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SHORT COMMUNICATIONS

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DISPERSAL OF PHILIPPINE EAGLES RELEASED IN THE FORESTS OF MINDANAO, PHILIPPINES

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KEY WORDS: *Philippine Eagle*, *Pithecophaga jefferyi*; dispersal; experimental release; movements; satellite telemetry.

The Philippine Eagle (*Pithecophaga jefferyi*) is critically endangered (IUCN 2014). Because of hunting and deforestation, their population has significantly declined, with an estimated <400 eagle pairs left in the entire country (Bueser et al. 2003, Salvador and Ibañez 2006). Studies suggest that survival and dispersal of juveniles and sub-adults may be an important factor contributing to the decline of this species (Miranda et al. 2000). The dispersal of a juvenile Philippine Eagle that fledged from its nest was described through radiotelemetry (Afan et al. 2000), but little else is known about dispersal and survival of young. With the goal of helping augment eagle populations in the wild, researchers released seven Philippine Eagles in the forests of Mindanao Island, Philippines, from 2004–2011. Recognizing the importance of understanding dispersal to species conservation (Clobert et al. 2001), we here report the results of the first systematic attempt to describe through satellite telemetry the initial dispersal patterns of the eagles released in the wild.

METHODS

We released and monitored three young captive-bred (CB) and four young rehabilitated (R) eagles in different years and in different sites in Mindanao, Philippines (Table 1). Prior to their release, each eagle was tagged with either a conventional or GPS satellite transmitter (also called platform transmitter terminals or PTT; Microwave Telemetry, Inc., Columbia, Maryland, U.S.A.; North Star Science and Technology, King George, Virginia, U.S.A.) paired with a VHF radio transmitter (Telonics, Inc., Mesa, Arizona, U.S.A.) at the back (Kenward 2001). Six of them were acclimatized first (Sherrod et al. 1981) in a hack box (Mount Apo Natural Park in Kidapawan City: 7°1.14'N, 125°14.0'E at 1278 masl; Mount Kitanglad Natural Park in Bukidnon Province: 8°11.16'N, 124°55.68'E at 1402 masl and 8°10.32'N, 124°54.84'E at 1656 masl) for at least 3 wk before release. The last eagle was released in Mount Kimangkil in Bukidnon Province immediately after it was transported to the site.

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The PTTs varied in their duty cycles (8 hr for 8 d; 11 hr for 5 d; 10 hr for 10 d). We monitored the movements of the eagles through the ARGOS Data Collection and Location System. ARGOS reports PTT locations with different estimated errors, but we included in the analysis only the PTT locations with <350 m estimated error. PTTs on three of the eagles provided continuous data over a 5-mo period. Because of PTT malfunctions, two eagles provided sporadic data for up to 5 mo. Data were insufficient for two eagles because of early mortality.

Using ArcView 3.2 and Manifold System, we plotted the locations of the eagles on land-cover maps overlaid with topographic maps at a minimum scale of 1:20,000. Using the Xtools function of ArcView 3.2, we characterized the movements of each eagle as polylines connecting consecutive dispersal points. Using the Spider Distance Analysis function of the Animal Movement Extension Program of ArcView, we measured the distances moved by the eagles from the hack box or the release site. We calculated the percentage of PTT locations (dispersal locations) that occurred in forest and non-forested habitat types, and also classified them by altitude.

RESULTS AND DISCUSSION

A substantial percentage of the dispersal points of three eagles (R1, R2, CB2) occurred in non-forested habitats below 1500 m (Fig. 1, 2). The percentage of dispersal points in the same habitat type and altitude was smaller for the other two eagles (R3, CB3), but both eagles explored such habitats farther than did the former three (Table 2). Eagle CB1 had some locations in forest habitats, but a considerable percentage of its dispersal locations were in non-forested habitats. Only eagle R4 was consistently found in forested habitat (Fig. 1).

Movements of Philippine Eagles in non-forested habitats were also observed for some nesting Philippine Eagle pairs and one juvenile in Mindanao (Bueser et al. 2003, Afan et al. 2000). Nine of the 13 nests of natural breeding pairs were within 100 m of the forest edge; breeding pairs also soared far beyond the forest and into the open areas (Bueser et al. 2003). A post-fledging juvenile Philippine Eagle also spent considerable time outside the forest, often perched on isolated medium-sized dipterocarp trees about

Table 1. Summary of the released Philippine Eagles, their sex and age at release, and the period covered by telemetry data. CB: captive-bred at the Philippine Eagle Center (PEC) in Davao City; R: rescued from different parts of Mindanao and rehabilitated at PEC before release. MANP: Mount Apo Natural Park; MKRNP: Mount Kitanglad Range Natural Park; MK: Mount Kimangkil.

EAGLE	RELEASE SITE	SEX	AGE AT RELEASE	PERIOD COVERAGE
CB1	MANP	M	1 yr 5 mo	27 April–26 September 2004
R1	MKRNP	M	~ 3 yr	29 March–4 July 2008
R2	MKRNP	F	~ 2 yr	26 July 2008–2 February 2009
CB2	MKRNP	M	3 yr 9 mo	7 November–3 December 2009
R3	MKRNP	F	~ 2 yr	29 October 2009–31 May 2010
CB3	MKRNP	M	1 yr	12 March–3 August 2011
R4	MK	F	~ 2 yr	25 May–24 October 2010

500 m from the forest edge (Afan et al. 2000). Similar dispersal patterns were also observed in other raptors (Ferrer and Harte 1997, Aradis and Carpaneto 2001, Seavy and Apodaca 2002, Balcerzak and Wood 2003, Dzialak et al. 2005, Mellone et al. 2012).

Deforestation through logging, resource extraction, urbanization, and agriculture has occurred in the Philippines beginning in the 1900s (ESSC 2002). The movements of the released Philippine Eagles into lowland, non-forested habitats suggest either preference or forced usage of such disturbed habitats; the eagles may have used those habitats because there are no longer sufficient forests at low elevations. Nonetheless, further studies are needed.

Eagle R3 showed extensive dispersal into riparian forests a few months after it was released. This eagle began its movements in the forest interiors near streams above

2000 masl, and later ventured into open areas by moving down the narrow riparian forest corridors surrounded by open areas below 1500 m. It was near the edge of one of these riparian forest corridors at 500–600 masl that the greatest dispersal distance for this eagle was recorded (Fig. 3).

Eagle CB3 remained near the hack box for almost 3 mo after it was released (Fig. 4). This initial dispersal pattern was also observed in other raptors that were rehabilitated and released into the wild (Hamilton et al. 1988, Martell et al. 1991, González et al. 1989, Csermely and Corona 1994, Rafanomezantsoa et al. 2002, Powell et al. 2002).

The observed dispersal patterns may be attributed to a number of factors including: the occurrence of thermals that sustain soaring flights among eagles (Newton 1979), landscape characteristics (Mayer et al. 2002), availability of

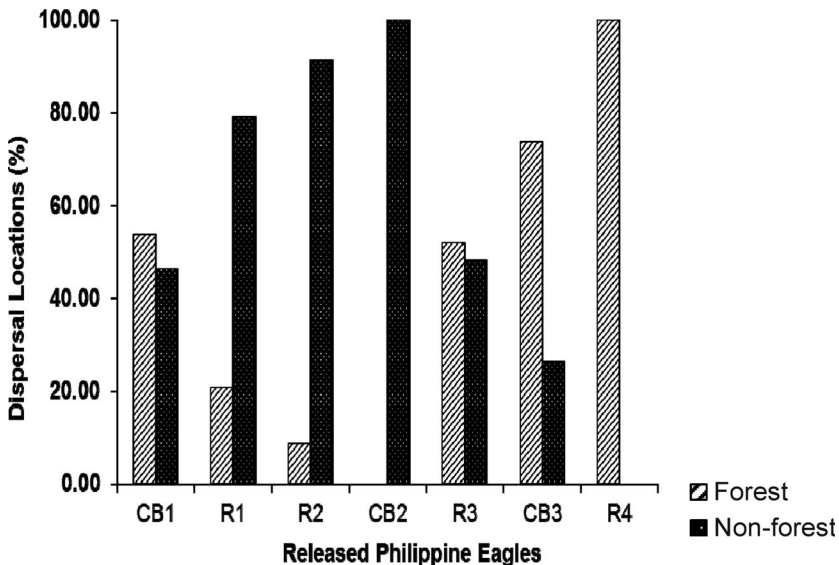


Figure 1. Percentage of dispersal locations of the seven young Philippine Eagles in forested and non-forested habitats during the first months after release.

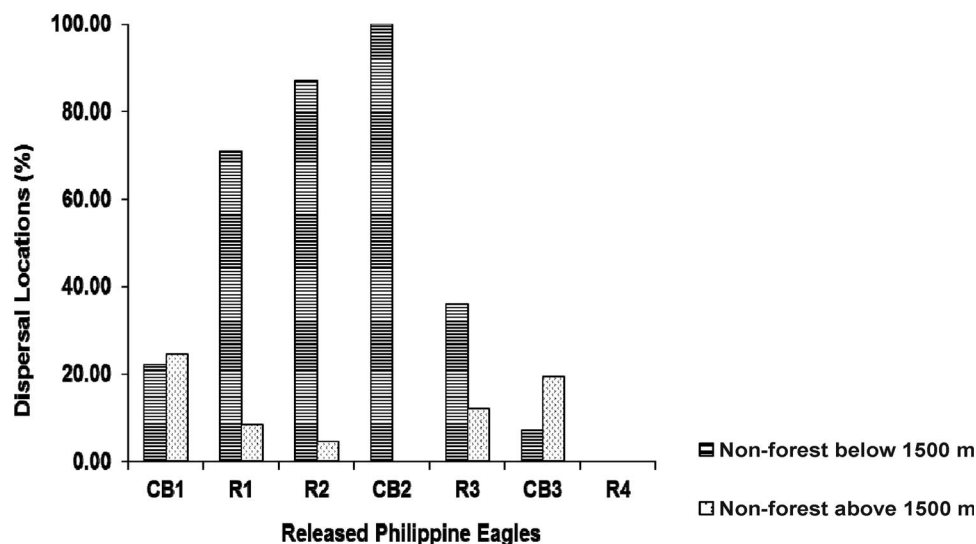


Figure 2. Percentage of dispersal locations of the seven young Philippine Eagles in non-forested habitats above and below 1500 m during the first months after release.

prey (Real and Mañosa 2001), age upon release (Newton 1979, Sarrazin and Legendre 2000), and life history (Sherrod et al. 1981, McPhee 2003). The individual differences in the dispersal patterns of the released eagles may be similar to the randomness of dispersal directions observed in other eagle species (Cadahía et al. 2005, Soutullo et al. 2006, Cadahía et al. 2010, Muñoz-López et al. 2012, Urios et al. 2014). Further studies are needed to substantiate the influence of various factors on movements of Philippine Eagles.

Upon reaching non-forested habitats, two eagles (R1, CB2) were deliberately killed <5 mo after their release. Two eagles (CB1, R4) survived longer and beyond the period covered in this study, but eventually died. Eagle CB1 was accidentally electrocuted by a power line in a non-forested habitat 10 mo after it was released. Eagle R4 dispersed farther from the release site, but it was

also persecuted and killed when it reached non-forested habitats >1 yr after its release. The deaths of released eagles as the consequence of their movements into lowland, non-forested habitats, and the eagle-human conflicts we documented there, emphasize the importance of considering these habitats in species management and conservation.

DISPERSIÓN DE *PITHECOPHAGA JEFFERYI* EN LOS BOSQUES DE MINDANAO, FILIPINAS

RESUMEN.—Durante el periodo 2004–2011 se liberaron tres individuos criados en cautividad y cuatro individuos rehabilitados de *Pithecophaga jefferyi* en los bosques del Parque Natural Mount Kitanglad Range, del Parque Natural Mount Apo y del Mount Kimangkil, en la isla de Mindanao, Filipinas. Con la ayuda de telemetría vía satélite, describimos los patrones de dispersión y la supervivencia de

Table 2. Longest dispersal distance (LDD) and features (habitat type and altitude) of the farthest dispersal points of the released eagles.

EAGLE	LONGEST DISPERSAL DISTANCE (m)	LOCATION OF FARTHEST DISPERSAL POINT	
		HABITAT TYPE	ELEVATION
CB1	11,716.68 ± 350	Forest	2000–2100 m
R1	8094.17 ± 350	Non-forest	<1500 m
R2	5842.25 ± 350	Non-forest	<1500 m
CB2	5937.49 ± 100	Non-forest	<1500 m
R3	16,361.67 ± 100	Non-forest	<1500 m
CB3	5042.69 ± 100	Non-forest	<1500 m
R4	4125.50 ± 350	Forest	1400–1500 m

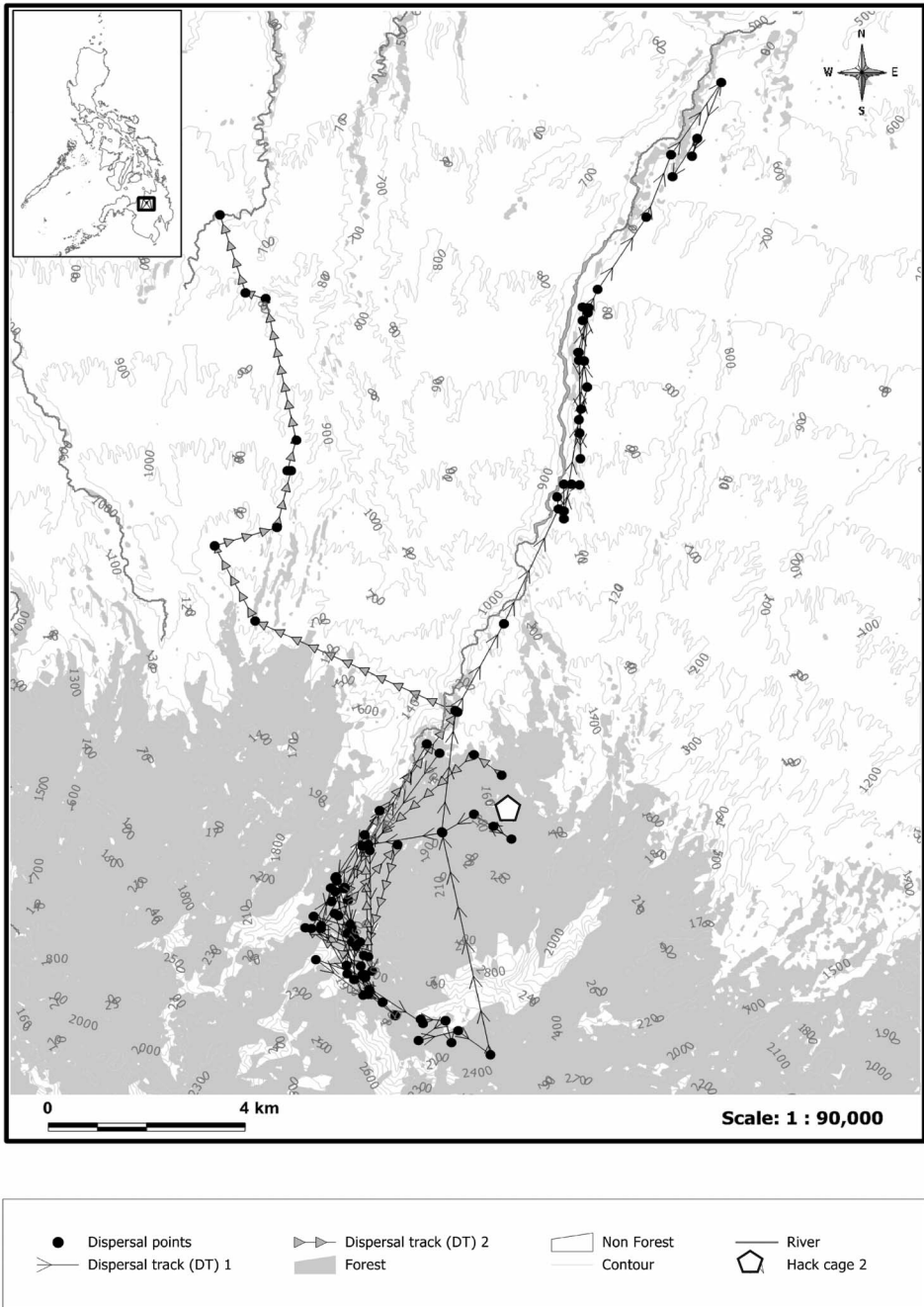


Figure 3. The dispersal of Philippine Eagle R3 from forest interiors in the south near streams above 2000 masl to riparian forest corridors to the northeast surrounded by open land (dispersal track 1: locations recorded from months 1–4 after release). The transmitter malfunctioned during months 5–6, and was replaced when the eagle was trapped in month 7 (dispersal track 2: locations recorded from month 7).

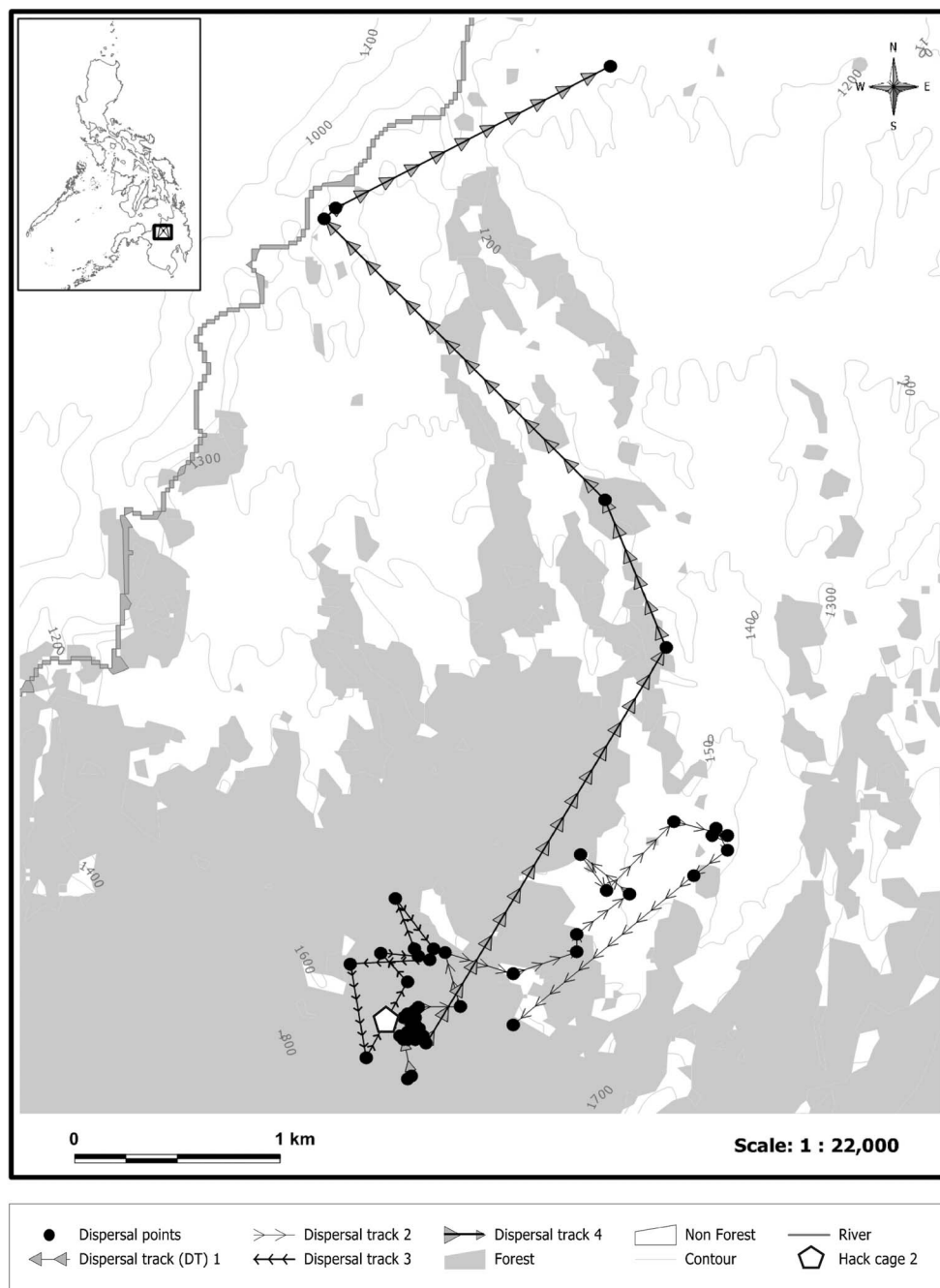


Figure 4. The dispersal of Philippine Eagle CB3 near hack box 2 after it was released (dispersal track 1: locations recorded during month 1). The eagle was then mistakenly caught by a local. After transportation back to the hack site and reacclimatization for a few days, the eagle was released again during month 2, during which time it eventually dispersed toward non-forested habitats (dispersal track 2: locations during month 2). When the eagle frequented human settlements, it was trapped by the researchers to prevent persecution and was reacclimatized for almost one month. When released again in month 4, the eagle initially moved within forest interiors, but eventually moved to non-forested

las águilas durante los primeros meses transcurridos tras su liberación. En Mount Kitanglad, tres águilas (dos rehabilitadas y otra criada en cautividad) se movieron consistentemente a hábitats no forestados por debajo de los 1500 m sobre el nivel del mar (snm). Otra águila rehabilitada siguió los estrechos corredores de bosque ribereño como ruta de dispersión. Una águila criada en cautividad permaneció cerca del lugar de liberación alrededor de tres meses tras su liberación. Otra águila criada en cautividad se desplazó hacia hábitats no forestados en una elevación menor en el Mount Apo, pero su exploración más lejana fue un bosque situado por encima de los 1300 m snm. Finalmente, un águila rehabilitada exploró áreas que se ubicaron a la mayor distancia del lugar de liberación, por encima de los 1300 m snm en Mount Kimangkil, pero también realizó numerosos intentos de llegar al borde del bosque a una altitud menor. Después de alcanzar hábitats no forestados, dos águilas (R1, CB2) fueron matadas de forma deliberada en menos de 5 meses después de su liberación. Dos águilas (CB1, R4) sobrevivieron más tiempo y más allá del periodo de duración de este estudio, pero murieron finalmente, una debido a una colisión con un cable de tendido eléctrico y la otra debido a persecución. Los grandes desplazamientos de las águilas y su persecución en hábitats no forestados de tierras bajas subrayan la importancia de estos hábitats para la conservación de la especie.

[Traducción del equipo editorial]

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habitats again (dispersal track 3; locations during month 4). The eagle was retrapped again as a precaution and released at the hack site at the start of month 5, after which it immediately started moving toward open areas again (dispersal track 4; locations during month 5).

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