Nest cycle and nestling development of a pair of Changeable Hawk-Eagles *Nisaetus cirrhatus* in Gunung Halimun-Salak National Park, West Java

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Summary. We monitored nesting of a pair of Changeable Hawk-Eagles *Nisaetus cirrhatus* at Gunung Halimun–Salak National Park, West Java, in two consecutive years (2012 and 2013). The single egg was laid in July in the first year, and June in the second. This is consistent with data from the early 20th Century which suggests these are the peak laying months for Java. Contrary to the literature, both sexes took part in incubation, though the female incubated more frequently. The incubation and nestling periods were estimated to be c.50 days and 62 days, respectively, but as neither laying nor hatching was observed directly, it is possible that the first period is over-estimated, and the second, under-estimated. The combined period (112 days) is consistent with the minimum estimate of 108 days in the literature. The body length (including tail) of the 2013 eaglet grew at an average rate of c. 6 cm per week. Of 21 identified prey items brought to the nest by the adults, 13 (62%) were reptiles, and only three were mammals.

Ringkasan. Kami melakukan monitoring sarang Elang Brontok (*Nisaetus cirrhatus*) di Taman Nasional Gunung Halimun Salak, Jawa Barat, terutama pada saat musim berbiak, di tahun 2012 dan 2013. Satu butir telur dikeluarkan pada bulan Juli pada musim berbiak pertama (2012) dan bulan Juni pada musim berbiak kedua (2013). Hal ini sesuai dengan data di awal abad 20 yang menyatakan bahwa bulan tersebut adalah puncak bertelur di Pulau Jawa. Berlawanan dengan literature, bahwa kedua induk melakukan pengeraman, walaupun induk betina yang lebih sering melakukannya. Masa pengeraman dan pengasuhan anak secara berurutan diperkirakan selama 50 dan 62 hari, tetapi karena saat bertelur dan saat menetas tidak teramati langsung, ada kemungkinan bahwa periode pertama kelebihan dan periode kedua kurang dari perkiraan. Gabungan periode tersebut (112 hari) sesuai dengan literatur yang menyatakan bahwa perkiraan minimum adalah 108 hari. panjang tubuh anakan (termasuk ekor) pada tahun 2013 bertambah sekitar 6 cm setiap minggu. Dari 21 jenis pakan yang dibawa indukan, 13 (62%) adalah reptil dan hanya tiga diantaranya adalah mamalia

Introduction

Of the nine species of Asian Hawk-Eagles (genus *Nisaetus*), six are found in the Indonesian archipelago (Eaton *et al.* 2016). Three species are endemic to Indonesia, while the other three also occur on the Thai-Malay Peninsula. The Changeable Hawk-Eagle *Nisaetus cirrhatus* is the most widespread, ranging from India eastwards through Southeast Asia to the Philippines and Greater Sundas, and is also the most variable, with five subspecies (Clark *et al.* 2016; GRIN 2016). Two species of hawk-eagles are found on the island of Java: the Changeable Hawk-Eagle and the endemic Javan Hawk-Eagle *N. bartelsi*. While the former is considered fairly common in parts of Indonesia (Eaton *et al.* 2016), the Javan Hawk-Eagle is rare and listed by IUCN as Endangered (BirdLife International 2013). For this reason, research in Indonesia has focused on the latter species, while the Changeable Hawk-Eagle has received little attention and little is known about its breeding biology.

Gunawan *et al.* (2016) conducted a study over three years (2012–2014) at Gunung Halimun Salak National Park (GHSNP; 06°43'S, 106°46'E), western Java, to compare the nests and breeding success of coexisting Changeable and Javan Hawk-Eagles. They found that breeding success of the former species (n=7 nests) was higher than that of the latter (n=5 nests). Nests of Changeable Hawk-Eagles were occupied almost every year, whereas Javan Hawk-Eagles sometimes vacated their nests for one or two years before re-use, though it is unknown whether they did not breed in the intervening period or simply nested elsewhere. Compared with the former, Javan Hawk-eagles built their nests in taller trees, at higher altitudes, on steeper slopes and closer to water sources (Gunawan *et al.* 2016).

One of the pairs of light-morph Changeable Hawk-Eagles was observed over two years around the rehabilitation facilities at Suaka Elang, on the eastern side of the Park, at an elevation of 823 m asl. Few observations were made in 2012, but in 2013 an effort was made to determine the role of the sexes in nesting, the duration of the incubation and nestling periods, and the diet and rate of development of the eaglet until it fledged. Unfortunately most of the raw data were lost due to the theft of the laptop on which they were stored, so the following is based on other notes taken in the field.

Observations in 2012

In early July 2012 one member of the pair was found incubating in a nest built in a Kapok *Ceiba pentandra* growing on a slope of c. 45°. The nest was c. 30 m from the ground, and only 5 m from the top of the tree. The vegetation around the nest was dominated by Merkus's Pine *Pinus merkusii*. By 18 July 2012 the nest contained one white egg (Plate 1). By 1 September, a chick with open eyes was present (Plate 2A). The first time the nestling was seen flapping its wings was on 12 October 2012, and the first time it was seen jumping out of the nest was on 18 October (Plate 2B). This eaglet fledged successfully by November 2012.

Plate 1. The first Changeable Hawk-Eagle nest, with egg on 18 July 2012 (photographer Djamaludin)

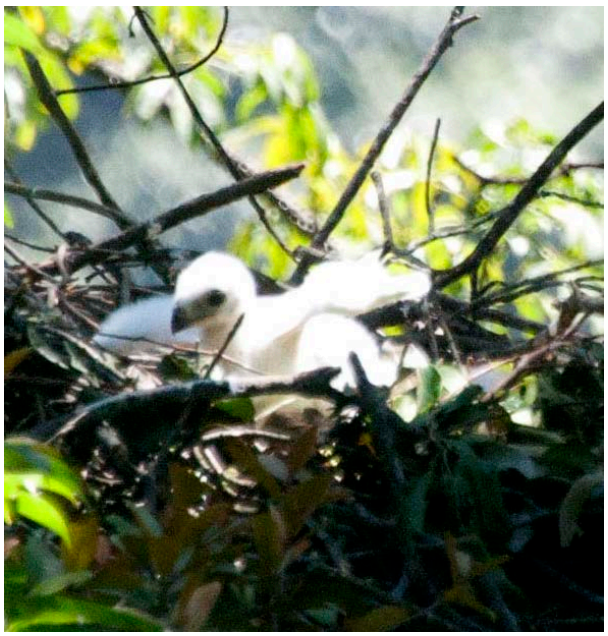

Plate 2A. The Changeable Hawk-Eagle eaglet on 1 September 2012 (photographer Djamaludin)

Plate 2B. The Changeable Hawk-Eagle eaglet on 18 October 2012 (photographer S. Nazar)

Observations in 2013

In early May 2013 the pair dismantled the 2012 nest, and from mid-May to early June the birds were seen building a new nest on a different branch of the same tree, c. 1.0 m higher that that of its predecessor, and c.4 m from the central trunk. The new nest was monitored by the first two authors once or twice per month from a hide that was erected at the same level as, but c. 150 m from, the nest, so that it was possible to see inside the nest. After the pair were first seen copulating, monitoring intensity increased to 2–3 h per week in order to estimate the date of egg laying, but thereafter was reduced to one hour per week to prevent disturbance, then slowly increased back to 2–3 h per week as hatching time approached. After the chick hatched, the nest was watched for one full day (07:00 to 17:00 hrs) each fortnight to observe the chick's behaviour and morphological development. The nest was observed with the aid of a pair of 8 x 40 Nikon binoculars, and a 392 x 95 Nikon telescope. Photographs were taken with a D90 Nikon digital camera with 400 mm lens. The parents were sexed according to their relative size, the female being assumed to be the larger bird. The total length, including the tail, of the eaglet was estimated by comparison with the parent.

The male and female cooperated in building the nest, the male more often carrying nest materials from the forest to the site, and the female arranging them. Nest materials comprised twigs and leaves. The adults were first seen sitting on the nest on 8 June 2013. They were subsequently seen incubating on many occasions during June and July, during which a single egg could also be seen. The male and female incubated the egg alternately, but the female sat for longer and more frequently than the male. During this period, the incubating bird was sensitive to any movement around the nest tree, and reacted by "freezing" or leaving the nest. On at least one sunny day, the pair left the egg unattended.

On 4 August 2013, an eaglet was seen on the nest. We estimated its length to be 6-10 cm, and as its eyes were open, its age was estimated to be c. 1 week. Thus hatching was assumed to have taken place around 28 July. Over the next nine weeks, the body of the nestling grew c. 5-7 cm per week, on average (Table 1). On 12 September, we observed the chick defecating out of the nest (Plate 3C). The chick started to leave the nest on 28 September 2013 (Plate 4),

c. 9 weeks after hatching, by which time it was feeding itself on prey brought to the nest by its parents, and flapping its wings while on the nest and nearby branches. On the following day, it left the nest tree. Assuming that the bird hatched on 28 July, the nestling period lasted 63 days (9 weeks). On 10 October, 10 weeks after hatching, the recently-fledged bird was seen flying and perching far from the nest tree. It was able to soar, glide and utilise breezes and thermals. A juvenile, presumably the same young bird, was often seen near the nest, including on 3 December.

Of 21 identified prey items brought to the nest, 13 (62%) were reptiles, including snakes and agamid lizards, five (24%) were birds, including a chicken and a White-breasted Waterhen *Amourornis phoenicurus*, and three (14%) were mammals, including one or more squirrels. When the eaglet was aged 4–5 weeks, the male brought in a medium-sized bird (possibly a quail), which the eaglet finally ingested after almost 6 h of handling. When the eaglet was 8–9 weeks old, the parents delivered prey away from the nest and beckoned the eaglet with calls, apparently to encourage the eaglet to fly.

Table 1. Physical and behavioural development of Changeable Hawk-Eagle eaglet in Gunung Halimun-Salak National Park in 2013. Estimated length includes tail.

Date	Length (cm)	Plumage coloration	Behaviour
4 August	6-15	Entirely white and downy.	Fed by parent; the eyes open; could only rear its head; often appeared to be asleep.
18 -19 August	15-25	Still mostly white and downy, with dark-brown pin-feathers emerging on the wings, back and tail.	Fed by parent; starting to stand up; starting to tear food by itself, with assistance from the female.
28 August	25-35	Head, legs and chest still downy; feathering (dark brown) on the wings, back and tail, with down remaining on the feather tips.	Walking in the nest; stretching and flapping the wings; wholly feeding itself on prey in the nest.
12 September	35-50	Head, chest and leg feathering light brown; longer wings and tail with clear pattern.	Flapping wings frequently; jumping in the nest; preening; defecated over the nest rim.
28 September	50-60	As above	Jumping out of the nest and flying from the nest tree to the nearest trees.
10 October	60-70	Similar to adults except for light-brown chest lacking black stripes.	Gliding and soaring.

Plate 3A. The Changeable Hawk-Eagle eaglet on 28 August 2013 (photographer S. Nazar)

Plate 3B. Female Changeable Hawk-Eagle perched on nest with eaglet, 28 August 2013. (photographer S. Nazar)

Plate 3C. The eaglet defecating out of the nest on 12 September 2013 (photographer S. Nazar)

Plate 4. The Changeable Hawk-Eagle eaglet on 28 September 2013 (photographer S. Nazar)

Discussion

The breeding season of the Changeable Hawk-Eagle varies over its wide geographic range, but in Peninsular Malaysia, Sumatra and Borneo, egg-laying has been recorded mainly from December to February (Smythies 1960; van Marle & Voous 1988; Wells 2010), corresponding with the wet season. Yet data for 33 clutches from West and Central Java show that egg-laying on this island occurred mainly from April to August, with 70% of clutches from June and July alone (Hoogerwerf 1949; Hellebrekers & Hoogewerf 1967). Egg laying at the GHSNP nest we observed probably occurred in June and July in 2013 and 2012, respectively. Moreover, in South Sumatra two active nests, at least one of which had a chick, were found on 21 August (Iqbal 2009), suggesting that egg-laying may extend until July in the southern part of that island. Robson (2011) reported a pair at a nest in Bali Barat National Park in late September, but its stage was unknown. These dates indicate that breeding may occur later in the year as one progresses eastwards into regions with a more seasonal climate.

Like other members of its genus, the Changeable Hawk-Eagle lays a single egg per clutch. According to the literature (Clark *et al.* 2017), incubation is performed by the female alone, but our observations of the nesting pair in GHSNP suggested that, on the contrary, the male also participated in incubating, though not as frequently, or as for as long, as the female. At one nest of the Javan Hawk-Eagle, incubation was performed predominantly by the female, who spent over 90% of her time at the nest during this stage, while the male only occasionally incubated, spending less than 5% of his time at the nest (Nijman *et al.* 2000). The male provided the female with food during this stage. It is possible that the male Changeable Hawk-Eagle at GHSNP did not provide sufficient food for the female, forcing her to leave the nest to hunt for herself.

The incubation period of the Changeable Hawk-Eagle has been estimated to take more than 40 days (Clark *et al.* 2017). At the 2013 GHSNP nest, the interval from the first sighting of the egg (8 June) to the estimated date of hatching (28 July) was 50 days. Although the egg was not actually seen on 8 June, it seems unlikely that the female (or male) would sit on the nest if no egg was present. The incubation period of the Javan Hawk-Eagle is 47 ± 1 days (Nijman *et al.* 2000). Data in Kaneda's (2009) study of a nest of the Mountain Hawk-eagle *N. nipalensis* in Japan show that the incubation period was also 47 days. Thus the implied

minimum incubation period of the Changeable Hawk-Eagle nest at GHSNP is 2-3 days longer than either of these species, despite its body being considerably smaller than the Mountain Hawk-eagle (data from Ferguson-Lees in Clark *et al.* 2017). However, it is possible that the development of the embryo at the GHSNP nest was slightly retarded due to protracted periods of absence of the adults from the nest, as occurred on at least one day. Alternatively we may have under-estimated the age of the nestling when it was first seen, so that hatching may have taken place a few days earlier than assumed.

The nestling period of the Changeable Hawk-eagle was hitherto unknown, but one bird is reported to have fledged after 68 days (Clark *et al.* 2017). At the 2013 GHSNP nest, the period from assumed hatching to fledging was 62 days. At one nest of Javan Hawk-eagles the chick was first seen outside the nest (c. 1 m from the edge) at c. 10 weeks (Nijman *et al.* 2000), while data for Kaneda's (2009) nest of the Mountain Hawk-eagle show that the chick fledged 80 days after hatching. Thus the implied nestling period at the GHSNP nest seems relatively short. As stated above, however, it is possible that we under-estimated the age of the nestling when it was first observed, so that the nestling period may have been closer to 65 days. Indeed at the 2012 nest, the elapsed time between the day the chick with open eyes was seen, and when it was first seen flapping its wings, was 42 days, whereas the flapping stage was reached 42 days after the presumed date of *hatching* at the 2013 nest. This is further evidence that we under-estimated the age of the latter chick. Nevertheless, the combined incubation and nestling period was at least 112 days, only slightly longer than the implied minimum combined period of 108 days in Clark *et al.* (2017).

Few studies have been conducted on the diet of Asian Hawk-eagles based on long-term observations of active nests (Fam & Nijman 2011). The Changeable Hawk-Eagle is known to eat both small and large birds, snakes, frogs, lizards and mammals, including squirrels, rats, hares, and occasionally monkeys and treeshrews (Ferguson-Lees & Christie 2001; Clark *et al.* 2017), but the relative importance of these animals in the diet has hitherto not been assessed. Although we identified only 21 items brought to the 2013 nest in GHSNP, reptiles predominated (62%) while mammals were the least well represented taxon. This contrasts with the diet of adult Javan Hawk-eagles, which feed predominantly on mammals. Of 90 observations of prey items of the latter species, 80% were mammals, 13% were birds and 7% were reptiles (calculated from Table 3, Prawiradilaga 2006). Similarly, at three nests in Taiwan, Mountain Hawk-eagles brought significantly more mammals (76% of a total of 118 items) than birds (16%) and reptiles (8%) (Sun *et al.* 2009). However, at one nest of this species in Japan, reptiles (mostly snakes) represented 33% of prey items (n=135), second only to mammals (40%), and birds (28%) (Kaneda 2009). However, prey selection differs significantly between the sexes in this species, with the male delivering more birds than the female, especially during the late nestling stage (Kaneda 2009). We have no explanation for the prevalence of reptiles in the prey brought to the Changeable Hawk-eagle nest at GHSNP.

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