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DISCOVERY OF A NEST AND THE DOWNY YOUNG OF THE MARBLED MURRELET

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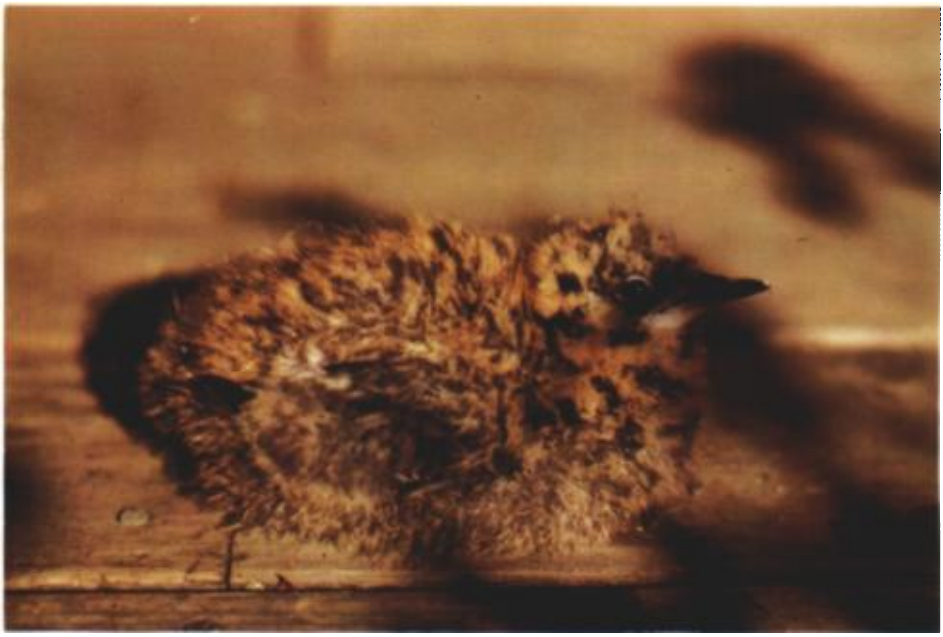
On the afternoon of 7 August 1974, Hoyt Foster, a tree surgeon for the Davey Tree Company, was removing branches from a large Douglas-fir (*Pseudotsuga menziesii*) in the Santa Cruz Mountains of coastal California. As Foster reached a limb high above the ground, he beheld the first North American nest and the only known downy chick of the Marbled Murrelet (*Brachyramphus marmoratus*). This discovery brought to a conclusion a search that has captured the imagination of North American ornithologists for 185 years (for partial historical summaries see Bent 1919, Guiguet 1956, Drent and Guiguet 1961, Sealy 1972 and 1974).

In this report we describe the nest, eggshell fragments, and nestling, all of which are now in the California Academy of Sciences (CAS), and discuss their bearing on the breeding biology and taxonomy of the species. Additional details of the circumstances surrounding this discovery have been published by Singer and Verardo (1975). The subspecies concerned here is *B. m. marmoratus*, which summers primarily from Kodiak Island, Alaska, south through the northern half of coastal California (A. O. U. 1957). Kuzyakin (1963) presents a well-documented account of a Siberian nest of the Palearctic race, *B. m. perdix* (see Discussion).

Locality.—The nest tree overshadows campsite J-1 at an elevation of about 310 m in Big Basin Redwoods State Park, Santa Cruz Co., California. The campsite is about 27 km northwest of the city of Santa Cruz and 10 km due northeast of the nearest point on the Pacific coast, the mouth of Elliot Creek on Año Nuevo Bay.

Marbled Murrelets are known to feed throughout the year in this portion of the Bay, as well as at Pigeon Point, 15 km west of the nest site. On 18 and 19 May 1914 Dawson (1923) saw a number of Marbled Murrelets flying down-valley along "Major Creek" (= Big Creek) on the slopes of Ben Lomond, a mountain southeast of Big Basin Redwoods State Park. Within



Chick and nest of the Marbled Murrelet *(Brachyramphus marmoratus marmoratus)* from Big Basin Redwoods State Park, Santa Cruz Co., California. Live chick photographed on 8 August 1974. Nest (as seen from above) on portion of horizontal limb after removal from tree; much of whitish ring of droppings missing; moss beyond brown ring was a much brighter green in life. From Kodachrome II transparencies.

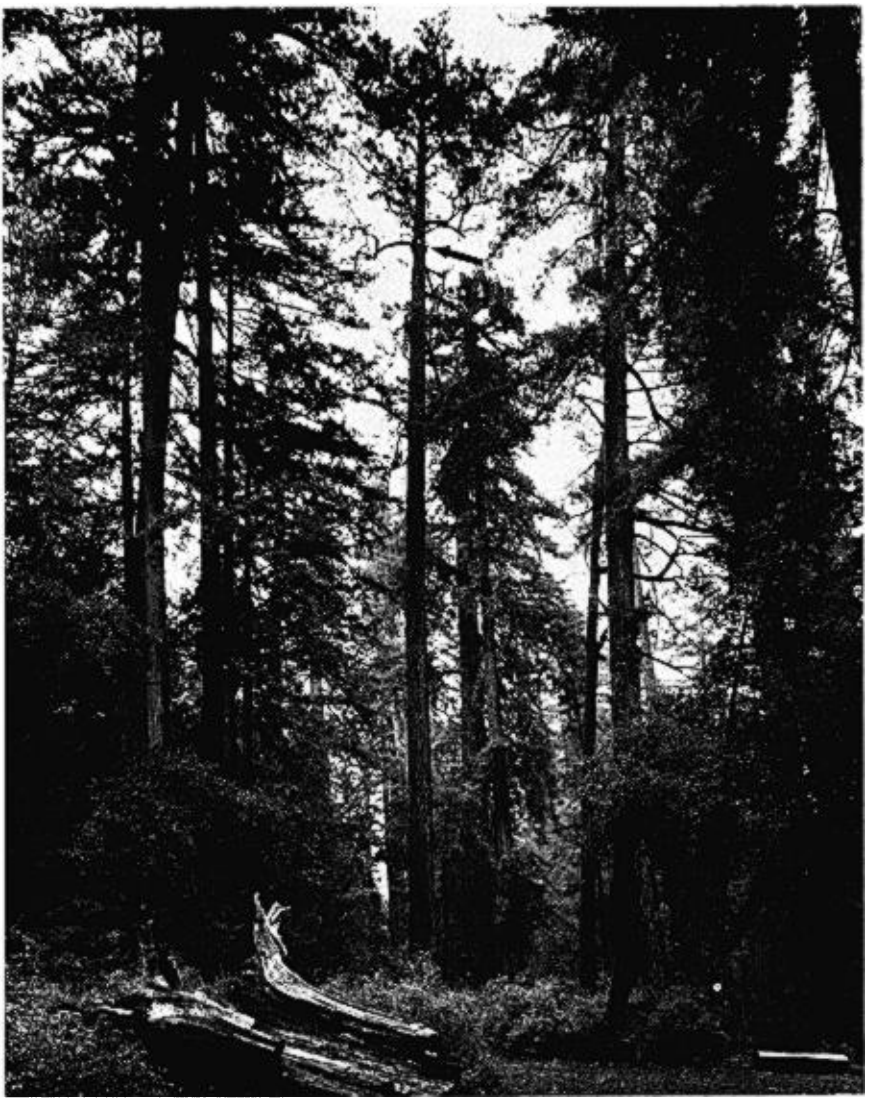


FIG. 1. Marbled Murrelet nest tree and surrounding habitat, Big Basin Redwoods State Park, Santa Cruz Co., California. Arrow indicates point where nest limb, which projected to the south (right), was removed. Photo taken by S. A. Mitchell on 10 January 1975.

Big Basin flying adults were noted on 19 April and in July 1959, and a live juvenile nearly devoid of natal down was discovered on the forest floor on 9 September 1974 (Singer and Verardo 1975). Other grounded juveniles in similar plumage were found in Big Basin on 18 August 1960 and in nearby Portola State Park on 15 June 1957 (Anderson 1972).

Habitat and nest site.—The nest was 45 m above the ground and 6.8 cm from the trunk (to nearest edge of nest bowl) on the broad almost flat top of a limb of a Douglas-fir. The nest tree, 61 m in height (determined by triangulation) and 167 cm in diameter (at 1.2 m), was situated (Fig. 1) amidst a virgin association of generally smaller Douglas-firs and mostly larger coast redwoods (*Sequoia sempervirens*), with a second-story of tanoak (*Lithocarpus densiflorus*), California live oak (*Quercus agrifolia*), and madrone (*Arbutus menziesii*). Within a 26 m radius of the nest tree were 7 other Douglas-firs and 14 coast redwoods, a ratio of 1:2. Beneath the tree, the ground was bare in the campsite and elsewhere densely coverd with a nearly pure growth of California huckleberry (*Vaccinium ovatum*) 1.5 to 2.5 m tall. From ground level the top of the nest tree appeared completely enclosed by branches. At the height of the nest, however, much of the southeast quadrant was open, owing to the lowness of the canopy, and would have provided the murrelets with easy, although not direct, access to the ocean. The vegetation in that direction would have allowed departing birds a 6 m drop within 3 horizontal meters of the trunk and practically unlimited descent beyond.

The nest limb, which measured about 41 cm in diameter at its base and about 15 m long, projected a few degrees west of south and sloped downward very slightly. The presence of a large southward-oriented limb beginning about 180 cm above, together with the slight southward slant of the trunk, provided a sheltering overhang for the nest. Another large branch, directed south-southwest, emerged 132 cm beneath the lower surface of the nest limb. The nest limb was located above a campground, and its distal 5 m was about 60% dead; as a safety precaution this entire limb (and nest), plus several other branches, were removed on 8 August.

Bright green moss (*Isothecium cristatum*) 5 to 10 mm in depth completely coated the upper surface of the basal half of the nest limb but became sparser toward the sunlit tip. When fresh this moss was a much brighter green than indicated in the Frontispiece. A scattering of brown, fallen fir needles and a few sprigs of lichen completed the covering. The only patch of brown moss on the limb was that surrounding the nest. The bark of the trunk was dark brown with scattered reddish brown streaks; it was lightly coated with bright green moss on the north side but virtually bare on the south (nest) side.

Opal Creek, approximately 215 m west of the nest tree, and Blooms Creek, about the same distance south, merge several hundred yards to the southwest to form Waddell Creek, which enters the Pacific Ocean about 10 airline km southwest. In late summer water in Opal and Blooms creeks is reduced to a trickle connecting deeper pools. According to Park records, rainfall occurs almost exclusively in the winter (Nov.–Apr.); from 1 July 1888 through 30 June 1973 the annual (1 July–30 June) average was 133.32 cm and the extremes were 315.62 cm (1889–90) and 51.18 cm (1923–24).

Nest.—Foster made an unsuccessful attempt to obtain photographs of the nest prior to removing the nest limb. Despite the most careful efforts, portions of the nest were lost and others damaged during the strenuous and hazardous task of lowering the limb to the ground. Detailed inspection of the nest, however, permits us to present a reasonably accurate description. The Frontispiece shows the nest as it now exists, i.e. without much of the white ring of droppings.

The nest (CAS 8717) is little more than a depression or "bowl" in the bark, incompletely ringed by droppings. The oblong bowl is lightly whitewashed, devoid of even a vestige of moss, and oriented at a 30° angle (approximately NNE–SSW) to the long axis of the limb. It measures about 9.5 × 6.5 cm, but because the sides turn up at an abrupt angle, the effective size for holding an egg is about 8.0 × 4.5 cm. The thin layers of bark that line the bowl curl up marginally to form small ridges. The bowl appears to be natural, although we cannot discount the possibility that the adults had removed flakes of bark (and adhering moss). There are no apparent bill or claw marks in the wood.

We could find no loose nest material that might have been assembled by the adults. At first the nest rim probably was composed solely of naturally growing moss. Later it was built up in a fortuitous manner through the voiding action of the chick (and perhaps adults) to form a thick "ring" of droppings held together by an underlying meshwork of moss. The ring is broken on the trunk side by a mound of bark 5.0 cm wide (at bowl edge) and covered with brown-tipped moss, which apparently was too high for the nestling to reach with its droppings. Elsewhere the ring varies from 16.5 to 19.5 cm in outer diameter (maximum perpendicular to limb axis) and 4.0 to 7.0 cm in width; the latter variation is a result of the off-center position of the bowl. A few dried needles and twig fragments, in the same frequency as on the remainder of the branch, are scattered under and within the droppings. The upper (more recent) layers of droppings throughout most of the ring have been lost by handling, thus revealing the faintly buffy-white, rather crumbly, lower layers. The few intact portions reach a maximum thickness of about 5 mm (down to the

moss tips) and average about 3.0 cm above the deepest part of the bowl. They demonstrate that the surface of the outer coat was composed of smooth, rounded, slightly glossy hillocks that varied in color from buffy-white to pale Cream-Buff (capitalized colors from Ridgway 1912). The latter color is most prominent in the centers of the hillocks and resembles closely the Pale Ochraceous-Buff of the chick. The underlying moss is in surprisingly good condition; the tips of some plants are brown, but other tips and all bases are dark green, somewhat less bright than the moss away from the nest. Surrounding the ring of droppings is an area of Cinnamon-Buff moss, varying in width from 3.5 to 6.0 cm. Some plants are brown throughout, but most are green basally. The nest gives off a rather strong fishy odor reminiscent of a marine bird colony.

Eggshell fragments.—During the nest recovery approximately 165 fragments of eggshell (CAS 8717), ranging in size from less than a millimeter to 7.1 mm across, were removed from the ring of droppings (mostly from the lower layers) and surrounding moss. Several other pieces remain embedded in the ring. None was found in the bowl. The pieces represent perhaps a third of a shell, but whether they come from more than one egg cannot be determined. In ground color a few fragments are very slightly paler than the others, but this may be due to fading. A few fragments are lined with shell membrane. The absence of yolk and blood suggests normal hatching.

The colors of the fragments agree closely with those ascribed by Sutton and Semple (1941) to an egg taken from the oviduct of a female: Pale Glass Green with spots of Lavender-Gray, Deep Madder Blue, Sepia, Bone Brown, and Black. In addition we noted markings of Saccardo's Umber. The spots range in size from 4 to less than 0.1 mm in diameter.

Nestling.—When first seen the nestling was squatting motionless in the nest bowl and facing northwest toward Foster. It was very reluctant to leave the nest, turning somewhat and shifting up and down when its body was prodded and wings lifted with a pruning saw. It pecked the saw vigorously. When Foster attempted to cover the chick with a shirt, it scuttled quickly backward, toppled off the limb, and fluttered silently to the ground, bouncing and sliding off several other branches on the way and landing 7.5 m south of the trunk. Foster believed that the bird "intentionally" jumped rather than be caught. These actions suggest that the nestling defends itself against predators and leaves the nest only upon great provocation. The speed of fall was described by observers on the ground as like a parachute—about 30 kph; the wings were flapped rapidly.

Apparently unharmed by its fall, the chick was captured and remained in captivity until its death on the evening of 8 August, on which date the

live bird was photographed extensively by Elliott (Frontispiece). The bird appeared very alert and active. It moved quickly with a peculiar and comical waddling gait and demonstrated no aggressive behavior when handled. At no time between its discovery and death did it utter any sound.

When left in direct, late afternoon sunlight for only a minute, the chick began panting and almost immediately moved into nearby shade, where it remained motionless. Foster believed that the nest site would receive several hours of hot direct sunlight in the middle of a typical summer day. During the remainder of the day the site would be in warm filtered light. Early morning fog is sporadic at the site and, in any event, would rarely provide shade during midday because it usually burns off by mid-morning. These observations suggest that during the day a chick of this age can independently maintain its body temperature and hence could be left unbrooded. No adult was seen near the nest. However, Foster had been working in the nest tree for 3½ hours before discovering the nest and probably would not have noticed a departing adult.

The chick, prepared by Binford as a study skin and body alcoholic (both CAS 68895), proved to be a male weighing 95.6 g and possessing testes measuring 3½ × 1 (left) and 2½ × ½ (right) mm. Fat, termed moderate, was restricted to the feather tracts, primarily on the ventral surface of the body, where the feather bases were about half obscured. The digestive tract contained only some partially digested egg, which was fed to the bird during its 24-hour period of captivity, and a few down feathers.

The chick was undergoing complete molt into juvenal plumage. Although the flight feathers are about three-fourths grown and the remainder of the contour feathers almost completely unsheathed, most retain neossoptiles attached to their tips. This nestling down is long, soft, lax, and moderately dense. Average down feather lengths for selected regions are: center of the back, 30 mm; forehead, 5 mm; underparts, 20 mm. Regions of the specimen that lack nestling down are the forecrown, chin, upper throat, cheeks, eyelids, most of the forehead, all but one primary, most upper lesser wing coverts, most upper greater primary coverts, all under wing coverts, and the alular quills. Neossoptiles missing from a small patch on the breast probably were lost during preparation. Some down apparently was lost during captivity, perhaps as a result of handling, since photos (Frontispiece) taken on 8 August show down at the tips of the alular quills and on anterior portions of the head. We can find no evidence that the chick possessed 2 sets of nestling down; the tips of the down feathers seem too long, slender, and tapered (hairlike) to have supported protoptiles.

The unusually late retention of nestling down may function in affording the chick cryptic coloration for as long as possible before fledging; the black-and-white juvenal plumage against the brown and green moss of the nesting limb would be quite conspicuous to predators. The down must also function as insulation and perhaps has been selectively favored over the development of a thick layer of subcutaneous fat in this species that probably must be light enough to fly on young wings directly from the nest site to the ocean.

To determine the degree of development of the chick, we compared its dimensions with the averages of 9 adult males (CAS) taken on 26 March 1907 in Monterey Bay, California. In the following list each chick measurement is presented first, followed in parentheses by the average of the adult males and the percentage of this average that the chick had attained: chord of wing, 93.8 mm (124.3 mm; 75.5%); tail, 24.3 (31.9; 76.2); tarsus, 17.1 (17.7; 96.6); middle toe without claw, 23.3 (24.1; 97.7); culmen from anterior edge of nostril, 11.0 (17.0; 64.7). Chick measurements for the tarsus and middle toe fall between the extremes for adults and hence could represent maximum growth in this individual. The weight of the chick was about 43% of adult weight (loss of weight from unusual exertions, starvation, and freezer desiccation not considered). Newly fledged birds have attained about 70% of adult weight (Sealy 1972). Because growth patterns in the Marbled Murrelet are unknown (Sealy 1972), we cannot estimate the age of the chick.

The underparts posterior to the throat are unpatterned. The individual down feathers of the abdomen are whitish at the base, Pale Smoke Gray medially, and Light Buff at the tip, the combination producing an overall aspect of light buffy-gray. This area blends into the darker buffy-gray sides and flanks, the feathers of which are Pale Smoke Gray at the base, Deep Mouse Gray medially, and Light Ochraceous-Buff at the tip.

The throat and upperparts bear an intricate pattern of deep buff with Sooty Black patches. The buff areas vary from Pale Ochraceous-Buff on the throat to Light Ochraceous-Buff on the upperparts (strongest along the midline of the back). The individual feathers are tipped with either Sooty Black or buff; their basal and medial portions may be Deep Mouse Gray, Sooty Black, Light Buff, or Pale Ochraceous-Buff, in a variety of combinations.

Prior to preparation of the study skin Binford made sketches of the pattern of down on the head and neck (from the bill tip to a point about 90 mm posterior). Because the down is long and loose, delineation of the pattern is difficult and must be treated as approximate until a much younger bird can be acquired. Twenty-seven spots of Sooty Black can be discerned

FIG. 2. Diagrammatic representation showing the distribution of black spots on the anterior portion of the Marbled Murrelet chick. Drawing by Ken Carlson.

(Fig. 2 and Frontispiece): one each on the midlines of the occiput, nape, and upper throat; 2 on each side of the lower throat; and 10 on each side of the head and neck. Because the down is attached to the tips of nearly full-grown contour feathers, the spots appear at first inspection to be located much farther posteriorly than they actually are; all originate from contour feathers anterior to the back and breast. The areas of down now missing from the anterior portions of the head also possessed dark spots, as evidenced by a few remaining tufts and by photos of the live bird. The pattern on the remainder of the upperparts is too intricate to diagram; the area can be described as Light Ochraceous-Buff mottled with a lesser amount of Sooty Black.

Near the tip of each mandible is an egg tooth consisting of a horn-colored area surrounding a single, slightly off-center (toward the bill tip), white bump that is anteroposteriorly oval and highest toward its anterior end. The tooth on the upper mandible measures about 2.5 mm long and that on the lower mandible 1.6. Each is as wide as its respective mandible, but neither reaches the tomium. The lateral edges of both teeth appear chipped, as if they were being lost by fragmentation rather than in toto. The egg teeth are still present in newly fledged chicks (Sealy 1970).

The following notes on "soft part" colors were taken from the photographs and from the fresh specimen after it had been frozen for 20 days. The iris was dark brown. The bill, except for the egg teeth, was entirely jet black. The posterior half of each tarsus was black; the anterior half was pinkish white for the distal two-thirds, then blending into a dark purplish pink base. The toes were jet black below and pinkish white above, with shiny black nails. Dorsally (above) the basal third of the webs was pale pinkish gray and the remainder dark gray tinged with maroon. Ventrally the webs were blackish tinged with dark maroon. This seemingly reversed coloration—pale above and dark below—may represent countershading that operates when the feet are extended posteriorly (R. W. Storer, in litt.).

The Marbled Murrelet chick was compared directly with the only known chick of the Kittlitz's Murrelet (*B. brevirostris*; University of Kansas 60504), which is said to be 1–2 days old (Thompson et al. 1966). The colors of the bill and eye are identical, and those of the tarsi, toes, and webs are similar. Each chick has 2 egg teeth, a pale belly, a buffy back marked with black, and a buffy head discretely blotched with blackish. In the Kittlitz's chick, however, the ground color of the head is paler and brighter—buffy yellow instead of Ochraceous-Buff; the abdomen is creamy white faintly tinged with grayish, instead of buffy gray; the breast is an unmarked, moderately dark gray, rather than concolor with the abdomen; and the upperparts posterior to the neck, rather than being Ochraceous-Buff strongly variegated throughout with blackish, are medium gray, lightly and evenly suffused (grizzled) with pale buffy yellow and broken only by two black spots on the midline of the middle and lower back. Each chick possesses a large black spot on the nape. A younger Marbled chick is needed to determine whether or not other spots on the head, neck, and back of the two species are homologous. The Kittlitz's nestling has a very dense patch of down on each side of the lower abdomen, merging in a crease along the midline; this down may function as extra insulation from cold ground. The age differential would not seem to account for the apparent absence of these patches in the Marbled Murrelet chick.

DISCUSSION

Relationships.—A number of authors, including Bent (1919), Peters (1934), and most recently Mayr and Short (1970), have merged *Endomychura* (*hypoleuca hypoleuca*, *h. scrippsi*, and *craveri*), with *Brachyramphus* (*marmoratus* and *brevirostris*) while retaining *Synthliboramphus* (*antiquus* and *wumizusume*). Storer (1945b), on the other hand, presented abundant evidence that *Endomychura* is closer to *Synthliboramphus* and that *Brachyramphus* is the most widely divergent of the 3 genera and deserves to be placed in a group by itself; pending further study, he preferred to maintain the separation of *Endomychura* from *Synthliboramphus*.

Our study of the downy plumages and nesting habits of the murrelets, based on data not available in 1945, strongly supports Storer's arrangement. Comparison of all 6 species of murrelets, including both races of *E. hypoleuca* (CAS; Museum of Vertebrate Zoology, Berkeley; University of Michigan Museum of Zoology), demonstrates that in the plumage color and pattern of the downy young, *Endomychura* and *Synthliboramphus* are much more similar to each other than either is to *Brachyramphus*. Chicks of the 5 forms included within the first 2 genera are essentially dark above and white below (see photograph of *E. h. scrippsi* in Bent 1919). They share the following characteristics: forehead and crown uniform black or dark gray; rump black; orbital region with a small white spot above and another below eye; chin with some black adjacent to lower mandible; throat, breast, abdomen, and posteriormost flanks essentially white; wing below mixed with gray and white; wing above solid dark gray or blackish on manus and anterior part of antebrachium; and thighs bicolored.

In *S. antiquus*, *S. wumizusume*, and *E. h. hypoleuca*, the entire back and, to a somewhat lesser extent, the sides, anterior part of the flanks, and dorsoposterior portion of the antebrachium are strongly grizzled. This grizzled effect results from an elongated grayish-white subterminal band on each otherwise black barb. In *E. h. scrippsi* and *E. craveri*, on the middle and lower back and the sides of the upper back, the subterminal bands are missing on some barbs and reduced in length on the remainder, thus producing a faintly spotted effect; elsewhere the spotting is very scattered and difficult to discern in the former and obsolete in the latter. A second important feature shared by *S. antiquus* and *E. h. hypoleuca*, but significantly not by *S. wumizusume*, is a large white auricular patch. This region in *E. h. scrippsi*, *E. craveri*, and *S. wumizusume* is blackish. The lores and temporal regions of *E. h. hypoleuca* are uniquely white, except for a small blackish crescent anteroventral to the eye. *E. craveri* has a blackish wedge extending from the side onto the breast.

Certain other plumage characters of the chicks exhibit degrees of variation that might prove useful in assessing relationships within this 5-form group were series to be studied: the extent and uniformity of the dark rump and pale flank patches; the darkness and hue of the sides, anterior flanks, and upperparts, especially the crown; the exact degree of grizzling or spotting; the amount and extent of the faint streaking resulting from the black hairlike tips on the otherwise white feathers of the underparts; the distribution of the dark feathers on the chin, which appear to be connected to the subocular region only in *E. craveri* and *S. wumizusume*; and the size of the white orbital spots.

Thus *Synthliboramphus* and *Endomychura* are linked by the numerous characters shared by all 5 forms; by the probable homology of the spotting in *E. h. scrippsi* and *E. craveri* to the grizzling in *S. antiquus*, *S. wumizusume*, and *E. h. hypoleuca*; by the similarity of *E. h. hypoleuca* to both *Synthliboramphus* species in the possession of strong grizzling and to *S. antiquus* in the presence of a white auricular patch; and by the resemblance of *S. wumizusume* to *E. h. scrippsi* and *E. craveri* in the possession of dark auriculars.

The chicks of the 2 *Brachyramphus* species, on the other hand, are unique among murrelets in possessing buff color on the back, rump, and head (including chin and throat); a strong pattern of blackish variegations or discrete spots on the back and head; and color on the breast and abdomen. The similarities between the chicks of the Marbled and Kittlitz's murrelets demonstrate their close relationship, whereas the relatively minor differences we interpret as cryptic adaptations to their respective nest sites.

Brachyramphus nests in the open, *B. marmoratus* on moss- or lichen-coated tree limbs, and *B. brevirostris* on the ground amid lichen-covered rocks (Thompson et al. 1966). The other genera nest in more or less enclosed situations, *Synthliboramphus* in burrows and *Endomychura* under low plants or in natural or slightly improved rock crevices (Bent 1919). In addition, the young of the 4 species of *Endomychura* and *Synthliboramphus* are precocial, while those of *Brachyramphus* are semi-precocial (Sealy 1973).

Cryptic coloration.—The Big Basin discovery enables us to construct a theory correlating the nesting habitat of the species with the widely divergent colorations of the egg, downy young, and breeding adult. Winter rains wash away the droppings from any previous nesting, quickly freshen the underlying, already green moss, and cause the moss in the brown area surrounding the ring to send up new shoots. Thus the green egg blends as soon as it is laid. The spots on the egg could be disruptive in nature or could mimic shadows or the fruiting capsules of moss.

The dark brown plumage of the breeding adult matches almost perfectly

the predominant color of moist Douglas-fir bark; and the rufous scapulars simulate the small, rusty bark streaks. Although the plumage could simulate a bare or freshly broken portion of limb (Sealy 1974), we believe that the positioning of the nest near the mossless south side of the trunk is significant both in allowing the incubating bird to blend with bark and in reducing silhouetting against day and night sky.

The color of the pale down on the head and upperparts of the nestling closely matches the weathered portions of the droppings and the surrounding brown moss; the dark down probably simulates shadows. We speculate that the moss surrounding the ring of droppings changes to brown from an interaction between sunlight (or some other weathering agent) and leachings from the ring; apparently neither acts alone, as the moss both beneath the droppings and exposed to sunlight on the rest of the limb remains green. Possibly the phenomenon is similar to that known to horticulturists as "fertilizer burn" (D. E. Breedlove, pers. comm.). We do not believe that the brown moss owes its color to salt water introduced by the adults, since we found no salt crystals, nor to some substance from the mouths of the adults, because the sitting birds almost certainly would align themselves with the long axis of the bowl (NNE-SSW), whereas the brown encircles the nest.

We suspect that the adults, rather than the chick, initiate the ring of droppings, because the brown color of the droppings and surrounding moss would seem to be of greatest selective value to the chick if present at the time of hatching. The droppings of the chick increase the dimensions of the ring and probably the brown area. The conspicuousness of the raised white ring of droppings is reduced by the buffy coloration of its uppermost layers. Probably the ring has no meaning to predators and may be advantageous in obscuring the outline of the nestling and perhaps even in providing a target for adults approaching in darkness.

Siberian nest.—A nest of *B. m. perdix* was found on 17 June 1961 by Kuzyakin (1963) about 12 km northwest of the city of Okhotsk, Siberia. The nest tree was a larch (*Larix dahurica*), 12 m tall and 17 cm in diameter (at 1.5 m), located 6–7 km from the sea at the edge of a forest. The nest, containing one egg, was situated 6.8 m from the ground and 25 cm from the trunk on a cushion of dendroid lichen (*Bryopogon* sp.) that grew on a branch with a wide flat surface formed by a dense intertwining of small twigs. The nest cushion measured 14 × 17 cm in diameter and 3–4 cm in height, and the hollow (bowl) 6 × 9 cm diameter and 2–2.5 cm deep.

The Big Basin and Siberian nests share several important characteristics: both were located near the trunk on a horizontal branch thickly covered

with vegetation; had similar dimensions; were little more than a depression in the natural vegetative growth on the limb; and, although placed at different heights, afforded easy access to the ocean, which was about the same distance away. Two other similarities are doubtfully significant: both nest trees were near streams and bore branches below the nest limb.

Nest site.—Tree nesting (Harris 1971, Savile 1972, et al.) is now proven. That the Marbled Murrelet sometimes nests in burrows, rock crevices, and river gravels, as suggested by some authors (e.g. Darcus 1927, Gabrielson and Lincoln 1959, Guiguet 1971; but see also Sealy 1974), seems highly unlikely in view of the positions of the Siberian and Big Basin nests and the strong adaptations to tree nesting exhibited by adult, egg, and chick coloration. However, we cannot as yet rule out these other possibilities, for the nesting behavior of the species may differ from one locality to another, especially where large trees are unavailable, such as on Mittelnach Island, B. C., near which Sutton and Semple (1941) collected an egg from the oviduct of an adult.

We suspect that the Big Basin nest site was used traditionally. No apparent peculiarity of the bowl would prevent the natural growth of moss that would occur if the nest were unattended over a period of years. Therefore the adults probably removed the moss. That every vestige, including the rhizoids, could or would have been pecked or scratched away in a single season by the adults (and subsequent movements of the chick), seems to us highly unlikely. Rather, we suspect that the moss was removed and prevented from regrowth, probably inadvertently, over a period of years. The quantity of droppings in the Big Basin nest is not helpful; a single year's use could account for the amount, and the abundant rainfall in Big Basin probably would dissolve away accumulations from previous years. The few old eggshell fragments that might become entrapped in the moss probably could not be told from others originating from the same adult.

To aid future workers, we here summarize those characteristics of the Big Basin site that may prove significant in nest location, at least in the southern portions of the range of this subspecies. The nest was found in a (1) humid (2) virgin forest that was (3) near coastal feeding areas, (4) contained water-filled streams, and was in part composed of (5) a large species of tree (Douglas-fir) with (6) an open crown structure and (7) bark colored like the plumage of breeding adults. The nest was positioned (8) high above the ground, at a point allowing (9) easy access to the exterior of the forest, and (10) next to the trunk on a (11) wide, (12) horizontal, (13) southward-projecting limb that was (14) densely covered with (15) green moss and (16) protected by a slanting trunk and a closely

overhanging branch. We feel that the most critical factors are the following: the ease of access (which may dictate the height of the nest and nest tree and require a tree species with an open crown structure); the slope, diameter, and vegetative coating of the nest limb (the last two depend on, respectively, the age and humidity of the forest); and the color and proximity of the trunk. The distance to coastal feeding areas probably is determined by the availability of suitable nesting forests, with preference shown for the closest forests. The southward direction of limb projection could be significant in providing solar heat for the chick, proper wind conditions for landing and takeoff of adults (and young?), and a mossless trunk side.

The summer range of *B. m. marmoratus* corresponds closely with the distribution of the coastal portions of the moist coniferous forest biome (Shelford 1963). In Alaska this biome terminates on Kodiak Island and the adjacent mainland, which are also the northwesternmost points where the murrelet summers commonly. Murrelet records from farther north and west in Alaska for which dates are given by Gabrielson and Lincoln (1959), except for summer occurrences at Unalaska, extend from early fall into winter and hence represent nonbreeding birds.

The following 13 species of trees are extensively and coastally distributed within this biome and have branches wide enough to support a nest: Pacific silver fir (*Abies amabilis*), noble fir (*A. procera*), giant fir (*A. grandis*), western white pine (*Pinus monticola*), Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), Douglas-fir, coast redwood, giant-cedar (*Thuja plicata*), California-laurel (*Umbellularia californica*), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), and big-leaf maple (*Acer macrophyllum*). The 9 conifers are tall and open enough to provide easy access for adult murrelets. The 4 angiosperms, however, probably may be eliminated as potential nest trees by virtue of the limited access afforded by their rather closed crowns and smaller stature, the latter characteristic usually resulting in enclosure by the taller conifers. The angiosperms, as well as certain of the conifers, may well possess other undesirable characteristics, such as sloping branches, improperly colored or textured bark, or insufficient epiphytic growth (see below). Although tree species that attain large size and hence wide branches probably provide the best sites, the small stature of the Siberian nest tree indicates that we cannot entirely eliminate smaller trees in which conditions such as unusual twig growth produce suitable platforms.

None of the 13 trees is found throughout the summer range of *B. m. marmoratus*. The Douglas-fir, for example, ranges only from central California to northwestern British Columbia. Thus the birds must use at least

2 species of trees. As noted previously, the Siberian nest was in an Old World species of larch (*Larix dahurica*). Harris (1971) reports a young bird taken from beneath "a cedar, probably the western red cedar (*Thuja plicata*)," felled on Vancouver Island. Guiguet (1956) mentions an adult and broken egg found under a "large hemlock" (presumably *Tsuga heterophylla*) logged on the Queen Charlotte Islands. In California south of the mouth of San Francisco Bay, the only large conifers are the coast redwood and Douglas-fir. We suspect that in this region the murrelets would usually select Douglas-firs instead of coast redwoods because the latter, even though larger and twice as abundant at the Big Basin site, do not support a sufficiently dense growth of moss or lichen (D. Breedlove, pers. comm.; pers. obs.).

Number of broods.—The temporary persistence of a pale ring of droppings and surrounding brown moss after a chick has fledged may preclude the use of a nest for a second brood during the same nesting season. A new egg would not blend in until most of the droppings were washed away to expose the underlying green moss. Also, the fouling of the feathers that might result from an adult incubating atop the messy droppings of its previous chick would seem highly disadvantageous to an aquatic species.

Clutch size.—Our findings support Sealy's (1974) determination that clutch size in the Marbled Murrelet is one. In addition to the presence of a single chick in the Big Basin nest, evidence is provided by the nest bowl, the effective size of which is too small to accommodate 2 eggs measuring 58.5 × 39.5 mm each (Sutton and Semple 1941).

Fledging.—Available evidence suggests that young Marbled Murrelets breeding in forests reach the ocean by flying directly from the nest sites or nearby trees, rather than by walking or swimming as suggested by Kuzyakin (1963). The stream near the Siberian nest was reduced to a series of disconnected pools and thus could not have provided a convenient avenue to the sea. In August 1974 the Big Basin stream beds contained no more than a trickle of water, probably not enough to float a murrelet, and were clogged with debris that a chick could negotiate only with great difficulty. Accidents could account for the few known groundings. If terrestrial or stream travel were the rule, many more young should have been discovered, especially in such well-populated localities as Prairie Creek Redwoods State Park, Humboldt Co., California (Baldridge et al. 1970) and Big Basin. Mammalian predators surely exert strong selective pressures against ground travel, especially considering that a young bird probably is unable to take flight from the ground in a windless forest (Storer 1945a) and would have to walk many kilometers from its nest to the ocean.

SUMMARY

The first nest of *Brachyramphus m. marmoratus* was found on 7 August 1974 in Big Basin Redwoods State Park, Santa Cruz Co., California. The nest, located 45 m above the ground at the base of a limb of a Douglas-fir, consisted of a depression in bark nearly surrounded by murrelet droppings atop living moss. Eggshell fragments removed from the nest are similar in color to previously described eggs but exhibit one new spot color. A downy nestling, the first of the species known to science, is described and compared to *B. brevirostris*; morphological similarities demonstrate their close relationship, while differences are believed to be cryptic adaptations to nest site. The nesting habits and downy plumages of these 2 species support the treatment of *Brachyramphus* as a genus distinct from *Endomychura* and *Synthliboramphus*. A theory is presented that correlates the nest site with the cryptic colorations of the breeding adult, egg, and chick. The nest site is similar to that of *B. m. perdix*, proves tree nesting, and is thought to be used traditionally but not more than once per year. The characteristics of the Big Basin site are summarized to facilitate the future discovery of nests. The summer range of the murrelet corresponds closely with the distribution of the coastal portions of the moist coniferous forest biome. Within this area optimal nesting sites are provided by about 9 species of trees, all conifers, of which the birds must use at least 2. In central California possibly only the Douglas-fir is used. Evidence indicates a clutch size of one. The fledglings are believed to reach the ocean by flying.

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