INHERITANCE OF COAT COLOR AND CHANGES IN PELAGE COLORATION IN BLACK BEARS IN NORTHEASTERN MINNESOTA

Black bears (*Ursus americanus*) exhibit several color phases in different portions of their range (Brown, 1894; Cowan, 1938), and in at least two cases individuals were known to have changed pelage color. A captive brown-phase female in Arizona molted into very dark pelage at 2.5 years of age but was killed before her color change could be ascertained as permanent or temporary (Miller, 1955). In the other case, a captive bluish-gray female in New York changed to dark brown before she died at 1.5 years of age (Van Wormer, 1966). Little is known of the frequency with which wild black bears change color or of the genetics of their coat color. Information on these topics would be useful in evaluating evolutionary and environmental factors that influence coat color in black bears. Additionally, information on the extent and frequency of color change is needed it pelage characteristics are to be used for identification of individuals in studies of populations or behavior.

Brown-phase black bears are relatively common in the semiopen areas of the Pacific Northwest (Cowan, 1938) but are rare in most areas east of the Great Plains. No brown phase bears were found among 126 bears captured in Michigan (Rogers et al., 1976), among 209 bears captured in New York (Black, 1958), among over 12,000 bears examined at hunter registration stations in Maine (R. Hugie, pers. comm., 1979), among over 400 bears captured in eastern Tennessee (M. R. Pelton, pers. comm., 1979), among over 300 bears captured in the vicinity of North Bay in southeastern Ontario (G. B. Kolenosky, pers. comm., 1978), among over 1,500 bears examined at hunter check stations in West Virginia (J. Rieffengerger, pers. comm., 1979), or among an unstated number of bears observed in Florida and Louisiana (C. J. Jonkel, in litt., 1967). In Pennsylvania, brown-phase bears comprise less than 1% of the population and are found mainly in the northcentral part of the state (True, 1882; Grove, 1957; Alt, pers. comm., 1979).

In the brushy forests of eastern North America, dark fur could be advantageous if melanin-rich fur has resistance to abrasion as do melanin-rich feathers (Averill, 1923). Conversely, in the more open habitats of the West, black individuals may be more susceptible to heat stress. Jonkel

(in litt., 1967) observed a disproportionately low number of black-phase (as compared with brown-phase) individuals feeding in mountain meadows in midday when potential heat stress was greatest. In swine, black individuals absorb 90% more solar energy than white ones under certain conditions (Kelley et al., 1954). Other possible advantages of brown fur in predominantly open regions where black bears are sympatric with grizzly bears (*Ursus arctos*) or timber wolves (*Canis lupus*) might be camouflage from these predators or mimicry of grizzly bears.

The many shades of brown that occur (Brown, 1894) suggest that several genes control pelage coloration in black bears. Some of those genes may have pleiotropic effects as evidenced by larger litters produced by brown-phase than by black-phase females in northeastern Minnesota (Rogers, 1976).

To obtain information on color change and on inheritance of coat color, pelage color of 322 black bears captured 1 to 33 times in northeastern Minnesota was recorded during 1969-1978. Mother-offspring relationships were determined in March when culls were 2 months of age and still in natal dens. This method precluded any chance that relationships were confounded by adoptions. Coat colors of cubs were re-examined when the cubs denned with their mothers during the following winter. Methods of capturing bears in live traps in summer and in dens in winter were described by Rogers (1977).

No mature brown-phase male was observed in the main study area during the 10 years of intensive trapping and aerial observation, so all sires in that area were assumed to be black. Outside the main study area, however, a large brown-phase male was observed paired with a black-phase female. He was assumed to lie the father of the brown-phase cub she produced the following January because estrus in black bears is short enough in Minnesota (less than 4 days, probably 1-2 days in most cases) that females usually mate with only one male where bears are not aggregated (Rogers, 1977).

Of 285 bears captured in adult pelage (i.e., after the postjuvenile molt, which occurred in early summer at 5 to 7 months of age), 91% (259) were black, 6% (17) were brown, and 3% (3 males, 6 females) were either molting from light brown to very dark pelage or had changed color since an earlier capture. The proportion of brown-phase bears in this sample was higher than in any previously reported sample from east of the Great Plains.

Bears in Minnesota may have been subject to some of the same selective factors that favor the brown phase in open areas of the West. Open areas were more extensive in Minnesota during the warmer, more xeric mid-Holocene (4,000-8,000 B.P.) than they are today (Fries, 1962; Janssen, 1968; Wright, 1968; Wright et al., 1969), and northern Minnesota has a history of frequent and extensive forest fires, which tend to reduce canopy cover (Heinselman, 1973; Swain, 1973).

Color changes of adults observed in this study appeared to be primarily due to bleaching or to differences in the colors between tips and bases of hairs. Fully developed dorsal guard hairs in individuals that changed color were black-tipped or very dark-tipped with light brown bases. By contrast, those of permanently black individuals were black-tipped with very dark gray bases. Guard hairs in permanently brown individuals were entirely brown. In one light brown individual, underfur and bases of guard hairs were nearly white.

Three adult females that changed color were radio-marked bears that were observed frequently during 1971-1976. One had completed her annual adult molt and was growing a new coat of black or very dark brown fur when she was first captured on 30 July 1971; dorsal guard hairs were 4 to 6 cm long. However, she appeared brown 11 months later when her coat was fully grown. At that time, the distal 2 to 4 cm of the dorsal guard hairs were still black to dark brown, but the proximal 5 to 7 cm and the entire underfur were light brown, giving a brown appearance overall. Her new fur, less than 2 cm long, was black. In subsequent years, she appeared brown in dens in January 1974 and March 1975 but appeared black or very dark brown shortly after molting in August 1975 and August 1976 when only the dark tips of her new coat were visible. Two other adult females molted into black or dark brown fur each year but bleached to medium or light brown by the time each coat was shed.

The reason that some adults produce dorsal fur that is easily bleached or that is black only at the tips in unknown. Genetic factors evidently are involved because mothers that changed color produced a significantly ($X^2 = 22$, 1 *d.f.*, $P < 0.0001$) higher proportion of brown-phase cubs than did females that remained black year-round (Table 1). Moreover, the brown offspring of females that changed color remained brown in all cases studied, but 9 of 10 brown cubs from black mothers became black after the postjuvenile molt and remained black year-round. The

TABLE 1.—*Coat colors of adult black bears and their 2-month-old offspring as determined in natal dens in northeastern Minnesota during 1969-1978.*

Coat color of parents	Black cubs (N)	Brown cubs (N)
Black male X black female[1]	85	9[3]
Black male x variable-color female[1]	16	15
Black male x brown female[1]	4	5
Brown male x black female[2]	0	1
Total for mixed color-phase matings	20	21

[1] Sires were assumed to be black because all males observed in the territories of the dams during the 10 years of study were black.
[2] This female lived outside the main study area and was observed paired with a brown male.
[3] All nine brown cubs born to black parents became black after the postjuvenile molt; none was found to revert to brown in later life.

only brown-phase cub that was born to a black mother, and that did not become black after the postjuvenile molt, was born to the only black mother known to have paired with a brown-phase male. All other mothers lived in the main study area where no adult brown-phase male was found during the study. Similarly, in Pennsylvania, Alt (pers. comm., 1979) found that two brown cubs born to black parents became black, or nearly so, by 24 months of age.

Cubs in Minnesota showed marked changes in their chest patches, ear pelage, and eye color in addition to the changes in color of main body pelage. Patches of white fur (in some cases these consisted of only a few white hairs) were found on the chests of 76 of 96 (80%) cubs in juvenile pelage, on 36 of 74 (49%) cubs between first and second molts, and on only 39 of 184 (21%) older bears. Seventy-six percent of culls whose mothers had white chest marks retained their own white chest marks beyond the postjuvenile molt, hut only 40% of cubs of mothers with unmarked chests did so. No cub that lacked a white chest patch in juvenile pelage was known to develop one later.

Prominent patches of light brown fur, present on the ears of all 96 cubs examined, were lost or greatly reduced during the first two molts. Eye color was gray-blue in all cubs at 2 months of age but changed to brown by 1.5 years, with both the age at color change and the final shade of brown differing among individuals. Eyes of most culls turned brown between 6 and 8 months of age, but at least two bears retained gray-blue eyes through 14 months.

In adult males, scrota were gray-brown during late spring and summer when testes were scrotal but showed reduced pigmentation during the denning period when testes were abdomenal.

Support for this research was received from 26 organizations including the Special Projects Foundation of the Big Game Club, the WM Foundation, the National Rifle Association, the Boone and Crockett Club, the McGraw Foundation, the Minnesota State Archery Association, the Wildlife Management Institute, the American Petroleum Institute, the Minnesota Department of Natural Resources, and the Variety Sports Professional Society. Appreciation is expressed to L. D. Mech, L. F. Ohmann, D. M. Rogers, R. M. Shackelford, and two anonymous reviewers for critical reviews of the manuscript.

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