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The impact of human interference on Hill Mynahs *Gracula religiosa* breeding in Thailand

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Summary

The breeding biology of Hill Mynah *Gracula religiosa* was studied in eight provinces of Thailand from 1991 to 1998 to evaluate how breeding behaviour has evolved to enhance reproductive success in the face of human interference. The northern race *G. r. intermedia* bred mostly during February to April whereas the southern race *G. r. religiosa* bred mostly later during April to June. Both races were cavity-nesting, non-excavating, monogamous and similar in breeding activities except for differences in body size. They nested at the bottom of deep cavities with a long entrance (mean 45 cm), in tall trees. Average nest height was 23 m. Nests were sometimes abandoned (10% of nests) during nest-building or incubation. Most Hill Mynahs (70%) had clutches of three eggs. Both parents shared incubation and feeding of young. The most detrimental factor to the reproductive success of this species was human theft of the young, rather than any natural factors. During 1991 to 1998, 80% of eggs laid were hatched, but 88% of all eggs hatched were lost before fledgling. Those illegally stolen by humans amounted to 61% of eggs hatched. Only 37 of 308 nestlings or 12% of eggs hatched survived to independence. In 1999, nests were experimentally guarded to prevent human interference, and fledgling success increased to 75% of eggs hatched. The remaining 25% of nestlings were lost to predators and unknown causes, close to the 27% lost to these causes in unguarded nests during 1991 to 1998. Although the breeding pattern of this species has evolved to promote survival of young, it does not seem to have evolved adaptations to human predation. The continuing decrease of wild Hill Mynah populations has prompted attempts at captive breeding. Data on breeding biology from this study should enhance its success.

Introduction

Two of the 10 subspecies of Hill Mynah *Gracula religiosa* are found in Thailand: a northern race (''Indian Mynah'' *G. r. intermedia*) and a southern race (''Greater Hill Mynah'' *G. r. religiosa*) (Peters 1962). Hill Mynahs are sedentary, arboreal birds living in forest. They are normally seen in pairs during the breeding season, but at other times flocks of up to 50 birds roost communally and gather at feeding trees. Their diet consists of fruits, with some insects and small lizards. Because they are first-rate mimics in captivity, Hill Mynah is a favourite species for the pet market. They rarely breed in captivity, so wild populations have decreased greatly as a result of human demand.

Few studies have presented details of Hill Mynah's natural reproductive biology (Bertram 1967, 1970, 1972, Medway and Wells 1976, Rutgers and Norris

1977, Long 1981, Martin 1983, Whitefield 1986, Ali 1987, Ali and Ripley 1987). In this paper, therefore, I describe the breeding biology of Hill Mynahs in Thailand from 1991 to 1998, to investigate the impact of human interference on survival of Hill Mynah fledglings in Thailand.

Study area

The breeding biology of Hill Mynah was studied during January to July in 1991 to 1997. Surviving fledglings were censused from 1991 to 1998. The study took place in protected areas of eight provinces of Thailand (between 6° and 20° N). Generally, the breeding season is January to July, including the relatively dry period of March and April (average rainfall per month 63 mm, mean monthly temperature 29 °C, relative humidity 70%) and the wet period of May to July (average rainfall per month 218 mm, mean monthly temperature 28 °C, relative humidity 78%).

Methods

Fieldwork was conducted in mainland southern Thailand on birds of the southern race in 1991, 1993 and 1998 at Phangnga, Satun and Pattalung provinces respectively. In 1992 and 1994 to 1997, birds of the northern race were studied in Chachoengsao (east), Phetchabun (central), Ubon Ratchathani (north-east), Kanchanaburi (west) and Mae Hong Son (north) provinces.

Observations

Observations were made at sites known from previous years (pers. obs. from 1990 to 1996, Table 1), and nest trees were marked with zinc-plated tags. A mean

Table 1. Number of nests in the study of breeding biology of Hill Mynahs in Thailand (1991–1997). Arrows indicate numbers of nests reoccupied in following year.

	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
Subspecies[a]	S	N&S	S&N	N&S	N	N	N	N
Hill Mynah nests ($n = 167$)	28(S)	28(N)	31(S)	20(N)	15(N)	20(N)	25(N)	–
Reoccupied nests ($n = 152$)	–	↘ 25(S)	↘ 24(N)	↘ 29(S)	↘ 19(N)	↘ 15(N)	↘ 16(N)	↘ 24(N)
Abandoned nests during								
Nest building	–	2	2	–	3	1	–	2
Incubating	–	–	1	1	2	–	1	–
Nestling	–	–	–	–	–	–	–	–
Study nests ($n = 137$)	–	23	21	28	14	14	15	22
% Study nests of reoccupied nests	–	92	87.50	96.55	73.68	93.33	93.75	91.67
% Abandoned nests of reoccupied nests	–	8	12.50	3.45	26.32	6.67	6.25	8.33

[a] Subspecies N, Northern race *G r. intermedia*; S, Southern race *G. r. religiosa.*

of 91% of these trees were reused in following years (1991 to 1997). Nests were located primarily by listening for the species-specific calls of birds perching nearby and by searching for dead trees. Hill Mynah is a cavity-nesting bird, and nests were considered active when birds entered the nesting cavities with sticks and leaves during the nest-building period, with fresh green leaves during incubation, or with small fruits, insects, and lizards during feeding of the young.

The study nests included only those found during nest-building and laying, and excluded those found when incubation or the nestling period had already started. Nests were checked every day to record the date of egg-laying, length of incubation, and date of hatching. Nest contents, clutch size, egg size, and mass (g) of nestlings at hatching were also recorded. To minimize disturbance to the nests after hatching, they were checked every three days to determine the nestling period and survival of the young.

All nests in the study areas were accessible. A few dead trees, which had nests inside large branches, were not safe to climb, so ladders were built from bamboo to reach these nests. Information from a few nests in very deep cavities was gathered by using mirrors and lights to look into the cavities. Nest failure was identified when no activity was seen at a nest on two successive visits. Cases in which parents abandoned nests for unknown causes or eggs or nestlings disappeared for unknown reasons were also classified as nest failure. The number of surviving fledglings was the number of fledglings that left the nest with their parents and never returned. Behaviour during the day, such as nest-building, incubating, foraging, feeding, and vigilance, were observed from blinds built near the nest trees. Temperature (°C), relative humidity (%), and pressure (mmHg) inside and outside the nests were measured using field tools during nest activity.

Nest cavity characteristics

After fledglings left their nests, the following measurements were obtained for all active nests: the height of the tree in which the nest was located ('nest tree height', m), the height of the nest ('nest height', m), the size (width × length, cm) of the nest, the circumference of the cavity entrance (cm), and cavity depth (from the lower edge of the entrance to the cavity floor, cm). The angle of the cavity from a vertical line (degree) and the orientation of the cavity were recorded using a compass.

Fledgling survival

Fledgling survival was determined from observations from 1991 to 1998. For these eight years, the number of eggs laid, hatched (hatching success), unhatched, and lost before hatching were recorded for each nest. Unhatched eggs were those that remained in the nest for more than a week after the parents began feeding young. Eggs that disappeared before the first egg of each clutch hatched were recorded as lost. The number of nestlings that survived through to independence (fledgling success) was recorded, together with the number of nestlings predated, stolen by humans, and lost through unknown causes. Predated nestlings were recorded when there were tracks of predators such as snakes or lizards at the nest. Broods predated by humans could be recognized easily because people left wooden ladders or nail holes for metal ladders used for climbing to the nests. Nestlings lost to unknown causes were those that disappeared without any traces.

Additional experiments were conducted in 1999 to compare the nesting success of Hill Mynahs with and without human interference. Human interference was eliminated during February to June in Mae Hong Son and Satun provinces by hiring workers to watch nine and 13 active nests, respectively. Each nest was completely guarded 24 hrs per day, using two workers per 12 hrs.

Results

Study nests

Of 167 nests located between 1990 and 1996, 152 (91%) were reoccupied in the following year (Table 1). Observations were conducted at 137 active nests (90% of reoccupied nests) whereas 15 nests (10% of reoccupied nests) were abandoned during nest-building or incubation. Nests were deserted either during nest-building (67% of abandoned nests) or after they had laid eggs (33%). No nest was abandoned during the nestling period.

Nest cavity characteristics and nest-building

Most of the northern Hill Mynahs bred during February to April while most of the southern birds bred during April to June. The northern birds nested in a variety of forest types such as dry or hill evergreen or pine or mixed deciduous forests, whilst southern birds nested only in rain forest. However, there was no significant difference in height of trees chosen for nesting (*Lagerstroemia* sp., *Pinus* sp., *Parkia* sp. or *Shorea* sp.) between the two races and average nest heights were almost the same (Table 2). Both races used old cavities of other species of excavating bird or holes created by fallen branches or fungus. Not surprisingly, due to their body size, nest size at the cavity bottom of southern birds was significantly greater than that of northern birds ($t = -9.26$, $P < 0.001$). Southern birds nested in cavities with larger entrances and shallower depth on average than those of their northern counterparts, but the differences were not significant. Tree branches containing cavities were at an angle of *c.* 48–50° from the vertical trunks. All nest cavities opened on the side of a branch, but there was no discernible pattern in their geographical orientation (Table 2).

From February to June, the average ambient temperature in the south was slightly lower than in the north. Nevertheless, temperature inside the cavities of northern and southern birds was similar. Ambient relative humidity in the south was significantly higher than in the north ($t = -2.67$, $P = 0.008$) but there was no significant difference in relative humidity inside cavities between northern and southern nests. Relative humidity inside the cavities was higher than outside in both subspecies (northern birds, $t = 4.18$, $P < 0.001$; southern birds, $t = 2.33$, $P = 0.02$). Although Hill Mynah nests were in tall tree cavities, atmospheric pressure at ground level was not significantly different from that at nest level.

Both parents simply stacked sticks and leaves collected from the nest tree or

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Table 2. Nest cavity characteristics of Hill Mynahs in Thailand (1991–1997). Values are means ± SD.

Nest cavity variables	Northern race *G. r. intermedia* (n = 86)	Southern race *G. r. religiosa* (n = 51)	*P*
Nest tree height (m)	27.79 ± 11.37	27.59 ± 11.55	NS
Nest height (m)	23.31 ± 5.12	23.36 ± 6.65	NS
Nest size (cm^2)	283.92 ± 11.35	298.20 ± 6.69	< 0.001
Nest cavity			
Circumference of the entrance (cm)	52.25 ± 11.52	55.33 ± 8.59	NS
Depth (cm)	48.00 ± 24.94	45.07 ± 27.11	NS
Angle of cavity from vertical (degree)	49.23 ± 24.45	48.5 ± 20.77	NS
Orientation of the entrance (no. of nests)			
North	9	8	-
North-east	10	3	-
East	8	4	-
South-east	11	11	-
South	12	7	-
South-west	12	6	-
West	16	6	-
North-west	8	6	-
Temperature (°C February–June)			
Inside	29.58 ± 1.72	29.47 ± 1.96	NS
Outside	28.63 ± 1.78	28.32 ± 2.11	NS
Relative humidity (% February–June)			
Inside	72.77 ± 11.51	73.68 ± 8.44	NS
Outside	65.49 ± 8.31	70.26 ± 9.60	= 0.008
Pressure (mmHg)	997.38 ± 0.99	997.02 ± 0.91	NS

nearby trees, to form a cup-shape 4–5 cm thick at the cavity bottom. Nest-building activity lasted for 7–11 days. Both male and female flew together to gather nest materials and also returned together, but they took turns to enter the cavity. When one bird was inside working on the nest, the other perched vigilantly on a branch very close to the entrance waiting for its partner to come out and then eagerly entered the cavity.

Egg clutches and egg-laying

Clutch size ranged from one to three eggs, with a mode of three (Table 3). Average clutch size of northern and southern birds differed slightly but not signific-

Table 3. Number of Hill Mynah nests with different clutch sizes in Thailand, 1991–1997.

Clutch size	Northern race *G. r. intermedia*		Southern race *G. r. religiosa*	
	n = 86	(%)	n = 51	(%)
1	11	(12.79)	1	(1.96)
2	18	(20.93)	11	(21.57)
3	57	(66.28)	39	(76.47)

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Table 4. Data on breeding biology of Hill Mynahs in Thailand during 1991–1997.

Clutch size	Northern race *G. r. intermedia*		Southern race *G. r. religiosa*		*P*
	n	Mean ± SD	*n*	Mean ± SD	
Clutch size	86	2.53 ± 0.71	51	2.75 ± 0.48	NS
Egg size (mm)	164	24.44 ± 0.79 × 34.13 ± 1.51	92	26.93 ± 0.88 × 36.77 ± 1.23	< 0.001
Length of incubation (day)	156	15.13 ± 0.91	99	15.68 ± 0.88	NS
Mass at hatching (g)	150	10.98 ± 0.66	88	13.94 ± 0.75	< 0.001
Nestling period (day)	15	41.40 ± 3.84	19	42.58 ± 3.63	NS

antly (Table 4). Mean breadth and length of northern eggs were significantly smaller than those of southern eggs (breadth, $t = -13.54$, $P < 0.001$; length, $t = -12.44$, $P < 0.001$). Egg sizes within a clutch varied with the sequence of laying, the first egg usually larger than the third, but no significant difference was found in size of first egg between one-, two-, and three-egg clutches. There were slight differences in egg size between nests but the differences were not significant when compared with variation within the same race.

Females laid one egg per day, of turquoise blue with blotched brown colour. Sometimes, though rarely, females skipped one or two days between the second and third eggs but never longer than two days. Overall, the total egg-laying period lasted three to five days. Incubation presumably began with the first egg, as hatching asynchrony was common. They mostly had two clutches although a few had three clutches. During egg-laying, males perched watchfully on the stem closest to the entrance of the cavity. When a female came out of the nest, she hopped to perch near her mate and started preening with his assistance.

Incubation

Both parents took turns to enter the nest. Mean length of incubation ranged from 14 to 17 days, with no significant difference between subspecies (Table 4). While one parent was incubating, the other often remained vigilant near the entrance of the cavity. When one parent exited, the other entered the nest. During the night, one parent always remained in the cavity with the eggs whilst the other remained near the entrance. During the day pairs left the nest to forage and came back together. Sometimes they returned with fresh green leaves to add to the nest, possibly to adjust humidity or to avoid disease and ectoparasite infection (Collias and Collias 1984).

Hatching asynchrony never exceeded three days. On average about 79% of eggs laid were hatched, 10% were unhatched and 11% were lost (Table 5).

Nestlings

Parents removed eggshells from the nest, but unhatched eggs remained in the nest with the nestlings unless they were broken by accident and then eggshells were removed by the parents. Southern nestlings were significantly heavier than the northern ones ($t = -32.19$, $P < 0.001$) at hatching.

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Table 5. Breeding data showing status of Hill Mynah eggs and nestlings in Thailand from 149 nests: northern race (86 nests) and southern race (63 nests) during 1991–1998.

	Hill Mynahs in Thailand		Northern race *G. r. intermedia*		Southern race *G. r. religiosa*	
	n	%	*n*	%	*n*	%
Eggs laid	389	100.00	218	100.00	171	100.00
Eggs hatched	308	79.18	178	81.65	130	76.02
Eggs unhatched	38	9.77	25	11.47	13	7.60
Eggs lost before hatching	43	11.05	15	6.88	28	16.38
Nestlings	308	100.00	178	100.00	130	100.00
Nestlings lost before fledgling	271	87.99	163	91.57	108	83.03
Predated	49	15.91	27	15.17	22	16.92
Stolen by humans	188	61.04	118	66.29	70	53.85
Unknown cause	34	11.04	18	10.11	16	12.31
Nestlings fledged	37	12.01	15	8.43	22	16.92

Both male and female parents fed the nestlings. They left the nest, foraged and returned together, with small fruits, insects or lizards. Before parents fed lizards to the nestlings, they beat the lizards against a branch near the nest entrance. The frequency of food delivery varied with the age of the nestlings and the type of food. When nestlings were more than 10 days old, parents delivered food twice as often as compared with the first 10 days. Nestlings were fed by one parent at a time, most frequently in the morning and evening. During the nestling period, the nest was full of faecal sacs and food remains. Faecal sacs were removed daily or every other day by both parents. The nestling period lasted *c.* 38–45 days and did not differ between the two races. No parents deserted their nests during the nestling period.

Fledglings and survival

Of all eggs hatched, about 88% were lost before fledgling (Table 5). Of these, young illegally stolen by humans accounted for 61% of eggs hatched (188/308) or about 70% of the nestlings lost before fledgling (188/271). Only 37 nestlings survived to independence from unguarded nests (12% of eggs hatched). Loss of nestlings, other than by being taken by humans, was due to natural predators such as, amongst others, snakes, large lizards and hornbills (Bucerotidae). Young known to have been taken by predators accounted for 16% of eggs hatched; another 11% of eggs hatched were lost to unknown causes, which might have included predators that left no evidence.

In 1999, when human interference was prevented in Mae Hong Son and Satun provinces, fledgling success increased to 75% of eggs hatched (Figure 1), compared with 12% during 1991 to 1998. The remaining 25% of nestlings lost to predators and unknown causes in guarded nests in 1999 was close to the 27% lost to these causes in unguarded nests during 1991 to 1998.

When nests were guarded at Mae Hong Son, 81% of eggs laid subsequently hatched, and 77% of eggs hatched resulted in fledged young; at Satun 80% of eggs laid hatched, and 74% of eggs hatched resulted in fledged young.

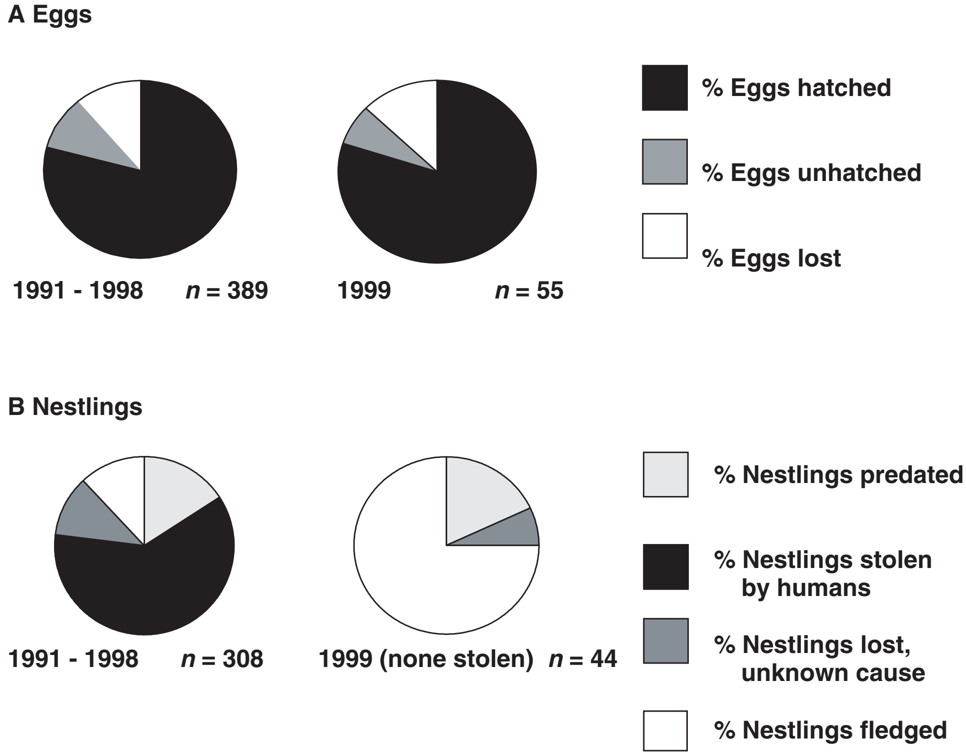

Figure 1. Comparisons of breeding data showing status of Hill Mynah eggs (A) and nestlings (B) between unguarded nests during 1991–1998 and guarded nests in 1999.

Discussion

Nest predation is the primary cause of the reproductive failure in many bird species (Lack 1954, 1968, Nilsson 1984, Martin 1988). The various defences against nest predators include concealment, false or double entrances, camouflage, multiple nests, colonial nests and inaccessible nests in cliffs, banks or tree cavities (Collias and Collias 1984). To nest in a tree cavity with a deep entrance is one of the best nest defences because it is difficult for the predators to find or to reach the nest. Half of all avian orders nest in cavities (Pandey and Mohan 1993), more frequently among the passerines than among the non-passerines (Collias 1997).

Cavity nests have been thought to provide greater protection against nest predation than open nests (Lack 1954, Nice 1957). Nesting success in North American cavity-nesting birds ranged from 22 to 100% with an average of 68%. Excavators had higher success than non-excavators (Scott and Kermott 1994). Predation may decrease in nests in higher positions because predators can reach lower nests more easily (Nilsson 1984, Li and Martin 1991). In a study of predation on nests of Pied Flycatcher *Ficedula hypoleuca* (Alatalo *et al.* 1988, 1990), the safest cavities had characteristics like those of Hill Mynah nests, which were high in tall trees with long entrances.

The ultimate advantage of nesting in cavities rather than in the open, especially

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for non-excavators, is still unclear. For instance, a study of Black-Capped Chickadees *Parus atricapillus* showed that heights of successful and depredated nests were not significantly different (Christman and Dhondt 1997). In addition, Nilsson (1986) found that fledgling success of cavity-nesting birds was about the same as open-nesting birds, as a result of competition for cavities, hyperthermia and nest parasites in cavity-nesters.

Because Hill Mynah is a secondary cavity-nester (non-excavator), they must compete to occupy old cavities abandoned by primary cavity-nesters (excavators) or the cavities resulting from rotten wood or fallen branches. Natural tree cavities are probably rare, and the possibility of obtaining a high-quality cavity is limited. The primary requirement for suitable habitat thus seemed to be the availability of cavities.

However, from this study, it appeared that Hill Mynahs enhanced their reproductive success by nesting in high cavities. These presumably experienced less predation, and to avoid nest flooding, no nest had an entrance oriented toward the sky. It also appeared that it was easier to control humidity in cavity nests than open nests. Nevertheless, survival was actually persistently low. The most detrimental factor to the reproductive success was human theft of the young, rather than any natural factors. In a study of Black-billed Magpies *Pica pica*, human disturbance affected nest height in some habitats (Dhindsa *et al.* 1989). In habitats with less human disturbance, birds nested in shorter trees. Unfortunately, Hill Mynahs do not seem to have evolved adaptations to human depredation.

The dramatic improvement in fledging success from the guarded nests in 1999 indicated that natural predators such as snakes and lizards or natural causes such as heavy rain were less important in reducing reproductive success than human interference. From 1991 to 1998, the northern birds lost more young than did the southern ones, and as a consequence more of the southern young reached independence. The habitat in the south was evergreen rainforest, with trees more densely spaced than in the north, which may have made it more difficult for humans to find the nests. Although breeding birds can produce additional broods when the nesting cycle is shortened by nest predation (Nolan 1978, Martin and Li 1992), re-nesting did not improve the reproductive success in this species. According to personal communications with Hill Mynah nest poachers, heavy human disturbance caused birds to lay up to seven clutches per season, but humans took all of their young.

Although recent data are not available, the official number of Hill Mynahs exported from Thailand from 1967 to 1971 was 200,334 birds (Martin 1973). Moreover, from various traders verbally (1998, 1999, 2000) not all nestlings taken for trade survive: more than 50% die of starvation and exhaustion while being transported. Even when they survive, they are likely to be kept in solitary cages in order to stimulate imitations of sounds for human whimsy. Nowadays, official data on exported Hill Mynahs from Thailand are not presented. It is not therefore possible to determine whether the listing of Hill Mynah as protected wildlife in Thailand in 1992, or its increased rarity, has had an impact on numbers traded.

The misuse of wildlife is a critical issue worldwide. In some countries, people are poor and not educated well enough to understand the value of those natural resources. Even though wildlife is a renewable resource, human demand is often unsustainable. Hill Mynah is very popular in the pet market in Thailand. The impact of human interference on Hill Mynah populations in forests of Thailand has raised the issue of practical wildlife protection. Although the protected status of Hill Mynahs in Thailand is sometimes not strong enough, the impact of human interference on Hill Mynah populations during the past 10 years reported here should encourage the wildlife agency to take more effective action.

Captive breeding is another alternative for increasing Hill Mynah populations for human demand and decreasing human depredation of wild populations. The findings on breeding biology from this study should provide basic information for captive management and thereby aiding the conservation of a conspicuous component of Thailand's wildlife.

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