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BREEDING BIOLOGY AND HOME RANGE OF TWO *CICCABA* OWLS

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ABSTRACT.—Thirteen Mottled Owl (*Ciccaba virgata*) nests are described from Tikal National Park, Peten, Guatemala. These were cavities in live trees at a mean height of 12.9 m. Mean clutch size was 2.2 (range 2–3). Nine nests fledged 16 young. Young left the nest at 27–33 days of age. Mean home range size was 20.8 ha (85% harmonic mean) for six radio-tagged breeding males, and density was seven breeding adults per km^2. Mottled Owls were found to be highly territorial, sedentary, and monogamous. Four nests of the Black-and-white Owl (*C. nigrolineata*) are also described. All were in epiphytes in large, live trees. Mean nest height was 20.5 m. Each nest contained one egg. The home range size of a single radio-tagged male was 437.3 ha (85% harmonic mean). One pair studied during three consecutive years was found to be monogamous and completely sedentary. *Received 14 Sept. 1993, accepted 11 Feb. 1994.*

Wood owls of the genus *Ciccaba* are poorly known, and data have been largely limited to morphological descriptions. Detailed information on natural history has been reported for only one species, the African Wood Owl (*C. woodfordii*), found only in Africa and the sole Old World representative of the genus (Steyn and Scott 1973; but see Amadon and Bull 1988, who place this species within *Strix*). New World *Ciccaba* inhabit Neotropical forests where they are mostly unstudied (Burton 1973).

The Mottled Owl (*C. virgata*) is believed to be the most numerous and widespread wood owl of the neotropics and subtropics; its range extends from Chihuahua and Sonora, Mexico, to northern Argentina and southern Brazil (Peterson and Chalif 1973). It has also been reported from Hidalgo County, Texas (Lasley et al. 1988). The literature contains few references to nests of the Mottled Owl (Belcher and Smooker 1936). Despite being widespread and numerous, virtually nothing is known of its breeding biology.

The Black-and-white Owl (*C. nigrolineata*) inhabits humid lowland and foothill forests from southern Mexico to northwestern Venezuela and northwestern Peru. It is uncommon to rare throughout its range (Peterson and Chalif 1973, Stiles and Skutch 1989). The literature mentioning this species is mostly brief anecdotal descriptions and individual accounts

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(Land 1963, Grossman and Hamlet 1964, Smithe 1966, Burton 1973). Much of the natural history of the Black-and-white Owl, including nests and breeding biology, has not been described.

We studied nesting Black-and-white Owls in Tikal National Park, Guatemala. Presented here are the first descriptions reported in the literature of the nests and eggs of this species and an estimate of home range size for a male based on radio-telemetry. We also describe nests, clutch size, and reproductive success of Mottled Owls in this same study area. We report home range size, present an estimate of breeding density, and discuss such characteristics of population dynamics as territoriality and monogamy.

STUDY AREA AND METHODS

We studied owls in Tikal National Park (576 km^2) in the Department of Peten in northeastern Guatemala (17°13'N, 89°38'W). Climate, physiography, and vegetation were described by Gerhardt et al. (1994). Owls were located by walking established trails within the park at dusk or dawn and listening for vocalizations. We found diurnal roosts by arriving at areas of previous activity at least 0.5 h before sunrise and listening as the owls called. Most Mottled Owl nests were found after hearing the female's food solicitation call, given from near the nest shortly after sunset. We found two nests after radio-tagging females. We located Black-and-white Owl nests by watching males leave their roosts at dusk. Prior to hunting, they typically flew to the nest tree and vocalized.

Once nests were located, we attempted to trap the adults using bal-chatri traps baited with mice or rats and placed either near the nest or under the bird's diurnal roost. We trapped female Mottled Owls by placing hoop-shaped mist nets over the nest cavity, and a male Black-and-white Owl was captured using a noose wire on a roost branch.

We affixed 3.5-g Holohil Systems Ltd. (Woodlawn, Ontario) transmitters to the central rectrices with thread and epoxy. Several Mottled Owls pulled the rectrices out, however, and we subsequently affixed transmitters as backpacks (Kenward 1987), using satin ribbon as the harness, sewed together with cotton thread.

We typically radio-tracked owls beginning the night after trapping. We followed each male owl and each non-nesting female for one hour every night and determined locations every 15 min. Radio-tracking was done on foot, using hand-held three-element yagi antennas and Falconer RB4 receivers. In most cases, a two-person team was able to observe and determine the location of the owl directly. Rarely was it necessary to triangulate to determine a location. All hours of the night were equally represented in 11-night regimes of random sampling. We followed owls sequentially in a given night, beginning with the bird farthest from the base camp. The hour of tracking this first bird was randomly chosen, and determined the schedule for following each of the other radio-tagged owls in the 11-night rotation. We followed as many as five owls in a given night, while only a single location was determined each night for nesting females.

We also located radio-tagged birds daily at their roosts. We used both diurnal and nocturnal locations in home range determinations. Owls were followed until their radios failed or were lost or until 15 Aug. (in 1989 and 1990) or 30 Aug. (in 1991).

We estimated home range areas using minimum convex polygon (Mohr 1947) and 85% harmonic mean (Dixon and Chapman 1980) methods generated by the computer program

HOMERANGE (Samuel et al. 1985). Owl density was determined by an extensive search for all pairs in the study area.

We climbed to Black-and-white Owl nests during the hour before dusk to minimize heat stress on nest contents. Mottled Owl nests were generally checked during late afternoon. We weighed eggs (to the nearest 0.5 g) with a 100-g Pesola scale and measured length and width (to 0.1 mm) with vernier calipers. Nest site characteristics—height, length, width, and depth of the cavities and tree height and diameter at breast height—were recorded after fledging had occurred. We report values throughout as means ± standard deviations.

RESULTS

Nests and eggs of Mottled Owls.—Thirteen active nests were located, seven in 1990 and six in 1991. Eggs were laid during March except in one nest in which eggs were laid in late April. The last fledgings occurring by the last week of May (the one later nest had failed by that time). While all seven pairs monitored in 1990 nested, only six of 11 did so in 1991.

All nests (N = 13) were in live trees. Most cavities (N = 10) were in the trunk itself and were formed by the rotting of a branch. One cavity was formed by the breaking of the trunk itself. This nest was open above, but was partly protected both by a branch of the nest tree that reached above and by the large leaves of a climbing vine (*Philodendron* sp.). Two other nests were in the main crotch of the tree. One of these was a depression only 10 cm deep, but it, too, was overhung by a *Philodendron.* Mean entrance size was 17.2 × 32.3 cm (N = 12; range = 8.0 × 16.0–30.0 × 40.0 cm) and the mean depth was 62.3 ± 61.3 cm (N = 13; range = 10–250 cm).

Nine species of trees were used as nests. *Pimenta dioica* and *Brosimum alicastrum* were used four and two times, respectively. Mean nest height was 12.9 ± 3.3 m (N = 13; range = 8.4–17.5 m) above ground.

Mean clutch size for 13 nests was 2.2 ± 0.14. All eggs were non-glossy, off-white, and elliptical, being only slightly longer (mean = 42.2 ± 2.2 mm) than wide (mean = 36.1 ± 0.7 mm; N = 16). Mean egg mass was 28.2 ± 1.8 g (N = 16).

Incubation apparently began with the laying of the first egg; females remained in the cavity beginning at that time, and young hatched asynchronously. Incubation period was not determined, but two eggs hatched after a minimum of 28 days. Females did all of the incubating and brooding, and males did all of the hunting. Even after brooding had ceased, females remained near the nest while males foraged.

Development of young Mottled Owls.—At hatching, nestlings had closed and protruding eyes and swollen (yolk-filled) abdomens. White natal down originating from the major feather tracts (pterylae) covered most of the nestling's body, whereas areas of bare skin (apteria) covered the remainder of the body. The cere and feet were flesh-colored and talons

were grey. The beak was grey with a small white egg tooth that disappeared by day six. About 8–10 days of age, young began to open their eyes and to tongue-click. At this time, the head and, more particularly, the orbital region, were the most thickly-feathered portions of the young owls (second generation down).

Prejuvenal molt began at 10–12 days of age. Contour feathers similar to those of adults appeared on the wings and back, and the tail began slowly growing in. The rest of the owl chick became covered in soft down and semiplumes, the body being of a peach or golden hue and the head creamy white. The first prebasic molt was not detected until four months of age, when adult-plumage contour feathers began appearing on the head and breast. This molt likely began earlier, but we did not capture fledglings to inspect them.

Three young fledged between 27 and 29 days after hatching and another at 32 or 33 days of age. Ten young weighed within three days of fledging had a mean body mass of 190.6 ± 19.9 g. Seven adult males and nine adult females had mean body masses of 239.7 ± 13.3 g (range = 220–256 g) and 335.6 ± 13.7 g (range = 308–366 g), respectively. Young were not observed on branches outside the nest prior to fledging. When fledging, the young owls were incapable of sustained flight, but merely glided downwards, either landing in low vines or underbrush or reaching the ground. They then climbed up into brush or leaning trees. These fledged owls never returned to the nest. Three months after fledging, young were still in the natal home range, roosting with and being fed by one or both of their parents.

Reproductive success of Mottled Owls.—Nine of the 13 nests (69%) fledged at least one young. Of the two 1990 nest failures, one female abandoned the nest during incubation, and the other nest was preyed upon when the chicks were two weeks old. In 1991, one nest was preyed upon by a mammal during incubation. Another nest was preyed upon one week after the hatching of the first chick. The second egg had disappeared just before it was due to hatch, and the adult female, captured at this time, had the quill of a porcupine (*Coendou mexicanus*) in her feathers. It is possible that this porcupine was involved in the partial and/or the eventual complete failure of this nest.

Home range, roosts, and territoriality of Mottled Owls.—Seven males and four females were radio-tagged. Two females pulled out their central rectrices and radios prior to nesting, and the two other females incubated and brooded for most of the life of their transmitters. We did not calculate home ranges for these nesting females.

Two of the seven males also molted their central tail feathers before sufficient data could be recorded. One was retrapped and equipped with

a backpack transmitter. Home range size was estimated for six males, four in 1990 and two in 1991. These were followed for 81, 63, 25, 61, 27, and 33 night-h and, with diurnal roost locations included, yielded 399, 301, 117, 294, 128, and 115 total locations, respectively. Mean home range size was (Fig. 2) 20.8 ha (85% harmonic mean) and 21.7 ha (minimum convex polygon).

Breeding density in the 2-km^2 1990 study area was 14 adults, or seven adults per km^2. In 1991, 11 pairs of adults were found in an area of 2.5 km^2. As has been reported, only six of these pairs actually attempted nests. The other five pairs, however, each engaged in copulation and territorial advertisement. If these are included, the 1991 estimate of density (territorial adults) was 8.8 adults per km^2. Of five pairs identified in the second year, only one female was a new owl.

Two hundred seventy-four different diurnal roosts were located on 407 occasions. The typical perch was a horizontal branch or vine in a dense section of wooded swamp. Mean diurnal roost height was 5.3 m (range = 0.5–18 m; N = 407). Cavities were never used for day-time roosting. Mottled Owls often spent the day within 2 m of the forest floor, particularly on the hottest day, and, when not on nests, females tended to roost with their mates, and later, family groups roosted together. Members of a pair or family were often found roosting within 1 m of one another. While females were on nests, males generally roosted a considerable distance away (mean = 252 m; N = 114), neither at the center nor at the perimeter of their home ranges.

We climbed to nests during late afternoon. Nest defense varied in intensity among females. Two females struck the climber repeatedly on every occasion. Another attacked the climber initially, but apparently became accustomed to the climbing and ceased striking. Four other females never struck but remained nearby, tongue-clicking and vocalizing. One female flew a considerable distance from the nest and roosted. One female sat tightly on the nest, and we were forced to pick her up to examine her eggs. Only on one occasion did a male arrive in apparent response to a female's vocalizing.

Nests and eggs of Black-and-white Owls.—Four occupied nests were found, one in 1989, two in 1990, and one in 1991. Three nests were in the same territory from 1989–1991 and attended by the same banded male (1989–1991) and same female (1990–1991). The female was captured in the 1990 season. The 1991 nest was 300 m from the 1989 nest and 450 m from the 1990 nest. All three nests were near the edge of an extensive bajo (wooded swamp). The second 1990 nest was in transition zone forest near a large bajo and approximately 3.5 km from the other three nests. The four nests were between 175 and 200 m above sea level. Nests were

in three species of trees, two in puctes (*Bucida bucerus*), one in mahogany (*Swietenia macrophylla*), and one in ramon (*Brosimum alicastrum*). Mean DBH was 87.3 ± 32.6 cm. Mean tree height was 26.3 ± 7.1 m (range = 21–30 m), and mean nest height was 20.5 ± 5.8 m (range = 16–26 m).

Eggs were laid on bare epiphytes; there was no nest construction by the owls. Two nests were formed by the orchid *Trigonidium egertonianum,* one by the orchid *Mormolyca ringens,* and one by a bromeliad of the genus *Tillandsia.* Each nest contained one egg. Eggs were off-white, non-glossy, and elliptical and were laid on the roots or foliage at the center of the epiphytes (Fig. 1). Mean egg mass was 33.8 ± 2.3 g (N = 4); mean length and width were 46.4 ± 1.1 mm and 38.4 ± 1.1 mm, respectively (N = 4).

Nests were apparently initiated in late March, as all hatching occurred in the last week of April. We were unable to collect reliable data on incubation, brooding, and food delivered to the nest because darkness and vegetation limited our viewing. The females' periodic vocalizations from the nest and activity of the radio-tagged male indicated the female likely performed all incubation. A female captured in 1990 had a small single brood patch; the male of the pair did not.

Reproductive success of Black-and-white Owls.—None of the four nests fledged young. The 1989 nest failed when the single young disappeared at approximately 24 days old. In 1990, the egg in this pair's nest failed to hatch, while in 1991, the same pair's chick disappeared within four days of hatching. The second nest found in 1990 failed when that young disappeared within a week after hatching.

Home range and roosts of Black-and-white Owls.—One male was radio-tagged and followed from 13 Apr. to 1 Aug. 1989 (118 locations of which 56 were diurnal roost locations) and from 12 May to 7 July 1990 (90 locations, 42 diurnal roosts). The home range size of this male using the 85% harmonic mean method was 437.3 ha. The area contained within the minimum convex polygon formed by these locations was 261.6 ha. A 50% harmonic mean estimate yielded an area of high utilization of 78.2 ha. This area included the nest site, several well-used diurnal roosts, and two foraging areas.

The home range size of this male was also estimated using only that subset of locations that was obtained following nest failure in both years. This subset included 123 locations, 62 of them diurnal roosts. These data yielded home range size estimates of 175.9 ha (85% harmonic mean) and 116.4 ha (minimum convex polygon) and a 50% harmonic mean area of 50.8 ha. In other words, this male utilized a much larger area while his mate was on a nest than following nest failure.

The radio-tagged male was located 98 times at 37 different diurnal

FIG. 1. Black-and-white Owl egg in nest in the orchid *Trigonidium egertonianum.*

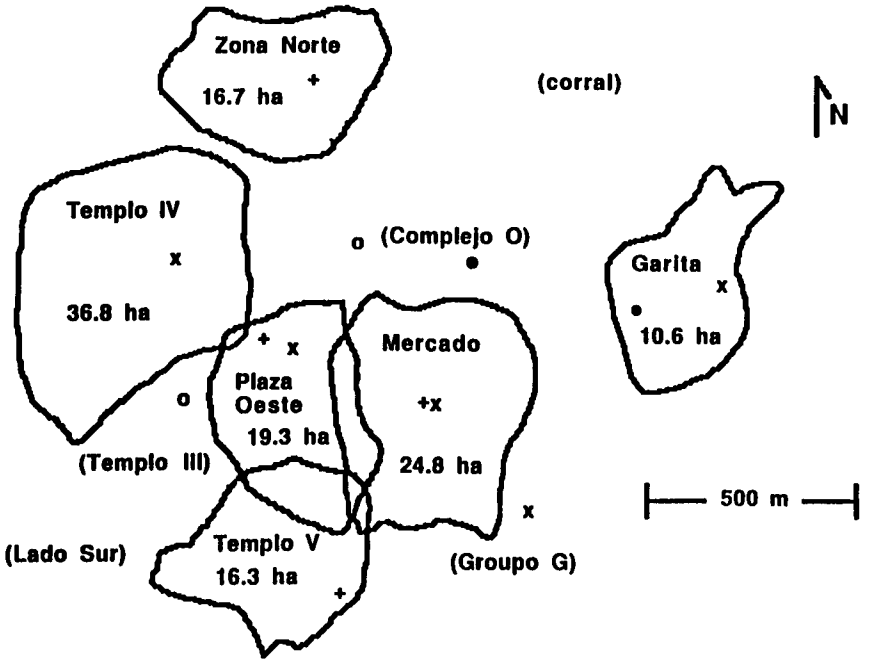

FIG. 2. Juxtaposition of home ranges (85% harmonic mean) and nests of Mottled Owls. x = successful nests in 1990; + = successful nests in 1991; ○ = failed nests in 1990; ● = failed nests in 1991.

roosts. Twenty roost trees were identified and included 10 species, of which zapotillo (*Diospirus* sp.), cedrillo (*Guarea* sp.), and ramon were most commonly used. Overhanging vines were a feature of many of these perches. Roost heights ranged from 3.5 to 26.0 m (mean = 14.0 m).

DISCUSSION

Ciccaba owls are reported to nest in tree cavities or in abandoned nests of other raptors (Burton 1973). Mottled Owls in this study used cavities for their nests. None of the Black-and-white Owl nests we located were in cavities or abandoned nests of other birds. In each case, the nest structure was a bare epiphyte, and we found no evidence to suggest that these sites had been used previously by other raptors. All Black-and-white Owl nests were in emergent trees, among the largest in the general vicinity. We believe neither snakes or mammals could reach these nests without climbing the nest tree itself. Indeed, the situation of all four nests seemed to make them more vulnerable to avian predators than to reptilian or

mammalian predators. Cavity nests of Mottled Owls were considerably lower than Black-and-white Owl nests and were not in lone or emergent trees. While such nests might still be vulnerable to avian predation, they are also more accessible to snakes and mammals.

Both Black-and-white Owls and Mottled Owls exhibited synchrony in their nesting, with nests being initiated and completed during the dry season. We have no data on the seasonal abundance or availability of their prey, and food supplies may certainly be a factor in nesting synchrony. It may be important that nesting be completed prior to the first hard rains because of the exposure of nests. Several Mottled Owl nests were situated such that rainwater collected where the eggs and young had been, and all Black-and-white Owl nests were exposed to the elements.

To date, no other owl species has been reported to have a clutch size of one, as did the Black-and-white Owls in this study. Clutch size tends to decrease with proximity to the equator, both within a species and between species of birds of similar taxa, size, and ecology (Moreau 1944, Lack 1966, Ricklefs 1969a). Our findings are in keeping with this tendency.

Of particular interest is the difference in home range size of these two sympatric congeners. This single Black-and-white Owl male had a home range more than 20 times larger than the mean home range size of the six male Mottled Owls. The difference in body size of these two species could account for at least some of this difference in home range size. We suggest, however, that the difference in food habits between these species plays a larger role in explaining this difference in home range. Both fed on large insects, particularly scarab beetles (Gerhardt et al. 1994). The vertebrate components of their diets, however, were quite different, with Mottled Owls eating small rodents and Black-and-white Owls capturing bats (Ibanez et al. 1992, Gerhardt et al. 1994).

It appears that Black-and-white Owls and Mottled Owls are monogamous and, as adults, sedentary. We suggest that Mottled Owls exhibit territorial defense of the entire home range, as has been reported for Barred Owls (*Strix varia*) (Nicholls and Fuller 1987). Overlap of home range among nonpaired birds amounted to no more than 20% of any pair's home range, while paired birds shared the same home range through two full seasons. Moreover, our observations of physical combat on the very edge of a radio-tagged male's home range supports the view that the entire home range is defended.

It is possible that the Black-and-white Owl is susceptible to human disturbance, and that the 100% failure rate was, at least in part, observer-induced. In general, however, tropical species are known to have a lower

fecundity and reproductive success than their counterparts in temperate zones (Ricklefs 1969b).

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