Felis lynx.   By Renn Tumlison

Felis lynx Linnaeus, 1758

Lynx

Felis lynx Linnaeus, 1758:43. Type locality near Upsala, Sweden.
Lynx vulgaris Kerr, 1792:157. Type locality Sweden (=*Felis lynx* Linnaeus).
Lynx canadensis Kerr, 1792:157. Type locality eastern Canada (=Quebec).
F(*elis*) *borealis* Thunberg, 1798:14. Type locality forests of northern Sweden.
Felis kattlo Schrank, 1798:52. Type locality Bohemia.
Felis lyncula Nilsson, 1820:14. Type locality Scandinavian forests.
Felis cervaria Temminck, 1824:106. Type locality Asia.
Felis pardina Temminck, 1824:116. Type locality Lisbon, Portugal.
Felis lupulinus Thunberg, 1825:189. Type locality North Scandinavia.
Felis vulpinus Thunberg, 1825:192. Type locality Uppsala, Sweden.
Felis virgata Nilsson, 1829:pls. 3-4. Type locality Sweden.
Felis isabellina Blyth, 1847:1178. Type locality Tibet.
Lynx cervaria Fitzinger, 1870:108. Type locality Norway.
Lynx subsolanus Bangs, 1897:49. Type locality Codroy, Newfoundland.
Lynx pardella Miller, 1907:398. Type locality Coto Doñana, Huelva, Spain (new name for *pardina* Temminck thought to have been preoccupied by *Lynx pardina* Oken).
Lynx sardiniae Mola, 1908:48. Type locality Nuoro, Sardinia.

CONTEXT AND CONTENT. Order Carnivora, Family Felidae, Subfamily Felinae, Genus *Felis*, Subgenus *Lynx*. *Lynx* is here recognized as a subgenus in compliance with taxonomic arguments by Van Gelder (1977), although Kratochvil (1975) believed subfamilial classification (Lyncinae) might be justified. The number of genera, species, and subspecies is much debated. Matjuschkin (1978) and Werdelin (1981) suggested that *lynx*, *canadensis*, and *pardina* are specifically distinct under the generic designation *Lynx*. The context and content used herein is not definitive, but is a conservative view of lynx taxonomy, treating these forms as subspecies. The subgenus *Lynx*, then, includes two extant species: *F. lynx* and *F. rufus*. At least eight subspecies are recognized (Corbet, 1978):

F. l. canadensis (Kerr, 1792:157), see above (*mollipilosus* Stone is a synonym).
F. l. isabellina Blyth, 1847:1178, see above (*tibetanus* Gray, *kamensis* Satunin, and *wardi* Lydekker are synonyms).
F. l. kozlovi (Fetisov, 1950:21). Type locality Barun-Burinkhan, Salenginskiy region, Buryatskaya ASSR, USSR.
F. l. lynx Linnaeus, 1758:43, see above (*vulgaris* Kerr, *borealis* Thunberg, *kattlo* Schrank, *lyncula* Nilsson, *cervaria* Temminck, *lupulinus* Thunberg, *vulpinus* Thunberg, *virgata* Nilsson, *orientalis* Satunin, *dinniki* Satunin, *wrangeli* Ognev, *alba* Kerr, *melinus* Kerr, *baicalensis* Dybowski, and *guttata* Smirnov are synonyms).
F. l. pardina Temminck, 1824:116, see above (*pardella* Miller is a synonym).
F. l. sardiniae (Mola, 1908:48), see above.
F. l. stroganovi Heptner, 1969:1260. Type locality Glazkovka, Supunskiy reserve, Primorsk territory, Lake Baikal, USSR (new name for *Lynx lynx neglectus* Stroganov, preoccupied by *Felis neglecta* Gray).
F. l. subsolanus (Bangs, 1897:49), see above.

DIAGNOSIS. Lynxes are distinguished from other *Felis* by the slender nasal branch of the premaxilla, the thinner, less depressed, and sharper postorbital processes, shallower notching of the suborbital edge of the palate, and proximity to the canine and

more forward setting of P3 (Pocock, 1917*a*). In the Nearctic, *F. lynx* differs from *F. rufus* in the following: black tip completely encircles tail; anterior condyloid foramen (hypoglossal canal) distinct from posterior lacerate (jugular) foramen; presphenoid wider (>6 mm); upper carnassial longer (>16.6 mm); interorbital breadth greater (>30 mm); smaller postorbital processes; and tail shorter than one-half length of hind foot (Durrant, 1952; Hall, 1981; Merriam and Stock, 1932). Palearctic *F. lynx* can be distinguished from the caracal (*Felis caracal*) by the former having spots on the fur and a facial ruff (Werdelin, 1981), and distinction of the anterior condyloid from the posterior lacerate foramen (Van den Brink, 1970). *F. l. pardina*, however, also has confluence of these foramina in common with the caracal, but differs from the caracal (and *F. l. lynx*) in having no metaconid on m1 (Van den Brink, 1970). The presphenoid is wide in *F. lynx* but narrow in *F. caracal* (Ognev, 1935; Van den Brink, 1970).

GENERAL CHARACTERS. Prime winter pelage consists of long, thick fur that is yellowish gray to grizzled grayish brown; summer pelage is shorter, more ragged, pale, and brownish (Durrant, 1952; Jackson, 1961; Saunders, 1961). Lynx fur is spotted to varying degree, depending on the subspecies. The ears are brown with a central silvery-gray spot, and terminate in long (approximately 4-5 cm) black ear tufts (Ognev, 1935). The eyelids, chin, inside of ears, underparts, and throat are white. A flared facial ruff, short tail, and short body with long legs are characteristic (Fig. 1). Digitigrade posture is supported by large, spreading, well-furred paws possessing five toes on the forepaw and four on the hind (McCord and Cardoza, 1982). The digits are joined by a web (No-
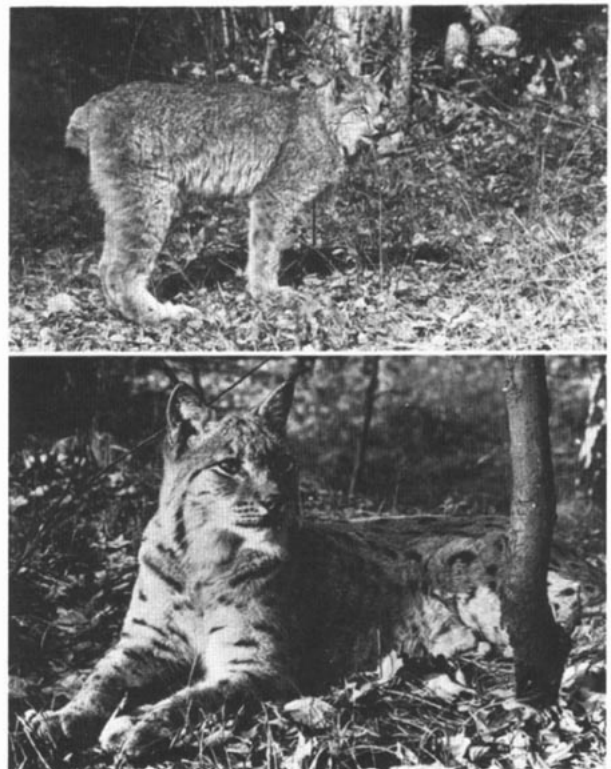

FIG. 1. Photograph of Canada lynx, *F. l. canadensis* (upper), by Tom J. Ulrich, and of European lynx, *F. l. lynx* (lower) from the Carpathian Mountains of Czechoslovakia by Josef Stehlík.
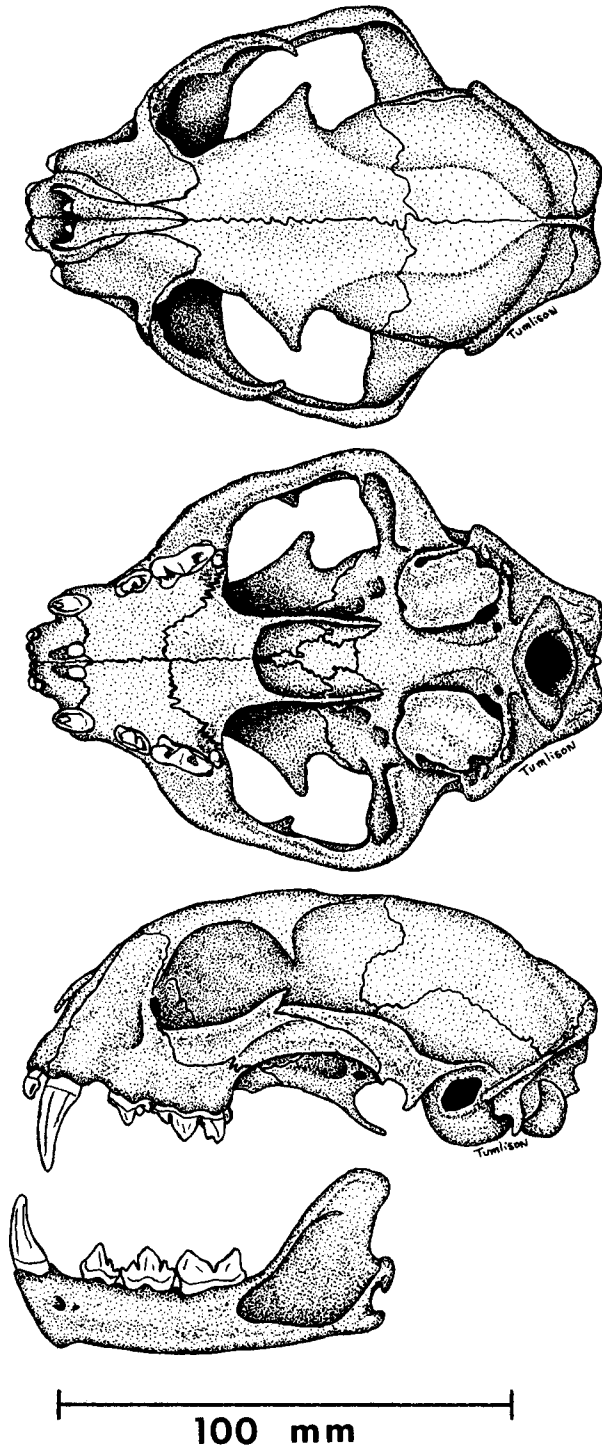
FIG. 2. Dorsal, ventral, and lateral views of skull and lateral view of mandible of *Felis lynx canadensis*. Uncataloged specimen from British Columbia, Canada, housed in the Arkansas State University Museum of Zoology (ASUMZ).

vikov, 1956). Claws are sharp and retractile. The eyes are prominent with ovoid pupils (Nawa, 1967).

The lynx is the largest of the bob-tailed cats, although bobcats are sometimes larger than Nearctic lynxes. Body masses of Nearctic lynxes range from 4.5 to 17.3 kg (Nava, 1970; Saunders, 1961, 1964). Palearctic lynxes are much larger, averaging 17.9 kg for males in Sweden (Haglund, 1966), and reaching 32.0 kg (Ognev, 1935). Kazlauskas and Matuzevicius (1970) reported an old female at 38 kg. Males are generally larger than females. Ranges of standard measurements (in mm) of lynxes from North America (Hall, 1981), northern Europe (Guggisberg, 1975), Russia (Novikov, 1956), Newfoundland (Saunders, 1964), Alberta (van Zyll de Jong, 1975),

and Alaska (Nava, 1970), respectively, as follows: total length, 825 to 954, 910 to 1,545, 820 to 1,050 (sans tail), 740 to 1,070, 780 to 1,050, 670 to 850; tail length, 95 to 125, 110 to 245, 200 to 310, 50 to 130, 80 to 120, 70 to 130; length of hind foot, 203 to 250, no data, no data, 190 to 260, 210 to 250, 180 to 250.

The permanent dental formula for *F. lynx* is i 3/3, c 1/1, p 2/2, m 1/1, total 28; for deciduous dentition, i 3/3, c 1/1, p 2/2, m 0/0, total 24 (Saunders, 1961, 1964). The skull of *F. l. canadensis* (Fig. 2) was described by Durrant (1952) as being large with small postorbital processes on the frontals, and having a transversely wide presphenoid constricted anteroposteriorly. The posterior palatine foramina are situated near the orbital rim of the palate, the anterior margin of the interpterygoid fossa is semicircular, and the anterior condyloid foramen is separate from the posterior lacerate foramen. The rostrum is abbreviated. Hall (1981) provided skull measurements (in mm) for North American lynx as follows: greatest length, 120 to 136; zygomatic breadth, 82 to 93; alveolar length of maxillary toothrow, 38.1 to 41.6. Cranial measurements for *F. l. lynx* include: greatest length, 131 to 153; zygomatic breadth, 91 to 106.2; length of upper tooth row, 45.7 to 51.9 (Ognev, 1935).

DISTRIBUTION. The lynx has a Holarctic distribution (Fig. 3). Primary habitats in the Nearctic include boreal forests with openings, rugged outcrops, bogs, and thickets (Berrie, 1973; Koehler et al., 1979; Nellis, 1971; Saunders, 1961). Palearctic habitats include old-growth taiga, mixed or deciduous forests, and wooded steppe up to an elevation of 2,500 m (Iurgenson, 1955; Kratochvil, 1968a; Novikov, 1956; Ognev, 1935).

In North America, the range (Fig. 3) of *F. l. canadensis* includes Labrador, Quebec to central British Columbia and the Yukon, Alaska (with the exception of the panhandle and Seward Peninsula) to tree line, northern New England, portions of the Lake States, the Pacific Northwest, and the Rocky Mountains south to Utah, but *F. l. subsolanus* is restricted to Newfoundland (Hall, 1981; McCord and Cardoza, 1982).

Distribution of Palearctic *F. lynx* has changed appreciably during the last 2,000 years largely because of hunting and changes in land use (Eiberle, 1972; Kratochvil, 1968b; Matheson, 1948; Pulliainen, 1964; Van den Brink, 1970). The range (Fig. 3) includes the entire taiga forest from Scandinavia to eastern Siberia, the Iberian peninsula, the Balkan peninsula (Miric, 1974), the Carpathians, Caucasus, and Asia minor, south to Iran and the Kurdish Mountains of northern Iraq, and east through the Siberian forest to the island of Sakhalin, including Mongolia, Manchuria, Chinese Turkestan, the Kopet Dhag of Turkmenistan, southeastern Tibet, the Gilgit, Ladak, and Kashmir regions of northern India, Korea, northern China, and Kamchatka (Corbet, 1978; Ellerman and Morrison-Scott, 1966; Guggisberg, 1975; Matjuschkin, 1978; Novikov, 1956; Ognev, 1935).

Lynx distribution in northern Norway has remained about the same but expansion has occurred in southern Norway (Heggberget and Myrberget, 1980). Lynxes occur regularly between 61°N and 68°N in Norway and Sweden but the most northern distribution is unclear and much debated (Curry-Lindahl, 1969; Mazak, 1968, 1970). In France, lynxes were thought to be nearly extinct until some were found in the Pyrenees (Beaufort, 1965, 1968), and reintroductions have been attempted (Fernex, 1977). Reintroductions also were attempted with some success in Yugoslovia (Cop 1977a, 1977b). Schauenberg (1969) believed lynxes were extinct in Switzerland and Italy. The southern boundary of the range in the western USSR crosses the Moscow, Ryazan, and Vladimir districts (Sysoyev, 1966). In Siberia, the southern limit of the constant range is in pine-birch forests but migrating individuals often travel further south (Azarov, 1976). Mitchell and Derksen (1976) recorded a specimen from Nepal, about 75 km south of the range reported by Ellerman and Morrison-Scott (1966). Hell (1972) believed that the lynx had become extinct in western Europe except in Spain, but since 1950 an increase in the populations of the Carpathian Mountains had occurred. In a symposium on lynx distribution in Europe, populations of lynxes in Norway, Sweden, Finland, Poland, Czeckoslovakia, Rumania, and Yugoslavia were reported to be stable or increasing largely because of reduced hunting, immigration from areas of higher density, and increased food supply (Kratochvil, 1968a).

FOSSIL RECORD. The assumed common ancestor of lynxes, *F. issiodorensis*, is believed to have originated in Africa in the
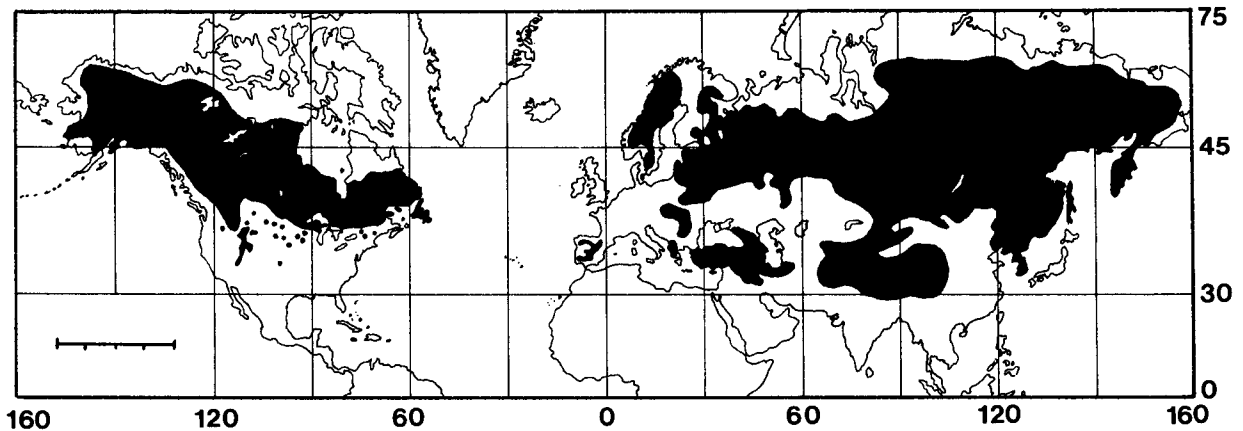
FIG. 3. Distribution of the lynx (*Felis lynx*). Nearctic range modified from McCord and Cardoza (1982) and Palearctic range modified from Matjuschkin (1978). Scale bar equals 4,000 km at the equator.

early to middle Pliocene. This ancestor had lynx-like dental features but skeletally resembled other *Felis*. It is believed to have migrated throughout the northern hemisphere by the middle Villafranchian. *Felis lynx* developed in China and reached Europe from Asia during the Steinheimian land-mammal age of the Pleistocene. It also migrated into North America and gave rise to the Canada lynx (Werdelin, 1981).

Fossil remains of *F. lynx* in North America are recorded from Sangamonian faunas and from the Wisconsinan of Alaska, Idaho, Wyoming, and the Yukon (Kurtén and Anderson, 1980). Records are more common in Europe, including specimens from the F-Emian in the travertines near Weimar and records from the 4-Würm of Italy and the Balkans (Kurtén, 1968a). Specimens are known from the Ipswichian and Devensian of England, the Weichselian of northern Europe, and the Postglacial of England and Denmark (Werdelin, 1981). Fossil specimens have been reported from England (Matheson, 1948), France (Boule and de Villeneuve, 1927), Spain (Sos, 1932), and Greece (Symeonidis et al., 1977).

FORM. Moore et al. (1974) provided detailed descriptions of three forms of guard hair from *F. l. canadensis*. Maximum length of the coarsest hair was 61 mm, maximum diameter 118 μm. The basal medulla is continuous and vacuolated, usually more than one-half the shaft width. Melanin is usually confined to the distal tip and a midshaft band; pigment intensity varies with season and ontogeny (Saunders, 1961).

The hyoid apparatus is held near the base of the skull and is not imbedded in the throat musculature (Pocock, 1916a), therefore the lynx can purr but not roar. In *F. l. isabellina*, the tympanic bulla has a large partition that does not reach the summit of the bulla but terminates toward the inner angle of its anterior edge (Pocock, 1916b). The outer chamber extends more forward than the inner chamber. *F. l. canadensis* differs in that the partition does not advance so far in front so that the anterior part of the inner chamber is broader.

Some external characters of *F. lynx* differ from other lynxes (Pocock, 1917b). The ears are angular, pointed, and tipped with long hairs. The upper margin of the rhinarium is more convex than in other lynxes and the nostrils are somewhat larger, possibly an adaptation to life at higher altitudes. The interramal tuft of tactile vibrissae is absent but the mystacial and superciliary tufts are well developed. Genal tufts are obscured by the long facial ruff, and may consist of a single bristle. The feet of *F. l. isabellina* differ from *F. rufus* by having larger inner lobes of the sheaths of the claws and the plantar pads are shorter compared with their width. The plantar pads are also more overgrown with hair in *F. lynx*.

The distal end of the baculum of *F. lynx* is conical to slightly compressed laterally and slightly decurved (Kratochvil, 1975). The proximal end is bifurcated and the rami are concave on the inner surface. Dimensions (in mm) of the largest os penis were: length, 9.4; greatest width, 3.8; least width, 0.5.

The deciduous carnassial pair is formed by dP3/dp4, but the adult pair is composed of P4/ml (Saunders, 1961). Greatest sectorial development on dP3 and P4 is seen in the paracones and metastyles that shear along the paraconids and protoconids, respectively, of dp4 and ml. The dP4 and M1 are small and molariform,

but ml has practically lost the entire talonid. However, Kurtén (1963) suggested an evolutionary return of the metaconid-talonid complex of ml and the possible return of m2. Supernumerary teeth have been reported (Kratochvil, 1965; Miric, 1973; Vereshchagin, 1959). Manville (1959) reported a bregmatic fontanelle bone in only one lynx cranium (0.002%) from the Yukon territory of Canada, although bobcats possessed these bones in about 15% of the crania examined.

FUNCTION. Under experimental conditions, lynx guard hair had the lowest transmittance of solar radiation among Arctic mammals (Øritsland and Ronald, 1978), indicating that solar heating does not contribute significantly to energy conservation in the species. Thick fur and large, well-furred paws are thermoregulatory and structural adaptations to the Arctic environment (McCord and Cardoza, 1982). Lynxes maintain thermoneutrality but do not change respiratory frequency or minute volume (lung ventilation) at low temperatures, as do other Arctic mammals whose higher winter metabolic rates require greater oxygen consumption. Maximum minute volume is realized at 20°C with a respiratory frequency of 30/min (Casey et al., 1979).

Yearling lynxes have less bone-marrow fat than adults, suggesting greater energetic needs and undeveloped hunting skills (Stewart, 1973). Prey abundance affected renal and subcutaneous fat levels; also renal levels were affected by age, and subcutaneous fat by sex (Brand and Keith, 1979).

Scapino (1981) found that a stiffened mandibular symphysis functions to transfer muscle force from the balancing side of the head to teeth in the working jaw. Claw retraction is a function of the dorsal elastic ligaments but co-contraction of both forearm flexor and extensor muscles is necessary for claw protrusion (Gonyea and Ashworth, 1975). A comparative study of the appendicular skeleton of the caracal and lynx (Mandal and Talukder, 1975) indicated that lynxes had a longer presacral but shorter postsacral ilium and an elongated tibia, and concluded this modification was related to their springing behavior. Auditory, visual, tactile, and taste senses are highly developed, but olfaction is poor (Lindemann, 1955; Saunders, 1963a). Vision in the lynx is predominantly scotopic and is especially suited for perception of fine differences in brightness (Rager and Festetics, 1982).

ONTOGENY AND REPRODUCTION. The breeding season of lynxes varies geographically. In Newfoundland, mating occurred between early March and early April, peaking about the third week of March (Saunders, 1961); in Alaska, from March through April (Nava, 1970); in Alberta in April and May (Nellis et al., 1972). Lynxes in the Palearctic breed in February and March (Haglund, 1966; Novikov, 1956), and as early as January in southern Spain (Guggisberg, 1975). Saunders (1961) estimated that 10% of the ova were lost before implantation, and at least another 13% were lost between implantation and capture. In Alberta, Brand and Keith (1979) found that 73% of adult females conceived in years of snowshoe hare (*Lepus americanus*) abundance, but only 33% when hares were scarce. Gestation period for wild lynxes was estimated at 63 to 70 days (Saunders, 1961) and 67 to 74 days (Matjuschkin, 1978); Haglund (1966) determined a gestation period

of 63 to 73 days for captive European lynxes. Parturition occurs in late May to early June in Newfoundland (Saunders, 1961), and late May in Russia (Matjuschkin, 1978).

Litter sizes in lynxes may range from one to six, but are usually three to four in North America (Brand and Keith, 1979; Nava, 1970; Saunders, 1961) and two to three in the Old World (Novikov, 1956). Younger females tend to have smaller litters (Brand and Keith, 1979). Commonly, there is one litter per breeding season; however, individuals in some populations may have litters only in alternate years (Ognev, 1935; Saunders, 1961).

Newborn lynxes have closed eyes, folded ears, no teeth, poorly developed ear tufts, and well-developed pelage with dark longitudinal streaking on the back and limbs but less dark on the flanks (Merriam, 1886; Saunders, 1964). Lengths and body masses of two neonates in Newfoundland were 163 and 158 mm, and 197 and 211 g (Saunders, 1964). Guggisberg (1975) reported an average body mass of neonates as 70 g, but Stehlík (1983a) reported an average of 289 g (range 250 to 360).

Eyes open between 10 and 17 days after birth (Kunc, 1970; Lindemann, 1955; Novikov, 1956; Wayre, 1969). Young lynxes begin to walk at 24 to 30 days (Lindemann, 1955; Stehlík, 1983a). The pelage of a 2-month old kitten had lost the natal pattern on the body, but the bars on the inner side of the forelegs were more distinct than in newborns. All lacteal teeth had erupted. Lacteal canines possessed an accessory cusp located immediately above the incisors (Saunders, 1961). Eruption of lacteal teeth begins with the canines at about 17 days of age, then continues with the incisors at about 20 days, then premolars at about 30 days (Lindemann, 1955; Stehlík, 1983a; van Zyll de Jong, 1963). Lacteal dentition begins replacement at about 4 months of age (Lindemann, 1955; Saunders, 1961). Young European lynxes reportedly possess dP2 which is not replaced in the adult (Lindemann, 1955), however, van Zyll de Jong (1963) noted that this observation may represent misidentification of dP3 and dP4 as dP2 and dP3. Two-month-old lynxes in Europe had fully developed the ability to groom their body surface (Lindemann, 1955).

The stretch reflex begins at 10 days of age with stretching of the hind legs while lying on the back (Stehlík, 1975). This stretch is accomplished while standing at 14 days, and stretching of the forepaws occurs at 15 days. Stretching of the back appears by the 34th day, and simultaneous stretching of opposite fore and hind limbs is seen at 35 days. Yawning begins at 10 days. Reaction to optic stimuli was observed at 15 to 20 days and to acoustic stimuli at 18 to 20 days (Stehlík, 1983a).

The temporal ridges of the parietals are lyre-shaped but the lyre width decreases with age and joins in later life to form the sagittal crest on the interparietal bone (Saunders, 1964). The lambdoidal ridge also becomes more prominent with age. Epiphyses of long bones of the forelimb remain unossified up to 9 months of age (van Zyll de Jong, 1963). The distal epiphysis of the humerus and proximal epiphysis of the radius are ossified by 18 months, the proximal epiphysis of the ulna is ossified by 21 months, the distal epiphyses of the radius and ulna are ossified by 30 months, and complete ossification of all epiphyses probably occurs at about 32 months (van Zyll de Jong, 1963).

The duration of the suckling period is over 6 months (Lindemann, 1955) but young take meat from 30 days of age (Guggisberg, 1975). At about 40 days, young begin playful motions of stalking prey (Guggisberg, 1975). During ontogeny, litter mates lose their need for kinship and become more "envious" of prey caught by litter mates (Lindemann, 1955).

The litter remains with the mother until the next mating season, and young of late litters have not attained adult size at this time (Lindemann, 1955; Novikov, 1956). Ognev (1935) emphasized that some litters may remain with their mothers after 1 year, which may mean that some lynxes reproduce only in alternate years.

Female lynxes can breed during their first reproductive season, that is, at about 10 months of age (Nava, 1970) but may not breed until 22–23 months (Saunders, 1961; van Zyll de Jong, 1963). Sexual maturity may be delayed during periods of prey scarcity (Brand and Keith, 1979; Nava, 1970) and overall breeding declines during such periods. Parker et al. (1983) reported that reduced prey affected reproductive success in yearling females more than in older females.

Luteal bodies are large and persistent, and increase in number with age (Brand and Keith, 1979; Nellis et al., 1972). Largest Graafian follicles appeared in early March as blister-like promi-

nences on the ovary (Saunders, 1961). Testicular size also increases with age (Nava, 1970). Males apparently do not breed until their second year (Saunders, 1961; Stewart, 1973); gametogenesis may decline during summer and fall (Saunders, 1961; van Zyll de Jong, 1963).

Lynxes have lived almost 22 years in captivity (James, 1977) but seldom surpass 15 years in the wild (Nava, 1970). The primary mortality factors seem to be prey scarcity (Brand et al., 1976; Nava, 1970), that affects kittens and yearlings most, and man (de Vos and Matel, 1952; Mech, 1980).

ECOLOGY. Population irruptions or habitat disruptions sometimes force dispersal of lynxes (Gunderson, 1978; Mech, 1980). Reported long-range dispersal distances for lynxes have increased from 165 km (Nellis and Whetmore, 1969) to 483 km (Mech, 1977). Average daily cruising distance ranges from 5.0 km (Saunders, 1963a) to 19.2 km (Haglund, 1966). Differences in cruising distance are thought to be related to hunting conditions.

Home ranges in lynxes differ by sex, age, prey density, and survey method, from approximately 11 to 50 km² (Berrie, 1973; Brand et al., 1976; Novikov, 1956; Saunders, 1963a). However, a colonizing population of lynxes in Minnesota had home ranges of 51 to 243 km² (Mech, 1980) and lynxes in Riding Mountain National Park, Manitoba, had ranges of 118 to 221 km² (Carbyn and Patriquin, 1983). Larger home-range size could be related to low density of lynxes or low prey density, although Brand et al. (1976) found that lynx home ranges were unrelated to either. Females usually have smaller home ranges than males, and home ranges sometimes overlap (Brand et al., 1976; Mech, 1980; Nellis et al., 1972).

The major food of Nearctic lynxes is snowshoe hares, accounting for as much as 83% (frequency of occurrence) of the diet (More, 1976; Nellis et al., 1972; Saunders, 1963b; van Zyll de Jong, 1966a). These studies also indicate utilization of squirrels (*Tamiasciurus hudsonicus*, *Spermophilus* sp.), small mammals (Muridae), beaver (*Castor canadensis*), deer (*Odocoileus* sp.), moose (*Alces alces*), muskrats (*Ondatra zibethica*), and birds (Galliformes and Anseriformes); some is taken as carrion. Strong selection for hares (*Lepus* sp.) is believed to have resulted in predator-prey cycles. Brand et al. (1976) found that lynxes responded functionally and numerically to hare density. Palearctic lynxes also rely heavily on lagomorphs, as much as 79% by frequency of occurrence (Aymerich, 1982; Delibes, 1980; Guggisberg, 1975; Novikov, 1956) but cervids are sometimes the major food (Birkeland and Myrberget, 1980; Novikov, 1956). Additional foods in the Palearctic include small mammals (mostly Muridae), squirrels, insectivores, birds (Anseriformes, Galliformes, Passeriformes), reptiles (Squamata), and fish. Seasonal variation in foods is related directly to availability. In Spain (Delibes, 1980), rabbits (*Oryctolagus cuniculus*) were used most from July through October, ducks (*Anas* sp.) from March to June, and cervids (*Cervus elaphus*, *Dama dama*) from November to January. Nellis et al. (1972) estimated daily food requirements for adult lynxes at 600 g/day. Consumption rates were estimated at 591 g/day (Delibes, 1980) and 960 g/day (Brand et al., 1976); rates vary according to prey abundance (Brand et al., 1976). Hunting success improves with practice and group size (Parker et al., 1983), and has been estimated at 26% in Nova Scotia (Parker et al., 1983) and 36% in Alberta (Brand et al., 1976).

Two hundred years of trapping records from the Hudson Bay Company have shown cyclic fluctuations in *F. l. canadensis* harvests. These records show a regular periodicity of about 9.6 years but an irregular amplitude of oscillations of trapped lynxes (Elton and Nicholson, 1942). Elton and Nicholson (1942) believed lynx cycles to be geographically synchronous, but more recent investigation indicates that peak collection is first reached in the central provinces, and the western and eastern regions peak later and with less amplitude (Bulmer, 1974; Butler, 1953).

Several attempts have been made to analyze the lynx data by use of autoregressive models. Moran (1953a) used logarithms of the numbers trapped, Bulmer (1974) included a strictly periodic term, Campbell and Walker (1977) used a pure sine wave, and Tong (1977) and Bhansali (1979) considered harmonic components. These statistical treatments are attempts to explain the cyclic fluctuation in lynx populations in mathematical terms, which can aid in prediction of population status.

Sunspot and lynx cycles are not correlated (Moran, 1949), but lynx trapping is correlated with temperature and precipitation (Arditi, 1979; Fox, 1978; Moran, 1953b). Moran (1953b) suggested that the effect of weather on snowshoe hares was responsible

for synchronization of hare-lynx cycles through predator-prey interaction. Fox (1978) believed that forest fires caused plant succession favoring hares, that snowfall accounted for the variation not accounted for by fire, and that oscillation was forced through these events. Arditi (1979) found that a few linear combinations of 3 or 4 months of temperature and precipitation variables fit the lynx population index, with the critical variable occurring between summer and winter.

By use of a predator-prey model, Gilpin (1973) found that hares must "prey" on lynx. He interpreted this to mean that hare abundance could indirectly kill lynx by vectoring a disease, but also suggested that man, by trapping more heavily for lynxes during hare abundance, might artificially cause the lynx oscillation. Weinstein (1977) commented that trapping records may reflect short-term changes in hunting strategy related to hare abundance. Finerty (1979) noted that the phenomenon might be an artifact created by comparing data that are not comparable. Gilpin's (1973) data apparently compared harvests of hares in eastern Canada to that of lynxes in western Canada.

Van Zyll de Jong (1966b) summarized the known occurrence of ectoparasites of lynx, including eight species of fleas. Most fleas encountered were found commonly on rodents and lagomorphs so probably are accidental records for the lynx. Van Zyll de Jong (1966b) suggested that the scarcity of fleas on lynxes is linked to their habit of bedding on the trail and a lack of regularly used dens or burrows (with the exception of the nursing female). Hopkins (1960) described a louse (*Felicola spenceri*) from a lynx in British Columbia. In North America, seven cestodes (Adams, 1966; Bursey and Burt, 1970; Fyvie and Addison, 1979; Loewen, 1929; van Zyll de Jong, 1966b), two trematodes (Pearson, 1956; van Zyll de Jong, 1966b), seven nematodes (Pence et al., 1978; Rausch et al., 1956; van Zyll de Jong, 1966b), and one acanthocephalan (Schmidt, 1968) have been reported. Sadikhov (1952) described the nematode *Troglostrongylus assadovi* from *F. lynx* in Azerbaidzhan, USSR. Fagasinski (1961) reported the nematode *Toxocara cati* and the cestode *Taenia rileyi* from the lynx in Poland, but van Zyll de Jong (1963) questioned the identification of the cestode. Kazlauskas and Matuzevicius (1970) reported the cestodes *Taenia crassiceps*, *T. krabbei*, *T. pisiformis*, and *Hydatigera taeniaeformis*, and the nematode *Toxocara mystax* from the lynx in Lithuania. Diseases known to infect lynxes include panleucopenia, rabies, coccidiosis, and mycoplasmosis (Anpilogova and Sokov, 1973; Langford, 1974; Lewis, 1975; Povey and Davis, 1977; Matjuschkin, 1978).

Lynxes have been harvested for fur for over 2 centuries, but significant value (therefore trapping pressure) has developed more recently. The average price of lynx pelts in Canada rose from $38 (Canadian) to $216 between 1971 to 72 and 1975 to 76 (Brand and Keith, 1979). Increased harvest has been caused by price increases, but improved access to remote areas and the use of snowmobiles have increased trapper efficiency as well (Berrie, 1973).

Many of the studies about lynx have been conducted by tracking in the snow, telemetry on tagged individuals, and analysis of data obtained from carcasses. Berrie (1973) found lynxes were trapped most easily with a bait combination of grouse forms and beaver castor, producing one lynx per 74 trap nights. Leg-hold traps of various sizes commonly are used for capture (Berrie, 1973; Nellis et al., 1972; Saunders, 1963a). Immobilization has been accomplished with succinylcholine chloride at a dosage of 0.66 mg/kg of body mass, ketamine hydrochloride at a dosage of 15.0 mg/kg (Parker et al., 1983), and a phencyclidine hydrochloride called Sernylan (Berrie, 1973; Mech, 1980; Nellis et al., 1972). Berrie (1972) showed that males were more susceptible than females to comparable dosages, males being immobilized with 0.25 mg/kg Sernylan and females with 0.6 mg/kg. Mech (1980) immobilized lynxes with a combination of about 1 mg of phencyclidine hydrochloride and 0.5 mg of promazine hydrochloride per kg of body mass.

Harvest data may show a preponderance of males in younger age classes (Stewart, 1973), presumably because of dispersal, but sex ratios often approach equality when averaged over time (Brand and Keith, 1979; Parker et al., 1983). Yearly fluctuations in sex ratios reflect differential survivorship, phase of the cycle, and trapping sample biases. Kittens may be underrepresented in harvest samples (Berrie, 1973; Brand and Keith, 1979; Parker et al., 1983); possibly because of poor survival of kittens, trapping biases, and lack of maternal protection of yearlings.

Age can be estimated by examining ossification of epiphyseal plates of longbones (Nava, 1970; van Zyll de Jong, 1963), tooth

replacement and cranial characteristics (Saunders, 1964), or cementum annuli (Nellis et al., 1972). Presence of an apical root foramen in canines of lynx less than 19 months of age aids in distinguishing kittens (Saunders, 1961). Grue and Jensen (1979) indicated that the first incremental line appeared in lynx canines between February and March of the second year.

Lynx populations should benefit through forest management favoring hares (Parker et al., 1983). *Eucalyptus* plantings in optimal habitat in Spain may be detrimental to lynxes (Valverde, 1957). Harvest during periods of low recruitment delays or suppresses natural increases in lynxes by leaving fewer lynxes in the breeding population. Suspending harvest for 3 to 4 years during low populations would result in greater overall harvest during population increases and higher numbers at the peak (Berrie, 1973; Brand and Keith, 1979). Shortened seasons would change the age structure of the harvest, because the proportion of kittens in the harvest increases through the season, whereas the proportion of yearlings decreases (Parker et al., 1983). When recruitment is high, a delayed season (January–February) would insure higher harvest of yearlings and lower harvest of kittens; orphaned kittens in the later season have increased chances of survival (Parker et al., 1983).

BEHAVIOR. Lynxes usually are solitary animals except for females with litters (Parker et al., 1983). They exhibit a strong reaction to the smell of the feces of conspecifics, to the sexual smell, and other strange olfactory and taste stimuli (Lindemann, 1955). Mutual avoidance may be effected through this mechanism, but during periods of prey scarcity mutual avoidance may cease to function as a spacing behavior (Brand et al., 1976).

During the breeding season, vocalizations become common. Purring and meowing is performed especially at dawn and twilight, but the loud bass meow of the male may be given throughout the night (Ognev, 1935). The call of the female is more of a vibrating whine (Guggisberg, 1975). Male lynxes display Flehmen, a behavior involving scenting or tasting of urine of the female followed by a stylized facial expression, to determine the reproductive condition of the female (Lindemann, 1955; Stehlík, 1979b). The period of receptivity lasts 1–2 days but preceding that time there is an increase in urine marking by both sexes (Stehlík, 1983b). Males hold on to the skin of the neck of the female during copulation (Stehlík, 1983b).

By tracking lynxes in snow, Saunders (1963a) found that kittens buried their feces and covered urination sites except when the crust of the snow was too hard. By late April, kittens had abandoned the habit. Adults commonly urinated and defecated along trails, sometimes in the same location (latrines), presumably to scent mark territories.

When several lynxes travel together (most commonly family groups), they follow in the footprints of the leader. Although lynxes generally avoid water, they can swim across large stretches if necessary (Ognev, 1935). Familiar features of the surroundings are strongly imprinted on the lynx. Orientation and homing abilities are effected primarily by visual means, and an excellent memory allows the lynx to locate pre-established hiding places (Lindemann, 1955).

Lynxes may feed at any time of day, but they are most active between dusk and dawn, and hide in rest areas during the day (Ognev, 1935; Saunders, 1963a). Lynxes stalk as close as possible to prey, then pounce on it in one or two bounds, or less commonly they leap down from a branch onto larger prey (Guggisberg, 1975). Prey are usually pursued 20–50 m, but chases have reached 100 m (Stehlík, 1979a). Tracking an adult female with two offspring in the snow, Saunders (1963b) found that the kittens often flanked the adult 15 to 40 paces when hunting through wooded areas. Upon entering clearings, they rejoined the female and frequently followed in her footprints. Lynxes often made hunting or resting beds in the proximity of recent hare activity. Kills were sometimes made from such beds. Barash (1971), Parker et al. (1983), and Saunders (1963b) noted instances of cooperative hunting.

When food is less limiting, lynxes may cache food for later use. Nellis and Keith (1968) trailed lynxes through snow and found that at least portions of 6 of 11 hares killed were cached, and six old caches were revisited. Berrie (1973), Haglund (1966), and Matjuschkin (1978) also reported caching by lynxes.

Hancock et al. (1976) reported an attack on a trapper carrying 12 hares. Usually attacks on humans are during periods of prey scarcity or when the human wears animal-hide clothing.

GENETICS. The diploid number is 38 chromosomes. The

autosomal complement includes two graded series (ranging from large to small) of eight pairs of metacentrics and eight pairs of the submetacentrics, and two pairs of medium-sized acrocentrics (Hsu and Benirschke, 1974). The X is a large submetacentric and the Y is a small submetacentric.

Kurtén (1968b) believed that the Scandinavian lynx population had a dual origin, from the south across Denmark and from the east through Finland. Mingling of immigrants from these origins resulted in the presence of character gradients in tooth size. Lynxes of southern Sweden seemingly were isolated at some time, indicated by a more narrow postorbital constriction than in other forms. Dilute mutation was observed in a lynx from Alaska (Schwarz, 1938). Jones (1923) described color phases, including "drab blue," "tabby," "light brown," and "fawn yellow." Ognev (1935) described an "ocher-orange" specimen.

REMARKS. Phylogenetic relationships within the Felidae are unclear. Kurtén and Rausch (1959) tentatively attributed differences between lynx crania from Alaska and Fennoscandia to clinal variation, initiating a move to consider these lynxes conspecific. Van den Brink (1970) concurred, but showed that the confluence of the anterior condyloid foramen with the posterior lacerate foramen, used to distinguish bobcats from lynxes in the Nearctic, also was present in *F. l. pardina* in the Palearctic, and referred the latter to *Lynx pardina*. Kratochvil (1975) suggested that bacular morphology could justify subfamilial classification of the lynx group and later (Kratochvil, 1982) added mathematical evaluation of karyotypes as support. Van Gelder (1977) argued that the ability to hybridize negated generic distinction of *Lynx* and *Felis*. Herrington (1983) examined the Felidae with cluster, principal component, and cladistic analyses, and concluded that the genus *Lynx* was a valid category within the Felidae. Stehlík (1979a) believed that behavioral differences justified *Lynx* as a genus. The current tendency in original research papers appears to be to accept *Lynx* as a genus, but acceptance is still not widespread. Should *Lynx* become the accepted generic designation, it is likely that the forms *lynx, canadensis,* and *pardina* will be elevated to species rank.

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