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Nesting Habitats and Nesting Success of Hill Mynahs *Gracula religiosa* in Thailand

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Abstract: Nesting habitats of Hill Mynah *Gracula religiosa* were studied in order to gain a perspective of habitat features which were favoured by natural selection. A total of 76 nest trees and 310 neighbour trees of northern Hill Mynah (*G. r. intermedia*) and 25 nest trees and 136 neighbour trees of southern Hill Mynah (*G. r. religiosa*) were studied in eight provinces of Thailand between 6° and 20°N from 1991 to 1999. Nest characteristics including nest height, nest size, nest depth, cavity entrance, angle of nest cavity and cavity entrance were recorded. The characters of nest trees, including condition types, the height, canopy and trunk were studied. Habitat characteristics were measured within a square plot of 20x20 m around nest trees. Number and the characters of neighbour trees around each nest tree, distance from nest trees to the nearest neighbour trees were recorded. The results showed that Hill Mynah nest trees were taller, bigger and had thicker canopies than their neighbour trees. Their nests were higher and farther from the tree boles in dense canopies. Nest trees were live and solitary in the areas with foliage cover. Habitats of successful nests were different from unsuccessful ones in the term of higher first branches, bigger canopies, more surrounding trees and farther from neighbour trees. Although the natural selection successfully shapes the form of Hill Mynah nesting habitats to avoid natural predators and unfavourable climates, heavy human interference is the major cause of nesting failure in this species.

Key words: *Gracula religiosa*, Hill Mynah, nesting habitats, nesting success

Introduction

Individuals that are capable to increase reproductive success by leaving a large number of fertile young to the next generation are favoured by natural selection. Birds, therefore, evolve a variety of reproductive strategies in order to produce as many young as they can. Mating system as monogamy and biparental care to increase the amount of food delivery to the nest and to prolong the reproductive life of parents, as seen in most of bird species are advantageous. However, the major cause of nesting failure in birds is nest predation (Lack, 1954; Nolan, 1963; Best, 1978; Collias and Collias, 1984; Nilsson, 1984; Collias, 1997). Nest site selection in birds is a function of various factors, most of all, protection from predators and from severe climate. Nest concealment with vegetation, multiple nests, nest with false or two entrances, inaccessible nest sites, nest near aggressive insects or animals are selectively evolved in each species. Half of the bird orders nest in cavities (Gill, 1990). About two-thirds of the eggs of cavity-nesters give rise to fledged young whereas only a half of the eggs of open-nesters produce fledged young (Lack, 1954; Lack, 1968; Nice, 1957).

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Reproductive success in birds can be determined by nesting habitats (Collias and Collias, 1984; Martin, 1992). Study of habitat features and successful nesting may be useful in understanding the process of nest habitat selection (Martin and Roper, 1988; Li and Martin, 1991; Martin, 1993; Christma and Dhondt, 1997). There is no report examining nesting habitats such as characters of nest trees in relation to neighbour trees that are favoured by a cavity-nesting bird such as Hill Mynah (*Gracula religiosa*) which may affect the hatching survival from predators. Therefore, the present research was conducted to study the nesting habitats of Hill Mynahs to provide a perspective of vegetation structure of area adjacent to the nest trees in order to understand how natural selection shapes the form of nest sites in this species to enhance reproductive success.

Materials and Methods

The nesting habitats of both subspecies of Hill Mynahs, *G. r. intermedia* (northern birds) and *G. r. religiosa* (southern birds) (Archawaranon, 2002; Archawaranon and Techatraisak, 2002) were examined during a study of their breeding biology from 1991 to 1999 (Archawaranon, 2003). The study was conducted in protected areas in eight provinces of Thailand between 6° and 20°N. Normally, the breeding season is January to July, including the relatively dry climate in March and April (mean monthly temperature 29°C, average rainfall month⁻¹ 63 mm, relative humidity 70%) and the wet climate from May to July (mean monthly temperature 28°C, average rainfall month⁻¹ 218 mm, relative humidity 78%).

Hill Mynahs, a secondary cavity nester, used cavities earlier produced by woodpeckers, by termites or by fungal decay (Archawaranon, 2003). They nest in both large standing dead trees, called snags and live trees. Nests were presumed active when parents entered the nests, with nest materials during nest building, or with fresh leaves during incubation period and with food during nestling period. Only active nests were recorded. Nests were checked everyday during the incubation period. After hatching, nests were checked every 3 days to determine survival of the young (Archawaranon, 2003). After the young fledged, each nest characteristics and habitat surrounding the nest were measured.

Nest characteristics, including nest tree height (m), nest height (m), nest size at the bottom of the cavity (cm²), nest depth (m), cavity entrance (circumference, m), angle of nest cavity from vertical (or from the trunk, degree), angle of cavity entrance from vertical (cavity entrance orientation, degree) were recorded. Trees with active nests were considered as nest trees. Habitat characteristics were measured within a square, extending 10 m from the nest tree in the four cardinal directions. Vegetation structure was studied in each square of 20x20 m centered on the nest trees. The vegetation structure analyzed in this square plot was called neighbour trees. Dead trees without canopy were identified as snags. Snags or live trees were classified for both nest trees and neighbour trees. The number of neighbour trees around each nest tree was counted. Distances from nest trees to the nearest neighbour trees, both from trunk to trunk and from edge of canopy to edge of neighbour canopy, were measured. In case that canopies of nest trees overlapped vertically with neighbour tree canopies which normally were shorter, the heights from neighbour tree canopies to nest tree canopies were measured. Characters of nest trees and neighbour trees were studied in the following variables: tree height (m), first branch height (m), canopy height (m), radius of canopy averaged from four directions under the trees (m), canopy area calculated from πr^2 (m²), diameter at breast height approximately 1.30 m (m), basal area calculated from $3.14 \times r^2$ (m²). A total of 76 nest trees and 310 neighbour trees of northern Hill Mynahs and 25 nest trees and 136 neighbour trees of southern Hill Mynahs were analyzed.

Nesting habitats of successful nests versus unsuccessful ones were examined and compared by Student's t-test. Predation was assumed when the eggs or nestlings disappeared. The study of breeding biology of Hill Mynahs in Thailand from 1991 to 1999 found that no nest was abandoned during the nestling period whereas only 3% was abandoned during the incubation period (Archawaranon, 2003). Therefore, unsuccessful nests in this study implied that eggs lost before hatching and nestlings lost before fledgling were due to predation, stealing and unknown causes.

Results

The northern birds nested in a variety of forest types such as dry or hill evergreen or pine or mixed deciduous forest, whilst the southern birds nested in rain forest. However, there was no significant difference in the height of trees chosen for nesting, *Lagerotromia* sp., *Pinus* sp., *Parkia* sp. or *Shorea* sp. between the two subspecies. Both of them preferred live trees to snags meanwhile neighbour trees such as *Barringtonia* sp., *Lithocarpus* sp., *Artocarpus* sp., *Parashorea* sp., *Dyera* sp. or *Caryota* sp. around nest trees of the two subspecies were all live trees (100%) (Table 1). Nest trees with neighbour trees (n = 66) surrounded were mostly live trees (72% in the northern birds and 80% in the southern birds). Nest trees which had no neighbour trees (n = 35) surrounded in the northern group were mainly live trees (63.33%) whereas those in their southern counterparts were all snags (100%) (Table 1).

Most characteristics of nests and nest sites of two subspecies were not significantly different, except nest size at the cavity bottom of the southern birds which was significantly larger ($t = -9.26$, $df = 99$, $p < 0.001$). Nest heights were almost the same but the southern birds nested in cavities with larger entrances and shallower depth on average than those of their northern counterparts (Table 2). Angle of nest cavity from vertical was not significantly different but cavity entrance of the southern birds from vertical (74.32°) was slightly more than that of the northern birds (70.91°). The number of neighbour trees in the northern birds was mostly in the range 1-5 (59%) but in the southern birds mostly in the range 6-10 (60%). Distance from trunk of nest trees to trunk of the nearest neighbour trees in the northern birds was mostly (63%) about 1-4.9 m but in the southern birds was mostly (55%) about 5-10 m. Distance from edge of nest tree canopies to edge of the nearest neighbour tree canopies in both subspecies was mostly about 0.1-2.5 m. Height from neighbour tree canopy to nest tree canopy in the southern birds was found higher than in the northern birds. However, the nest trees were significantly higher than neighbour trees and had bigger trunks and canopies (Table 3).

There was non significant difference of nest characteristics (nest height, nest size, nest depth, cavity entrance, angle of nest cavity and cavity entrance from vertical) between successful and unsuccessful nests (Table 4). However, successful nests were all in live trees whereas unsuccessful nests were in both live trees (62.22%) and snags (37.78%). Successful nests were significantly different from unsuccessful nests in terms of higher first branch ($t = 2.26$, $df = 65$, $p < 0.05$), more canopy

Table 1: Frequency (%) of Nest Tree (NT) condition types in relation to Neighbour Trees (NBT)

	Tree condition (%)								
	NT with NBT			NT with NBT			NT with NBT		
	n	Live	Snag	n	Live	Snag	n	Live	Snag
<i>G. r. intermedia</i>	46	71.73	28.27	30	63.33	36.67	310	100	0
<i>G. r. religiosa</i>	20	80.00	20.00	5	0	100.00	136	100	0

Table 2: Nest site characteristics (mean±SD) of Hill Mynahs (NT = Nest Tree, NBT = Neighbour Tree)

Variable	<i>G. r. intermedia</i> (n = 76)	<i>G. r. religiosa</i> (n = 25)	p-value
Nest height (m)	23.21±7.75	23.32±6.94	NS
Nest size (cm ²)	284.71±12.24	299.14±6.03	<0.001
Nest depth (m)	0.48±0.27	0.42±0.28	NS
Cavity entrance (m)	0.52±0.04	0.56±0.07	NS
Angle of nest cavity from vertical (degree)	49.80±14.03	48.72±15.08	NS
Angle of cavity entrance from vertical (degree)	70.91±13.39	74.32±6.64	NS
Number of NBT around NT	3.43±4.92	5.48±7.30	NS
Distance from NT to the nearest NBT (m)			
- trunk to trunk (base)	2.50±2.70	4.32±3.47	<0.05
- edge to edge (canopy)	0.55±1.17	0.80±1.41	NS
Height from NBT canopy to NT canopy (m)	2.03±4.74	3.88±6.62	NS

Table 3: Characteristics (mean±SD) of Nest Trees (NT) and Neighbour Trees (NBT) of two subspecies of Hill Mynahs

Variable	<i>G. r. intermedia</i>				<i>G. r. religiosa</i>			
	n	NT	n	NBT	n	NT	n	NBT
Tree height (m)	76	26.61±8.99	310	13.49±7.81	25	26.46±8.93	136	13.16±6.80
First branch height (m)	52	17.98±8.08	310	7.86±6.26	16	22.06±7.03	136	8.33±5.83
Canopy height (m)	52	9.19±7.53	310	5.63±4.08	16	7.66±4.83	136	4.85±3.76
Radius of canopy (m)	52	4.83±1.49	310	2.57±1.27	16	3.99±1.12	136	1.95±1.02
Canopy area (m ²)	52	80.12±50.28	310	25.78±26.07	16	53.81±29.91	136	15.17±20.97
Diameter at breast height (m)	76	0.86±0.35	310	0.28±0.23	25	0.86±0.63	136	0.25±0.25
Basal area (m ²)	76	0.68±0.55	310	0.10±0.19	25	0.71±1.25	136	0.10±0.30

Table 4: Comparison of nesting habitats (mean±SD) between successful and unsuccessful Hill Mynah nests

Variable	Successful (n = 11)	Unsuccessful (n = 90)	p-value
Nest height (m)	23.26±11.05	23.06±6.43	NS
Nest size (cm ²)	287.72±18.31	288.13±7.05	NS
Nest depth (m)	0.47±0.23	0.43±0.26	NS
Cavity entrance (m)	0.53±0.02	0.55±0.05	NS
Angle of nest cavity from vertical (degree)	48.70±11.12	49.71±14.14	NS
Angle of cavity entrance from vertical (degree)	73.82±12.36	72.21±7.53	NS
Nest tree condition (%)			
- Live	100	62.22	-
- Snag	0	37.78	-
Nest tree height (m)	30.05±9.43	26.14±8.83	NS
First branch height (m)	20.27±6.81	12.48±11.14	<0.05
Canopy height (m)	9.78±7.05	6.37±8.04	NS
Radius of canopy (m)	4.45±1.36	2.92±2.57	<0.05
Canopy area (m ²)	67.46±41.69	47.61±53.10	NS
Diameter at breast height (m)	1.04±0.72	0.83±0.38	NS
Basal area (m ²)	1.23±1.72	0.62±0.55	NS
Number of cavity/tree	1.09±0.30	1.11±0.32	NS
Number of NBT around NT	7.73±3.00	3.48±5.71	<0.05
Distance from NT to the nearest NBT (m)			
- trunk to trunk (base)	4.36±2.11	2.78±3.05	<0.05
- edge to edge (canopy)	1.27±1.00	0.53±1.24	<0.05
Height from NBT canopy to NT canopy (m)	7.95±6.67	1.82±4.72	<0.05

radius ($t = 1.96$, $df = 65$, $p < 0.05$), more number of neighbour trees ($t = 2.42$, $df = 99$, $p < 0.05$), longer distance from the nearest neighbour trees (trunk to trunk, $t = 1.97$, $df = 99$, $p = 0.05$, edge to edge, $t = 1.95$, $df = 65$, $p < 0.05$) and higher from neighbour trees canopies ($t = 3.88$, $df = 65$, $p < 0.05$).

Discussion

Hill Mynahs nest in the cavities (Archawaranon, 1994) which are believed that provide a relatively stable and protected environment together with protection from predators (Collias, 1997; Gill, 1990; Martin and Li, 1992). Although snags are an important source of nest sites for cavity-nesting birds (Newton, 1998), Hill Mynahs preferred to nest in live trees with wide, thick and high crown covers and surrounded with live neighbour trees which were at least less conspicuous to predators than in snags. Besides, nest trees were located among shorter neighbour trees which had smaller canopies than those of nest trees. Meanwhile, trees with cavities but were surrounded with taller neighbour trees which had bigger canopies were not selected for nesting.

There were some arguments about the role of dense foliage around cavity nests. Some reported that greater foliage cover around cavity nests might increase nest predation because parent birds ability to detect or deflect or attack approaching predators might be reduced (Nilsson, 1984; Belles-Isles and Picman, 1986; Finch, 1989). Conversely, dense foliage near nests may reduce predation by concealing the nest (Martin and Roper, 1988; Knopf and Sedwick, 1992; Riley *et al.*, 1992; Martin, 1993). as seen in the success of open-nesting species with more concealed nests (Martin, 1992). Successful Hill Mynah nests in this study characterized wider and thicker canopies with more number of neighbour trees than those of unsuccessful nests. In addition, there was a study in Hill Mynah supported the nest site concealment selection, the southern birds nested in inaccessible habitat fledged more young than the northern ones (Archawaranon, 2003).

Other nest site characteristics revealed that there was only one hole nest per tree in order to avoid having more than one nest in the same tree. Furthermore, nest trees were not food trees at all in order to avoid any disturbance from other bird species. It showed that angle of cavity entrance avoided a direct exposure to sun or rain especially in the southern Hill Mynahs (75°) which inhabited in the rain forest.

In summary, the perspective of Hill Mynah nest trees were taller, bigger and had thicker canopies than neighbour trees. They placed nests higher and farther from the tree boles in dense canopies, using only live trees in area with foliage cover. Nest trees were solitary, without any branch connected to neighbour trees. Habitats of successful nests were different from unsuccessful ones in the term of higher first branches, bigger canopies, more surrounding trees and farther from neighbour trees.

The major cause of nesting failure in this species is human interference. This study showed that there was only 11% successful nests whereas 89% was depredated and among this number, 54% was stolen by humans (Archawaranon, 2003). Moreover, the investigation of the detrimental effect of human interference on breeding success of Hill Mynahs in 1999 by completely guarded 22 nests 24 h d^{-1} , using two workers p 12 h, found that fledgling success increased from 12% (unguarded nests during 1991 to 1998) to 75% of eggs hatched (Archawaranon, 2003). Therefore, it might be possible that these nest site characters were evolved in favour of avoiding from the natural predators and unfavourable climates but not from humans.

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