tion. This manuscript has been improved greatly by the comments of D. D. Gibson, J.-P. Savard, and an anonymous reviewer. This manuscript is dedicated to the memory of my late friend F. H. Fay.

LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1983. Check-list of North American birds, 6th ed. American Ornithologists' Union, Washington, DC.

BAILEY, E. P. 1973. Discovery of a Kittlitz's Murrelet nest. Condor 75:457.

DAY, R. H., K. L. OAKLEY, AND D. R. BARNARD. 1983. Nest sites and eggs of Kittlitz's and Marbled murrelets. Condor 85:265–273.

FOX, J. L., AND J. E. HALL. 1982. A Kittlitz's Murrelet nest in southeast Alaska. Murrelet 63:27.

KISHCHINSKII, A. A. 1965. [On the biology of the Short-billed and Long-billed Murrelets (*Brachyramphus brevirostris* and *B. marmoratum*), p. 169]. Novosti Ornitologii, Contributions of the Fourth All-Union Ornithological Conference, 1–7 September 1965, Alma Ata, USSR. (Translation in Van Tyne Memorial Library, Univ. of Michigan Museum of Zoology, Ann Arbor, MI.)

SMETANIN, A. N. 1992. [The location of nesting of the Short-billed Murrelet (*Brachyramphus brevirostris*) on Kamchatka], p. 28–29. *In* [Studies of colonial sea birds in the USSR]. Russian Academy of Sciences, Magadan, Russia.

THAYER, J. E. 1914. Nesting of the Kittlitz Murrelet. Condor 16:117–118.

The Condor 97:273–275

NEST-SITE CHARACTERISTICS OF THE MADAGASCAR BUZZARD IN THE RAIN FOREST OF THE MASOALA PENINSULA[1]

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

Key words: Madagascar Buzzard; Buteo brachypterus; *nest-site selection; habitat; rain forest; Madagascar.*

Raptor breeding density may be limited in part by the availability of suitable nest sites (Newton 1979). Numerous studies in North America have sought to quantitatively describe raptor nesting habitat (Titus and Mosher 1981, Andrew and Mosher 1982, Bednarz and Dinsmore 1982, Moore and Henny 1983). The need for studies of raptor nesting habitat is particularly important in tropical regions such as Madagascar, that are experiencing rapid habitat loss.

The Madagascar Buzzard (*Buteo brachypterus*), one of eight species of diurnal raptors endemic to Madagascar, is reported to be common in wooded habitats (Langrand and Meyburg 1984). The habitat requirements of the Madagascar Buzzard, however, have not been investigated. The goal of this study was to describe the nests, nest trees, and nesting habitat of the Madagascar Buzzard in the rain forest of the Masoala Peninsula.

STUDY AREA AND METHODS

The study was conducted during December 1991 and from November 1992 to January 1993 near the Andranobe Field Station at the mouth of Andranobe Creek about 8 km south of the village of Ambanizana on the west coast of the Masoala Peninsula in Madagascar (15°41'S; 49°57'E). The west coast of the peninsula is sparsely inhabited by people in widely scattered villages. Along the coast and major rivers, the landscape is a mosaic of slash-and-burn clearings, secondary growth, and primary forest. The interior of the peninsula, except along the Ambanizana River, is undisturbed rain forest. The entire peninsula is roadless; however trails were cut to reach nest sites.

The lowland rain forest of the Masoala Peninsula has a canopy height $\leq$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 for the area is not yet available; however 6,501 mm of rain was recorded at the field station in 1992. 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 31°C throughout the year.

I located ten nests by imitating the buzzard's call, a "piercing, plaintive mew" (Langrand 1990), and walking in the direction of responding calls. I located two nests by climbing emergent trees to look out over the canopy. I found one nest by offering a reward to local people for reports of nesting activity. I found nine nests in 1991 and four new nests in 1992. Three (33%) of the nests found in 1991 were reused in 1992. Since I did not mark the birds, I do not know if any buzzard pairs I observed in 1991 relocated to new nests in 1992.

[1] Received 4 May 1994. Accepted 13 October 1994.
[2] Present address: Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

TABLE 1. Habitat characteristics measured at Madagascar Buzzard nest sites (n = 13) and random sites (n = 21) on the Masoala Peninsula, 1991 and 1992.

Variable description	Nest sites Mean	Nest sites SE	Random sites Mean	Random sites SE	P[1]
Ground slope (°)	35.2	3.2	33.0	3.0	0.786
Aspect (°)	297	15	234	14	0.022
Elevation (m)	205	36	207	45	0.386
Canopy cover (%)	74	6	84	1	0.078
Canopy height (m)	12.9	1.6	18.2	1.4	0.035
Number of tree species	13	1	15	1	0.097
Density of trees <10 cm DBH (stems/ha)	16,440	2,366	19,939	1,834	0.530
Density of trees >10 cm DBH (stems/ha)	863	138	738	66	0.067
Density of vines (stems/ha)	8,489	2,181	7,129	1,151	0.810
Density of palms and tree ferns (stems/ha)	725	183	2,883	1,285	0.127
Distance to nearest stream (m)	72	15	81	18	0.609
Distance to nearest human disturbance (m)	610	199	687	142	0.633
Distance to nearest conspecific nest (m)	917	103	513	64	0.001
Distance to ocean (m)	994	194	824	179	0.282

[1] Probability level for Multiple Response Permutation Procedures on nest site vs. random site data (Slauson et al. 1991).

All of the nests were within 4 km of the Andranobe Field Station.

I used a clinometer to measure nest and nest tree heights. I measured nest tree diameter-at-breast-height (DBH) to the nearest cm. I recorded number of supporting branches, composition, and lining material of each nest by looking into nests from adjacent hillsides. I identified 10 nest trees to genus or species. I noted whether the nest was in the top, middle, or bottom third of the nest tree canopy and whether it was supported by a fork of the main trunk, a side fork, or a hanging epiphyte. I measured length (longest dimension), width (shortest dimension) and outer depth of two nests to the nearest cm.

To determine how nest-site characteristics differed from characteristics of the surrounding area, I measured habitat variables at 13 nest sites and 21 random sites. Habitat variables included ground slope, aspect, elevation, canopy cover at the nest tree (Moore and Henny 1983), canopy height, number of tree species, plant-stem densities, and distances to landscape features. I recorded stem densities for (1) small trees (DBH < 10 cm), (2) large trees (DBH > 10 cm), (3) vines, and (4) palms and tree ferns. Landscape features included distance to the nearest stream, human disturbance (cleared areas or houses), conspecific nest, and the ocean.

At each site, I measured slope with a clinometer, aspect with a compass, elevation with an altimeter, and canopy cover with a spherical densiometer. I estimated canopy height in 5 m intervals (0–<5 m, ≥5–<10 m, ≥10–<15 m, etc.) and used the interval midpoints to obtain means and standard errors. As an index of tree species richness at each site, I recorded the number of different tree species among 20 trees. I selected 20 trees by finding the nearest tree to the nest tree in each of four quadrants separated by north-south and east-west axes centered at the nest tree, and likewise at points 20 m from the nest tree in the four cardinal directions (four trees each at five points). I measured stem densities within four 20 m-long, 1.75 m-wide belt transects oriented in the four cardinal directions starting at the nest tree (Andrew and Mosher 1982). I estimated distances from a 1:100,000 scale topographic map of the area. I chose random sites by selecting random coordinates on a grid overlaying a map of the study area.

I performed univariate Multiple Response Permutation Procedures (MRPP) tests on each of the 14 measured habitat variables to determine which variables differed between nest sites and random sites (Slauson et al. 1991). I used the MRPP option for data from a circular distribution with no endpoint to analyze site aspects.

RESULTS

Nest height ranged from 8.1 to 25.0 m ($\bar{x}$ = 18.7 m, SD = 4.5 m). Nest tree height ranged from 10.1 to 43.4 m ($\bar{x}$ = 24.9 m, SD = 8.7 m). Percentage nest height relative to tree height ranged from 54.6% to 92.5% ($\bar{x}$ = 78.2%, SD = 13.5%). Nest tree DBH ranged from 20 to 122 cm ($\bar{x}$ = 69.0 m, SD = 32.8 m). Number of supporting branches ranged from 0 (for nests on hanging epiphytes) to 7 ($\bar{x}$ = 3.2, SD = 2.2). All of the nests were built of sticks and lined with green leaves. Nest tree species included *Albezia* sp., *Canarium madagascariensis, Intsia bijuga, Syzygium* sp., *Onthostema madagascariensis, Ravensara perillei, Polyscias ornifolia, Garcinia* sp., and *Foucheria* sp. Only two of the nest trees were of the same genus (*Albezia*), and three nest sites were not identified. Three nests (23%) were in the top third of the nest tree canopy, two (15%) in the middle third, six (46%) in the bottom third, and two (15%) below the nest tree canopy. Eight nests (62%) were in a fork of the main trunk of the nest tree, three nests (23%) were in forks to one side of the main trunk, and two nests (15%) were on hanging epiphytes. The dimensions of the two measured nests were 103 cm (length) by 69 cm (width) by 70 cm (outer depth) and 64 cm by 41 cm by 36 cm.

Aspect, canopy height, and distance to nearest conspecific nest differed ($P < 0.05$) between nest sites and random sites (Table 1). Nest sites were found over a narrower range of aspects (220° to 7°) than random sites (122° to 342°). Mean canopy height at nest sites was 5.3 m lower than at random sites. The smallest inter-nest distance was 520 m, whereas 13 of 21 random sites were <520 m from a buzzard nest. None of the 11 remaining variables differed significantly between nest sites and random sites.

DISCUSSION

The 13 nest sites in the study were similar, regardless of whether they were found in primary forest or in slash-and-burn clearings. Nests were built either in large central forks or on hanging epiphytes in a central part of the tree. Nest height varied little, but the height and diameter of the nest trees were more variable. Nest trees were tall, had a narrow canopy, and were isolated from neighboring trees. Nests were built high in the nest trees. The mean percentage nest height relative to tree height in this study was very similar to the 78.5% that Titus and Mosher (1981) reported for the Red-tailed Hawk (*Buteo jamaicensis*) in the central Appalachians. Bednarz and Dinsmore (1982) hypothesized that Red-tailed Hawks place their nests high in isolated trees or edge situations to increase nest accessibility. Access is probably an important factor in the nest-site selection of the Madagascar Buzzard as well.

The difference between mean canopy height of nest sites and random sites, although statistically significant ($P < 0.05$), was not great, but may have biological significance. Madagascar Buzzards may select prominent nest trees overlooking a lower surrounding canopy. The combination of a high percentage nest height and a low surrounding canopy would further facilitate access to the nest.

Distance to nearest conspecific nest for nest sites was nearly twice that for random sites. The nests were uniformly spaced (Berkelman 1993), which provides evidence for intraspecific territorial behavior (Newton 1979).

The results of the analysis of 14 habitat variables measured in this study, along with evidence on breeding biology and food habits (Berkelman 1993), suggest that the Madagascar Buzzard has broad ecological requirements on the Masoala Peninsula. The buzzard may, therefore, be less vulnerable to the effects of forest fragmentation than species with more specialized requirements. It is the third most common raptor in Madagascar (Langrand and Meyburg 1984), and its success probably attests to its ability to use modified habitats. As human population density increases on the Masoala Peninsula and more of the forest is cleared, effects on the nesting habitat of this species may become more apparent.

I thank Victor, Fortunat, Fortuné, Barthélemy, Palôtte, Martin, and Fulgence for field assistance in Madagascar. I thank R. T. Watson for doing much of the groundwork that made this study possible. I thank Lila Borge for encouragement and support during my second field season on the Masoala Peninsula. I thank T. J. Cade, M. Bechard, J. Munger, R. T. Watson, and J. Fraser for reviewing drafts of the manuscript. I thank The Peregrine Fund, Inc., Boise State University, and the Explorer's Club for providing funding to support this research.

LITERATURE CITED

Andrew, J. M., and J. A. Mosher. 1982. Bald Eagle nest-site selection and nesting habitat in Maryland. J. Wildl. Manage. 46:383–390.

Bednarz, J. C., and J. J. Dinsmore. 1982. Nest-sites and habitat of Red-shouldered and Red-tailed Hawks in Iowa. Wilson Bull. 94:31–45.

Berkelman, J. 1993. Ecology of the Madagascar Buzzard, *Buteo brachypterus*, in the rain forest of the Masoala Peninsula. M.Sc. thesis, Boise State Univ., ID.

Donque, G. 1972. The climatology of Madagascar, p. 87–144. *In* R. Battistini and G. Richard-Vindard [eds.], Biogeography and ecology in Madagascar. Junk Publishers, The Hague, Netherlands.

Guillaumet, J.-L. 1984. The vegetation: an extraordinary diversity, p. 27–54. *In* A. Jolly, P. Oberlé, and R. Albignac [eds.], Key environments—Madagascar. Pergamon Press, New York.

Langrand, O. 1990. Guide to the birds of Madagascar. Yale Univ. Press, New Haven, CT.

Langrand, O., and B. -U. Meyburg. 1984. Birds of prey and owls in Madagascar: their distribution, status, and conservation, p. 3–13. *In* J. M. Mendelsohn and C. W. Sapsford [eds.], Proc. Symp. African Predatory Birds, Natal Bird Club, Durban, South Africa.

Moore, K. R., and C. J. Henny. 1983. Nest site characteristics of three coexisting accipiter hawks in northeastern Oregon. Raptor Res. 17:65–76.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

Slauson, W. L., B. S. Cade, and J. D. Richards. 1991. User manual for BLOSSOM statistical software. Natl. Ecol. Res. Cent., U.S. Fish and Wildl. Serv., Fort Collins, CO.

Titus, K., and J. A. Mosher. 1981. Nest-site habitat selected by woodland hawks in the central Appalachians. Auk 98:270–281.