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DISEASES DIAGNOSED IN GRAY FOXES (*UROCYON CINEREOARGENTEUS*) FROM THE SOUTHEASTERN UNITED STATES

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ABSTRACT: Diagnostic findings were reviewed on 157 sick or dead gray foxes (*Urocyon cinereoargenteus*) from the southeastern United States examined during the period 1972 through 1989. Most foxes (n = 118) originated from Georgia; fewer animals were from Florida, Kentucky, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia. Etiologic diagnoses included canine distemper (n = 125), congenital absence of guard hairs (n = 7), traumatic injuries (n = 7), rabies (n = 3), suspected toxicoses (n = 3), verminous pneumonia due to *Paragonimus kellicotti* (n = 1), bacterial septicemia secondary to *Dracunculus insignis* (n = 1), and tick paralysis (n = 1). Concurrent toxoplasmosis or cryptosporidiosis was noted in six and three foxes with canine distemper, respectively. Only lesion diagnoses were attainable for three foxes, and six cases were classified as undetermined. Canine distemper was diagnosed in 78% of the foxes, was geographically widespread, was detected in 16 of 18 yr, and exhibited a seasonal pattern of occurrence. These facts indicate that canine distemper is more significant as a mortality factor for gray foxes than all other infectious and noninfectious diseases combined.

Key words: Gray fox, *Urocyon cinereoargenteus*, diseases, survey, canine distemper, mortality factors.

INTRODUCTION

The gray fox (*Urocyon cinereoargenteus*) is the most abundant and widely distributed species of fox in the southeastern United States. Despite its common occurrence and wide distribution, little published information is available regarding the relative or absolute importance of various diseases as mortality factors in the species. Only canine distemper (Helmboldt and Jungherr, 1955; Moller and Nielsen, 1964; Hoff et al., 1974; Monson and Stone, 1976; Nicholson and Hill, 1984) and rabies (Lewis, 1966; Carey, 1982; Reid-Sanden et al., 1990) have been reported with substantial frequency.

Since 1972, we have had the opportunity to examine numerous gray foxes found sick or dead in the southeastern United States. This report summarizes diagnostic examinations on gray foxes submitted to the Southeastern Cooperative Wildlife Disease Study (SCWDS) (Department of Parasitology, College of Veterinary Medicine, The University of Georgia, Athens, Georgia 30602, USA) during this 18-yr period.

MATERIALS AND METHODS

Necropsy and laboratory records for gray foxes submitted to the SCWDS for diagnostic examination were reviewed for the period 1 January 1972 through 31 December 1989. Whole animals, usually refrigerated but often frozen, were available for examination in most instances; however, in some cases only formalin-fixed or frozen tissues were submitted. All cases were submitted by personnel of state or federal wildlife agencies. Because necropsies were oriented toward determination of the cause of morbidity or mortality, diagnostic procedures varied among cases. Examinations were sometimes hampered by postmortem decomposition or inadequate preservation techniques; however, such problems were encountered in <10% of the cases. Data reviewed for each case accession were the number, sex and age of animals in-

volved, location, date, case history, and major diagnostic findings. An effort was made to categorize diagnostic findings as to whether they were primary or secondary factors. Diseases that occurred with sufficient frequency were evaluated for patterns of occurrence relative to temporal, geographic, and host sex and age factors. Monthly frequencies of diagnoses were evaluated for temporal differences using a Chi square test and the runs test (Remington and Schork, 1970). Differences in prevalence among host sex and age classes were tested by the G-statistic.

RESULTS

Over the 18-yr period, 157 gray foxes from 10 states were submitted for diagnostic purposes. Most of the foxes were from Georgia (n = 118); fewer were from Virginia (n = 11), North Carolina (n = 10), West Virginia (n = 7), South Carolina (n = 5), Maryland (n = 2), and Florida, Kentucky, Mississippi, and Tennessee (n = 1 each). Female foxes outnumbered males (89 versus 61; 7 unknown), and adults outnumbered young (101 versus 44; 12 unknown). Case histories disclosed that usually only a single animal was found; however, in several instances more than one fox was reported sick or dead.

Naturally acquired canine distemper was the most frequent diagnosis and occurred in 123 (78%) foxes (Table 1). Foxes with distemper were submitted from 52 counties in nine states. Distemper was diagnosed in foxes during each of the 18 yr except for 1973 and 1980 when only three animals and one animal, respectively, were submitted. The occurrence of distemper cases differed among months (χ^2 = 37.5; df = 11) with the largest number of cases in March and the fewest in August. Calculation of 3-mo moving averages to smooth the trend of monthly submissions of distemper cases produced a distinct seasonal pattern (Fig. 1). Runs tests on smoothed data indicated the monthly values were nonrandom (P = 0.05) whereas raw data only approached significance (P = 0.10). The prevalence of distemper diagnoses did not differ ($P > 0.05$) between sexes (males 80%, females 79%) nor between young (75%) and adult (82%) foxes.

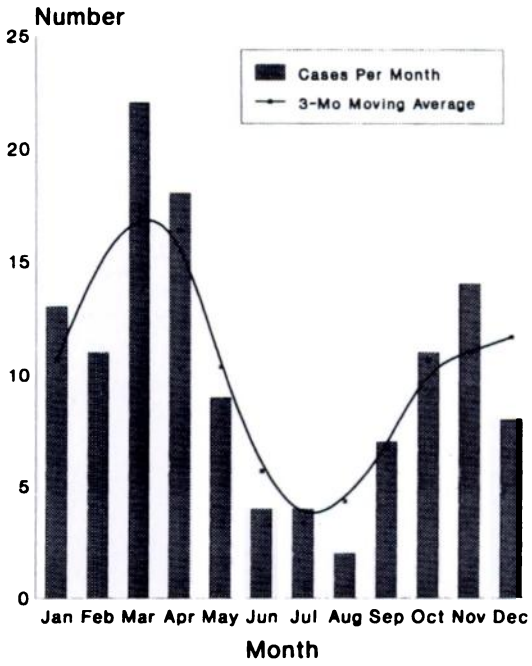

FIGURE 1. Frequency of canine distemper diagnoses in gray foxes from the southeastern United States by month over the period 1972 through 1989.

Two instances of presumed vaccine-induced distemper were noted in addition to the 123 naturally occurring cases. Case histories indicated that both occurred in wild-caught foxes which had been vaccinated with modified live-virus canine vaccines at fox hunting preserves. In one instance, many gray foxes were reported to have died following vaccination, although red foxes (*Vulpes vulpes*) which reportedly also had been vaccinated were unaffected.

Foxes with distemper often were in good physical condition with substantial endogenous fat reserves, although occasionally they were thin or emaciated. Clinical signs recorded for foxes with distemper included lack of fear, aimless wandering, incoordination, tremors, weakness, aggression, and profound depression. The most pronounced gross lesions noted were diffuse interstitial pneumonia or bronchopneumonia which usually involved all lobes of the lungs. Lungs of foxes with distemper typically were swollen, mottled, and firm.

TABLE 1. Diagnostic findings in 157 sick or dead gray foxes from the southeastern United States from 1972 through 1989.

Diagnosis	Number of (%) foxes	States	Years
Canine distemper (naturally acquired)	123 (78)	FL, GA, KY, MD, MS, NC, SC, VA, WV	1973–1977, 1981–1989
Canine distemper (vaccine induced)	2 (1)	GA	1984, 1989
Congenital lack of guard hairs	7 (5)	GA, VA	1978–1983
Trauma	7 (5)	GA, SC	1972, 1981, 1984, 1986, 1987
Rabies	3 (2)	GA, VA	1981, 1986, 1987
Suspected toxicoses	3 (2)	GA, TN	1984, 1987, 1988
Paragonimus kellicotti/pneumonia	1 (<1)	WV	1988
Dracunculus insignis/secondary bacterial septicemia	1 (<1)	GA	1982
Tick paralysis	1 (<1)	GA	1973
Bronchopneumonia	1 (<1)	NC	1973
Emaciation	1 (<1)	GA	1986
Hemolytic anemia	1 (<1)	GA	1972
Undetermined	6 (4)	GA	1972, 1978, 1983, 1988

Bronchi and bronchioles contained foamy syncytical cells, excessive mucus, sloughed epithelium, and necrotic debris, and often were obstructed by plugs of these materials. Microscopic examinations of lungs disclosed that secondary bacterial infections were almost universal. Distemper infections also were nearly always characterized microscopically by multifocal areas of nonsuppurative encephalitis and often by gastroenteritis. Intranuclear and/or intracytoplasmic eosinophilic inclusion bodies were found often in bronchiolar, bile duct, pancreatic duct, gall bladder, urinary bladder, gastric, intestinal, nasal, or foot pad epithelial cells. In addition, inclusions were present in the adrenal medulla and in glial cells, ependymal cells, or occasionally neurons in the brain.

Six foxes with distemper also had protozoal organisms in the lungs identified as *Toxoplasma gondii*. Foxes with secondary toxoplasmosis had zones of focal necrosis surrounding organisms in the lungs. Occasionally, individual *T. gondii* organisms were noted in macrophages or free in the alveolar spaces. Three foxes with distemper, all from Craven County, North Carolina, had protozoa identified as *Cryptosporidium* sp. in the microvillar border of intestinal epithelial cells. Within individual tissue sections of intestine, the distribution of *Cryptosporidium* sp. was focal except in one animal in which approximately 50% of the epithelial cells were infected.

The second most frequent diagnosis was an absence of guard hairs, often referred to as a "Samson fox" in the lay literature, which was observed in seven foxes (Table 1). These animals appeared to be in good health otherwise and were submitted solely because of their external appearance. All were submitted from 1978 through 1983, and six of seven were from five contiguous counties (Jasper, Monroe, Morgan, Putnam, Walton) in north central Georgia.

Trauma was the third most frequent diagnosis (Table 1). In five of the seven instances, the cause of the injuries was not determined. One case was a chronic gunshot injury, and one fox had been caught by dogs.

The remaining diagnoses involved only small numbers of foxes. Rabies was diagnoses in three foxes (two from Georgia and one from Virginia). Three other cases were categorized as suspected toxicoses based on case histories, lesions, and absence of other etiologic agents, although the specific toxin

responsible was not determined. One juvenile female fox from Randolph County, West Virginia had verminous pneumonia due to infection by the lung trematode, *Paragonimus kellicotti*. One adult male from Putnam County, Georgia had a bacterial septicemia that apparently developed secondary to skin ulcers initiated by *Dracunculus insignis*. One adult male from Oconee County, Georgia was diagnosed as having tick paralysis. Only lesion diagnoses (bronchopneumonia, emaciation, and hemolytic anemia) were attainable for three foxes. Six cases were categorized as undetermined. These included two apparently normal animals (only heads submitted) that were shot and submitted for rabies testing, and four animals for which there were no significant diagnostic findings.

DISCUSSION

The data presented in Table 1 were not obtained in a manner that would allow an accurate assessment of the relative importance of most natural mortality factors in gray foxes. The submission of cases was influenced by many unknown factors, and the data are undoubtedly biased. For example, field personnel normally would not submit a fox that died of a known source of trauma. Conversely, foxes with strikingly obvious external abnormalities, such as absence of guard hairs, might be submitted at a rate higher than their actual occurrence. One factor that obviously influenced submissions was proximity to the SCWDS laboratory.

Despite the potential unknown factors regarding case submissions, the data clearly indicate that canine distemper is the major disease affecting gray foxes in the southeastern United States. Furthermore, our data suggest that canine distemper exceeds all other infectious and noninfectious diseases combined as a mortality factor for gray foxes. Monson and Stone (1976) reported that canine distemper was the predominant disease among gray foxes they examined in New York, accounting for 64% of 131 animals examined. Helmboldt and Jungherr (1955), Hoff et al. (1974), and Nicholson and Hill (1984) also reported outbreaks of canine distemper involving gray foxes in Connecticut, Florida, and Alabama, respectively.

Our data disclosed several additional interesting aspects with regard to distemper in gray foxes. First, its occurrence in nine southeastern states confirms that it is geographically widespread among gray fox populations in the region. Second, its detection over a period of almost two decades indicates that it is a frequent and not an ephemeral mortality factor for the species. These observations, in combination with previous reports of distemper among gray foxes from other eastern regions of the United States (Helmboldt and Jungherr, 1955; Moller and Nielsen, 1964; Monson and Stone, 1976; Jakowski and Wyand, 1971), suggest that canine distemper is a major, if not the most significant, disease impacting gray foxes in the entire eastern United States. Third, the monthly frequency of cases suggested a strong seasonality of occurrence, with peak occurrence during the period of January to April. Similarly, previous workers have reported canine distemper among gray foxes (Monson and Stone, 1976) and dogs (Gorham, 1966) to exhibit a seasonality of occurrence, being more frequent during colder months. Fourth, concurrent toxoplasmosis or cryptosporidiosis can be expected to occur in some gray foxes with distemper. Secondary toxoplasmosis has been reported as a complication in several species of animals with canine distemper (Campbell et al., 1955; Diters and Nielsen, 1978; Budd, 1981), including gray foxes (Helmboldt and Jungherr, 1955; Moller and Nielsen, 1964). Cryptosporidiosis also is known to occur secondarily in animals compromised by other diseases (Current, 1985). Presumably these complications in gray foxes resulted from activation of latent or subclinical parasitic infections due to the immunosuppressive aspects of distemper virus infection (Mangi et al., 1976; Kauffman et al.,

1982), as has been suggested for protozoal infections in other species with canine distemper (Moller and Nielsen, 1964; Diters and Nielsen, 1978; Williams et al., 1988).

The two occurrences of vaccine-induced distemper among gray foxes that apparently had been vaccinated with modified live-virus vaccines was not unexpected since previous workers have reported vaccine-induced distemper in gray foxes (Halbrooks et al., 1981). These cases illustrate the necessity of utilizing appropriate canine distemper vaccines in wildlife, as previously recommended for gray foxes (Halbrooks et al., 1981) and other species (Carpenter et al., 1976; Montali et al., 1983). In addition, the history of one vaccine-induced case reiterates that gray foxes and red foxes respond quite differently to modified live-virus canine distemper vaccines, as noted by Halbrooks et al. (1981).

Absence of guard hairs, presumably a congenital condition, is relatively well known among free-ranging gray foxes (e.g., Allen, 1974; Davidson and Nettles, 1988). All of our cases with this condition arose when otherwise normal animals caught by trappers were submitted for diagnostic examination. We do not believe this condition significantly impacts survival. Factors responsible for the spatial clumping of six of seven foxes with this condition are not known, although this pattern would be compatible with an inherited genetic trait. The temporal clumping may have been related to increased trapping effort during a period of high fur prices in the late 1970's and early 1980's, although this pattern also would be compatible with a genetic disorder.

The detection of rabies among three foxes was not considered unusual since gray foxes historically have been one of the most frequently infected species in the Appalachian highlands and surrounding areas in the eastern United States (Carey, 1982). The number of rabid foxes in the southeastern United States during the period of our survey was lower than during earlier epizootics (Wood, 1954; Wood and Davis, 1959; Lewis, 1966; Carey, 1982); however, fox rabies is still considered enzootic in some localities in the region (Carey and McLean, 1978; Carey, 1982), and rabid foxes continue to be reported in several states in the region (Reid-Sanden et al., 1990).

The remaining causes of morbidity or mortality were infrequent. Although such cases may be encountered occasionally, such as the instance of tick paralysis noted by Jessup (1979), individually none of them appear to be significant to gray fox populations.

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