Reproductive biology of the Square-tailed Black Bulbul *Hypsipetes ganeesa* in the Western Ghats, India

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Abstract

Black bulbuls (genus: *Hypsipetes*) are a poorly known group of passerine birds, distributed widely in Africa and southern Asia. In this article, I provide the first detailed examination of the reproductive biology of Square-tailed Black Bulbul *Hypsipetes ganeesa* based on 81 nests studied in Silent Valley National Park, Western Ghats, southern India, from 2003 through 2005. Breeding occurred from January to June with peak egg laying during April–May. The small open-cup nests were placed 1.2–11 m off the ground in trees 2–15 m tall. Black Bulbul used ten plant species as nest substrates, with about half of the nests placed together in *Glochidion ellipticum,* and *Wendlandia notoniana*. Clutch size was two in more than 96% of nests. Incubation, and nestling periods were 13, and 12 days, respectively. Overall nest success rate was 12.84%. Egg, and nestling predation were the main causes of nest failures. In general, most life history traits of the Square-tailed Black Bulbul were similar to those reported for other members of the family; however, this comparison is constrained by the paucity of information on the breeding biology of most *Hypsipetes* species, and indicates the need for further studies of life histories in the genus.

Introduction

The family *Pycnonotidae* (bulbuls) is a large group of passerines of the Old World tropics comprising 138 species and 355 taxa, widespread in southern Asia, Africa, Madagascar, and islands of the western Indian Ocean (Sibley & Monroe 1990; Fishpool & Tobias 2005). Of the 27 genera currently treated within the family, 11 are exclusively Asian, and 14 are restricted to Africa, and islands of the western Indian Ocean (Fishpool & Tobias 2005). The genus *Hypsipetes* is treated as a complex of seven species, collectively known as 'black bulbuls' that occur in islands of the Indian Ocean, and continental Asia, from Madagascar to central China (Gregory 2000; Fishpool & Tobias 2005). All the Asian mainland forms are lumped together under the polytypic species *Hypsipetes leucocephalus*, but the isolated races of southern India (*ganeesa*) and Sri Lanka (*humii*) are presently treated as the Square-tailed Black Bulbul *H. ganeesa* (Fishpool & Tobias 2005; Rasmussen & Anderton 2005). Apart from comprehensive molecular studies (Pasquet *et al*. 2001; Moyle & Marks 2006), information on the life histories, and morphological characteristics of all members of the genus may help in elucidating the phylogenetic relationships among taxa, and also to understand the selective pressures acting on the biology of individual species. However, little is known about the biology and ecology of *Hypsipetes* bulbuls.

The aim of the present study was to provide a detailed description of the breeding biology of Square-tailed Black Bulbul (Fig. 1) distributed throughout the Western Ghats in southern India. The Square-tailed Black Bulbul is a locally abundant and resident species that shows regular seasonal altitudinal movements (Ali & Ripley 1987; Raman 1999). It inhabits wet evergreen forests and sholas from 1,000 m to the top of the hills, and also occurs in eucalyptus, shade coffee, tea, and cardamom plantations. It is a conspicuous bird with slate-grey to black body, black crest, slightly forked tail; and red bill, legs and feet (Ali & Ripley 1987). The breeding biology of this species is poorly known and only limited characteristics of the nests and eggs have been described (Baker 1932; Ali & Ripley 1987; Fishpool & Tobias 2005). Here, I present data on breeding season, nest characteristics, clutch sizes, developmental periods, breeding success, and causes of nest failures, and compare this information with available data for other Pycnonotids.

Materials & methods

Study area

The study was conducted from 2003 through 2005 breeding seasons (January–June) in the core areas of Silent Valley National Park (11º00'–11º15'N 76º15'–76º35'E; 90 km^2, 600–2,383 m above sea level) in the Western Ghats, India. The breeding habitat of the species is mainly located on the northern slopes of the park, at altitudes ranging from 1,100 to 2,300 m above sea level. The

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Fig. 1. Incubating Square-tailed Black Bulbul *H. ganeesa*.

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Fig. 2. Nest and nestlings of Square-tailed Black Bulbul.

dominant vegetation types at these elevations are west coast tropical evergreen forest, southern subtropical broad-leaved hill forest, and southern montane wet temperate forest (shola forests) interspersed with savannah woodlands and montane grasslands. Dominant tree families in the study sites were Lauraceae, Euphorbiaceae, Myrtaceae, Clusiaceae, and Myristicaceae (Manilal 1998; Das 2008). Mean minimum and maximum daily temperatures during the study were 19.83ºC and 25.78ºC, respectively. Annual rainfall ranged from 4,900 to 8,260 mm, with more than half of it occurring during the south–west monsoon (May–September).

Nest searching & monitoring

The breeding population of the Square-tailed Black Bulbul arrived at the study sites by late December (first sighting dates were 23.xii.2003, and 30.xii.2004 for the 2004 and 2005 breeding seasons respectively), and moved to the lower altitudes by early June. I searched for nests during 2003 through 2005. Nests were located by following individuals carrying nesting material or food to the nests, based on other behaviour cues, and by searching vegetation. Once found, I monitored nests every 1–2 days, and everyday during the transition of nesting stages to determine the clutch size, start and duration of the developmental periods (incubation and nestling) and the fate of the nest. Nests accessible from the ground were monitored by direct observation. I used a pole and mirror to check the contents of higher nests. Standard protocols were followed during nest monitoring to minimize disturbance to birds, and habitat, and prevent observer-induced nest predation (Martin & Geupel 1993; Balakrishnan 2007). Timing of breeding was determined by pooling the number of clutches initiated per month for all the three breeding seasons. Clutch initiation dates were determined either by direct observation of the egg laying or by calculations made using the known hatching dates and mean developmental periods. For the calculation of the developmental periods, I used only those nests whose breeding stage transitions could be observed directly. Nests that produced at least one young were considered successful. Hatching, nestling, and breeding success were defined as the probability that eggs laid would hatch, the probability that hatchlings would fledge, and the probability that eggs laid would survive from laying to fledging, respectively. I measured inner diameter, external diameter, and height and depth of nests to the nearest centimeter in the field, and cup thickness, cup volume and material volume were calculated from these measurements (Soler *et al*. 1998; Balakrishnan 2007). Nest height, plant species, and height of the nest substrate were recorded immediately after the fledging of the young or their predation. Orientation of the nest around the substrate plant was recorded to the nearest degree using a Suunto MCA-D compass.

Data analysis

To compare the relationship between breeding seasonality and climatic variables, I used meteorological data from the Walakkad forest station of the Kerala Forests and Wildlife Department. The nonparametric Spearman's rank correlation was used to evaluate the relationship between clutch initiations per month, and climatic variables. Variation in the nest placement attributes among breeding years, and successful and failed nests were analyzed with univariate ANOVA. I used nonparametric Watson one-sample U^2 tests for circular distributions to test for uniform distributions of nest orientations (Zar 1999).

Daily nest survival rates were estimated using the Mayfield method (Mayfield 1961, 1975). Exposure days were calculated from the interval between the day the first egg was laid or the day the nest was found if after laying, and the day of fledging. For failed nests, the date of failure was estimated as the mid-point between the date the nest was last known to be active and the date it was found to have failed. Daily survival rates and nest success were calculated separately for the incubation, nestling, and overall nesting stages, and breeding seasons. Standard errors for survival rates were calculated as described in Johnson (1979). Reported values are mean ± SD for all measurements unless otherwise indicated. All tests were two tailed, and differences were considered significant at $P < 0.05$. All statistical analyses were performed by using SPSS 10.0 (SPSS Inc.) and Oriana 2.0 (Kovach Computing Services).

Results

Timing of breeding

I located and monitored a total of 81 active nests of the Square-tailed Black Bulbul in Silent Valley National Park during 2003 through 2005 breeding seasons. All the nests were found within an altitude range of 1,210–2,050 m. The breeding season started in January–February and ended in early June, by the onset of heavy monsoon. First egg laying dates were 17 February, 26 January, and 20 February for the 2003, 2004, and 2005 breeding seasons respectively. Peak egg laying was observed during April–May (Fig. 3). The number of clutches initiated per month was not correlated with the monthly rainfall ($r_s = -0.043$, $P = 0.824$) and number of rainy days per month ($r_s = -0.021$, $P = 0.915$), but weakly correlated with the maximum temperature ($r_s = 0.418$, $P = 0.024$, $n = 29$).

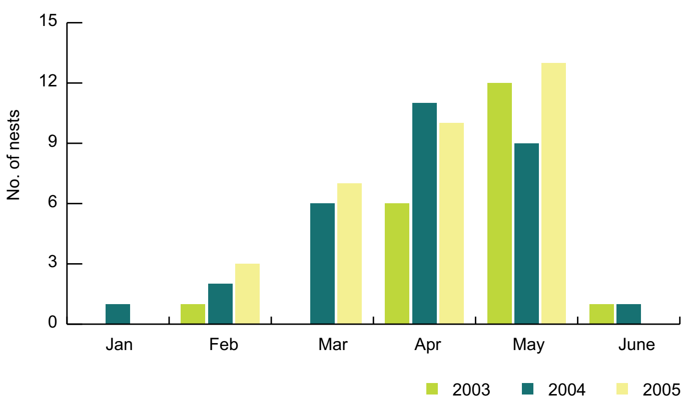

Fig. 3. The number of Square-tailed Black Bulbul nests initiated per month ($n = 81$ nests from the 2003 to 2005 breeding seasons).

Nest characteristics and placement

Square-tailed Black Bulbuls build cup-shaped nests out of grasses, dead leaves (*Glochidion ellipticum, Oreocnide integrifolia, Symplocos cochinchinensis, and Wendlandia notoniana*), plant fibers, moss, lichens, and cobwebs, decorated with dry moss, and rarely, spider cocoon, and bark pieces. The internal linings constituted of rootlets of pteridophytes and other soft materials. The measurements of nests are shown in Table 1. Both sexes participate in nest building but there is considerable variation in each sex's contribution, which is not quantified, as the population is not colour marked. Nest construction took an average of 4.43 ± 0.79 days (range = 3–5 days, $n = 7$).

Table 1. Measurements of Square-tailed Black Bulbul nests ($n = 65$ nests).

Particulars	Mean	SD	Range
Outer diameter (cm)	8.84	0.55	7.60–10.20
Inner diameter (cm)	5.54	0.52	4.70–6.80
Outer nest height (cm)	6.58	0.76	5.00–9.20
Cup depth (cm)	4.50	0.59	3.20–6.00
Nest thickness (cm)	3.30	0.36	2.20–4.00
Cup volume (cm^3)	292.71	74.61	180.34–561.42
Material volume (cm^3)	792.51	162.03	477.36–1557.81

The mean nest height was 4.42 ± 2.09 m (range = 1.2–11 m), and the mean height of trees in which nests were built was 7.01 ± 3.40 m (range = 2–15 m). The mean relative height of nests was 0.66 ± 0.17 (range = 0.25–0.92). In general, there was no annual variation in the nest (ANOVA, $F_{2,78} = 0.049$, $P = 0.952$) and relative heights ($F_{2,78} = 0.073$, $P = 0.930$). However, the successful nests had significantly low nest height compared to failed nests (mean = 3.38 ± 1.41 m vs 4.77 ± 2.17 m; $F_{1,79} = 7.094$, $P = 0.009$).

Majority of the successful nests were placed closer to the middle of the trees, and significantly varied from the failed nests which were placed in the top layer of the trees (mean relative height = 0.44 ± 0.11 vs 0.74 ± 0.11; $F_{1,79} = 104.438$, $P = 0.001$). Square-tailed Black Bulbuls used ten plant species as nest substrates, with about half of the nests placed together in *Glochidion ellipticum*, and *Wendlandia notoniana* (Table 2). The mean (± SE) nest orientation of Square-tailed Black Bulbul nests was 168.29 ± 20.07°. The nests were not distributed uniformly around the plants (mean vector (r) = 0.221, Watson's $U^2 = 0.217$, $P < 0.05$), but situated without any strong directionality in placement ($n = 81$, Fig. 3).

Table 2. Plant species used for nesting with nest placement attributes and success rate.

Plant species	Nest height in m ± SD	Tree height in m ± SD	No. of nests (%)	% successful	Fledged /nest
Glochidion ellipticum	3.53 ± 0.92	5.44 ± 1.18	21 (25.93)	33.33	0.67
Wendlandia notoniana	2.89 ± 1.12	4.24 ± 1.45	18 (22.22)	22.22	0.44
Symplocos cochinchinensis	4.72 ± 1.66	7.28 ± 2.93	9 (11.11)	22.22	0.44
Clerodendrum viscosum	4.14 ± 1.58	6.21 ± 2.75	7 (8.64)	28.57	0.57
Syzygium palghatense	5.86 ± 1.70	10.50 ± 2.50	7 (8.64)	28.57	0.57
Syzygium cumini	6.70 ± 2.54	11.70 ± 2.22	5 (6.17)	20.00	0.40
Elaeocarpus munronii	7.14 ± 1.87	13.20 ± 2.49	5 (6.17)	20.00	0.40
Oreocnide integrifolia	3.63 ± 1.34	5.63 ± 0.85	4 (4.94)	25.00	0.50
Unidentified species	8.67 ± 2.52	11.33 ± 2.89	3 (3.70)	0.00	0.00
Schefflera stellata	5.00 ± 2.12	7.01 ± 3.40	2 (2.47)	0.00	0.00

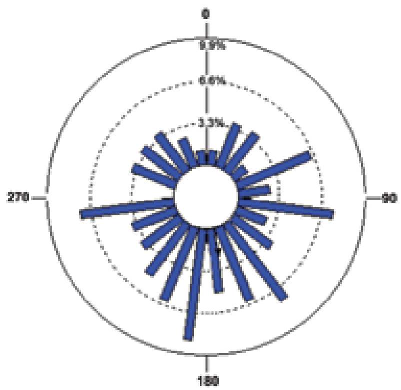

Fig. 4. Circular frequency distributions of nest placement around the nest plants (n = 81 nests, bin width =15°). Doted circles indicate scale (% of nests).

Clutch size, and duration of the incubation, and nestling periods

Mean clutch size was 2.04 ± 0.19 (n = 81 nests, 78 with two eggs, and three with three eggs). Eggs were laid in the morning, and the laying interval was approximately 24 hrs. The incubation period ranged from 12–13 days (mean = 12.75 ± 0.45 days, n = 12), and nestling period averaged 11.88 ± 0.34 days (range = 11–12 days, n = 16). The overall incubation and nestling periods together was 24.82 ± 0.40 days (range = 24–25, n = 11). Thus, the complete breeding cycle from the start of nest construction to the time when nestlings left the nest, took about a month.

Nest success & causes of failures

Of 81 active nests monitored, 24.69% fledged at least one chick. The hatching success of all eggs known was 46.06% (76 hatchlings from 165 eggs, n = 81 nests), and fledging success was 52.63% (40 fledged out of 76 hatched, n = 38 nests). Overall breeding success (% eggs fledged) was 24.24%. Daily mortality rate during the incubation period was 0.084 (n = 512 egg-days for 81 nests), and during the nestling period was 0.069 (n = 262 nestling-days for 38 nests). The daily survival rate (±SE) for the entire nesting period was 0.921 ± 0.010, which equates to an overall nest success rate of 12.84%. Nest success did not vary greatly among the breeding years (Table 3).

Table 3. Mayfield daily nest survival rate and nest success of Square-tailed Black Bulbul during different breeding stages and years, Silent Valley National Park, southern India.

Reproductive period/year	Exposure days	No. of nests	No. of nests failed	Daily nest survival ± SE	Nest success
Incubation	512	81	43	0.916 ± 0.012	31.97
Nestling	262	38	18	0.931 ± 0.016	42.57
Overall nesting	774	81	61	0.921 ± 0.010	12.84
2003	194	20	16	0.918 ± 0.020	11.63
2004	297	28	21	0.929 ± 0.015	15.99
2005	283	33	24	0.915 ± 0.017	10.91

Nest predation was high, accounting for 93% (57 of 61 nests) of all known nest failures. These nests were characterised by the complete loss of the eggs or chicks. Black-shouldered Kite *Elanus caeruleus* was observed depredating one Square-tailed Black Bulbul's nest, and consuming its entire contents. Indian rat snake *Ptyas mucosa* was also observed depredating Black Bulbul nests at Muthikkulam reserved forest (*pers. obs*.). Other possible predators include colubrid snakes, corvids, raptors, and arboreal mammals. Two nests were destroyed when their nesting plants collapsed due to strong winds. No brood parasitism was observed in Silent Valley, however, the presence of two blue-coloured oval-shaped eggs (probably those of Pied Cuckoo *Clamator jacobinus*) in one of the Square-tailed Black Bulbul nests at Muthikkulam reserved forest (*pers. obs*.) indicates the species is parasitised.

Discussion

Pycnonotids breed at varying times of the year, and are multi-brooded. The equatorial Asian, and African species are reported to breed throughout the year, and some are known quite commonly to raise three broods in a year, and rarely up to five broods (Ali & Ripley 1987; Fishpool & Tobias 2005). However, throughout their range the breeding activities of the montane forest species tend to be suppressed during the wettest, and coldest months (Ali & Ripley 1987; Fishpool & Tobias 2005). Breeding of Square-tailed Black Bulbul in Silent Valley National Park occurred between January and June with peak breeding in April–May (>72% total clutch initiations; Fig. 3). On the other hand, co-existing bulbuls in the mid-elevation forests, such as Yellow-browed *Iole indica*, and Grey-headed Bulbul *Pycnonotus priocephalus*, breed slightly earlier. Peak breeding of Yellow-browed Bulbul was in January–February, and that of Grey-headed Bulbul was in April–March (Balakrishnan 2007). Higher levels of insectivory, compared to these two species' requirements, could be a reason for the closeness of peak breeding of Square-tailed Black Bulbul towards the monsoon, so that the peak food demand of chicks coincides with the arrival of the monsoon (Ali & Ripley 1987). Moreover, a majority of the Square-tailed Black Bulbul's egg-laying dates fall within the peak breeding months of south Indian passerines (Pramod & Yom-Tov 2000).

Nests of Square-tailed Black Bulbul are typically like those of similar species, made with materials available in the immediate vicinity of the nest sites. Nest construction period was similar (3–5 days) to the durations reported for other Pycnonotids: 2–5 days for Red-vented Bulbul *P. cafer*, 3–8 days for Yellow-throated Bulbul *P. xantholaemus*, and 3–8 days for Grey-headed Bulbul (Ali & Ripley 1987; Venkataswamappa & Chaitra 1999; Fishpool & Tobias 2005; Balakrishnan 2007). Nests were found in medium-sized trees, mostly in the rainforest–savannah woodland edges, placed at varying heights (1.2–11 m). Similar nest placement attributes (2–15 m) were reported for the Himalayan sub-species (*psaroides*) of the Black Bulbul (Ali & Ripley 1987). Diversity of nest substrates used was too low, with strong preference for *Glochidion ellipticum*, and *Wendlandia notoniana* (Table 2). More than 96% of nests had two eggs; the remaining had three. Ali & Ripley (1987) also reported the clutch size as two, and rarely three, which is the typical range of most of the African, and Asian species of bulbuls (Fishpool & Tobias 2005). Incubation, and nestling periods of Square-tailed Black Bulbul fall within the ranges of most species of bulbuls (11–14 days) (Liversidge 1970; Vijayan 1975, 1980; Walting 1983; Ali & Ripley 1987; Hsu & Lin 1997; Krüger 2004; Fishpool & Tobias 2005; Balakrishnan 2007), but are slightly lower than those of some African pycnonotids (Safford 1996; Fishpool & Tobias 2005).

The Mayfield success rates of breeding Square-tailed Black Bulbul were 31.97% for the egg stage, 42.57% for the nestling stage, and 12.84% for both combined. The success rates are similar to that of the Grey-headed Bulbul (10.79%), but slightly lower than that of the Yellow-browed Bulbul (17.21%) breeding at the same elevations (P. Balakrishnan, *unpubl. data*). Although nest predation rate is much higher than reported generally for tropical passerines (71%) (Robinson et al. 2000; Stutchbury & Morton 2001), most studies of Pycnonotids indicate high predation rates, often higher than 70% (Liversidge 1970; Vijayan 1975, 1980; Walting 1983; Hsu & Lin 1997; Krüger 2004; Fishpool & Tobias 2005; Balakrishnan 2007). Predation rates were higher during the egg stage than the nestling stage as reported for other species (Mermoz & Reboreda 1998; Balakrishnan 2007). Predation was the major factor limiting nesting success as reported for other open-cup nesting passerine birds (Ricklefs 1969; Martin 1993). The two predators confirmed as nest depredators were Black-shouldered Kite, and Indian rat snake. Species like common vine snake *Ahaetulla nasuta*, White-bellied Treepie *Dendrocitta leucogastra*, Greater Coucal *Centropus sinensis*, and jungle striped squirrel *Funambulus tristriatus* are also recorded as the predators of other bulbuls in Silent Valley National Park (Balakrishnan 2007). A majority of the Square-tailed Black Bulbul nests were placed high off the ground, so the role of arboreal mammals, raptors, and colubrid snakes in nest predation, and the level of brood parasitism deserve detailed investigation. A small portion of the late season nests also failed due to harsh weather.

In conclusion, the reproductive biology of Square-tailed Black Bulbul was similar in many aspects of other Pycnonotid species. However, this comparison is constrained by the lack of information on the breeding biology of most *Hypsipetes* species. Further research is needed to understand the growth rates, parental care patterns, and predators, and nest mortality rates for other populations of Black Bulbul along their distribution range. This would greatly benefit in understanding the geographic diversity of avian reproductive traits, and life history strategies in general, and to improve our understanding of the proximate, and ultimate factors that shape life-history traits of *Hypsipetes* bulbuls.

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