SHORT COMMUNICATIONS

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BREEDING BIOLOGY OF THE MADAGASCAR BUZZARD IN THE RAIN FOREST OF THE MASOALA PENINSULA[1]

JAMES BERKELMAN[2]
Biology Department, Boise State University, Boise, ID 83725

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The Madagascar Buzzard (*Buteo brachypterus)* is reported to be common in wooded habitats throughout Madagascar (Langrand and Meyburg 1984). Information on the biology and ecology of the species is limited to brief accounts of individuals and nesting pairs (Rand 1936, Benson et al. 1976, Thiollay and Meyburg 1981, Langrand and Meyburg 1984, Berkelman 1995). The goal of this study was to describe the nest reoccupancy, breeding density, nest dispersion, breeding season, productivity, nesting success, and breeding behavior of the Madagascar Buzzard in the rain forest of the Masoala Peninsula.

METHODS

I conducted the study from August to December 1991 and from September 1992 to January 1993 in the vicinity of The Peregrine Fund's Andranobe Field Station. The station is at the mouth of Andranobe Creek (15°41'S, 49°57'E) about 8 km south of the village of Ambanizana on the west coast of the Masoala Peninsula in northeastern Madagascar. The study area is a mosaic of undisturbed rain forest, secondary growth, and small (< 10 ha) agricultural clearings (Berkelman 1995). I located Madagascar Buzzard nests by imitating the call and walking in the direction of responding calls, climbing emergent trees to look out over the canopy, and offering a reward to local people for reports of nesting activity (Berkelman 1995). I considered nests to be occupied if eggs were laid or if I observed a pair of buzzards constructing a nest (Steenhof 1987).

To determine breeding density, I first estimated the area of a convex polygon that enclosed the nests that I observed each year. I produced the polygon by connecting the outermost nests on a map and then extending the sides by half the mean minimum internest distance (Watson 1990). I measured the area enclosed using a planimeter and used this area as the value for breeding density. I calculated nest dispersion (R) using the corrected Clark and Evans (1954) method (Donnelly 1978, Sinclair 1985):

$$R = \bar{y}/E(\bar{y})$$

where $\bar{y}$ is the mean minimum internest distance and $E(\bar{y})$ is the expected mean minimum internest distance in a randomly distributed population of the same density as the observed population. A value of $R = 1$ indicates a random distribution, $R = 0$ maximum aggregation, and $R = 2.15$ maximum spacing. I tested the departure of the observed mean minimum internest distance from an expected random distance by the normal curve (Clark and Evans 1954), using Sinclair's (1985) corrected standard variate of the normal curve.

I visited all of the occupied nests at least once every five days to monitor productivity. I obtained information on clutch and brood size for most nests by climbing trees uphill and adjacent to nest trees, or in two cases by climbing up to the nests. I examined nests by climbing at least once during incubation and once soon after eggs had hatched. I took care to minimize disturbance to the nests (Grier and Fyfe 1987). I could see the young in the nest from the ground after they reached about two weeks of age. When I no longer saw young at a nest prior to estimated fledging date, I searched the ground surrounding the base of the nest tree for evidence of nest failure. I recorded dates of estimated egg laying, hatching, first flights, and nest failures for each nest in both years of the study.

I constructed observation blinds from leaves, sticks, and vines near each occupied nest as soon as the nest was found. Since the nest trees were located on steep slopes, I could observe nests from near eye-level by placing blinds about 20 to 30 m uphill from the nest trees. I observed nests between 05:30 and 17:30 on a rotating schedule throughout the season, beginning when I found the nests and until young departed. For each nesting pair, I calculated the percentage of total observation time that I observed adults engaged in nest attendance, incubation, and feeding, and the number of prey deliveries per hour of observation. I calculated these rates separately for each period of the nesting

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[2] Present address: Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

cycle: incubation, early nestling (one to 23 days old) and late nestling (24 days old to fledging). I could not consistently distinguish male and female buzzards based on plumage or vocalizations. When both adults were together, there was a noticeable size difference (Brown and Amadon 1968), and I recorded separate behaviors of male and female buzzards.

RESULTS

I found and observed eight nesting pairs in 1991. In 1992, I found six nesting pairs, of which three reoccupied nests used the previous year, one nested < 200 m from a nest used the previous year, and two were > 0.9 km from unoccupied nests studied in 1991. Since I did not mark the birds, I do not know whether the buzzard pairs I observed in 1992 were the same ones I observed in 1991. I saw and heard buzzards in the vicinity of the remaining 1991 nests when I revisited them in 1992, but the nests were not reused, and I did not find new nests nearby.

The eight nesting buzzard pairs I observed in 1991 were found within a 10.2 km^2 polygon resulting in a breeding density of 0.79 nests km^{-2}. The six pairs I observed in 1992 were found within a 11.7 km^2 polygon resulting in a breeding density of 0.51 nests km^{-2}. Mean (± SE) internest distance was 1.0 ± 0.1 km (range 0.6 to 1.2) in 1991 and 1.0 ± 0.2 km (range 0.5 to 1.2) in 1992. Nest dispersion departed from random towards uniform dispersion in 1991 ($R = 1.41$, $C = 1.97$, $P = 0.05$) but did not significantly differ from random in 1992 ($R = 1.15$, $C = 0.63$, $P = 0.52$).

The breeding season was later in 1992 than in 1991 for most of the buzzard pairs observed. In 1991, egg laying occurred between 16 September and 4 October, hatching between 23 October and 11 November, and first flights between 3 and 28 December. In 1992, egg laying occurred between 28 September and 26 October, hatching between 3 and 27 November, and first flights between 12 December and 16 January. Based on these dates, I estimated an incubation period of 34 to 37 days and a nestling period of 39 to 51 days. Four of the eight nests I observed in 1991 fledged one young each. All six nests I observed in 1992 fledged one young. Two eggs hatched at three of these nests, but the second chick did not survive. I could not determine the cause of nestling mortality. Productivity was 0.5 young per pair in 1991, 1.0 young per pair in 1992, and 0.71 young per pair (10 young fledged from 14 nesting pairs) for the two years combined.

I observed nests for a total of 1,545 hours over 1991 and 1992. Mean (± SE) nest attendance by either adult (sex unknown) during the incubation, early nestling, and late nestling periods was 91.2 ± 2.0%, 54.8 ± 5.2%, and 12.0 ± 3.3% of observation time, respectively. The mean incubation rate was 84.0 ± 1.8% of observation time. Mean feeding rates during the early and late nestling periods were 8.9 ± 1.2% and 2.4 ± 0.6% of observation time, respectively. Mean prey delivery rates during the early and late nestling periods were 0.35 ± 0.04 prey per hour and 0.22 ± 0.04 prey per hour, respectively.

I recorded male and female behaviors separately for the 139 occasions during which I saw both adults at the nests and was thus able to distinguish them. On these occasions, females attended the nest more than 90% of the time throughout the breeding season (Fig. 1). Females were incubating 94.9% of the time and males 5.1% of the time. In many of these instances, the male brought food to a tree near the nest and called, the female left the nest to get the food, and the male took over incubating while the female ate. For the first two weeks following hatching, I saw only males delivering prey to the nest and only females feeding the young. I rarely saw both adults at the nest after this time, so both adults may have been engaged in either activity later in the season.

DISCUSSION

The breeding densities of 0.79 and 0.51 Madagascar Buzzard pairs km^{-2} determined in this study were high for a non-colonial rain forest raptor. Due to the difficulty of locating nests in dense rain forest, I do not know whether I found all occupied nests within the study area in either 1991 or 1992; therefore I may have underestimated the actual breeding densities. Thiollay (1989) estimated breeding density for 23 raptor species in the rain forest of French Guiana and found only two species at densities greater than 0.12 pairs km^{-2}, and the remaining species at 0.01 to 0.08 pairs km^{-2}. Thiollay and Meyburg (1981) reported seeing eight Madagascar Buzzard pairs in less than 20 km^2 further north on the Masoala Peninsula. The uniform spacing of nests in 1991 suggested that breeding density of these buzzards was limited by territorial behavior (Newton 1979).

Most bird species in eastern Madagascar breed between September and January (Langrand 1990). The breeding season coincides with the driest period of the year (Donque 1972), with young departing nests at the start of the summer rains. The lengths of the incubation and nestling periods in this study were similar to those reported for most other buteos (Newton 1979).

Productivity in this study was similar to that of the Galapagos Hawk (*Buteo galapagoensis*) (de Vries 1975), but was low compared to that of temperate buteos (Newton 1979); however tropical raptors typically lay smaller clutches than their temperate congeners (Newton 1979). Greater day length at higher latitudes may allow parents more time to gather food for their young, so that more young can be produced (Lack 1954, Cody 1966). Only one young survived to fledge in each successful nest although two eggs were laid in at least four nests in this study and in all previously reported nests of this species (Rand 1936, Brown and Amadon 1968, Milon et al. 1973, Langrand and Meyburg 1984).

There appears to be a division of labor between male and female Madagascar Buzzards during nesting. Previous reports record only females incubating and being fed on the nest by the male (Brown and Amadon 1968). Farquhar (1992) recorded a division of labor similar to that of this study for the White-tailed Hawk (*Buteo albicaudatus*) in Texas. Unfortunately, I usually could not see the adult buzzards away from their nests because of dense vegetation, so I do not know how much time either sex was engaged in other activities such as perching, foraging, and territorial displays.

Based on numbers seen and breeding density, the Madagascar Buzzard appeared to be thriving on the Masoala Peninsula. It did not appear to be sensitive

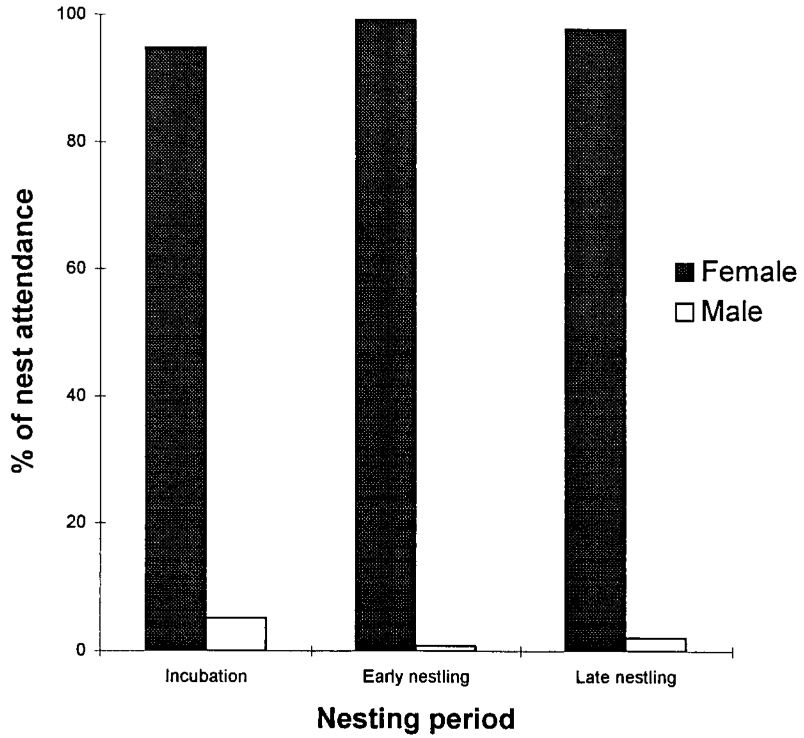

FIGURE 1. Percentage of nest attendance by female and male Madagascar Buzzards during the incubation, early nestling (one to 23 days old), and late nestling (24 days old to fledging) periods when the sexes could be distinguished ($n = 139$).

to localized habitat degradation, such as the small (< 10 ha) agricultural clearings in this study, but it may be sensitive to disturbances that involve a greater degree of habitat modification, as are occurring throughout Madagascar (Jolly and Jolly 1984).

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DIVING ABILITY OF BLUE PETRELS AND THIN-BILLED PRIONS[1]

OLIVIER CHASTEL AND JOEL BRIED
Centre National de la Recherche Scientifique, Centre d'Etudes Biologiques de Chizè 79360
Beauvoir sur Niort, France

Key words: Blue Petrel; Thin-billed Prion; maximum diving depths; foraging behavior; Halobaena caerulea; Pachyptila belcheri.

Capillary depth recorders (Burger and Wilson 1988) are useful tools for studying the foraging ecology of seabirds, and have been used successfully on penguins, alcids, shags and gannets (Burger 1991, Wanless et al. 1991, Adams and Walter 1993, Croxall et al. 1993). Recent studies of Procellariiformes have revealed that diving petrels (*Pelecanoides georgicus* and *P. urinatrix*) are able to dive routinely down to 25-40 m (Prince and Jones 1992, Chastel 1994). Furthermore, investigations on albatrosses (Prince et al. 1994), and on the White-chinned Petrel *Procellaria aequinoctialis* (Huin 1994), have shown that these seabirds can reach a depth of several meters, giving a new insight on the foraging techniques of albatrosses and petrels, which are generally regarded as surface-seizers (Harper 1987, Prince and Morgan 1987).

The Blue Petrel *Halobaena caerulea* and the Thin-billed Prion *Pachyptila belcheri* are small burrow-nesting petrels (190 and 150 g, respectively). At Kerguelen Islands these two seabirds breed in very large numbers (up to 1 million pairs, Weimerskirch et al. 1989); the prions particularly are believed to have a significant impact on subantarctic resources (Ridoux 1994). During the chick-rearing period (50 days, Weimerskirch et al. 1994), both species alternate long and short foraging trips over pelagic and neritic waters (Weimerskirch et al. 1994) and prey mainly on small crustaceans (Harper 1972, Prince 1980, Ridoux 1994), principally by surface-seizing (Harper 1987, Prince and Morgan 1987).

This paper reports the first study on maximum dive depths attained by Blue Petrels and Thin-billed Prions, during the chick-rearing period at Kerguelen Islands.

METHODS

Field work was carried out on Mayes Island, Kerguelen Archipelago (48°28 S, 69°57 E), between 17 January and 7 February 1993. Maximum depth recorders consisted of 12 cm lengths of plastic tubing (internal diameter, 0.8 mm.) lined with icing sugar and sealed at one end. Each tube weighed approximately 1 g (< 0.7%

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