FIRST NEST DESCRIPTION, BREEDING, RANGING AND FORAGING BEHAVIOR OF THE SHORT-LEGGED GROUND-ROLLER *BRACHYPTERACIAS LEPTOSOMUS* IN MADAGASCAR

By

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SUMMARY

The secretive and endemic Short-legged Ground-roller *Brachypteracias leptosomus* was studied during the breeding season October 1996 to February 1997 on Masoala Peninsula, northeastern Madagascar. Several other vocalizations were associated with contact, courtship feeding and food solicitation. One study pair ranged within an area of 19.1 ha and spent 90% of the time together. Four contiguous pairs were located within a 1 km^2 area. The study pair used small trees for foraging and resting, and perches averaged 6.1 m above the ground, 1.2 cm diameter, and in trees of 12.3 cm DBH. Perch time averaged 9.8 min. Roost sites were slightly taller than day time perches and averaged 9.1 m above the ground, 1.1 cm diameter, and in trees of 7.6 cm DBH. Of the 318 prey items observed, 63.2% were invertebrates, 8.8% vertebrates and 28.0% unidentified. Terrestrial crabs, cicadas, katydids, dwarf chameleons and pill-millipedes represented the most numerous prey type taken representing 68.2% of the identified prey. Prey capture height averaged 6.1 m above the ground. The birds captured 76% of the prey from above the ground and 24% off the ground. Courtship feedings by the male to the female accounted for 36% of the observed prey items captured. Two nesting attempts were observed in December 1996 and January 1997. The first nest was in a natural tree cavity 18.1 m above the ground in 132.8 cm DBH *Weinmannia* sp. and contained 3 white eggs slightly spotted or stained. This nest failed on 1 January 1997 when a swarm of honey bees *Apis mellifica* overtook the cavity. On 7 January, the pair began excavating another nest 22 m above the ground in a 174 cm DBH *Canarium madagascarensis*. This nest was situated in the root mass and decayed material of epiphytes and below a 1 m diameter forked branch.

INTRODUCTION

The Short-legged Ground-roller *Brachypteracias leptosomus* is considered a relatively rare and secretive endemic bird that has been recorded throughout the central to northern rain forest belt in eastern Madagascar (Langrand 1990, Evans *et al.* 1992, Thompson and Evans 1992). It was categorized "vulnerable" (a taxon facing a high risk of extinction in the wild in the

medium-term future) in the recently updated Red Data List, Birds to Watch 2 (Collar *et al.* 1994). This species does not appear to be common anywhere throughout its distribution and is the most localized of the four rainforest ground-rollers (Langrand 1990, Thompson and Evans 1992). This species is the most arboreal of the 5 species found throughout Madagascar (Turner 1984, Langrand 1990) and is an inhabitant of the least disturbed primary forests with a preference for low, dark, humid places covered with small saplings and trees with a litter of dead leaves (Rand 1936, Langrand 1990, Thompson and Evans 1992).

The behavioral ecology and breeding biology of Short-legged Ground-rollers are poorly known (Langrand 1990, Collar *et al.* 1994). To date, no ecological study has focused on this species and what is known is based on incidental observations of foraging behavior and diet (Rand 1936, Thompson and Evans 1992, Evans *et al.* 1992). This paper reports the first systematic study of the species behavior and ecology. Although most of the information presented in this study comes from one breeding pair, our findings add new information to the nesting habits as we documented the first nesting attempts in trees and possibly the first for the species, and behavior of this species during the breeding season. This species is predatory and may have ecological needs similar to raptors that require large areas in which to survive and may be particularly sensitive to subtle changes in habitat structure and function. This study was conducted in response to proposals for "sustainable use of forest resources in buffer zones around the proposed Masoala National Park" because knowledge of sensitive species' natural history is needed to make well informed decisions about management in such zones.

STUDY AREA AND METHODS

The study was conducted in the proposed Masoala National Park from October 1996 to February 1997 near Andranobe Field Station (AFS) on the west coast of Masoala Peninsula in northeastern Madagascar (15°41'S; 49°57'E). The west coast of the peninsula is roadless and composed of a mosaic of slash-and-burn clearings, secondary growth, and primary forests. The lowland rain forest of the Masoala Peninsula has a canopy height less than 30 m with few emergent trees, high floristic diversity, and steep mountainous topography (Guillaumet 1984). Elevations on the Masoala Peninsula range from 0 to 1,200 m. Average annual rainfall recorded at AFS from 1992-1996 was 6, 049 mm. Monsoon rains and cyclones occur between December and April, whereas rain falls steadily between May and August (Donque 1972). September through November are normally the driest months. Temperatures vary between 18° and 33°C throughout the year.

Short-legged Ground-rollers were located during the early morning hours by moving toward calling birds. Vocalizations were recorded and four pairs of ground-rollers were detected by their response to broadcasting their vocalizations along the limited trail system in the area. All pairs were within 2 km of the Andranobe Field Station. Calls were categorized into 1 hour blocks (e.g., a call at 04.30 h falls in the 05.00 h block).

Two of the four pairs of ground-rollers were selected for trapping and marking. In the general area where the pair responded, we set up elevated mist nets (2.6 x 12.2 m, 36 mm mesh) between trees and positioned from 5-15 m above ground by a pulley system. Two mist nets were attached together for greater coverage (5.2 x 12.2 m). Birds were drawn into the mist nets by call playback perpendicular to the mist nets. The mist nets were adjusted to the height the birds crossed the mist nets until they were caught. Captured ground-rollers were measured, ringed and one was fitted with a 2.1 g tail-mounted transmitter (Holohil Systems Ltd., Canada). The bird was radio tracked the following day for recording general behavior and movements.

Foraging, roosting and nest observations

Foraging activities and prey were recorded and identified during radio-tracking sessions (when the radio-tagged bird was located and followed continuously ranging from 1 to 7.5 h). Tracking observations totaled 136.5 h. The location of prey capture was placed into 5 categories: ground, tree trunk, branch, leaves, and epiphytes. The height of prey capture was estimated to the nearest meter (m). We measured nest tree height at the first nest using a plumb line from the nest cavity entrance. The second nest height was measured with a range finder due to difficulty of climbing the tree. We measured nest tree, roost tree, and perch tree diameter-at-breast-height (DBH) to the nearest cm. We estimated perch and roost branch diameters and roost distances from center of the tree trunk (cm). At each roost tree, slope (°) and distance to nearest creeks (m) were measured. (Values represent mean ± s.d.).

One radio-tagged individual was followed nearly five times a week from October to January, alternating between morning and afternoon periods, prior to the onset of nesting to determine foraging behavior, diet, habitat use, and nesting activity. Home range size was determined from radio tracking sessions and one randomly chosen location a day was plotted on a map. Nest observations lasted half days from 05.00 h to 11.30 h and from 11.30 h to 18.00 h and totaled 225.5 h. Observations were made using 10x binoculars 40 m from the nest tree. Data collected included adult behavior, time and duration of the incubation break, type and frequency of prey items captured.

RESULTS

Vocalizations

Short-legged Ground-rollers gave several different types of calls during the breeding season. We associated 5 different calls to the behavior of the birds: territorial, contact, and contact in close proximity to another bird (courtship feedings and food solicitation). Most territorial calls were initiated in the early morning hours prior to sunrise (Fig. 1). This species is one of the first diurnal calling birds to initiate vocalizations during the dawn chorus, averaging

04.45 h ± 4.7 min (range 04.35-04.54 h, n=36 call days from 20 October 1996 to 15 January 1997) excluding all territorial calls after the 06.00 h category. The territorial call consisted of a single deep, low frequency "*poop*" or "*boop*" uttered while the head was pushed downwards. Territorial calls were delivered from perches in the canopy, normally 15-30 m above ground. Neighboring birds respond to territorial calling birds by vocalizing the same "*poop*".

On 23 December 1996, the radio-tagged male was observed chasing and perching near another bird at the periphery of his territory. Territorial calls on average lasted for 4.1 ± 3.9 min (range 1.0-13.0 min, n=36 call days). After territorial calling, the birds would descend below the canopy to a foraging level. The startup call, a second call type, sounded like an accelerated version of the territorial call. This call was only heard in the early mornings, averaging 04.42 h ± 7.2 min (range 04.34-4.48 h, n=5 calls) and had a duration of 1.0 ± 0.0 min. After several seconds at an accelerated tempo this call descended to a lower pace until arriving at the typical territorial call (n=5 days detected). The startup call sounded similar to another bird heard occasionally in the forest, the Madagascar Coucal *Centropous toulou*. The context of this call was unknown to us but may have some association with advertising the pair's territory.

A third type of call was associated with contact communication while the pair moved through the forest. This call was used when the pair was separated and they called to identify the location of their mate when out of visual contact. This call consisted of a single "*poop*" similar to the territorial call but much softer and sometimes barely audible. If a mate did not respond the calling individual continued calling and the longer without a response from the mate the louder the calling became until contact was established.

A fourth call type consisted of a soft, brief, purring note "*prrrr*". This vocalization was used when a bird flew in and perched near its mate, anticipation before courtship feedings and after courtship feedings (possibly food soliciting toward the male). This close contact "*prrrr*" call was difficult to detect unless within close quarters to the birds.

A fifth call type, a raspy squawk, resembling a tree frog vocalization occurred after courtship feeding when the female responded to the continued presence of the male perched by her. She gave the call on several occasions, and a bird from a neighboring territory gave a similar call. This call suggested that the female was demanding (food soliciting) food from its mate.

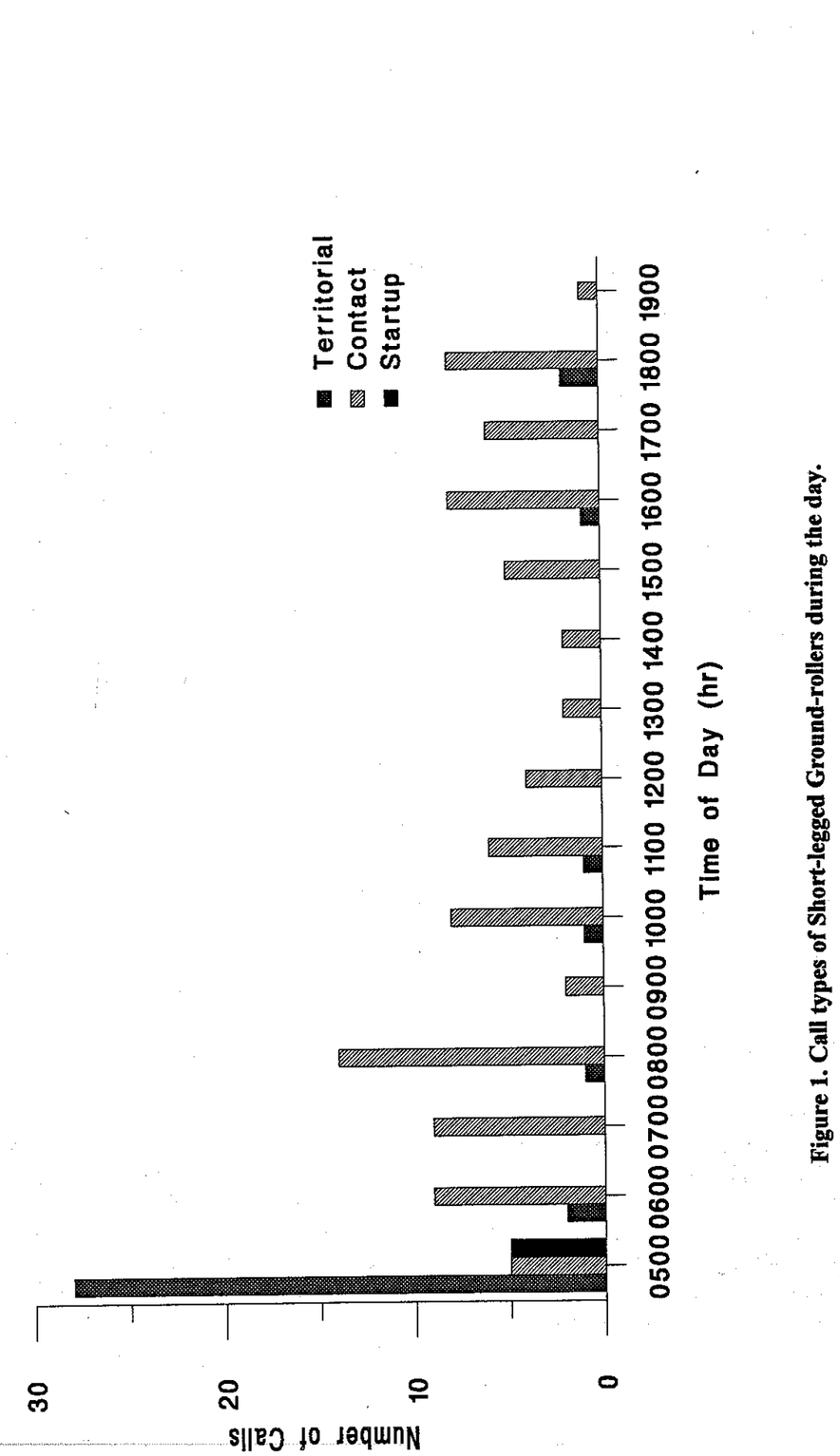


Figure 1. Call types of Short-legged Ground-rollers during the day.

Measurements

Three ground-rollers were trapped using elevated mist nets (Table 1). On 19 October 1996, two birds, a suspected mated pair was trapped on the same day. The sex was not confirmed for either bird until we observed the first copulation on 23 November 1996. The paired birds were sexually dimorphic in morphology and coloration. The female had the purplish blue color extending from the back of the neck to the crown and the white supercilium was distinct. In contrast, the male only had the purplish blue extending from the back of the neck to nape and the supercilium was a buffy white coloration. The male was the larger of the two and the difference was noticeable when compared to the female in hand. On 8 November 1996 another bird was trapped in a neighboring territory and we suspected this to be a gravid female because it was smaller than the male but heavier (Table 1).

Table 1. Measurements of one male, one female and one unknown Short-legged Ground-roller from this study.

Sex	Bill-length (mm)	Wing-length (mm)	Tarsus-length (mm)	Tail-length (mm)	Mass (g)	Body-length (cm)
Male	19.5	144 (unflatten)	34.8	164	186	33.0
Female	14.5	134 (unflatten)	33.0	145	154	29.0
Unknown	16.3	140 (unflatten)	-	134	217	-

Ranging behavior and density

The radio-tagged male Short-legged Ground-roller was located 46 times from 20 October 1996 to 15 January 1997. The minimum convex polygon home range for this bird was 19.1 ha, which includes the 2 nest sites and all roost sites. This area was composed of pristine primary forest with very little human disturbance throughout. The home range area of the radio-tagged male ranged in elevation from 5-200 m amsl. The two nests were at the eastern and northern periphery of the pair's territory. In a 1 km^2 estimated area, we detected 4 contiguous territorial pairs within 2 km of Andranobe Field Station. These four territorial pairs included the study pair and a neighboring bird we banded.

Foraging behavior

Of the 318 prey items observed, 63.2% were invertebrates, 8.8% vertebrates and 28.2% were unidentified. Disregarding the unidentified prey category, the most numerous prey taken were terrestrial crabs (*Sesarma* spp.) 29.7%, cicadas 11.0% (*Yanga pulverilla*), katydids 10.0%, dwarf chameleons (*Brookesia* spp.) 9.2%, and pill-millipedes (*Sphaeroterium* sp.) 8.3%, representing 68.2% of identified prey (Table 2). Prey size ranged from a 1 cm terrestrial crab to a 20 cm snake. All prey was killed by hitting it against a branch or rock or by squeezing it with the tip of the bill. Terrestrial crabs and urticating-spined caterpillars were hit continuously until pincers and stinging spines were removed, respectively. All prey was swallowed whole. After swallowing the birds always cleaned their bill, especially after eating sticky animals like caterpillars, snails and slugs. On 19 November the male courtship fed the female a large leaf-tailed gecko, nearly 20 cm long, and it took the female 25 min to swallow this large lizard. The mean height above ground of prey capture was 6.1 m ± 4.0 (n=69, range 0-18 m). Prey was taken from a variety of locations with over one-third (38.9%) coming from tree trunks, 27.8% from leaves, 24% from the ground, 7.4% branches, and 1.9% from epiphytes.

Of 195 prey items observed and delivered by ground-rollers, 41.0% were consumed by the male (n=80), 35.9% the male fed to the female before the nesting period (n=70), 12.8% female fed herself (n=25), 3.1% male captured and fed to the female at and off the nest during incubation period (n=6), 2% male fed to a vagrant bird (n=4), 1.5% male captured and lost prey (n=3) and 3.6% a bird of unknown sex fed itself (n=7).

The wing flick was a behavior observed to be associated with adjusting or preparing ground-rollers for a foraging attempt or change of perches. The wing flick occurred when the bird bent slightly down, extended and then pulled in its wings and pumped its tail rapidly. This activity was always followed by a foraging attempt or a flight to a new perch. Nearly all foraging attempts off a perch were initiated by this behavior.

Table 2. Prey observed captured, delivered and eaten by Short-legged Ground-rollers from 20 October 1996 to 20 February 1997 (n=318 prey items).

Prey Type (Class, Order or Genus)	Number	Percent (%)	Percent Without Unidentified (%)
Crab (*Sesarma* spp.)	68	21.4	29.7
Cicada (Homoptera)	25	7.9	11.0
Katydid (Orthoptera)	23	7.2	10.0
Pill-millipede (*Sphaeroterium* sp.)	19	6.0	8.3
Beetle (Coleoptera)	15	4.7	6.6
Caterpillar (Lepidoptera)	12	3.8	5.2
Spider (Arachnida)	7	2.2	3.1
Stick insect (Phasmida)	6	1.9	2.6
Millipede (Diplopoda)	5	1.6	2.2
Preying mantis (Mantodea)	4	1.3	1.8
Snail (Gastropoda)	2	0.6	0.9
Centipede (Chilopoda)	2	0.6	0.9
Grasshopper (Orthoptera)	1	0.3	0.4
Slug (Gastropoda)	1	0.3	0.4
Unidentified insects	11	3.5	5.0
Reptiles			
Dwarf chameleon (*Brookesia* spp.)	21	6.6	9.2
Leaf-tailed Gecko (*Uroplatis* spp.)	3	1.0	1.3
Chameleon (*Calumna* and *Furcifer* spp.)	2	0.6	0.9
Snake (*Liophidium* sp.)	2	0.6	0.9
Unidentified	89	28.0	---
Total	318	100.0	100.0

Habitat use

The radio-tagged male ranged only in the primary forest. Throughout the day the birds selected perches that averaged 6.1 above the ground, perch diameter 1.2, and in trees 12.3 DBH (Table 3). The average time spent on a perch before flying to another perch was 9.8 ± 10.6 min (n=196, range 1.0 to 63.0 min). The radio-tagged bird was frequently found in the valley bottoms along creek drainage and on slopes. Perch limb status was characterized by 90.3% live and 9.7% dead limbs. Perch orientation was divided between horizontal and diagonal positions, 59.2% and 40.8%, respectively. The distance from perch trees to water were in the categories 25-50 m (39.8%), 50-100 m 22.9%), above 100 m (22.9%) and 1-25 m (14.3%).

The radio-tagged male Short-legged Ground roller was located 7 nights at 7 different roost sites. Roost sites were usually near the top of small trees, averaging 9.1 m above ground and 7.6 cm D.B.H. (Table 3). Roost trees averaged 7.7 ± 7.6 m from small creeks (range 0 to 20 m). The roost perch was a small flimsy branch averaging 1.1 cm diameter and 103 cm from the center of the tree. Most roost sites were located on slopes averaging 23°. At five of seven roost sites, the female was roosting in the same tree as the radio-tagged male, averaging an estimated 20 cm from the male.

Table 3. Habitat variables of day (n=196) and roost (n=7) perches of Short-legged Ground-rollers from 20 October 1996 to 15 January 1997.

Habitat Variables	Day Perch (Mean±SD)	Roost Perch (Mean±SD)
Perch Height (m)	6.1±4.9	9.1±2.5
(range)	(0.2-25.0)	(7.0-13.0)
Tree DBH (cm)	12.3±16.9	7.6±3.3
(range)	(0.5-120)	(4.0-10.5)
Perch Diameter (cm)	1.2±0.8	1.1±0.2
(range)	(1.0-10.0)	(1.0-1.5)

Nest description

The first documented nest was in a natural tree cavity 18.4 m above the ground in a 30 m *Weinmannia* sp. This large tree had a 132.8 cm DBH and was at 180 m elevation above mean sea level on a 40° slope. The nest cavity entrance was 16x19 cm and contained no nesting material, only decayed wood substrate lined the bottom of the cavity. The cavity was inside a

dead upward branch with a 35 cm diameter at 241° orientation, west-southwest. The nest cavity was approximately 1.5 m in depth in a downward diagonal direction. The area above the nest branch was an open canopy. The closest water was a small creek 150 m down the slope (SW). On 31 December 1996, the nest was climbed by RT and it contained 3 dull white subelliptical eggs. They appeared to be lightly spotted caramel, either natural colored or stained from the wood substrate.

The second documented nest was approximately 350 m down a slope to the northwest of the first nesting attempt. This nest was estimated at 22 m above the ground in a 35 m *Canarium madagascariensis* with 174 cm DBH. This nest was under the base of a large branch 1 m diameter that was heavily laden with epiphytes. From 7 to 15 January 1997 the ground-roller pair excavated a hole at the fork of the branch by digging into the buildup of decayed material and epiphytic root mass. The nest tree was 10 m from a permanent creek at an elevation of 50 m amsl. The orientation of the nest hole was 300°, west-northwest.

Breeding behavior

The first courtship feedings were observed in early October. The study pair traveled around in their territory together during the courtship period. During 80 h of observation, from 13 November 1996 to 16 January 1997, the pair was observed together for 90.3% ± 17.3% of the time (range 44-100%, n=23 observation days). During the middle of November, the female dropped all her tail feathers. By the middle of January, she had replaced all her tail feathers. On 8 November, the third bird captured dropped 6 tail feathers from the right side of the tail. This bird was possibly a gravid female because of the enlargement of its lower abdomen and its small body size with a heavy mass. The male fed the female continuously during the courtship period. Copulations were only seen twice during observations from 20 October 1996 to 15 January 1997. On 23 November 1996, the male courtship fed the female and perched beside her. He allopreened the female's head for several minutes, then mounted her and copulated with wing flapping for one minute.

Only the female incubated. The male visited the nest normally once a day (n=11 nest observation days). Occasionally, the incubating female would leave the nest to rest and forage in the vicinity of the nest tree within 25-75 m. On four observation days the female was followed and 21 prey captures were observed in 3.9 h (5.4 prey items/h). The female would leave the nest 3 to 4 times a day from 05.00-18.00 h. The time spent off the nest or on incubation breaks by the female averaged 17.2% ± 9.7% (range 7.3-33.3%) or 55.1 ±33.6 min (range=21-109 min, n=10 observation days and 60.2 h) during nest observations. The female would return slowly and cautiously back to the nest, stopping at a large tree or the cavity branch and scan for several minutes (ranging from 15 sec to 7 min) and then enter the cavity rapidly. On four occasions from 14 December 1996 to 1 January 1997, the male flew to the nest with prey, delivering one *Uroplatis* sp., one preying mantis, one chameleon and one unidentified prey item to the incubating

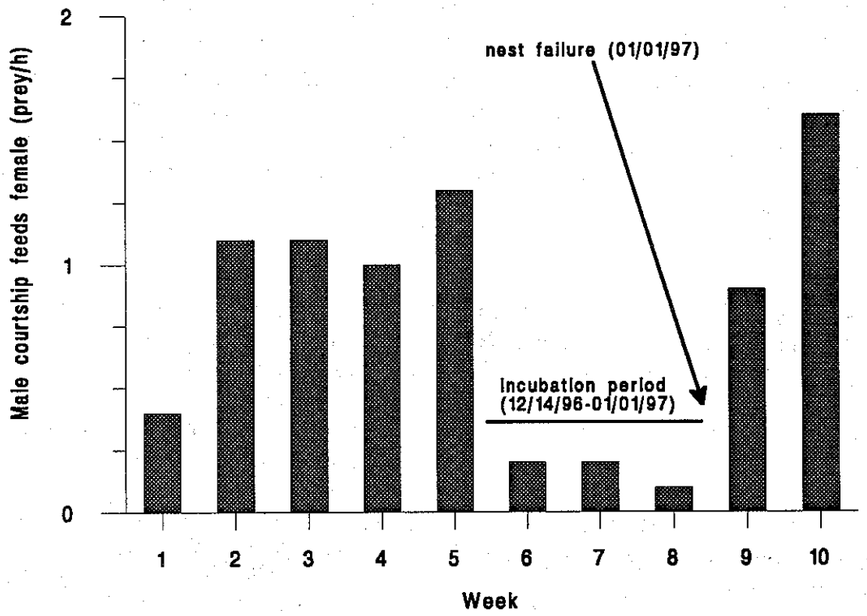
female in the nest. The female ate the prey items in the nest, would leave to relieve herself and preen for several minutes, and then return to the nest.

On 1 January 1997 a swarm of honey bees (*Apis mellifica*) took over the nest cavity at 10.30 h. The female, and later that afternoon the male, tried to enter the nest cavity but were driven away by the aggressive honey bees and appeared to be stung. On 2 January 1997, the birds tried to enter the nest cavity in the morning but were driven away by the bees. That afternoon, the pair remained within 50 m of the nest tree. The ground-rollers abandoned the nest site on the afternoon of 3 January 1997.

During incubation, the male roosted 150-300 m down a slope from the nest tree (n=10 nights). The male would territorial call in the early morning hours, occasionally interacting with the neighboring bird to the west at the area of overlap between the two territories. After that, he would descend down from the canopy to the foraging level. The male would head slowly up toward the nest site. The average arrival of the male to the nest site was 08.49 ±2.54 h from 05.36-12.37 h (n=7 days). Upon his arrival the male would spend all day in and around the nest tree, ranging from 25 to 100 m and on several occasions deliver prey to the incubating female (n=3). On one occasion he delivered a prey item to the female outside of the nest during one of her incubation breaks. After the nest failure, the male began feeding the female at a similar rate to the period before incubation (Fig. 2).

On 7 January 1997, the pair was located in a large tree investigating it for a potential nest site. The male would fly to an area among the large branches and begin searching for a site. The female would follow the male around the large tree. At 09.56 h the female began pulling at some decayed root mass formed by epiphytes. At 10.22 h, the female and male flew to a large forked-branch, laden with epiphytes supported by decomposed material of dirt, decayed vegetation and epiphytes. This site was 5 m above the area where the female removed material at 09.56 h. At 10.38 h the pair was observed pulling at material with their bills and dropping it to the forest floor. On several occasions, they pulled at the material and then pushed it out of the hole by scratching with their feet. The male and female took turns excavating the hole. The average time excavating the hole was 4.9 ±2.8 min by the male (n=28, range 1-15 min) and 6.4 ± 4.6 min by the female (n=30, range 1-16 min). While one bird was in the hole, its mate perched on a vine outside of the hole. After several minutes, the bird excavating came out and its mate hopped into the hole and began excavating. The average time excavating the nest hole during observation periods was 114 ± 109 min (n= five days, range 30-300 min beginning at 05.45 h and ending at 11.30 h). The birds worked at this site for seven contiguous days until 15 January when the cavity hole appeared completed.

Figure 2. Courtship feedings by male Short-legged Ground-roller.



Interactions with other birds

On the day the pair was trapped and on several other occasions during daily observations (n=4 times), we observed several small passerines (Madagascar Paradise Flycatcher *Tersiphone mutata*, Madagascar White-eye *Zosterops maderaspatana*, Common Newtonia *Newtonia brunneicauda*, Souimanga Sunbird *Nectarinia souimanga*, Red-tailed Vanga *Calicalicus madagascariensis* and White-headed Vanga *Leptopterus viridus*) vocalizing defensively and attacking the ground-rollers. The small passerines would hit the backs of the ground-rollers repeatedly and they would shrug and take the hits. The ground-rollers appeared to be unaffected by the hostile attacks of the small passerines but on one occasion the flycatchers drove the ground-rollers away. The attacks appeared to come from passerines that were defending or trying to drive the ground-rollers from their nesting area. On two occasions when the female descended from the first nest, Crested Drongos (*Dicrurus forficatus*) and Madagascar Bulbuls (*Hypsipetes madagascariensis*) gave warning calls and attacked the female at her perch similar to their reaction toward hawks.

DISCUSSION

The perceived rarity of this species may be due to its secretive behavior. Most of the information on its distribution stems from observations and sightings from high elevation forests above 800 m such as: Ranomafana National Park, Analamazaotra Special Reserve, Manatady National Park, Ambatavoky Special Reserve, and Marojejy (Langrand 1990, Evans *et al.* 1992, Thompson & Evans 1992). There are very few ground-roller observations in low elevation rain forests because of the lack of intact primary forests. Where this species has been observed in low elevation forests, it appears to be almost common, such as in Mananara Biosphere Reserve (Langrand 1990), Marojejy Strict Nature Reserve (Evans *et al.* 1992) and ubiquitous in the forests of Masoala Peninsula (Thorstrom and Watson in press). Throughout the Masoala Peninsula, the largest intact low elevation forest in Madagascar, this species can be heard and found frequently. The territory size of the radio-tagged male was 19.1 ha and was comparable to the density of four pairs in one square kilometer. This suggests that the average area required by one territorial pair is roughly 25 ha of pristine forest. The large territory size for this species makes it more difficult to visually detect.

Another reason that this species may be difficult to detect is because it is an early morning vocalizer, calling before sunrise, and it broadcasts from canopy level (Fig. 1). The territorial call is the most distinct call given by this species usually at day break and it lasts for an extremely short period, less than five minutes on average, making it difficult to detect. The other call types are extremely short range communication calls and very difficult to detect.

The final reason that this species is difficult to detect is because of it's motionless behavior while on a perch. It can sit still for long periods on a perch and then move a short distance to another perch. Sightings during the day are rare, and usually when it is flushed along a trail. Most written observations of this species' behavior and food habits come from incidental encounters (Rand 1936, Evans *et al.* 1992, Evans & Thompson 1992).

During the breeding season the study pair called, moved and foraged through the forest together. The female stayed close to the male because she would receive food from him. The pair was together for 90% of the time. The male courtship fed the female approximately 1.0 prey/h from October until incubation started (December). Courtship feeding is an important behavior seen in many species of birds where the female is fed by her mate to prepare her body for egg laying and incubation (Newton 1979). On several occasions during the incubation period, the male delivered food to the female in the nest and outside of the nest during her foraging forays. Courtship feedings were cut back to a very low rate, 0.1-0.2 prey/h during the incubation period by the male (Fig. 2). After the first nest failed the male began courtship feeding at a rate of 1.0 prey/h. This increased feeding rate was probably associated with conditioning the female for a second nesting attempt. This species appears to have the ability to renest if the first nest fails

during the incubation stage. Eggs in the first nest had 17 days of incubation when the honey bees occupied the nest cavity causing their abandonment.

Nearly 70% of the diet during the breeding season was based on invertebrates, mainly terrestrial crabs, pill-millipedes, beetles and caterpillars but one vertebrate, the dwarf chameleon was consumed frequently, too. Ground-rollers are more predatory and have a broader diet than has been reported for this species as entirely insectivorous (Turner 1984, Thompson and Evans 1992).

Our observations of the small passerines attacking the ground-roller hinted that they may be defending their nesting areas from a hawk-like bird or possibly Short-legged Ground-rollers may prey upon nestling birds. It is possible to imagine this large arboreal ground-roller extracting nestlings out of nests with its long and large bill. Their handling of crabs, poisonous caterpillars and lizards was well executed with their massive bill, especially the way they hit them on a perch to kill and soften the body parts. Rand (1936) and Evans *et al.*(1992) suggested that this species forages on the ground (based on the prey items it captures). In contrast our study pair captured 76% of their prey from above ground, especially from tree trunks and leaves, while 24% of the captures were from the ground (Fig. 3) suggesting it is a more arboreal species than previously believed.

The two documented nests from the same territorial pair suggest that Short-legged Ground-rollers are more inclined to nest in trees than in burrows in the ground as suggested by Langrand (1990). The first nest was a natural tree cavity in a dead branch that required no excavation. The second nest was in the soft material of an epiphytic root mass that took the pair working side-by-side one week to excavate. It isn't impossible for the Short-legged Ground-roller to excavate and occupy a burrow in the ground but it seems more probable that they would prefer nesting in trees because of their arboreal habits and our documentation of two tree nesting attempts. One interesting observation of the female, was prior to entering a nest site she dropped all her tail feathers during the middle of November one month before incubation started. We do not know if this was done by a predation attack or a natural tail molt before the start of the nesting period. This bird regrew a complete set of tail feathers by the middle of January, possibly when it would have young in the nest and was foraging frequently. A third captured bird of unknown sex, dropped the side of its tail (6 complete feathers) while being held in hand. This bird was heavy, a possible indication of a gravid female. These two observations suggest that in females tail molt prior to incubation may occur in this cavity nesting species, but a larger sample size is needed to verify if this is a consistent trait in the species.

This species is reported to inhabit the most humid, dark areas with short saplings, underbrush and a carpet of leaves (Rand 1936, Langrand 1990, Thompson and Evans 1992). Our observations during the breeding season suggest that this species moves around in the forest canopy in the early mornings and then descends to an area between the lower canopy and the

ground. This is the area where prey captures occurred (6.1 m), birds perched and rested (6.1 m) on average during the breeding season on Masoala Peninsula. On average the birds selected small DBH trees (12.3 cm) and perched on small limbs (1.2 cm) during their daily activities. At night, average roost perches were 9.1 m above the ground in 7.6 cm DBH trees, not much different from day perches. The two nest sites were in large DBH trees which are fairly common in an undisturbed forest.

In the Masoala region, the common land claiming practices and swidden agriculture threaten forested habitats by fragmentation, degradation and habitat loss. The preliminary data collected from this study suggests that the Short-legged Ground-roller is a forest dependent species that requires a large area of undisturbed forest with small trees for foraging, perching and roosting, and large trees for nesting. A potential conflict for this species throughout its range may be this specialized requirement for small and large trees, and large areas of forested habitats. Most human disturbances and modification to forests begin by thinning and/or cutting shrubs and small trees. Some human disturbances remain at this level and maintain large trees for shade and cover. Proponents of sustainable use of forest resources have suggested that forest biodiversity can be maintained by keeping canopy trees while clearing undergrowth for planting with shade loving cash crops. The Short-legged Ground-roller is one bird species that clearly would be eliminated by such a practice. This could have a potential effect on ground-roller populations by altering foraging, perching and roosting habitat. The cutting of small vegetation opens up the accessibility for humans to down large trees. Also, selective logging could have a drastic effect on the reproductive output of ground-rollers if large trees are removed from the landscape. As the downed trees dry they are torched for creating a cleared patch of what was once a forested habitat. Nothing is as permanent as the removal of all vegetation in the forests. Loss of a forest block would be the ultimate impact on the nesting and survivability of Short-legged Ground-rollers. This degradation and fragmentation may drastically affect populations of Short-legged Ground-rollers by limiting or eliminating their required resources. Further research is needed to understand how habit disturbances affects Short-legged Ground-rollers. Understanding the resource needs is the important component for the ecological welfare of this species and all other species with specialized requirements for forested environments.

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A DESCRIPTION OF NESTS, DIET AND BEHAVIOR OF THE BANDED KESTREL

By

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INTRODUCTION

The elusive Banded Kestrel (*Falco zoniventris*) is endemic to Madagascar, ranges from sea-level to 2,000 m in original to degraded forests, and has a distribution throughout the island except for the High Plateau (central region of Madagascar) (Langrand 1990). Historically, this species was fairly common in the northeast, but was rare elsewhere (Rand 1936) and was considered mainly a species of the tropical forests of the humid eastern part of the island (Cade 1982, Brown and Amadon 1989). Nowadays it is reported to be fairly common in the west and south, rare in the northwest, north and east (Langrand 1990). The population status is estimated to be no more than 1000 pairs predicted throughout Madagascar (del Hoyo et al. 1994).

Many natural history aspects of the Banded Kestrel remain poorly known and this species has not been reported on in the past 24 years. Colebrook-Robjent (1973) described two potential nests, and some notes on courtship behavior during a 2 week period in the Marojejy region of northeastern Madagascar and a description of an egg. Herein, I present further and new information on the nest sites, diet, eggs and first description of the young of the Banded Kestrel from the Masoala Peninsula of northeastern Madagascar from the 1995 and 1996 breeding seasons. Some of the information reported here is contradictory with that gathered from earlier field work, notably the egg description reported by Colebrook-Robjent (1973).

METHODS

The study site was located near Ambanizana (15°37'S, 49°58'E), a village on the western side of the Masoala Peninsula, of extreme northeastern Madagascar and is a few meters above sea-level. This area of the peninsula is relatively remote and composed of a mosaic of swidden agriculture fields, secondary growth, and primary forests. The lowland rain forest of the area has a canopy height of <30 m with few emergent trees, and high floristic diversity. Average annual rainfall recorded at Andranobe Field Station 7 km south of the study site was 6,046 mm (Thorstrom *et al.* 1997). Monsoon rains and cyclones occur between December and April, whereas rain falls steadily between May and August (Donque 1972).