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ANCIENT MURRELETS MOLT FLIGHT FEATHERS AFTER THE PRECOCIAL YOUNG BECOME INDEPENDENT

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ABSTRACT—Knowledge of timing and pattern of wing molt is important for explanations of post-breeding movements and inland vagrancy in Ancient Murrelets (*Synthliboramphus antiquus*). Examination of specimens coupled with observations of family groups and recently independent young suggests that chick rearing and wing molt probably occur separately in adults, although it may commence before the last chicks of the season become independent. An adult Ancient Murrelet beached in September 1976 (Alaska Peninsula) and a probable second-year murrelet beached in July 1987 (Oregon) were synchronously molting remiges. Adults in family groups, collected in July 1920 (southeast Alaska) and July 1948 (British Columbia), and observed in July 2009 (British Columbia), were not molting remiges, although an adult observed with a family group on 18 July 1971 (British Columbia) may have commenced molt. Family groups immediately moved offshore from colonies on Langara Island, Haida Gwaii (Queen Charlotte Islands), British Columbia, from late May through mid-June, 1970 and 1971. During boat surveys in that area from May to August, a family group was observed on 10 July 1971, and independent juveniles also began to appear inshore in early July, consistent with observations of recently independent young recorded off the Goose Islands, British Columbia, by CJ Guiguet in 1948.

Key words: Ancient Murrelet, British Columbia, family groups, field observations, fledglings, Haida Gwaii, museum specimens, prebasic molt, *Synthliboramphus antiquus*

Strategies of post-hatching development in birds have interested ornithologists for several decades (for example, Nice 1962; Lack 1968; Ricklefs 1983; O'Connor 1984). Patterns of development exhibited by the marine bird family Alcidae have provided fertile ground for studies of their life-history costs and benefits (Cody 1973; Sealy 1973a; Gaston 1985, 1992; Ydenberg 1989). Among the murrelets of the genus *Synthliboramphus*, the Ancient Murrelet (*S. antiquus)* has been studied the most, but mainly during the short land-based portion of the nesting cycle from pre-laying through hatching (for example, Sealy 1976, 2015; Jones and others 1987, 1990; Gaston 1992). Movements and development at sea under the care of one or both parents have recently received attention (for example, Sealy 1976; Sealy and Campbell 1979; Duncan and Gaston 1990; Sealy and others 2013a, b). Family groups move immediately offshore at 2–3 d of age (Heath 1915; Willett 1915; Sealy 1976; Duncan and Gaston 1990). Some groups have been recorded hundreds of kilometers from the nearest known colonies (Sealy and Campbell 1979; Sealy and others 2013a, b). Ancient Murrelets have been suspected of molting flight feathers synchronously, thus becoming temporarily flightless at sea (Gaston 1992, 1994; Pyle 2009), but whether the timing of molt and chick rearing overlap has not been confirmed. Overlap of these events would be similar to that of male murres (*Uria* spp.), which depart colonies at approximately 20 d of age, accompanied by single chicks, and soon molt remiges synchronously, which renders them temporarily flightless (Gaston 1982;

Scott 1990). Postponing molt until young become independent would be similar to some semi-precocial alcids whose young complete their development at the nest, such as murrelets of the genus *Brachyramphus* (Sealy 1977; Carter and Stein 1995; Peery and others 2008).

Ancient Murrelets might be expected to molt flight feathers while rearing young because foraging may be more efficient when flightless (Livezey 1988; but see Bridge 2004). Adults would be tied to the chicks, however, precluding foraging farther afield, as Gaston (1992) implied, especially when conditions are poor or unpredictable (Sealy 1975). Overlapping molt and chick rearing may permit earlier onset of molting (when prey resources often are more abundant) and, following molt, earlier initiation of fall movements to wintering areas. Disadvantages may include high concurrent energetic demands of chick rearing and molt, as well as less ability to avoid predators at sea when flightless.

Vagrant Ancient Murrelets have been recorded inland throughout North America, primarily during the non-breeding season (Munyer 1965; Verbeek 1966; Sealy and others 2001; Sealy and Carter, unpubl. data). Interpretation of the timing of these movements requires elucidation of the pattern and timing of wing molt and resumption of flight. We evaluated evidence for initiation of synchronous wing molt following chick rearing from specimens and observations of family groups and recently independent juveniles at Langara Island (Fig. 1), Haida Gwaii (formerly Queen Charlotte Islands), and elsewhere, particularly in British Columbia.

METHODS

Observations of Family Groups and Recently Independent Juveniles

SGS observed family groups and independent young, and collected samples of Ancient Murrelets, during research on seabird ecology on and around Langara Island, British Columbia, from 6 May to 10 July 1970 and 17 March to 9 August 1971 (Sealy 1972, 1975, 2015). Anecdotal observations of family groups were also made at other sites by HRC and others who provided information to which we also referred in studies of long-distance movements of family groups (see Sealy and Campbell 1979; Sealy and others 2013a, b).

In 1970–1971, opportunistic observations were made from a pneumatic boat generally travelling from Hazardous Cove on the west-central side of Langara Island to McPherson Point on the northeast side (Fig. 1). Family groups and independent juveniles that had returned inshore from offshore rearing areas were detected only in 1971 because SGS left the study area in early July 1970. Trips of 3- to 4-h duration were conducted at different times of the day, as weather permitted, at 1–5-d intervals on 32 d from 26 May, after the 1st chicks left the colonies, until observations ceased on 9 August 1971. The route was similar on each trip but the direction of travel was not always the same. On some days, travel was along the east side of Cloak Bay to Hazardous Cove, then back through Parry Passage and along the east side of Langara Island past Egeria Bay to McPherson Point; whereas on other days, travel was to McPherson Point and back to Hazardous Cove. It was recorded whether each juvenile was alone, or was with 2 or more adults that remained within a few meters of each other for a period of at least 15 min. Juveniles were assumed to be independent if no interactions with adults were observed.

Examination of Specimens

SGS initiated a study of vagrant Ancient Murrelets inland in North America in the late 1970s; HRC joined this effort around 1980. Plumages of different age classes were assessed from specimens collected by SGS during the breeding season at Langara Island in 1970 and 1971 and during the non-breeding season by RW Campbell, SGS, and HRC off Victoria, British Columbia, in 1977–1981 (see Gaston and others 1993). A sample of specimens collected at Langara Island was deposited in the University of Manitoba Zoology Museum (UMZM), University of Michigan Museum of Zoology (UMMZ), and American Museum of Natural History (AMNH). Specimens collected near Victoria were deposited in the UMZM and Royal British Columbia Museum (formerly British Columbia Provincial Museum). Additional specimens were borrowed or examined during visits by SGS, HRC, or both, to other museums (additional acronyms in acknowledgments) as well as specimens examined by PP (see Pyle 2009) whose notes have been incorporated here. We located specimens of 1 complete and 1 apparently incomplete family group collected

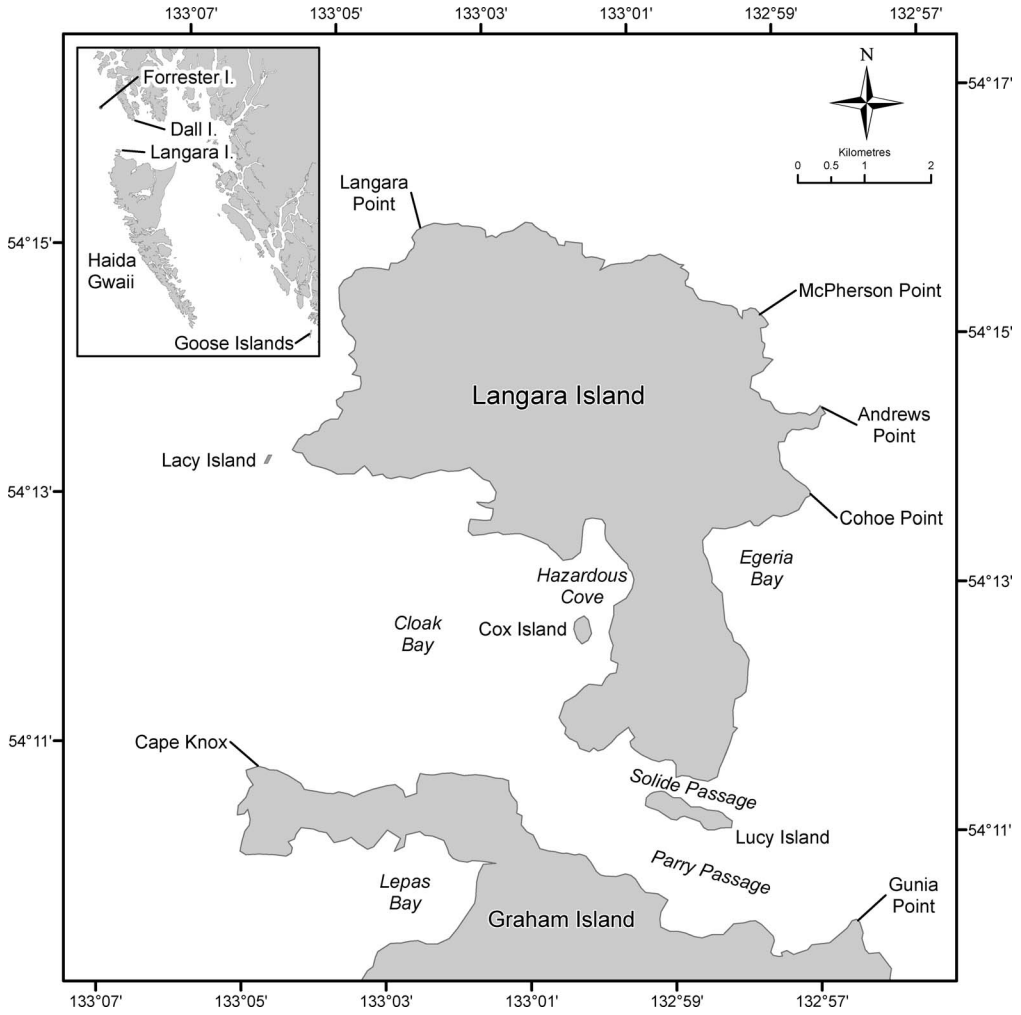

FIGURE 1. Langara Island, Haida Gwaii (Queen Charlotte Islands), British Columbia. Map prepared by CloverPoint Cartographics, Victoria, British Columbia.

in July 1920 and July 1948, which supplemented information on wing molt of chick-rearing Ancient Murrelets. The dearth of museum specimens of molting Ancient Murrelets may be attributable to the occurrence of molt offshore (Pyle 2009) where few specimens have been collected in late summer and fall.

Results

Molt Status of Adults Attending Family Groups

1. One family group (Fig. 2) was collected between Forrester Island and Dall Island, Alaska (54°50′N, 133°16′W), by G Willett, accompanied by AM Bailey, on 21 July 1920 (Willett 1915, 1920; Bailey 1927). The group was composed of 2 adults (USNM 270860, ♂; LACM 21801, ♀) and 2 downy young (USNM 270861, ♂; LACM 21800, ♂). Flight-feather molt had not begun in either adult, and the female's primaries were especially worn and faded. Wing coverts of both young, but not remiges, had emerged.
2. On 13 July 1948, an apparently incomplete family group (photograph in Sealy and others 2013a:212) composed of an adult female (RBCM 9744) and 1 downy chick (RBCM 9742) was collected by CJ Guiguet

FIGURE 2. Family group of Ancient Murrelets collected by G Willett between Forrester Island and Dall Island, Alaska, 21 July 1920. From left: adult female (LACM 21801) and male (USNM 270860) and young (USNM 270861, LACM 21800). Photo credit: SG Sealy.

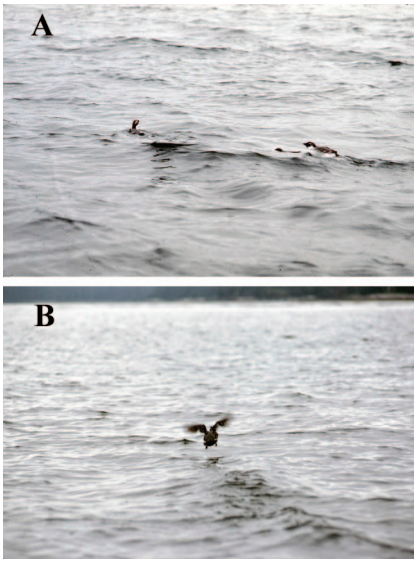

FIGURE 3. Family group of Ancient Murrelets. (A) 1 adult with 2 nearly fledged young. (B) adult flushing as boat approached, revealing that flight-feather molt may have begun (see text), Egeria Bay, Langara Island, Haida Gwaii, British Columbia, 18 July 1971. Photo credits: SG Sealy.

about 35 km west of Goose Island, British Columbia (51°57′N, 128°48′W) (Guiguet 1953). The adult's primaries were worn and faded and prebasic molt had not begun. As in the chicks in the family group described above, coverts but not remiges were growing.

3. At Langara Island (54°14′N, 133°01′W), 1 family group (1 adult with 2 adult-sized young, Fig. 3) was observed by SGS in Egeria Bay on 18 July 1971 (see also Sealy and Campbell 1979). The chicks could not or would not fly, but dove as the boat approached to within several meters. The agitated adult flushed (Fig. 3), flew approximately 30 m, then landed on the water uttering "rasping" sounds similar to those heard on the colony at night before flying back to rejoin the vocalizing young. This was repeated 3 times within 15 min of observation (also see Sealy 1976). The adult's burst of calling appeared most similar to the trill-rattle call, later described by Jones and others (1989), which is uttered by adults during aggressive encounters, in this case apparently in defense of the young. This was likely the same family group that was observed the following day approximately 1 km east of Egeria Bay (not included in Table 1), but subsequently only independent juveniles were encountered. The adult's spread wings, visible when flushed (Fig. 3), revealed symmetrical gaps in the flight feathers. Scrutinized more closely, this image suggested that the inner 1–2 primaries (among p1-p2) had been dropped on both wings, indicating initiation of the primary molt.
4. At Goletas Channel, British Columbia, 1 family group (1 adult with 1 adult-sized young) was observed by HRC for 10 min <50 m from shore at the southeast end of the Gordon Islands (50°48′N; 127°28′W) on 1 July 2009 (see Sealy and others 2013b). The adult dove near kelp beds, whereas the chick remained on the surface and vocalized frequently, uttering a 3-note call. After each dive, adult and chick called, apparently to each other, and reunited by swimming together; the adult did not feed the chick. The chick dove once when the boat approached to within <20 m. At one point, the adult flapped its wings between dives, revealing that molt had not been initiated.

TABLE 1. Specimens and observations of 64 juvenile Ancient Murrelets off Langara Island, Haida Gwaii, British Columbia, 10 July to 8 August 1971.

Date	Location	No. of individuals	Notes
10 July	Cloak Bay	1	UMMZ 21810, ♂; down adhering to side of nape, developing papillae on abdomen and flanks
13 July	Cloak Bay	2	AMNH 803778, ♂; AMNH 803779, ♂
16 July	Egeria Bay	1	UMMZ 218018, ♀; developing papillae on head, alighted on sea
18 July	Egeria Bay	1	UMMZ 218017, ♀; flushed
19 July	E of Egeria Bay	1	
19 July	E entrance to Solide Passage	1	
19 July	Parry Passage	1	
19 July	Off Lacy Island	8	1 collected; 8 juveniles in mixed-species flock feeding on Pacific Sandlance (*Ammodytes hexapterus*), with Rhinoceros Auklets (*Cerorhinca monocerata*) and Black-legged Kittiwakes (*Rissa tridactyla*)
20 July	E of Egeria Bay	1	
21 July	Cloak Bay	5	2 feeding together amid bull kelp (*Nereocystis luetkeamia*); 3 together along the edge of the same kelp bed
22 July	Egeria Bay	2	single individuals
22 July	Egeria Bay	4	4 individuals in a single mixed-species feeding flock; 2 foraged closely together, 2 foraged singly
24 July	Off Lacy Island	5	1 single, 2 groups of 2 individuals
27 July	Egeria Bay	1	observed flying
27 July	Egeria Bay	4	in mixed-species feeding flocks
28 July	Egeria Bay	4	in mixed-species feeding flocks
31 July	Cloak Bay	3	3 single individuals
31 July	Off Cape Knox	9	1 single, 4 groups of 2 individuals
31 July	Lepas Bay	5	1 group
8 August	Egeria Bay	5	1 single, 2 groups of 2 individuals feeding in the same kelp bed

Recently Independent Juveniles

1. The first 5 juveniles encountered inshore near Langara Island from 10–18 July 1971 were collected; none bore an egg tooth, but natal down adhered to 1 individual (UMMZ 218010; Table 1). Two birds flew and another juvenile was observed flying on 27 July. Only these 3 birds, of up to 64 juveniles (some may have been observed more than once) noted at Langara Island between 10 July and 8 August 1971 (Table 1), were observed flying, albeit usually <50 m. From 19 July to 8 August, the number of juveniles encountered inshore increased, with up to 17 recorded on 31 July, plus 4–8 juveniles observed in mixed-species feeding flocks between 19 and 28 July (Table 1; also see Sealy 1973b).
2. A juvenile Ancient Murrelet (SDMNH 38233, ♀; Fig. 4) was found dead by JB Crowell, Jr at McCall along the shore of Lake Payette (44°55′N, 116°06′W), Valley County, Idaho, on 15 August 1972 (P Unitt, *in litt*. 14 June 2011). This is the earliest late-summer record among approximately 125 Ancient Murrelets reported inland in North America (Sealy and Carter, unpubl. data); however, an unsexed after-second-year (ASY) individual was found dead by GR Ryder on the shore of Lake Okanagan, British Columbia, on 17 August 1945 (Sealy and Carter 2014).
3. At Goletas Channel, British Columbia, 1 juvenile flew strongly when HRC approached it in the protected waters about 0.3 km from shore off Songhees Creek, Vancouver Island, about 9 km northwest of Port Hardy (50°47′N; 127°34′W) on 2 July 2009 (Sealy and others 2013b). Other independent young have been reported "diving" (Table 1). The earliest recorded date of an independent juvenile is 29 June 1988 (off Goose Island), but juveniles may be observed at sea as early as mid-June,

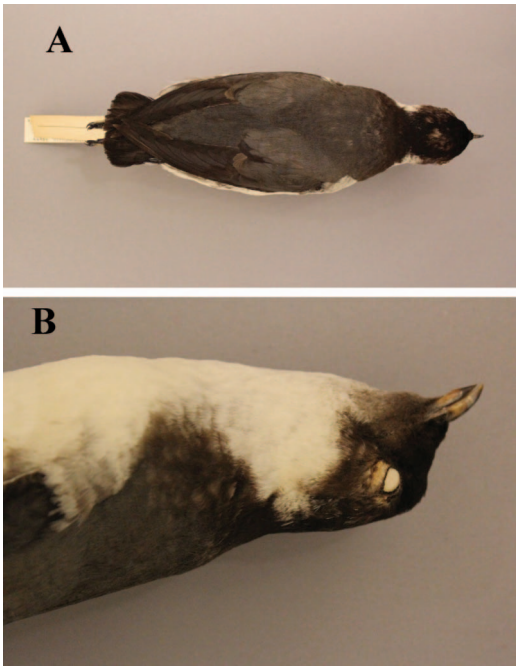

FIGURE 4. A and B: Vagrant hatch-year female Ancient Murrelet (SDMNH 38233) found dead at McCall, Payette Lake, Valley Co., Idaho, 15 August 1972. Photo credit: SG Sealy.

based on the earliest known date of colony departure (8 May) plus approximately 6 wk for development (Sealy and others 2013a).

Molting AHY Birds

None of the last 6 breeding adults (brood patches refeathering [Sealy 1976]) unaccompanied by young, collected near Langara Island on 28 June (2 ♂), 3 July (1 ♂, 2 ♀) and 7 July (1 ♀) 1971, had shed primaries or secondaries. However, feathers were growing on the head and flanks of 1 individual. Although they were breeding adults, it was not clear whether these individuals had recently separated from independent chicks, incubation had failed, or chicks had not survived to independence. Only 2 specimens undergoing flight-feather molt were located:

1. A male (CSU, SJ 5650) was found dead on a beach in Nelson Lagoon, Alaska (56°06′N, 161°11′W), by RE Gill on 25 September 1976 (Fig. 5A). Primaries and secondaries were being replaced synchronously, but the bird would have been flightless when it died. There were no incoming feathers on the mottled throat, forehead feathers were new, whereas marginal and secondary coverts and alular quills were old. The condition and coloration of older feathers in the head and upperparts suggested that this individual was at least 2 y old (ASY). The bird weighed 139 g; its flat wing of 92 mm compared to a mean of 141 mm for adult males (n = 41) attending nests on Langara Island (Sealy 1976). Primary #10 measured 35.8 mm from insertion, compared to a mean of 88 mm (n = 41) for fully developed primaries of adults.
2. A molting specimen (CAS 84044) was found beached by J Anderson 1.5 km north of Alsea ("Waldport"), Oregon, on 21 July 1987 (Fig. 5B). It had replaced most back feathers, but still retained worn feathers on the upperparts and underparts. The wear and dull color of the older feathers suggest that it was likely a second year (SY) individual. This is also strongly suggested by the early date of molt in comparison with the 1976 specimen from Alaska (CSU SJ 5650), and the far-south location in July also suggested over-summering off Oregon or early southern movement before molt (Peery and others 2008). All primaries were the same length, about 27 mm from insertion. Many of these feathers and some greater coverts had white tips, evidently leucism. Most or all of the wing coverts were new, although some of the greater coverts appeared to be still growing.

Completion of wing molt in ASY birds prior to migration also is suggested by 2 specimens recorded inland in late summer at Okanagan Lake, British Columbia, on 17 August 1945 (Sealy and Carter 2014; also see above), and a fall record of a male (RAM Z75.92.1; photograph in Sealy and others 2001) salvaged by DV Weseloh east of Edmonton, Alberta (53°34′ N, 116°22′W), on 25 October 1975 (Weseloh and Weseloh 1976; also see Sealy and others 2001:177). The remiges of these specimens were fully grown, consistent with that of other vagrants recovered after October (Sealy and Carter, unpubl. data).

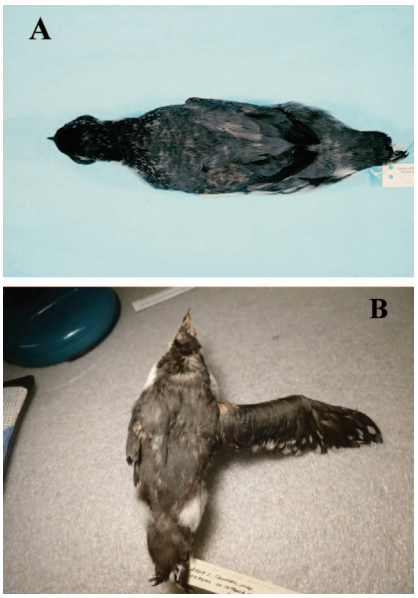

FIGURE 5. (A) after-second-year Ancient Murrelet (CSU, SJ #5650) molting primaries synchronously, discovered dead on a beach in Nelson Lagoon, Alaska, 25 September 1976. Photo credit: W Heck. (B) second-year Ancient Murrelet (CAS 84044) molting primaries synchronously, found dead on a beach north of Alsea, Oregon, 21 July 1987. Photo credit: P Pyle.

Observations of Adults Feeding Young

Observations of Ancient Murrelet family groups suggest adults feed and accompany young until they become independent. In addition to observations near Langara Island in 1971 and in Goletas Channel in 2009, we collated observations of family groups from other field observers (Sealy and Campbell 1979; Sealy and others 2013a, b), paraphrased below:

1. Triangle Island, British Columbia (50°51′N, 129°04′W), 2 July 1974 (Vermeer and others 1976; KR Summers, *in litt.* 1 November 2011): 2 adults and one ⅓-grown downy young. When the boat approached, the adults guided the chick away but dove when apparently approached too closely. Instead of diving, the chick "bill dipped"; when separated, adults and chick called until reunited.
2. Byers Island, British Columbia (52°33′N, 129°24′W), 11 June 1988 (Rodway and Lemon 1991:88): family group of 2 adults feeding 1 downy chick with feathers visible on the wings (coverts) and head. The parents dove to feed the chick, which stayed on the surface even though most dives did not result in feeding. "The chick swam from 1 adult to the other, intermittently peeping, sometimes swimming directly on an adult's tail. There were a few calls by the adults. When the adults surfaced at a distance from the chick and gave a single call, the chick paddled toward them and appeared to be fed."
3. Gillam Islands, British Columbia (50°26′N, 127°57′W), 7 July 1988 (Rodway and Lemon 1990; Sealy et al. 2013a): 1 adult feeding one ¾-grown chick.
4. Shirley, British Columbia (48°22′N, 123°55′W), 6 June 2007 (Sealy and others 2013b): 2 adults feeding 2 small downy chicks.

Discussion

The range of dates reported for colony departures of family groups in British Columbia (8 May–7 July), plus 6 to 7 wk for chicks to reach independence (Litvinenko and Shibaev 1987), suggests that young become independent between late June through late August in British Columbia (Sealy and others 2013a). To calculate the approximate range of molt for adults in British Columbia, we used the range of dates for colony departures and added the estimated period of chick rearing, assuming that flight-feather molt begins within 2–4 wk of chick independence and molt requires less time than the 1–2 mo based on estimated duration of molt in Marbled Murrelets (*Brachyramphus marmoratus*) (Carter and Stein 1995; Peery and others 2008), due to primaries molting synchronously in most Ancient Murrelets as opposed to sequentially in blocks in Marbled Murrelet. Initiation of molt for adults that successfully reared chicks could range from early July to late September, with completion from early August to late October. Subadults and adults whose breeding attempt failed may molt earlier than successful breeders (for example, Bédard and Sealy 1984; Emslie and others 1990; Thompson and others 1998; Pyle 2008, 2009), possibly as early as June.

Molt of Ancient Murrelets in British Columbia thus may span June to late October,

although most occurs in late July to mid-October. Pyle (2008, 2009) reported molt of SY birds in June and July and definitive molt of ASY birds between late August and late October, which roughly matches our estimate for British Columbia. Pyle's molting periods were based on examination of specimens of SYs and ASYs that were collected both prior to and following molt, and on 1 specimen in molt (CAS 84044; Fig. 5B), which was considered SY. Waterbirds that delay breeding to age 2 y or more universally show 2nd prebasic molts that are initiated earlier than definitive prebasic molts of breeding birds (Pyle 2008, 2009). In Ancient Murrelets, this may include SYs that over-summer south of the breeding range, including CAS84044 and others observed off California in summer, for example, a worn individual (wing molt not begun) found dead on Pomponio Beach (37°18′N, 122°24′W) on 30 June 2013 (Beach Watch, unpubl. data; photograph of carcass examined and aged by PP).

Synchronous flight-feather molt was observed in only 2 specimens of the Ancient Murrelet. The date for the ASY bird, 25 September, suggests it had bred and initiated the molt after chick independence. Adults not yet molting, confirmed in family groups in British Columbia and southeast Alaska, also suggest that molt is initiated after the young have become independent and is usually completed by October before most autumnal movements begin. The location, timing, and progression of molt remains a gap in knowledge of the biology of Ancient Murrelets. Additional molting birds could be captured at sea at night (for example, Whitworth and others 1997) to extend the limited information currently available.

Close scrutiny of the photographs of the adult with chicks on 18 July (Fig. 3) suggests that molt may have been initiated by dropping inner primaries. If so, this suggests that some Ancient Murrelets molt sequentially rather than synchronously, or perhaps initiate molt by dropping blocks of primaries as occurs in Marbled Murrelets (Carter and Stein 1995; Pyle 2009). Occasional examples of sequential molt have been found in several other species of murrelets, auklets, and puffins that normally undergo synchronous molt (Harris and Yule 1977; Bédard and Sealy 1984; Pyle 2009). Alternatively, this individual may have just begun primary molt and would have dropped the remainder of its remiges shortly after being photographed. Some other alcids have been shown to have an underlying sequence of rapid primary molt (Thompson and others 1998; Thompson and Kitaysky 2004). In any case, wings of the individual in the photograph (Fig. 3) show that molt may commence before chicks become independent in some cases, especially in adults whose chicks gain independence late in the chick-rearing season.

Moving recently hatched chicks away from the colonies not only avoids land-based predators, but new foraging possibilities are opened up for adults and young compared with species that commute between foraging areas and colonies. The few observations of Ancient Murrelets feeding young suggest that family groups remain together and adults forage nearby, feeding chicks 1 prey item at a time. This would eliminate the need to fly, unless adults fly short distances to procure their own food, thus benefiting from retaining the ability to fly.

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