these two populations. Available data fail to reveal any obvious differences in the temperatures of comparable water masses in any of the five lakes at any time during the ice-free period. Further, year-to-year fluctuations in water temperature in the region are greater than between lake differences (J. B. Livingstone, unpublished manuscript, Mount Allison University).

The lack of any apparent correlation between number of anal fin rays in the five populations and either the temperature or the other limnological characteristics of the lakes suggest that the observed differences are most probably not the result of obvious environmental differences between the habitats. In addition, the absence of differences in anal ray numbers between the two year classes examined in detail would appear to preclude short-term environmental shifts during critical periods of development as being responsible for the observed population differences, unless it is assumed that such shifts were consistent in timing and intensity for each lake over at least a two-year period. The available data appear to be best interpreted by postulating genetic differences between the populations.

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Literature Cited

Barlow, G. W. 1961. Causes and significance of morphological variation in fishes. Systematic Zoology 10: 105–117.

Clair, T. and **C. G. Paterson.** 1976. Effect of a salt water intrusion on a freshwater Chironomidae community: a paleolimnological study. Hydrobiologia 48: 131–135.

Hubbs, C. L. 1921. Geographical variation of *Notemigonus crysoleucas*—an American minnow. Transactions of the Illinois State Academy of Sciences 10: 147–151.

Hubbs, C. L. 1926. The structural consequences of modifications of the developmental rates in fishes, considered in reference to certain problems of evolution. American Naturalist 60: 57–81.

Hubbs, C. L. 1941. Increased number and delayed development of scales in abnormal suckers. Papers of the Michigan Academy of Science, Arts and Letters 26: 229–237.

Lee, C. L. and **W. D. Williams.** 1970. Meristic differences between two conspecific fish populations in Australian salt lakes. Journal of Fish Biology 2: 55–56.

Lindsey, C. C. 1958. Modifications of meristic characteristics by light duration in kokanee, *Oncorhynchus nerka*. Copeia 1958: 134–136.

Schultz, L. P. 1926. Temperature-controlled variations in the golden shiner, *Notemigonus crysoleucas*. Papers of the Michigan Academy of Science, Arts and Letters 7: 417–432.

Scott, W. B. and **E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 pp.

Taning, A. V. 1952. Experimental study of meristic characters in fishes. Biological Review (Cambridge) 27: 169–193.

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Unreliability of Strip Aerial Surveys for Estimating Numbers of Wolves on Western Queen Elizabeth Islands, Northwest Territories

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Abstract. Numbers of wolves (*Canis lupus arctos*) were obtained by aerial survey and by ground observation on western Queen Elizabeth Islands, Northwest Territories. Six transect-strip "census" aerial surveys were flown in March-April and July-August of each year from March 1972 to August 1974. The estimates based on aerial surveys were usually misleading. The behavior of observed wolves and their associations with other animals or objects that helped attract the observers attention to the wolves greatly influenced the number of observations. These reported shortcomings of aerial surveys must be considered during any future attempts at determining numbers of wolves.

The so-called Melville Island wolf (*Canis lupus arctos* Pocock, 1935) that occurs on the Queen Elizabeth Islands, Northwest Territories, is the Canadian High Arctic form of the gray wolf, *Canis lupus*. This subspecies has apparently recently invaded Banks Island and replaced the Banks Island tundra wolf, *C. l. bernardi* Anderson, 1943 (Manning and Macpherson 1958). It is likely that *C. l. arctos* now occurs on most or all islands south of Melville Sound, although the Baffin Island tundra wolf *C. l.*

manningi Anderson, 1943, is still apparently found on Baffin Island. The Canadian High Arctic form of *Canis* apparently radiated out from the refugium of Pearyland after the Wisconsin glaciation (Macpherson 1963).

Information on High Arctic wolves is fragmentary, but existing reports (Parry 1821; Belcher 1855; M'Dougall 1857; M'Clintock 1859; Bernier 1910; Stefansson 1921; MacDonald 1954) suggest that historically wolves have not occurred in high numbers on the western Queen Elizabeth Islands. More recent observations (Macpherson 1961; Tener 1963; Riewe 1975) further emphasize the low numbers of wolves even during periods of high prey populations. High Arctic wolves prey mainly on Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*). The future of *C. l. arctos* is questionable in view of the recent (1973–74) crash of both prey species and increasing human contact on the western Queen Elizabeth Islands.

Man's activities in the High Arctic will most likely encourage a wider range of wildlife inventories by involved agencies. The most practical method of counting arctic ungulates and large carnivores over extensive areas is by aerial survey. The "transect-strip census" method is the design most often used for such counts.

We flew six transect-strip aerial surveys between March 1972 and August 1974 to estimate Peary caribou and muskox numbers. Analysis of wolf observations made by us during the surveys shows that attempts to determine wolf numbers by this technique gave disparate estimates. Therefore, we present our observations of wolves obtained from aerial surveys and from additional sightings by observers on the ground in order to draw attention to the variation and possible error that can occur even from intensive (25% coverage) aerial strip surveys.

Survey Area

The Queen Elizabeth Islands included in our surveys are listed in Table 1 by descending order of size. The islands surveyed lie between latitudes 74° and 78° North and longitudes 95° and 124° West. The survey area, except western Melville Island is low-lying and mainly below 150 m elevation. Western Melville Island is mostly mountainous terrain with many sites from 300 m to 1000 m above sea-level. The

TABLE 1—Sightings of wolves on western Queen Elizabeth Islands, Northwest Territories, between March 1972 and August 1974

Islands surveyed	Size of island (km²)	Wolf sightings					
		1972		1973		1974	
		winter	summer	winter	summer	winter	summer
Melville	42220	15*	0(15)*	9(1)	14(22)	12 (7)	0(26)
Bathurst	16090			1		0 (8)	0
Prince Patrick	15830			1(5)	12 (3)	0(10)	0(25)
Mackenzie King	5100			0		0	
Borden	2790			0			
Eglinton	1550	0	0	0	8	1 (4)	0
Lougheed	1300			0		0	
Byam Martin	1160	2	0	0	0	1	0
Vanier	1130			0		0	
Cameron	1060			0		0	
Brock	790			0			
Emerald	550			0	0	0	
Alexander	490			0		0	
Massey	440			0		0	
Little Cornwallis	410			0		0	0
Helena	330			0		0	
Edmund Walker	82			0		0	
Marc	56			0		0	
Fitzwilliam Owen	34			0		0	
Eight Bears	18			0		0	

*Sightings not in parentheses were obtained from aerial surveys and those sightings in parentheses were made by observers engaged in other activities. No entries (blank spaces) indicate that the islands were not surveyed during that period.

terrain is open and for the most part is suitable for aerial surveys. Locally, broken terrain could hinder observation.

Methods

The islands were surveyed by use of a standard transect survey (Miller and Russell 1974). Surveys were flown on 13 days between 20 March and 7 April 1972, 8 days between 7 August and 24 August 1972, 18 days between 19 March and 15 April 1973, 18 days between 5 July and 21 August 1973, 12 days between 25 March and 17 April 1974, and 17 days between 18 July and 26 August 1974. Parallel flight lines were drawn on 1:250 000 scale topographical maps. In 1972 flight paths were at 6.4-km intervals. In 1973 and 1974 flight paths were also at 6.4-km intervals, except on Mackenzie King, Borden, and Brock islands where they were 12.8 km apart, and on Eglinton and Byam Martin islands the spacing was 3.2 km. The flight lines on Melville Island were oriented either east–west or north–south in each stratum to provide maximum contact with the coast for accurate navigation. Flight lines were oriented east–west on all other islands although on Byam Martin and Eglinton islands, north–south surveys were added to provide double coverage in March–April 1973, then changed to all east–west lines for remaining surveys. A Helio Courier fixed-wing aircraft was used for all surveys, except in August 1972 when a Bell 206 turbo-helicopter was used.

A 1.6-km strip, 0.8 km on each side of the aircraft, was surveyed. The 0.8-km strips were divided into two 0.4-km strips to determine the efficiency of observing within the 1.6-km strip. To mark the boundaries of each strip, wires were strung from an eye-bolt on the wing to one on the fuselage of the Helio Courier. Lines marked on each observer's window were aligned with corresponding tabs on the wires. At an altitude 150 m above ground, these tabs were checked against fuel drums located at 0.4- and 0.8-km intervals from a reference point on the ground. Allowance was made for the blind spot beneath the aircraft so that an entire 0.8-km strip was visible on each side of the aircraft. Wildlife sightings were recorded as being within the two 0.4-km strips closest to the aircraft, within either of the two 0.4-km strips farthest from the aircraft, or outside both sets of strips (off transect).

All survey flights were flown about 150 m above ground level according to altimeter readings except on western Melville Island where broken terrain forced us higher. Speeds ranged from 110 to 190 km/h, depending on the number of animals encountered. Observations were located on the survey maps and recorded on tape. At the end of each day the sightings were transcribed and located on a second map.

Results and Discussion

The distributions of wolves observed during our six aerial surveys and by observers on the ground are given in Table 1. Table 2 gives numbers of wolves observed on each aerial survey, and estimated densities and numbers of wolves for all the islands and includes sizes of areas surveyed and distances flown. Observations in Table 1 show that during periods when no wolves were seen by aerial survey, wolves were seen by ground observers. Such discrepancies between aerial and ground observations further support the apparent observational error resulting from aerial survey of wolves. Tener (1963) saw 18 wolves during his aerial survey of the entire Queen

TABLE 2—Observed and estimated numbers of wolves on western Queen Elizabeth Islands, Northwest Territories, obtained from six aerial surveys

Survey period	Area surveyed (km^2)	Distance flown (km)	Total wolves seen	Observed density* by strip location (wolves/1000 km^2)			Estimates of total numbers based on widths of strips	
				Outer strips (total 0.8 km)	Inner strips (total 0.8 km)	All strips (total 1.6 km)	0.8 km	1.6 km
Mar.–Apr. 1972	44930	7020	17	0.0	3.0	1.5	135	67
Aug. 1972	26240	4100	0	0.0	0.0	0.0	0	0
Mar.–Apr. 1973	91430	13930	11	1.0	0.0	0.5	0	46
July–Aug. 1973	61310	10000	25**	3.2	0.0	1.6	0	98
July–Aug. 1973	61310	10000	34***	4.2	0.0	2.1	0	129
Mar.–Apr. 1974	50400	7920	14	2.2	0.0	1.1	0	55
July–Aug. 1974	67800	10340	0	0.0	0.0	0.0	0	0

*Density was determined by multiplying distance flown (km) by width of transect strip (km), which equals area censused (km^2), then total wolves seen on transect was divided by the area censused: e.g., $7020 \times 0.8 = 5616$ km^2, then $17/5616 = 0.0003$ wolves/km^2 or 3.0 wolves/1000 km^2.

**Observations do not include newborn pups.

***Total wolves seen includes nine newborn pups.

Elizabeth Group in summer 1961 and only three of those wolves were on western Queen Elizabeth Islands. Coverage was only 6% for the 1961 survey. At that time on the western islands Peary caribou were estimated to number 24 320, about 10 times as numerous as we estimated in 1974 (2676). Muskoxen occurred at similarly estimated numbers (2161 in 1961 and 2704 in 1974).

Of the 202 total sightings of wolves made both from the air and from the ground between March 1972 and August 1974 (Table 1), 69% (140) wolves were seen in 24 packs. Pack size averaged 5.8 and ranged from 2 to 15. Twenty-four percent (49) of the wolves seen were in six family groups of adults and pups, five groups in summer 1973 and only one in summer 1974. Family groups averaged 4.2 adults/4.0 pups, and adults/pups varied as follows: 2/5, 3/2, 4/2, 5/1, 5/10, and 6/4. Two dens were found on Melville Island and one on Prince Patrick Island in 1973. Only the den on Prince Patrick Island was occupied in summer 1974. Only 6% (13) of the wolves seen were solitary. Of all the wolves seen (Table 1) 14% were stalking muskoxen, 12% were feeding on muskox carcasses, 9% were stalking caribou, 17% were at wolf dens, 17% were travelling and not associated with anything that would have helped to attract our attention to them, and 31% were seen at permanent or temporary camp sites.

Only 76 wolves were seen on 53 310 km of flight paths during the six aerial surveys (Tables 1 and 2): 53% were in packs, 35% were in family groups (20% at den sites), and 12% were solitary wolves. Of the 76 wolves seen, 28% (21) were stalking muskoxen, 22% (17) were feeding on muskox carcasses, 3% (2) were stalking caribou, 35% (27) were in family groups (15 at den sites and 12 travelling cross-country), and 12% (9) were travelling and not associated with any other animals or objects.

The variations in the estimates (Table 2) established the inaccuracy of the estimates, but we are unable to calculate correction factors as we cannot verify the accuracy of any of the estimates. Our inability to determine how many of the wolves sighted by ground observers represented different individuals prohibits the establishment of a ratio of wolves seen from the ground to wolves seen from the air. Such a ratio would have allowed evaluation of errors in the estimates obtained from aerial surveys. It is clear, however, that transect-strip aerial surveys are not reliable for determining wolf populations on the open tundra of the High Arctic.

Some of the problems inherent in aerial surveys of large mammals (Graham and Bell 1969) particularly apply to our surveys of wolves. The size and relative lack of color contrast between pelage and background, especially in winter, reduce the visibility of wolves from the air. In addition the behavior of the wolves can influence their chances of being seen from the air. Although we do not have quantitative measurements, ground observations of wolves reveal that wolves will sometimes remain stationary during overflights by aircraft. The effect that arbitary selection of transect strip widths has on subsequent estimation is shown in the estimates by strip width (Table 2). We cannot explain the unexpected pattern of occurrence of wolves on the outer and inner strips (Table 2). Our results do not follow the expected pattern of most observations of inconspicious animals on narrow transects (Pennycuick 1969). We suggest that some wolves had moved from the inner to the outer strips before being sighted and/or remained stationary on the inner strips and were not sighted.

These conditions and the above factors, and possibly many more, contribute to confounding the observations of wolves by aerial survey.

Our consistently low counts of wolves do suggest that wolves are in low numbers throughout the western Queen Elizabeth Islands. The current numbers of Peary caribou and muskoxen could not sustain high numbers of wolves, and alternate food sources are often scarce.

It is our opinion, however, that even the number of wolves seen on each aerial survey is not necessarily representative of the true number of wolves present. Therefore, resultant estimates would often be erroneous; this condition must be borne in mind by future observers.

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Literature Cited

Belcher, E. 1855. The last of the Arctic voyages: being a narrative of the expedition in HMS Assistance under the command of Capt. Sir Edward Belcher, C.B., in search of Sir John Franklin, during the years 1852, 1853, and 1854. With notes on the natural history by Sir John Richardson, Prof. Owen, Thomas Bell, J. W. Slater, and Lovell Reeve. L. Reeve, London. 383 pp.

Bernier, J. E. 1910. Report on the Dominion Government Expedition to the Arctic Islands and Hudson Strait on board the C.G.S. Arctic in 1908–1909. Government

Printing Bureau, Ottawa. 529 pp.

Graham, A. and **R. Bell.** 1969. Factors influencing the countability of animals. *In* Proceedings of the workshop on the use of light aircraft in wildlife management in East Africa. *Edited by* W. G. Swank, R. M. Watson, G. H. Freeman, and T. Jones. Special Issue East African Agricultural and Forestry Journal. 108 pp.

Macdonald, S. D. 1954. Report on biological investigations at Mould Bay, Prince Patrick Is., N.W.T., in 1952. Annual Report of the National Museum of Canada, 1952–53, Bulletin 132: 214–238.

Macpherson, A. H. 1961. On the abundance and distribution of certain mammals in the Western Canadian Arctic Islands in 1958–9. Arctic Circular 14(1): 1–16.

Macpherson, A. H. 1963. The origin of diversity in mammals of the Canadian Arctic tundra. Systematic Zoology 14(3): 153–173.

Manning, T. H. and **A. H. Macpherson.** 1958. The mammals of Banks Island. Arctic Institute of North America Technical Paper Number 2: 1–74.

M'Clintock, F. L. 1859. The voyage of the Fox in the Arctic Seas: A narrative of the discovery of the fate of Sir John Franklin and his companions. J. Murray, London. 403 pp.

M'Dougall, G. F. 1857. The eventful voyage of H. M. Discovery ship Resolute to the Arctic regions in search of Sir John Franklin and the missing crews of H. M. Discovery ships Erebus and Terror 1852, 1853, 1854. Longmans, London. 529 pp.

Miller, F. L. and **R. H. Russell.** 1974. Aerial surveys of Peary caribou and muskoxen on western Queen Elizabeth Islands, Northwest Territories, 1973. Canadian Wildlife Service Progress Note Number 40: 1–18.

Parry, W. E. 1821. Journal of a voyage for the discovery of a Northwest passage from the Atlantic to the Pacific: performed in the years 1819–20, in His Majesty's ships Hecla and Griper, under the Orders of William Edward Parry... with an appendix, containing Scientific and Other observations. John Murray, London. 309 pp.

Pennycuick, C. J. 1969. Methods of using light aircraft in wildlife biology. *In* Proceedings of the workshop on the use of light aircraft in wildlife management in East Africa. *Edited by* G. W. Swank, R. M. Watson, G. H. Freeman, and T. Jones. Special Issue East African Agricultural and Forestry Journal. 108 pp.

Riewe, R. R. 1975. The High Arctic wolf in the Jones Sound region of the Canadian High Arctic. Arctic 28(3): 209–212.

Stefansson, V. 1921. The friendly arctic. Macmillan Co., New York. 784 pp.

Tener, J. S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Paper Number 4: 1–50.

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The Flowering Phenology of Common Vascular Plants at Bailey Point, Melville Island, Northwest Territories

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A collection of the vascular flora at Bailey Point, Melville Island (74°58′ N, 115°01′ W) was made during the course of studies of caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) from 24 June to 20 August 1974. That collection is preserved in the Vascular Plant Herbarium of the Biosystematics Research Institute, Ottawa. Cody et al. (1976) have reported on new additions to the vascular flora of Melville Island resulting from the collection.

Throughout the period of observation, notes were kept on when the most common plants came into flower, the period of peak bloom, and when the last flowers of a species were seen. A search of the literature showed a paucity of information on the flowering phenology of vascular plants in the high Arctic. Existing records usually include the date of first flower for a few species only (Savile 1959, 1961, 1964; Parmelee 1963; Beschel 1963). Bruggemann and Calder (1953) provide a useful comparison of first-flowering dates for 16 vascular species at four locations in the Canadian Arctic.

Records of flowering periods are useful in documenting species differences in phenology during a single growing season at specific locations. Broader regional differences in phenology may become apparent when more data become available. Such records are also useful to those persons planning to study certain species in specific northern locations.

The period of flower, with approximate date of peak bloom, is shown in Figure 1 for the most common and conspicuous vascular plants at Bailey Point from 28 June to 15 August 1974.

The first vascular plant in flower was *Saxifraga oppositifolia*; the last to appear was *Senecio congestus*. The period when the most species were in peak flower was 18 to 25 July. The degree of habitat