

XI. FOXES

A. INTRODUCTION

1. History

Foxes are carnivorous mammals of the family Canidae which, with other canids such as the wolf, coyote, jackal and dog, probably all trace back to a common ancestor, the *Tomarctus*, that emerged during the upper Miocene era (Fox, 1975).

Modern day foxes comprise a number of separate species belonging to several genera that are widely distributed across the world. The most numerous of these species is the red fox (*Vulpes vulpes*), members of which may be found throughout North America, Asia, North Africa and Europe. Unless otherwise specified, all the data presented in this section refer to the red fox.

Wild foxes are found in all the provinces and territories of Canada and are extensively trapped for their fur, an activity that has had a very considerable socio-economic impact on the earlier development of this country.

Initial attempts to domesticate and farm foxes began during the late 19th century. Fox farming fortunes have fluctuated widely, almost disappearing during the mid-century period but rebounding during the past decade in response to improved fur prices (Ag. Cda, 1979). In the 1981-82 season over 16,000 fox pelts, with a value of over \$4.5 million were ranch-produced in Canada, predominantly in the Maritime Provinces. Almost 120,000 other fox pelts of all kinds were harvested by Canadian trappers during the same period (Stats Cda, 1983).

2. Biological Characteristics

Foxes, like most other canids, have five digits on the anterior and four on the posterior limbs. Dentition includes four upper and four lower premolars, with the first upper one being very small; two upper and three lower molars are well developed as are the canine teeth (Linhart, 1968). The development of the latter and the number of annular cementum rings around the teeth are used in age determination (Monson, Stone and Puks, 1973).

The blood picture and hematological values for the fox have been described in both domestic and wild red foxes (Kennedy, 1935; Brooks and Morris, 1979) and are summarized in Table I. The wild type coat colour of the red fox is a chestnut red to a pale sandy colour. Mutations have resulted in several different coat colours and patterns (silver black, etc.), which have been exploited through genetic selection by the fur farmer (Shackleford, 1980). The blue or Arctic fox (*Alopex lagopus*) exhibits seasonal dichromatism, being slate gray/brown in summer and white or blue (gray/blue) in the winter. Newborn foxes, regardless of their expected definitive coloration, will all have a more or less dark brown coat for the first two or more weeks of their lives.

3. Research Uses

The economic importance of the fox to both the farming and trapping industries has resulted in a considerable and continuing level of research effort being directed towards improvements both in productivity under domestication and in conservation and humane trapping. Fox diseases, particularly rabies have been the subject of numerous investigations, as have field studies on fox behavior. A very useful bibliography of the investigative literature on the fox from 1900 to 1980 has recently been compiled (Jone and Anlerich, 1981). Many of the studies cited emanated from Russia and the Scandinavian countries, with the majority being seemingly either field or ranch-based investigations.

TABLE I HEMATOLOGY VALUES RED FOX¹

	Ranch Raised ²		Wild Raised ³	
	Mean	Range	Mean	Range
RBC (millions)	9.35	7.1-11.2	8.42	7.8-9.4
Hgb%	13.0	11.85-13.75	15.2	13.9-16.2
WBC (thousands)	8.0	4.9-12.4	6.4	4.4-7.3
Neutrophils (%)	59.5	49.0-79.0	65.4	48.0-87.0
Lymphocytes (%)	33.1	27.2-42.0	20.8	8.0-30.0
Monocytes (%)	1.8	0.3-3.5	1.2	0.0-3.0
Eosinophils (%)	5.6	1.5-8.2	12.6 ⁴	5.0-20.0

¹ Adapted from A. Kennedy and Brooks, C. Morris, K.D.

² 20 foxes, 10-12 months old (10 males; 10 females)

³ Five foxes, 2.7-4.5 kg (6-10 lbs) body weight (two males; three females)

⁴ Intestinal parasites numerous in two foxes with high eosinophil counts

B. COLONY MANAGEMENT

1. Procurement and Transportation

Domestic foxes of known pedigree, age, health, and nutritional status should be purchased from reputable breeders. Ranches are spread all across Canada and breeder lists may be obtained either through provincial and/or territorial governments or from fur breeders' associations*.

Wild foxes may be required for certain studies and/or for experimental breeding purposes. These must be trapped as humanely as possible by using a suitable method such as cage or leg-snare (Novak, 1980). Use of the leghold trap for this purpose will induce a high proportion of injuries and is not acceptable on humane grounds. If foxes are to be trapped for any purpose in Canada, a permit must be obtained from the wildlife service branch of the provincial or territorial government concerned.

The standard method of identification of foxes under captive conditions is by ear tattoo, which is mandatory for purebred registered animals. A variety of marking procedures and tracking devices may be used for field studies (see chapter on Wild Vertebrates).

Research and breeding stock should, whenever possible, be obtained from readily accessible sources to minimize the stress of transportation. Foxes will travel quite well by air, but must be properly crated (IATA, 1984) and shipped by carriers equipped to transport animals. It should be noted that foxes are very susceptible to carbon monoxide poisoning and that protection from the exhaust fumes of ground transport vehicles and the provision of good ventilation are important precautions.

2. Quarantine

A two week period of isolation and observation is considered adequate for previously vaccinated domestic foxes of known background. Foxes captured from the wild or whose prior history is unclear should be quarantined for a longer period and should be vaccinated on arrival for distemper and hepatitis. Wild foxes must be observed closely for any signs of rabies and if this disease is suspected, it must immediately be reported to the nearest branch of the Animal Health Division, Food Products and Inspection Branch, Agriculture Canada.

Newly acquired foxes, particularly those from the wild, will frequently harbour numerous internal and external parasites, for which they should be examined and treated on arrival.

The quarantine and isolation area should be completely separated from the main fox holding area, and should preferably be a self-contained, separate compound, with its own entrance and maintenance facilities.

3. Housing

Many research projects that are directed towards a farming application will need to be undertaken under standard ranch conditions using conventional fox farming facilities (Ag. Cda, 1979) as briefly described below:

Foxes are generally kept in pens, measuring approximately 120 x 120 x 240 cm (48 x 48 x 96 in) for breeders, each having an attached nest box for whelping. The nest box should have an entrance tunnel into an insulated double compartment (permitting the vixen to get away from her young). Nest boxes should have hinged lids for ease of checking from the outside. Bedding should be of hay. Pens for foxes destined for pelting are usually 90 x 90 x 150 cm (36 x 36 x 60 in) and will be located within a shed to protect the animals' fur from the weather. A trapdoor-like opening approximately 45 cm (18 in) square should be located in the pen top. It is essential that the fox holding area be surrounded by guard fence so constructed as to prevent the entry of wild animals, pets, or other intruders.

Research on captive foxes for other than farming purposes will usually be undertaken in similar, essentially open-air holding areas, but may be within a suitable, enclosed building, providing the environmental conditions are satisfactory. Foxes do better in the outdoors and their feces and urine, which are highly odoriferous, will also prove far less objectionable. As facilities, caging, and management will vary with the objectives of the research, only some general concepts will be outlined here^{**}.

Pens should be constructed from 5 x 2.5 cm (2 x 1 in) mesh, 12 gauge GAW (galvanized after welding) wire, as this provides adequate support, minimizes leg injuries, permits passage of feces and inhibits urine erosion of the mesh welds. Nest boxes for single animals (non-breeding) should be at least 60 x 60 x 40 cm (24 x 24 x 16 in) with a 15 cm (6 in) entrance to one side. A weather break in the form of an incomplete partition running from the front wall 2/3 of the way back on the inside adjacent to the entry is advisable. The whole should be constructed of 2 cm (3/4 in) marine plywood. The hinged lid of the box should have a movable 1 cm (1/2 in) mesh wire screen located directly below it to facilitate observation and capture without escape.

Pens for maintaining foxes other than breeders within an enclosed building need not be fitted with nest boxes; however, a platform placed above the cell floor is recommended and will be used as a resting place by most captive foxes. The guard fence surrounding the research compound should be sunk at least 45 cm (18 in) into the ground, to discourage entry by burrowing, should be about 2.5 m (8 ft.) high and overhung or otherwise modified to prevent entry or escape by climbing. Occasionally one or a few foxes may have to be held for short periods in regular animal facilities, not equipped with fox pens. If this should occur, the animal(s) may be housed in large dog cages provided with portable nest boxes or in small primate squeeze cages. The latter are particularly useful where frequent handling and treatments are required.

4. Feeding

The nutrient requirements for foxes as compiled and published by the U.S. National Research Council constitute a generally accepted standard (NRC U.S., 1968). A high proportion of animal protein is required for foxes, and ranch feeding practices have traditionally involved mixing commercial cereal with chicken or beef offal at a ratio of about one:two for this purpose (Ag. Cda, 1979). Fish may also be fed as a portion of the diet.

The feeding of total dry rations, several of which are now available commercially, is gaining popularity and is usually the preferred system for research animals.

Feed should be presented in a suspended bucket or a feeder specially constructed to inhibit excessive waste from scratching. Water should be available *ad libitum*. Foxes will use an automatic watering system, but should be provided with an alternate source such as water in a large container when temperatures are freezing (Bollert, 1979).

C. REPRODUCTION

1. Sexual Cycle

Seasonal reproductive activity is displayed by both sexes and is probably influenced by the photoperiod. The vixen usually comes into heat in early February, although the estrous cycle may be initiated at any time from late December through March (Finley, 1979). The male is sexually active through a comparable period and it is only at this time that spermatogenesis occurs, the testicular blood supply and testosterone secretion become markedly increased, and the male expresses libido (Joffre, 1977).

Proestrus in the female is marked by a gradual vaginal swelling which intensifies at estrus, at which time her behavior becomes similar to that exhibited by the bitch (*Canis familiaris*). A single estrus occurs, lasting an average of three days, with ovulation usually occurring on the second day. A missed estrus will result in a lost opportunity to breed that year.

2. Breeding and Gestation

The male fox in the wild is usually monogamous, staying with the vixen through her gestation and assisting in food procurement and feeding of the cubs. In fact, he tends to return to the same vixen each mating season, although he will be indifferent to her during the interim period and the ritual to successive courtships becomes more abbreviated (Ewer, 1973). Wild fox males will only occasionally exhibit polygamy, even when inhabiting a common territory with several vixen.

Under conditions of domestication, most ranchers use a polygamous mating system in which the vixens are housed separately, watched for vaginal swelling (heat) and taken to the fox's territory for mating (Finley, 1979). Under research conditions, breeding pairs are often housed together indefinitely.

The gestation period is about 52 days.

3. Parturition to Weaning

Up to 10 pups, each averaging about 100 g at birth, be born to a litter. Any unusual disturbance at this time tends to precipitate cannibalism. However, most domestic fox litters can be safely viewed shortly after birth by the regular attendant if the vixen is used to his/her presence. Until fox pups are about three weeks of age, urination must be evoked by stimulating the external genitalia (licking by the vixen). Cubs will start to eat solid food at three weeks, at which time either parent may be noted to regurgitate food for them. Litters may be weaned at eight to ten weeks of age.

4. Selection

Under ranch conditions, grading of juveniles on the basis of such criteria as fur quality, size, and reproductive background, will take place in the fall, at which time replacement breeding stock is selected.

Potential sires should be checked for testicular development before mating is attempted. They should also be tested for sperm motility, quantity and morphology following their first mating; this may be accomplished by microscopic examination of semen removed from the vixen's vagina. A good animal of either sex should remain as an active breeder for at least five years.

Interspecific crosses such as the red fox with the blue fox can be made using artificial insemination (Nyberg, 1980).

D. RESTRAINT AND ANESTHESIA

1. Handling

Although ranch bred foxes are classed as domestic animals, they are nevertheless high strung, nervous creatures that have not become really tame. They must therefore always be handled with caution and with particular care to avoid opportunities for escape.

Retrieving a fox from the type of outdoor caging described above involves isolating the animal in its nest box, into which it will usually retreat, by inserting a (sheet metal) slide over the 15 cm (6 in) entry port leading from it to the wire pen. The wooden lid may then be opened and the wire screen lifted carefully just far enough to permit securing the fox with a pair of fox handlers (commercially obtainable tongs for capturing foxes). Once the head is secured and the hind legs immobilized, the animal may be safely removed from the box for examination and further procedures.

2. Chemical Restraint and Sampling

The fox must first be caught and physically restrained, as outlined above. Once firmly held, the animal should be injected with a chemical restraining agent before sampling or minor surgical procedures are undertaken. For these purposes, ketamine hydrochloride at 10-20 mg/kg i.m. is usually effective (Brooks and Morris, 1979; Ramsden, Coppin and Johnston, 1976). Ketamine-xylazine, mixed at 6 and 2 mg/kg respectively, is also relatively safe for chemical restraint (Ramsden, Coppin and Johnston, 1976). Blood samples may be obtained using the same procedures and sites as for cats and dogs. The cephalic vein of the forelimb and the jugular vein are the blood vessels that are most accessible.

3. Anesthesia and Euthanasia

Excessive salivation and hypothermia may prove to be problems during surgical anesthesia in foxes. These conditions may be countered respectively

by the use of atropine at 0.05 mg/kg i.m. and by placing a heating pad or hot water bottle under the animal.

Conventional anesthetic procedures used on dogs can generally be successfully applied to the fox following preanesthetic chemical immobilization, providing it is remembered that the anesthetic agent dose required will need to be reduced by as much as 60% (Green, 1979).

Experimental subjects that must be killed should first (provided the experimental protocol will permit) be immobilized with ketamine, followed by an intravenous or intracardiac overdose of a barbiturate or T-61.

E. HEALTH CARE AND DISEASE

1. General Information

Relatively little information on the diseases of foxes was published in the period from the mid-1940's to the 70's; however, the past decade has seen an increased interest in this species, particularly on the subjects of rabies control (Bacon and MacDonald, 1982; Black and Lawson, 1980) and internal parasitism (Bjotvedt, Tomkiewicz and Golightly, 1980; Eaton and Secord, 1979; Smith, 1978). Unfortunately, relatively few overviews on fox disease problems and their control have been published (Ag. Cda, 1979; Finley, 1979).

When confronted with problems on health care and disease in foxes, investigators should take advantage of the expertise usually available to them from the veterinary service branches of their respective provincial governments.

2. Prevention

Effective vaccination can and should be practised against several of the diseases of foxes, notably distemper and encephalitis (hepatitis), both of which are caused by canine viruses. While foxes are not as susceptible as mink to meat products contaminated with *Clostridium botulinum*, vaccination against botulism with the toxoid used for mink, is a good precaution to take if traditional feeding, using raw meat products, is practised (Ag. Cda, 1979; Hagsma, 1980). Rabies vaccination is not usually indicated in groups of ranch bred experimental foxes unless wild caught animals are also to be introduced.

Clinical parvovirus infection has not been recognized to date in red foxes (Barker, Povey and Voigt, 1983), although antibody to parvovirus has been demonstrated in wild red foxes.

In addition to a vaccination program and equally important, is the adherence to good management and sanitary practices. These may be summarized as follows:

- a. **Quarantine:** Quarantine is instituted to provide for the isolation and observation of new arrivals (see above under Procurement) and for the

segregation and treatment of sick animals. This area should be physically completely separated from the main holding facilities if it is to function effectively. Separate coveralls, overboots, and gloves must be used when working in the isolation facilities.

- b. **Sanitation:** Feed containers and nest boxes should receive special attention. Regular and frequent removal of manure followed by liming under the pens will control odour and possible spread of disease by flies.
- c. **Rodent Control:** Entry of rats and mice from without will be inhibited if the guard fence is sunk about 46 cm (18 in) into the ground. Chemical control may be necessary within the compound as rodents may act as vectors of a number of infections and parasites of foxes.
- d. **Foods:** Proper cooler and freezer storage of perishables, particularly meat and fish products, should be practised. Spoiled food should never be fed and food handling equipment should be thoroughly cleaned after use. Food poisoning can prove a very serious problem in foxes.

3. Parasites

- a. **Ectoparasites:** Fleas are a particularly common problem accentuated by warm weather. If the infestation is sufficiently heavy it may cause a severe anemia and will certainly result in irritation. Flea eggs and larvae will be located in cracks in nest boxes and pens and may be controlled by disinfection of these areas. Infection with ear mites is of common occurrence, leading to excessive scratching of the ears and the appearance of a dark discolouration and matting of the hair from accumulated debris in the ear canal. Treatment of both fleas and ear mites can make use of rotenone applied as a dusting powder for the former and as ear drops in a mineral oil base for control of the latter condition, after first cleaning the outer ear canal region. Exposure to the vapour from a dichlorvos impregnated strip (vapona) for two or three days will also provide effective control of many ectoparasites. These insecticides are not effective against the parasite eggs and therefore must be repeated several times at about 14 day intervals to prevent reinfestation.

Sarcoptic mange may cause severe debilitating disease in both wild and domestic foxes. Clinical signs resemble those seen in dogs, with potentially severe pruritic dermatitis characterized particularly by hyperkeratosis (thickening of affected skin). Treatments used are those commonly recommended in dogs; in addition, the use of ivermectin should be considered (Yazwinski, Pote, Tilley *et al.*, 1981).

- b. **Helminths:** Roundworms (*Toxocara*, *Toxascaris*), hookworms (*Ancylostoma*) and tapeworms (*Dipuyidium* and *Taenia*) are all of concern in foxes. The species encountered are those seen in dogs and may be treated in a similar fashion.

Heavy larval roundworm infestation in fox pups may occur in utero resulting in liver and lung damage and leading to a potbelly from massive accumulations of adults in the gut by about three or four weeks of age. Treatment with piperazine or other more broad spectrum anthelmintics repeated several times at about three week intervals, beginning when the kits are two to three weeks old, is usually effective and safe.

4. Infectious Diseases

Foxes are susceptible to a variety of bacterial and viral infections, only a few of the more common of which will be mentioned here.

- a. **Botulism:** Causes of this acute form of food poisoning, as well as measures for its prevention, have been outlined above under "Prevention". Signs of an outbreak are its sudden onset in numerous animals which will exhibit, in rapid succession, a flaccid paralysis, abdominal breathing, coma, and death. Blue or Arctic foxes are seemingly more susceptible than other species to this toxin (Barker, Povey and Voigt, 1983).
- b. **Colibacillosis:** Colon organisms under certain circumstances will cause a severe gastroenteritis in neonatal foxes. The signs are a severe diarrhea, dehydration, and rapid death. A generalized septicemia may also occur following umbilical infection with these organisms (Finley, 1979). Nest box hygiene is important in prevention. Treatment of affected neonates is not generally practicable, although antibiotic therapy may be attempted.
- c. **Salmonellosis:** Septicemias involving the nervous system and leading to abortion in vixens are among the signs reported from *Salmonella typhimurium* infections. Foxes under stress are seemingly highly susceptible to this organism.
- d. **Distemper:** The virus of this disease is common to dogs, ferrets, foxes, mink, raccoons, and skunks. Signs of the disease are the same as in dogs, with the incubation period being about two weeks. A combined mink vaccine against distemper, botulism and virus enteritis is sometimes used; however, as virus enteritis does not occur in foxes, and botulism should not be a threat to the properly managed research unit, it is probably much more appropriate to use a combined canine distemper-hepatitis vaccine. Young animals should receive a first vaccine at eight to ten weeks and a distemper booster vaccination in the winter when about ten months old.
- e. **Infectious Canine Hepatitis (Fox Encephalitis):** Both the encephalitis and hepatitis types are seen in foxes. Signs of the latter include anorexia, vomiting, diarrhea, jaundice, and convulsions. The virus may be spread by dogs. Prevention is by vaccination (see above under Distemper). As a single hepatitis vaccination will last for life, the combined vaccine does not need to be used for the booster inoculation.

- f. **Rabies:** Foxes are highly susceptible to rabies infection and the major cause of its spread under wild conditions. The disease, however, should not be a problem in domesticated foxes. It is important that all personnel working with wild foxes, both under captive conditions and in field studies, be fully familiar with the various signs suggestive of rabies in this species (Ag. Cda, 1979; Sikes, 1981). Consideration should be given to having all in-contact persons vaccinated for rabies.

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