UPDATES ON THE NESTING BIOLOGY AND POPULATION STATUS OF THE PHILIPPINE EAGLE *Pithecophaga jefferyi*

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New findings suggest that the Philippine Eagle may not be seriously suffering from reproductive failures and that the key factor to the species' survival is the dispersal and survival of juveniles and subadults and/or subadults. Also, estimates based on the distribution of nests in Mindanao suggest that each pair cover an average of 133 sq. km, with an average of 68 sq. km of forest. The breeding population in Mindanao is estimated at 200 pairs. Similar extrapolations to include the islands of Samar, Leyte and Luzon suggest that there could be a total of 300 pairs remaining in the wild. Over the short-term, hunting is identified as the most serious problem. In the long-term, fragmentation and degradation of the lowland rainforest is serious, with only 3 percent of the original old-growth lowland dipterocarp expanse left at present.

The Philippine Eagle (*Pithecophaga jefferyi*) is one of three most critically endangered eagles in the world (Bildstein et al. 1998). Historically found in the islands of Luzon, Samar, Leyte, and Mindanao of the Philippine archipelago, it has always been regarded as one of the rarest eagles in the world. Previous estimates of the Philippine Eagle population have been speculative (Alvarez 1970, Gonzales 1971, Rabor 1971). Kennedy (1978, 1985), with considerably more data, gave an estimate of 200 to 400 birds in Mindanao.

The Philippine Eagle is described as rare and endangered. This is based largely on the presumed correlation between its large body size, adaptation to the lowland rainforest that is fast disappearing, and the species' low reproductive rate.

After 20 years of research, a large amount of data on nesting success and distribution of the Philippine Eagle has been gathered. The recent information on their nesting ecology and distribution reported in this paper is hoped to provide baseline information and direction for the conservation research on the Philippine Eagle through the next millennium.

Nesting biology

Philippine Eagles lay a single egg, and have a 2-year cycle in case of successful breeding, whiel breeding again the following year in case of failure (Kennedy 1977, 1985). In Mindanao, breeding starts September until early January.

One long standing hypothesis posed as contributing to the eagle's population decline is the low rate of reproduction. Recent analysis of the Philippine Eagle's nesting success in Mindanao based on 50 nesting attempts by 29 pairs of eagles provides an estimate of 0.38 young/pair/yr and the overall success averaged 58.0 percent (Miranda et al. 2000). Breeding success based only on 8 pairs with more than one recorded nesting attempt averaged 76.3 percent (Table 1). This is a conservative estimate since we did not take into account that eagles breed the following year, instead of a two-year cycle, when the previous breeding fails during the early stages of development. A successful nesting attempt following a failed one should increase the rate of breeding success and the production of young/per pair/year. The analysis suggests that the Philippine Eagle is not suffering from reproductive failures. This finding points to another factor, the survival and success of dispersal of juveniles and adults across inhospitable areas.

Nesting density and population estimate for Mindanao

By mapping the nests of Philippine Eagles from 8 provinces in Mindanao from 1991 to 1998, the density of adult breeding pairs is estimated at one pair every 127 - 133 sq. km. (Bueser et al unpublished). Mean inter-nest distances was calculated at 12.7 km with the minimum at 10.2 km, while the average distance between breeding areas (including pairs wherein nests were not located) was 12.95 km (Figure 1).

Using the nest space average, the amount of forest for each territorial space centered on nests was mapped on 1:250,000 land satellite interpretation maps (NAMRIA, 1987). The average extent of forest cover for each nest area was estimated at 55 percent, or an average absolute value of about 70 sq. km (Table 2). We approximated the total forest cover for each nesting "space" to include closed canopy (with more than 50% cover) forest, open canopy (with less than 50 % cover) forest, montane and mossy forest. Old-growth forest averaged 51.0 % for pairs with located nests (N = 13) and 56.0 % for all pairs (N = 25).

Of the thirteen nests, three nests were in primary dipterocarp forest while ten pairs were found on mature secondary growth dipterocarp forest. Four pairs nested in the forest interior while nine pairs built their nest less than 100 meters closer to forest edges (Figure 2). Surrounding and within the eagle areas are mosaics of dipterocarp forest at various states of degradation and human-induced modifications characterized by agricultural lands, agroforestry and grassland.

To determine a population estimate of Philippine Eagles in Mindanao, two forest cover averages of 68 km^2 for pairs with located nests only, and 72 km^2 for all breeding pairs were used. Using these densities, and the estimated forest area of approximately 13,898 km^2 (FMB-DENR 1997) considered suitable for Philippine Eagle, we estimate that there are about 201 ± 19 and 190 ± 23 occupied territories in the island (Table 3). This estimate is conservative since we excluded subadults and "floaters" as these are difficult to incorporate into the data set without information on survival rates and dispersal. Implicit to this estimate is the assumption that all suitable areas are occupied.

However, there exists the possibility that breeding Philippine Eagles might already be absent in some suitable areas and have never been recolonized. Some mountains in Luzon, like Mt. Makiling and the Zambales mountains have relatively large forest covers than occupied relict forests in Mindanao, but do not harbor any breeding pairs or individuals. In Mindanao, some small forest fragments like Mt. Sinaka, is as small as 25 sq. km and have Philippine Eagles breeding successfully. Nevertheless, our result demonstrates that Philippine Eagle breeding populations are still present in forests of Mindanao.

Entire Philippine population estimate and the Luzon dilemma

Similar extrapolations on the population estimate to include the islands of Luzon, Samar and Leyte suggest a total population of 340 pairs (Table 4). However, the estimate for Luzon may have a large margin of error. Extensive surveys by Kennedy and Miranda in late 1970s and early 80s did not result in locating an active nest. Although, more than 50 nestings by 30 pairs have been monitored in Mindanao during the last two decades, no nest has been adequately studied in Luzon, despite the fact that the island has about as much forest cover remaining as Mindanao. At present, it is arguable whether this is a reflection of differential nesting densities, forest type specificity of habitat, biogeographical history of the population, or differences in research and conservation efforts. This will be the subject of the PEF's program in the near future.

Although there are historical records of the presence of Philippine Eagles in the Cordillera mountains, we did not include it because much of the statistical information from that region include pine and montane forests. Our present estimate will be revised soon as the PEF obtains more refined information on nesting density and lowland dipterocarp distributions.

Studies on the population of Philippine Eagles in Luzon is imperative because of many reasons. Luzon may have been separated from the Greater Mindanao (which include Samar, Leyte, and Mindanao) by 10 million years (Heaney and Regalado 1998). From the standpoint of conservation genetics, a vicariant

historical event could have led to genetic differentiation between the Luzon and Samar-Leyte-Mindanao populations. This will be tested in the near future using molecular tools and should be an important consideration in management decisions involving releases of captive bred or rehabilitated birds from one island to another.

The radio-telemetry program

The radio telemetry program was initiated to address several important biological questions; 1) home range and territoriality, 2) habitat and hunting use, and 3) juvenile dispersal and mortality. Since late 1998, the PEF has tagged two juveniles and one adult female. The first one tagged, a juvenile, was tracked for 8 months until it was caught by farmers. One female was trapped by a farmer June of 1999 and was soon released harnessed with a radio transmitter. Another juvenile was caught March, 2000 and is currently being tracked by the PEF research team.

The prolonged presence of researches that are conducting radio telemetry in an area has an added benefit. The local villagers who live in proximity with the eagles' nests are made aware of the plight of the eagles and immediately provide information on illegal trapping or hunting.

The conservation status

As old-growth forest in the Philippine archipelago continues to diminish, the eagle population is expected to dwindle further. Efforts to arrest deforestation are focused on reforestation projects using fast-growing species of trees, some of them non-native. The increasing demand for agricultural productivity imposes continued pressures in the foreseeable future to convert marginal forest areas for agriculture. At present, there are no indications that the eagles nest inside tree plantations, although claims of eagle predation on domestic animals outside the forest are increasing.

Presently, only 18 percent of the original forest remains. Of these, about 3 to 5 percent are classified as lowland dipterocarp forest, the presumably preferred habitat of the Philippine Eagle. Research is on-going on the level of dependency of the eagles on the lowland dipterocarp forest for nesting, hunting, and long term survival. With so little lowland forest left in the Philippines, the population estimate of more than 600 individuals appears to be higher than expected. How could we account for such a relatively large population estimate for Philippine Eagles?

It has been recently shown that the time-lag to community extinction following historical deforestation can be long in human time scale (Magsalay et al 1995, Brooks et al 1999). This is based on the assumption that patterns and rates of local extinction in forest fragments can be expressed as a function of natural decay. Similar patterns can thus be inferred for populations in a constantly fragmenting landscape. Extinction of threatened species in this scenario is only a matter of time. Since the time to extinction of a long-lived large -bodied species such as the Philippine Eagle can take decades or centuries, there is enough time for conservationists to set priorities and employ proactivist programs.

Conclusions and Recommendations

Although the estimated current population number is larger than previous estimates, this does not contradict the fact that the Philippine Eagle is critically endangered. Our study suggests that Philippine Eagles require a fair amount (at least 50 percent per territory) of old-growth forest for every nesting pair that we have investigated. However, this may not be reflective of eagle densities in optimal habitat condition as would have normally occurred prior to massive deforestation in Mindanao during the last 50 years. Some of the forest habitat where nests were located were marginal and all have varying degree and forms of habitat disturbance. Whether the eagles' breeding density fluctuates, as a direct response to prey population changes or availability of nesting sites is unknown. Changes in raptor densities as correlated with prey density fluctuation have been documented (Dare 1961, Brown and Hopcraft 1972). Availablity of nest trees may not be a critical factor because trees large enough for nesting are not inadequate in the

mountains of Mindanao. Perhaps, the availability of nesting sites far enough from other breeding pairs and with large enough forest cover to support a breeding pair is critical.

Captive breeding is progressing and successful raptor reintroductions elsewhere are encouraging. But since destruction of the lowland rainforest appears to be irreversible in human time scale, conservationists in the Philippines have to realize that the survival of this most magnificent raptor may depend on sustained hands-on management in a fragmented habitat surrounded by mosaics of agricultural landscape .

But in the short term, the likelihood to extinction can be hastened by hunting. From 1999 to early 2000 alone, five Philippine Eagles have been shot, captured and donated to the Philippine Eagle Center. Two of those later died. It may be impossible to ascertain the overall effect of hunting on the rate of Philippine Eagle mortality since this activity is totally unchecked. For a long lived terrritorial animal with a long (7 years) period to sexual maturity, a high annual rate of loss due to hunting, especially on breeding individuals, is expected to have severe consequences on the population.

There are existing laws to protect the eagles but the proliferation of firearm use and the lack of control on their use for hunting in the forested mountains in the Philippines may be exerting an undocumented but heavy toll on the remaining eagle populations. An intensive campaign to stop the hunting of the eagles should be initiated as soon as possible. Although the captive breeding program has been progressing and community based programs for habitat rehabilitations are gaining momentum, the eagles can possibly disappear faster than we presumed under the long time-lag to extinction scenario without the intensive drive against hunting.

It has become clear that conservation efforts on the Philippine Eagle should address two parallel issues: the short term problem of hunting, and secondly, the challenge to preserve as much lowland dipterocarp forest and promote the connectivity of forest fragments for the long term viability of the Philippine Eagle populations. The PEF, with its limited funds, seeks to address the long term problem thru field research, captive breeding as "genetic insurance" for the species, and developing community based reforestation programs. But the PEF is resource limited to address the more immediate threat of hunting in all areas where the eagles are present.

There are existing mechanisms to address the hunting problem. The Philippine government has created regional teams called Philippine Eagle Watch Teams to monitor and gather information on the Philippine Eagle in their respective regions. But the majority of those personnel are currently poorly trained in the fundamentals of scientific research and raptor biology. The PEF is currently working closely with two regional teams in Mindanao on the radio telemetry project on two sites. As government personnel, these groups can be properly trained to conduct acceptable research. They are also mandated to impose government laws and regulations within their respective jurisdictions. Their continued presence alone in located eagle areas should have an impact on the upland communities' attention and sympathy on the Philippine Eagle.

In conclusion, a synthesis of all available information on the Philippine Eagle conservation program suggests several new hypotheses.

1) The eagles may not be suffering from reproductive failures.
2) There may be more than 322 to 340 pairs left in the wild.
3) Although the lowland dipterocarp rainforest is almost gone in the Philippines, the likelihood to extinction may take many decades, even a century. This can be viewed as a window of opportunity to set conservation priorities and actions, provided that hunting is stopped.
4) The likelihood to extinction of one of the world's most spectacular eagles could be much sooner than conservationists realize if hunting is not stopped.

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Table 1. Summary of Philippine Eagle reproductive success in percentages, 1978-1998.

Breeding result	Based on 50 nesting Attempts by 29 pairs	Based on 28 nesting attempts by 8 pairs with more than one nesting attempts
Successful fledging	58.0	76.3
Failed fledging	30.0	9.7
Unknown	12.0	14.0

Modified form Miranda et al (2000)

Table 2. Estimates of microhabitat variables for located Philippine Eagle nests and apparent breeding areas[a].

	MEAN	
Habitat variable	Nests (N=13)	All pairs (N=25)
Total forest cover (km2)	68.96	72.96
Closed canopy > 50 % cover	33.70	32.19
Open canopy < 50 % cover	35.26	40.77
Open grassland/agricultural land (km2)	57. 71	59.77

[a] Modified form Bueser et al (unpublished)

Table 3. Philippine Eagle density and population estimates in Mindanao[a].

Mean nearest neighbor distances	Inferred nesting density (km^2)	Mean forest coverage per territory (in %)	Mean forest cover per nesting space (km^2)	Estimated number of pairs
Based on nests distances 12.61 km [b]	1 pair / 127 km^2	54 %	68 km^2 / pair	204 ±19 pairs
Based on nests and major roosts distances 12.95km [c]	1 pair / 133 km^2	55 %	72 km^2 / pair	193± 23 pairs

[a] From Bueser et al (unpublished)
[b] Based on eight adjacent nests
[c]Based on 25 terrritorial pairs including those with located nests

Table 4. Philippine Eagle population estimates for the whole archipelago.

Island or region	Suitable habitat size	Estimated number of pairs	
		Based on 13 pairs with located nest only	Based on 25 pairs with and without located nests
Sierra Madre mountains	6,850	99	94
Samar and Leyte	2, 753	40	38
Mindanao[a]	13, 898	201	190
Total	23,501	340	322

[a] after Bueser et al (unpublished)

Figure 1. Philippine Eagle estimated circular territories based on mean internest distances, overlaid on the existing forest in Mt. Apo range. Forest cover map is based on the 1987 SPOT satellite images (NAMRIA/Swedish Space Corporation).