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Impact of Electromagnetic Radiation, Predation, and Habitat on House Sparrow (Passer domesticus) Abundance: Implications for Conservation Strategies

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AUTHORS' CONTRIBUTIONS

THIS WORK WAS CARRIED OUT IN COLLABORATION BETWEEN THE TWO AUTHORS. AUTHOR A[1]MEM DID THE FIELD STUDY, ANALYZED AND INTERPRETED THE DATA, AND WAS A MAJOR CONTRIBUTOR IN WRITING THE MANUSCRIPT. AUTHOR B[2]PR GUIDED IN DESIGNING THE STUDY AND PROOFREADING THE MANUSCRIPT AND MANAGED THE LITERATURE SEARCHES. BOTH AUTHORS READ AND APPROVED THE FINAL MANUSCRIPT.

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ABSTRACT

The house sparrow (Passer domesticus), one of the most widespread bird species across urban and rural environments globally, has seen a notable decline in population in recent years, raising concerns among ecologists. This study explores the factors influencing house sparrow abundance, including mobile towers, electromagnetic field (EMF) exposure, and predation. House sparrows were recorded in 169 of the 205 study sites, thriving in suburban (94.7%), urban (86.3%), and rural (80.4%) areas. While statistical analysis showed no significant relationship between the presence of mobile towers and sparrow abundance, high-level EMF radiation (E > 40V/m, M > 0.4μT) had a significant negative impact on their population, with a p-value of < 0.05. Predators, such as Eurasian sparrow hawks, house crows, monkeys, and cats, were also identified as significant threats. Interestingly, artificial nests showed a positive influence, with an average encounter rate of 15 ± 1.4 nests per block, indicating their potential for conservation. Soil type also played a role, with red loam and black cotton soils found to support more favorable conditions for foraging and nesting.

This study underscores the influence of land-use practices, EMF radiation, and predation on house sparrow populations, highlighting artificial nests as a viable conservation measure. Further research is needed to explore additional factors affecting house sparrow abundance and refine conservation strategies through artificial nest provisioning.

KEYWORDS: *EMF, mobile towers, electromagnetic fields, house sparrow, Passer domesticus, predators, conservation.*

I. INTRODUCTION

The house sparrow (*Passer domesticus*) is most common and adaptable bird species in the world has been rapidly declining in the last few decades, raising an alarm among researchers and conservationists (Devereux et al., 2010). An examination of the variables that can contribute to

the abundance of house sparrow is therefore necessary in order to conserve this species include effects of electromagnetic radiation EMF (Everaert & Bauwens, 2007), predation pressure (Groom, 1993), and habitat conditions (Hole et al., 2002). EMF exposure was reported to affect reproductive success of kestrels, increasing fertility, egg size, embryonic development, and fledging success but reducing hatching success (Fernie et al., 2000). American kestrel males exposed to EMFs showed evidence of oxidative stress (Fernie and Bird, 2001). Similarly, short-term EMF exposure for one breeding season resulted in a set of responses including depressed total proteins, erythrocytes, lymphocytes, hematocrits, carotenoids and melatonin (Fernie *et al.,* 1999). Additionally, Steenhof et al., (1993) studied ravens and raptors that nested on a transmission line in an area of Idaho where a lack of natural nesting sites was clearly limiting the size of the breeding population. They found that nesting success of birds nesting on transmission towers was significantly higher for ferruginous hawks (Buteo regalis Gray) and similar for ravens, golden eagles (Aquila chrysaetos L.), and red-tailed hawks (Buteo jamaicensis Gmelin) compared with conspecifics nesting on natural substrates. This increased nesting success of ferruginous hawks is an obvious benefit to the species, which is listed as threatened on the IUCN Red List (IUCN, 2002). Towers often provided more secure nesting places where chicks were more protected against range fires and mammalian predators than at natural nest sites. Furthermore, nesting raptors on towers were less susceptible to heat stress compared with birds at natural sites, where wind and air circulation were much reduced. Another factor that can have an impact on the house sparrow population density is predation pressure. Groom (1993) also showed that nest predation by various forms including the Eurasian sparrow hawks, house crows and cats affects house sparrows. Moreover, hunting and persecution are other causes of populations reduced numbers as cited by Shultz and Cooney (2014). Ecological factors such as soil type, vegetation cover, and availability of nesting sites also greatly affect the abundance of house sparrows. Hole et al. (2002) also observed that proportional cover of ground vegetation and nest sites increases the density of house sparrows. It has been suggested to use artificial structures to provide nesting sites to house sparrows in an attempt to reverse the declining trend. Sumasgutner et al., 2014 revealed that improved design of artificial nests obtain better breeding success and consequently population enhancement rates. Habitat characteristics have also pointed out that soil type is also significant in determining the house sparrow abundance. Tryjanowski et al. (2011) stated that house sparrows select habitats with good nesting sites and food resource availability. Understanding the interplay between these factors is crucial for developing effective conservation strategies. This study investigates the effects of mobile towers, electromagnetic field (EMF) exposure, predation, and habitat variables on house sparrow abundance, providing critical insights for conservation efforts.

II. Methodology

Study area

Madurai is the oldest inhabited city in the Indian peninsula. It is referred with names like Thoongaa Nagar, Malligai Maanagar, Athens of the East and Koodal Maanagar. (Alaguraja, et al., 2010). It is one of the 38 districts in southern part of Tamilnadu, lies between 9° 30′ north to 10° 30′ north latitudes and 77° 30′ east to 78° 30′ east longitudes. The areal extent of the study area is 3741.73 sq.km (Eswari *et al.,* 2020). The 205 places of study area was given in Figure 1 including 164 rural, 19 suburban and 22 urban gradients from the period of two years from February 2019 to December 2021.

Data collection and analysis

The preliminary information of the number of mobile towers and the status of house sparrows was observed and collected using line transect method. Later for an in-depth study the point count method is more effective when studying radiation impact because it measures radiation levels in a specific area. Hence, the point count method was used to conduct this study rather than the line transect method. A data collection sheet used in the field study was given in Figure 2. In all places, 5 Point location sites are randomly chosen and an EMF meter was used to get the values of Electric field (E- field) and Magnetic field (F-field) and the readings were recorded. Sutherland, 2006 explains that the point count method involves counting the number of house sparrows either seen or heard at a fixed point and at a given time; this is mostly at the roadside. It should be understood that the majority of bird species are most active during early morning hours. These counts are very useful because they give information about the birds that are being found as well as those that are not being found out. The challenging part of a point count is that one has to familiarize with various songs and calls of birds in the area. This is especially true of birds as it is much easier to listen for them than to look at them based on habitat. Point counters should have an understanding of the songs and calls of the birds that are found in the region. Point count was conducted utilizing a fixed area for a given period of time. However, it was not limited to the breeding season but was done all the year round. In this context, point count stations were randomly placed

in the study area. Habitat was used to select residential and open field stations. When there were two count locations between two points, there were at least 50 m in residential areas and up to 100 m in open fields. At each count location, counts were performed for a given amount of time. The count time was set to a range of 5–10 minutes in a 20-meter circular area to avoid counting the population twice. The nesting sites of house sparrows were digitally recorded in the form of photos and videos and documented.

The data was processed and analysed using statistical software. In order to determine the significant relationship between the occurrence of house sparrow and occurrence of mobile towers, ANOVA test was performed whereas to determine the impact of EMF on the occurrence of house sparrow, MANOVA test was performed. The percentage pie diagrams were made using excel and the mean plots were made using IBM SPSS Statistics 21 software. P-value less than 5% was considered to be the level of significance in both univariate and multivariate analyses. Data on the encounter rate was tested statistical significance using the Mann-Whitney tests.

III. Results and Discussion

I. Status of house sparrow

The house sparrows were found present in 170 places out of 205 places including 22 urban, 19 suburban and 164 rural gradients in Madurai district from the period of two years from February 2019 to December 2021. The nesting sites in EB boxes, electric posts, streetlight frames were also documented. Out of 170 research sites show nests and nesting habits, with 80.4% (132/164) in rural gradients, 94.7% (18/19) in suburban slopes, and 86.3% (19/22) in urban gradients. This suggests that house sparrows prefer to nest in suburban, urban, and rural areas, indicating a versatile habitat use. The percentage diagram of house sparrows found in suburban, urban and rural gradients respectively was given in the Figure 3.

II. Factors influencing the abundance of house sparrow

i. Statistical analysis for the impact of mobile towers:

Initially, the status of observed house sparrows and mobile towers was categorized into four groups which were given in Table 1. The mean plot of the groups was given in Figure 4. By comparing the four groups, the 1st and the 3rd group point out that the presence of mobile towers was significantly HIGH irrespective of the presence or absence of house sparrow whereas the 2nd and the 4th group specify that the absence of mobile towers was significantly LOW irrespective of the presence or absence of house sparrow. The result shows that the presence of house sparrows was high in the places where the mobile tower is present. Hence, there is a highly significant (*P*-value is less than 5% level of significance) relationship between mobile towers and the occurrence of house sparrows. In Figure 5, the house sparrow occurrence has been scatter plotted against the Mobile towers available in its habitat indicating a positive correlation between the two variables. The bigger blue bubble in the scatter plot suggests that house sparrows exist where mobile towers exist therefore implying that the presence of mobile towers does not necessarily determine sparrows hence the smaller red bubble in the plot suggests that where mobile towers exist house sparrows are not exit hence there are probably other factors such as availability of food, nesting materials and nesting places that may hinder sparrows from existing than the presence of mobile towers. This study shows that the increasing of mobile towers has no significant impact on availability of the house sparrows. The photographs of house sparrows recorded in the vicinity of mobile tower areas in and around Madurai district are provided in Annexure 1.

ii. Statistical analysis for the impact of Electromagnetic Field:

In this study the unit of electric field strength was recorded in volt per meter (V/m) whereas the units of the magnetic field strength are recorded in microtesla (μT). The limitation of the units is, if the values of Electric Field resides above 40V/m and Magnetic Field resides above 0.4μT, it has an effect on the presence of house sparrows whereas If the values of Electric Field resides below 40V/m and Magnetic Field resides below 0.4μT, it does not have an effect on the presence of house sparrows. The estimated marginal mean plot of the Electric field and Magnetic field against the abundance of house sparrow presence are shown in the Figure 6 and Figure 7 respectively. These plots clearly show a correlation between the abundance of house sparrows and the levels of Electric Field (E Field) and Magnetic Field (M Field) in the environment. In areas where the E Field and M Field are higher than the recommended safe levels, the population of house sparrows is significantly lower than in areas where the E Field and M Field are below the safe levels. Therefore, MANOVA results indicates that there is a highly significant (*P*-value is less than 5% level of significance) relationship between the Electromagnetic Field and the abundance of house sparrows. Similarly, Balmori and Hallberg, 2007, suggested that electromagnetic radiation may be related to the urban sparrow's decrease.

Additionally, In Figure 8, the estimated marginal mean of locations where the house sparrow presents was plotted against the values of Electric Field (E Field) and Magnetic Field (M Field). From the results, it is noted that there is a significant correlation between the estimated marginal mean of locations where house sparrow is found and the values of E Field and M Field in their habitat.

However, when E Field <40V/m and M Field < 0. 4μT; the number of locations where the house sparrow present is much higher, in contrast when both fields are more than the dangerous level (E Field >40V/m and M Field > 0. 4μT); the number of locations with the house sparrow present reduces gradually. Notably, in some locations where the house sparrows present in both conditions: less than 0. 4μT and are higher than 0. 4μT of M Field respectively. This implies that the house sparrow has a certain degree of tolerance and more importantly, it is able to withstand M Field exposure beyond the harmful levels to invoke an effect whereas Electric Field exposure at levels >40V/m means that there is a gradual withdrawal of the areas in which the house sparrow is known to exist in the habitat. Thus, the study will indicate that house sparrows can tolerate the exposure of M Field greater than the level that could be harmful while their exposure to E Field greater than a harmful level has a significant impact on their abundance in their environment.

iii. Predators and Intruders

In this study, there are 4 predators (Figure 9) and 3 intruders (Figure 10) of house sparrow were recorded. The following species have been identified as the most natural predators of house sparrows: (Figure 9 A) the Eurasian sparrow hawk (*Accipiter nisus*), (Figure 9 B) House crow (*Corvus splendens*), (Figure 9 C) monkeys, and (Figure 9 D) cats. Some of the natural intruders of house sparrow documented in the study area include; (Figure 10 A) Brahminy starling (*Sturnia pagodarum*), (Figure 10 B) Oriental garden lizard (*Calotes versicolor*), and (Figure10 C) Indian palm squirrel (*Funambulus palmarum*). Likewise, Kumar (2018) observed that natural enemies like the Shikra (*Accipiter badius*), House Crow (*Corvus splendens*), Rufous Treepie (*Dendrocitta vagabunda*), Myna (*Acridotheres tristis*), cats, dogs, monkeys, snakes, house lizards and some other avian predators are also responsible for the mortality of the house sparrows. He also mentioned that house sparrows which nested were forced to have to search for food in places where cats and dogs are found because they are usually close to these animals especially in human populated areas. This was occasioned by loss of foraging grounds due to interruption by human beings and increase in the land use practices.

A noted incident during the study was the predation of an Indian palm squirrel (*Funambulus palmarum*) on a house sparrow nest, an aggression that prompted a series of attacks from the sparrows on the squirrel that lasted for several minutes. Both the male and the female house sparrows protected their newly hatched young with considerable aggression and never allowed the squirrel to come near their nest. This intense interaction highlighted the sparrows' concern for the chicks and the squirrel as a nest invader pointing to the interaction between these species in their surroundings.

Likewise, red squirrels (*Tamiasciurus hudsonicus*) are important avian nest predators in northern conifer forests and that birds avoid habitats that increase squirrels predation risk according to Willson et al., 2003. Likewise, Birdsacademy (2022) suggested that squirrels will also consume eggshells in the same way as other rodents do due to their rich calcium content. As other omnivores, though most of their diets consist of plants and nuts. Squirrels will eat just about any type of bird egg that they can get their paws on, including robin and dove eggs. Additionally, the some insecure natural nesting sites of house sparrow are identified in this study including in trees: white gul mohur (*Delonix elata), rusty acacia (Prosopis spicigera)*, Indian tree spurge (*Euphorbia tirucalli*), henna tree (*Lawsonia inermis),* lemon tree *(Citrus limon),* and mesquite tree (*Prosopis juliflora);* climbers: red pea eggplant · (*Solanum trilobatum*), rangoon creeper (*Combretum indicum*), lesser bougainvillea (*Bougainvillea glabra*), wild jasmine (*Jasminum angustifolium*), purple allamanda (*Allamanda blanchetii*); and other sites: rolled wires, pipe holes in the highway bridges, unsafe holes in the building structures, unused chimneys, optical receiver connections, and street light frames. The photographs of such insecure nesting places of house sparrow are presented in Annexure 2.

Thus, this study shows that house sparrows are prone to predation in the breeding period where exposed nests in these insecure places which facilitate attacks from predators like cats, crows and kites that compromise their reproductive capabilities, breed density and force-shifted nesting behaviors, and stressful conditions. The mentioned insecure nesting sites leads to the exposure of materials, eggs, and chicks to threats; while socialization of the nests takes place, eggs can fall and break due to the unsafe nesting sites, real predation occurs when the juveniles look out of the nests for their expected food. Another vulnerability that is exhibited by the house sparrows is perching on risky points such as the electrical posts, wires or even an open roof which, in turn, exposes them to predation.

To prevent this, protective measures that include providing safe breeding sites by means of artificial nest, raising awareness to the communities and conducting further research into the impacts of predation on the increase of house sparrows are recommended. Hence, the study concludes that the predator and intruders having a significant impact on the house sparrow encounter rate.

iv. Artificial nest encountered

The study was able to estimate the mean encounter rate of nests to be 155 ± 2. 1/ Blocks overall for the study sites. The mean encounter rate estimated for artificial nest although less than natural nest but it

is significant at $p < 0.05$ (Table 2). This implies that there is a large variation in the encounter rates between the natural nest and the artificial nest offered. Similarly, the house sparrows were encountered around 121 natural nests among 169 study sites with a close encounter rate of 4936 house sparrows in the vicinity of 1820 natural nests and 384 house sparrows in the vicinity of 192 artificial nests were observed in 48 sites where both natural and artificial nests were observed. These artificial nests were probably to offer a secondary option of nest site preference for house sparrow. In response to this, Bhattacharya *et al.,* 2011 recommended that since house sparrows nest in cavities, putting up nest boxes may be an attempt at combating the falling sparrows' population especially within urban and suburban settings. Further, artificial nest sites were reported in one-third of the surveyed sites, suggesting an emerging trend for nest choice. The changes in sparrow nesting habits may therefore be as a result of factors such as; limited availability of food, natural nesting places and increased human interference in their habitat.

Moreover, the photographs of the natural nests (Annexure 3) and different kinds of artificial nests available in and around Madurai district which are kept by the public volunteers (Annexure 4) are included. These were cardboard boxes, coconut coir nests, wooden boxes, metallic tins, pipes, plastic bottles, and earthen pots. House sparrows have the habit of breeding in all types of artificial nests. This indicates that there is versatility in house sparrow nests depending on the type of material used in constructing artificial nests. It may also be so because of their change of behaviour due to the change of environment in the exercise of this flexibility. Thus, the study revealed that artificial nest can serve as a substitute to natural nest in order to boost the existing population in the area. The artificial nest was also found to have a positive impact to the house sparrow population making it a viable option to consider in conservation of the species.

v. Relationship between soil type and land use on house sparrow distribution

This study reveals a significant association between the availability of natural nests and presence of house sparrows with specific soil types. Figure 11 illustrates that areas characterized by red loam and black cotton soils had the highest availability of natural nests and house sparrow presence. Among single type soil areas, clay loam soil showed a slightly higher presence of sparrows and nests compared to red loam soil. In contrast, areas with a combination of red loam and clay loam soils had the lowest presence of natural nests and house sparrows. This distribution pattern may be related to the different crops grown on these soil types, allow optimal foraging and breeding sites for the house sparrows thereby have a positive effect in their population dynamics and distribution.

The predominance of cereal crops such as sugarcane, cotton, and paddy in red loam and black cotton type of soils offers a plenty of seeds, millets, grains, and insects make a suitable habitat in relevant to the source of food and nesting materials for house sparrows. Additionally, red loam and black cotton soils as well support the cultivation of sunflower and groundnut, whose seeds are preferred by sparrows. In contrast, red loam and clay loam soil types are often employed for growing vegetables like brinjal, lady's fingers, and tomatoes, as well as pulses like black gram and red gram, which are less preferred by the house sparrows.

Moreover, seeds, grains, insects and small invertebrates serves as a ideal food sources as well as the nesting materials like straw and hay from paddy, sugarcane, and cotton, twigs from sunflower, leaves from sugarcane, and plant fibers from sunflower, cotton, and sugarcane resulting the house sparrows occurrence more frequently within the cultivation is practiced on the red loam and black cotton soils. Supportive photographs of the soil types, crops cultivated, the foraging and breeding activities of house sparrow in the study area is illustrated in Figure 12. Thereby, the study suggests that the type of soil and associated land-use practices have a significant impact on the abundance of house sparrow, further indicating their habitat preferences for feeding and breeding related activities.

IV. CONCLUSION

Although the house sparrows (Passer domesticus) are adaptable birds that can thrive in a range of environmental conditions, the results of this study indicate that they are susceptible to various threats, including electromagnetic field exposure, predation, and land-use practices. This study provides a comprehensive understanding on the status, distribution, and factors influencing the abundance of this species. Also, the house sparrow is a biological indicator species, which further underline the need for conservation. From the results it was determined that the house sparrows do have a negative response and are to some extent susceptible to the higher levels of electric field compared to the magnetic field that again shows a need for some good mitigation and the fact that the existence of mobile towers imposes no limitations on house sparrows abundance. As in general, the presence of predators and intruders, such as Eurasian sparrow hawks, house crows, cats, and monkeys, was found to have a negative impact on house sparrow populations. So it is crucial to counteract the effects of predation, possibly through the use of predator-resistant nest boxes in their appropriate habitats. As well as the use of

artificial nests as conservation tool, which would mainly be in areas where natural nesting places are scarce.

In general, this study emphasizes the need for a multi-faceted approach to conserve house sparrow populations, including reducing electromagnetic field exposure, controlling measures on predation, and protecting natural habitats. By knowing the factors influencing house sparrow abundance, an effective conservation strategy can be developed to protect this species and ensure its long-term survival. Furthermore, these studies contribute to our understanding of the complex relationships between urbanization, land-use practices, and biodiversity, and highlight the need for continued research and conservation efforts to protect this ubiquitous species and indeed all forms of urban wildlife.

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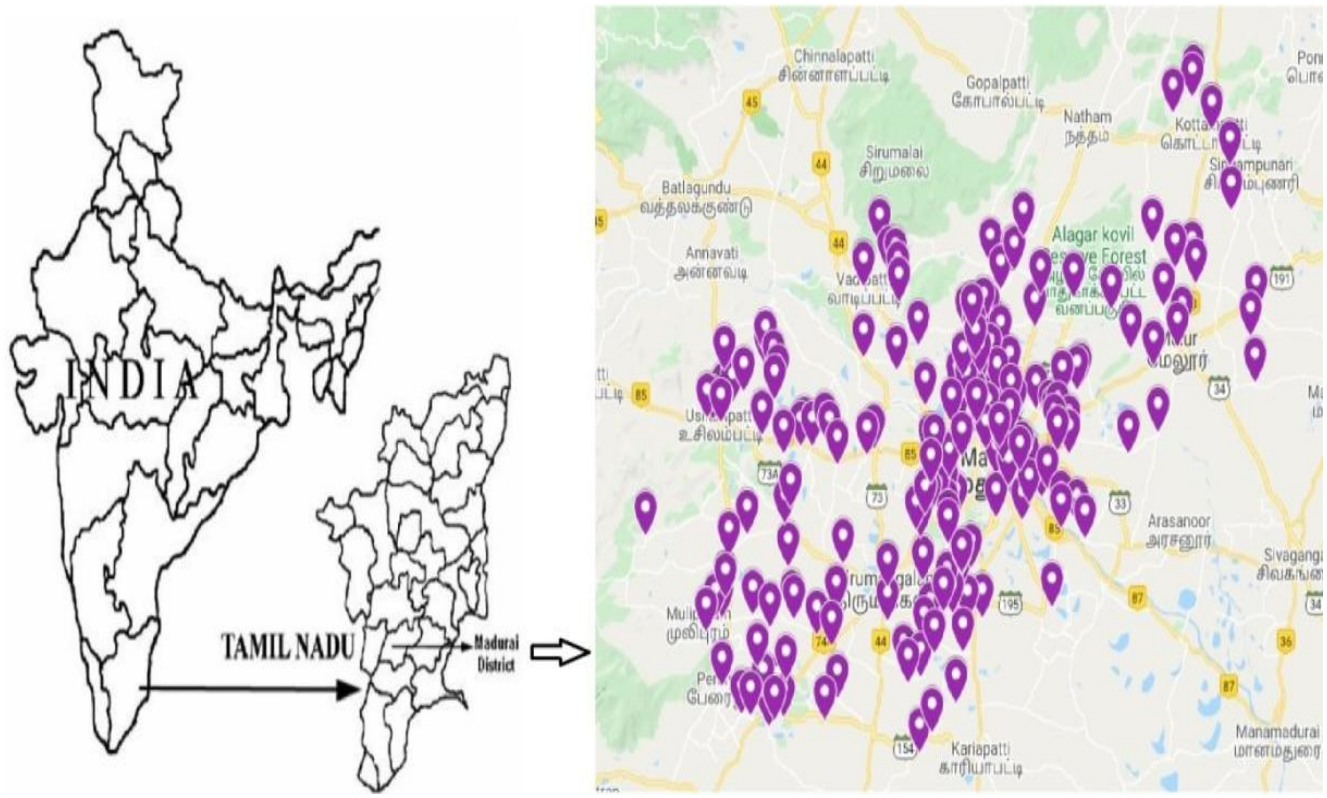


Figure. 1. Study places in Madurai District.

S.No	Basic information					
	Date of visit	Name of the Place	Name of the Block	Total distance observed	Observation starting time	Observation ending time
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

	Environmental Factors																				
	Occurrence of Mobile Phone tower	Number of towers		E- Field values					H - Field values					Status of E Field					Status of H Field				
S.No	Present / Absent	Mobile Phone towers	Internet towers	PLS 1	PLS 2	PLS 3	PLS 4	PLS 5	PLS 1	PLS 2	PLS 3	PLS 4	PLS 5	PLS 1	PLS 2	PLS 3	PLS 4	PLS 5	PLS 1	PLS 2	PLS 3	PLS 4	PLS 5
1																						
2																						
3																						
4																						
5																						
6																						
7																						
8																						

Figure. 2. Data collection form used in the field visit.

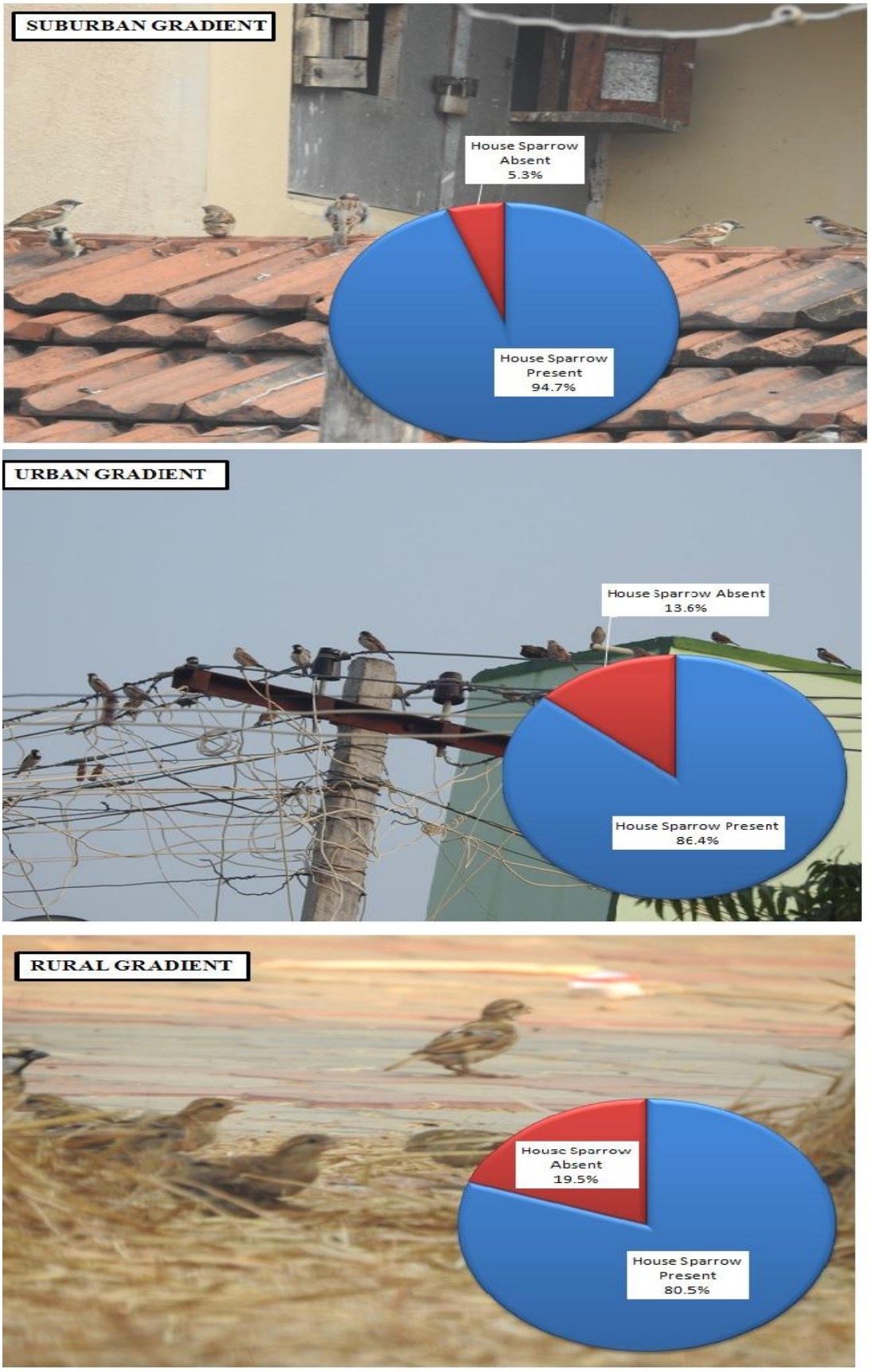


Figure. 3. Percentage diagram of house sparrows in three gradients of Madurai district

Number of Group	Details of the Group
1	Places where mobile tower present & house sparrow present
2	Places where mobile tower absent & house sparrow present
3	Places where mobile tower present & house sparrow absent
4	Places where mobile tower absent & house sparrow absent

Table 1. The information of the four Groups.

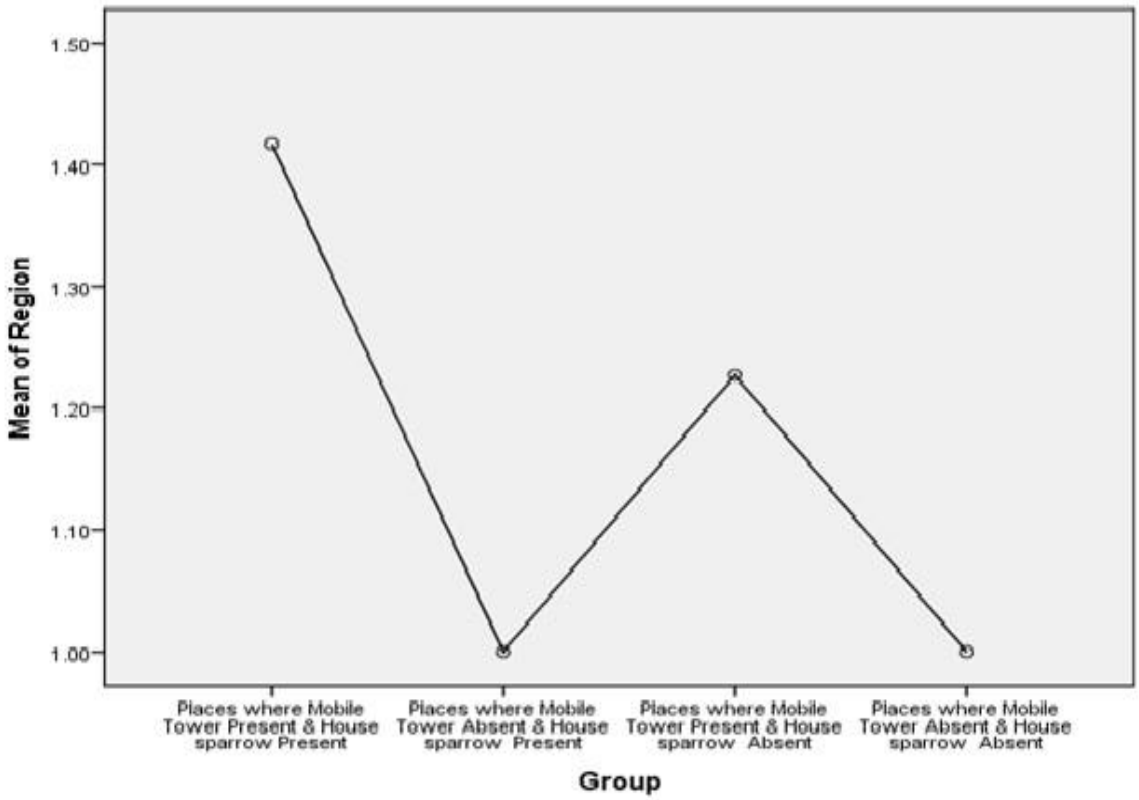


Figure. 4. The status of house sparrows and the mobile towers

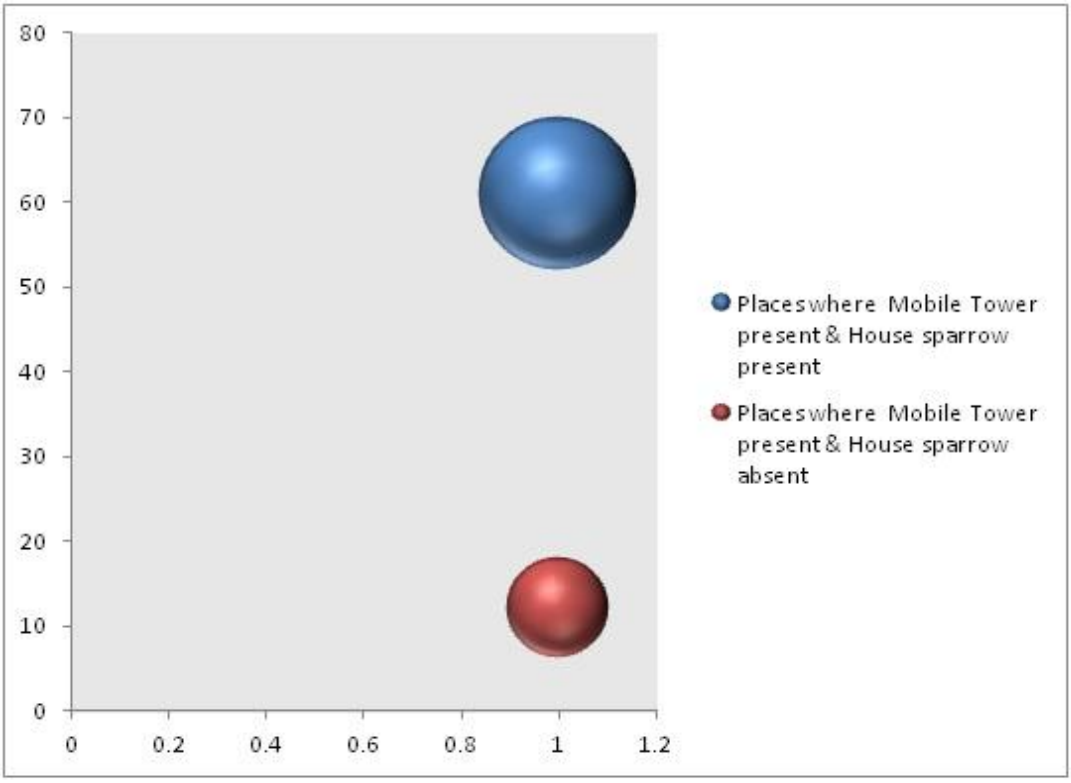


Figure. 5. Relationship between the abundance of house sparrow and mobile tower availability

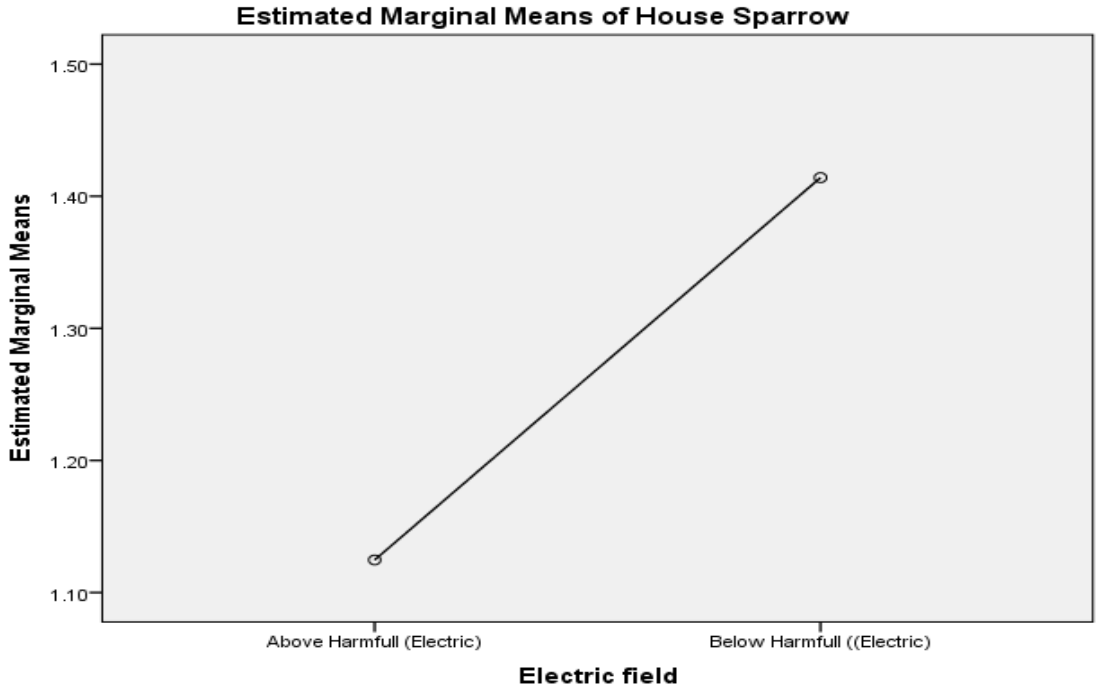


Figure. 6. The estimated marginal mean plot of electric field and abundance of house sparrow

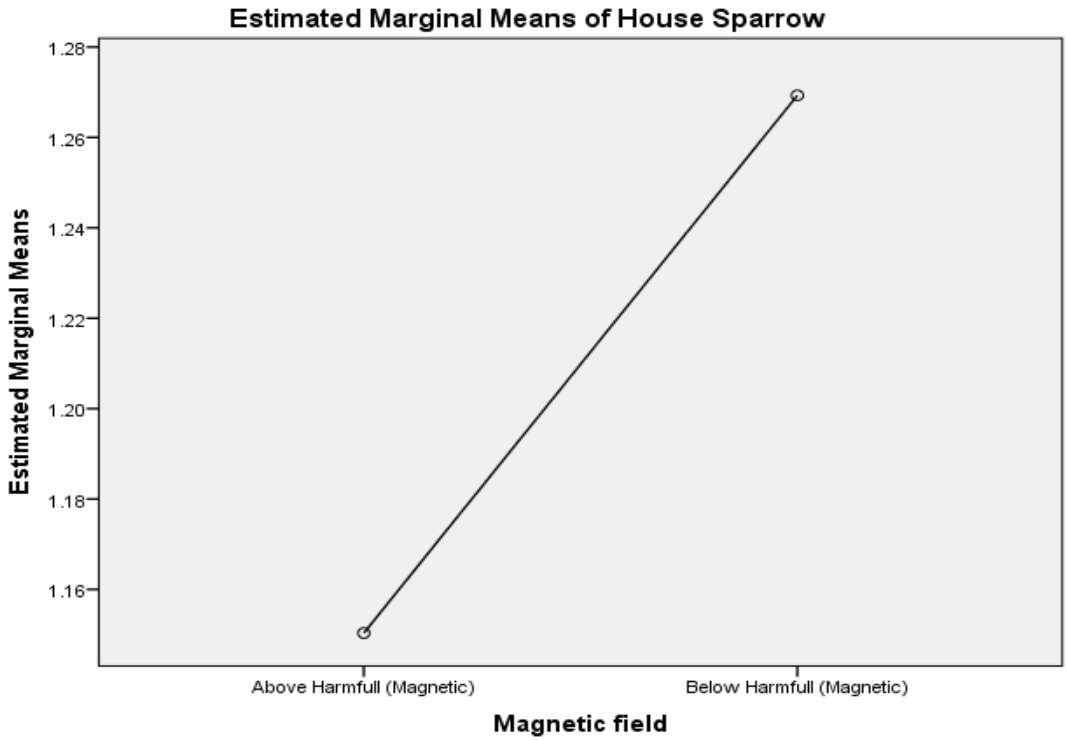


Figure. 7. The estimated marginal mean plot of magnetic field and abundance of house sparrow

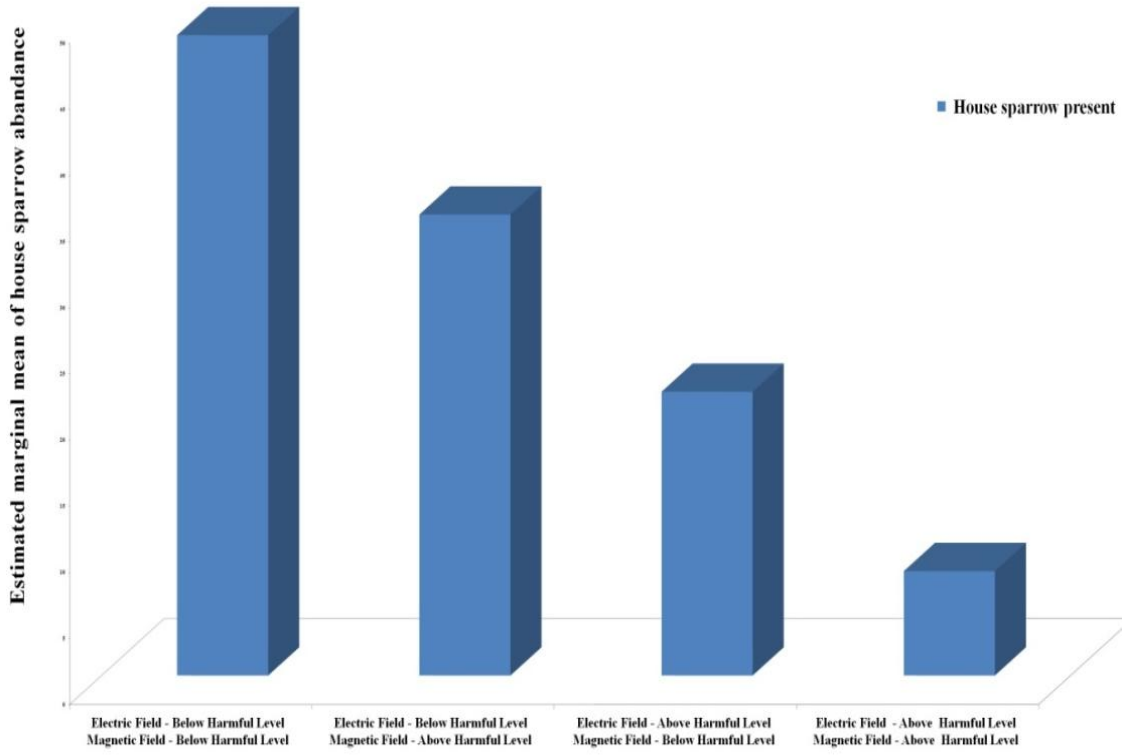


Figure. 8. Correlation between the house sparrow abundance and levels of electromagnetic field

A **B**

C **D**

A: Eurasian sparrow hawk, **B:** House crow, **C:** Monkeys, **D:** Cat

Figure.9. Predators of house sparrow

A

B

C

A: Brahminy starlings, **B:** Oriental garden lizard, **C:** Indian palm squirrel

Figure.10. Intruders of house sparrow

Nest status	Nest Total/ Blocks mean, SE and (*n*)
Natural Nest	140 ±1.4 (*n=1820*)
Artificial nest	15 ± 1.4 (*n=192*)
Overall	155 ± 2.1 (*n=2012*)
Mann-Whitney U Test (p) value	0 (0.00001)

Table.2. Overall nest status of house sparrow observed in and around Madurai district

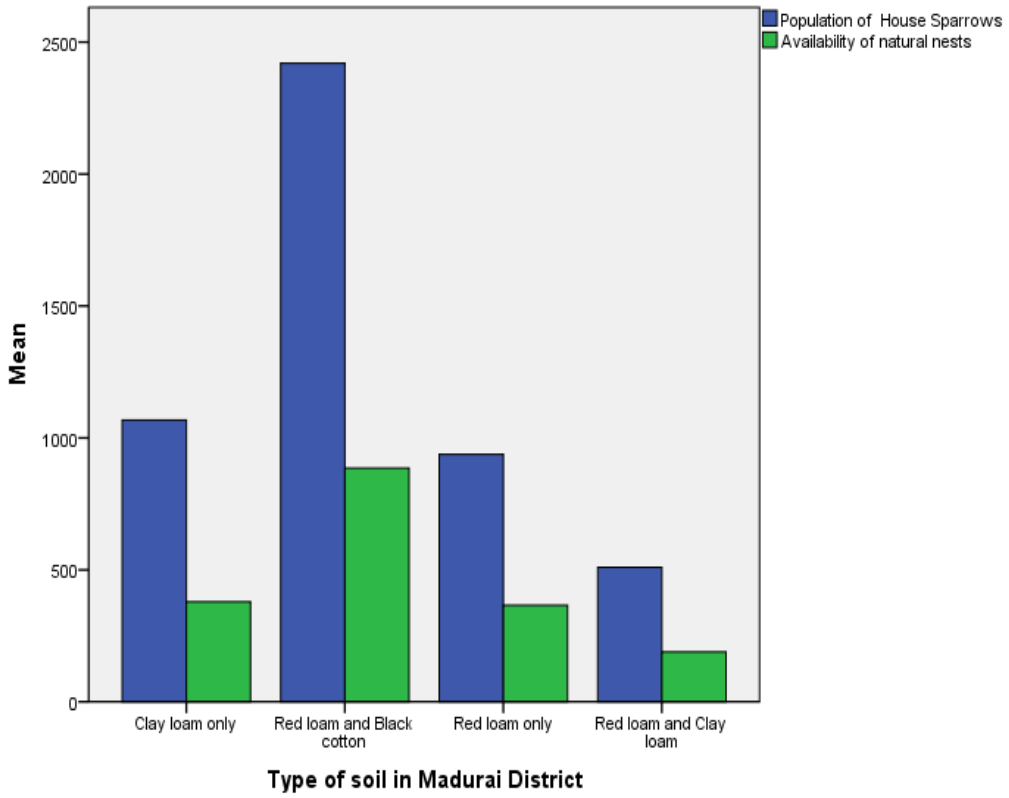
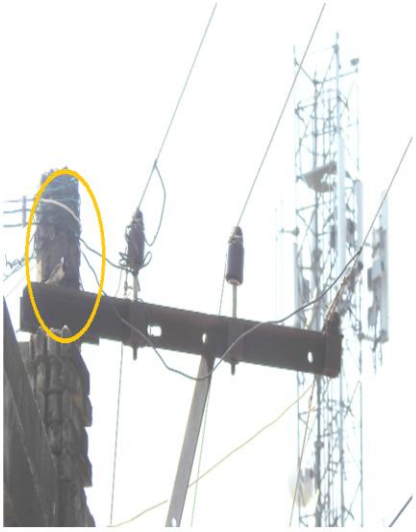
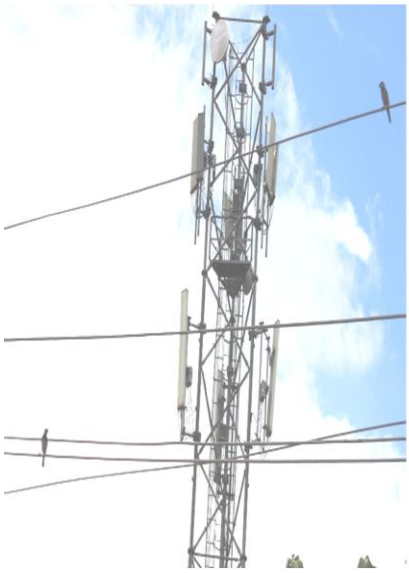
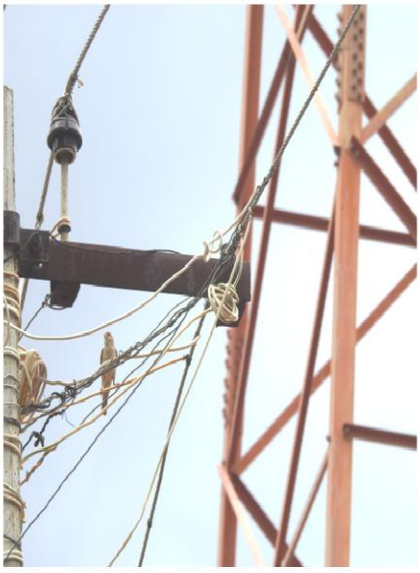


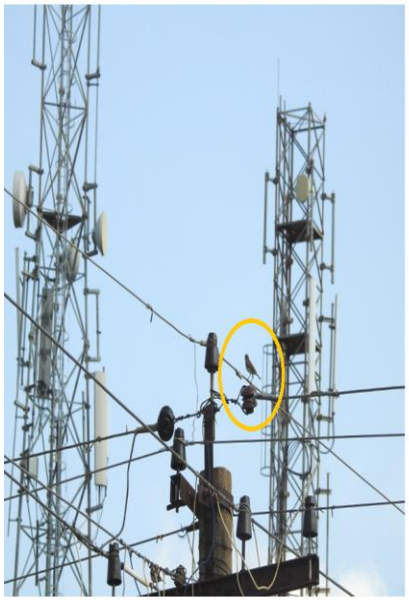
Figure.11. Correlation between soil type with house sparrow nests and population

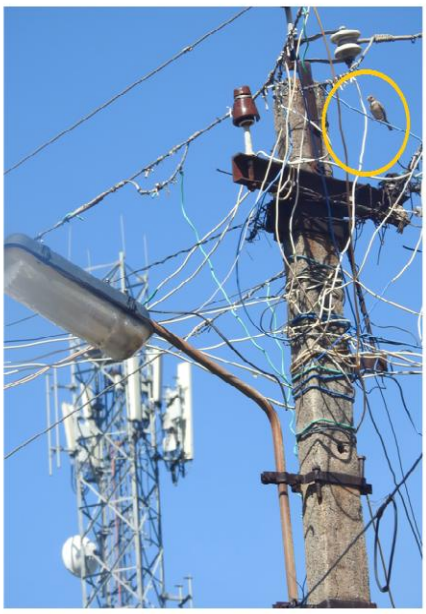
Figure.12. Soil types, crops cultivation, foraging grounds and breeding activities of house sparrow in and around Madurai district

Annexure 1: House sparrows recorded near the mobile tower area in and around Madurai district





Annexure 2: Natural nest of house sparrow in an insecure nesting places

Annexure 3: House sparrow natural nests documented in and around Madurai district

Annexure 4: Artificial nests provided by public volunteers in and around Madurai district