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# Difference in nesting ecology of purple sunbird *Nectarinia asiatica* among urban and rural habitats in New Delhi, India

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**Abstract** - The purple sunbird (*Nectarinia asiatica*) breeds in New Delhi, India, from February to May. A study of its nesting ecology in urban and rural areas of New Delhi revealed several differences. There was significant difference in time taken by female birds to build nests in urban and rural areas. Many urban nests had paper and wire pieces in them, a feature not observed among rural nests. Many urban nests were clumped around greener patches. In urban areas 40 nests were suspended from wires and pipes while others were suspended from twigs and branches of trees. However, all rural nests were suspended from thin branches and twigs of trees. There was significant difference in the height at which nests were built and their depth among rural and urban nests. Rural nests had significantly greater depth to support larger clutch sizes. Rural nests had significantly greater concealment than urban ones. Average egg/nest in urban and rural nests was 1.85 and 2.46 respectively. During incubation females were away from urban nests for significantly greater periods. Urban nests had significantly less hatching success, lower nesting and breeding success. Mortality was significantly higher in urban nests. We conclude that difference in breeding ecology in the two study areas was due to better food supply and nesting conditions in rural areas.

**Key-words**: breeding success, clutch size, predation, mortality.

## INTRODUCTION

Urbanization is one of the most widespread and profound changes underway in landscapes around the world. It often changes the abundance and type of resources upon which birds depend, including the type and availability of nesting sites (Emlen 1974, Beissinger & Osborne 1982, Lim & Sodhi 2004). Compared with rural sites, urban environments are typified by increased abundance and type of anthropogenic nesting sites, while numbers of natural nesting sites can be greatly reduced (Emlen 1974, Lancaster & Rees 1979).

In addition, several characteristics that are specific to urban ecosystems, such as the permanent presence of humans and higher densities of non-native predators (e.g., cats and dogs), have potential to affect avian nest placement (Knight & Fitzner 1985, Sorace 2002, Antczak *et al*. 2005, Eggers *et al*. 2006). These factors create urban-specific stress when individuals colonize and breed in urban environments.

As breeding habitat becomes more fragmented, nest predation increases (Gates & Gysel 1978, King *et al*. 1996, Bayne & Hobson 1997), brood parasitism increases (Brittingham & Temple 1983), interspecific competition for resources is more pronounced (Cawthorne & Merchant 1980, Ambuel & Temple 1983), and pairing success decreases (Gibbs & Faaborg 1990, Villard *et al*. 1993). The effects of urbanization on bird communities are well documented (Hoover *et al*. 1995, Friesen *et al*. 1995, Blair 1996, Morse & Robinson 1998, Porneluzi & Faaborg 1999). These studies show that total and native species richness decline at high levels of development.

Individual species, however, display differing responses to urbanization. Some birds reach peak densities in urban or suburban settings, while others reach peak densities at natural sites (Mills *et al*. 1989, Blair 1996, Clergeau *et al*. 1998, Gering & Blair 1999). The cumulative response of individual species to urbanization also results in changes at the level of the bird assemblage. Blair (2001) examined the distribution and abundance of birds along an urban gradient in southwestern Ohio. This study included a spectrum of habitat types created by urbanization, ranging from a pristine nature reserve to a highly developed urban center. Individual species displayed patterns of abundance along the gradient that reflect their level of tolerance for human impact.

Nest predation is the most common cause of nesting failure among open-cup nesting passerines (Ricklefs 1969, Martin 1988). As a result, predation pressure may be an important factor in regulating densities and distributions of birds (Emlen 1974). In birds inhabiting mid and high latitudes seasonal reproduction occurs at a time at which ultimate factors like food supply are most appropriate for survival of both parents and offspring (Thomson 1950, Lack 1968). Differences in the adjustment of reproduction to different environmental conditions can either be the result of genetic differences or of phenotypic flexibility, i.e. an environment-induced change of the phenotype. Phenotypic flexibility is often based on reaction norms that are themselves the result of natural selection. Consequently, identifying the effects of genetic and environmental sources of phenotypic variation is important for the understanding of population differences in reproductive timing (Endler 1986, Falconer 1989).

Wang *et al*. (2008) examined the responses of black-billed magpies (*Pica pica* (L., 1758)) to urbanization across an urban-rural gradient by assessing nest locations, nest height, and available nest sites at six habitats (mountains, farmlands, riparians, urban parks, strips of street trees, building areas) in Hangzhou, China. Ditchkoff *et al*. (2006), Fleischer *et al*. (2003), McKinney (2002), Partecke *et al*. (2004), Reale & Blair (2005), Wang *et al*. (2008, 2009), Yeh *et al*. (2007) have previously worked on differences in feeding and breeding biology of various birds across the urban gradient.

The purple sunbird (*Nectarinia asiatica*) is a resident species in New Delhi (28° 35¢ N 77° 12¢ E), India. It roosts, feeds and breeds in the city and on its outskirts. It feeds on honey, insects and mistletoes (Ali 1992). Our hypothesis was that various nesting aspects of purple sunbirds, including, clutch size, nest height, spacing of nests, nest concealment, hatching success, nesting and breeding success, incubation period, nest attendance, nest predation, mortality, among other factors would differ significantly across the urban gradient.

## MATERIALS AND METHODS

During the breeding season of the purple sunbird (February to May) in 2007 we were able to locate 70 nests in urban areas of the city comprising 8X8 (64 $km^2$) and 150 nests on city outskirts among dense vegetation and farmlands (64 $km^2$). For locating the nests we observed parental behavior in nest construction wherein birds returning with dry grass and leaves led us to the nests they were constructing. Bird droppings, at times, led us to the vicinity of the nests. We used a foldable aluminium pole with an elliptical mirror attached to it to observe the shape and content of nests located at a height. A 8X42 binocular and 40X telescope were used to study the nesting ecology i.e. clutch size, nest height, spacing of nests, nest concealment, hatching success, nesting and breeding success, incubation period, nest attendance, nest predation, mortality, among other aspects. After the nesting cycle was complete the nests were brought down and the material used in their construction was studied with the help of a hand lens. Height of nest above the ground was measured. Ladders were used to access nests. A small scale with measurements was used to record nest depth to the bottom of the nest cup. The nests were marked with a wooden stake at a distance of 10m from them. All the nests were observed every second day (two hours in the morning, two in the afternoon and two at night). All mean values are accompanied with standard deviation. The t-tests undertaken for statistical significance were two-tailed t-tests.

We measured nest concealment from four directions (North, East, South and West) at 1 m from the nest at nest height level. We estimated mean percentage of the nest concealed to nearest 10% (Burhans 1997). To standardize measurements all measurements were done by first author. For example, a nest which was visible 20% received an 80% score.

## RESULTS

The purple sunbird builds an oval shaped nest with an opening at the anterior end. Only the female bird built the nest and it took the female bird in urban areas significantly more time than rural birds to build nests ($t = 20.76$, $df = 219$, $P < 0.05$) (Table 1).

For nest construction the birds used dry plant matter including dry grass, leaves and small pieces of wires and paper in 50 urban nests (71.42%). However, pieces of paper and wires were not found in rural nests. The nest these birds construct are of hanging type and in urban areas 40 nests (57.14%) were suspended from thin wires, electric wires and narrow pipes; all these 40 nests had paper and wire pieces in them. Other urban nests were suspended from thin twigs and branches of plants. All rural nests were suspended from thin branches and twigs of plants and not man made structures. The greener regions in gardens and parks of the urban areas were first chosen for nest construction and then man made structures. All the clumped nests were located in February and first week of March among the greener areas while other urban nests were located after first week of March. The urban nests showed

**Table 1**. Data on breeding biology of *Nectarinia asiatica*.

| | Urban nests | Rural nests |
|---|---|---|
| Nest construction time | 11-14 days (13.2±1.04) | 10-12 days (10.5±0.80) |
| Nest spacing | 20-40m (35.2±2.6) | 80-90m (85.5±2.9) |
| Nest concealment | 20%-40% (28±3.2) | 60%-80% (70±2.8) |
| Nest height | 1.2-2.4 m (1.65 ± 0.42) | 2.4-4.26 (3.9±0.38) |
| Nest Depth | 5-7.5 cm (5.8±0.70) | 5.5-8 cm (6.5±0.82) |
| Average no. of eggs per nest | 1.85 | 2.46 |
| Hatching success | 80% (1.53±0.74) | 90% (1.46±1.11) |
| Nest attentiveness | 30-40 min (36.2±1.8) | 10-15 min (13.4 ±0.8) |
| Male's distance from nest | 10-15 m (12.6±0.7) | 80-100 m (92.4±2.7) |
| Mortality rate | 30% (0.57±0.61) | 22% (0.6±0.73) |
| Nesting success | 55.38% (1±0.6) | 78% (1.7±0.92) |
| Breeding success | 84.3% (1.28±0.98) | 90% (1.95±1.42) |

clumping with 3-4 nests occurring at a distance of 20-40 m (35.2±2.6). We recorded 8 groups each with 3-4 clumped nests in urban areas. 6 groups had 4 clumped nests each and 2 groups had 3 clumped nests each. The rural farmland nests were evenly spaced at a distance of 80-90 m (85.5±2.9) from each other. The rural nests were better concealed with a score of 60%-80% (70±2.8) as against urban nests 20%-40% (28±3.2). The difference between urban and rural nest concealment was significant (t=30.2, df=219, P<0.05) (Table 1). Urban nests were located at a significantly lower height than farmland nests (t=45.2, df=219, P<0.05) (Table 1). Many urban nests were visibly thinner to the extent that the silhouette of the incubating bird inside it was visible (20 nests). The depth of urban nests was significantly lesser than the depth of rural nests, which in order to support a larger clutch size had a greater mean depth (t=7.78, df=219, P<0.05) (Table 1). These birds laid 1-3 eggs. Among urban nests 10 (14.28%), 40 (57.14%) and 20 (28.57%) nests had clutch size of 3, 2 and 1 egg respectively (average number of eggs/nest: 1.85). The rural farmland nests, in comparison, had clutch size of 3, 2 and 1 egg among 80 (53.33%), 60 (40%) and 10 (6.66%) nests respectively. The difference between urban and rural clutch size was significant (t=2.36, df=219, P<0.05). The average number of eggs per nest in rural nests was 2.46. The female bird did the incubation duties, males did not incubate eggs. During incubation we recorded 200 observations on pattern of nest attendance of female birds. In urban nests the females were away from nests each time for 30-40 minutes (36.2±1.8) 3-4 times a day (90% observations) whereas in rural areas it was 10-15 minutes (13.4±0.8) 7-8 times a day (95% observations). The difference between urban and rural female nest attendance was significant (t=158.3, df=219, P<0.05) (Table 1). Hatching success was significantly lower in urban nests as compared with rural nests (t=5.3, df=219, P<0.05) (Table 1). Both parents in urban nests fed the hatchlings (males: 40% females: 60% of 200 observations) whereas in rural nests mostly female birds fed hatchlings (90% of 200 observations). There was significant difference between males feeding hatchlings in urban and rural areas (t=320, df=219, P<0.05).

Ever time a parent bird fed a hatchling we counted it as a single observation. In rural nests female birds kept returning to their nests for feeding and protecting hatchlings at short intervals of 15-20 minutes (17.4±0.8) (180 observations). The females, however, rarely entered the nests after hatching of eggs in rural areas (only 4 observations of females entering nests in rural areas). The males in rural areas stayed within 80-100 m (92.4±2.7) of the nest (300 observations). However, in urban nests parent birds returned after a longer duration of 30-40 minutes (36±0.8) (200 observations). The difference in time between parent birds returning to their nests in urban and rural areas was significant (t=3720, df=219, P<0.05). Females were seen entering the urban nests after hatching of eggs to avoid predator detection while predatory animals such as snakes, mongoose or cats were lurking in nest vicinity (25 nests: 80 observations). Males were never seen entering urban nests though they stayed at a close distance to provide protection to hatchlings (100 observations). The difference between the males' distance from the nest in urban and rural areas was significant (t=3325, df=219, P<0.05). The purple sunbird in urban areas showed less hostility to members of its own species and humans near their nests, possibly due to regular presence of humans. They did not take defensive manoeuvres and did not give out alarming calls when we came 10-15 m distance of their nests (50 observations). In rural nests the territorial behavior, which included defensive manoeuvres like rapidly flying at us in a threatening manner and giving out shrill alarm calls, became evident when we came at a distance of 10-15 m near the nests (60 observations). We also recorded instances of male purple sunbirds attacking and driving out other conspecific males from vicinity of their nests (80 observations). These birds of clumped urban nests, when searching for food, were observed in small groups of 3-4 birds in greener areas near their nests (25 observations). However, rural birds foraged for food individually during nesting period (40 observations).

Predatory attacks on these birds were observed in both study areas. Cats, snakes, kites, mongooses were observed as predators. Maximum predation was observed in urban nests located away from green patches and hanging from wires and other manmade structures, with both parents away for long durations in search of food. We observed predator attacks on 21 urban nests. These attacks included one attack on a nest not harmful to the brood, 3 attacks on eggs and 17 attacks on nestlings in which 24 nestlings were killed. Among 40 urban nests located away from greener areas and hanging from manmade structures 40% nests (16 nests) came under predatory attacks as against a mere 16.5% nests (5 nests of 30) located in greener urban areas. Among the 21 urban nests attacked, predation was by cats (10 nests) mongooses (6 nests), kites (4 nests) and snakes (1 nest).

Among rural nests predatory attacks took place on 30 among 150 nests. These attacks included 2 on nests not harmful to brood, 5 attacks on eggs and 23 attacks on nestlings. Here predation was by snakes (13 nests), cats (8 nests), kites (7 nests) and mongooses (2 nests). The mortality rate among fledglings was significantly higher among urban nests. It was due to predators, inclement weather, accidentally falling off nests and diseases. Among 104 hatched eggs 32 nestlings fell prey to predators and other factors (mortality rate 30%). As many as 24 nestlings fell prey to predators while 8 died due to other factors including bad weather (4), accidentally falling off nests (2) and diseases (2). Among rural nests, mortality rate was significantly lower at 22% ($t=3.75$, $df=219$, $P<0.05$) (Table 1). As many as 55 nestlings fell prey to predators, while 18 others died due to other factors including bad weather (8), accidentally falling off nests (4) and diseases (6). Among urban and rural nests 72 and 260 birds respectively fledged (nesting success: 55.38% and 78% respectively). The difference between urban and rural nesting success was significant ($t=70$, $df=219$, $P<0.05$) (Table 1). Urban breeding success was significantly different from rural breeding success ($t=33.5$, $df=219$, $P<0.05$) (Table1).

## DISCUSSION

There were significant differences in nest site selection, nest construction, clutch size, incubation, nest attendance, foraging, hatching success, mortality, nesting success and breeding success in the two habitats, possibly due to factors such as food availability, better nesting sites and predator frequency. During nest construction birds prefer natural material such as grass, twigs, creepers. However, in urban habitats, due to lack of availability of these materials, they use pieces of paper and wire to support the base of nests. The urban purple sunbirds took significantly more time to construct nests due to lack of availability of nesting material.

Mazumdar & Kumar (2006) studied the nesting ecology of red whiskered bulbul in urban and peripheral areas of Lucknow, India. The city centre nests were less in number, had lesser mean depth, mean clutch size, mean height, had greater mortality rate, lower nesting success and took a longer duration to complete in comparison to nests on city periphery, which was attributed to better nesting conditions and food availability on city outskirts. The present study on purple sunbirds also had similar findings. Wang *et al.* (2008) found the use of urban nest sites by magpies differed significantly across habitats, and increased significantly with the availability of urban nest sites along the urban gradients. Nest height of magpies differed significantly across habitats, and increased significantly with urbanization intensity. They attributed the increase in nest height in urban environments to the increase in human disturbance (the number of pedestrians). In our study, the nest height of the purple sunbirds differed significantly across the urban gradient. The purple sunbirds chose greener areas to construct nests in urban areas. Food scarcity was a potent factor that seems to have caused this clumping, as the clumped nests were located near patches of greenery. We attributed the evenly spacing out of rural nests to better food supply in rural areas. According to Farner *et al.* (1971) non-uniform food distribution leads to nest clumping. There was significant difference in nest concealment of these birds in urban and rural areas. We attribute it to availability of better nesting sites among dense vegetation in rural areas that prevented these nests from being spotted by predators.

The clutch size was smaller in urban areas, possibly due to risks of predation, less food supply and unfavourable nesting conditions. Clutch size reduction due to high risk of nest predation has been thought of as adaptive due to two reasons. First, when nest predation increases with clutch size the smaller broods will shorten the periods when nests are susceptible to predators and reduce the nest visits of birds, which in turn will attract less attention of predators. Second, if parental survival declines with clutch size, then a reduction in clutch size will improve parental survival prospects and future reproduction. Eggers *et al*. (2006) for the first time demonstrated experimentally clutch size adjustment and nest site selection in siberian jays (*Perisoreus infaustus*) as a result of phenotypic plasticity in an open nesting passerine reflecting a facultative response to the perceived risk of nest predation. Skutch (1949, 1966, 1985) suggested that predators force parents to limit the rate of visiting nests, ultimately resulting in evolution of smaller families. In the present study, among urban nests parent birds limited visits by being away for longer durations than returning frequently. Martin *et al*. (2000) monitored 1331 nests in sub-tropical Argentina and 7284 nests in Arizona. Clutches were smaller in Argentina (2.58 eggs/nest) than Arizona (4.61 eggs/ nest), thus supporting the Skutch theory since clutch size was smaller for species with higher predation rate, where they observed fewer but bulkier meals. Our study concluded that average egg/nest was higher in rural areas which had both more food supply and lesser nest predation risk. Fontaine & Martin (2006) demonstrated that birds can assess nest predation risk at large and that nest predation plays a key role in the expression of avian reproduction strategies and in safer environments parent birds increased investment in young by increasing the rate of feeding the nestlings, and females spent less time incubating eggs. Based on the analysis of incubation and provisional behavior of 97 species of passerines, Conway & Martin (2000) suggested that environments with high nest predation risk favour long periods in the nests and a few foraging trips. This was in consonance with our study in which urban birds made a few trips of significantly longer duration a day than rural birds. We concluded that long periods of departure of female birds in urban areas during incubation was due to shortage of food forcing the females to search for food for a longer time and also due to the fact they wanted to avoid predator attention by entering and leaving the nest fewer times. Nest attendance during incubation represents a parent-off spring conflict wherein incubating birds must balance a trade-off between caring for embryos by staying on the nest versus caring for themselves by getting off the nests to forage. Martin & Ghalambor (1999) showed that nest predation might directly affect female incubation behavior by directly affecting incubation feeding by males. Lack (1954, 1966) said that commonly birds have shortage of food due to high metabolic rates. In the present study the rural males took significantly less part in feeding the hatchlings possibly because there was a lot of food available in the vicinity and also to avoid predator detection. The females were seen entering the urban nests after hatching occurred. We concluded that it was done to avoid predator detection especially as we recorded 80 observations of the females entering urban nests with predators lurking nearby. The mortality rate was significantly higher in urban nests, as these nests had lesser protection available given the fact that many were made around manmade structures. This made them visible to predators and also susceptible to inclement weather. The rural nests were located in dense vegetation and it made them less visible to predators and also offered better protection from bad weather.

Mac Gregor-Fors *et al*. (2011) studied the effect of urbanization on avian communities in tropical areas. They concluded that species richness is inversely related to urbanization degree while total bird density increases with it. Our study concluded that urbanization brought about clumping of nests in urban areas. Stracey & Robinson (2012) studied the nests of northern mocking bird (*Mimus polyglottos*), northern cardinals (*Cardinalis cardinalis*) and brown thrashers (*Toxostoma rufum*) to assess if there were consistent patterns in nest predation rates for different species. They monitored nests in parking lots, residential areas and natural areas and concluded that nest predation rates are lower in urban areas than non-urban areas. Shustack & Rodewald (2008) studied the effects of urbanization on reproductive phenology of resident and long distant migrant birds. They found small yet potentially important differences in the timing and length of nesting season across urban-rural gradient. For resident species breeding occurred earlier in urban areas while opposite was true for long distance migrants. Our study revealed that hatching success in purple sunbirds is significantly less in urban areas as compared with rural areas. Salvati *et al*. (1999) studied breeding ecology of kestrels (*Falco tinnunculus*) in urban, suburban and rural areas of central Italy and found nest density very high at city centre (1.9 pairs/$km^2$) and high in suburbs (0.6 pairs/$km^2$). Breeding success was consistent with that of other European urban areas. Significant differences were found among study areas in density, spacing, use and reoccupation of nest sites. In our study, the rural nests were evenly spaced out, while the urban nests showed clumping in groups.

Wang *et al*. (2009) examined the responses of the chinese bulbul (*Pycnonotus sinensis*) to urbanization by assessing nest composition and available nesting materials at five land-use categories (mountains, farmlands, riparians, urban parks, strips of street trees) of intensifying development in Hangzhou, China. They found that the proportion of anthropogenic nesting materials used by chinese bulbuls differed significantly across land-use categories, and it increased significantly with urbanization. In the present study on purple sunbirds, anthropogenic material like pieces of paper and wire were used in constructing nests in urban areas, while the rural nests were free from such material.

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