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Urocyon cinereoargenteus.

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Urocyon Baird, 1858

Urocyon Baird, 1858:12. Type species *Canis virginianus* Erxleben (=*Canis virginianus* Schreber). Proposed as subgenus of *Vulpes.*

CONTEXT AND CONTENT. Order Carnivora, Family Canidae, Subfamily Caninae. Two recent species, *Urocyon cinereoargenteus* and *U. littoralis,* are usually recognized; *U. littoralis* is a smaller insular form and may not deserve specific status. Two recent revisions of the family have suggested that *Urocyon* be included in *Vulpes* (Clutton-Brock et al., 1976) or *Canis* (*Vulpes*) (Van Gelder, 1978). We have retained the earlier nomenclature based solely on its persistence and familiarity.

Urocyon cinereoargenteus Schreber, 1775

Gray Fox

Canis cinereo argenteus Schreber, 1775:pl. 92. Type locality eastern North America.

Canis virginianus Schreber, 1775:585. Type locality Carolina and warmer parts of North America.

[*Vulpes*] *Pensylvanicus* Boddaert, 1784:97. Type locality Pennsylvania.

Canis nigrirostris Lichtenstein, 1850:106. Type locality Real Arriba, Estado Mexico.

Urocyon californicus Merriam, 1899:103. Elevated *californicus* Mearns to species status.

Urocyon parvidens Miller, 1899:276. Type locality Mérida, Yucatan.

Urocyon guatemalae Miller, 1899:278. Type locality Nentón, Huehuetenango, Guatemala.

CONTEXT AND CONTENT. Sixteen subspecies are recognized as follows:

U. c. borealis Merriam, 1903:74. Type locality Marlboro, Cheshire Co., New Hampshire.

U. c. californicus Mearns, 1897:459. Type locality Tahquitz Valley, San Jacinto Mts., Riverside Co., California.

U. c. cinereoargenteus Schreber, 1775, see above (*virginianus* Schreber and *pennsylvanicus* Boddaert are synonyms).

U. c. costaricensis Goodwin, 1938:2. Type locality Sabanilla de Pirris, Prov. San José, Costa Rica.

U. c. floridanus Rhoads, 1895:42. Type locality Tarpon Springs, Hillsboro Co., Florida.

U. c. fraterculus Elliot, 1896:80. Type locality San Felipe, Yucatan (*parvidens* Miller a synonym).

U. c. furvus Allen and Barbour, 1923:266. Type locality Balboa, Canal Zone.

U. c. quatemalae Miller, 1899:278, see above.

U. c. madrensis Burt and Hooper, 1941:4. Type locality Carimechi, Rio Mayo, Chihuahua.

U. c. nigrirostris Lichtenstein, 1850, see above.

U. c. ocythous Bangs, 1899:43. Type locality Platteville, Grant Co., Wisconsin.

U. c. orinomus Goldman, 1938:497. Type locality Orizaba, Veracruz.

U. c. peninsularis Huey, 1928:203. Type locality San Ignacio, Baja California.

U. c. scottii Mearns, 1891:236. Type locality Pinal Co., Arizona (*texensis* Mearns and *inyoensis* Elliot are synonyms).

U. c. townsendi Merriam, 1899:103. Type locality Shasta Co., California (*sequoiensis* Dixon a synonym).

U. c. venezuelae Allen, 1911:259. Type locality El Tocuyo, Lara, Venezuela.

DIAGNOSIS. Members of the genus *Urocyon* can be distinguished readily from most other canids by their grizzled upperparts, cinnamon to buff neck and underparts, and black-tipped tail with dorsal median mane of coarse, black-tipped hairs (Fig. 1). The skull (Fig. 2) can be separated from those of other North American canids by conspicuous, widely separated temporal ridges that approach each other posteriorly to produce a lyrate- or U-shaped form (also found in *Otocyon*). The supraorbital crest is slightly downcurved and has a distinct concave depression on the upper surface. The temporals are roughened below the temporal ridges. The dentary has a prominent "step" or notch near the posterior ventral border (also found in *Otocyon* and *Nyctereutes*). *Urocyon cinereoargenteus* is approximately 20% larger in major body dimensions than *U. littoralis.* Grinnell et al. (1937) provided detailed comparisons. The bones of the post-cranial skeleton are more massive in *U. littoralis* and have more accentuated rugosites and muscle scars (Hildebrand, 1954).

GENERAL CHARACTERS. The grizzled appearance of the back and sides of *Urocyon* results from individual guard hairs being banded with white, gray, and black. A predominance of black-tipped hairs near the middle of the back forms a dark longitudinal stripe which extends into a conspicuous black mane of coarse hair on the top of the black-tipped tail. Portions of the neck, sides, and limbs are cinnamon-rufous. White shows on the ears, throat, chest, belly, and hind legs. Black, white, and rufous facial markings are distinctive. Underfur is mostly buff and gray.

External body measurements range as follows: total length, 800 to 1,125 mm; tail length, 275 to 443 mm; hindfoot length, 100 to 150 mm (Hall, 1981). Adult weights range from about 3 to 7 kg; males are slightly larger than females (Grinnell et al., 1937; Jackson, 1961; Sullivan, 1956). Condylobasal length of the skull ranges from 110 to 130 mm (Hall, 1981). Additional body and cranial measurements are presented by Clutton-Brock et al. (1976), Grinnell et al. (1937), Jones (1964), and Paradiso (1969).

DISTRIBUTION. Gray foxes inhabit wooded, brushy, and rocky habitats from extreme southern Canada to northern Venezuela and Colombia, excluding portions of mountainous northwestern United States, the Great Plains, and eastern Central America (Fig. 3). During the last 50 years their range has expanded into areas formerly unoccupied or into areas where the species had been extirpated. Noteworthy regions of range extension include: New England (Godin, 1977; Palmer, 1956), Ontario (Downing, 1946; Peterson et al., 1953), Michigan (Allen, 1940; Ozoga and Verme, 1966), Minnesota (Timm, 1975), Iowa (Bowles, 1975), Manitoba (Sutton, 1958), North Dakota (Schantz, 1950),

FIGURE 1. An adult gray fox (*Urocyon cinereoargenteus*) (photo from Kansas Fish and Game).

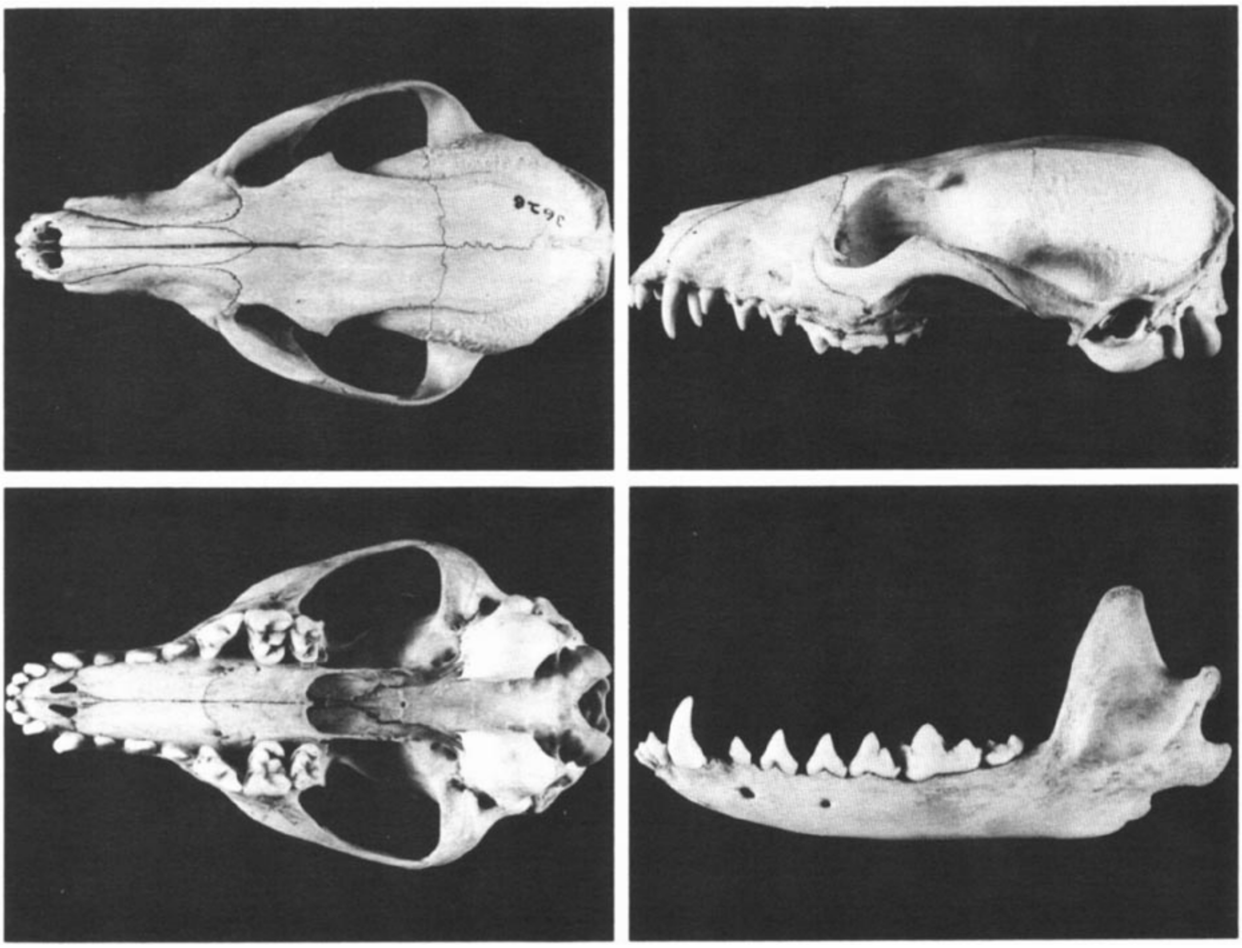

FIGURE 2. Views of skull and mandible of *Urocyon cinereoargenteus* (Univ. Missouri 3628). Greatest length of skull is 121.0 mm.

South Dakota (Jones and Henderson, 1963), Nebraska (Jones, 1964), Kansas (Choate and Krause, 1974), Oklahoma (Halloran and Glass, 1959; Schendel, 1942), and Utah (Durrant et al., 1955). An extralimital record resulted from a specimen trapped near Lake Athabasca, Alberta (Banfield, 1974). Archeological evidence suggested that *U. cinereoargenteus* arrived on Martha's Vineyard, Massachusetts, about 1,500 years ago, but was extirpated when Europeans arrived in the mid-1500's (Waters, 1967).

FOSSIL RECORD. Kurtén and Anderson (1980) summarized the fossil record as follows. The genus *Urocyon* has been present in North America since the Hemphillian land mammal age (Pliocene). The extinct *U. progressus* occurred throughout most of the Blancan age; it is found in Rexroad, Red Light, and possibly Broadwater local faunas. *U. cinereoargenteus* has been found at almost 40 Pleistocene localities, the oldest of which date back to the late Irvingtonian (Cumberland, Conard Fissure, and Coleman IIA local faunas) or possibly the early Irvingtonian (Port Kennedy local fauna). Sangamonian interglacial records include the Cedazo, Haile VIIIA, and Reddick local faunas. During the Wisconsin glaciation the gray fox was widely distributed from California to Florida and reached its northern limit in Pennsylvania. *U. littoralis* evidently reached the Channel Islands off California in the late Pleistocene (Stock, 1943).

FORM AND FUNCTION. Guard hairs range from 50 to 70 mm; hair scales are imbricate with edges acuminate proximally, gradually changing to crenate medially and flattened distally. Light gray underfur is approximately 30 to 40 mm in length; scales are coronal with edges dentate (Adorjan and Kolenosky, 1969); additional descriptions and keys to hair are included in Brown (1942) and Mayer (1952). A single annual molt extends from summer through autumn (Grinnell et al., 1937). Hair slope patterns, arrangement of body hairs and vibrissae, mastology, and tail gland characteristics were described in detail by Hildebrand (1952*a*, 1954). *U. cinereoargenteus* has the largest tail gland of the North American canids, extending one-third to one-half the length of the tail (Hildebrand, 1952*a*; Seton, 1923). Six mammae are usually present.

There are 42 teeth (i 3/3, c 1/1, p 4/4, m 2/3). Dental anomalies have been described (Easterla, 1968; Hall, 1940; Pavlinov, 1975). Body proportions and post-cranial skeleton were described and compared to those of other canids by Hildebrand (1952*b*, 1954). He suggested that *U. cinereoargenteus* is able to rotate the forearm as much or more than any other canid, perhaps as an adaptation for climbing. Skeletal measurements were also reported by Rohde (1966); males were found to have longer pelves, longer and wider scapulae, more massive limb bones, and longer calcanea than females of corresponding age classes. An *os clitoridis* is present (Hildebrand, 1954). Comparative studies of the calcanea (Stains, 1975), brain (Radinsky, 1969, 1973), adrenals (Heinrich, 1972), and ovaries (Mossman and Duke, 1973) include descriptions of these organs in *Urocyon*. Immunological and electrophoretic data relating to canid taxonomy were reported by Seal (1975). Trehalase activity in kidney tissue from a gray fox measured 14 micromoles glucose produced per gram of tissue (Van Handel, 1969).

A dwarf, brachycephalic gray fox was described by Stone et al. (1971).

ONTOGENY AND REPRODUCTION. The breeding season of gray foxes varies geographically. Wood (1958) collected pregnant females in early January but suggested early February as the peak breeding period in southern Georgia; no females were in estrus later than March. Mating dates of gray foxes from New York have been estimated by Layne and McKeon (1956*a*) and Sheldon (1949); breeding activity extended from late January to May and peaked in March. Breeding activity occurs from late January through February in southern Illinois (Layne, 1958) and from late January through March in Wisconsin (Richards and Hine, 1953; Root, 1981). The peak of mating of gray foxes in Alabama is in February (Sullivan, 1956). Where *U. cinereoargenteus* and *Vulpes vulpes* are sympatric, gray foxes breed 2 to 4 weeks later than do red foxes (Layne and McKeon, 1956*a*; Richards and Hine, 1953; Sheldon, 1949). The gestation period of gray foxes is unknown; however, it has been reported to be 63 days (Asdell, 1964; Grinnell et al., 1937) or 53 days, as in *Vulpes vulpes* (Sheldon, 1949; Wood, 1958).

The annual reproductive cycle of males has been described by the use of epididymal smears (Layne, 1958; Root, 1981; Wood, 1958), testicular and epididymal smears (Sullivan, 1956), and histological techniques (Follmann, 1978). In those studies, males were fertile (with abundant spermatozoa in the epididymides) during periods bracketing the respective breeding seasons of females. Therefore, males become fertile earlier and remain fertile longer than females.

The annual reproductive cycle of males in southern Illinois was described by Follmann (1978). Numbers of spermatogonia began increasing in September, peaked in January, and gradually declined until April. Primary spermatocytes were present in the testes throughout the year but in reduced numbers during the summer, suggesting some spermatogenic activity year-round. Spermatids first formed in November, reached peak numbers in January, and declined until March. Spermatozoa were present in the testes from November to April with their peak abundance in March. Epididymides, however, contained spermatozoa from October through June suggesting that full spermatogenesis had begun as early as September; spermatozoa were abundant in the epididymides between December and March.

Most females are sexually mature at 10 months of age. Ten of 54 yearlings examined from Wisconsin were barren (Root, 1981). Of 78 yearlings from Georgia examined by Wood (1958), six did not show signs of sexual maturity. In that study, no difference was detected between the times of breeding of 56 yearlings and 44 older females. Layne (1958), however, suggested that some yearlings may reach puberty too late for successful mating. He collected a barren female in mid-June whose reproductive tract and teats were virginal, but whose ovaries contained well developed corpora lutea.

Level of spermatogenesis during the breeding season is not influenced by age or previous spermatogenic activity (Follmann, 1978). Testes of adult and yearling males had equivalent numbers of spermatogonia, primary spermatocytes, spermatids, and spermatozoa throughout the reproductive cycle. Testes of two juvenile foxes collected in July were similar to those of adults, including the presence of primary spermatocytes, indicating that testicular activity begins about 4 months after birth. Fewer spermatozoa in epididymides of yearling males than in adult males during January and February, however, suggested to Follmann that yearlings began spermatogenesis later than adults or that testes of yearlings reached full activity slower than those of adults.

The synthetic estrogen, diethylstilbestrol (DES), may inhibit or delay ovulation in gray foxes. In a field test, females consuming baits treated with 50 mg of DES and a physiological marker failed to ovulate; but the results, as the authors indicated, were equivocal (Oleyar and McGinnes, 1974).

Mean litter size of gray foxes based on counts of fetuses and placental scars from seven studies ($n = 304$) was 3.8 young per female (Layne, 1958; Layne and McKeon, 1956*a*; Lord 1961*a*; Richards and Hine, 1953; Root, 1981; Sheldon, 1949; Sullivan, 1956). Four fetuses or scars are most common, but 1 to 7 have been recorded. Litter sizes did not vary among foxes 1.5 to 4.5 years old (Root, 1981). Primary sex ratios do not differ significantly from 1:1. Of 102 fetuses examined in three studies, 54 were male and 48 were female (Layne and McKeon, 1956*a*, Sheldon, 1949; Wood, 1958).

Data describing development of gray foxes are meager and often anecdotal (e.g., Taylor, 1943); however, several methods of estimating age have been described. Wood (1958) reported on tooth wear, closure of skull sutures, vomer and baculum development, and weight changes based on 22 individuals of known and 375 of unknown age. He distinguished five distinct age groups by the amount of wear on the conules of M1. The basisphenoid-presphenoid suture closed during month 10 or 11. The vomer was fully developed and continuous with the presphenoid at about 24 months. He found no clear-cut differences in baculum weights of juveniles and adults, contrary to Petrides (1950). The changes in weight (g) of juvenile gray foxes were as follows: at birth, 86; 11 days, 129; 19 days, 169; 23 days, 234; 30 days, 249; 51 days, 588; 78 days, 1,200; 90 days, 1,500; 120 days, 2,000; 150 days, 2,500; 180 days, 3,400; 210 days, 3,700 ("adult-sized"). When using eye lens weights to distinguish between adult and juvenile foxes, Lord (1961*b*) found 90% agreement with Wood's methods. Distal epiphyses of the radius and ulna ossified between 8 and 9 months of age (Sullivan and Haugen, 1956). Sequences of eruption of cheekteeth were described by Slaughter et al. (1974).

FIGURE 3. The geographic range of the gray fox (*Urocyon cinereoargenteus*). Modified from Hall (1981) and Hershkovitz (1953).

Cementum annuli counts, amounts of tooth wear, and eye lens weights were compared among 211 gray foxes from Alabama and Georgia (Nicholson and Hill, 1981). In that study, three observers independently estimated age from annuli and tooth wear categories. Ages assigned by tooth wear were highly variable among observers; counts of cementum annuli were believed to be the most accurate aging method; but eye lens weights separated most juveniles and adults. Root (1981) reported a subjective aging method based on the examination of roots of upper canines, apical foramina, widths of pulp cavities, and cementum annuli.

ECOLOGY. No carnivore in eastern North America is more closely associated with the deciduous forest than the gray fox (Hall, 1981). In Wisconsin, gray foxes were most abundant near brush covered bluffs where woodland and farmland were well interspersed (Petersen et al., 1977; Richards and Hine, 1953). Likewise, woodland/farmland edge provided the best gray fox habitat in southern Georgia (Wood et al., 1958), Virginia (Carey et al., 1978), and the post oak woodlands of Texas (Wood, 1952). In western North America, gray foxes favored brushy vegetation in association with rugged, broken terrain (Grinnell et al., 1937; Hardy, 1945; Johnson et al., 1948; Leopold, 1959; Nelson, 1930). Gray foxes in California are most abundant at elevations of 1,150 to 1,525 m (Grinnell et al., 1937; Johnson et al., 1948).

Several studies using radio-telemetry provided detailed information on habitat use by gray foxes. Follmann (1973), in southern Illinois, and Trapp (1978), in southwest Utah, found that early old fields were used more than expected relative to habitat availability, agricultural and brushy habitats were used less than expected, and woodlands were used in proportion to that expected. Gray foxes in California selected against agricultural habitats and in favor of woodlands when present within their home range; otherwise old fields were used more than expected (Fuller, 1978). Seasonally, old fields were used most during summer or fall when fruits and insects were abundant (Follmann, 1973; Yearsley and Samuel, 1980). Gray foxes used woodlands more during the day than at night throughout the year (Follmann, 1973; Yearsley and Samuel, 1980).

Gray foxes use dens at any time of the year, but most use occurs during the whelping season. Dens are usually located in brushy or wooded habitats and are less conspicuous than dens of *Vulpes vulpes* (Failor, 1969; Layne and McKeon, 1956*b*; Nichelson and Hill, 1981; Sullivan, 1956). In Wisconsin, most dens of gray foxes were situated on east, southeast, or south-facing slopes (Richards and Hine, 1953). Hollow logs or trees, rock outcrops, underground burrows, cavities under rocks, abandoned buildings, piles of wood, sawdust, or brush serve as suitable den sites for gray foxes. Most underground dens are probably abandoned dens of other animals (Schmeltz and Whitaker, 1977), which do not require an extensive amount of excavation by foxes (Sullivan, 1956). Grinnell et al. (1937) described a whelping den 7.6 m above the ground in a hollow tree. Diurnal retreats of gray foxes in southwest Utah were usually above ground in the shade of boulders, trees, or cliffs (Trapp, 1978). In California and east-central Alabama, daytime resting sites were located in areas of dense vegetation (Hallberg and Trapp, in press; Nichelson and Hill, 1981). No difference was observed in the habitats of summer and winter daytime resting areas (Nichelson and Hill, 1981).

As determined by radio-telemetry, average home-range size varies according to sex and geographic location as follows: 97 ha for males (n = 3) and 75 ha for a female in West Virginia (Yearsley and Samuel, 1980); 136 ha for males (n = 2) and 107 ha for females (n = 4) in southern Illinois (Follmann, 1973); 653 ha for males (n = 5) and 626 ha for females (n = 15) in eastcentral Alabama (Nichelson and Hill, 1981); 102 ha for males (n = 4) and 113 ha for females (n = 4) in southwest Utah (Trapp, 1978); 129 ha for males (n = 2) and females (n = 2) (Hallberg and Trapp, 1982) and 122 ha for females (n = 4) in California (Fuller, 1978). Home range size increases for both sexes in late fall and winter; during the whelping period it decreases for females but peaks for males (Follmann, 1973; Nichelson and Hill, 1981). Home ranges are typically elongate (Follmann, 1973; Montague, 1975; Trapp, 1978). Home-range diameters estimated without the aid of radio-telemetry varied from 0.4 to 3.2 km (Lord, 1961*a*; Richards and Hine, 1953).

Juvenile gray foxes have dispersed as far as 84 km from their natal area (Sheldon, 1953). Of nine juveniles (three males, six females) radio-marked in eastcentral Alabama, only the males dispersed. Females made exploratory movements as far as 3 km from their natal area but always returned (Nichelson and Hill, 1981). In contrast, Follmann (1973) radio-tagged five subadult gray foxes (two males, three females) which exhibited no long range dispersal.

Based on the age ratios of gray fox populations trapped during two consecutive years in northern Florida, Lord (1961*a*) estimated that 43 to 47% of the foxes born died in their first 7 months, and that 61 to 64% of the adults died annually. In southern Georgia, annual mortality rates were 50% for a juvenile's first summer, 90% for the first winter, and 50% for adults (Wood, 1958). Michod and Anderson (1980) estimated rate of increase and age specific longevities for the same Georgia fox population using Wood's (1958) data. In a sample of 435 gray foxes collected in Georgia, 89.4% were less than 2 years old (Wood, 1958). During fall and winter, 58% of 43 females trapped in Ohio and 52% of 54 females trapped in Illinois were juveniles (Layne, 1958; Petrides, 1950). Yearlings constituted 80% of the 107 foxes trapped in Virginia from May through August (Carey et al., 1978). Nevertheless, a few gray foxes may reach 14 to 15 years of age in the wild (Seton, 1929).

The adult sex ratio does not usually vary significantly from 50:50 (Carey et al., 1978; Layne, 1958; Petrides, 1950; Richards and Hine, 1953; Root, 1981; Wood, 1958). One exception was reported in New York, where 59% of 1,132 adults trapped were male (Layne and McKeon, 1956*a*).

Estimated densities of gray foxes vary from 1.2 to 2.1 per km^2, depending on location, season, and method of estimation (Errington, 1933; Gier, 1948; Lord, 1961*a*; Trapp, 1978). Grinnell et al. (1937) reported 15 gray foxes being trapped within a 260 ha area during the last half of February (mating season) in California. Based on bounty data, Richmond (1952) found that the gray fox population in Pennsylvania was highest during years in which January, February, and March were wetter and warmer than average and lowest during years when the same months were colder and drier than normal.

Dyson (1965) maintained captive gray foxes on diets of natural and prepared foods equalling 3.8% of their body weight (daily feedings are assumed but not specified). Specific foods consumed in the wild vary among locations and seasons. Mammals compose the greatest portion of winter gray fox diets in the eastern and central U.S. Rabbits (*Sylvilagus*) are the principal prey but rodents (especially *Microtus, Peromyscus, Neotoma,* and *Sigmodon*) are also important, as determined by studies of food habits in Florida, Georgia, and South Carolina (Wood et al., 1958), Iowa (Scott, 1955), Massachusetts (MacGregor, 1942), Minnesota (Hatfield, 1939), Missouri (Korschgen, 1957), eastern Texas (Wood, 1954), Virginia (Nelson 1933), West Virginia (Glover, 1949), and Wisconsin (Errington, 1935). Although mammalian prey is important in the diet throughout the remainder of the year in these regions, invertebrates (particularly orthopterans) often predominate during summer (Korschgen, 1957; Wood et al., 1958) or autumn (Kozicky, 1943). Plant foods, especially persimmon (*Diospyros virginiana*), grapes (*Vitis*), apples (*Malus*), and corn (*Zea mays*), also increase in importance during autumn (Korschgen, 1957; Llewellyn and Uhler, 1952) and may form 70% of the diet by volume (Pils and Klimstra, 1975). Other foods less commonly eaten by gray foxes throughout the eastern and central U.S. include birds (including poultry), squirrels (*Sciurus*), opossum (*Didelphis virginianus*), and deer (*Odocoileus*) carrion. However, McKinnerney (1978) noted that gray foxes in the Chihuahan Desert only scavenged on fresh (1- or 2-day-old) carrion. In southwest Utah, fruits were the most important food, followed by mammals (mainly *Odocoileus, Thomomys, Peromyscus,* and *Neotoma*) and arthropods, primarily orthopterans and coleopterans (Trapp, 1978). Seasonally, arthropods dominated the summer diet and fruits dominated the fall and winter diets, with *Opuntia* fruits being most important in the fall and *Juniperus* in the winter and early spring. Juniper berries were also the most frequently eaten food during spring and summer in Arizona (Small, 1971). Mammalian prey formed the largest portion of the diets of gray foxes in California (Fitch, 1948; Grinnell et al., 1937).

Gray foxes host at least 15 species of fleas, 2 species of lice, 9 species of ticks, 2 species of chiggers, and 7 species of mites (Coultrip et al., 1973; Eads and Menzies, 1950; Whitaker and Goff, 1979; Wilson and Baker, 1972). Unlike the red fox, gray foxes are highly resistant to infestation by sarcoptic mange mites (*Sarcoptes scabiei*); two of five adults became only mildly infested and quickly recovered when experimentally contaminated with "thousands" of mange mites, whereas red foxes subjected to similar treatment died as a result (Stone et al., 1972). Gray foxes also host at least 5 species of trematodes, 8 species of cestodes, 17 species of nematodes, and 2 species of acanthocephalans (Buechner, 1944; Chandler and Melvin, 1951; Erickson, 1944; Miller and Harkema, 1968). Diseases known to infect gray foxes include rabies, canine distemper, St. Louis encephalitis, tularemia, listeriosis, leptospirosis, histoplasmosis, toxoplasmosis, Q fever, and Tyzzer's disease (Davis et al., 1970; Emmons and Lennette, 1967; Enright et al., 1971; Marchiondo et al., 1976; Stanley et al., 1978).

Gray foxes have been examined for the accumulation of mercury in their hair (Cumbie and Jenkins, 1975) and for the effects of exposure to acute gamma radiation (Golley et al., 1965), tear gas (Andrews, 1964), and vertebrate pesticides (Bell and Dimmick, 1975; Wade, 1977).

After analyzing Pennsylvania bounty records, Latham (1952) thought that population levels of foxes (both red and gray) were inversely related to population levels of weasels (*Mustela* spp.), and suggested that foxes were capable of reducing weasel populations. The weasel population on a Virginia turkey farm erupted after gray foxes were trapped out, but levels of skunks (*Mephitis mephitis*), opossums, and raccoons (*Procyon lotor*) remained unchanged. The weasel population later dropped as the foxes became reestablished (Hensley and Fisher, 1975). Sympatric ringtails (*Bassariscus astutus*) and gray foxes in southwest Utah differed in habitat use patterns and food habits (Trapp, 1978). In southern Illinois, Follmann (1973) found greater overlap in home ranges between red and gray foxes than overlap in home ranges within either species. He believed that as farmland reverted through the secondary successional stages, gray foxes would gradually replace red foxes. In New York, Saggese and Tullar (1974) reported possible predation by a gray fox on a red fox pup. Dudley (1976) described an agonistic encounter between a bobcat (*Lynx rufus*) and two gray foxes in New Mexico.

Undoubtedly the most important predator of the gray fox is man. The total fur harvest of gray foxes in the U.S. increased from 26,109 animals during the 1970–71 season to 163,458 animals during the 1975–76 season, which paralleled a five-fold increase in average pelt price over the same period (Deems and Pursley, 1978). Petersen et al. (1977) estimated that nearly half of the gray fox population present on 1 October in Wisconsin was harvested annually. Other predators of gray foxes include golden eagles (*Aquila chrysaetos*) (Grinnell et al., 1937; Mollhagen et al.,

1972) and possibly coyotes (*Canis latrans*) and bobcats (Gander, 1966; Grinnell et al., 1937). Local populations of gray foxes may also be reduced by diseases, especially canine distemper (Nichelson and Hill, 1981) and rabies (Trapp and Hallberg, 1975). Weaver (1939) described a gray fox that starved as the result of an encounter with a porcupine (*Erethizon dorsatum*).

BEHAVIOR. Gray foxes are primarily nocturnal or crepuscular (Follmann, 1973; Grinnell et al., 1937; Hallberg and Trapp, in press; Kavanau and Ramos, 1975; Montague, 1975; Nichelson and Hill, 1981; Seton, 1929; Taylor, 1943; Trapp, 1978; Yearsley and Samuel, 1980), although local shifts in diurnal resting places are common (Hallberg and Trapp, in press; Trapp, 1978). In West Virginia and California, gray foxes were more active at night than during the day, as determined by radio-telemetry (Hallberg and Trapp, in press; Yearsley and Samuel, 1980). Likewise, in southern Illinois and California, gray foxes traveled greater distances per hour at night than during the day (Follmann, 1973; Hallberg and Trapp, in press). The average distance between a diurnal rest area and each individual nocturnal radio location of gray foxes in southwest Utah was 525 m (Trapp, 1978). Young gray foxes given instrumental control over the ambient light level in the laboratory preferred bright light after about 4 weeks of age (Kavanau et al., 1972; Kavanau et al., 1973). Adults showed a sharp drop in activity indices when illuminence dropped below 0.1 lux (50% of full moon), suggesting that their vision may be limited in dim light (Kavanau and Ramos, 1975).

Indirect observations of social organization of gray foxes, derived from radio-telemetry and relative trap success, suggest that family units, comprising an adult male and female and possibly juveniles, maintain spatially or temporally separate home ranges (Follmann, 1973; Lord, 1961*a*; Trapp, 1978). However, Hallberg and Trapp (in press) described the home ranges of four gray foxes (two males, two females) that occupied the same area during spring and summer.

Gray foxes are assumed to be monogamous, but conclusive evidence is lacking. Nichelson and Hill (1981) radio-tracked two mated pairs during parts of the breeding and denning seasons. They found that males foraged separately from females at night and usually returned to the den at daylight, but did not make repeated trips to the den as did the females. By 3 months of age, young accompany female parents away from the den and by 4 months of age, they begin to forage independently (Nichelson and Hill, 1981; Wood, 1958).

Fox (1969*a*, 1969*b*, 1970, 1971) compared the ontogeny of various behavior patterns between selected species of Canidae raised in captivity. Gray foxes were judged to be more social than red or arctic (*Alopex lagopus*) foxes because only they exhibited allogrooming; however, gray foxes had the least obvious facial expressions (Fox, 1970). Young gray foxes (5 to 8 weeks) frequently raised a hind leg and presented their genitalia to a conspecific in an apparent submissive or appeasement gesture (Fox, 1971; Taylor, 1943). Aggressive or playful attacks between gray foxes were directed at the cheek, where the fur is accentuated by white hair and the skin is especially thick (Fox, 1969*a*). Prey-killing patterns were present early in the life of gray foxes; subsequent development of play behavior suggested that play did not contribute to the organization of prey-killing patterns (Fox, 1969*b*).

Urine and feces apparently play a role in gray fox communication, as evidenced by deposition in conspicuous locations, such as on bare ground, on logs, rocks, and other elevated sites, or along trails (Grinnell et al., 1937; Richards and Hine, 1953; Trapp, 1978). Scats are often deposited in groups: 72% of 240 scats found in southwest Utah occurred singly and 17% occurred in groups of 2 to 8 (Trapp, 1978). Tembrock (1963) reported the principal sound frequencies of the bark of gray foxes.

Gray foxes are well known for their tree-climbing behavior. They have been observed climbing vertical, branchless tree trunks to heights of 18 m by grasping the trunk with their forefeet and pushing with their hindfeet (Bailey, 1941; Leopold, 1959; Seton, 1929; Taylor, 1943; Terres, 1939). Climbing is also accomplished by jumping from branch to branch (Grinnell et al., 1937; Seton, 1929). Trees are climbed for purposes of foraging (Grinnell et al., 1937; Gunderson, 1961), resting (Leopold, 1959; Seton, 1929; Yeager, 1938), or escape (Carr, 1945; Terres, 1939). Descent may be accomplished by backing down a vertical tree (Seton, 1929) or running headfirst down a sloping tree (Nelson, 1930; Yeager, 1938). Gray foxes in the forested eastern regions of Mexico have sharper and more recurved claws than conspecifics in more arid western regions (Goldman, 1938).

Turkowski (1971) observed an adult gray fox attempting to decoy human intruders away from a whelping den by feigning an injured leg.

GENETICS. Wurster and Benirschke (1968) described the karotype of a female to which most authors (Chiarelli, 1975; Matthey, 1973, Pizzimenti, 1971) subsequently refer. The gray fox has a diploid chromosome number of 66 with a fundamental number of 70. The autosomes include one pair of medium-size metacentrics and 31 pairs of size-graded acro- or subacrocentrics, two of which possess achromatic regions in the long arm next to the centromere. The X chromosome is the largest element and is submetacentric. The Y chromosome is the smallest element and is metacentric (Hsu and Benirschke, 1970).

An albinistic gray fox was described from New York (Shipherd and Stone, 1974). "Samson" gray foxes lacking guard hairs have been described (Grinnell et al., 1937; Root, 1981). A single report of a *Urocyon* × *Vulpes* hybrid was based solely on the description of a pelt bought by an Ohio fur dealer (Bezdek, 1944).

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LITERATURE CITED

Adorjan, A. S., and G. B. Kolenosky. 1969. A manual for the identification of hairs of selected Ontario mammals. Res. Rep. (Wildl.), Ontario Ministry Nat. Res., 90:1–64.

Allen, D. L. 1940. Two recent mammal records from Allegan County, Michigan. J. Mamm., 21:459–460.

Allen, G. M., and T. Barbour. 1923. Mammals from Darien. Bull. Mus. Comp. Zool., 65:259–274.

Allen, J. A. 1911. Mammals from Venezuela collected by Mr. M. A. Carriker, Jr., 1909–1911. Bull. Amer. Mus. Nat. Hist., 30:239–273.

Andrews, R. D. 1964. Effects of tear gas on some mammals. J. Mamm., 45:321.

Asdell, S. A. 1964. Patterns of mammalian reproduction. Second ed. Cornell Univ. Press, Ithaca, New York, 670 pp.

Bailey, V. 1941. Gray foxes—all Americans. Nat. Mag., 34: 493–495, 528.

Baird, S. F. "1857" [1858]. Mammals. *In* Reports of explorations and surveys for a railroad route from the Mississippi River to the Pacific Ocean. Washington, DC, 8:1–757.

Banfield, A. W. F. 1974. Mammals of Canada. Univ. Toronto Press, Toronto, 438 pp.

Bangs, O. 1899. A new gray fox from the upper Missouri valley. Proc. New England Zool. Club, 1:43–44.

Bell, H. B., and R. W. Dimmick. 1975. Hazards to predators feeding on prairie voles killed with zinc phosphide. J. Wildl. Mgmt., 39:816–819.

Bezdek, H. 1944. A red-grey fox hybrid. J. Mamm., 25:90.

Boddaert, P. O. 1784. Elenchus animalium. C. R. Hake, Rotterdam, 174 pp.

Bowles, J. B. 1975. Distribution and biogeography of mammals of Iowa. Spec. Publ. Mus., Texas Tech. Univ., 9:1–184.

Brown, F. M. 1942. The microscopy of mammalian hairs for anthropologists. Proc. Amer. Phil. Soc., 85:250–274.

Buechner, H. K. 1944. Helminth parasites of the gray fox. J. Mamm., 25:185–188.

Burt, W. H., and E. T. Hooper. 1941. Notes on mammals from Sonora and Chihuahua, Mexico. Occas. Pap. Mus. Zool., Univ. Michigan, 430:1–7.

Carey, A. B., R. H. Giles, Jr., and R. G. McLean. 1978. The landscape epidemiology of rabies in Virginia. Amer. J. Trop. Med. Hyg., 27:573–580.

Carr, W. H. 1945. Gray fox adventures. Nat. Hist., 54:4–8.

Chandler, A. C., and D. M. Melvin. 1951. A new cestode, *Oochoristica pennsylvanica*, and some new or rare helminth host records from Pennsylvania mammals. J. Parasitol., 37: 106–109.

Chiarelli, A. B. 1975. The chromosomes of the Canidae. Pp. 40–53, *in* The wild canids; their systematics, behavioral ecology, and evolution (M. W. Fox, ed.). Van Nostrand-Reinhold Co., New York, 508 pp.

Choate, J. R., and J. E. Krause. 1974. Historical biogeography of the gray fox (*Urocyon cinereoargenteus*) in Kansas. Trans. Kansas Acad. Sci., 177:231–235.

Clutton-Brock, J., G. B. Corbert, and M. Hills. 1976. A review of the family Canidae, with a classification by numerical methods. Bull. British Mus. Nat. Hist., Zool., 29:117–199.

Coultrip, R. L., et al. 1973. Survey for the arthropod vectors and mammalian hosts of Rocky Mountain spotted fever and plague at Fort Ord, California. J. Med. Entomol., 10:303–309.

Cumbie, P. M., and J. H. Jenkins. 1975. Mercury accumulation in native mammals of the southeast. Southeastern Assoc. Game and Fish Comm. Ann. Conf. Proc., 28:639–648.

Davis, J. W., L. H. Karstad, and D. O. Trainer (eds.). 1970. Infectious diseases of wild mammals. Iowa State Univ. Press, Ames, 421 pp.

Deems, E. F., Jr., and D. Pursley (eds.). 1978. North American furbearers. Internat. Assoc. Fish and Wildl. Agencies, 157 pp.

Downing, S. C. 1946. The history of the gray fox in Ontario. Canadian Field-Nat., 60:45–46.

Dudley, D. 1976. Agonistic encounter between a bobcat and two gray foxes. Southwestern Nat., 21:413.

Durrant, S. D., M. R. Lee, and R. M. Hansen. 1955. Additional records and extensions of known range of mammals from Utah. Univ. Kansas Publ., Mus. Nat. Hist., 9:69–80.

Dyson, R. F. 1965. Experimental diet for gray foxes, *Urocyon cinereoargenteus*. Internatl. Zoo Yearb., 5:145.

Eads, R. B., and G. C. Menzies. 1950. Fox ecto-parasites collected incidental to a rabies control program. J. Mamm., 31: 78–80.

Easterla, D. A. 1968. Abnormal dentition of a gray fox. Southwestern Nat., 13:362–363.

Elliot, D. G. 1896. On sundry collections of mammals received by the Field Columbian Museum. Field Columbian Mus., Publ. 11, Zool. Ser., 1:67–81.

Emmons, R. W., and E. H. Lennette. 1967. Isolation of St. Louis encephalitis virus from a naturally-infected gray fox, *Urocyon cinereoargenteus*. Proc. Soc. Exp. Biol. Med., 125: 443–447.

Enright, J. B., et al. 1971. *Coxiella burneti* in a wildlife-livestock environment: distribution of Q-fever in wild mammals. Amer. J. Epidemiol., 94:79–90.

Erickson, A. B. 1944. Helminths of Minnesota Canidae in relation to food habits, and a host list and key to the species reported from North America. Amer. Midland Nat., 32:358–372.

Errington, P. L. 1933. Bobwhite winter survival in an area heavily populated with gray foxes. Iowa State Coll. J. Sci., 8:127–130.

— 1935. Food habits of mid-west foxes. J. Mamm., 16:192–200.

Failor, P. L. 1969. Calling the gray fox. Pennsylvania Game News, 40:15–19.

Fitch, H. S. 1948. Ecology of the California ground squirrel on grazing lands. Amer. Midland Nat., 39:513–596.

Follmann, E. H. 1973. Comparative ecology and behavior of red and gray foxes. Unpubl. Ph.D. dissert., Southern Illinois Univ., Carbondale, 152 pp.

— 1978. Annual reproductive cycle of the male gray fox. Trans. Illinois State Acad. Sci., 71:304–311.

Fox, M. W. 1969*a*. The anatomy of aggression and its ritualization in Canidae: a development and comparative study. Behaviour, 35:242–258.

— 1969*b*. Ontogeny of prey-killing behavior in Canidae. Behaviour, 35:259–272.

— 1970. A comparative study of the development of facial expressions in canids; wolf, coyote and foxes. Behaviour, 36: 49–73.

— 1971. Socio-infantile and socio-sexual signals in canids: a comparative and ontogenic study. Z. Tierpsychol., 28:185–210.

Fuller, T. K. 1978. Variable home-range sizes of female gray foxes. J. Mamm., 59:446–449.

Gander, F. F. 1966. Friendly foxes. Pacific Discovery, 19:28–31.

Gier, H. T. 1948. Rabies in the wild. J. Wildl. Mgmt., 12:142–153.

Glover, F. A. 1949. Fox foods on West Virginia wild turkey range. J. Mamm., 30:78–79.

Godin, A. J. 1977. Wild mammals of New England. Johns Hopkins Univ. Press, Baltimore, 304 pp.

Goldman, E. A. 1938. List of the gray foxes of Mexico. J. Washington Acad. Sci., 28:494–498.

Golley, F. B., E. L. Rauber, E. L. Morgan, and J. H. Jenkins. 1965. Effect of acute gamma radiation of wild opossum, gray fox, raccoon and bobcat. Health Physics, 11:1573–1576.

Goodwin, G. G. 1938. Four new mammals from Costa Rica. Amer. Mus. Novitates, 987:1–5.

Grinnell, J., J. Dixon, and J. M. Linsdale. 1937. Fur-bearing mammals of California. Univ. California Press, Berkeley, 2: 377–777.

Gunderson, H. L. 1961. A self-trapped gray fox. J. Mamm., 42:270.

Hall, E. R. 1940. Supernumerary and missing teeth in wild mammals of the orders Insectivora and Carnivora, with some notes on diseases. J. Dental Res., 19:103–142.

— 1981. The mammals of North America. John Wiley and Sons, New York, 2:601–1181 + *90*.

Hallberg, D. L., and G. R. Trapp. In press. Gray fox (*Urocyon cinereoargenteus*) temporal and spatial activity in a riparian-agricultural habitat in California's Central Valley. California Riparian Systems Conf. (R. Warner, ed.). Univ. California, Davis.

Halloran, A. F., and B. P. Glass. 1959. The carnivores and ungulates of the Wichita Mountains Wildlife Refuge, Oklahoma. J. Mamm., 40:360–370.

Hardy, R. 1945. The influence of types of soil upon the local distribution of some mammals in southwestern Utah. Ecol. Monogr., 15:71–108.

Hatfield, D. M. 1939. Winter food habits of foxes in Minnesota. J. Mamm., 20:202–206.

Heinrich, D. 1972. Vergleichende Untersuchungen an Nebennieren einiger Arten der Familie Canidae Gray 1821. Z. Wiss. Zool., 185:22–192.

Hensley, M. S., and J. E. Fisher. 1975. Effects of intensive gray fox control on population dynamics of rodents and sympatric carnivors. Southeastern Assoc. Game and Fish Comm. Ann. Conf. Proc., 29:694–705.

Hershkovitz, P. 1953. A synopsis of the wild dogs of Colombia. Novedades Colombianas, 3:157–161.

Hildebrand, M. 1952*a*. The integument in Canidae. J. Mamm., 33:419–428.

— 1952*b*. An analysis of body proportions in the Canidae. Amer. J. Anat., 90:217–256.

— 1954. Comparative morphology of the body skeleton in recent Canidae. Univ. California Publ. Zool., 52:399–470.

Hsu, T. C., and K. Benirschke. 1970. *Urocyon cinereoargenteus* (gray fox), an atlas of mammalian chromosomes. Springer-Verlag, New York, 4(Folio 180):1–2.

Huey, L. M. 1928. A new fox from the cape region of lower California, Mexico. Trans. San Diego Soc. Nat. Hist., 5:203–210.

Jackson, H. H. T. 1961. Mammals of Wisconsin. Univ. Wisconsin Press, Madison, 504 pp.

Johnson, D. H., M. D. Bryant, and H. H. Miller. 1948. Vertebrate animals of the Providence Mountains area of California. Univ. California Publ. Zool., 48:221–375.

Jones, J. K., Jr. 1964. Distribution and taxonomy of mammals of Nebraska. Univ. Kansas Publ., Mus. Nat. Hist., 16:1–356.

Jones, J. K., Jr., and F. R. Henderson. 1963. Noteworthy records of foxes from South Dakota. J. Mamm., 44:283.

Kavanau, J. L., and J. Ramos. 1975. Influences of light on activity and phasing of carnivores. Amer. Nat., 109:391–418.

Kavanau, J. L., J. Ramos, and F. M. Havenhill. 1973. Compulsory regime and control of environment in animal behavior. II. Light level preferences of carnivores. Behaviour, 46:279–299.

Kavanau, J. L., J. Ramos, and C. R. Peters. 1972. Light preferences of young foxes, *Urocyon cinereoargenteus*. Z. Tierpsychol., 31:404–409.

Korschgen, L. J. 1957. Food habits of coyotes, foxes, house cats and bobcats in Missouri. Missouri Conserv. Comm. P-R Ser., 15:1–64.

Kozicky, E. L. 1943. Food habits of foxes in wild turkey territories. Pennsylvania Game News, 14:8–9, 28.

Kurtén, B., and E. Anderson. 1980. Pleistocene mammals of North America. Columbia Univ. Press, New York, 442 pp.

Latham, R. M. 1952. The fox as a factor in the control of weasel populations. J. Wildl. Mgmt., 16:516–517.

Layne, J. N. 1958. Reproductive characteristics of the gray fox in southern Illinois. J. Wildl. Mgmt., 22:157–163.

Layne, J. N., and W. H. McKeon. 1956*a*. Some aspects of red fox and gray fox reproduction in New York. New York Fish and Game J., 3:44–74.

— 1956*b*. Notes on red fox and gray fox den sites in New York. New York Fish and Game J., 3:248–249.

Leopold, A. S. 1959. Wildlife of Mexico; the game birds and mammals. Univ. California Press, Berkeley, 568 pp.

Lichtenstein, K. M. H. 1850. Erläuterungen der nachrichten des Franc. Hernandez von den vierfüssigen Thieren Neuspaniens. Abh. K. Akad. Wiss. Berlin, 1827:89–129.

Llewellyn, L. M., and F. M. Uhler. 1952. The foods of fur animals of the Patuxent Research Refuge, Maryland. Amer. Midland Nat., 48:193–203.

Lord, R. D. 1961*a*. A population study of the gray fox. Amer. Midland Nat., 66:87–109.

— 1961*b*. The lens as an indicator of age in the gray fox. J. Mamm., 42:109–111.

MacGregor, A. E. 1942. Late fall and winter foods of foxes in central Massachusetts. J. Wildl. Mgmt., 6:221–224.

Marchiondo, A. A., D. W. Duszynski, and G. O. Maupin. 1976. Prevalence of antibodies to *Toxoplasma gondii* in wild and domestic animals of New Mexico, Arizona, and Colorado. J. Wildl. Dis., 12:226–232.

Matthey, R. 1973. The chromosome formulae of eutherian mammals. Pp. 531–616, *in* Cytotaxonomy and vertebrate evolution (A. B. Chiarelli and E. Capanna, eds.). Academic Press, New York, 783 pp.

Mayer, W. V. 1952. The hair of California mammals with keys to the dorsal guard hairs of California mammals. Amer. Midland Nat., 48:480–512.

McKinnerney, M. 1978. Carrion communities in the northern Chihuahuan Desert. Southwestern Nat., 23:563–576.

Mearns, E. A. 1891. Description of a new species of weasel, and a new subspecies of gray fox from Arizona. Bull. Amer. Mus. Nat. Hist., 3:234–238.

— 1897. Preliminary diagnoses of new mammals of the genera *Lynx*, *Urocyon*, *Spilogale* and *Mephitis*, from the Mexican boundary line. Proc. U.S. Natl. Mus., 20:457–461.

Merriam, C. H. 1899. Results of a biological survey of Mount Shasta, California. N. Amer. Fauna, 16:1–179.

— 1903. Eight new mammals from the United States. Proc. Biol. Soc. Washington, 16:73–77.

Michod, R. E., and W. W. Anderson. 1980. On calculating demographic parameters from age frequency data. Ecology, 61:265–269.

Miller, G. C., and R. Harkema. 1968. Helminths of some wild mammals in the southeastern United States. Proc. Helminthol. Soc. Washington, 35:119–125.

Miller, G. S., Jr. 1899. Descriptions of two new gray foxes. Proc. Acad. Nat. Sci. Philadelphia, 51:276–280.

Mollhagen, T. R., R. W. Wiley, and R. L. Packard. 1972. Prey remains in golden eagle nests: Texas and New Mexico. J. Wildl. Mgmt., 36:784–792.

Montague, F. H., Jr. 1975. The ecology and recreational value of the red fox in Indiana. Unpubl. Ph.D. dissert., Purdue Univ., 285 pp.

Mossman, H. W., and K. L. Duke. 1973. Comparative morphology of the mammalian ovary. Univ. Wisconsin Press, Madison, 461 pp.

Nelson, A. L. 1933. A preliminary report on the winter food of Virginia foxes. J. Mamm., 14:40–43.

Nelson, E. W. 1930. Wild animals of North America. Natl. Geogr. Soc., Washington, DC, 254 pp.

Nichelson [sic], W. S., and E. P. Hill. 1981. An ecological study of the gray fox in eastcentral Alabama. Coop. Wildl. Proj. Final Rep., Proj. No. W-44-5, 47 pp.

Nicholson, W. S., and E. P. Hill. 1981. A comparison of tooth wear, lens weights, and cementum annuli as indices of age in the gray fox. Pp. 355–367, *in* Proc. Worldwide Furbearer Conf. Inc., 2056 pp.

Oleyar, C. M., and B. S. McGinnes. 1974. Field evaluation of diethylstilbestrol for suppressing reproduction in foxes. J. Wildl. Mgmt., 38:101–106.

Ozoga, J. J., and L. J. Verme. 1966. Noteworthy locality records for some upper Michigan mammals. Jack-pine Warbler, 44:52.

Palmer, R. S. 1956. Gray fox in the northeast. Maine Field Nat., 12:62–70.

Paradiso, J. L. 1969. Mammals of Maryland. N. Amer. Fauna, 66:1–193.

Pavlinov, I. Y. 1975. Tooth anomalies in some Canidae. Acta Theriologica, 20:507–519.

Petersen, L. R., M. A. Martin, and C. M. Pils. 1977. Status of gray foxes in Wisconsin, 1975. Wisconsin Dept. Nat. Res. Rep., 94:1–18.

Peterson, R. L., R. O. Standfield, E. H. McEwen, and A. C. Brooks. 1953. Early records of the red and gray fox in Ontario. J. Mamm., 34:126–127.

Petrides, G. A. 1950. The determination of sex and age ratios in fur animals. Amer. Midland Nat., 43:355–382.

Pils, C. M., and W. D. Klimstra. 1975. Late fall foods of the gray fox in southern Illinois. Trans. Illinois State Acad. Sci., 68:255–262.

Pizzimenti, J. J. 1971. List of karyotypes of mammals from the northern plains region (USA). Kansas Acad. Sci. Trans., 74:67–75.

Radinsky, L. B. 1969. Outlines of canid and felid brain evolution. Ann. New York Acad. Sci., 167:277–288.

— 1973. Evolution of the canid brain. Brain Behav. Ecol., 7: 169–202.

Rhoads, S. N. 1895. New subspecies of the gray fox and Say's chipmunk. Proc. Acad. Nat. Sci. Philadelphia, 47:42–44.

Richards, S. W., and R. L. Hine. 1953. Wisconsin fox populations. Tech. Bull. Wisconsin Dept. Conserv., 6:1–78.

Richmond, N. D. 1952. Fluctuations in gray fox population in Pennsylvania and their relationship to precipitation. J. Wildl. Mgmt., 16:198–208.

Rohde, T. D. 1966. Skeletal variation in gray fox from southern Illinois. Unpubl. M.S. thesis, Southern Illinois Univ., Carbondale, 43 pp.

Root, D. A. 1981. Productivity and mortality of gray foxes and raccoons in southwestern Wisconsin. Unpubl. M.S. thesis, Univ. Wisconsin, Stevens Point, 106 pp.

Saggese, E. P., and B. F. Tullar, Jr. 1974. Possible predation of a gray fox on a red fox pup. New York Fish and Game J., 21:86.

Schantz, V. S. 1950. The gray fox in North Dakota. J. Mamm., 31:197–198.

Schendel, R. R. 1942. Mammals of Payne County, Oklahoma. Proc. Oklahoma Acad. Sci., 22:75–76.

Schmeltz, L. L., and J. O. Whitaker, Jr. 1977. Use of woodchuck burrows by woodchucks and other mammals. Trans. Kentucky Acad. Sci., 38:79–82.

Schreber, J. C. D. 1775. Die Säugethiere in Abbildungen nach der Nature mit Beschreibungen. W. Walther [Leipzig], 3: 281–590.

Scott, T. G. 1955. Dietary patterns of red and gray foxes. Ecology, 36:366–367.

Seal, U. S. 1975. Molecular approaches to taxonomic problems in the canidae. Pp. 27–39, *in* The wild canids; their systematics, behavioral ecology, and evolution (M. W. Fox, ed.). Van Nostrand-Reinhold Co., New York, 508 pp.

Seton, E. T. 1923. The mane of the tail of the gray fox. J. Mamm., 4:180–182.

— 1929. Lives of game animals. Cats, wolves, and foxes. Doubleday Doran and Co., Inc., Garden City, New York, 1:340–640.

Sheldon, W. G. 1949. Reproductive behavior of foxes in New York state. J. Mamm., 30:236–246.

— 1953. Returns on banded red and gray foxes in New York state. J. Mamm., 34:125.

Shipherd, S. V., and W. B. Stone. 1974. An albino gray fox. New York Fish and Game J., 21:184–185.

Slaughter, B. H., R. H. Pine, and N. E. Pine. 1974. Eruption of cheek teeth in Insectivora and Carnivora. J. Mamm., 55: 115–125.

Small, R. L. 1971. Interspecific competition among three species of Carnivora on the Spider Ranch, Yavapai Co., Arizona. Unpubl. M.S. thesis, Univ. Arizona, Tucson, 78 pp.

Stains, H. J. 1975. Calcanea of members of the Canidae. Bull. So. California Acad. Sci., 74:143–155.

Stanley, S. M., R. E. Flatt, and G. N. Daniels. 1978. Naturally occurring Tyzzer's disease in the gray fox. J. Amer. Vet. Med. Assoc., 173:1173–1174.

Stock, C. 1943. Foxes and elephants of the Channel Islands. Los Angeles Co. Mus. Quart., 3:6–9.

Stone, W. B., Jr., E. Parks, and H. Parish. 1971. A dwarf, brachycephalic gray fox. New York Fish and Game J., 18: 139–141.

Stone, W. B., E. Parks, B. L. Weber, and F. J. Parks. 1972. Experimental transfer of sarcoptic mange from red foxes and wild canids to captive wildlife and domestic animals. New York Fish and Game J., 19:1–11.

Sullivan, E. G. 1956. Gray fox reproduction, denning, range, and weights in Alabama. J. Mamm., 37:346–351.

Sullivan, E. G., and A. O. Haugen. 1956. Age determination of foxes by x-ray of forefeet. J. Wildl. Mgmt., 20:210–212.

Sutton, R. W. 1958. A Manitoba record of the gray fox. J. Mamm., 39:439–440.

Taylor, W. P. 1943. The gray fox in captivity. Texas Game Fish, 1:12–13, 19.

Tembrock, G. 1963. Acoustical behavior in mammals. Pp. 751–786, *in* Acoustic behavior of animals (R. G. Busnel, ed.). Elsevier Publ. Co., New York, 933 pp.

Terres, J. K. 1939. Tree-climbing technique of a gray fox. J. Mamm., 20:256.

Timm, R. M. 1975. Distribution, natural history, and parasites of mammals of Cook County, Minnesota. Occas. Papers Bell Mus. Nat. Hist., Univ. Minnesota, 14:1–56.

Trapp, G. R. 1978. Comparative behavioral ecology of the ringtail (*Bassariscus astutus*) and gray fox (*Urocyon cinereoargenteus*) in southwestern Utah. Carnivore, 1:3–32.

Trapp, G. R., and D. L. Hallberg. 1975. Ecology of the gray fox (*Urocyon cinereoargenteus*): a review. Pp. 164–178, *in* The wild canids; their systematics, behavioral ecology, and evolution (M. S. Fox, ed.). Van Nostrand-Reinhold Co., New York, 508 pp.

Turkowski, F. J. 1971. The tree fox. Animal Kingdom, 74:18, 21.

Van Gelder, R. G. 1978. A review of canid classification. Amer. Mus. Novitates, 2646:1–25.

Van Handel, E. 1969. Do trehalose and trehalase function in renal glucose transport? Science, 163:1075–1076.

Wade, D. A. 1977. Standard guidelines for the use and development of sodium monofluoroacetate (compound 1080) as a predacide (ASTM designator E 590-76). Spec. Tech. Publ., Amer. Soc. Testing Materials, 625:157–170.

Waters, J. H. 1967. Foxes on Martha's Vineyard, Massachusetts. J. Mamm., 48:137–138.

Weaver, R. L. 1939. Attacks on porcupine by gray fox and wild cats. J. Mamm., 20:379.

Whitaker, J. O., Jr., and R. Goff. 1979. Ecto-parasites of wild carnivora of Indiana. J. Med. Entomol., 15:425–430.

Wilson, W., and W. W. Baker. 1972. Ticks of Georgia (Acarina; Metastigmata). Tall Timbers Res. Sta. Bull., 10:1–29.

Wood, J. E. 1952. The effects of agriculture (ranching and farming) on the habitat and food supply of furbearers in the post oak region of Texas. Trans. N. Amer. Wildl. Conf., 7: 427–437.

— 1954. Food habits of furbearers of the upland post-oak region in Texas. J. Mamm., 35:406–45.

— 1958. Age structure and productivity of a gray fox population. J. Mamm., 39:74–86.

Wood, J. E., D. E. Davis, and E. V. Komarek. 1958. The distribution of fox populations in relation to vegetation in southern Georgia. Ecology, 39:160–162.

Wurster, D. H., and K. Benirschke. 1968. Comparative cytogenetic studies in the order Carnivora. Chromosoma, 24: 336–382.

Yeager, L. E. 1938. Tree-climbing by a gray fox. J. Mamm., 19:376.

Yearsley, E. F., and D. E. Samuel. 1980. Use of reclaimed surface mines by foxes in West Virginia. J. Wildl. Mgmt., 44:729–734.

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