LIFE HISTORY CHARACTERISTICS OF THE GENUS *MUSTELA*, WITH SPECIAL REFERENCE TO THE BLACK-FOOTED FERRET, *MUSTELA NIGRIPES*

by Steve Forrest

Tim W. Clark

Louise Richardson
BIOTA Research and Consulting Inc.
Box 2705
Jackson, Wyoming 83001
and
Dept. of Biology
Idaho State University
Pocatello, Idaho 83209

Dean Biggins
U.S. Fish and Wildlife Service
Denver Wildlife Research Center
Sheridan, Wyoming

Kathleen Fagerstone
U.S. Fish and Wildlife Service
Denver Wildlife Research Center
Denver, Colorado

Thomas M. Campbell III
BIOTA Research and Consulting Inc.
Jackson, Wyoming
and
Idaho State University
Pocatello, Idaho

ABSTRACT

Life history characteristics of ten mustelid species congeneric or taxonomically related to the black-footed ferret (*Mustela nigripes*) are presented. Commonly held attributes of the genus and related species (*Martes spp.*) are high turnover rates, high juvenile mortality, and low (1 yr. or less) average life spans. Reproductive strategies among the group differ, with an apparent lack of delayed implantation in some members of the genus possibly due to their different resource exploitation strategies. Black-footed ferrets in Wyoming bear 3.38 young/year, exhibit equal juvenile sex ratios, and females breed and bear young at 1 year of age. Large annual declines (disappearance) of ferrets (55-75%) has been observed.

INTRODUCTION

The discovery of black-footed ferrets (*Mustela nigripes*) in northwest Wyoming in 1981 has provided a new opportunity to gather life history information on this endangered and secretive mammal. What is known regarding this species comes from accounts from naturalists in the late 1800s and early part of this century (e.g., Coues 1877, Cary 1911, Seton 1929), from a small population studied from 1964-1972 in South Dakota (Hillman 1968, Henderson et al. 1969, Fortenbery 1972), from studies of a few captive animals at the Patuxent Wildlife Research Laboratory from 1972-78 (Carpenter and Hillman 1978, Carpenter et al. 1981), and from our present studies underway at Meeteetse.

This paper briefly reviews life history attributes for some congeneric and taxonomically related species of mustelids and compares these to our general impressions of black-footed ferret life history.

We would like to acknowledge financial support for these studies from the New York Zoological Society-Animal Research and Conservation Center, Wildlife Preservation Trust International, Inc., World Wildlife Fund-U.S., Charles A. Lindbergh Fund and the Endangered Species Program, U.S. Fish and Wildlife Service. We are deeply indebted to the many field personnel who spent long hours collecting observations, and would like to thank the Meeteetse ranchers for their patience and other agency personnel for their assistance, particularly Tom Thorne, DVM, Wyoming Game and Fish, for his veterinary expertise.

REVIEW

Life history attributes for selected mustelids are summarized in Table 1. Taxonomically, the closest relatives of *M. nigripes* in this group are the European polecat (*M. putorius*), the Siberian polecat (*M. eversmanni*) and the fitch ferret (*M. furo*) (Anderson 1977; Youngman 1982). The fitch ferret is a domesticated strain of either the European or Siberian polecat (Corbet and Southern (1977).

Comparisons within the species *Mustela* indicate many similarities in biological attributes (Table 1). Differences in reproductive and life history strategies (evolutionary time) and tactics (ecological time) noted in this group have been variously attributed to differences in species body size and bioenergetics, differences in exploitation of food resources, and variation in responses to resource condition (Powell 1979, Simms 1979, King 1983a, 1983c, Moors 1980, Powell and Zielinksi 1983). King (1983a) describes opportunist and equilibrium species in the Mustelidae as r- and K-strategists, with opportunists dependent on highly variable (unstable) food resources versus equalibrium species associated with resources having a long duration stability. Opportunists generally have high fecundity (8-10 ova/female/year in *M. erminea* - King 1983a) versus equilibrium species with low fecundity (1-4 ova/female/year in *Martes americana* - Strickland et al. 1982). Polecats (*M. putorius*) represent an "intermediate" species in this scheme, as presumably would black-footed ferrets.

Table 1. Some life history parameters for selected Mustelidae

POPULATION PARAMETERS FOR SELECTED MUSTELIDAE

	MARTES PENNANTI Fisher	MARTES AMERICANA Pine Marten	MUSTELA FRENATA Long-Tailed Weasel	MUSTELA ERMINEA Short-Tailed-Weasel, Ermine, Stoat	MUSTELA NIVALIS Least Weasel
AGE OF SEXUAL MATURITY	1 yr (M; probably not effective until 2nd yr)[22] 1 yr (F)[10]	15 mo[9]	1 yr (M)[2] 3-4 mo (F)[2]	1 yr (M)[2] 3-4 mo (F)[2] 5-6 wk[12]	3-4 mo (M)[2] 3-4 mo (F)[2]
FEMALE AGE AT FIRST REPRODUCTION	2 yr[10] Delayed implant	2 yr[9] Delayed implant	Delayed implant	1 yr (almost all females every year)[10] Delayed implant	3-4 mo[12]
AVERAGE NUMBER PER LITTER: Means	3[10] 2.5-2.75[22]	3[9]	6.8[25]	6.1[25]	5-6[12] 4.8[25]
Ranges	—	1-4[9]	6-9[2] 2-9[25]	6-9[2] 4-9[25] 4-13[24]	3-6[2] 1-10[25]
JUVENILE SEX RATIO	45:55 (NSD 1:1)[10]	1:1[9]	—	1:1[24]	1:1[14,30]
INTERVAL BETWEEN LITTERS	1 yr; 5-15% females barren annually[10]	1 yr[9]	1 yr[2]	1 yr[2]	2-3/yr[15] 2/yr (peak microtus)[23] 2nd litter if 1st is lost[29]
AGE SPECIFIC MORTALITY: % cohort dying	M[10] F[10] All[11]	M[9] F[9]	--	5 pop. aggreg.[16] All[24]	All[23] M[28] F[28]
in Year 1	70% 70% 50%	50% 54%		51% 37-90%	75-80% 80% 75%
Year 2	— — 20%	20% 15%		25%	
Year 3	— — 12%	13% 12%		14%	
Year 4	1% 9% 7%	5% 5%		6%	
Year 5+	11%	7% 15%		4%	
				97% annual turnover males; 89% annual turnover females; about 12-mo mean life span[12]	
REPRODUCTIVE LIFE SPAN	M: 8 yr (wild)[22] F: 10 yr (wild)[22] 7 yr (both sexes)[9]	12 yr (both sexes)[9]	—	4-6 yr (both sexes)[6] 6-7 yr (both sexes)[16]	3 yr (both sexes)[2]

1 Danilov and Rusakov 1969
2 Svendsen 1982
3 Hillman 1968
4 This study
5 Danilov and Tomanov 1975
6 Jackson 1961
7 Enders 1952
8 Liscombe et al. 1982
9 Strickland et al. 1982a
10 Strickland et al. 1982b
11 Kelly 1977
12 King, pers. comm.
13 Youngman 1982
14 King 1975a
15 Heidt et al. 1968
16 Stroganov 1937
17 Neal et al. 1977
18 Williams 1976
19 Walton 1970
20 Stroganov 1962
21 Walton 1976
22 Powell 1982
23 King 1983a
24 King 1983b
25 Heidt 1970
26 Carpenter et al. 1981
27 Corbet and Southern 1977
28 King 1980
29 Mead and Wright 1983
30 King 1975b
31 C. E. Svendsen, pers. comm.
32 Linder et. 1972

MUSTELA FURO Fitch Ferret	MUSTELA PUTORIUS European Polecat	MUSTELA EVERSMANNI Siberian Polecat	MUSTELA NIGRIPES Black-Footed Ferret	MUSTELA VISON American Mink	MUSTELA LUTREOLA European Mink
1 yr (M)[17]	1 yr (M)[1,21]	9 mo[20]	1 yr (M)[3] 1 yr (F)[3]	10 mo[7]	1 yr (?)[5]
1 yr[18]	1 yr[5]	—	1 yr[4]	1 yr (not all)[8] ,Delayed implant	—
8[18]	6.1[1,5]	8-9[20]	3.40[32] 3.38[4]	4[8] 4.6[25]	4.7[13] 4.5[5]
5-15[18]	5-8[27] 1-12[1,5]	4-14[20]	4-5[3] 1-5[4] 3-5[25]	1-8[8] 3-6[23] 1-9[25]	2-7[13] 3-6[5]
—	—	—	1:1[4]	—	1:1[13]
2/yr[18]	1/yr[19] 2nd litter if 1st is lost[29]	1 yr[20] 2nd litter if 1st is lost[29]	1/yr[3,4]	1/yr[5]	1/yr[5]
—	8 mo mean life span[27]	30% in nest 31 (captive)	—	65-75%[8]	—
2-5 yr (13 yr max)[18]	4-5 yr max[27]	8 yr (captive)[31]	M: 6 yr (captive)[26] F: 11+ yr (captive)	—	—

One important variant within the species not directly accounted for by resource exploitation strategies is the evolution of delayed implantation in only some members of the taxon. The polecats (M. putorius) are not delayed implanters, nor are M. nivalis or M. lutreola. M. eversmanni is somewhat ambiguous, with no evidence of delayed implantation in some populations (Stroganov 1962) to instances where some delay may have occurred (G. E. Svendsen, pers. comm.). Where there is no delayed implantation, ovulation may be stimulated by coitus in the event a first litter is aborted or lost (Mead and Wright 1983). In the extreme, M. nivalis may produce two successful litters/year when resources are optimal (C. M. King pers. comm.).

Although extensive information on mortality and survivorship for many mustelids are not available, the studies cited in Table 1 and other population work (M. furo - Moors and Lavers 1981, Lavers 1973. M. erminea - King and McMillan 1982) indicate that high turnover rates, mean life expectancies of a year or less, and high (50% or greater) juvenile mortalities are commonly held attributes in populations of all these species.

OBTAINING INFORMATION ON BLACK-FOOTED FERRET LIFE HISTORY PARAMETERS AT MEETEETSE

Because the extent of the population of ferrets at Meeteetse was initially unknown, our studies were designed to extract maximum data while disturbing the population as little as possible (Clark 1984). We therefore focused data collection on a few key life history attributes we could derive simply through observation and on intensive radio-telemetry and marking of a relatively small part of the population. Although this strategy did not address many aspects of ferret biology, (e.g. reproductive physiology), we have investigated the more crucial questions of immediate concern regarding the welfare of this population, such as aboveground productivity rates, general rates of change in population numbers, and mortality sources and estimates. These efforts give an emerging picture of ferret life history not unlike other members of the genus Mustela which have been studied more intensively.

Because M. nigripes spends much of its life underground, collecting precise data on many species of its life history in the field is not presently possible and may be more appropriately addressed in the laboratory. Among these are birth rates in the nest and breeding and maternal behavior. Recovery of carcasses of dead ferrets to determine cause and age at death has also proven difficult, probably because many of these remains stay below ground.

Techniques used to locate and study black-footed ferrets have been discussed elsewhere in this workshop (Campbell et al.; Richardson et al.; Biggins et al.; Fagerstone et al.; Thorne et al.), and will only be briefly mentioned here. The three basic activities in which life history data are collected are:

1. Summer counts by spotlighting to count the total number of litters produced, number of young associated with each litter, and counts of other adults (males or non-breeding females) present.

2. Winter counts by snow-tracking and observation of sign to obtain independent minimum counts, to recover ferret remains, and to sample disappearance rates.

3. Trapping and marking for sex ratios of adults and juveniles, life spans, and sources of and age-specific disappearance and mortality.

BLACK-FOOTED FERRET LIFE HISTORY

Reproduction

Aboveground litter counts reported from South Dakota indicate a mean of 3.40 young per litter from 11 litters observed from 1964-1972 (range=3-5) (Linder et al. 1972). Carpenter et al. (1981) reported one litter of 5 stillborn in captivity. One trapped litter of 5 young was reported from South Dakota (Garst 1954). We observed a mean litter size of 3.38 young per litter from 55 litters observed in Wyoming (range=1-5). The juvenile sex ratio (Table 1) is a preliminary estimate based on juveniles trapped aboveground.

Carpenter and Hillman (1978) observed captive ferrets breeding in late March and early April, with a gestation of 45 days. A simulated growth curve for small mustelids (Stromberg et al. 1983, unpubl. data) based on data for young M. eversmanni (Svirdenko 1935) and a sigmoidal growth equation is shown in Figure 1. Comparisons using this curve with estimated sizes of young observed aboveground in South Dakota and Wyoming suggests parturition occurs from mid to late May.

No delayed implantation has been suggested for this species. One marked yearling female reared a litter in 1984. Our observations indicate that not all females in Meeteetse are successful at producing litters every year.

Ferret Disappearance

Despite the fact that 38 young ferrets were produced in Mellette County from 1964-1972, only 9 total ferrets could be found for captive breeding from 1972-74. A high rate of mortality and/or emmigration would account for such losses in the population during that time. Our data suggest a large seasonal rate of numerical change at Meeteetse as well. It is difficult to classify animals which are found missing from the population as mortalities or emmigrants, because those which die underground or are wholly consumed by predators can be mistaken with those who simply leave the area. "Disappearance" accounts for all mortality, emmigration, and counting biases (where we cannot detect some animals which are actually present) where we cannot separate these causes.

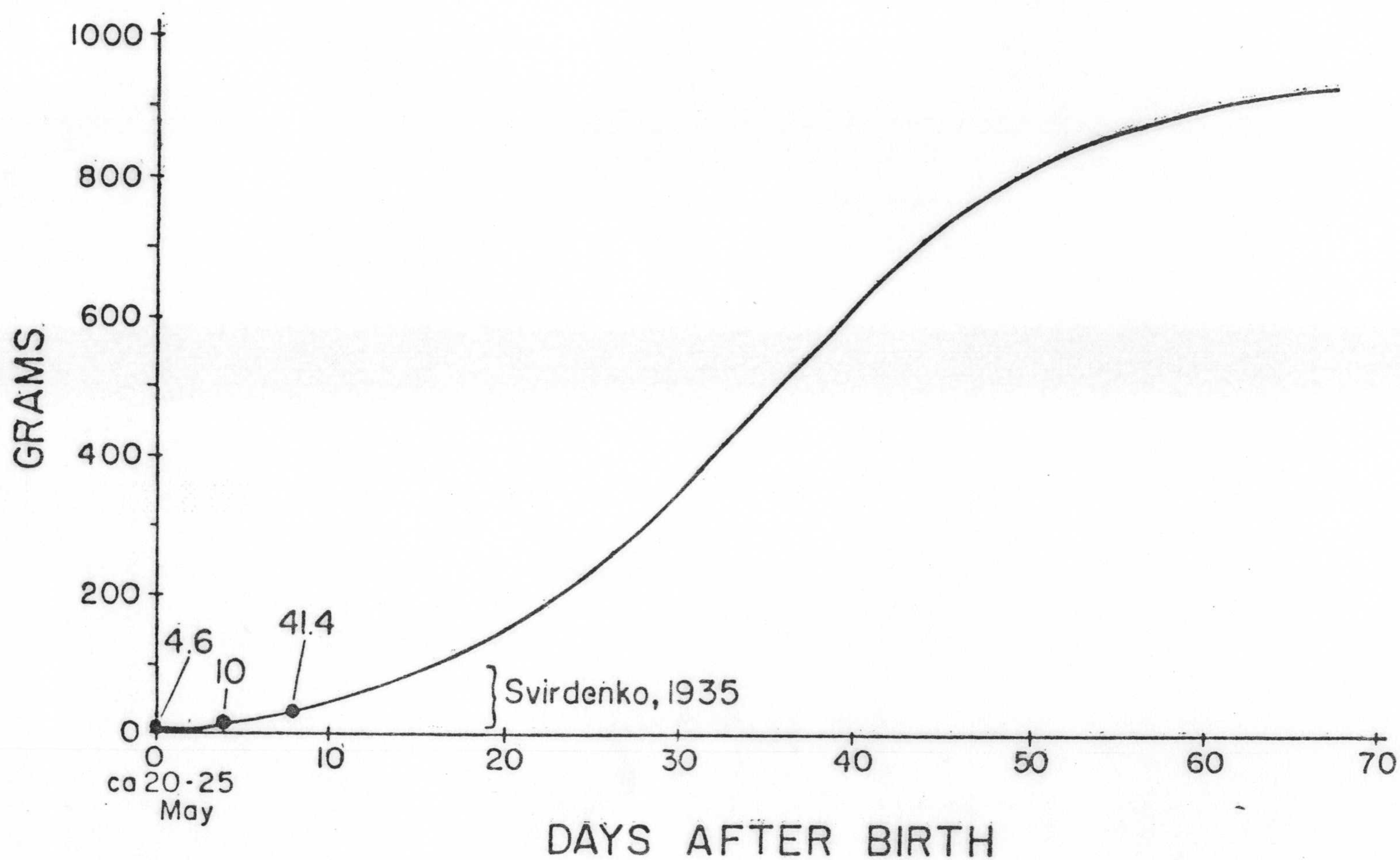

Figure 1. Hypothetical growth curve for a small mustelid (Stromberg et al. 1983, unpubl.)

High rates of disappearance have been noted for other mustelid populations studied in Table 1. We have observed annual declines in numbers of ferrets on one large colony at Meeteetse of 75 and 55% over 3 summers.

Ferret Mortality

Very little data exist on which to base even the roughest actuarial table on ferret survival. Most sources of ferret mortality can at best only be inferred. Studies of other mustelids indicate high rates of juvenile mortality, with equally high adult mortality (50% of each cohort/year-see Table 1). Mortality distributions listed in Table 1 are derived from age distributions found in "stable" populations.

Sources of ferret mortality can be broken down into four general areas:

1. Resource related. It has often been stated that reduction of prairie dogs through their former range is the principal cause for the current endangered status of the black-footed ferret (Cahalane 1954; Hillman and Clark 1980). It is clear that social interactions and spacing behavior around food resources in other mustelids is extremely important in regulating mortality and reproductive success (Powell 1979; King 1983a). The South Dakota experience suggests that when habitat (prairie dog) reduction leads to a single small ferret population clustered around a small food resource, population decline is likely. The incidence of genetically linked diseases in that population and the inability to bear viable young in one female (Carpenter et al. 1981) suggests inbreeding as one possible cause of decline.

2. Disease. In addition to the genetically linked and probably aberrent occurrence of diabetes melitus and neoplasm tumors found in the South Dakota ferrets (Carpenter et al. 1981), diseases which may be fatal to ferrets include canine distemper (Carpenter et al. 1976), and human influenza virus (Thorne et al., these proceedings). Domestic ferrets (M. furo) have been found infected with Aleutian Disease, a disease common to ranch mink (M. vison) (Porter et al. 1982). It is not known whether ferrets are susceptible to sylvatic plague, which is endemic in most prairie dog populations and often responsible for population collapses in prairie dog populations during epizootic outbreaks (Lechleitner 1962).

3. Human related. Human related mortalities (shooting, trapkills, roadkills, poisoning, attacks by domestic pets) were probably historically important sources of mortality (Henderson et al. 1969). We also cannot disregard the possibility that environmental contaminants have caused black-footed ferret mortality or reduced reproductive success. Halogenated biphenyls (PCB's etc.) are quite toxic to M. vison (Aulerich and Ringer 1977, Platonow and Karstad 1973) but less so to M. putorius (Bleavins et al. 1980, Shull et al. 1982). PCB's have been found in wild mink from areas with no recognized source of this pollutant (O'Shea et al. 1981). No toxicity studies have been

conducted on black-footed ferrets, but they could conceivably receive doses of environmental contaminants concentrated by their prey.

It is possible that extant populations unknown to us at this time may be subjected to some ongoing mortalities. However, the contribution of human-associated mortality on a protected population, such as Meeteetse, seem extremely low.

4. Predation. Predation appears to represent a significant regulating factor in natural populations of ferrets. Evidence of predation is noted from Pleistocene skeletal materials at January Cave, Alberta (J. A. Burns, pers. comm.). Sperry (1941) found ferret hair in stomachs of 3 coyotes (Canis latrans) collected in Montana. Henderson et al. (1969) noted badgers (Taxidea taxus), bobcats (Lynx rufus), golden eagles (Aquilla chrysaetos), great-horned owls (Bubo virginianus), and "various hawks" as potential predators based on field observations from South Dakota. Our own observations from Wyoming suggest that both avian and mammalian predators are contributing to ferret mortality. Studies are currently underway to quantify the contributions to mortality by the various predator groups.

DISCUSSION

Research on rare and protected species is primarily conducted through observation of live animals in the field. For this reason, detailed demographic analyses such as those for other mustelids taken for fur or sport is lacking (King 1983a). Erlinge (1983) states that long-term live-trapping studies with background data on prey populations and other components of the community are required to obtain an overall understanding of demography and dynamics in mustelid populations. Even when this is undertaken properly, some attributes of the population will only be partially known. As in other studies of small mustelids we may have to be satisfied with general notions like disappearance or turnover to describe rates-of-change in the population (Moors and Lavers 1981; King and McMillan 1982; King 1980).

We can utilize comparative studies on less sensitive yet closely related species, such as M. furo in the wild (Lavers 1973; Moors and Lavers 1981) and other Mustela to fill some of these voids while avoiding too intrusive a research program on the small existing population. I* is likely that our estimates for the upper and lower bounds of various life history attributes will have to be sufficient to construct models which explicitly recognize our lack of precise estimates for the attributes involved.

Some of the general characteristics of this genus which appear consistent with observations from Meeteetse include:

1. High turnover (or disappearance) rates. Observation of rates-of-change and survivorship of some marked animals at Meeteetse substantiate this.

2. Short reproductive lives in the wild (ca. 4 years) and average life spans less than a year. Long-term (10+ years) studies of the type currently conducted will be required to verify this, but high turnover implies high mortality in all age classes.

3. The suspected lack of delayed implantation suggests that black-footed ferrets may not be obligately bred at only one time and may maintain a capacity to produce more than one litter per year. The implications for artificially raising additional litters born in one year are great if this phenomenon can be verified in this species. However, field observations have not verified the presence of "late" litters to date.

Unlike most of this genus, however, black-footed ferrets appear to be associated with only one type of habitat; prairie dogs. Despite small gains in natality or survivorship, limited habitat at Meeteetse insures that the only known population cannot expand indefinitely. If, as King (1983a) suggests, that "intermediate" mustelids, like black-footed ferrets, are adapted for expansion into new habitats, then we should take every opportunity to assist them to do so, and in the process learn more of this endangered mammal.

LITERATURE CITED

Anderson, E. A. 1977. Pleistocene Mustelidae (Mammalia, Carnivora) from Fairbanks, Alaska. Bull. Mus. Comp. Zool. 148:1-21.

Aulerich, R. J. and R. K. Ringer. 1977. Current status of PCB toxicity to mink, and effects on their reproduction. Arch. Environ. Contam. Toxicol. 6:279-292.

Bleavins, M. R., R. J. Aulerich, and R. K. Ringer. 1980. Polychlorinated biphenyls (Arclors 1016 and 1242): Effects on survival and reproduction in mink and ferrets. Arch. Environ. Contam. Toxicol. 9:627-635.

Cahalane, V. H. 1954. Status of the black-footed ferret. Journal of Mammalogy 35:418-424.

Carpenter, J. W., J. G. Appel, R. C. Erickson, and N. N. Meliton. 1976. Fatal vaccine-induced canine distempter virus infection in black-footed ferrets. Journal of American Veterinary Med. Association 169:961-964.

Carpenter, J. W. and C. N. Hillman. 1978. Husbandry, reproduction and veterinary care of captive ferrets. Proceedings of the American Association Zoo. Vet., Knoxville, Tennessee. 36-47.

Carpenter, J. W., N. N. Meliton, and H. E. Kaiser. 1981. Neoplasia and other disease problems in black-footed ferret: implications for an endangered species. In: Neoplasms: Comparative pathology of growth in animals, plants, and man. H. E. Kaiser, ed., 739-746.

Cary, M. 1911. Biological survey of Colorado. USDA Bur. Biol. Surv., N. Amer. Fauna No. 33:184-185.

Clark, T. W. 1984. Strategies in endangered species conservation: A research view of the ongoing black-footed ferret conservation program. In: Issues and technology in the management of impacted western wildlife. Thorne Ecological Institute, Boulder, Colo., 145-154.

Clark, T. W., T. M. Campbell, M. H. Schroeder and L. Richardson. 1984. Handbook of methods for locating black-footed ferrets. Wyoming Bureau of Land Management Technical Bulletin No. 1, 55 pp.

Corbet, G. B. and H. N. Southern. 1977. Handbook of British mammals, 2nd ed. Blackwell Scientific Publ., Oxford. 520 pp.

Coues, E. 1877. The fur-bearing animals of North America. Estes and Lauriat, Boston, 147-157.

Danilov, P. I. and O. S. Rusakov. 1969. The ecology of the polecat. M. putorius, in northwest European Russia. In: Biology of Mustelids: Some Soviet Research, Vol. 2. Science Information Div., Department Science and Ind. Res., New Zealand, 24-35.

Danilov, P. I. and I. L. Tumanov. 1975. Female reproductive cycles in the Mustelidae. In: Biology of Mustelids: Some soviet research, Vol. 2, 1980. Science Info. Div., of Scientific and Indust. Res., Wellington, New Zealand, 81-92.

Enders, R. K. 1952. Reproduction in the mink. Proceedings American Phil. Society 96:691-755.

Erlinge, S. 1983. Ecological research on mustelids. Acta Zool. Fennica 174:167-168.

Fortenbery, D. K. 1972. Characteristics of black-footed ferrets. U.S.D.I., F.W.S. Res. Pub. 109:1-8.

Garst, W. E. 1954. Black-footed ferret in South Dakota. Journal of Mammalogy 35:594.

Heidt, G. A., M. K. Peterson, and G. L. Kirkland. 1968. Mating behavior and development of least weasels in captivity. Journal of Mammalogy 49:413-419.

Heidt, G. A. 1970. The least weasel. Michigan State University Mus. Publ. Biol. Serv. 4:230-283.

Henderson, F. R., P. F. Springer and R. Adrian. 1969. The black-footed ferret in South Dakota. South Dakota Department Game, Fish and Parks, Technical Bulletin No. 4, 37 pp.

Hillman, C. N. 1968. Life history and ecology and the black-footed ferret in the wild. M.S. Thesis, South Dakota State University, Brookings. 28 pp.

Hillman, C. N. and T. W. Clark. 1980. Mustela nigripes. Mammal. Spec. 3:1-3.

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

Kelly, G. M. 1977. Fisher biology in the White Mountain National Forest and adjacent areas. Ph.D. Dissertation, University of Massachusetts, Amherst. 178 pp.

King, C. M. 1975a. The home range of the weasel (M. nivalis) in an English woodland. Journal of Anim. Ecol. 44:639-668.

King, C. M. 1975b. The sex ratio of trapped weasels (Mustela nivalis). Mammal Rev. 5:1-8.

King, C. M. 1980. Population biology of the weasel M. nivalis on British game estates. Holarctic Ecology 3:160-168.

King, C. M. 1983a. Factors regulating mustelid populations. Acta Zool. Fennica 174:217-220.

King, C. M. 1983b. Mustela erminea. Mammalian Species 195:1-8.

King, C. M. 1983c. The life-history strategies of Mustela nivalis and M. erminea. Acta Zool. Fennica 174:183-184.

King, C. M. and C. D. McMillan. 1982. Population structure and dispersal of peak-year cohorts of stoats (Mustela erminea) in two New Zealand forests, with especial reference to control. New Zealand Journal Ecol. 5:59-66.

Lavers, R. B. 1973. Aspects of the biology of the ferret (M. putorius forma furo) at Pukepuke lagoon. Proc. New Zealand Ecol. Soc. 20:7-12.

Lechleitner, R. R., J. V. Tileston and L. Kartman. 1962. Die-off of a Gunnison's prairie dog colony in central Colorado. I. Ecological observations and descriptions of the epizootic. Zoonoses Research 1:185-199.

Linder, R. L., R. B. Dahlgren, and C. N. Hillman. 1972. Black-footed ferret-prairie dog interrelationships. In: Proc. Sympos. on Rare and Endangered Wildlife of the Southwestern U.S., September 22-23, 1972, Albuquerque, New Mexico, New Mexico Department Game and Fish, Santa Fe. 22-37.

Linscombe, G., N. K. Kinler, and R. J. Aulerich. 1982. Mink. Pp. 629-643 In Wildlife Mammals of North America. J. A. Chapman and G. A. Feldhamer, Eds., John Hopkins University Press, Baltimore.

Mead, R. A. and P. L. Wright. 1983. Reproductive cycles of Mustelidae. Acta Zool. Fennica 174:169-172.

Moors, P. J. 1980. Sexual dimorphism in the body size of mustelids (Carnivora): the roles of food habits and breeding systems. Oikos 34:147-158.

Moors, P. J. and R. B. Lavers. 1981. Movements and home range of ferrets (Mustela furo) at Pukepuke Lagoon, New Zealand. New Zealand Journal Zool. 8:413-422.

Neal, J., B. D. Murphy, W. H. Moger, and L. W. Oliphant. 1977. Reproduction in the male ferret: Gonadal activity during the annual cycle; Recrudescence and maturation. Biol. of Reprod. 17:380-385.

O'Shea, T. J., T. E. Kaiser, G. E. Askins, and J. A. Chapman. 1981. Polychlorinated biphenyls in a wild mink population. In: Proc. Worldwide Furbearer Conf., August 3-11, 1980, Frostburg, Maryland. pp. 1746-1752.

Platonow, N. S. and L. H. Karstad. 1973. Dietary effects of polychlorinated biphenyls on mink. Canadian. Journal Comp. Medicine 37:391-400.

Porter, H. G., D. D. Porter and A. E. Larsen. 1982. Aleutian disease in ferrets. Infection and Immunity 36:379-386.

Powell, R. A. 1979. Mustelid spacing patterns: Variations on a theme by Mustela. Zeit. Tierpsychol. 50:153-165.

Powell, R. A. 1982. The fisher: Life history, ecology, and behavior. University Minnesota Press, Minneapolis, 217 pp.

Powell, R. A. and W. J. Zielinski. 1983. Competition and coexistence in mustelid communities. Acta Zool. Fennica 174:223-227.

Seton, E. T. 1929. Lives of game animals, Vol. II. Doubleday, Doran and Co., Garden City, New York, 565-574.

Shull, L. R., M. R. Bleavins, B. A. Olson, and R. J. Aulerich. 1982. Polychlorinated biphenyls (Arochlors 1016 and 1242): Effect on hepatic microsomal mixed function oxidases in mink and ferrets. Arch. Environ. Contam. Toxicol. 11:313-321.

Simms, D. A. 1979. North American weasels: Resource utilization and distribution. Canadian Journal Zool. 57:504-520.

Sperry, C. C. 1941. Food habits of the coyote. U.S. Fish and Wildlife Service Wildlife Res. Bulletin 4, 70 pp.

Strickland, M. A., C. W. Douglas, M. Novack and N. P. Hunziger. 1982a. Marten. In: Wild Mammals of North America. J. A. Chapman and G. A. Feldhamer, eds., 599-612.

Strickland, M. A., C. W. Douglas, M. Novack and N. P. Hunziger. 1982b. Fisher. In: Wild Mammals of North America. J. A. Chapman and G. A. Feldhamer, eds., 586-598.

Stroganov, S. U. 1937. A method of age determination and an analysis of the age structures of ermine populations (M. erminea). In: Biology of mustelids: Some Soviet Research Vol. 2. Sci. Information Div., Dept. Sci. and Ind. Res., New Zealand. 93-108.

Stroganov, S. U. 1962. Carnivorous mammals of Siberia. Acad. of Sci. of the USSR, Siberian Branch, Biol. Institute. Translation: Israel Prog. for Sci. Transl., Jerusalem, 1969. 381-394.

Stromberg, M. R., R. L. Rayburn and T. W. Clark. 1983. Black-footed ferret prey requirements. Journal of Wildlife Management 47:67-73.

Svendsen, G. E. 1982. Weasels. In: Wild mammals of North America. J. A. Chapman and G. A. Feldhamer, eds., John Hopkins University press, Baltimore, 613-628.

Svirdenko, P. 1935. The light ferret (Putorius eversmanni) and its economic importance. Akademiia Nank Inst. Zashcity Rastenii. Trudy po Zashchite Rastenii. Ser. 4, Vyp. 4, Leningrad, USSR, 4 pp.

Walton, K. C. 1970. The polecat in Wales. Welsh Wildlife in Trust: 93-108.

Walton, K. C. 1976. The reproductive cycle in the male polecat. (M. putorius) in Britain. Journal Zool. London 180:498-503.

Williams, C. S. F. 1976. Practical guide to laboratory animals. C. V. Mosby Co., St. Louis, 65-71.

Youngman, P. M. 1982. Distribution and systematics of the European mink Mustela lutreola Linnaeus 1761. Acta Zool. Fennica 166:1-48.