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HOME RANGES OF BARRED (*MICRASTUR RUFICOLLIS*) AND COLLARED (*M. SEMITORQUATUS*) FOREST-FALCONS DURING THE BREEDING SEASON IN TIKAL NATIONAL PARK, GUATEMALA

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Resumen. – Área de acción de Gavilancito de la Selva (*Micrastur ruficollis*) y Gavilán de Collar (*Micrastur semitorquatus*) durante la temporada reproductiva en el Parque Nacional Tikal, Guatemala. – El Gavilancito de la Selva (*Micrastur ruficollis*) y el Gavilán de Collar (*M. semitorquatus*) son especies comunes y ampliamente distribuidas en el Neotrópico pero no existe información sobre sus áreas de acción (del ing. "home range") durante la temporada reproductiva. Se determinaron las áreas de acción de individuos residentes, de ambas especies, durante la temporada reproductiva (Febrero–Agosto) en el Parque Nacional Tikal, Guatemala, desde 1989 hasta 1992. El superficie promedia del área de acción de 13 machos reproductivos de Gavilancito de la Selva fue 125 ha (100% de polígono convexo mínimo; PCM), y el área de acción promedio de tres hembras reproductivas fue 74 ha (100% PCM). El solapamiento entre las áreas de acción de los machos reproductivos fue 5,5% (PCM). El área de acción de un macho adulto no reproductivo se solapó un 52% (100% PCM) con las áreas de los machos reproductivos. Las áreas de acción de dos machos reproductivos de Gavilán de Collar fueron de 713 y 1176 ha (100% PCM), respectivamente. El área de acción de un macho reproductivo del Gavilán de Collar (masa media = 587 g) abarcó el área correspondiente a seis machos reproductivos de Gavilancito de la Selva (mas media = 168 g).

Abstract. – Barred (*Micrastur ruficollis*) and Collared *(M. semitorquatus*) forest-falcons are common and widespread species throughout the Neotropics, but no information exist on their home ranges and movements during the breeding season. Home ranges were determined for resident Barred and Collared forest-falcons during the breeding season (February to August) in Tikal National Park, Guatemala from 1989–1992. Average home range size for 13 breeding male Barred Forest-Falcons was 125 ha (100% minimum convex polygon; MCP), and for three breeding females was 74 ha (100% MCP). Overlap among breeding male home ranges was 5.5% (MCP). One adult non-breeding male's ranging area overlapped with breeding males by 52% (100% MCP). Home ranges for two breeding male Collared Forest-Falcons was 713 and 1176 ha (100% MCP). The home range area of one breeding male Collared Forest-Falcon (average mass 587 g) encompassed six breeding male Barred Forest-Falcons (average mass 168 g) home ranges. *Accepted 20 March 2007.*

Key words: *Micrastur ruficollis*, Barred Forest-Falcon, *Micrastur semitorquatus,* Collared Forest-Falcon, home ranges, breeding season, Tikal National Park, Guatemala.

INTRODUCTION

Among Neotropical birds, raptors are poorly known, especially the forest-dependent species which are inconspicuous in their habits. The secretive forest raptors of the genus

Micrastur are among the least-studied raptors and most accounts of their basic natural history come from incidental and anecdotal observations (Thiollay 1985, Bierregaard 1995). Recently, new information has been provided on natural history, food habits, productivity, and population dynamics from an intensive field study targeting Barred (*Micrastur ruficollis*) and Collared (*M. semitorquatus*) forest-falcons. They are cavity nesters, lay 2–3 eggs, fledge young in 35–50 days, and feed mainly on lizards, birds, and mammals (Thorstrom *et al.* 1990, 2000a, 2000b; Thorstrom 2000). Population densities have been estimated for several *Micrastur* species from surveys and census work in South America (Thiollay 1989a, 1989b; Terborgh *et al.* 1990, Robinson & Terborgh 1997), but little is known about breeding activities and movements. The only study to date that has given an estimate of home range size was in Brazil for three radio-tagged Lined Forest-Falcons (*M. gilvicollis*), but there was no reference to the breeding period (Klein & Bierregaard 1988). No other detailed observations or studies have been made on the home ranges of any *Micrastur* species, especially during the breeding season. In this paper, I report on home ranges of Barred and Collared forest-falcons during the breeding season in northeastern Guatemala.

STUDY AREA

Observations were made of Barred and Collared forest-falcons from March to July during the breeding seasons of 1989 to 1992 at Tikal National Park (17°13'N, 89°36'W) in the Petén Department of northeastern Guatemala. The forest is characterized as a lowland, dry, semi-deciduous, tropical forest with an elevation ranging from 200 to 350 m. A description of the habitat presently surrounding Tikal is given in Schulze & Whitacre (1999). Two extremes of this forest type continuum are upland forests (tall, semi-evergreen forests on well-drained shallow soils) and low forests (low in stature, open canopy with dense understory, occurring in low-lying sites of deep clay-rich soils, subject to seasonal flooding and drought).

METHODS

Forest-falcon radio-tracking. Barred and Collared forest-falcons were captured (see Thorstrom 1996), banded and a selected number were radio-tagged for observations on nesting activities and foraging and ranging behavior. Transmitters (Holohil Systems Ltd.) were attached either dorsally to the base of two tail feathers, with the antenna tied along the shaft of one feather (Kenward 1978), or by means of teflon ribbon backpacks (Dunstan 1972, Smith & Gilbert 1981). Transmitters weighed between 3.5 and 6.5 g for Barred Forest-Falcons and 6.0 and 18.0 g for Collared Forest-Falcons and were less than 3.5% of male and 2.5% of female body weights, respectively. Transmitters lasted 3–12 months for Barred Forest-Falcons and 6–18 months for Collared Forest-Falcons.

Signals were detected with Wildlife Materials Model TRX-1000 receivers, using hand-held, three-element folding directional yagi antennas. Under the best conditions in the forest, signals were detectable to less than 300 m (from the bird's location). Telemetry data (fixes) were taken systematically by recording bird locations hourly during 1- to 6-h tracking periods (Andersen & Rongstad 1989) every 2 to 4 days in the mornings and afternoons. All radio-tagged falcons were radio-tracked by foot. Due to the secretive nature of forest-falcons, their wariness of humans, and the dense understory, we tried to visually observe the forest-falcons. On many occasions it was too difficult to observe them, so my assistants and I located the forest-falcons by signal strength while

TABLE 1. Home ranges of adult Barred Forest-Falcons (*Micrastur ruficollis*) during the breeding season defined by minimum convex polygon (MCP) method in Tikal National Park, Guatemala from 1989 to 1992.

Territory	Year tracked	100% MCP (ha)	95% MCP (ha)	No. of fixes
Breeding adult males				
Complex R	1989	151.4	128.5	69
Mundo Perdido	1989	76.2	62.3	101
Temple 5	1989	114.2	98.4	46
Caoba Trail	1989	124.4	114.3	83
Temple 4	1989	122.1	102.9	274
La Garita	1989	139.3	113.4	123
Ramon	1990	78.6	63.5	90
La Curva	1991	127.6	95.8	82
Silion	1991	158.1	97.2	76
Basurero	1991	174.8	137.7	69
Complex R	1991	107.1	86.9	71
Complex R/Caoba Trail	1992	99.4	89.1	52
Group F	1992	150.9	125.0	40
GEOMETRIC MEAN		121.4	98.6	
Non breeding adult male				
Complex P	1991	100.1	72.6	74
Breeding adult females				
Mundo Perdido	1989	67.0	–	51
Temple 4	1989	88.0	–	61
Ramon	1990	67.0	–	68
GEOMETRIC MEAN		73.4		

walking around the birds to verify their general position.

Range analysis. Nonparametric estimations were used to determine home ranges. Data were analyzed by Program Home Range (Akerman *et al.* 1990) and Ranges IV (Kenward 1990) to estimate the minimum convex polygon (MCP) size (Mohr 1947, Southwood 1966). I could not locate forest-falcons randomly and had to change to systematic relocations, thus violating time independence and autocorrelation principles. The MCP circumscribes the smallest convex polygon that encloses the outermost points of the radio relocations but shows larger increases in home range areas as sample size increases (number of locations) (Boulanger & White 1990).

I used the 100% MCP (using all detections), and 95% MCP, that omitted outlying points for Barred Forest-Falcons to obtain a more accurate home range estimate, and 100% MCP for Collared Forest-Falcons. Measurement of home range size is sensitive to sample size (Schoener 1981), with estimated home range sizes increasing asymptotically (Bekoff & Mech 1984) with an increasing number of fixes. Home range estimates are presented as geometric mean ± SD.

RESULTS

Home ranges were determined during the

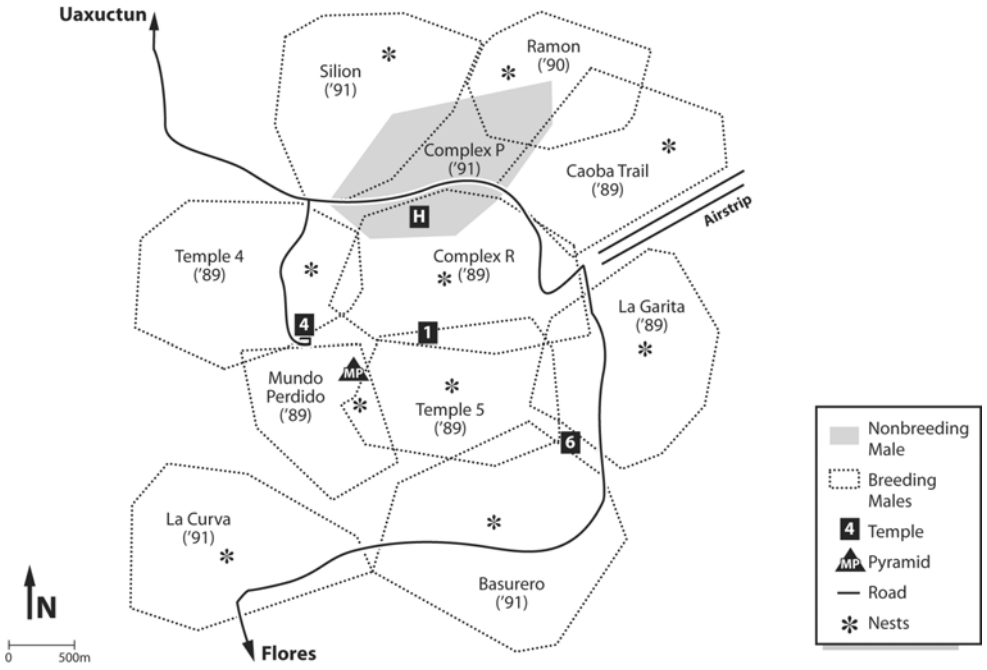

FIG. 1. The 100% minimum convex polygon (MCP) home ranges of male Barred Forest-Forests (*Micrastur ruficollis*) in Tikal National Park, Guatemala during the breeding seasons 1989–1991 (dark shaded home range polygon is of the one non-breeding male).

breeding season for 16 Barred Forest-Falcons and 7 Collared Forest-Falcons from 1989 to 1992. We collected 2033 locational fixes for the 22 individual forest-falcons. All tracking of radio-tagged forest-falcons took place between February and August of 1989–1992, hence home ranges, including those of non-breeders, were recorded during the breeding season. Nonbreeders had no dependent young during the time they were radio-tracked.

For most breeding male Barred Forest-Falcons, the asymptote was reached at 50 ± 5.0 locational fixes, beyond which additional locations did not result in a larger home range estimate. For breeding and non-breeding adult Collared Forest-Falcons, the asymptotic home range estimate was reached at 70–90 locational fixes.

Breeding Barred Forest-Falcons defended home range boundaries with breeding neighbors but this was not observed with the non-breeding adult male Barred Forest-Falcon or between neighboring breeding Collared Forest-Falcons. Home range boundary defense with breeding Collared Forest-Falcons might occur but was never observed during radio-tracking sessions.

Home range estimates for Barred Forest-Falcons. The geometric mean 100% MCP home range for 13 breeding males was 121.4 ± 29.9 ha (range 76.2–174.8), and for one non-breeding male was 74.8 ha (Table 1). For the same 13 breeding males, the average 95% MCP home range estimate averaged 101.2 ± 22.9 ha (range = 62.3–137.7 ha). All home ranges of Barred

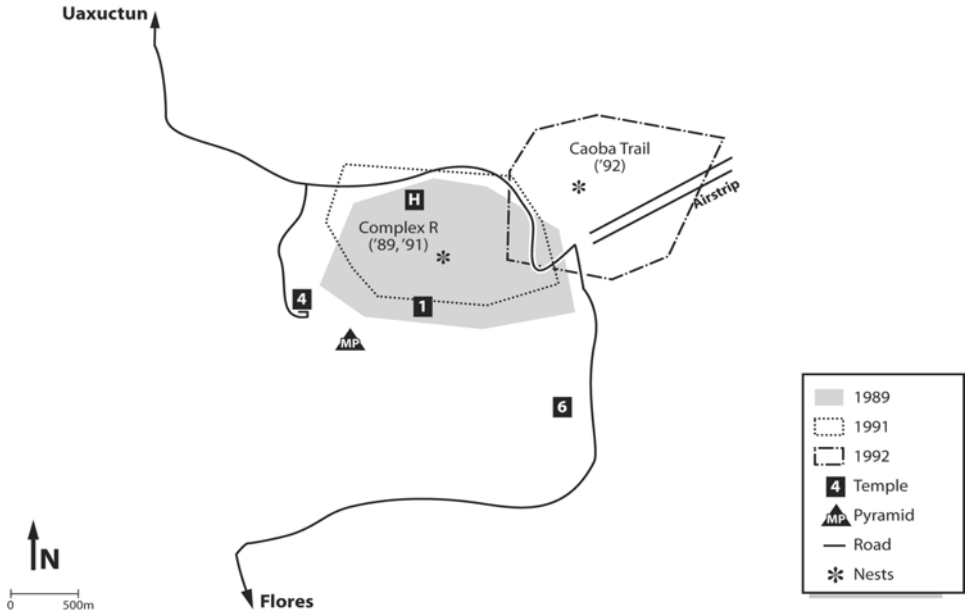

FIG. 2. The 100% minimum convex polygon (MCP) home range of the breeding male Barred Forest-Falcon (*Micrastur ruficollis*) in Tikal National Park, Guatemala during two breeding seasons on the same territory in 1989 and 1991 and his breeding home range switch in 1992.

Forest-Falcons were in the upland forest habitat.

A home range map was created on the 100% MCP for one non-breeding and 11 breeding males (Fig. 1). Using the 100% MCP, there was 5.5% overlap among home ranges of 11 breeding males. The home range of the one non-breeding adult male overlapped those of breeding males by 51.8% (100% MCP).

One breeding male was followed during three different breeding years and had a 95% MCP of 128.5 ha (1989), 86.9 ha (1991) and 89.1 ha (1992) (Fig. 2). In 1992, this male paired up with his neighboring female at her nest site. His home range during this period was mostly in his neighbor's territory. For three breeding females radio-tracked late in the nestling period, the geometric mean 100% MCP home range estimate was 73.4 ± 12.1 ha (range = 67.0–88.0 ha) (Fig. 3). Males had on average significantly larger home ranges than females for MCP ($t_{.05(13)} = 2.85$).

Home range estimates for Collared Forest-Falcons. Estimated home ranges for Collared Forest-Falcons ranged from 229 to 1176 ha (100% MCP) (Table 2; Fig. 4). Home ranges of Collared Forest-Falcons were predominantly in denser habitat composed of transition and low forests.

While breeding, the Aguadita male had an estimated home range 100% MCP of 1176 ha, while the banded La Curva male as a non-breeder ranged over 885 ha and as a breeder over 713 ha.

One breeding female had an estimated MCP home range of 1098 ha, while three

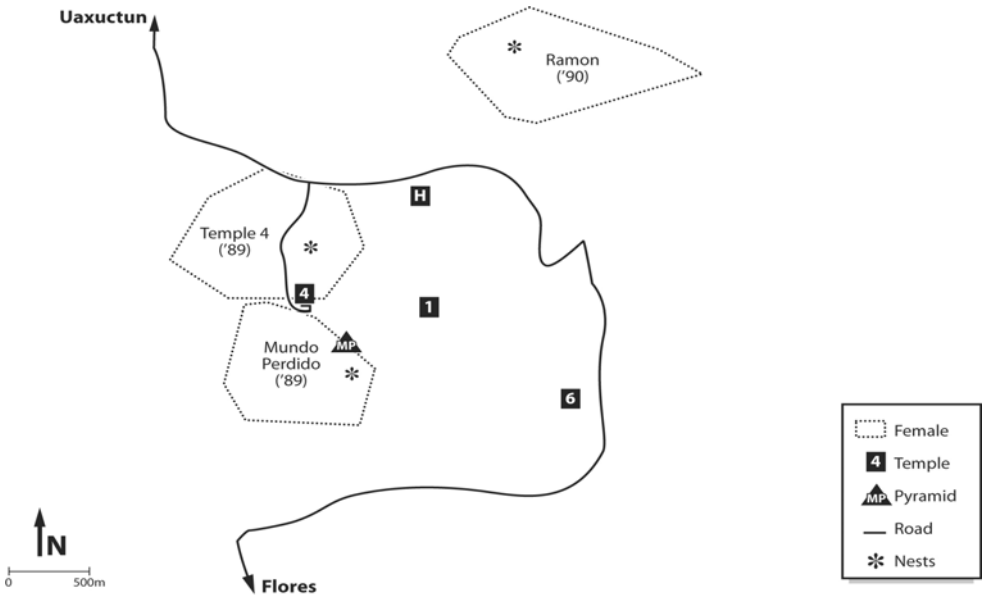

FIG. 3. The 100% minimum convex polygon (MCP) home ranges of three female Barred Forest-Forests (*Micrastur ruficollis*) in Tikal National Park, Guatemala during the breeding seasons 1989 and 1990.

non-breeding females had home ranges estimated at 229, 572, and 535 ha (mean = 445 ± SD 188 ha). During incubation and the first part of the nestling period, females were closely tied to nest vicinities.

Other birds monitored by radio telemetry were an adult-plumaged female trapped in May 1989 and an adult male trapped in March 1991 south of the park. This female ranged over a large area around the old airstrip in Tikal and appeared to be a nonbreeder without a defined territory. Her signal disappeared one month later when either the radio failed or she moved out of radio contact. The adult male was radio-tagged several kilometers south of the southern park boundary, near the village of Caoba. This male was impossible to radio-track by foot as he traveled great distances in the human-altered farming landscape of this area, and two weeks after radio-tagging his signal disappeared. When I examined the nest of this male it contained three addled eggs. The nest appeared to be abandoned, and we believe that one or both adults were killed during this nesting attempt.

DISCUSSION

Home range estimates for Neotropical raptors are poorly known and very few studies have attempted to determine the ranging area and spatial requirements of birds of prey in Neotropical environments. Andersen & Rongstad (1989), and Ackerman *et al.* (1990) discuss the values of the MCP home range estimation technique. The MCP was best suited for this study, rather than more sophisticated statistical models due to the way the data were collected.

The home range size of Barred Forest-Falcons from this study was six times less than reported for the same species in French Guiana (Thiollay 1989a). The reasons for these differences may be attributed to the fact

TABLE 2. Home ranges during the breeding season of breeding and nonbreeding adult Collared Forest-Falcons (*Micrastur semitorquatus*) defined by minimum convex polygon (MCP) methods in Tikal National Park, Guatemala from 1989 to 1991.

Territory	Year tracked	100% MCP (ha)	No. of fixes
Breeding adult males			
Aguadita	1990	1176.0	160
La Curva	1991	712.6	90
Nonbreeding adult male			
Naranajal	1990	885.4	90
Breeding adult females			
Aguadita	1990	1098.1	103
Nonbreeding adult females			
Pista	1989	228.9	40
Cedro	1990	572.0	90
Pucté	1991	535.2	30

that French Guiana home ranges were determined from density estimates and not actual ranging behavior. In another home range comparison from density estimates, Barred Forest-Falcons in Guatemala had an average home range nearly twice the size in Amazo-

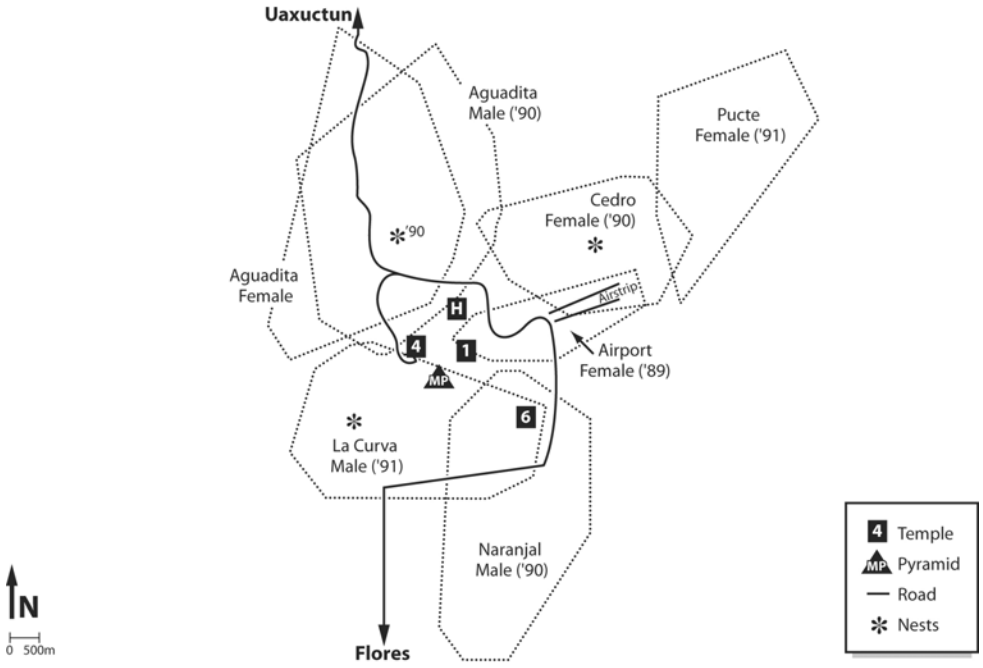

FIG. 4. The 100% minimum convex polygon (MCP) home ranges of Collared Forest-Falcons (*Micrastur semitorquatus*) in Tikal National Park, Guatemala during the breeding seasons 1989–1991.

nian Peru (Terborgh *et al.* 1990). In addition, there are habitat differences between the drier forests in Guatemala versus the wetter forests in French Guiana and Peru (variability in environmental factors), and the occurrence of the two species of forest-falcons in Guatemala compared to the three to five species occurring sympatrically in the two other studies may be the reason for some of the differences observed among the Barred Forest-Falcon home ranges.

The home range size for Barred Forest-Falcons from this study were also twice the size of radio-tagged Lined Forest-Falcons studied in Brazil (Klein & Bierregaard 1988). The reasons for this may be attributed to the slightly larger size of Barred Forest-Falcons (range 156–301 g, this study), which may require a larger ranging area than Lined Forest-Falcons (range 172–223 g, del Hoyo *et al.* 1994). In addition, the seasonal demand for food of male Barred Forest-Falcons is at its greatest during the breeding season when the male is provisioning the female and young; the home ranges in Tikal National Park were determined during this period, contrasting with Lined Forest-Falcons which may not have been breeding, and this may be the case for the studies in French Guiana and Peru.

In Tikal National Park, the adult male Barred Forest-Falcon at Complex R had slight home range size differences between the 1989 to 1991 breeding seasons. This might be attributed to the number of fledglings successfully raised in both years. In 1989, three young fledged and in 1991 two young fledged. The male may have searched over a greater area for food in 1989 than in 1991, leading to an increase in the home range estimation.

In 1992, this male lost his mate in April and was later located and radio-tagged as a breeder with the neighboring Caoba Trail female, who had also lost her mate during the same period. This territory switch by the Complex R male showed that he ranged in part of his former area, the eastern part of his old Complex R territory, and shifted most of his ranging area into the new territory that the previous Caoba Trail male had utilized and defended. The new Caoba Trail male ranged over some of his former territory, nearly a 20% overlap into his 1989 and 1991 home range areas during his ranging pattern in 1992.

Referring to the maps of the Barred Forest-Falcons home range representations, the areas around Temple 4 and Mundo Perdido where no territories are indicated were man-made clearings in the forest which the forest-falcons avoided. These maps were constructed from data collected during different breeding seasons from 1989 through 1991 and I believe they are an accurate representation of the average year-to-year range sizes of breeding Barred Forest-Falcons in the area we studied. Moreover, I believe this spatial arrangement and density of nesting pairs is typical of that found in areas of upland forest throughout Tikal, northeastern Guatemala and surrounding areas of similar forest type.

One non-breeding adult male Barred Forest-Falcon overlapped with neighboring breeding males by at least 50%. This non-breeding male appeared to occupy an area between breeding male territories but also ranged farther into the territories of neighboring breeding males than breeding males ranged into one another's territories. This male appeared not to present a threat to the breeding males and was constantly moving in and out of his neighboring males' home ranges without encountering agonistic confrontations. Breeding adult males barely overlapped in their home ranges, showing less than 5% for all ranges and appeared to maintain well defined territories. Several incidents were observed when two breeding/territorial males were observed in agonistic conflicts, with loud and repetitive calling towards each

other. The end result of this activity was the chases that broke off after several minutes of pursuing and one bird retreating into the safety of his territory.

Collared Forest-Falcons are the largest forest-falcon species, and 3–4 times larger than the Barred Forest-Falcons (see Thorstrom 2000). This may largely explain why they occupy home ranges nearly 7–8 times as large as those of Barred Forest-Falcons. Home ranges of the Aguadita Collared Forest-Falcon pair encompassed territories of at least six pairs of Barred Forest-Falcons. There were no territorial disputes or agonistic behavior observed between neighboring Collared Forest-Falcons. The larger home range size for this species may be too difficult to defend and this most likely reduces the chance of encounters between neighboring birds.

The ranging area of the one breeding female Collared Forest-Falcon was slightly larger than the male's home range area, basically because the female appeared to roam in an unspecified area and tended to avoid contact with her young after they fledged. The female rarely provided food during the post-fledgling period, and was not associated with a specific area or activity, unlike the male who was the main food provider to the fledglings until the young male was killed. After this predation incident, an unknown adult male provided food to the fledgling female. We lost telemetry contact with her 10 weeks after fledging. This breeding female also had a larger home range than those estimated for the non-breeders partly because our telemetry efforts on this individual were during the early part of the fledgling period, when she ranged widely and was not entirely responsible to her fledglings.

To characterize spatial needs of this species, we used the mean home range size of breeding males, based on the foraging demands of the male and his spatial needs to locate and capture prey, which were probably maximal during this period of the breeding season. Females during the post-breeding and non-breeding periods appeared to wander a great deal and hence, we feel, would be less useful in estimating the spatial needs of a territorial pair. Two breeding males had 100% MCP home range of 7.1 and 11.8 km^2. Home range size no doubt varies among pairs and over time, depending on habitat and other factors including density of prey, experience, climate, and other unknown environmental factors. However, as an overall estimate of home range size, we regard the figure of 8–11 km^2 as appropriate; this accords well with the mean nesting density we calculated of 1 pair per 9.6 km^2 (Thorstrom 2001).

Barred Forest-Falcon home ranges were in open upland forests whereas Collared Forests-Falcons had home ranges in the denser transition and low forests. For both Barred and Collared forest-falcons there was little overlap in their estimated home ranges with breeding neighbors, even when estimated in different years; this suggests fairly stable, saturated, and rigidly defined spatial use patterns and home ranges characteristic of long-lived birds. The distribution of home ranges suggested that suitable habitat was largely filled with bordering home ranges or territories, rather than having significant amounts of unused space between neighboring territories.

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