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NOTES ON THE BIOLOGY AND POPULATION STATUS OF THE MONKEY-EATING EAGLE OF THE PHILIPPINES

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The Monkey-eating Eagle (*Pithecophaga jefferyi*, see Frontispiece) is a huge forest raptor endemic to the Philippines. After its discovery in 1896 on the island of Samar (Ogilvie Grant 1897b), it was considered so rare that nearly every specimen obtained before 1940 prompted a published account. Gonzales (1968) provided the first life history data in his 10-month study of a nesting pair in the province of Davao del Sur, on the island of Mindanao.

Field censuses of this endangered species in 1969 on Mindanao, where the species is most abundant, produced estimates of 40 (Alvarez 1970) and 36 (Gonzales 1971). Rabor (1971) estimated the numbers in 1970 at 50 to 60 birds.

During a study of this species on Mindanao from August 1972 to April 1973, I assisted the Philippine Research, Parks, Range, and Wildlife Division of the Bureau of Forest Development in efforts to conserve this eagle. I collected data on the behavior of wild eagles and on their numbers and distribution. Here I report on my findings and include a summary of the former and present status of the species on other islands where it has been recorded.

STUDY AREA AND METHODS

I studied activities of a pair of Monkey-eating Eagles at Tudaya Falls in Mt. Apo National Park on Mindanao. The area is dissected by a series of deep ravines carved by swift mountain rivers. Elevation ranges from 700 to 1200 m. Because of the close proximity to the equator, the time for sunrise and sunset varied little over the year. A canyon below Tudaya Falls was the primary study area. It was ca. 400 m wide, 100 to 200 m deep, and 2 km long (Fig. 1). On the ridges surrounding the canyon, Bagobo natives have cleared some of the virgin forest (see Fig. 2). I spent 8 full days and 14 one-half days from September to March (153 hours of observation) at 3 lookouts overlooking the canyon, the choice of which depended on the location of the eagles at the time.

With personnel from the Philippine Parks stationed in Davao City and Zamboanga City, I traveled to 10 provinces of Mindanao: Lanao del Norte, Misamis Occidental, Zamboanga del Norte, Zamboanga del Sur, Davao City, Davao del Norte, Davao Oriental,



FIG. 1. View of canyon in the Tudaya Falls study area. Photo taken from Lookout #1 facing the southeast.

Davao del Sur, North Cotabato, and South Cotabato. Coverage was greatest in the last 6 provinces. Records of eagles killed, sighted, or captured since 1970 were collected from local residents and were accepted or rejected on the basis of the information provided. Personnel from logging companies and natives provided the most reports.

Aerial surveys over 12 of the 17 provinces of Mindanao facilitated plotting the distribution of Monkey-eating Eagle habitat on Joint Operation Graphic (AIR) Maps, Series 1501 AIR, 1:250,000, current through 1969. Observations from the ground contributed additional data for habitat plotting. Provinces surveyed by air in their entirety were Davao City, Davao del Sur, Lanao del Sur, and Misamis Occidental. Partially surveyed were Bukidnon, Davao del Norte, Davao Oriental, Lanao del Norte, North Cotabato, South Cotabato, Zamboanga del Norte, and Zamboanga del Sur. For other areas, the extent of the habitat was estimated from the topography and the density of human habitations, as printed on the air maps. Areas of questionable human density were plotted with the 3000 foot contour line as the perimeter of the eagle's habitat. By use of squared graph paper, the area of potential eagle habitat was determined from the air maps. The method does not account for the increase in surface area due to variation in altitude.

BEHAVIOR OF WILD EAGLES

Hunting techniques.—Monkey-eating Eagles hunt both singly and in pairs. I did not see a pair of eagles hunt together, but several natives and loggers

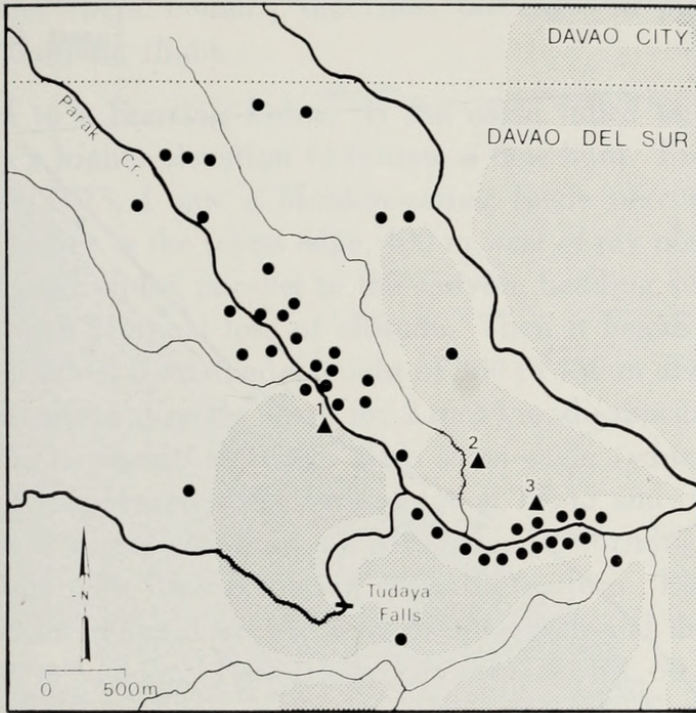


FIG. 2. Map of Tudaya Falls showing the distribution of cleared land (shaded area), forests (unshaded area), sightings of eagles (dots), and lookouts (triangles).

reported that pairs of eagles course through the forest looking for groups of monkeys. An engineer with the Misamis Lumber Co., stated that one eagle would distract the monkey, which would then be captured from behind by the other bird. He reported that, after the kill, the eagle covered the prey with its wings and then gutted and skinned the animal. Gonzales (1968) suggests that eagles are more successful when hunting in pairs than when hunting alone, because of the wariness of monkeys and the defense of the family unit by a lead male.

Thirty of 38 observations at Tudaya Falls, and several elsewhere on Mindanao, were of eagles on the hunt. Though I never observed a complete hunting sequence, because of the bird's sudden appearance and disappearance in the forest, a general 3 part hunting pattern can be reconstructed as follows (Fig. 3):

Part 1—Preparatory Period: On 28 September I watched an eagle perched on the lower branch of a tree above the near-vertical cliffs across the canyon from Lookout #3 (Fig. 2). There it called from 13:00 to 13:30. It then became increasingly alert to the sounds and movements in the canyon below. The usual position of a perched Monkey-eating Eagle is vertical, and, from a distance, the white breast and belly of a bird in this stance closely resemble the light-colored bark of the trunks and main branches of many Philippine

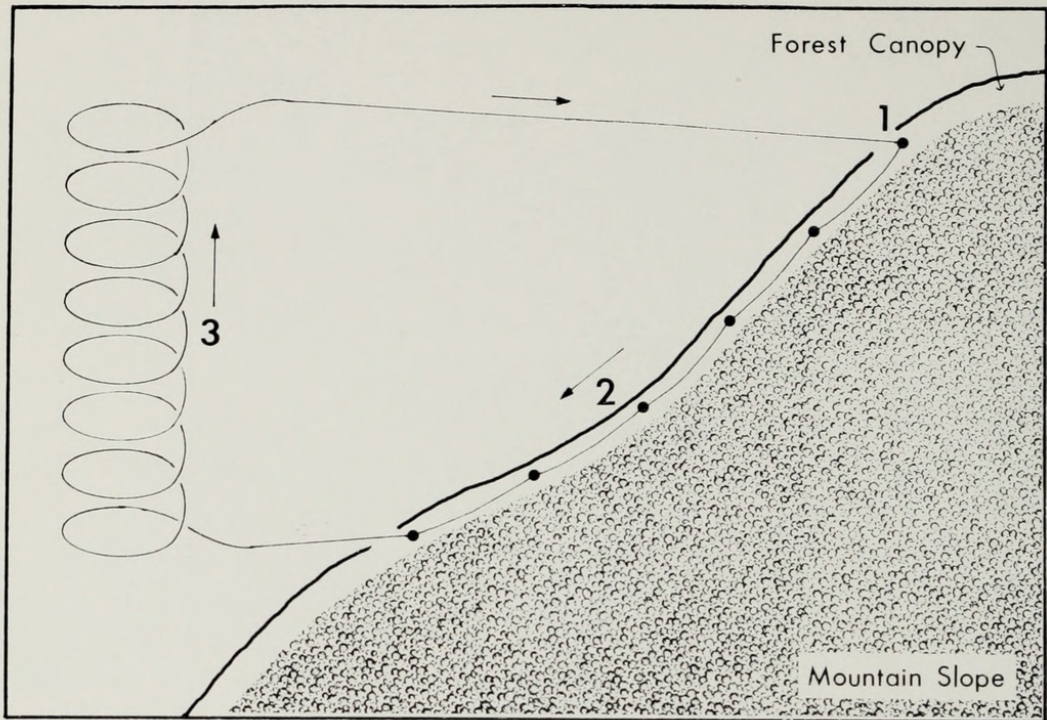


FIG. 3. Schematic representation of a hunting sequence, consisting of three parts: Part 1—a preparatory period; Part 2—the act of hunting within the forest canopy; Part 3—return to a starting point.

trees. This may be a form of cryptic coloration. Because I observed the preparatory period only once, I do not know if the calling activity is characteristic of all hunting sequences.

Part 2—The Act of Hunting: At 13:35, the eagle dropped from its perch and without flapping, glided about 75 m at a downward diagonal, along the canyon wall, to a resting place in a small tree growing out of the canyon wall. Because of the minimal vegetation growth, I could see the bird clearly. It remained there for 5 min surveying the surrounding trees. When the eagle seemingly perceived movements, it would shift its head to the right and left of the body axis, frequently twisting its head upside down. It made 6 more short flights before it disappeared at 14:35. In flights ranging from 75 to 125 m, the bird moved toward the floor of the canyon. The short direct flights from one perch to another usually within the forest canopy (Fig. 3) are the most common hunting technique used by the eagles when they work down a mountain slope or along a heavily forested ridge. I noted one variation from the pattern: on steep slopes, instead of gliding directly to a perch, the eagle would frequently drift out of the forest canopy away from the slope, circle one or more times, and then return to another perch. During these flights, the birds searched the forest around them, apparently for prey or for a suitable

perch. J. Hamlet (pers. comm.) described the eagle in pursuit of prey as having direct, flapping flight.

Part 3—Return to a Starting Point: If the eagle failed to capture prey, it would return to a higher elevation to initiate a new hunt. From Lookout #2, on 13 February 1973, I saw a Monkey-eating Eagle perched on the lower branch of a large tree at the forest edge, 400 m west of my position. At 09:45, it left the perch and glided parallel to the canyon, heading south for approximately 500 m, with minimal loss of altitude. Then it began to circle slowly, gaining altitude. When it attained a height of 300 to 450 m above its initial elevation, the eagle glided directly north for 2 to 3 km, disappearing into the forest higher up the mountain at 10:05. This same eagle (which had 2 left primaries missing) reappeared at the forest edge at 13:45 and repeated a similar sequence. I saw 3 eagles elsewhere on Mindanao performing this part of the hunting technique with little deviation from the pattern. Elevations attained varied from 150 to 700 m above the start of the spiral, and the distance glided varied from 400 m to 3 km. Part 1 lasted 35 min, Part 2, 60 min, and Part 3, 20 min.

If one assumes that the eagle used to exemplify Part 3 did not engage in any other activities besides hunting from the time it was first seen at 09:45 to the time it reappeared at 13:45, then this hunting cycle lasted 4 h. In another case, the cycle lasted 2 h 55 min. The times for the 3 hunts average 2 h 56 min.

Figure 4 indicates 2 peak periods in the day when eagles are likely to be seen. During these periods, the birds often emerge from the forest and fly to another location on the mountain, as described earlier. For the morning peak, 8 of 11 and 7 of 8 sightings made at 09:00 and 10:00, respectively, were of eagles ostensibly hunting. In the afternoon, the sightings at 13:00 and 14:00 were of eagles hunting. The peaks for calling (Fig. 4) suggest that vocalizations occur in Part 1 of the hunting cycle.

I observed the result of a successful hunt at Tudaya on the morning of 16 February 1973. While at Lookout #1, I heard an eagle calling at 08:20 from the side of the canyon. It was apparently perched in a tree, and I did not see it until 15 min later, when it stopped calling, flew over the canyon, circled once, then glided 150 m west up Parak Creek and landed in a small tree. I noticed a monkey in the eagle's talons when the bird flew past me. At the perch, the eagle resumed calling but did not mantle the prey or attempt to eat it. At 08:45, the eagle left its perch, glided west about 500 m, and disappeared into the forest. The manner in which it traveled from one resting place to another was similar to Part 2 of the hunting cycle.

Flight.—Brown and Amadon (1968) state that Monkey-eating Eagles "sometimes, but rather rarely, soar over the forest . . .," and Grossman

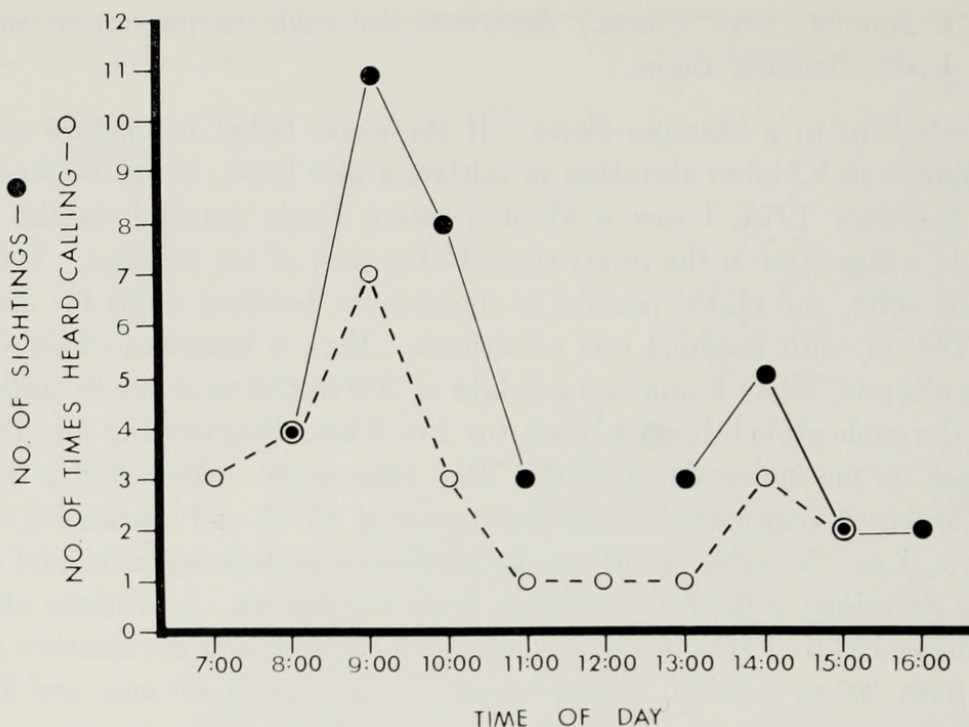


FIG. 4. Plot of time of day when eagles were sighted or were heard calling at the Tudaya Falls study area.

and Hamlet (1964) claim that these eagles have “flapping flight with little soaring.” With but 2 exceptions, I never saw eagles flap their wings, and I frequently saw birds soaring, though not for extended periods. In traversing an area, they would either glide in a straight line from a higher to a lower elevation or drift over a mountain slope or canyon, riding thermals and mountain updrafts. The most typical glide occurred when the eagles were hunting, and during it the wings were usually fully extended. Sometimes, when greater speed was required, the wings were folded partially or completely. A gliding or soaring Monkey-eating Eagle holds the wings horizontally.

When riding updrafts, the eagles usually circle, but they occasionally tack back and forth just above a ridge or glide in a straight line at high altitudes. In these situations, the birds usually either maintain or gain altitude. Circling flight exhibits at least 3 forms. During Part 2 of the hunting cycle, when the bird leaves the forest canopy, it may circle one or more times. During these circles, it maintains its altitude but drifts horizontally as it turns. It reenters the forest at about the same elevation as the exit point. Circling also occurs during Part 3 of the hunting cycle (Fig. 3) when the bird gains altitude. Here the eagle leaves the forest and, finding an appropriate updraft, circles slowly without flapping, gaining height all the time. The diameter of the circles I

observed varied from 25 to 40 m. At the highest point, the birds either glide directly toward a mountain slope, usually without loss in altitude and always without flapping, or begin a series of short glides and large sweeping circles. This third form is frequently initiated in instances where a bird has gained altitude. Sometimes, a bird drifts from the forest at a higher elevation and glides over the lower slopes, where it begins soaring. The duration of this third type of circling averaged 5 min. Gonzales (1968) once noted 3 eagles soaring together. I saw only 1 or 2 birds at a time, though I received a report (Engineer Rizado, pers. comm.) that as many as 7 eagles were seen soaring together.

The Monkey-eating Eagle is relatively short-winged and long-tailed. This structural pattern, which has been termed the Goshawk silhouette by Brown and Amadon (1968), is an adaptation of forest-hunting species which require maneuverability and quick bursts of speed to overtake their prey. Birds with this silhouette usually have flapping flight and seldom soar without flapping. Though the eagle is a forest-hunting bird and is capable of quick flapping flight in pursuit of prey, it is also a bird that frequently soars. This soaring ability is, energetically, clearly an adaptive advantage for this species which has a rather large territory.

Vocalizations.—Gonzales (1968), Seth-Smith (1910), and Whitehead (1899), have described the calls of the Monkey-eating Eagle. Whitehead (1899) rendered the call phonetically as “*w-aū waū*,” and Gonzales noted it as a long, mellow whistle ending sometimes with a downward inflection but usually with an upward inflection. He stated that the latter call was the one more frequently given by the breeding pair he was studying. When I heard eagles call, the downward inflection was most frequent. A series of 3 to 9 whistles was repeated at intervals ranging from 45 sec to 5 min. The individual whistles lasted 0.5 to 1.5 sec and were uttered at 1 to 2 sec intervals. The number of series varied from 1 to 15.

A possible juvenile bird at Tudaya gave a different call. Calling began in the morning with the typical downward inflection; but as the day progressed, the call changed to a more plaintive whine-whistle, as if the bird was distressed. Each whine-whistle lasted about 2 sec, and a series of these calls was repeated every 45 sec for up to 0.5 h. This type of vocalization resembled that of an eaglet calling after long periods without food as described by Gonzales (1968).

At Tudaya, adult eagles called (1) during Part 1 of the hunting cycle, (2) just after the capture of a prey, and (3) during and immediately after being pursued by Rufous Hornbills (*Buceros hydrocorax*). In the first 2 cases, the call had the typical downward inflection. In the third case, the call consisted of a single whine-whistle repeated every 10 sec. This was unlike the call

Gonzales (1968) described as "short, intense, high-pitched notes" during attacks on eagles by avian enemies.

Interspecific encounters.—The presence of a Monkey-eating Eagle in an area is often revealed by the noisy mobbing of the bird by groups of up to 20 Rufous Hornbills whose raucous call can be heard as much as 2 km away. The eagle tries to avoid the hornbills by flying from perch to perch within the forest. If unsuccessful, it leaves the canopy and begins circling slowly, gaining altitude as in Part 3 of the hunting cycle. The hornbills follow for awhile, but eventually are outdistanced and retire to the forest. I saw such mobbing on 5 occasions. On the average, the incidents lasted 2 to 3 min, but the duration varied from less than 30 sec to just over 15 min. Though I never observed contact, Gonzales (1968) reported that Rufous Hornbills actually strike the eagle's head. He also noted that Writhed-billed Hornbills (*Aceros leucocephalus*) and Large-billed Crows (*Corvus macrorhynchos*) mob eagles. Both these species were numerous at Tudaya, but I saw no interactions between them and eagles. I watched an Oriental Hobby (*Falco severus*) attack a Monkey-eating Eagle as the larger bird flew slowly at about 60 m above a ridge. Three times the falcon stooped, nearly grazing the eagle's head. During the harassment the eagle continued flying normally, but it landed shortly afterwards.

HABITAT AND HOME RANGE

Habitat.—The original habitat of the Monkey-eating Eagle on Mindanao was undoubtedly dipterocarp forest, which comprised 75% of the virgin forest in the Philippines (Whitford 1911). Dipterocarp forests are characteristic of moist plains and extend up mountain slopes to 800 m (Brown and Mathews 1914). Today eagles are mainly confined to the larger mountain masses (Rabor 1971), but at one time they occupied lowland forest down to sea level. A specimen taken in 1954 in Cotabato City at an elevation of ca. 15 m provided evidence for eagles using lowland forests. The highest elevation at which eagles occur is about 2000 m, where their preferred prey becomes scarce. At Tudaya, I saw eagles enter the forest to begin a hunt at about 1700 m.

As land has been cleared for agriculture and for lumber, the lower edges of the forests inhabited by the eagles have been retreating up the sides of mountains. The birds have partially adapted to this change by hunting over cleared land and living in second growth forest. This adaptive ability was first indicated by Whitehead (1899), who stated, "He [the eagle] is well known to the natives as a robber of their poultry and small pigs . . .," thereby implying that the birds forage near clearings. Gonzales (1968) described the habitat of the pair he studied as follows: "Some of the hills are still clothed

with original dipterocarp forest, but others are either naked... or covered with coarse cogon grass mixed with shrubs and small trees. The forested hills, however, have not remained virgin for they too have been invaded by the natives as well as logging concessionaires."

At Tudaya, the eagles' territory included cleared farmland, various stages of secondary growth, and virgin forest. The birds mainly confined their activity to virgin forest or advanced secondary growth (Fig. 2). Of the 11 eagles I sighted on Mindanao, 10 were in areas of virgin forest or in mixed virgin and advanced secondary forest.

Occasionally eagles were reported in areas where no typical habitat existed. Most of the reports probably resulted from misidentifications, but one confiscated eagle (LSUMZ 73747) was shot in a cornfield about 10 km from the closest forest. The abnormal occurrence of the bird at this location is possibly attributable to destruction of habitat in its former territory.

Apparently suitable Monkey-eating Eagle habitat on Mindanao in 1973 (Fig. 5a) comprised 29,000 km² (without allowing for increased area resulting from elevational differences) or about 30% of the 95,587 km² of land area of the island. The alarming rate of forest destruction was reported by Gonzales (1971), quoting the Philippine Free Press for 7 June 1969, which stated that the rate of deforestation in the Philippines at that time was 1 ha every 3 min. This problem is not new, however, for Whitehead (1899) stated: "The forests that are left in Samar are still very vast, especially on the Pacific Coast, but for miles inland those of the western coast have been destroyed, leaving ranges of low undulating clay hills chiefly covered with lalang grass. When this country has been passed, the traveler finds himself at an elevation of nearly 1,000 feet and meets with the true virgin forest of Samar. This forest is becoming annually smaller owing to the cultivation of hemp...."

Land clearing has confined suitable habitat on Mindanao to the mountain ranges, but even there the trees have been removed up to at least 500 m in most cases, and sometimes to as high as 1586 m (Gonzales 1971).

Nine eagles I sighted on Mindanao were associated with steep mountain slopes that formed the sides of deep ravines, canyons, or valleys. Data collected on the hunting and soaring behavior of the eagle indicate that it is well adapted to such topography, thus I believe that steep mountains are important in the eagle's habitat.

Home range.—Rabor (1968) believes that a pair of Monkey-eating Eagles have a home range comprising from 40 to 50 km². Gonzales (1968, 1971) says that the range can be as large as 100 km². Grossman and Hamlet report a smaller range, 31 to 34 km².

To determine the area used by the pair at Tudaya, I have drawn upon my own observations and those of Parks personnel as well as verbal reports by

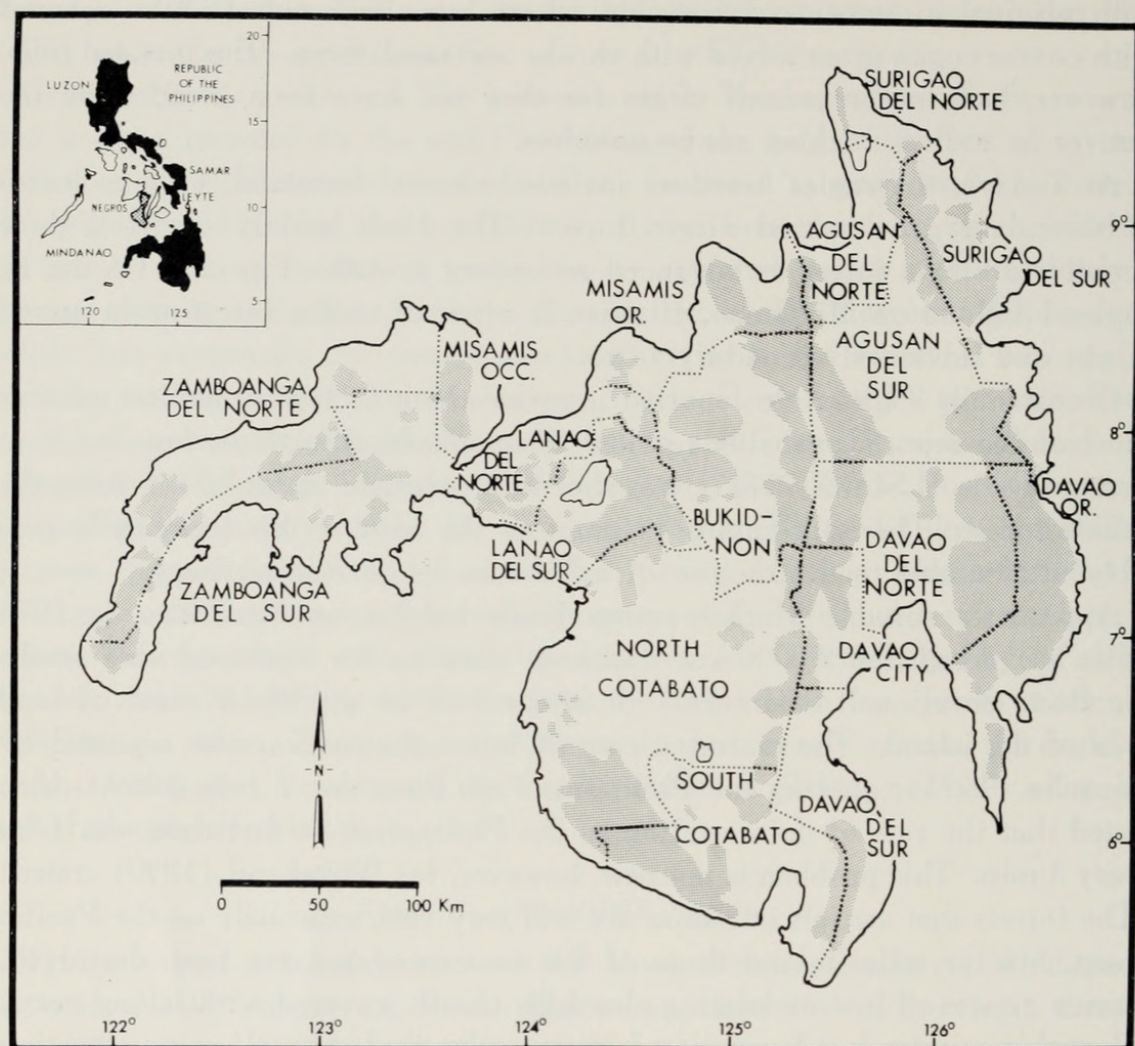


FIG. 5. a. Distribution of the remaining habitat for the Monkey-eating Eagle on Mindanao. b. (Insert) The Philippine Islands, showing the islands where the species has been positively recorded (colored black) and where it was believed present (shaded area).

the natives living there. Bagobo natives said that the eagles mainly confined their activities to the Tudaya canyon, Parak Creek, and the adjacent ridges and that they were rarely seen elsewhere in the area. Parks personnel first sighted the eagles at Tudaya on 8 April 1972. They found the birds to be restricted to the Tudaya Falls area also. My own observations (Fig. 2) confirm these reports. I saw eagles on 7 of 8 full days and 10 of 14 half days of surveillance. Clearly, the vicinity around Tudaya Falls has been a center of the eagles' activity for several years.

I calculated the area of the home range of this pair by 2 methods. Connecting the outermost points where eagles were sighted (shown in Fig. 2) forms a polygon with an area of 6.34 km², the minimum home range. A sec-

ond method was to determine the range by measuring the greatest distance between sightings. If this length is considered the diameter of a circular home range, the area would be 12.5 km². Since the range was measured as horizontal surface area and does not account for the increased surface resulting from elevational differences, the total area would be greater, perhaps twice as much. The adjusted home range would then be 12.68 km² (polygon method) to 25.0 km² (circular method). These figures suggest that the area necessary to support a pair of eagles may not be as great as formerly believed.

DISTRIBUTION AND STATUS

The Monkey-eating Eagle is known from accounts in the literature to occur on 4 of the larger islands in the Philippines: Luzon, Samar, Leyte, and Mindanao (Fig. 5b). John Hamlet, while visiting the island of Negros in 1945–1946, received a photograph of a Monkey-eating Eagle allegedly captured on that island. He personally sighted 2 birds soaring over a small island in the Surigao Straits, just north of the province of Surigao del Norte on Mindanao. These reports of eagles from additional islands suggest that the species was probably more widely distributed in the recent past. An account of the present and former status of the eagle on the islands from which specimens have been taken follows.

Luzon.—Earlier records of Monkey-eating Eagles from Luzon were frequently reported in the literature and chronologically follow: 1 killed near the Agus River in Rizal Province on 11 May 1907, the first specimen positively known from Luzon (McGregor 1907); 2 sighted near Montalban, Rizal Province on 13 August 1907 by W. P. Lowe (Seth-Smith 1910); 1 captured on Mt. Ballong, south of Imugan, Nueva Vizcaya Province in January 1917 (McGregor 1918); 1 captured near Pagbilao, Tayabas Province in July 1926 (McGregor 1927); 1 taken from Albay Province (Davidson 1934).

More recent data on the status of the eagle on Luzon were gathered by Rabor (1971) during collecting trips in 1959, 1960, and 1961. In the Cordillera and Ilocos mountain ranges in northwest Luzon, he received reports that eagles were last seen in the late 1930's. However, in the Sierra Madre Mountain Range in northeastern Luzon, including the provinces of Cagayan, Isabela, Nueva Vizcaya, and Quezon, the eagles were still being sighted by natives as late as 1960. A specimen captured by personnel from the Philippine Parks in the Isabela–Nueva Vizcaya territory in 1963 is the last known record from this island (Gonzales 1968).

Samar.—The type of the Monkey-eating Eagle was taken on this island by one of Whitehead's collectors in 1896 (Ogilvie Grant 1897a). Davidson (1934) cites one other record of the species on Samar; and Rabor (1971), on the basis of the absence of verbal reports in the 20 years prior to his

collecting trip in the north central mountains in 1957, considers the bird extinct on Samar. There are no recent data to confirm or refute this supposition.

Leyte.—For a long time, the only indication that the Monkey-eating Eagle occurred on Leyte was provided by Ogilvie Grant (1897a), who mentioned that J. Whitehead had heard the call of the eagle on this island. Recently, personnel from the Philippine Parks learned of the following records in the province of Southern Leyte: eagles reported sighted in 1951, 1963, and 1968; nest site with young observed in 1969; and 2 eagles killed in 1965 (S. E. Macanas, Regional Director of the Parks, pers. comm.). Macanas and others sighted the bird in Southern Leyte on 21 November 1970, and he estimated the number remaining there to be 8 to 10.

Mindanao, early population data.—There are many reports in the literature (Clemens 1907; Davidson 1934; McGregor 1907, 1921; Mearns 1905; Seth-Smith 1910) of specimens of the Monkey-eating Eagle acquired throughout Mindanao in the early part of this century, and apparently the first record came from 1 taken near Davao City on 3 September 1904 (Mearns 1905). Published population reports are lacking for the first 6 decades of its known existence on the island. However, Hamlet, who worked on Mindanao from 1945 to 1946, has informed me that the eagle was not uncommon there, since he located several active nests and knew of many other pairs.

In a recent report, Gonzales (1971) attempted to estimate the population of Monkey-eating Eagles on Mindanao in 1910, when the forests still covered 65% of the island. Assuming a home range of 100 km² and the use of all the available habitat, he calculated that at least 600 pairs existed on Mindanao in 1910.

Mindanao, recent population data.—According to the 3 surveys mentioned earlier, the population on Mindanao in 1969 and 1970 was between 36 and 60 birds. Careful examination of each report reveals discrepancies among the estimates. In 9 of 17 provinces, the authors agreed on the presence or absence of the eagles; and in 5 of the 9, the estimates were the same. However, Rabor (1971) reported the eagle in 4 provinces where neither of the other investigators did. Also, in 4 provinces, 2 of the authors were in agreement as to the eagle's presence, but the third considered it to be absent. A striking area of such disagreement is the province of North Cotabato. There, Alvarez (1970) recorded 11 birds, Rabor (1971) 8, and Gonzales (1971) none.

In Table 1, I have combined the population data of the 3 workers, and without duplicating records collected from specific locations, derived a population size of 70 birds. This number is 16.6% greater than the highest total and thus clearly shows their estimates to be low. Reasons for their low figures are that they counted only birds that they saw or that were reported to them,

TABLE 1
SUMMARY OF MONKEY-EATING EAGLE POPULATION DATA ON MINDANAO

Present Study January 1970–April 1973											
	Published Population Accounts			Habitat Remaining (km ²)	No. of Breeding Pairs Calculated	No. Actually Sighted ^c	No. Reported Sighted	No. Known or Reported Shot	No. Known or Reported Captured		
	1 ^a 1969	2 1969	3 1970							1–3 Combined ^b	
Agusan del Norte	–	–	–	–	9	–	–	–	–		
Agusan del Sur	–	–	2	2	32	–	–	(1)	–		
Bukidnon	3	3	2	3	29	–	2	1	–		
Davao City	–	–	–	–	9	(1)	(3)	–	–		
Davao del Norte	2	2	–	2	28	(4)	2(4)	(1)	(2)		
							6				
Davao Oriental	2	–	2	4	28	5(10)	9(15)	1(5)	1(3)		
						12	24	6	4		
Davao del Sur	9	3	4	11	8	3(5)	8(1)	1	(2)		
						5	9				
North Cotabato	11	–	8	11	37	3(6)	6	5(2)	3		
						6	7				
South Cotabato	4	4	4	6	21	–	6	1	2		
Lanao del Norte	2	2	2	2	7	–	2	–	–		
Lanao del Sur	–	–	6	6	18	–	–	–	–		
Misamis Occidental	2	2	8	8	4	–	6	–	2		
Misamis Oriental	–	–	2	2	9	–	–	–	–		

TABLE 1—Continued

Published Population Accounts				Present Study January 1970–April 1973					
1 ^a 1969	2 1969	3 1970	1–3 Combined ^b	Habitat Remaining (km ²)	No. of Breeding Pairs Calculated	No. Actually Sighted ^c	No. Reported Sighted	No. Known or Reported Shot	No. Known or Reported Captured
Surigao del Norte	—	—	—	300	3	—	—	—	—
Surigao del Sur	3	—	3	1600	16	—	—	—	—
Zamboanga del Norte	—	2	2	1800	18	—	8	1	1
Zamboanga del Sur	2	2	6	1400	14	(1)	2	—	—
Total	40	18	50	29000	290	11 (27)	51 (23)	10 (9)	9 (7)
		36 ^d	70			29	74	19	16

^a Published population accounts by 1, Alvarez (1970); 2, Gonzales (1971); 3, Rabor (1971).

^b Nonrepetitive combined data.

^c First numbers are data I collected. Numbers in parentheses are data collected by personnel from the Philippine Research, Parks, Range, and Wildlife Division of the Bureau of Forest Development. These unpublished data are subject to revision. Underscored numbers equal the combined total.

^d Gonzales (1971) considered the population size to be twice the total records he collected; thus $2 \times 18 = 36$.

they did not survey all the habitat available to the eagles, and they did not extrapolate their findings to include all the habitat.

Mindanao, present population data.—To determine a reasonably accurate population estimate of the Monkey-eating Eagle on Mindanao during the period January 1970 to April 1973, I used 3 censusing methods. Though each method differed slightly, all used the following formula to derive the total population size:

$$\hat{T} = (N/n) t$$

where \hat{T} = total population size; t = sample total; N = area of total habitat remaining on Mindanao; and n = area of habitat censused.

Similar to the one Gonzales (1971) used to estimate population size for 1910, the first method involved determination of the extent of the eagle's habitat remaining on Mindanao. The amount remaining (N_1) was found to be approximately 29,000 km² (see Fig. 5a and Table 1). Using the maximum home range size of 100 km² (n_1) for one pair ($t_1 = 2$), the total population estimate (\hat{T}_1) equals 580 birds.

A second method involved sampling an area of known size. The Mt. Apo range, west of Davao City proper, was chosen as the site for this study. The amount of suitable habitat in this area was found to be approximately 640 km² (n_2). Nine eagles were sighted in this area (t_2), but as it was physically impossible to cover the whole mountain range, there were probably more. Since the area of total habitat remains the same, $N_1 = N_2 = 29,000$ km², the total population estimate (\hat{T}_2) is 408 birds.

A third method entailed the visitation of as many areas as possible, collecting reports of eagles sighted, captured, or killed, and confirming as many reports as possible. The results of this method are shown in Table 1. The combined totals were: number actually sighted by official investigators, 29; number known or reported captured, 16; number known or reported shot, 19; and number of additional eagles reported to the investigators, 74. These data were obtained from 12 of the 17 provinces of Mindanao, but only 6 provinces (Davao City, Davao del Norte, Davao Oriental, Davao del Sur, North Cotabato, and South Cotabato) were visited regularly, but none was completely surveyed. A rough estimate of the area covered by this method would be 1/3 of the total habitat on the island; thus $n_3 = 1/3 N_1$. Excluding the numbers shot or captured, the total known population in the wild on Mindanao (t_3) was 103 birds (number actually sighted plus number reported sighted) during the period of investigation. This gives a \hat{T}_3 of 309 birds.

Implicit in these censusing methods are the following assumptions: (1) all the habitat is used by eagles; (2) all the birds in areas sampled were known;

(3) each pair of birds occupies a fixed range; (4) results found in one area are applicable to other areas not sampled; (5) population is stable; (6) ranges did not overlap.

The degree of variance among the different methods results from not meeting these assumptions entirely, because of insufficient data and the difficulties of censusing. But these techniques do provide a reasonable range (309 to 580) in which the number of surviving eagles probably lies.

Mortality should be considered in connection with these estimates since evidence indicates that the population is decreasing. No data are available regarding natural causes of mortality, such as disease and predation, but something is known about 2 unnatural factors. These are: (1) loss of habitat (discussed earlier in this paper); and (2) the shooting and capturing of wild birds.

During the course of this study, 35 eagles were known to have been taken from the wild either by being captured or shot (see Table 1). Since the duration of the entire study was 40 months, the average number of birds known to have been lost from the population was 0.87 birds per month or 10.4 birds per year. As previously mentioned, these data were collected from about 1/3 of the available habitat. Thus, the estimated number removed from the population is an average of 31.2 per year. This calculation introduces still another assumption, that each eagle, regardless of the degree of its isolation, has an equal chance of being captured or shot.

The importance of this unnatural mortality depends greatly upon the size and annual recruitment rate of the population. If the population does lie within the limits suggested by the census methods above, i.e., 309 to 580 birds, then the mortality rate would be from 10.1 to 5.4%.

With high reproductive success and a great percentage of young surviving to adulthood, the 5.4% and possibly the 10.1% mortality could be absorbed on an annual basis. However, few data are available concerning the reproductive biology of these birds. Grossman and Hamlet (1964) summarized what was known in 1964. "Although as a rule only one eaglet seems to survive in each nest, there may be two eggs, and occasionally (in at least one known instance) two young birds. The adults at several nest sites have produced young every year." Gonzales (1968) found that the pair he studied produced 1 egg and that 1 eaglet per nesting reached fledging age for 2 consecutive attempts. Rabor (1968) also feels that the eagles breed every year. We do not know the age at which these eagles attain sexual maturity nor do we know the proportion of fledglings that survive to that age.

The age of the individuals captured or killed also influences the importance of the unnatural mortality. If all were birds successfully breeding for the first time, the loss would be extremely damaging, as at the 10.1% level it

would nearly eliminate this, the most valuable age class. Since the ages of the birds that were captured or shot are not known in all cases, the effect of their loss from the population cannot be determined.

Population ecologists generally agree that a pair of a species requires and usually defends a certain semi-fixed area or territory. From this premise, it follows that the number of individuals a system can support is directly proportional to the available habitat. On Mindanao, the habitat is being destroyed by logging and other land clearing practices to such a degree that many birds are forced to leave their former range and search out new suitable habitat. I believe that a good percentage of the individuals that are captured or shot are birds whose habitat has been destroyed and that have become "surplus." Thus, presumably, even if they had not been captured or shot, they would not have contributed significantly again to the continuation of the species, unless they were able to establish a new territory in an unoccupied area.

The population surveys conducted have, in the main, shown that the eagles are rather evenly distributed over Mindanao. In some cases, especially parts of Davao del Norte, Davao Oriental, and North Cotabato, the eagles were as common in 1973 in the remaining habitat as they probably had ever been.

CONCLUSIONS AND RECOMMENDATIONS

The total range of the Monkey-eating Eagle has been greatly reduced during the time in which the species has been known. The reduction has been caused by the loss of the eagle's habitat, and, since the population varies directly with the amount of habitat, it has suffered also. In this paper, I have brought up-to-date most of what is known concerning this species, knowledge that is still extremely patchy. Though the population is larger than formerly believed, the census techniques used are based on a modest amount of data, and thus the resulting figure should be considered only a rough estimate. Since the third census included data from about 1/3 of the remaining habitat and was the most extensive survey, I am inclined to regard it as the most accurate. However, no census technique is entirely dependable, especially one based on extrapolation. Taking everything into account, I feel that the population on Mindanao during the period of investigation was about 300 ± 100 . The total number of individuals of the species is unknown, as little population work has been conducted on the other islands where it exists or could exist.

Alvarez (1970), Gonzales (1971), and Rabor (1968) have listed the following as the principal reasons for the eagles' decline: (1) the loss of the eagle's habitat by logging and agricultural practices; (2) shooting the eagles for trophies; and (3) capturing the eagles for private and public display. In addition, Gonzales (1971) and Rabor (1968, 1971) have presented excellent

recommendations for the conservation of the eagle. Though all their recommendations are sound, the 2 that I feel most important are:

1. Educational programs on the conservation of the natural resources in the Philippines, including wildlife.
2. The establishment of Wildlife Sanctuaries and the protection of lands from illegal logging and agricultural practices.

Though shooting and capturing of the eagle certainly contribute to the population decrease, I feel that the primary reason for its decline is the loss of habitat, and therefore, base my recommendations for the conservation of the species on maintenance of its natural environment, as follows:

1. The establishment of preserves in mountain ranges where logging and agricultural practices are not economically feasible. The size of these preserves should be at least 200 km², in order to encompass enough land for several pairs of birds.
2. For areas used as commercial forests, I suggest that the minimum interval between selective logging be 30 years, to allow regeneration of the *native* forest.
3. When areas are reforested, I recommend that a diversity of *native*, Philippine species be planted, thereby recreating as closely as possible, the natural state of the forest.

The destruction of forests in the Philippines is the result of broad social-economic problems that need not be described here. However, if the above minimal recommendations are heeded, they should eventually prevent any further decline in this rare endemic.

SUMMARY

A study of the Monkey-eating Eagle was conducted on the island of Mindanao, Republic of Philippines, from August 1972 to April 1973, in conjunction with the Philippine Research, Parks, Range, and Wildlife Division of the Bureau of Forest Development. Information on the hunting techniques, flight, calls, interspecific encounters, territory size, habitat, and population status are presented.

Though the eagles at one time occupied mature forests from sea level to 2000 m, the forests have been destroyed at lower elevations and thus suitable habitat and the eagles are primarily confined to the mountains. The size of the home range of a pair may range from 12 to 100 km².

The eagles are known to have occurred on Luzon, Samar, possibly on Negros, on a small island in the Surigao Straits north of Mindanao, on Leyte, and on Mindanao. Except for Leyte and Mindanao, no recent population data are available. An eagle was sighted on Leyte in 1970 and an estimated 8 to 10 birds were thought present at that time on the southern half of that island. On Mindanao, the combined data collected by the author and by personnel from the Philippine Parks from June 1970 to April 1973 suggest that

earlier population estimates of 36 to 60 for 1969 and 1970 were low, and that the population size for the period 1970 to 1973 was about 300 ± 100 .

The species is declining annually because of destruction of its habitat. Recommendations to prevent further decline are presented.

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NEW LIFE MEMBER



Robert S. Kennedy is a new life member of the Wilson Ornithological Society. He is presently completing his doctoral work at Louisiana State University. His research interests include studies of several species of raptors, including the Monkey-eating Eagle of the Philippines. Other studies deal with avian population dynamics. Mr. Kennedy has had extensive field experience in the Philippines and in North and South America. In addition to his research interests, Mr. Kennedy enjoys traveling, and collecting and marketing wildlife art.



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