CLIFF AND DECIDUOUS TREE NESTS OF MARBLED MURRELETS IN SOUTHWESTERN BRITISH COLUMBIA

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ABSTRACT—We report on nests of radio-marked marbled murrelets (*Brachyramphus marmoratus*) nesting in unusual habitats in southwestern British Columbia. We found 1 confirmed and 2 probable marbled murrelet nest sites on cliffs. These represent the 1st substantiated accounts of ground nesting in this species south of Alaska. In addition, we found a marbled murrelet nesting in a 130 (±5)-yr-old red alder (*Alnus rubra*) deciduous tree. A survey of available nesting sites in both the nest tree patch and the mixed coniferous-deciduous stand adjacent to this deciduous nest tree indicated most potential nesting trees were deciduous and that deciduous trees had a higher density of potential nesting sites. These unusual sites represent a very small proportion (7% of confirmed sites, 3% of suspected sites) of nest sites found in British Columbia using radio telemetry. Both confirmed nest sites consisted of a platform with heavy epiphyte cover and an adjacent flyway, similar to nests found in mature coniferous forest.

Key words: *Brachyramphus marmoratus*, marbled murrelet, cliff, deciduous tree, nesting, radio telemetry, British Columbia

Study of the nesting habits of the marbled murrelet (*Brachyramphus marmoratus*) has challenged ornithologists for over 2 centuries. This small seabird is unique among the Alcidae because of its preference for breeding in coastal forests. The 1st verified nest of this species was documented in California in 1974 (Binford and others 1975). The 1st confirmed nest in Canada was not reported until 1990 (Kelson 1991), and the 1st active nest was not documented until 1993 (Jones 1993). The marbled murrelet is listed as threatened through most of its range (Nelson 1997) and in the last decade there has been a substantial increase in research on the nesting biology of this species. This intense research effort has greatly expanded our knowledge of the breeding ecology of marbled murrelets.

Most murrelet nest sites have been found in mossy platforms on limbs of old-growth trees (Nelson 1997). All known tree nests have been located in evergreen trees in old-growth coniferous forests or mature coniferous forests with old-growth components (Nelson 1997). There have been 15 marbled murrelet nest sites found on the ground, all in Alaska (Nelson 1997). These ground nests have been found in the open, under vegetation, in cavities, on rock scree slopes, or on cliffs (Day and others 1983; Johnson and Carter 1985; Kuletz and Marks 1997). Most of these nests have been found in areas with no vegetation or scattered shrubs and small trees (Nelson 1997). However, in SE Alaska, ground nesting has been documented in areas of old-growth coniferous forest (Ford and Brown 1995). South of Alaska, birds are known to nest only in coniferous trees (Nelson 1997). There is 1 account of a possible ground nest near the Nooksack River in Washington State (Booth 1927), but this report never states clearly where the egg was found. Here we document 2 confirmed and 2 probable marbled murrelet nests in unusual sites in southwestern British Columbia.

STUDY AREA AND METHODS

The findings reported here are part of a large multidisciplinary study of the demography of marbled murrelets in British Columbia (Cooke 1999) Our general approach was to catch and mark a sample of birds prior to nesting, find their nests, and record their breeding status through radio telemetry. Adult marbled murrelets were captured in April and May, in Desolation Sound, British Columbia (50°05′N, 124°40°W), in 1999 and 2000 and in Mussel In-

let, British Columbia (52°54°N, 128°06°W), in 1999. Birds were captured from small boats at night using a ''dip netting'' technique (Whitworth and others 1997; Vanderkist and others 1999) and fitted with subcutaneous anchor radio transmitters (Model 386, Advanced Telemetry Systems, Isanti, MN) following methods of Newman and others (1999) but without the use of anesthetic.

Nest locations and incubation status of marbled murrelets were determined by aerial helicopter telemetry (Hull and others, in press). Daily marine detections of birds were used to determine the initiation of breeding, as incubating marbled murrelet pairs alternate regular 24 hour incubation shifts and exchange duties at dawn (Nelson 1997; Centre for Wildlife Ecology (CWE), Simon Fraser University, unpubl. data). Therefore, an incubating bird shows a regular pattern of marine detections every 2nd day. Daily marine detections from the entire breeding season ensured that radios of nesting birds continued to function properly. Nests were located by inland aerial radio telemetry search flights. Approximate nest locations (within about a 100-m × 100-m area) were determined from the helicopter by hovering near the strongest telemetry signals. In order to determine exact nest locations, ground telemetry, using a handheld 3 dimensional Yagi antennae (Advanced Telemetry Systems, Isanti, MN), and visual searching were conducted at accessible sites.

After estimated hatch date, radio-marked parents were no longer present at nest sites during the day but visited their nests mainly at dawn and dusk to feed their young (Nelson 1997). Telemetry receivers and remote data collection computers (Advanced Telemetry Systems, Isanti, MN) monitored sites for the presence of radio signals from nesting birds, and the alder tree nest was also monitored visually during the day. We climbed to both confirmed nests at the end of the breeding season, and data were collected on nest structure and success (Hamer and others 1994; Manley 1999)

At the deciduous tree nest, a ''potential nesting platform survey'' (Falk Huettmann, CWE, Simon Fraser University, unpubl. data) was conducted along 4 transects in the cardinal directions based at the nest tree. This was done to quantify nesting platforms by tree species available in the adjacent forest stand. Transects were 500 m in length, but 2 transects were shortened by terrain features. The south and east transects were only surveyed for 120 m and 400 m, respectively. Data were collected on tree species and number of potential murrelet nesting platforms in 4 classes: 1, 2 to 4, 5 to 9, and >9. Potential murrelet nesting platforms are defined as tree limbs >15 m above the ground and >18 cm in diameter, including moss (RIC 1997). In addition, a Resource Inventory Council of British Columbia (RIC) standard 25-m radius marbled murrelet forest habitat plot was conducted around the nest tree (RIC 1997). This smaller-scale inventory of all trees adjacent to the nest tree was collected to compare data on potential nesting platforms directly adjacent to the deciduous nest tree. This nest tree was cored with an increment borer to determine its age through standard dendrochronology methods.

RESULTS

Nest Characteristics

We found 2 confirmed and 2 probable murrelet nests. Of the 2 confirmed nests, 1 site was located on a small cliff in coniferous forest (Fig. 1), while the other site was in a 130 (±5)-yr-old red alder (*Alnus rubra*) deciduous tree in previously unlogged mixed forest (Fig. 2). The 2 probable nests were on large steep cliffs where only low scrub and mossy vegetation were available. Nest characteristics and reproductive success were recorded (Table 1).

Nesting Platform Survey and 25-m Radius RIC Plot Around Deciduous Nest Tree

Potential nesting platforms were recorded in 115 trees during the transect survey. Of these, 64% were deciduous trees (58% big leaf maple [*Acer macrophyllum*], 6% red alder) and 36% were coniferous trees (21% western red-cedar [*Thuja plicata*], 11% western hemlock [*Tsuga heterophylla*], 4% Douglas-fir [*Pseudotsuga menziesii*]). Deciduous trees had a higher proportion of potential nesting platforms than coniferous trees in all 4 density classes (Table 2). In the smaller-scale 25-m radius RIC plot around the nest tree, 57% of trees directly adjacent to the nest had no potential nesting platforms; the great majority of these trees were red alder (Table 3). The nest tree was the only red alder with potential nesting platforms; the majority of available nesting platforms in deciduous trees

FIGURE 1. Cliff face (left) and nest cup (right), with pencil for scale, of successful marbled murrelet nest. Arrow indicates nest location on the cliff face. In photo of nest cup, the cup and fecal ring are just left of pencil.

were found in big leaf maple (Table 3). Like the larger-scale platform survey, the majority of trees with potential nesting platforms in the RIC plot were deciduous in all density classes (Table 3).

DISCUSSION

These results represent the 1st documented marbled murrelet ground nest south of Alaska and the 1st use of a deciduous tree for nesting by this species. Although nesting murrelets

FIGURE 2. Adult marbled murrelet incubating in a red alder tree (left) and unsuccessful nest cup, with pencil for scale (right).

TABLE 1. Nest characteristics of confirmed and suspected marbled murrelet nests in unusual habitats.

Nest feature	Theodosia Valley	Toba Inlet	Powell Lake	Mussel River
Latitude	50°09.78N	50°23.93N	50°10.12N	53°02N
Longitude	124°34.75W	124°38.00W	124°25.13W	125°09W
Type	Cliff	Tree (*Alnus rubra*)	Cliff	Cliff
Status	Confirmed	Confirmed	Suspected	Suspected
Visual ID of incubating adult?	No	Yes	No	No
Year	2000	2000	2000	1999
Slope	90°	40°	90°	70°
Elevation	1300 m	200 m	885 m	800 m
Flyway distance to ocean	15 km	0.3 km	21 km	18 km
Adjacent vegetation	Shrub-like yellow cedar mountain hemlock	Mixed coniferous and deciduous forest	Shrub-like conifers	Willows (*Salix* sp.) and sedge (*Cyperaceae*)
Nesting platform	Yes	Yes	Suspected	Suspected
Heavy moss cover	Yes	Yes	Visible from air	Visible from air
Flyway opening	Yes	Yes	Yes	Yes
Success	Successful	Failed in late incubation or early chick rearing	Radioed parent regularly visited nest throughout breeding period	Unknown
Comments	Nest on ledge about 25 m from top of a 50 m cliff face	Nest 18 m up 29.7 m tall alder tree (DBH = 0.71 m)	No large trees with nesting platforms, signal localized to mossy ledges on 300 m cliff face	No large trees with platforms within 500 m

have not been previously observed in these habitats, the "structure" of these nest sites (heavy epiphyte cover, large platform, flyway opening) is similar to nests in coniferous trees (Table 1). These nest sites are part of a sample of 30 confirmed and 78 suspected nest sites located by these methods in British Columbia from 1998–2000 (CWE, Simon Fraser University, unpubl. data). Confirmed nests were visually inspected while suspected sites were located only from the air due to inaccessible terrain.

TABLE 2. Proportion of trees (n = 115) with potential nesting platforms of varying densities on all transects around a nest in a deciduous tree. Deciduous trees represent a higher proportion of trees with platforms, relative to coniferous trees, at all densities.

Number of potential nesting platforms	Deciduous trees (% of total)	Coniferous trees (% of total)
1	12	9
2 to 4	41	23
5 to 9	6	3
>9	4	1

Ground Nests

Previously documented ground nests were ≤6.2 km from the ocean, but most were <1 km from shore (Nelson 1997). The high elevation and great distance from the ocean (Table 1) of these confirmed and probable nests are more characteristic of the ground nests of the closely related Kittlitz's murrelet (*B. brevirostris)* and

TABLE 3. Proportion of trees (n = 41) by species and number of nesting platforms in 25-m radius RIC plot around a deciduous tree containing a marbled murrelet nest. Values are percentage of total trees in the plot. Big leaf maple (BLM) and red alder (RA) are deciduous species while western red-cedar (CW) and western hemlock (HW) are coniferous species. Deciduous trees represent a higher proportion of trees with platforms, relative to coniferous trees, at all densities.

Number of potential nesting platforms	RA	BLM	CW	HW
0	56	7	0	5
1	0	0	0	0
2 to 4	0	7	0	0
5 to 9	0	7	2	2
>9	2	10	0	2

long-billed murrelet (*B. perdix*). Kittlitz's murrelets' nests have been found exclusively on the ground on scree slopes and cliffs (Day and others 1999). In the southern portion of their Alaskan range, Kittlitz's murrelets have been found breeding at a mean elevation of 760 m, up to 75 km inland (Day and others 1999). The only ground nest of a long-billed murrelet (*B. perdix*) ever reported came from Russia and was found at 700 m elevation in mixed forest, 30 km inland (Konyuhov and Kitaysky 1995). In all 3 of our cliff sites, moss-covered ledges and crevices seemed to provide many more potential nesting platforms than any adjacent trees.

There is little genetic and morphological divergence between tree- and ground-nesting populations of marbled murrelets in Alaska (Pitocchelli and others 1995). Congdon and others (2000) concluded that population genetic structure of British Columbia and Alaska birds shows no selection associated with different nesting habits. There is no evidence that ground-nesting murrelets represent a different population from tree-nesting birds.

Deciduous Tree Nest

This nest was located in a stand where most potential nesting sites were in deciduous trees at both relatively large (Table 2) and small (Table 3) spatial scales. While long-billed murrelets have been observed nesting in broad-leaved trees (Konyukhov and Kitaysky 1995), the discovery of a marbled murrelet nesting in mixed deciduous-coniferous forest has implications for survey methodologies that assess nesting densities. In surveys which count potential marbled murrelet nesting platforms, deciduous tree platforms are often assumed to be too exposed to be used as nest sites (Rodway and Regher 1999). In addition, deciduous trees with potential nesting platforms have been excluded from nest-finding studies done by climbing trees (Newsom and Bahn 1999).

Conservation Context

While these findings increase our knowledge of the breeding ecology of this species in British Columbia, it is important to view them in the context of our present knowledge of marbled murrelet breeding habitat. In Alaska, only 3% of the marbled murrelet population is estimated to nest on the ground (Piatt and Ford 1993). Mature forest and late seral environment (heavy epiphyte cover) are associated with all known nest sites in the southern range of this species, including the ones described here. Radio-telemetry studies in British Columbia (CWE, Simon Fraser University, unpubl. data) have allowed for a less-biased method of finding nests compared to visually searching for nests or climbing trees. Radio tracking follows birds wherever they choose to nest, while tree climbing and visual searching only survey areas where nests are thought to be. Results from this method show 7% (2/30) of confirmed sites and 3% (2/78) of suspected sites as ground or deciduous tree nests. However, the number of suspected sites in unusual habitats may be biased low because telemetry observers may have the preconception that suspected nest sites that are inaccessible to ground-based telemetry and climbing are in coniferous trees.

The selection of these unusual nesting habitats by marbled murrelets may be due to heavy modification of the original old-growth forest. The Desolation Sound area, where we found the 2 confirmed nest sites and 1 of the suspected cliff nests, has been subjected to heavy timber harvesting, whereas the Mussel River site, where the other suspected cliff nest was located, is a ''pristine'' unlogged watershed.

Despite our observations of ground- and deciduous tree-nesting, the great majority of marbled murrelet nest sites found using radio telemetry are associated with old-growth coniferous forests or mature coniferous forests with old-growth components. Land management decisions for this species should incorporate the entire breadth of our knowledge of the nesting requirements of this seabird.

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LITERATURE CITED

BINFORD LC, ELLIOT BC, SINGER SW. 1975. Discovery of a nest and downy young of the marbled murrelet. Wilson Bulletin 87:202–319.

BOOTH EJ. 1927. Egg of the marbled murrelet. Murrelet 8:16.

CONGDON BC, PIATT JF, MARTIN K, FRIESEN VL. 2000. Mechanisms of population differentiation in marbled murrelets: historical versus contemporary processes. Evolution 54:974–986.

COOKE F. 1999. Population studies of marbled murrelets (*Brachyramphus marmoratus*) in British Columbia. In: Diamond AW, Nettleship DN, editors. Biology and conservation of forest birds. Special Publication No. 1. Fredericton, NB: Society of Canadian Ornithologists. p 43–51.

DAY RH, OAKLEY KL, BARNARD DR. 1983. Nest sites and eggs of Kittlitz's and marbled murrelets. Condor 85:265–273.

DAY RH, KULETZ KJ, NIGRO DA. 1999. Kittlitz's murrelet (*Brachyramphus brevirostris*). In: Poole A, Gill F, editors, The Birds of North America, No. 435. Philadelphia, PA: The Birds of North America, Inc. 28p.

FORD C, BROWN M. 1995. Unusual marbled murrelet nest. Wilson Bulletin 107:178–179.

*HAMER TE, NELSON SK, HUBBART AK, HUGHES SK, BECKING RW, HARDIN JG, KULETZ KJ, NASLAND NL, SINGER S. 1994. Guidelines for collecting data at marbled murrelet nest trees or landing trees. Pacific Seabird Group Marbled Murrelet Technical Committee. Available from: Pacific Seabird Group MMTC, Anne Harfenist, PO Box 2498, Smithers, BC V0J 2N0 Canada.

HULL CL, KAISER GW, LOUGHEED C, LOUGHEED L, BOYD S, COOKE F. 2001. Intra-specific variation in commuting distance of marbled murrelets *Brachyramphus marmoratus*: Ecological and energetic consequences of nesting farther inland. Auk. In press.

JOHNSTON S, CARTER, HR. 1985. Cavity-nesting marbled murrelets. Wilson Bulletin: 97:1–3.

JONES P. 1993. Canada's first active marbled murrelet nest, Caren Range, Sechelt Peninsula, BC. Discovery 22:147–150.

KELSON J. 1991. Mystery of the murrelet. Equinox 3: 59–62.

KONYUKHOV NB, KITAYSKY AS. 1995. The Asian race of the marbled murrelet. In: Ralph CJ, Hunt GL, Raphael MG, Piatt JF, editors. Ecology and conservation of the marbled murrelet. Albany, CA: USDA Forest Service General Technical Report. PSW-152. p 23–32.

KULETZ KJ, MARKS DK. 1997. Post-fledging behavior of a radio-tagged juvenile marbled murrelet. Journal of Field Ornithology: 68:421–425.

MANLEY IA. 1999. Behaviour and habitat selection of marbled murrelets on the Sunshine Coast [thesis]. Burnaby, BC: Simon Fraser University. 163 p.

NELSON SK. 1997. Marbled murrelet (*Brachyramphus marmoratus*). In: Poole A, Gill F, editors. The Birds of North America No. 276. Washington, DC: The American Ornithologists' Union. 32p.

*NEWSOM D, BAHN V. 1999. Marbled murrelet nest density estimate and characteristics of nests and nest trees in lower slope and valley bottom habitats of the Ursus Valley, Clayoquot Sound, British Columbia. Available from: Ministry of Environment, Lands, and Parks, 2080 Labieux Road, Nanaimo, BC V9T 6J9 Canada.

PIATT JF, FORD RG. 1993. Distribution and abundance of marbled murrelets in Alaska. Condor 95:662–669.

PITOCCHELLI J, PIATT J, CRONIN MA.1995. Morphological and genetic divergence among Alaskan populations of *Brachyramphus* murrelets. Wilson Bulletin 107:235–250.

*[RIC] RESOURCES INVENTORY COMMITTEE. 1997. Standardized inventory methodologies for components of British Columbia's biodiversity: marbled murrelets in marine and terrestrial habitats. Available from: Ministry of Environment, Lands, and Parks, PO Box 9374, Station Provincial Government, Victoria, BC V8W 9M4 Canada.

RODWAY MS, REGHER HM. 1999. Potential nesting density of marbled murrelets in valley-bottom old-growth forest in Clayoquot Sound, British Columbia. Pacific Seabirds 26: 3–7.

VANDERKIST BA, XUE XH, GRIFFITHS R, MARTIN K, BEAUCHAMP W, WILLIAMS TD. 1999. Evidence of male bias in capture samples of marbled murrelets from genetic studies in British Columbia. Condor 101:398–402.

WHITWORTH DL, TAKEKAWA JY, CARTER HR, MCIVER WR. 1997. A night lighting technique for at sea capture of Xantus' murrelets. Colonial Waterbirds 20:525–531.

* Unpublished.

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