.37 (0.018)	18.70 ± 4.70 (0.157)	14.881	0.001
Population	4.60 ± 2.29	5.44 ± 2.07	3.71 ± 1.81	6.799	0.033

Table 2. The effect of microclimate on roost selection and colony size of *S. kuhlii* in different habitats. The values of microclimate are given as mean ± SD. MLR and Kruskal Wallis H test significant at the 0.05 level.

Variable	Urban	Suburban	Rural	H	P
	Mean ± SD	Mean ± SD	Mean ± SD		
Ambient temperature	29.14 ± 12.46 (0.302)	26.15 ± 5.56 (0.047)	18.95 ± 9.16 (10.076)	9.91	0.007
Humidity	77.20 ± 19.95 (0.123)	74.06 ± 16.57 (-0.062)	72.8 ± 18.29 (-0.289)	2.46	0.29
Roost tem	32.18 ± 10.08 (0.482)	29.53 ± 4.88 (0.402)	28.07 ± 8.24 (0.637)	4.79	0.09
Population	4.60 ± 2.29	5.02 ± 2.07	3.71 ± 1.81	3.9	0.14

and level of obstruction (Fir, renovation and construction) (H=10.177, p = 0.0006) and colony size was significant (H= 36.55, p = 0.0001) (Figure. 2). In an abandoned building, it was observed that the population size of *S. kuhlii* was highest in the non-plastered building compared to plastered buildings in all three habitats whereas Mann-Whitney U test showed significant different (U=163.50, p = 0.0001) (Figure 3).

Microclimate

Multiple linear regression (MLR) showed positive effect with colony size on ambient temperature (r = 0.302) in urban, followed by suburban (r = 0.047) and rural (r = 0.076), and roost temperature (r = 0.482), (r = 0.402) and (r = 0.637) among habitats such as urban, suburban and rural respectively. While MLR showed negative effect on humidity (r = -0.062) and (r = -0.289) in suburban and rural habitats except urban (r = 0.123). Whereas KW showed significantly different among habitats at p < 0.05 level of significant except urban (H = 9.91, p = 0.00) (Table 2).

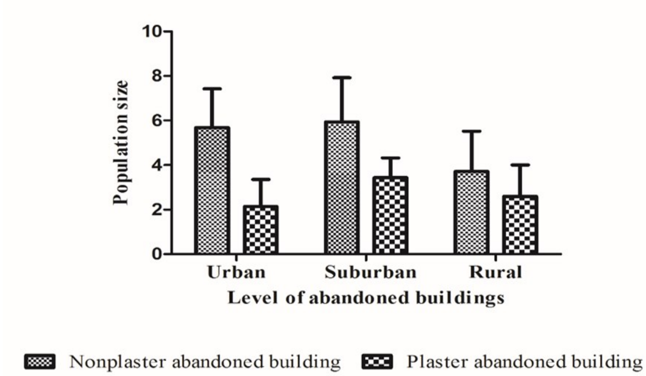

Figure 3. The population size of *S. kuhlii* in an abandoned building in three habitats

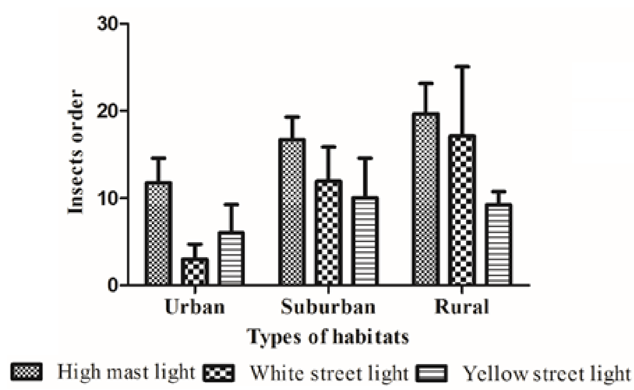

Figure 4. Insect orders collected from different streets light pole in three habitats

DISCUSSION

Urbanization factors influence the roost selection of *S. kuhlii* in urbanization habitats, at the time when the serious distraction of natural habitats surrounding us. Then these factors play a crucial role in the survival of bats in adverse conditions. *S. kuhlii* selects several types of habitats areas to complete their life cycle. The present study is revealed that *S. kuhlii* prefers the highest roosts in suburban followed by urban and rural. The significant differences in urbanization factors in habitats. Present and absences of roosts depend on the feature of the building but its selection for roosting depend on bats. Entwistle *et al.,* (1997) was reported that roost selection depends on the feature of the buildings. Buildings are often occupied by female bats during the reproductive season to raise offspring and lower predation risk (Voight *et al.,* 2016). Our result showed that the colony size and number of a roost of *S. kuhlii* were significantly higher in non-plaster abandoned buildings that closed to a human-occupied building than isolated plaster building in among habitats. Non-plaster buildings provided different kinds of space such as a hole, crevices, and cavities which important for roost selection compared to plaster building. Roost closed to a human-occupied building which radiuses the nocturnal predator. Roosting in buildings may expose bats to opportunistic predators (Threlfall *et al.,* 2013).

Bats might accept a compromise between suitable features such as microclimate and roost location, and level of disturbance. However, some bats are known to be sensitive to human disturbance and can switch their roost when frequently disturbed (Tuttle, 1979; Kunz, 1982; Speakman *et al.*, 1991; Lewis, 1995; Thomas, 1995). Previous works reported that the reduction of roosts fidelity depends on roost disturbance (Lewis,1995). In the previous study found that *Myotis nattereri*, *P. auritus*, *Pipistrellus* species and *Eptesicus serotinus* are never returned to the same building for roosting when once buildings are renovated (Briggs, 2004). In the present study, showed that among the habitats obstruction were one of the main negative factors that affected on roosts selection of *S kuhlii* in three habitats. whereas increases the obstruction decreasing the colony size and number of the roost. *S. kuhlii* never occupied the same roost when once disturbed by fire. Similar work was found in the previous study on *P. auritus* (Briggs, 2004).

The level of obstruction such as fire was frequently higher in urban habitats, followed by suburban and rural because often human set on fire front of the roost entrance for removing roost. Generally, bat not switch their roost frequently without any disturbance

(Findley and Wilson, 1974) They spoil food and make ceilings, walls, and floors dirty with the accumulation of guano and urine and offensive odors to cause a serious public health problem (Greenhall, 1964). Process of renovation was higher in urban habitats, followed by the suburban and rural ones, while constructions were higher in suburban in among the habitats. The previous studies found that older buildings are more susceptible to roost loss and more prone to renovation (Entwistle *et al.,* 1997). However, it provides a different kind of space. In the present study, *S. kuhlii* selected old buildings for roosting which important for roost selection because a large number of unwanted spaces. It often occurred in suburban, urban compared to rural. Several studdies reports that bats can occupy a several kind of roosts including natural structures such as caves (*Rhinolophus ferrumequinum* and *R. hipposideros*), rock crevices (*Eptesicus fuscus*) and man-made structures such as churches, houses and farm buildings (*Pipistrellus pipi strellus* and *Plecotus auritus*) and bridges (*Eptesicus fuscus*) (Kunz, 1982; Altringham, 1996; Kunz & Lumsden, 2003). Therefore, human constructions may simulate the structural and functional properties found in cliffs, caves or trees, all important natural roosts, so bats may have easily learnt to exploit the new artificial roosting habitats (Russoa & Ancillotto, 2014), to maintained the ecosystem balance. Previous studies reports bats have long been postulated to play crucial ecological roles in prey and predator, arthropod suppression, material and nutrient distribution, and recycle (Kunz *et al.,* 2011).

The height of roost negative effect on colony size of *S. kuhlii* in among the habitats while selecting the highest height for roosting relative to the availability of potential level of abstraction and roost cavities.Several previous studies found roost height increases predation rates decrease and productivity increases (Nilsson, 1984; Rendell & Robertson, 1989; Elliott *et al.,* 1996). While few reports have been suggested that high height roosts also offer bats greater protection from predators (Rydell *et al.,* 1995; Vonhof & Barclay, 1996). High levels of urbanization can negatively affect biodiversity (McKinney, 2002). Several authors have been reported that high house density negative effects on species richness and low house density support high species richness compared to natural habitats (Reside & Lumsden, 2012; Threlfall *et al.,* 2012; 2013; Soga *et al.,* 2014). In present study showed increases the house-density decrease the colony size among the habitats. Dense house density areas cause their lake of a suitable site such as an unwanted hole, crevices, and cavities which important for roosting. While the intermediate house density area provided suitable space for roosting and least house density area also provides space but less number of the house cause less space. Hence, an intermediate level of house density may play a crucial role in the selection of the roost site. Similar studies found in previous work on *Austronomus australis* species Fiona *et al.,* (2016). The previous study reported that increase predation risk in high house density areas such as crows, kestrels, seagulls, rats, possums, dogs and especially domestic cats for preferring in urban environments (Ancillotto *et al.,* 2013; Mikula *et al.,* 2013; Threlfall *et al.,* 2013). The abundance of light in surrounding roost increases the light intensity creates a problem from their flight causes easily hunt by a predator. Insects availability less around high light intensity. Geggie & Fenton, 1985 were reported that the abundance of artificial light sources dilutes the concentration of insects near each light source in urban habitats. Increases light intensity increases the predation risk (Avila-Flores & Fenton, 2005; Stone *et al.,* 2009; Threlfall *et al.,* 2013; Hale *et al.,* 2015).

Previous studies reports increases in the light intensity increase the insect's diversity (Threlfall, *et al.,* 2013 Hale *et al.,* 2015). The least number of a light pole in habitats site insect abundance more on each light pole compared to the high and intermediate light pole. High mast light focuses long distance cause easily locate at night from a long distance so several insects pull to light while other two white and yellow streets light focus to less distance (Chu *et al.,* 2003). Hence insect abundance is low. A similar study found on *Nyctalus* and *Pipistrellus* was attracted to artificial light because its short-wavelength light attracts more insects as a result increases their foraging efficiency. (Voigt *et al.,* 2016). Furlonger *et al.,* 1987 and Gaisler *et al.,* 1998 were reported that white-light lamps are strongly preferred by some species bats. Rainho., 2011 was reported street lamp post may play a crucial role in the roost selection of bats. Geggie & Fenton, 1985 were suggested that no strong correlation possible insects abundance around each light pole where artificial lights are higher in urban habitats. Our results showed that colony size was significantly higher around the moderate level of light intensity such as in suburban followed by urban and rural. Several species occupied their habitats in a moderate level of urbanization such as suburban i.e. mammals (Racey & Euler, 1982), lizards (Germaine & Wakeling, 2001)**,** avian and butterfly (Blair, 2001), bumblebees (Pawlikowski & Pokorniecka 1990), ants (Nuhn & Wright, 1979).

Previous work has been reported that water sources may affect on bats population and community. The present study showed that adjacent water source distance was negatively affected by colony size among the habitats i.e. increases the water distance decrease the colony size. Food resources would long distance from roost may bat spent more energy on foraging and would increase the predation risk. Roosting sites near the water resources for maintaining the daily torpor and avoid the predation risk. Our results of suburban support of previous work of Rainho *et al.,* 2012 on *Rhinolophus mehelyi* select roosts closer distance from opened foraging and water source than *Myotis schreibersii*. Maternity roost of *N. gouildi* near the watering points and ditches sites (Lunney *et al.,* 1988; Webala *et al.* 2010). Artificial water sources, such as pits, swimming pools, and water reservoirs were essential components for an urban living animal which provided drinking opportunity (Russo, 2012;Rainho & palmeirim, 2011 were suggested. Bruun, 2003 reported that mobile species such as bat and bird cover a long distance to reach their resources destination. While the vegetation distance was also a negative impact on colony size among the habitats i.e. increases the distance while decreasing the colony size. Hence *S. kuhlii* prefers roosts near the vegetation sources to decline energy cost for foraging. Because of prey concentration higher near the vegetative sources. Optimal foraging theory predicts limit the forager's ability to maximize energy (Pyke, 1984). Willis & Brigham, 2004; Whitaker, 1995 suggested that deciduous trees, agriculture fields, and open area provided potential food sources for big brown bats. The maternity roosts of *Nyctophilus gauldi* roosted near the dance bushy area but the way from the semi-urban area (Threlfall *et al.,* 2013). The big brown bat was selected as their maternity roost near the trees (Vonhof &

Barclay, 1997; Rabe *et al.,* 1998; Cryan *et al.,* 2001). Marques *et al.,* 2004 were reported on *T. teniotis* forage five kilometers away from their won day roost. *T. teniotis* most of the foraging areas were within 5 km from the roost (Marques *et al.,* 2004).

Stable microclimates such as humidity and temperature would help lower the metabolic rate and energy expenditure of bats (Usman, 1988). For successful reproduction, water, as well as energy, is an important factor (Kurta *et al*., 1990) and in small bats, water balance is very sensitive to temperature and humidity (Herreid & Schmidt-Nielson, 1966). Our data also indicates that *S. kuhlii* selecting roosts with almost high and stable humidity and temperature without much change within the habitats. Harbusch & Racey, (2006) reported that buildings offered suitable temperatures during gestation and lactation periods that are critical for the survival of their offspring. The results of the present study support the earlier observation that *S. kuhlii* tolerated to high temperature (Shek & Chan, 2006). Therefore, microclimate such as ambient temperature, humidity, and roost temperature was influencing for selection of roost of *S. kuhlii*in among habitats.

CONCLUSION

Some species of chiropteran have colonized urban environments. Several studies have found that negative effects on bat roosting in urban environments compared to surrounding natural habitat. We examined the possible contributions of urban factors to limiting bat abundance and roost in urban habitats. These factors included house density, abandoned building, obstruction, street light, insect abundance, roost height, building age and adjacent water and vegetation sources in three different habitats. In the present study, all of these factors such as house density, obstruction, roost height could negatively impact on roost selection and colony size of *S. kuhlii* among the habitats. Abandoned building, street light and insect abundance showed positive correlation with roost and colony size. Beside Anthropogenic activities, lower availability of suitable building and plant roost availability are likely to affect on *S. kuhlii* for roost selection urban and rural habitats. Likewise, the abundance of light sources in urban habitats would divide insect groups. These kinds of effects could reduce the availability of food for bats in urban habitats. Hence, *S.kuhlii* preferred most rooting in suburban habitats in among habitats.

ACKNOWLEDGEMENTS

We thank the Archaeological Survey of India for permitting us to conduct the field survey in old monuments of Uttar Pradesh. The financial assistance of Science and Engineering Research Board, Department of Science and Technology, New Delhi through a major research project (No. EEQ/2018/000104) to VE is acknowledged. The special thanks to Dr. B. Lal and Dr. Poonam, of Remote Sensing Application Center U.P, Lucknow for making Arc GIS map.

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