

MOVEMENTS OF ANCIENT MURRELET BROODS AWAY FROM A COLONY

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Abstract. Radio-tagged Ancient Murrelets (*Synthliboramphus antiquus*) were tracked by aircraft to monitor movements away from a colony. Family groups travelled 48 ± 8 (SE) km from the colony during the first day after departure, at an average speed of 2–3 km/h. Chicks catabolized 41% of their lipid reserves in the two days between hatching and departure from the colony. The remaining reserves can sustain chicks for <2 days more. The presence of some family groups in central Hecate Strait 2–4 days after departure shows that chicks must be being fed there.

Key Words: Ancient Murrelet; *Synthliboramphus antiquus*; energetics; parental behavior.

Alcids exhibit an array of chick-rearing modes, from feeding semi-precocial young at the nest site until fully grown to rearing precocial young completely at sea (Gaston 1985). The latter group is comprised of the *Synthliboramphus* murrelets. Because *Synthliboramphus* chicks go to sea within a few days of hatching (Sealy 1973), their ecology is almost unknown.

Ancient Murrelets (*S. antiquus*) are small precocial alcids that nest in burrows, often in mature forests, on islands in the North Pacific Ocean. Newly hatched chicks go to sea with their parents about two days after hatching (Sealy 1976). Parents lead their two chicks from the burrow at night, then generally fly to the sea and call, as the chicks run down to the shore to rejoin them (Jones et al. 1987a, b). Family groups of Ancient Murrelets appear to move rapidly offshore because they rarely are seen near colonies, and few have been observed at sea (Sealy and Campbell 1979, Gaston, pers. obs.). Sealy and Campbell (1979) considered the paucity of sightings of Ancient Murrelet broods puzzling in light of the large number of breeding birds (254,000 pairs in the Queen Charlotte Islands (QCI) (Vermeer and Lemon 1986)).

The study of animals at sea is difficult. Attempts to use radio telemetry on small seabirds have been hampered by difficulties in waterproofing and attaching small transmitters, and in tracking birds over large areas of water (Wanless et al. 1985), because studies have been restricted to tracking the birds from land (Harrison and Stoneburner 1981, Wanless et al. 1985, Croll et al. 1986, Anderson and Ricklefs 1987). We used small transmitters and fixed-wing aircraft to determine the movements of Ancient Murrelet broods away from a colony.

METHODS

Field work was conducted at a breeding colony on Reef Island, off the east coast of the QCI archipelago, and in Hecate Strait between the QCI and mainland British Columbia (Fig. 1). Transmitters were attached

to Ancient Murrelet adults and chicks between 29 May and 6 June 1987. Two types of transmitters were used: RI-2 (2.0 g) for adults and BD-2 (0.8 g) for chicks (Holohil Systems Ltd., Woodlawn, Ontario, Canada).

Five adults whose young had hatched were removed from burrows during daylight and transmitters were glued to their lower backs using 5-min epoxy and then covered with waterproof tape (Superstik, Superior Insulating Tape Co., St. Louis, Missouri). Birds were then replaced in their burrows. Transmitters were also attached to two adults that were captured on the ground at night with a dipnet, while leading their chicks to the sea. Chicks were caught at night using funnel traps made of two 50-m-long fences of 0.5-m-high clear plastic sheeting positioned to guide departing chicks towards a catching point near shore. Sixteen chicks had transmitters glued to them and were released at the water's edge 10 min later. Only one transmitter was attached per batch of concurrently captured chicks to minimize the possibility of having more than one transmitter per family group. Some additional chicks were weighed and banded in their burrows to provide data on weight loss between hatching and departure.

Departures of families were monitored from the shore of the island with a hand-held Yagi antenna at approximately 15-min intervals for up to 4 h. Time of departure was noted, departure headings were estimated with a compass, and weather and sea conditions were estimated visually at Reef Island at midnight. Local wind speed and direction were obtained from Transport Canada at Sandspit Airport.

Aerial surveys were made from a Beaver aircraft with a Yagi antenna attached to each side of the plane, parallel to the wing. Surveys were conducted the day following departure of radio-marked birds and were concentrated in the area indicated by the birds' initial direction of departure. The area most intensively surveyed was between Sandspit and Reef Island, northeast across Hecate Strait to Banks Island. Locations of birds were plotted by triangulation from compass bearings on landmarks where possible, or by triangulation from bearings from radio beacons using an automatic direction finder (ADF). Surveys on subsequent days were conducted over central and northern portions of Hecate Strait, and were generally concentrated over an area indicated by extrapolation from the initial positions and directions of travel of the birds. These less frequent surveys covered an area due east from Reef Island

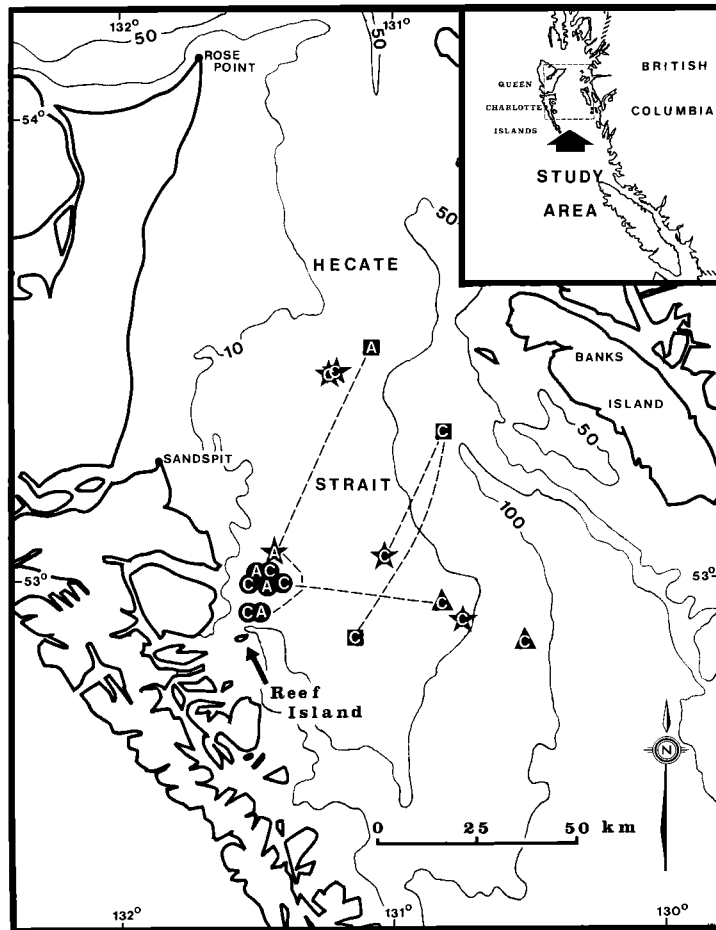


FIGURE 1. Bathymetric map (fathoms) of Hecate Strait, British Columbia showing the movements of radio-tagged Ancient Murrelet chicks (C) and adults (A) away from their breeding colony on Reef Island. Positions are 6–8 h (circles), 12–18 h (stars), 36–42 h (triangles), and 60–84 h (squares) after departure from the colony. Dashed lines connect positions of the same bird.

across Hecate Strait, north to Rose Point. Surveys were flown at an altitude of 90–180 m in an approximate grid pattern and extended virtually the entire width of Hecate Strait. The area where the surveys were conducted and over which birds potentially ranged was about 7500 km² (width of Hecate Strait × distance between Reef Island and halfway to northern tip of QCI). Twelve survey flights were made from May 29 to June 9. Detection distance of transmitters was 2–4 km as determined from time between radio contact and maximum signal strength, and from transmitters attached to pieces of wood floating at sea. The large area over which the birds ranged and small detection distance of transmitters, combined with presumed loss of some transmitters and mortality of chicks, resulted in few locations of radio-marked birds per flight, particularly of birds that had left the colony >1 day previously.

To determine energy reserves of chicks as they departed the colony, chicks were collected from the funnel traps in 1986. Yolk sacs of these chicks were excised and weighed, and all material was preserved in 9% formalin. Lipid was extracted from chicks and yolk sacs with petroleum ether in a Soxhlet apparatus. Energy reserves of these chicks were compared to those of newly hatched chicks (from Duncan and Gaston 1988). Lipid content is expressed as a lipid index (g lipid/g lean dry mass). Statistics are given as mean ± 1 se.

RESULTS

Thirteen chicks captured in funnel traps had been weighed previously in their burrows. These chicks lost 5.1 ± 0.6 g during the 36 ± 3 h between weighings (N = 13). Because the chicks

were 0–24 h old when first weighed, total weight loss between hatching and departure would be higher. Some weight loss was caused by catabolism of most of the yolk; yolk sacs of departing chicks were 0.6 ± 0.2 g ($N = 10$) compared to 3.4 g ($N = 7$) in newly hatched chicks (Duncan and Gaston 1988). Lipid from both the yolk sac and carcass was used during this time (Table 1); the lipid indices of chicks decreased from 0.71 to 0.41 between hatching and departure, representing a mean loss of 41% of their lipid.

We assume that the transmitters did not substantially interfere with the normal behavior of the birds and that radio-marked adults were accompanied by chicks. Observations of radio-marked chicks and adults leaving the colony supported this assumption with the following exception. One of the two adults captured above ground while accompanying chicks to the sea moved more rapidly at sea than the other birds and was observed twice from the aircraft, each time without chicks and in the company of 4–6 other adults (this was the only radio-marked individual observed from the air). This bird was excluded from all analyses.

All sixteen radio-tagged chicks left the island between 00:00–02:00. Signals from chicks were detected from shore for an average of 108 ± 12 min ($N = 15$) but those from adults (larger transmitters) were heard for 148 ± 24 min ($N = 6$). In all cases signal strength diminished within 30 min of chicks being released, indicating rapid movement away from the colony. All birds headed northeast, although it was difficult to determine direction because signal strength fluctuated, presumably because of obstruction from waves.

Wind was from the south on all dates when radio-marked birds departed from the colony. On 29 May, wind was from the southeast and increased from 20 km/h at 00:00 to 60 km/h by mid-afternoon. Birds located 6–8 h after leaving the colony that day (two chicks and one adult) were farther west than those located on other dates, probably due to the strong wind and consequent rough sea conditions.

Eleven birds (48%) were located from the air within 24 h of their leaving Reef Island. Mean distance from the colony 6–8 h after departure was 13 ± 2 km with an average speed of 1.9 ± 0.3 km/h ($N = 7$) (Figs. 1, 2). By 12–18 h after departure birds were 48 ± 8 km ($N = 5$) northeast of Reef Island, and were distributed over an area > 1000 km². Average speed of the family groups at this time was 3.0 ± 0.4 km/h ($N = 5$).

Four birds located > 24 h after they left the colony were at least 25 km from land, but were not much farther from the colony than those located after 12–18 h (Figs. 1, 2). No aggregations

TABLE 1. LIPID AND LEAN MASS (G) AND LIPID INDEX (G LIPID/G LEAN DRY MASS) OF CARCASSES, YOLK SACS, AND WHOLE BODIES OF ANCIENT MURRELET CHICKS AT HATCHING AND AT DEPARTURE FROM COLONY ($\bar{X} \pm SE$)

Status of chick	N	Carcass ¹			Yolk sac		Whole body	
		Lipid	Lean	Lipid index	Lipid	Lean	Lipid index	Lipid index
Recently hatched ²	8	2.96 ± 0.10	4.60 ± 0.07	0.64 ± 0.02	0.97 ± 0.08^3	0.96 ± 0.09	1.03 ± 0.07	0.71 ± 0.02
Leaving colony	10	2.01 ± 0.15	5.18 ± 0.19	0.39 ± 0.02	0.31 ± 0.12^4	0.25 ± 0.13	1.64 ± 0.49	0.41 ± 0.02

¹ Carcass = whole body (plucked) minus yolk sac.

² From Duncan and Gaston (1988).

³ $N = 7$.

⁴ $N = 5$; yolk sacs of the others were too small for analysis.

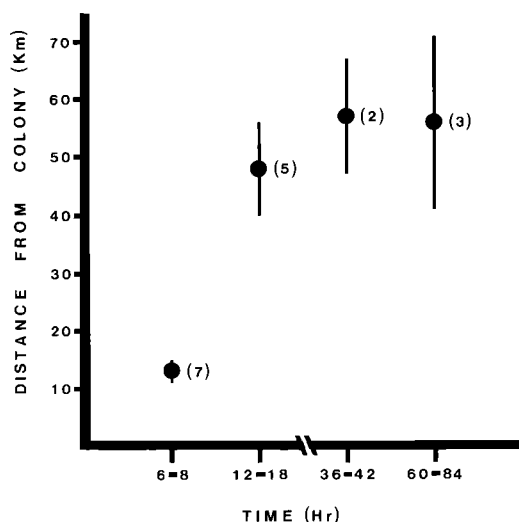


FIGURE 2. Mean (\pm SE) distances of radio-marked Ancient Murrelet family groups from Reef Island within 4 days of leaving the colony. Numbers in parentheses denote sample sizes.

of birds were observed, although two chicks were an estimated 500 m apart 12–18 h after departure (Fig. 1; northeast of Sandspit). The chicks differed in weight more than most siblings (Gaston, unpubl. data), suggesting that two family groups may have been travelling together. They may, however, have been siblings, despite attempts to mark only one member of a family group.

DISCUSSION

Ancient Murrelet chicks hatch with one of the highest lipid contents among birds (Duncan and Gaston 1988). However, they lose >5 g between hatching and leaving the colony (see also Sealy 1976, Vermeer and Lemon 1986), including 1.6 g of lipid. When the chicks go to sea, their lipid indices are 0.41. At indices of <0.20 – 0.30 , lipids of migrating birds can only be used with a concurrent catabolism of non-fat tissue (Odum et al. 1964, Johnston 1968), and at 0.1–0.2, a chick is close to starving to death (Duncan 1988 and references within). An emaciated chick that was found dead at sea had a lipid index of 0.08. If the rate of lipid catabolism remained the same at sea as it was between hatching and colony departure, the lipid index of an unfed Ancient Murrelet chick would be 0.1 (i.e., starvation) about two days after leaving the colony. However, energy utilization is likely higher at sea because of increased costs of locomotion and of thermoregulation due to lower ambient air and water temperature (but see Eppley 1984). Thus,

Ancient Murrelet chicks must probably be fed <2 days after leaving the colony.

The rapid attenuation of radio signals supports observations of family groups quickly leaving the vicinity of the island. Within 4 h after sunrise, Jones et al. (1987a) found some family groups swimming rapidly away from Reef Island, 4–12 km from the island, and Sealy (1976) reported that family groups from Langara Island in the QCI archipelago were >10 km from shore by daybreak. The rapid movement may be to reach areas of high food availability quickly, or to get away from land where avian predators (e.g., gulls) are more abundant, or both.

The rate of movement of family groups in the first 24 h after leaving the colony was 2–3 km/h, which is over two times greater than the theoretical maximum swimming speed of chicks (1.0–1.3 km/h; from Prange and Schmidt-Nielsen's (1970) equation). This suggests, assuming the theory is correct, that the chicks moved by running on the water (which they have been observed to do while departing from the island) or by moving with the currents.

Tidal flow apparently did not determine direction of travel because the direction of the tidal flow at night would have been reversed over the one-week span that birds departed; tidal flow generally runs north and south in Hecate Strait (Thomson 1981). Despite this, all family groups initially travelled northeast after leaving Reef Island. Also, family groups maintained this general heading for 12–18 h after leaving the colony even though the tidal current changed direction twice each day. Surface water flow in Hecate Strait is primarily due to wind-induced currents (Thomson 1981), and these probably influence the movements and survival of murrelet broods. For example, on May 29, the strong northeasterly wind and resulting rough sea conditions appeared to push birds to the west more than subsequent groups and may also have caused mortality of chicks. Three of the first four birds radio-tagged (three chicks and one adult) were located by aircraft early on that day, when they left Reef Island, but none was found subsequently. Because these were the first birds marked, they were available for the greatest number of searches and thus had the highest probability of being detected later.

Some family groups remained in central Hecate Strait for 2–4 days after leaving the colony despite the fact that they had the speed to move out of the study area within about two days. Although chicks must be fed during this time, it is unknown whether this is a brood-rearing area or merely a resting area. The initial northeastern heading suggests some family groups may have travelled to the north end of the QCI. Vermeer

et al. (1985) recently observed Ancient Murrelet family groups over a seamount and along the edge of the continental shelf break > 15 km off the northwest coast of the QCI. The water depth in those areas is 50–200 m, similar to that in which we found broods > 24 h after leaving the colony (25–100 fathoms; Fig. 1). The shallow bank in northern Hecate Strait may make this area unfavorable and could be the reason no family groups were found there. It is not known if birds moved into southern Hecate Strait because surveys were not conducted south of Reef Island. Although Ancient Murrelet family groups appeared to be widely dispersed as suggested by Sealy and Campbell (1979), Vermeer et al.'s (1985) observations of aggregated groups shows how interpretation of spatial patterns is scale dependent (Hunt and Schneider 1987).

The use of radio telemetry to study small seabirds such as Ancient Murrelets is limited by the short transmission range of small radio transmitters and the wide dispersion of birds at sea. Surveys such as those of Vermeer et al. (1985) which census and document locations of birds at sea, combined with information on food habits and energy reserves of the chicks, are needed to further elucidate the chick-rearing ecology of Ancient Murrelets.

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