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The Arctic Fox (*Alopex lagopus*)

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INTRODUCTION

The arctic fox (*Alopex lagopus*) is Holarctic in distribution, primarily in the tundra zone. Over most of its range, this fox preys heavily on microtine rodents, especially lemmings, and seasonally on marine invertebrates, birds, and seals. Most of its populations are strongly cyclic averaging about four years between peaks, and corresponding to local cycles of rodent abundance. The arctic fox is the basis of a fur industry in northern regions, with some thousands of pelts taken annually in most of its range. Its importance to the fur industry has decreased in some parts of northern Alaska in recent years, because alternate and more lucrative sources of income have become established in connection with northern development.

The arctic fox is a carrier of two significant human diseases in the Arctic: rabies and alveolar hydatid disease, the prevalence and transmission of which to man also involves domestic animals. The importance of the arctic fox to man in northern regions, therefore, stems from (1) its place as a major predator on avian and mammalian subsistence resources, (2) its economic role in the fur industry, and (3) as a

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carrier of diseases affecting domestic animals and man. Being an opportunistic scavenger as well as predator, the arctic fox is attracted to unnatural food sources such as waste disposal sites in and near villages and construction camps. Because it is less shy and more inquisitive than other foxes, it is more prone to frequent the areas where people work or live, and has been known to damage certain types of supplies and equipment by chewing on them. These attractions increase the potential for contact between foxes and man.

The following is a resume of the available information on the biology and ecology of the arctic fox, with emphasis on its role in Alaskan coastal and marine environments.

Scientific Nomenclature

Kingdom - Animalia, Linnaeus, 1758

Phyl urn - Chordata, Linnaeus, 1758

Class - Mammalia, Linnaeus, 1758

Order - Carnivora, Bowdich, 1821

Suborder- Caniformia, Kretzoi, 1943

Superfamily- Canoidea, Simpson, 1945

Family - Canidae, Gray, 1821

Genus - Alopex, Kaup, 1829

Species - lagopus, Linnaeus, 1758

The single circumpolar species A. lagopus has been regarded as comprising three to nine subspecies (Ellerman and Morrison-Scott, 1951; Heptner and Naumov, 1967), the validity of most of which still remains in question. Alaskan populations are primarily of the holarctic form,

A. l. lagopus, (Linnaeus, 1758), with the exception of a well differentiated insular race, A. l. pribilofensis, Merriam, 1902, on the Pribilof Islands (Pengilly, 1981).

Common Names

In Alaska, commonly known in English as "arctic fox" or as "white fox" or "blue fox" where the two color phases coexist. The Inupiat Eskimo names for the white fox are tigiganniak and kusrhaak in the North Alaska and Kobuk River dialects, respectively, and kiangaktuluk and kiangak, respectively, for the blue fox (Webster and Zibell 1970).

General Description

The arctic fox is a small fox about 1.1 m long and 3 kg in average weight. Males tend to be slightly larger than females. The muzzle and appendages are somewhat shorter in relation to body size than in red foxes, and the feet are heavily furred. The thick winter coat on the head and torso exaggerates the shortness of the snout, ears, and legs. The tail is approximately half as long as the body and is heavily furred. The arctic fox in its winter coat is one of the best insulated animals in the North.

The pelage of the white phase of the arctic fox is seasonally dimorphic, being white in winter and gray-brown with white to huffy tail, ears, and underparts in summer. Both pelages blend well with the seasonal background coloration of the tundra. The blue phase of the arctic fox does not change dramatically in color from winter to summer, remaining charcoal gray to black year-round. In some areas, however,

the blue fox does become slightly lighter in summer. There are two molts per year with great individual variation in timing (Chesemore 1970). The spring molt takes place from March to June and the fall molt from late August to December. Arctic foxes of the Aleutian, Commander, and Pribilof Islands and the western coast of Greenland are predominantly of the blue phase; white foxes predominate in all other areas (Vibe 1967).

DISTRIBUTION AND ABUNDANCE

Worldwide

The worldwide distribution of the arctic fox is depicted in Figure 1. The breeding range is limited to the tundra zone of northern Eurasia, North America, Greenland, and Iceland (Banfield 1974; Bee and Hall 1956; Heptner and Naumov 1967; Ognev 1931). Arctic foxes do range farther south, particularly during late fall to early spring. Long range movements southward into forested zones often are associated with low availability of prey in tundra areas (Chirkova 1955; Wrigley and Hatch 1976).

The arctic fox is unique among foxes in that some individuals leave the terrestrial environment in winter and wander over the sea ice, often hundreds of kilometers from shore (Chesemore 1968; Rausch 1970). Their tracks are common everwhere on the sea ice, and the animals themselves have been sighted within 300 km of the pole (Rutilevskii and Uspenskii 1957). Movement back to the tundra takes place in spring, as the breeding season approaches. Some of these animals may be unable to return to shore when coastal leads open; others may be transported long distances

on drifting ice floes (Elton 1949). Periodic mass movements apparently take place over the ice between the Canadian Arctic and Greenland, when lemming populations are low (Braestrup, 1941).

Alaska

On the mainland of Alaska, the distribution of the arctic fox extends from the Canadian border on the Beaufort Sea, westward along the arctic coast to Point Barrow and southward about to the mouth of the Kuskokwim River (Figure 2). The arctic fox also is a natural inhabitant of St. Lawrence, St. Matthew, Nunivak, and the Pribilof Islands in the eastern Bering Sea. It was introduced by the fur industry on the Aleutians and on several islands in the Gulf of Alaska during the 18th to early 20th centuries. On Nunivak Island and much of the mainland coast, arctic foxes coexist with red foxes.

There have been no estimates of the abundance of arctic foxes in Alaska, and as yet there are no data on which to base a realistic estimate of numbers. Abundance may vary between peaks and lows of the cycle by at least one order of magnitude. Within any given year, the number of foxes at large in autumn, after the young have dispersed, will tend to be about three times the number in the previous spring. The highest recorded number of pelts marketed in Alaska was about 16,600 in 1925 (Chesemore 1972), but this probably was onlya portion of the total number taken. At St. Lawrence Island, alone, the catch of arctic foxes was about 2,000 per year on a sustained basis, during the 1950's and 60's (Fay, unpubl. data).

Arctic foxes range widely from September to March following breakdown of breeding territories and dispersal of the young-of-the-year. In addition to movements onto the pack ice, foxes have been reported as far south as the Kuskokwim River and inland in interior Alaska to Ruby, Arctic Village, Anaktuvuk Pass, and Bethel (Dice 1921; Rausch 1953; D.G. Ritter, pers. commun.). The movements of arctic foxes onto the pack ice of the Beaufort, Chukchi and Bering Seas are well known. The latter take place annually, whereas movements inland from the coastal tundra appear to be irregular and more in response to occasional scarcity of food than to annual events.

HABITATS AND MIGRATION

The tundra habitats occupied by arctic foxes are diverse, indicating no distinctive selection other than for treeless, brush-free environments. Only in choice of den sites do arctic foxes appear to be selective (Chesemore 1969; Danilov 1958). Dens are used year-round but are most important from late spring to late summer when the pups are reared (McPherson 1969; Stephenson 1970). Den sites in the tundra usually are located in mounds 1 to 4m high (Chesemore 1975). These heights are needed to insure an adequate drainage and thickness of active soil above the permafrost. Most dens are dug by the foxes; some may be enlargements or alterations of arctic ground squirrel (*Spermophilus undulatus*) dens (Stephenson 1970). Size of dens varies considerably and seems to be associated with age of the den, the largest with the most extensive burrow systems being used over many years (McPherson 1969). Permafrost

probably is a significant factor limiting the number of den sites available in a given area.

A den may not be used every year (Danilov 1958; Kaikusalo 1971; McPherson 1969). During population highs, most dens may be occupied, but during population lows, only a small proportion may be used. Den occupancy is utilized in the Soviet Union to predict the size of the fox population during the subsequent fall and winter (Bannikov 1970; Skrobov 1970). The number of dens per unit area varies considerably on a geographic basis, ranging from a low of 0.03 per km^2 reported in Canada (McPherson 1969) to0.6 per km^2 in some parts of the Soviet Union (Dani 10V 1958; Skrobov 1961).

Foxes living in coastal areas having rocky bluffs often use crevices in the rocks for dens. These dens probably cannot be modified or enlarged because of the rocky substrate. Such dens also are used over many years, probably more regularly than those in the tundra. Coastal fox populations tend to be more stable than those dependent on lemmings.

Fox dens in the tundra support luxuriant surface vegetation, principally grasses, which contrasts with the surrounding tundra vegetation. The addition of organic matter to the soil from scats and food remains and the disturbance of the soil by burrowing appear to be responsible for this floristic alteration (Chesemore 1969; Danilov 1958; Skrobov and Shirokovskaya 1968; Underwood 1975). This characteristic of the dens facilitates their being located during surveys.

Long-range movements of arctic foxes have been reported in the Soviet Union by Bannikov (1970), Chirkova (1955), Dementyeff (1955), Shilyaeva (1967), and Shvarts (1967), in Canada by Wrigley and Hatch

(1976), and in Greenland by Braestrup (1941) and Vi be (1967). Typically these movements involve a large number of animals and, in most cases, the movements are to the south. The proximate cause for these events is reduced food supply in tundra areas, forcing the animals to seek food elsewhere (Braestrup 1941; Peterson 1966; Vibe 1967). These movements can occur in broad waves or along narrow fronts; in some instances, they take place in successive waves. Males seem to predominate in these movements (Pulliainen 1965; Vibe 1967), which usually take place in fall and early winter. These are not migrations in the strict sense, for they take place at irregular intervals, usually during or following a population peak, and the participants are not known to return to the home area. The movement of foxes onto the sea ice in fall and winter is more akin to migration, since it does occur annually, and some or many of the animals move back to the terrestrial environment in advance of breeding. These "migrations" are more gradual and less dramatic than the irregular, mass movements, hence are less apparent to the casual observer. They are, however, well known to the resident Eskimos.

Chesemore (1968) did not find any evidence for overland migration in arctic foxes of northern Alaska either in his own work, in reports from trappers, or in the literature of the region. Long-range movements of foxes take place there sporadically (Eberhardt and Hanson 1978; Rausch 1953; D.G. Ritter, pers. comm.), but mass movements such as those reported in the Soviet Un on and Greenland are unknown in Alaska.

LIFE HISTORY

The breeding season varies geographically, but generally takes place in March to May, with the peak in April. After a gestation of about 52 days, the female gives birth to the pups during May and June. Litter size, based on counts of placental scars, averaged about 10.5 pups per female in a study by Macpherson (1969) and did not vary significantly between years. On St. Lawrence Island, Bering Sea, litter size averaged 12.2 pups (Fay, unpubl. data). The number of weaned pups per litter, however, generally was much lower in both studies and tended to vary with available food supply. Other investigators also noted the relationship of weaned litter size to food availability (Braestrup 1941; Chirkova 1951, 1955).

Availability of food also seems to affect the age at first breeding in females but not in males. The percentage of females breeding during their first year of life is larger when food is abundant than when food is scarce (McPherson 1969). Males, however, always mature at 10 months (Sokolov 1957), irrespective of the food supply.

Arctic foxes in captivity have lived for 14 years (Burt and Grossenheider 1976); wild foxes more than five or six years old are uncommon (Fay, unpubl. data). In some areas, man is the most significant predator of arctic foxes; natural predators include red foxes, polar bears, wolverines, wolves, and dogs. The most common lethal disease in arctic foxes is rabies (Ognev 1931; Secord et al. 1980; Shvarts 1967; Smirnov 1968; Syuzyumova 1968); other recorded diseases are coccidiosis, nosematosis, encephalitis, tularemia, and paratyphoid fever (Lavrov 1932; Mohn et al.

1974; Chirkova 1953). Parasitic infections are common but do not appear to play a significant role in mortality of arctic foxes (Fay 1973; Madsen 1961; Rausch 1956, 1959; Webster 1974), although Shilyaeva (1970) suggests that they do influence fox population dynamics. Starvation takes its toll during periods of food shortage (e.g. lemming crashes).

The presence of industrial pollutants, especially polychlorinated biphenyls in arctic fox tissues, has been reported (Clausen and Berg 1975; Clausen et al. 1974; Norheim 1978). Increased concentrations of these and other contaminants may affect this species, which is highly susceptible because of its place at the top trophic level.

FOOD HABITS

The arctic fox is primarily a predator on arvicoline (=microtine) rodents of tundra regions. Throughout most of its range, it is typically dependent on lemmings of the genera Lemmus and Dicrostonyx and, in some areas, on voles of the genus Microtus. The predator-prey relationship between the arctic fox and these small rodents is so great that in most areas, the foxes show dramatic population fluctuations, closely correlated with those of the rodents (Braestrup 1941; McPherson 1969; Siivonen (1948; and others).

Birds also form a major portion of the diet during summer (Eberhardt 1977), especially in areas where colonial' sea birds are abundant (Braestrup 1941; Vibe 1967; Stephenson 1970). Stephenson's (1970) work on St. Lawrence Island, comparing the summer diets of arctic foxes frequenting the coastal cliffs and those on the inland tundra, illustrates. the

relationship of the foxes' diet to prey availability. About ninety percent of the food of foxes inhabiting coastal areas was birds; the food of inland foxes was about ninety percent small rodents. Fishes, insects, and marine invertebrates also were included but in trace amounts.

Carrion also contributes significantly to the diet where and when it is available. This is especially important in coastal areas where marine mammals, fishes, and other marine organisms are cast up by the surf. Berries are taken seasonally but other vegetation probably is ingested accidentally, rather than intentionally.

Arctic foxes cache large amounts of food during the summer and fall for use in the winter, when the diversity of prey is low (Pedersen 1930). Up to forty percent of their food at that time can be marine carrion (Fay, unpubl. data). Foxes may wander widely in winter in search of food, particularly when small mammal populations have declined. In Alaska, movements inland beyond the breeding range are infrequent and appear to take place when foxes are very abundant and not necessarily in response to shortage of food (for example, see Rausch, 1953).

The Eskimos report a tendency for foxes to move to the coast in autumn. At Barrow, this movement is said to take place annually in October and November; at St. Lawrence Island, it takes place in December. Numbers on the coast decline through the winter, until late February or March, then increase again. Between these peaks of abundance, the foxes move out onto the sea ice, where they are reported to follow polar bears and feed upon the remains of polar bear kills, principally ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) (Dufresne 1946; Bee and Hall 1956; Stirling and Archibald 1977). They also feed on

other carrion at that time. The numbers of foxes around these carcasses can be large; Chesemore (1968) reported 40 foxes in and around a walrus (Odobenus rosmarus) carcass in the ice off the coast of Alaska. Arctic foxes also appear to be significant predators on ringed seal pups in subnivean lairs on the ice (Smith 1976). In southern parts of the pack ice, they also may prey on seabirds wintering in the open leads and polynyas.

Those foxes remaining on land during the winter prey on small rodents, ptarmigan (Lagopus spp.), and arctic hares (Lepus articus); they feed also on caribou and reindeer (Rangifer tarandus) carrion, and on other mammals and birds, as available. Food caches stored during the summer and autumn also are utilized at that time (Riewe 1977; Stephenson 1970). Mullen and Pitelka (1972) described the efficiency with which foxes were able to locate and consume rodent carcasses under the snow. Blanchet (1925) and Porsild (1945) reported that foxes attacked weak fawns of reindeer in northern Canada.

BEHAVIOR

General

Arctic foxes will approach people closely when searching for food or defending a den with pups. They are attracted to refuse dumps where waste foods are available, and they can easily become habituated to taking foods from people. This behavioral trait is an important reason why arctic foxes are potentially more dangerous than other canids in transmission of diseases to man.

The social structure of the arctic fox population changes seasonally, in that the foxes are territorial only during the breeding and pup rearing periods, approximately from April to August (Bannikov 1970; McPherson 1969). From September to March, they apparently do not maintain territories but wander widely in search of food. These wanderings account for the congregations of foxes in coastal areas in autumn and at prime food sources in winter. Their tolerance of each other increases during this period; in their competition for food, they appear only to defend a small individual space. This breakdown of territoriality and increase in tolerance of conspecifics is clearly adaptive for survival in the arctic winter, when food diversity and food supply are limited. This trait, however, also facilitates transmission of disease between foxes, because of the increased interspecific contact in winter.

The arctic fox is very vocal and this is most evident during the breeding and pup rearing periods. Fine (1980) described six vocalizations in a study of arctic foxes at Prudhoe Bay. Each of the calls appears to play a roll in social contexts, either during intersibling contacts, between parents and pups, or between adults 'on adjacent territories.

Reproductive Behavior

Basically solitary in winter, arctic foxes begin to pair in March, as indicated by paired tracks in the snow. The foxes are quite vocal at that time, the calls probably serving to maintain contact between the mated pair and to notify other foxes of the defended territory.

Arctic foxes are considered to be monogamous (Dementyeff 1955). Males and females pair immediately prior to the breeding season and they

remain together throughout the period of pup development, sharing in the care of the pups. Their pair bond gradually weakens during this period and appears to be broken when the young become independent. Monogamy may be the rule in wild foxes, because the defended territory would tend to keep strange males from the estrus female. In captivity, however, a single female will breed with two or more males (Follmann, unpubl. data).

As reported by Eskimos, the female often gives birth on the tundra, then carries the pups into a den, where she remains with them for a few days, leaving the den only for brief periods, if at all. The male brings food to the den during that time (Speller 1972). As the pups grow, the female also hunts, and both parents bring food to the den. The pups may emerge from the den when about 4 weeks old but remain close by. As the summer progresses, the pups gradually enlarge their area of activity and begin to forage for themselves. During this process, the parents gradually decrease their care of the pups, the male usually before the female (Fine 1980). The pups' travels during this period are within the territory established by the adults. The pups disperse, usually in September, completely abandoning the natal territory (Dementyeff 1955). At that time, the adults also leave the natal territory and begin their solitary ranging.

MANAGEMENT

The arctic fox is trapped for its pelt almost throughout its circumpolar range. Fox trapping is a major source of income in remote northern

areas, where the economic base is limited (Bailey and Hendee 1926; Chesemore 1972; Ognev 1931; Peterson 1966). The numbers of foxes taken annually varies primarily with the fox population level and to some extent the trapping effort, which is influenced by the market price for the furs (Geller and Skrobov 1967). When foxes are abundant and pelt prices are high, the trapping effort generally is intense; when the fox population is low, only a few trappers establish trap lines, even though the pelt price may be high. The extensive catch records maintained in Canada by the Hudson's Bay Company formed the basis for analyses of cycling of arctic fox populations in the Canadian arctic (for example, see Chitty and Elton 1937).

In North America, arctic fox populations are not managed in the sense of population or habitat manipulation. In Alaska, trapping and hunting seasons are established, but seasons are uniformly liberal and there are no bag limits. The high reproductive potential of the arctic fox allows rapid recovery of the population when prey are abundant.

In the Soviet Union, actual population management is attempted, as the arctic fox fur industry is a major economic resource (Syroechkovskii and Rugacheva 1961; Uspenskii 1958). A great effort is made to census regional populations, so that trapping effort can be distributed in relation to fox abundance (Geller and Skrobov 1967). Abundance predictions are based on surveys of den sites in summer (Bannikov 1970; Skrobov 1970). From estimates of population size and knowledge of annual movements in northern Siberia, certain areas are selected for heavy trapping. The maximal bag limit is 150 foxes per trapper.

The value of the arctic fox's pelt, particularly of the "blue" color phase, led to the establishment of fur farms in Alaska (Burris and McKnight 1973) and eastern Canada (Peterson 1966). In Alaska, this development was begun in the mid-eighteenth century by Russian fur hunters, who transplanted blue foxes from the Pribilof and Commander Islands to the Aleutian Islands (Buskirk and Gipson 1981). This was continued up to the first half of the twentieth century by American fur farmers (Burris and McKnight 1973). Islands in Prince William Sound, lower Cook Inlet, and southeastern Alaska also were stocked with blue foxes during that period (Ashbrook 1925).

The attraction of arctic foxes to sites of human habitation and work sites, principally by ready availability of garbage and improperly stored foodstuffs, is a current and potentially increasing problem in the petroleum development areas of northern Alaska (Klein 1973; Weeden and Klein 1971; West 1976). Foxes are drawn to garbage dumps for food and are attracted to other areas by odors and their natural curiosity about human presence. The problem is aggravated by the animals being directly fed by construction workers (Klein and Hemming 1976), who view the animals as unique "pets" and interesting subjects for photography. In those close contact situations, the foxes are a threat to the people, principally because of their ability to transmit rabies and alveolar hydatid disease, which are potentially lethal to man and domestic animals. When particular foxes become troublesome or are suspected or confirmed as carriers of rabies, animal control usually is initiated (Klein 1972). This consists of either trapping or shooting in local areas of concern.

Arctic foxes also have been reported to cause damage to wires and cables by chewing on them (Brooks et al. 1971; Urquhart 1973; and Weeden and Klein 1971). Such situations will become more common as development increases in areas inhabited by the arctic fox.

The foxes also use man-made structures for denning and shelter. This has been documented at Prudhoe Bay, and along the trans-Alaska pipeline system (Eberhardt 1977; Fine 1980). The ample shelter and food provided by major developments at Prudhoe Bay and at pipeline camps are suspected to have produced conditions which buffer the normally cyclic fluctuations of the arctic fox population, tending to maintain the populations at a more constant level of abundance,

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