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Tables, one to a page, should be double-spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be pencilled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (7th ed., 1998) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and “continental” dating (e.g., 1 January 1998).

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SUMMARY OF PHILIPPINE EAGLE REPRODUCTIVE SUCCESS, 1978–98

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Philippine Eagle Foundation, Garnet cor. Diamond Street, Marfori Heights, Davao City, 8000 Philippines

KEY WORDS: Philippine Eagle, Pithecophaea jefferyi; breeding success; population decline; forest fragmentation.

The Philippine Eagle (Pithecophaea jefferyi) is one of the rarest eagles in the world. Its present status has always been regarded as critically endangered. Previous estimates of the Philippine Eagle population have been speculative (Alvarez 1970, Gonzales 1971, Rabor 1971). The most recent estimate suggests that the total population consists of between 300–500 individuals (Kennedy 1977, 1985). Philippine Eagles lay a single egg and have a 2-yr cycle between successive breedings when pairs breed successfully, but in cases when breeding attempts fail, adults breed the following year. Since work began in earnest on this species, a large amount of information on nesting successes and failures in Mindanao have been amassed. Here, we report this information based on records collected over the past 20 yr, and provide insights as to the key reason for the decline of the population.

METHODS

We compiled all existing information on the reproductive success of Philippine Eagles based on published (Kennedy 1985) and unpublished documents gathered by the Philippine Eagle Foundation (PEF) between 1978–98. We defined a successful breeding attempt as those with young eagles that survived until fledging. Nests were located by daily surveillance from vantage points, usually along mountain ridges and in areas where eagle presence was reported by local settlers. Observers stayed in these areas for about a week during the breeding season between August–December and from 0600–1500 H. Blinds were built in trees adjacent to nest trees, usually about 50–100 m away. Life history information was obtained and daily activities were recorded. A reward system for reporting occupied nests was initiated in 1981. From 1985 to the present time, the reward system was intensified and coupled with other on-site programs such as the development of community-based initiatives and conservation education activities. Reports of sightings were improved further by forging partnership arrangements with broadcasting stations in Mindanao Island.

RESULTS AND DISCUSSION

Prior to 1970, only one nesting pair of Philippine Eagles was located (Gonzales 1971). From 1978–88, several nesting pairs were intensively studied within the logging concession of the Paper Industries Corporation of the Philippines (PICOP) in Surigao del Sur and Davao Oriental provinces, and within the Mount Apo National Park (Kennedy 1981, 1985). This was a period when intensive logging operations occurred on Mindanao Island and many nesting areas were logged or altered by slash-and-burn farmers. Eight breeding attempts by 6 pairs failed (72.7%) out of a total of 11 attempts during this period (Fig. 1). One nesting was retrieved from a nest at Mount Apo National Park and is currently being kept at the Philippine Eagle Center in Davao City.

From 1984–88, the PEF and the Department of Environment and Natural Resources (DENR) monitored the breeding population. Of the eight pairs monitored, there were 11 breeding attempts. Four failed (36.4%) and four young (36.4% nesting success) were produced. This represented an 18.2% increase in fledging success compared to the previous period.

From 1989–93, 11 breeding attempts by nine pairs resulted in eight fledglings (72.7% nesting success) and, from 1994–98, 17 breeding attempts by 12 pairs resulted in a higher success rate (88.2%). The increase in breeding pairs was mainly due to an increased awareness by local people and increased observer effort and was not indicative of the recovery of the population. Other strategies such as the reward system and media-based information campaign have also been widely used by the PEF since the early 1990s to increase the information on the number of breeding pairs in the population. The increase in breeding pairs during the last decade may also have been due to increasing fragmentation of lowland dipterocarp rainforest that result in increased contact with settlers.

Breeding success based on eight pairs with >1 nesting attempt was estimated at 0.38 ± 0.14 (±SD) young/pair/
<table>
<thead>
<tr>
<th>LOCATION*</th>
<th>YEAR(S) OBSERVED</th>
<th>NESTING STAGE OBSERVED</th>
<th>FLEDGING SUCCESS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Apo, Toril, Davao City(^b)</td>
<td>1977, 78</td>
<td>Egg to nestling</td>
<td>Failed</td>
<td>Nesting died at 27 d</td>
</tr>
<tr>
<td>Amabel, Magpet, North Cotabato(^b)</td>
<td>1978, 79</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Kianzang, Magpet, North Cotabato(^b)</td>
<td>1978, 79</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>PICOP, Surigao del Sur(^b)</td>
<td>1978, 79</td>
<td>Incubation to nestling</td>
<td>Failed</td>
<td></td>
</tr>
<tr>
<td>Rd. 6P, PICOP, Surigao del Sur</td>
<td>1981</td>
<td>Courtship to nestling</td>
<td>Failed</td>
<td>Young died</td>
</tr>
<tr>
<td>Rd. 78, PICOP, Surigao del Sur</td>
<td>1981, 82</td>
<td>Nesting</td>
<td>Failed</td>
<td>Young disappeared after a storm</td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>1983</td>
<td>Egg to nestling</td>
<td>Failed</td>
<td>Young died</td>
</tr>
<tr>
<td>New Dumangas, Tiboli, South Cotabato</td>
<td>1983</td>
<td>Nestling</td>
<td>Failed</td>
<td>Nesting died after retrieval due to apparent sickness</td>
</tr>
<tr>
<td>Amabel, Magpet, North Cotabato</td>
<td>1983</td>
<td>Egg</td>
<td>Failed</td>
<td>Egg abandoned, nest tree burned</td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>1983, 84</td>
<td>Egg to post-fledging</td>
<td>Failed</td>
<td></td>
</tr>
<tr>
<td>Rd. 6P, PICOP, Surigao del Sur</td>
<td>1983, 84</td>
<td>Egg to nestling</td>
<td>Failed</td>
<td></td>
</tr>
<tr>
<td>Laconon, Tiboli, South Cotabato</td>
<td>1985</td>
<td>Nesting</td>
<td>Unknown</td>
<td>Not revisited for verification</td>
</tr>
<tr>
<td>Upper Linam, Tupi, South Cotabato</td>
<td>1985, 86</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td>Not revisited for verification</td>
</tr>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>1986</td>
<td>Incubation to nestling</td>
<td>Failed</td>
<td>Eaglet retrieved by locals</td>
</tr>
<tr>
<td>Laligan, Valencia, Bukidnon</td>
<td>1986</td>
<td>Nesting</td>
<td>Failed</td>
<td>Eaglet retrieved by locals, later died</td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1986</td>
<td>Post-fledging</td>
<td>Unknown</td>
<td>Not revisited for verification</td>
</tr>
<tr>
<td>Rd. 6P, PICOP, Surigao del Sur</td>
<td>1986</td>
<td>Incubation</td>
<td>Unknown</td>
<td>Egg disappeared</td>
</tr>
<tr>
<td>Allah Valley watershed, Tiboli, South Cotabato</td>
<td>1986, 87</td>
<td>Incubation</td>
<td>Failed</td>
<td>Egg added</td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1987</td>
<td>Incubation</td>
<td>Failed</td>
<td></td>
</tr>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>1987</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1988</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Apog-apog, Magpet, North Cotabato</td>
<td>1988</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>1989, 90</td>
<td>Nesting to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Apog-apog, Magpet, North Cotabato</td>
<td>1990</td>
<td>Nesting</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Tambobong, Baguio District, Davao City</td>
<td>1990, 91</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Guinang-guinang, Manolo Fortich, Bukidnon</td>
<td>1992</td>
<td>Nesting to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Freedom, Cabanglasan, Bukidnon</td>
<td>1992</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mamag, Ganatan, North Cotabato</td>
<td>1992</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>1992</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Kibidtud, Tambobong, Davao City</td>
<td>1992</td>
<td>Nesting to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>LOCATIONa</td>
<td>YEAR(S) OBSERVED</td>
<td>NESTING STAGE OBSERVED</td>
<td>FLEDGING SUCCESS</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>--------------------</td>
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<td>---------------------------------</td>
<td>------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1992</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>1993</td>
<td>Nestling</td>
<td>Unknown</td>
<td>Nest not revisited</td>
</tr>
<tr>
<td>Kabalantian, Arakan Valley, North Cotabato</td>
<td>1993</td>
<td>Nestling</td>
<td>Failed</td>
<td>Young retrieved by locals after nest tree burned</td>
</tr>
<tr>
<td>Freedom, Cabanglasan, Bukidnon</td>
<td>1994</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Dumalaguing, Impasug-ong, Bukidnon</td>
<td>1995</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Guiang-guilang, Manolo Fortich, Bukidnon</td>
<td>1995</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>1995</td>
<td>Courtship to incubation</td>
<td>Failed</td>
<td>Egg addled</td>
</tr>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>1995</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Sinaka, Arakan Valley, North Cotabato</td>
<td>1995, 96</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1995, 96</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>San Fernando, Cabanglasan, Bukidnon</td>
<td>1995, 96</td>
<td>Incubation to nestling</td>
<td>Failed</td>
<td>Eaglet died</td>
</tr>
<tr>
<td>Lamlahak Lake, Sebu, South Cotabato</td>
<td>1996</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Sobrecarey, Caraga, Davao Oriental</td>
<td>1996</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Guiang-guilang, Manolo Fortich, Bukidnon</td>
<td>1997</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Minlanga, La Paz, Agusan del Sur</td>
<td>1997</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Sinaka, Arakan Valley, North Cotabato</td>
<td>1997, 98</td>
<td>Egg to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Batian, Maitum, Sarangani Province</td>
<td>1998</td>
<td>Post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Minlanga Range, La Paz, Agusan del Sur</td>
<td>1997, 98</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>1998</td>
<td>Nestling to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>1998</td>
<td>Incubation to post-fledging</td>
<td>Successful</td>
<td></td>
</tr>
</tbody>
</table>

a Entry for location generally proceeds as a combination of the locality (barangay, mountain range or a road marker [e.g., Rd. 6]) and the municipality (or district), followed by the province (or city).
b Kennedy (1985).
Precise assessment of the causes of breeding failure is difficult. Birds exposed to food shortages and disturbances during critical periods of the nesting cycle may abandon eggs or nests (Newton 1979). Our summary of causes of nesting failures (Table 1) was not complete because field methods varied over the years. Moreover, our results showed that many of the breeding pairs were disturbed by logging operations, slash-and-burn farming and by the observers themselves. Three of 15 failures (20.0%) were due to removal of young from nests or falling of nest trees with young. Most individuals currently kept at the Philippine Eagle Center in Malagos, Davao City were either confiscated or surrendered as juveniles. There were also three cases (23.5%) wherein eggs were addled and/or abandoned, but the causes of nest abandonment were unknown.

The information we obtained may also have been based on the most conspicuous or accessible breeding pairs and, therefore, it may not be indicative of the true productivity of the population of Philippine Eagles. Some Philippine Eagle pairs may be more experienced breeders and may also be overrepresented in our sample which could account for the high reproductive success we recorded. Also, the high breeding success may also reflect the diminishing persecution of Philippine Eagles by the local people. Despite the limitations of the data we collected, we believe that it provides important baseline information to help focus future research and conservation efforts on the Philippine Eagle.

The current status of the Philippine Eagle as Critically Endangered is based mainly on the fact that this is a large-sized bird requiring a large territory and adapted to a tropical rainforest ecosystem that is fast disappearing in the Philippine archipelago. Theoretically, the assessment of raptor population stability involves integration of reproductive data with survival data for various age classes (Henny et al. 1970), but the lack of information on survival of Philippine Eagles after fledging limits the precise assessment of their population status. Although it is clear that the major threat to tropical birds of prey is forest destruction (Thiollay 1985, 1989, 1992), it was un-

Table 2. Breeding rates of Philippine Eagle pairs with more than one recorded nesting attempt.

<table>
<thead>
<tr>
<th>BREEDING PAIR LOCATION</th>
<th>NO. BREEDING ATTEMPTS</th>
<th>% SUCCESS</th>
<th>BREEDING RATE (YOUNG/PAIR/YR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalwangan, Malaybalay, Bukidnon</td>
<td>5</td>
<td>60</td>
<td>0.50</td>
</tr>
<tr>
<td>Minlanga Range, La Paz, Agusan del Sur</td>
<td>2</td>
<td>100</td>
<td>0.50</td>
</tr>
<tr>
<td>Freedom, Cabanglasan, Bukidnon</td>
<td>2</td>
<td>100</td>
<td>0.50</td>
</tr>
<tr>
<td>Guiang-guialang, Manolo Fortich, Bukidnon</td>
<td>3</td>
<td>100</td>
<td>0.50</td>
</tr>
<tr>
<td>Mount Apo, Toril, Davao City</td>
<td>6</td>
<td>33.3</td>
<td>0.17</td>
</tr>
<tr>
<td>Amabel, Magpet, North Cotabato</td>
<td>2</td>
<td>50</td>
<td>0.25</td>
</tr>
<tr>
<td>Mount Sinaka, Arakan Valley, North Cotabato</td>
<td>2</td>
<td>100</td>
<td>0.50</td>
</tr>
<tr>
<td>Salaysay, Marilog District, Davao City</td>
<td>6</td>
<td>66.7</td>
<td>0.33</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>76.3</td>
<td>0.38</td>
</tr>
</tbody>
</table>
clear whether the population decline of the Philippine
Eagle is mainly due to reproductive failures or to in-
creased mortality of juveniles, subadults and/or adults. A
high rate of nesting failures could explain the population
decline because Philippine Eagles lay a single egg and
normally breed once every two years. Our data indicate
that it is not nesting failures that are responsible for the
population decline but that decreased survival of juv-
eniles and subadults and their inability to disperse be-
tween forest islands to establish eventual breeding terri-
ories may be limiting the number of breeding pairs in
this population. Past studies have suggested that the sta-
bility of breeding raptor populations is not related to pro-
longed good production of young but could be main-
tained by immigration or dispersal (Mebs 1964, Ratcliffe
1972, Newton 1979, Grier 1980). Nevertheless, forest
fragmentation has untold effects on large tropical forest
raptors such as the Philippine Eagle. Future research
should focus on aspects of metapopulation dynamics
such as survival and dispersal studies in a highly frag-
mented habitat, continued monitoring of reproductive
performance of known breeding pairs in Mindanao and
initiation of basic population ecology studies in other is-
lands of the archipelago where Philippine Eagles are his-
torically known.

Acknowledgments—El éxito reproductivo total del águila de las
Filipinas (Pithecorhaga jefferyi) promedio 58.0% de los in-
ternos reproductivos por 29 parejas desde 1978-98. El
éxito reproductivo con base en ocho parejas con mas de
un nido reproducido fue estimado en 0.38 ± 0.14

juvénil/pareja/ano y el éxito reproductivo pro-
medio 76.5%. Hubo 15 fracasos reproductivos, tres de los
cuals se debieron a la remoción de juveniles del nido o
muerte del nido, y en tres casos los huevos fueron infertility
o abandonados. Nuestro análisis sugiere que los frac-
asos reproductivos no son un factor mayor en la decli-
nación poblacional del águila de las Filipinas y apunta a
un decrecimiento de la sobrevivencia de los juveniles y
subadultos y su inahabilidad para dispersarse entre los
fragmentos de bosque como la causa de la declinación
numérica de esta especie.

[Traducción de César Márquez]

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