

## HOME-RANGE SIZE OF THE JAVAN HAWK-EAGLE (*SPIZAETUS BARTELSI*) ESTIMATED FROM DIRECT OBSERVATIONS AND RADIOTELEMETRY

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**ABSTRACT.**—The mean home-range size of the Javan Hawk-Eagle (*Spizaetus bartelsi*) on Java was estimated to be ca. 400 ha based on three different methods. The distance between nests of neighboring pairs was ca. 3 km in Gede-Pangrango and 2 km in the Salak Mountains. In the Halimun Mountains, the mean distance between territories was 1.8 km. Radiotracking of one adult male indicated a home-range size of 300 ha in the nonbreeding season. This finding suggested that earlier population estimates probably were too low, as they were based on home-range estimates of 2000–5000 ha per pair depending on habitat quality. The species should still be considered endangered, as it is threatened both from habitat loss and illegal hunting.

**KEY WORDS:** *Javan Hawk-Eagle*, *Spizaetus bartelsi*; *home range*, *population status*, *radio-tracking*, *Indonesia*.

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### TAMAÑO DEL ÁREA DE HOGAR DE *SPIZAETUS BARTELSI* ESTIMADO A PARTIR DE OBSERVACIONES DIRECTAS Y RADIOTELEMETRÍA

**RESUMEN.**—El tamaño medio del área de hogar de *Spizaetus bartelsi* en Java ha sido estimado en aproximadamente 400 ha considerando tres métodos distintos. La distancia entre los límites de las áreas de hogar de parejas vecinas fue de aproximadamente 3 km en Gede-Pangrango y 2 km en las montañas de Salak. En las montañas de Halimun, la distancia media entre territorios fue de 1.8 km. El seguimiento con radiotransmisores de un macho adulto indicó un área de hogar de 300 ha en la estación no reproductiva. Esto sugirió que las estimaciones poblacionales anteriores fueron probablemente muy bajas, ya que estuvieron basadas en estimaciones de áreas de hogar de 2000–5000 ha por pareja, dependiendo en la calidad del hábitat. La especie debe aún ser considerada en peligro, ya que está amenazada tanto por la pérdida de hábitat como por la cacería ilegal.

[Traducción del equipo editorial]

The Javan Hawk-Eagle (*Spizaetus bartelsi*) is endemic to the rainforests of Java, Indonesia, where less than 10% of the original natural forests remain (Whitten et al. 1996). Small population size, severe habitat loss, forest fragmentation, and illegal hunting have all contributed to the “endangered” status of this species on the world list of threatened

birds (BirdLife International 2000, BirdLife International 2001). The population size has been estimated differently by various authors; “Not more than 60 breeding pairs” (Meyburg et al. 1989), “67–81 pairs” (van Balen and Meyburg 1994), “81–108 pairs” (Sözer and Nijman 1995), and “137–188 pairs” (van Balen 1999, van Balen et al. 2000). These estimates were based on data on the size of two home ranges. Thiollay and Meyburg (1988) estimated the home-range size to be 2000–

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3000 ha, but used 1700–4500 ha when they calculated their population estimates. Meyburg et al. (1989) suggested that suboptimal habitat may support home ranges as large as 12 000 ha. The home-range size of a breeding male studied in west Java was estimated at a minimum of 1200 ha (Sözer and Nijman 1995), and of another adult in central Java at ca. 3600 ha (van Balen 1999).

To obtain accurate knowledge of population size, it is necessary to obtain reliable data on density and area of suitable habitat. Density estimates have usually been based on the size of a few home ranges mapped by sight observations (Meyburg et al. 1989, Sözer and Nijman 1995, van Balen and Meyburg 1994, van Balen et al. 2000) under the assumptions that the eagle pairs occupy contiguous breeding territories and that entire forest areas are used by breeding pairs. We studied the home range of the Javan Hawk-Eagle in western Java by three different methods: (1) direct observation of territorial behavior of breeding pairs, (2) the distances between nests, and (3) radio-tracking of one adult male.

Distance between neighbor pairs was defined as the distance between the centroids of their territories. When nests were known, we used the distance between occupied nests of the same year. In this paper, we assume that home range is the same as territory, as the entire home range seems to be defended by Javan Hawk-Eagles during the breeding season (pers. obs.).

#### STUDY AREA AND METHODS

**Halimun.** This study area is close to Ciptarasa village on the slopes of the Halimun Mountains in west Java, and is close to and partly inside Halimun National Park (Fig. 1). Most observations were made from open cultivated areas along the forest borders. The rainforests were of lowland or lower-montane type at ca. 1000 m above sea level (masl). The national park is comprised of ca. 20% lowland forest (Whitten et al. 1996). Halimun National Park (established 1992) covers an area of 40 000 ha (Whitten et al. 1996) and is one of the largest forested areas in Java. Around it are large forested areas in administrative management as production or protected forests. Relatively large areas of primary rainforest still exist outside the borders of the park. However, because of need for cultivated land, the surrounding forests are gradually transformed into gardens and rice fields. Annual rainfall is between 4000–6000 mm. During large parts of the year, the highest mountains are covered by mist and fog, which its Indonesian name indicates.

**Mt. Salak.** This mountain is a volcano 2211 masl, well vegetated to the top (Fig. 1). The area of forest containing Javan Hawk-Eagle has been estimated to 10 000 ha (van Balen et al. 1999). The forests have administrative



Figure 1. The study areas: 1 = Halimun, 2 = Mt. Salak, 3 = Gede-Pangrango.

status as production forest. Part of the forest, particularly on the lower slopes of the mountain, has been transformed into tree plantations or secondary forests. The lowermost part of the forest, bordering cultivated areas, is used by local villagers for collecting forest products. There are large areas of primary forest present on the mountain, mostly at higher elevations. Mt. Salak has a very high annual rainfall and is an important water-catchment area.

**Gede-Pangrango.** This national park includes the volcanoes Mt. Gede (2958 m) and Mt. Pangrango (3019 m). It contains 15 196 ha of rainforest (Fig. 1) and includes some of the oldest, protected forests in Indonesia. The annual rainfall is 3000–7000 mm (RePPPProT 1990). There is little seasonal variation with only a slight decrease in rainfall from May–August. However, El Nino events (such as in 1997) may result in extended and more pronounced dry seasons, lasting until November. The park consists mainly of montane forest and includes the botanical gardens of Cibodas. The nearby Telaga Warna Nature Reserve surrounds a small lake; the reserve proper covers an area of 350 ha. The total area of this study area is ca. 20 000 ha (van Balen et al. 2000).

**Field Observations.** *Behavior of territorial pairs.* When weather conditions are favorable, eagles may soar above the forest within their home ranges, and perform territorial displays. Therefore, the birds can be observed from places with a good view of the surrounding terrain. To identify the home ranges of the different pairs, we used

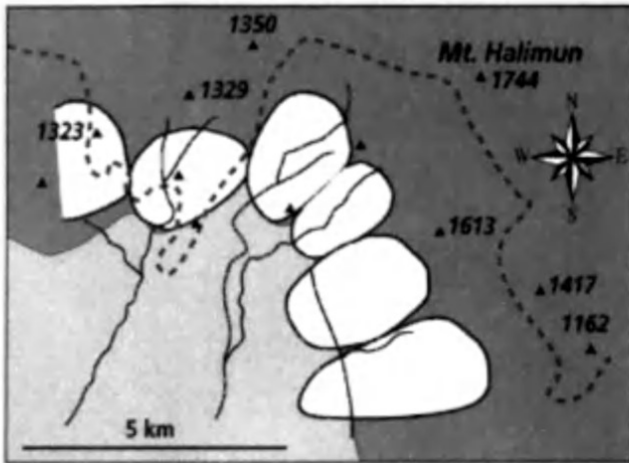


Figure 2. The distribution of Javan Hawk-Eagle home ranges at the southeastern border of Halimun. The home-range sizes were estimated using the distance between centroids of neighboring territories as the diameter of a hypothetical-circular home range. The dashed line denotes the boundary of the national park, the dark gray area represents forest, and light gray area represents open areas. Triangles and numbers = high points and elevation in m.

one of the following criteria: either simultaneous observation of neighboring pairs, individual recognition based on variation in plumage color, or molt pattern. To obtain an estimate of the density of territorial eagles in the area, four observers performed observations along a 10 km stretch of forest edge in the Halimun study area over 9 d during two time periods, 30 August–2 September and 26–30 September 1997. The total observation time was 67 hr. The map of the study area (Fig. 2) is based on maps in Whitten et al. (1996) and from Biodiversity Conservation Project in Indonesia (1997). The border between home ranges was mapped based on observations of territorial display and other flight activity, and the distances between the centroids of the five neighboring territories were measured from the map (Fig. 2).

**Distances between nests.** In the study areas in Mt. Salak and Gede-Pangrango, we were given the locations of six nests by local inhabitants. Therefore, we were able to measure the distances between nests of neighbor pairs in these areas. For this study, we included three nests which were identified in 1997 in Salak. These nests were plotted on available maps (Bakosurtanal 1997) and the distances between them were measured on the maps. The same method was used on three occupied neighbor nests in Gede-Pangrango in 1998, which were plotted on maps from Bakosurtanal (1990a, 1990b).

**Radiotelemetry.** An adult Javan Hawk-Eagle male was caught by use of a snare on the nest in Mt. Salak on 19 October 1997, and equipped with a VHF transmitter weighing 25 g (BioTrack Inc., Dorset, U.K.). The transmitter was equipped with a mercury activity switch. It was attached as a backpack by a harness made of Teflon (Bally Ribbon Mills, Bally, PA U.S.A.) ribbon using a Y-type attachment (Buehler et al. 1995). This male was ra-

dio-tracked intensively from five fixed receiver stations from 31 March–15 May 1998 with a four-element yagi hand-held antenna. The coordinates of these receiver stations (locations not differentially corrected) were determined with a GPS receiver (GPS 45, Garmin International Inc., Olathe, KS U.S.A.).

During observations, data were collected every 30-min during a 5–10 min interval. Locations were obtained by simultaneous triangulations from two different stations. The number of locations estimated from each station varied from 2–24/d. The positions were often confirmed by visual observations of the eagle flying or perching. The accuracy of the location estimates is probably reasonable due to the short distances (typically <500 m) from the receiver sites to the eagle and the good overview of the area from overlooks. Two types of behaviors were interpreted from radio signals: long pulse as sitting, short or variable pulse as flying or eating.

We collected 126 locations for this Javan Hawk-Eagle during our fieldwork. Home range was calculated with the minimum convex polygon and fixed kernel methods (Worton 1989) using the software program ArcView and the Animal Movements extension (Hooze and Eichenlaub 2000).

## RESULTS

**Home Range.** *Direct observation of territorial behavior.* In Halimun, we found six pairs of Javan Hawk-Eagle along a 10-km distance of forest edge (Fig. 2). The mean estimated distance between centroids of five neighboring territories was 1.8 km, which gives a hypothetical-circular home-range size of 254 ha (Table 1). One home range in Gede-Pangrango was mapped based on sight observations of eagles. This range was 530 ha, of which 220 ha was forest and the rest was tea plantation.

*Distances between nests.* In Gede-Pangrango, we found that the distances between three occupied nests from the same year were ca. 3 km, which gives a hypothetical circular home-range size of 710 ha. The distances between three nests occupied the same year in the Salak area were ca. 2 km, resulting in a hypothetical circular home-range size of 314 ha (Table 1).

**Radiotelemetry.** The home range of the radio-equipped Javan Hawk-Eagle male from 31 March–15 May 1998 was confined within an area of  $1.5 \times 2.2$  km. It was located at  $6^{\circ}40'–6^{\circ}41'S$  and  $106^{\circ}44'–106^{\circ}00'E$ , and between 620–1550 m altitude (Fig. 3). The home-range size according to the 95%-probability contour of the fixed-kernel method was 289 ha. A minimum-convex polygon around all fixes gave a home range of 310 ha. Hence, we estimated the home range of this eagle at ca. 300 ha (Table 1).

The types of habitat in the home range consisted



Table 1. Home-range sizes estimated by different methods: direct observations of territorial behavior of breeding pairs, distances between nests, and radio-tracking of an adult male.

METHOD	DISTANCE BETWEEN ACTIVITY CENTERS (km) (N)	ESTIMATED SIZE OF HOME RANGE (ha)	STUDY AREA
Distance between home-range centroids	1.8 (4)	254	Halimun 1997
Mapped by sight observations	(1)	530	Gede-Pangrango 1998
Distance between nests	3 (2)	710	Gede-Pangrango 1998
Distance between nests	2 (2)	314	Salak 1997
Mapped by radiotelemetry	(1)	300	Salak 1997

of undisturbed primary forest, production forest (*Pinus* sp.) and disturbed natural forest. Frequent observations of soaring and displaying Crested Serpent Eagle (*Spilornis cheela*), Black Eagle (*Ictinaetus malayensis*), and Changeable Hawk-Eagle (*Spizaetus*

*cirrhatu*s *limnaeetus*) indicated that the home range of the Javan Hawk-Eagle partly overlapped the home ranges of these eagles. In Gede-Pangrango, no observations of Javan Hawk-Eagles were made at altitudes over 2000 masl. The six nests were situated between 1200–1400 masl. **Time Budget and Behavior.** The time budget data from 75 hr of observations between 0600–1800 H of the radio-tracked male in Salak showed that this Javan Hawk-Eagle spent 42.8% of its time flying or feeding, and 57.2% perching.

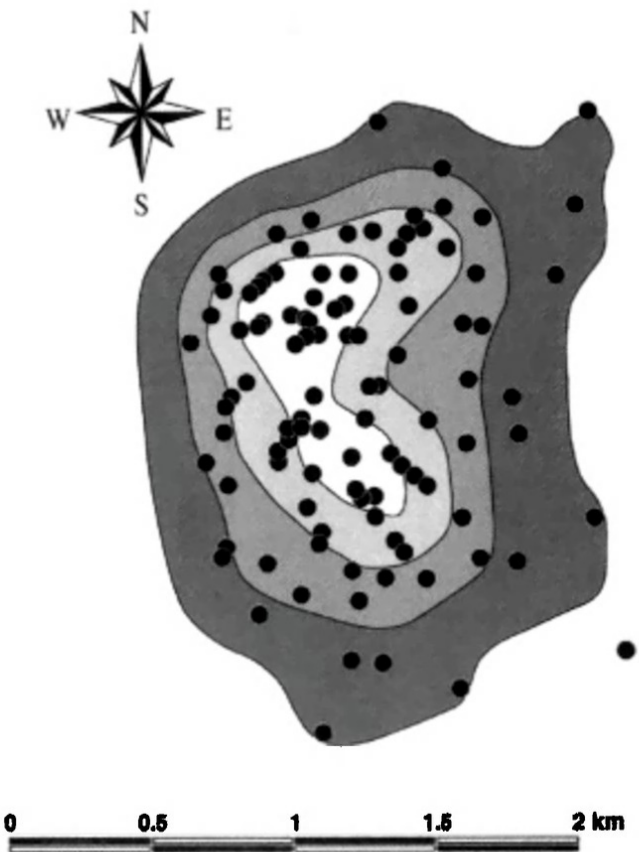


Figure 3. Home range of a VHF radio-equipped adult male Javan Hawk-Eagle in the nonbreeding season. The 95, 75, 50, and 25% probability contours using a fixed-kernel method as shown. The black circles show 126 radiotelemetry locations. A least-square cross validation for the smoothing factor (H) was performed, and its value was set to 200.

**DISCUSSION**

**Home-range Size.** When using a hand-held antenna in the field, it is difficult to obtain better than 5 degrees accuracy on the signal bearing. This would result in a 10 m error at a tracking distance of 100 m (Kenward 2001). The outermost fixes were up to 1 km away from the observer, thus involving a potential error of ca. 100 m in the location accuracy. Although we did not test the accuracy of locations, we suggest that some of our location errors may have been compensatory (i.e., one location could have had an error of several hundred meters to the east, while another location could have had an error similar distance to the west. Therefore, even though the accuracy of our telemetry data were limited, we feel that our results provided a reasonable approximation of the home-range size used by one Javan Hawk-Eagle.

Our estimates of home-range sizes of 230–710 ha, suggesting a median value of ca. 400 ha (Table 1) are considerably lower than those given by other authors (Meyburg et al. 1989, Sözer and Nijman 1995, Thiollay and Meyburg 1988), which ranged from 1200–12 000 ha. Madrid et al. (1991) found that the home-range size of the Ornate Hawk-Eagle

(*Spizaetus ornatus*) in Guatemala was 800 ha for males and 1300–2100 ha for females. In the Japanese Mountain Hawk-Eagle (*Spizaetus nipalensis orientalis*), Yamazaki (2000) found that home ranges were normally >2000 ha, (neighbor-nest distances 1.5–5.6 km,  $\bar{x}$  = 4 km). The mean density of breeding pairs of this species has been calculated at one pair per 2500–2800 ha uniformly throughout Japan (Yamazaki 2000). A similar home-range size (1270–3230 ha) has been recorded in the Philippine Hawk-Eagle (*Spizaetus philippensis*; Preleuthner and Gamauf 1998). However, relatively small home ranges (ca. 650 ha) have been documented in Crowned Hawk-Eagles (*Stephanoaetus coronatus*; Shultz 2002), and the nearest-neighbor distance between nests averaged 1.8 km. In the huge Harpy Eagle (*Harpia harpyja*), occupied nests have been recorded as close as 3–5 km apart in South and Central America (del Hoyo et al. 1994).

Our results from a single radio-tracked male probably represent the home-range size of a pair. We suggest that the male typically uses the combined home ranges of the male and the female exploited during the breeding season. Our telemetry data were collected about 5 mo after the young left the nest. This use area probably represents the breeding home range, as the juveniles stay with their parents for a year or longer (Nijman et al. 2000). Also, we repeatedly saw territorial interactions between neighboring pairs, suggesting that adjacent home ranges were defended.

In the Halimun area, we observed Changeable Hawk-Eagles, Black Eagles, and Crested Serpent Eagles commonly in the home ranges of Javan Hawk-Eagles indicating home-range overlap among these species (Røv et al. 2000).

**Habitat Use.** Thiollay and Meyburg (1988) suggested that the Javan Hawk-Eagle was dependent on primary rainforest, although those authors also mention that the species was seen in three degraded forest areas around Bogor. They also stated that hawk-eagles were seen flying over a plantation between two patches of forest as well as perched near a road in secondary forest at Meru Betiri in east Java. Nijman and van Balen (2003) found that the prime habitat for adult Javan Hawk-Eagles were evergreen forest and to a lesser degree secondary forest, and that immatures and juveniles had a greater preference for open woodland (forests with large clearings, small forest fragments, and young tree plantations) than adults.

Our observations suggest that the species uses

both primary and secondary forests for hunting and nesting. We have observed Javan Hawk-Eagles hunting over cultivated areas both in Halimun and Gede-Pangrango with home ranges that included such areas. We did not observe this for our radio-tagged bird in Salak as this home range did not include cultivated sites. When the home ranges are bordering open areas, the eagles may include some of these areas in their home ranges (Nijman and van Balen 2003, Nijman 2004, pers. obs.). However, our observations may be biased because they were made along forest borders. We have observed that the eagles can obtain food opportunistically from outside its primary habitat. This is based on prey remains of Barred Buttonquail (*Turnix suscitator*), an open-habitat species, and shows that some prey must be taken outside the forest. We have also obtained information from local people that domestic chickens have been taken in a village close to a nest of Javan Hawk-Eagle (Prawiradilaga et al. 2000).

**Population Status.** The number of breeding pairs of this species has been estimated by dividing the area of presumed suitable habitat by assumed home-range size. The Javan Hawk-Eagle normally does not nest above ca. 1400 masl (Nijman et al. 2000, pers. obs.); therefore, we excluded these high altitude areas to estimate population size. In areas such as Gede-Pangrango, the eagles sometimes soared to high altitudes, but they were never seen to be encountered by other conspecifics at these higher elevations. If we use 3 km as a mean home-range diameter for the Gede-Pangrango area, this habitat would provide space for about 20 pairs, which is 2–3 times more than previous estimate of 6–10 pairs (van Balen et al. 2001).

Van Balen et al. (2000) estimated the size of available Javan Hawk-Eagle habitat on all of Java at ca. 5480 km<sup>2</sup> in 22 forest areas (also see van Balen et al. 2001). Based on this finding and a density estimate of one pair per 2000–5000 ha, they estimated the total population of Javan Hawk-Eagles to be between 137 and 200 pairs (van Balen 1999, Nijman et al. 2000). Our data indicated that this estimate probably was too conservative. Extrapolation of our Gede-Pangrango densities to the entire forest habitat would place the population size between 270–600 (median = 435) pairs. However, we must admit that the accuracy of our home-range estimates are limited and our island-wide population estimate is based on a number of assumptions. Therefore, we recommend more studies to be car-



ried out in different forest habitats in other parts of Java. Nevertheless, the species should still be regarded as endangered; it is threatened by both habitat loss and illegal hunting. Because of this, we urge implementation of the Species Recovery Plan (Sözer et al. 1998) proposed by the Javan Hawk-Eagle Working Group to ensure the future conservation of the species.

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