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BREEDING BIOLOGY OF A LITTLE-KNOWN RAPTOR IN CENTRAL CHINA: THE CHINESE SPARROWHAWK (*ACCIPITER SOLOENSIS*)

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ABSTRACT.—The Chinese Sparrowhawk (*Accipiter soloensis*) is a little-known raptor distributed in southeast Asia. We here report a 5 yr study on its breeding biology at Dongzhai National Nature Reserve in Henan Province, central China. We banded 270 individuals (84 adults, 186 fledglings), recorded nest tree characteristics, and monitored nests with 24-hr digital cameras, video cameras, and ground observations from blinds. Among the 133 nests found, 91.7% were built on broad-leaved trees. Among 47 nests with known nest initiation dates, 57.4% were in mid-May. The most commonly used trees for nesting were chestnut (*Castanea mollissima*; 59.4%) and Chinese wingnut (*Pterocarya stenoptera*; 19.5%). Egg-laying occurred from 17 May to 17 June, with the largest number between 31 May and 4 June (n = 45, 28.9%). Eggs were laid throughout the day and also at night. Mean clutch size was 3.16 ± 0.75 eggs, with no significant interannual variation. Females contributed 87.4% of the total incubation effort. The incubation period was 28 ± 2 d (range 24–31 d, n = 46), and the nestlings fledged in 20.4 ± 1.6 d (range 18–25, n = 27). Overall breeding success was 58.7%, with no significant interannual variation. The daily nest survival rate was 0.993 ± 0.002 during incubation period, and 0.981 ± 0.003 during nestling period. Predation of eggs and nestlings by snakes and Eurasian Jays (*Garrulus glandarius*) was the main cause of nest failure.

KEY WORDS: *Chinese Sparrowhawk*; Accipiter soloensis; *breeding biology*; *China*; *clutch size*; *nesting success*.

BIOLOGÍA REPRODUCTIVA DE UN AVE RAPAZ POCO CONOCIDA EN CHINA CENTRAL: *ACCIPITER SOLOENSIS*

RESUMEN.—*Accipiter soloensis* es un ave rapaz poco conocida que se distribuye en el sureste de Asia. Presentamos resultados de un estudio de cinco años de la biología reproductiva de esta especie en la Reserva Natural Nacional Dongzhai en la provincia de Henan, centro de China. Anillamos 270 individuos (84 adultos, 186 volantones), registramos las características de los árboles nido y monitoreamos los nidos durante las 24 horas con cámaras digitales, cámaras de video y observaciones de campo desde escondites camuflados. De los 133 nidos encontrados, el 91.7% fue construido en árboles latifolios. De los 47 nidos con fechas de inicio conocida, el 57.4% tuvo lugar a mediados de mayo. Los árboles más utilizados para anidar fueron *Castanea mollissima* (59.4%) y *Pterocarya stenoptera* (19.5%). La puesta de huevos ocurrió desde el 17 de mayo hasta el 17 de junio, con mayor intensidad entre el 31 de mayo y el 4 de junio (n = 45, 28.9%). Los huevos fueron puestos a lo largo del día y también durante la noche. El tamaño medio de la nidada fue de 3.16 ± 0.75 huevos, sin variación interanual significativa. Las hembras contribuyeron al 87.4% del esfuerzo total de incubación. El período de incubación fue de 28 ± 2 días (rango 24–31 días, n = 46), y los polluelos volaron del nido a los 20.4 ± 1.6 días de edad (rango 18–25, n = 27). El éxito reproductivo general fue de 58.7%, sin variación interanual significativa. La tasa diaria de supervivencia del nido fue de 0.993 ± 0.002 durante el periodo de incubación y de 0.981 ± 0.003 durante el periodo de pollo. La depredación de huevos y pollos por parte de serpientes y de *Garrulus glandarius* fue la causa principal de fracaso del nido.

[Traducción del equipo editorial]

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Breeding biology is a fundamental aspect of avian biology. A detailed description of breeding patterns provides the foundation for interspecific comparisons and facilitates the generation of new hypotheses as well as the testing of older ones that are important for understanding the evolution of avian reproductive strategies (Auer et al. 2007). Demographic models are usually highly sensitive to variations in breeding parameters (Grier 1980, Nichols et al. 1980, Hiraldo et al. 1996, Real and Mañosa 1997), and demographic characteristics are important for management and conservation strategies (Shultz 2002, Sano 2003, Margalida et al. 2003, 2007).

Although reproductive details are known for a large number of raptors (Schnell 1958, Moss 1979, Delannoy and Cruz 1988, Malan and Shultz 2002, Millon et al. 2002, Mougeot and Bretagnolle 2006), the breeding biology of some species remains little known, especially for raptors distributed solely in Asia. The Chinese Sparrowhawk (*Accipiter soloensis*) is one of the least studied species among Asian raptors (Ferguson-Lees and Christie 2001, Robson 2005, Strange 2014).

The Chinese Sparrowhawk is a migratory species that breeds in central and eastern China and Korea (Xu 1995, Ferguson-Lees and Christie 2001, Gao 2002, Zheng 2011), winters in Indonesia and the Philippines, and passes through the remainder of southeast Asia on migration (Decandido et al. 2004, 2007, Cheng et al. 2006, Lorsunyaluck et al. 2008, Germi et al. 2009, 2013, Sun et al. 2010). The Chinese Sparrowhawk is common in its range (Thiollay 1994, Zhao 2001), but information on its breeding biology is sparse, based on data collected 40 yr ago in South Korea on eight nests (Kwon and Won 1975) and on one nest (Park et al. 1975). More information is needed for a better understanding of the breeding biology of this species, especially given the major environmental changes in eastern Asia in the past 30 yr as a result of economic development and regional habitat alterations. Here, we describe the breeding biology of the Chinese Sparrowhawk in central China.

STUDY AREA

We conducted the study at Dongzhai National Nature Reserve of Henan Province in central China (31°28′–32°09′N, 114°18′–114°30′E; Fig. 1). The reserve is located on the northern slopes of the Dabie Mountains in the transitional region between subtropical and temperate zones (Song and Qu 1996, Liu et al. 2008). The altitude of the reserve ranges from 100 to 828 masl, and the climate is warm and humid with a mean annual temperature of 15°C (range −18–40°C) and a mean annual precipitation of 1209 mm (Xu et al. 2007, 2010). The habitat contains mostly mature broadleaf forests with some mature or young plantations of Chinese fir (*Cunninghamia lanceolata*), Masson pine (*Pinus massoniana*), and small patches of tea (*Camellia sinensis*) and farms. Broad-leaved trees include oaks (*Quercus* spp.), chestnut (*Castanea mollissima*), Chinese wingnut (*Pterocarya stenoptera*), dyetree (*Platycarya strobilacea*), beautiful sweetgum (*Liquidambar formosana*) and Hupeh rosewood (*Dalbergia hupeana*). The subcanopy is dominated by young Oriental oak (*Q. variabilis*), sawtooth oak (*Q. acutissima*), glaucous allspice (*Lindera glauca*), and bamboo (*Pleioblastus* spp.).

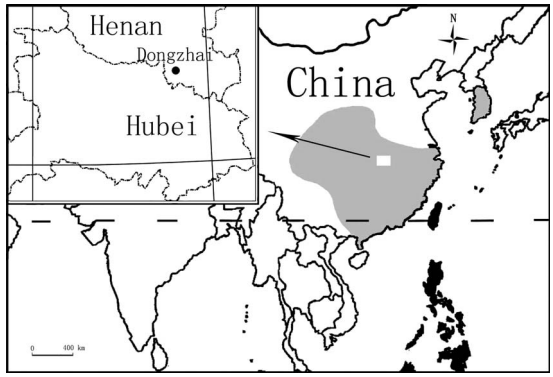

Figure 1. The study site and the distribution of the Chinese Sparrowhawk. Grey shading indicates breeding range; dark shading indicates the wintering range. The white square indicates the study area.

METHODS

From 2008 to 2012, we conducted fieldwork during the breeding season (May to August), with additional observations during migration before and after the breeding season. We located the hawks' nests by following males that were carrying prey or watching where the females landed after food exchanges (Deng et al. 2004, Andersen 2007). We determined the sex of the breeding pairs in the field based on their body size (males are smaller than females), eye color (adult females' are yellow, whereas males' are dark brown), vocalization (male calls are higher-pitched than female calls), and plumage (female slightly browner above with somewhat more apparent barring on breast and flanks; MacKinnon and Phillipps 2000, Ferguson-Lees and Christie 2006). When

we found a nest, we marked its location with a GPS (GPSmap60CSx, Garmin, Olathe, KS U.S.A.), and recorded the nest tree species and nesting habitat. For each nest tree, we measured height and the diameter at breast height using a diameter tape (P09, Panyi Garden, Qingdao, Shandong, China) and measuring rope (50 m, Wanxiang, Nanjing, Jiangsu, China).

For accessible nests, we climbed to each and measured nest height aboveground, nest width, nest length, the height of the nest structure, and the width, length, and depth of the nest cup during nest checking. We climbed to these nests every 5–7 d, noted the reproductive stage (nest-building, egg-laying, incubation, or nestling stage), and recorded the number of eggs or nestlings. We counted fledglings from the ground. To determine nestling growth and development, we measured the wing, tail, culmen, and tarsus length of nestlings in some nests every 2 d, and the body temperature of these nestlings with electronic thermometer (54-II, Fluke, Everett, WA U.S.A.). We minimized the time spent at each nest during visit, and tried to avoid disturbing the vegetation around the nests during the fieldwork to minimize potentially increased risk of nest predation.

We observed the activities and breeding behaviors of Chinese Sparrowhawks around the nests from above-canopy lookouts and ground blinds using spotting scopes (20–60×) and binoculars (8×). We monitored 20 nests with digital video cameras (SSC-ET185P, Sony, Tokyo Metropolitan, Japan) that sent video and audio signals to recorders in the blinds nearby and stored the information on hard disks in AVI format; we also installed 40 infrared-triggered digital cameras (Ltl-5210, Ltl Acorn, Shenzhen, Guangdong, China) at the Dongzhai National Nature Reserve to monitor events at the nests 24 hr per d. All the digital cameras were mounted on branches, focused on the center of the nests, camouflaged by twigs with leaves, and programmed to take one picture every minute. We changed memory cards and batteries when we visited the nests.

We captured adult Chinese Sparrowhawks with mist nets near the nests during the nestling-rearing stage. We banded each adult caught and measured its wing, tail, tarsus, and culmen, as well as body temperature. We banded nestlings a few days before fledging. We used radio transmitters (BD-2 and PD-2, Holohil, Carp, Ontario, Canada) and receivers (TRX-1000WR, Wildlife Materials, Murphysboro, IL U.S.A.) to detect the presence of 10 fledglings.

We obtained the egg-laying dates from pictures taken by digital cameras. We defined a breeding attempt as a nest with eggs. Breeding success was calculated on the basis of the number of nests with eggs in which at least one young fledged (apparent breeding success, Antonov et al. 2007). We used the MARK program version 7.1 (White and Burnham 1999) to estimate the daily survival rate (DSR) for nests, assuming a constant daily survival rate (Dinsmore et al. 2002). We determined predators mainly from photographs taken by the digital cameras. For nests not monitored by cameras, we followed Li et al. (2012) in assuming predation by snakes if eggs or nestlings disappeared before likely hatching or fledging dates and the nests were intact, containing no eggshell fragments or body remains. For nests that were damaged, or containing eggshell fragments or body remains, we assumed avian or mammalian predation. We analyzed data using SPSS 17.0 (SPSS, Chicago, IL U.S.A.). The means are presented with their standard deviations (SD). All the tests were two-tailed with significance level set at $P < 0.05$.

RESULTS

Body Size. During this study, we banded 36 adult males, 48 adult females, and 186 nestlings, and obtained body measurements from 25 adult males and 34 adult females. Females had longer wing, tail, and culmen than males, but the two sexes did not differ in tarsal length (Table 1).

Migration and Territorial Behavior. The earliest date a Chinese Sparrowhawk arrived at the study site was 30 April, and the latest was the end of May. They departed on southward migration from Dongzhai in late September, with the latest departure on 28 September 2009.

Chinese Sparrowhawks started to establish territories soon after arrival. The typical territorial displays included both short periods of flying and soaring. The former occurred in the early morning when the breeding pairs flew from tree to tree in their territories and called loudly. Soaring occurred both in the morning and late afternoon. During displays, a pair of birds soared together over their territory for several minutes, then suddenly dove down to perch on trees. The males appeared to be strongly territorial; when a third bird entered into an established territory, the territorial male flew straight at it to drive it out. This type of territorial defense occurred throughout the breeding season. We did not try to delineate territory boundaries, but in a 3.04 km^2 area carefully monitored all 5 yr, the

Table 1. Body measurements of adult Chinese Sparrowhawks.

MEASUREMENT	MALE (N=25)	FEMALE (N=34)	t	P
Wing (mm)	185.08 ± 4.08	195.89 ± 4.63	6.352	0.000
Tail (mm)	128.87 ± 6.44	138.53 ± 6.91	9.310	0.000
Culmen (mm)	12.00 ± 0.52	12.99 ± 0.58	5.485	0.000
Tarsus (mm)	43.54 ± 1.35	43.12 ± 7.27	−0.287	0.775

number of nests varied between 4 and 9, averaging 1.32 to 2.96 nests/km^2. The mean nearest neighbor distance ranged from 329 ± 199 m (n = 7; 2008) to 510.0 ± 214.1 m (n = 4; 2010), without significant variation among years (ANOVA, $F_{4,28}$ = 1.104, P = 0.374).

Nests and Nest-building. Most Chinese Sparrowhawk pairs at Dongzhai National Nature Reserve bred in deciduous forests, and built their nests on large broad-leaved trees (91.7%, total n = 133 nests), with only 8.3% on coniferous trees. The species most commonly used included chestnut and Chinese wingnut (Table 2). The mean nest-tree height was 14.2 ± 4.1 m, and the mean diameter at breast height was 40.3 ± 11.6 cm (n = 88).

Nest-building started from early May to early June, with the earliest initiated on 5 May (2012) and 57.4% initiated in mid-May. A nest typically took approximately 2 wk to complete (n = 47). Nest construction started at 0500 H and peaked at 0600–1000 H, and we observed no nesting material carried to the nest after 1400 H (Fig. 2). Based on 54 nests we measured, the mean inner dimensions of nests were 14.8 ± 1.8 × 16.5 ± 2.0 cm, the outer dimensions 36.0 ± 6.9 × 44.1 ± 7.4 cm, the average nest depth 5.6 ± 1.1 cm, and nest height was 18.8 ± 6.9 cm. In 5 yr only one nest at Badouyan (31°57.14′N; 114°14.62′E) was reused. Most old nests were badly damaged or had collapsed during the winter. We found one marked male breeder returned to his previous territory the second year, building a new nest 30 m away from his old nest.

Eggs and Egg-laying. We used digital cameras to monitor 115 nests (17 nests in 2009, 30 in 2010, 39 in 2011, and 29 in 2012), 45 of which we monitored starting before egg-laying. Most (95.6%) of the females started laying eggs before 10 June (range: 17 May to 17 June, n = 45), and laid an egg every other day, but the time of day for laying varied both among and within individuals. Egg-laying occurred throughout the day and even at night, with a peak at noon (n = 66; Fig. 3). Based on eight nests with known laying time for more than one egg in the clutch, the mean interval between eggs was 49.4 ± 2.0 hr (n = 8).

Table 2. Nest trees of Chinese Sparrowhawk at Dongzhai National Nature Reserve in central China.

SPECIES	NUMBER OF TREES	%
Chestnut (*Castanea mollissima*)	79	59.4
Chinese wingnut (*Pterocarya stenoptera*)	26	19.5
Masson pine (*Pinus massoniana*)	9	6.8
Sawtooth oak (*Quercus acutissima*)	7	5.3
Italian poplar (*Populus euramevicana*)	4	3.0
Beautiful sweetgum (*Liquidambar formosana*)	4	3.0
Water fir (*Metasequoia glyptostroboides*)	2	1.5
Oriental oak (*Q. variabilis*)	1	0.8
Pear (*Pyrus* spp.)	1	0.8

Average clutch size was 3.16 ± 0.75 eggs, with three eggs the mode (range: 1–4 eggs, n = 129 nests). The interannual variation of clutch size was not significant (ANOVA $F_{4,124}$ = 1.077, P = 0.371). Egg

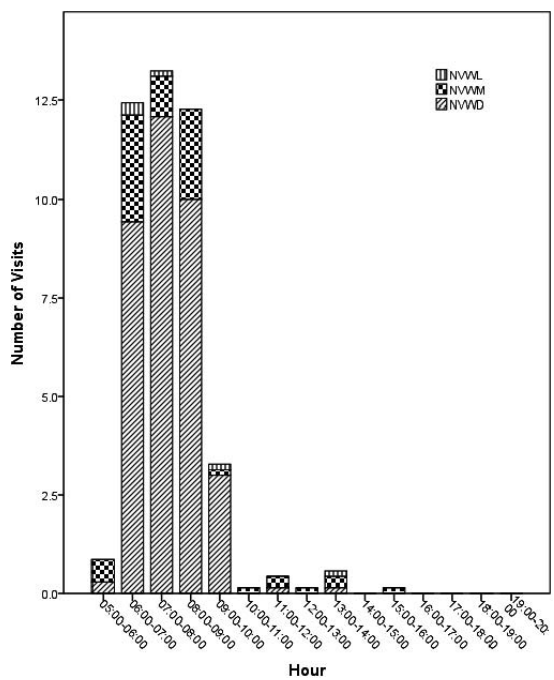

Figure 2. The daily nest-building activities of Chinese Sparrowhawks at Dongzhai National Nature Reserve. "NVWL" indicates "nest visit with living branch," "NVWM" indicates "nest visit without material," and "NVWD" indicates "nest visit with dry branch."

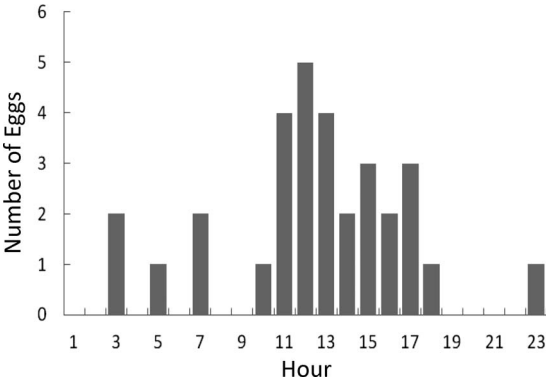

Figure 3. Egg-laying times for Chinese Sparrowhawks at Dongzhai National Nature Reserve in central China (2008–2012, n = 66).

length averaged 36.0 ± 1.4 mm (range: 32.7–39.7 mm), egg width was 29.6 ± 0.9 mm (range: 27.3–31.5 mm), and egg weight was 15.9 ± 1.6 g (range: 12.1–20.0 g; n = 182 eggs from 57 nests).

Incubation and Nestling-rearing. Based on 12 nests with close observation from the laying of the first egg, 66.6% of the females started incubation after the first egg was laid and 33.3% after the second egg. Hatching was asynchronous. Based on 22 nests with known laying and hatching dates for every egg, the incubation period steadily decreased from the first egg to the fourth egg (first, 29.5 ± 1.07 d, n = 19; second, 27.9 ± 1.38 d, n = 12; third, 26.5 ± 1.37 d, n = 12; fourth, 25.3 ± 0.58 d, n = 3), with the mean length of 28 ± 2 d (n = 46). Thus, for a 3- or 4-egg clutch, egg-laying spanned 5–7 d, but the hatching took only 1–3 d. Females discarded the eggshells after the nestlings hatched, but one female actually threw out a hatchling that was still within the eggshell (Fig. 4). Most clutches (92.2%, n = 51) hatched from late June to early July.

We monitored the incubation behavior of 20 pairs for a total of 657.9 hr on 51 d (in 2010 and 2011). Although both sexes incubated, only females incubated at night (2000 H to 0500 H the next day). Based on the incubation time-budget of one randomly selected day each from eight nests, females incubated 627 ± 114 min during the day, while the males incubated only 168 ± 75 min.

We videotaped nest attendance and prey delivery at five nests for a total of 501 hr over 40 d (2009–2010) during the nestling-rearing period. Our video recordings and radiotelemetry results showed that female Chinese Sparrowhawks typically attended the nest during nestling-rearing period, making

Figure 4. Female Chinese Sparrowhawk threw out a hatchling that was still within the eggshell, Dongzhai National Nature Reserve.

only short trips away from the nest. Based on video records of identifiable prey items, lizards constituted 70.9% of the nestlings' diet, invertebrates 23.0%, birds 3.1%, amphibians 2.0%, and small mammals 1.0% (n = 196 items identified).

According to the measurements of six nestlings in three nests, the growth of the nestlings' tarsi, wing length, body length, and body mass followed a logistic pattern. These nestlings obtained a steady body temperature at 11 d old (42.5 ± 0.7°C, range 40.8–44.2°C, n = 42), a temperature similar to that of adults (Fig. 5). Chinese Sparrowhawk nestlings fledged in 20.4 ± 1.6 d (range 18–25 d, n = 27). The fledging period at our study site lasted from early July to early August (Fig. 6). The young began dispersing 17–18 d after fledging (n = 10).

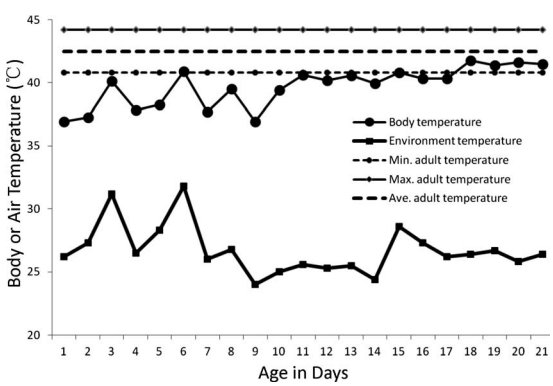

Figure 5. At the age of 11 d, nestlings (n = 6) reached a steady body temperature, similar to that of adults (n = 42).

Adult females left their territories approximately 12 d after the young fledged (n = 5). Adult males remained in the home range for a longer time, sometimes until the beginning of the autumn migration. However, failed breeders (n = 3) usually abandoned their territories next day and moved beyond radio-telemetry range.

Breeding Success. We used the 108 breeding attempts with known fate during incubation in nest survival analysis. Given that only 15 of these attempts failed during incubation, and the other nests hatched at least one young, the apparent nest survival of Chinese Sparrowhawk at Dongzhai National Natural Reserve was 86.1%. The daily nest survival rate during incubation period was 0.993 ± 0.002 (95% confidence interval), and the estimated nest success was 82.1% for a 30-d incubation period. On average, each nest that survived to the nestling stage hatched 2.87 ± 0.9 young (n = 93), and fledged 2.03 ± 1.35 young (n = 93).

Among the 129 breeding attempts monitored in this study, 104 nests hatched at least one young. Among these, 72 nests fledged at least one young and the other 32 nests fledged none. Apparent nest survival at the nestling stage was 69.2%. Daily nest survival during the nestling stage was 0.981 ± 0.003 (95% confidence interval) and the estimated nest success was 68.4% for the 20-d nestling phase.

Among the 133 nests we monitored in 5 yr, 55 nests failed. The interannual difference in the proportion of nests that failed was not significant (t = 0.056, P = 0.958). Predation was the most important cause of nest failure (81.8%). The interannual difference in the proportion of failed nests due to predation also did not differ significantly (2008, 83.3%, n = 6; 2009, 77.8%, n = 9; 2010, 90.0%, n = 10; 2011, 82.4%, n = 17; 2012, 76.9%, n = 13; t = 0.109, P = 0.918). Other factors leading to nest failure included nest abandonment (5.5%), accidental breakage of eggs by strong wind (1.8%), and unknown causes (10.9%). Among the nests lost to predation, 28.9% occurred during egg stage, 11.1% when there were both eggs and nestlings, and 60% during nestling stage. Predators included snakes (88.9%, n = 45), Eurasian Jays (*Garrulus glandarius*; 6.7%, n = 45) and raptors (Black Kite [*Milvus migrans*]; 4.4%, n = 45). The snakes we found in nests were Taiwan stink snake (*Elaphe carinata*), Big-eye snake (*Zaocys dhumnades*) and Taiwan beauty snake (*Elaphe taeniura*). We encountered snakes climbing nest trees twice during our fieldwork. Our digital cameras recorded snakes eating the eggs or nestlings of Chinese Sparrowhawks 20 times.

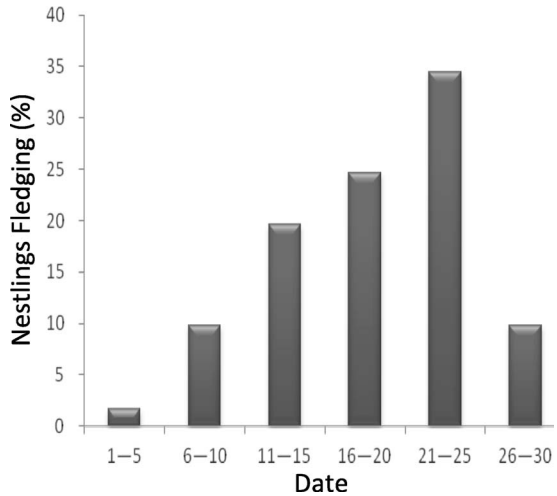

Figure 6. Fledging dates (n = 61) of Chinese Sparrowhawks during 2008–2012 (1 = 1 July, etc.) at Dongzhai National Nature Reserve.

DISCUSSION

We found Chinese Sparrowhawks breeding primarily in broad-leaved forests, whereas coniferous forests or coniferous and broad-leaved mixed forests were seldom used. Many raptors tend to breed in open canopy for easier access to the nests (e.g., Common Buzzard [*Buteo buteo*], Cerasoli and Penteriani 1996; Crowned Eagle [*Stephanoaetus coronatus*], Malan and Shultz 2002; Lesser Spotted Eagle [*Aquila pomarina*], Mirski 2009). Thorstrom and Quixchán (2000) in their study of Bicolored Hawk (*Accipiter bicolor*) suggested that a dense forest habitat may limit the hunting behavior of raptors. Other researchers also consider that open habitat is more accessible for hunting by raptors than dense coniferous forests (Accipiter hawks [*Accipiter* spp.], Moore and Henny 1983; Black Sparrowhawk [*Accipiter melanoleucus*], Malan and Robinson 2001). Open areas with bushes and grasslands in or around deciduous forests are high quality habitats for lizards (Ji et al. 1989, Lin et al. 2011), which are the main prey of Chinese Sparrowhawks at our study site.

In the area where we determined nearest neighbor distance among all the nests, the average nearest-nest distance ranged from 329–510 m. We did not measure prey abundance in the study site. However, breeder density should be a good indicator of

area quality and resource abundance (Newton 1979). Given that the overall fledging success of our study population did not differ among years, the variation in the number of nests most likely reflected variation of prey abundance among years. Northern Goshawks exhibited a similar pattern during food shortage, when population declined but brood size of successful pairs remained unaffected (Rutz and Bijlsma 2006).

The clutch size of Chinese Sparrowhawk in our study population was noticeably smaller than that recorded in Korea (3.16 ± 0.75 eggs at Dongzhai vs. 4.13 ± 0.99 eggs in Korea, Kwon and Won 1975). This difference could be an artifact of the very small sample size of the Korean study, but the difference was in alignment with the trend for increasing clutch size with increasing latitude (e.g., Payne 1976, Bahus 1993, Dunn et al. 2000, Boyer et al. 2010, Rose and Lyon 2013). Dunn et al. (2000) found that clutch size of Tree Swallows (*Tachycineta bicolor*) was related positively to latitude and relative resource abundance. We have no information on the relative resources availability at Dongzhai or the Korean site, but given that the Korean site is 5° 36′ higher in latitude than Dongzhai, with 33 min more daylight than at Dongzhai during the breeding season, it is possible that more food was available there than at Dongzhai. This was indirectly corroborated by the fact that the average egg size in Korea was somewhat larger than that at Dongzhai (in Korea 36.9 × 29.6 mm, Kwon and Won 1975; at Dongzhai 36.02 × 29.55 mm).

We found that the time of egg-laying in Chinese Sparrowhawk was highly varied both among and within individuals. Although it is known that energy deficiency can lengthen egg-laying intervals (Colwell 2006), specific time of egg-laying is seldom documented for wild birds. Time in the breeding season, energy needed to form eggs, predation pressure, and weather may all affect egg-laying intervals (Colwell 2006). Chinese Sparrowhawks at Dongzhai laid eggs within one month, thus timing is less likely a cause for irregular egg-laying. Predation was an important cause of nest failure, but we cannot eliminate food availability, or increment weather conditions as factors affecting the egg-laying time of our study population.

Accelerated egg-hatching was apparent in our study population, with each subsequent egg needing less time to hatch than the previous one, and the fourth egg 4.2 d less than the first egg. Accelerated hatching of later eggs is known for some species that hatch asynchronously. Raptor eggs often hatch asynchronously, with the last egg abandoned when conditions are bad (Thiollay 1994). Sibling competition may be strong and the later-hatched young may be fed only after the dominant one eats (Thiollay 1994). This strategy allows the weaker young to be culled and has adaptive value when food sources are low or uncertain. Accelerated hatching reduces hatching asynchrony, and thus decreases the size difference among young. This might increase fledging success when food supply is sufficient.

At Dongzhai National Nature Reserve, 70.9% of the prey fed to nestlings was lizards, whereas in Korea the most important prey for nestlings was frogs (Wolfe 1950, Won et al. 1967) or amphibians (Kwon and Won 1975, Park 1975). This difference likely reflects different prey availability in different habitats. In the Korean studies, Chinese Sparrowhawks foraged in paddy fields or in a paddy field and a marsh (Kwon and Won 1975, Park 1975), whereas the population in our study nested in forests and foraged on dry land, which contained many lizards and few amphibians.

In our study, 41.4% (total $n = 133$) of Chinese Sparrowhawk nests failed. This rate was similar to the 37.5% of the Korean study (total $n = 8$; Kwon and Won 1975), and within the 10–40% failure range typical for territorial raptors (Thiollay 1994). Nest predation caused 83.3% of nest failure at our study site, with snakes the most important predator of both eggs and nestlings, whereas in Korea the most important cause of nest failure was eggs that failed to hatch (81.8% of eggs in three nests). Only three of eight nests in Korea suffered partial predation loss. The reason for the low predation rate in Korea was unclear, but may be an artifact of the very small sample size.

We found that Chinese Sparrowhawk fledglings began their natal dispersal 17–18 d post-fledging, after spending some time near their nests in the care of their parents ($n = 10$). Juvenile Northern Goshawks (*A. gentilis*) spent an average of 46.3 ± 0.8 d in their natal territories ($n = 71$), reaching a maximum dispersal distance at 135 d post-fledging (Wiens 2004). Hawaiian Hawk (*B. solitarius*) juveniles stayed in their natal territories on average 30.2 wk ($n = 4$; Griffin et al. 1998). Griffin et al. (1998) hypothesized that Hawaiian Hawk fledglings spent such a long time in their parental territory because they prey primarily on birds, which require superior skills to capture. Northern Goshawks preyed on both birds and mammals, whereas Chinese Sparrowhawks captured mainly lizards and insects, which are easier to capture than birds.

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