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Morphometric measurements of red foxes (*Vulpes Vulpes*) in Egypt

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Abstract

The present study investigated the morphometric measurements in 44 red foxes in two developmental stages young and adult of different sexes male and female, from three localities of Egypt Giza, Sohag, and Qena governorates, Egypt, during the period from February 2016 to April 2021 along all year`s period except during winter to avoid stress and potential injury to pups and adults. Foxes were immobilized using ketamine hydrochloride (25mg/kg) injected intramuscularly in femoral or scapular body areas before the examination. Different measurements were selected; head and body length (HBL), tail length (TaL), hindfoot length (HFL), and neck circumference (NC) besides body weight. Results revealed that bodyweight, head and body length, and tail length in adult male foxes were significantly higher than in adult females. The results also revealed that all morphometric measurements besides body weight were significantly higher in adult male animals than young males, also the same parameters were higher in adult female animals than young females.

Keywords:
Carnivores, Head and body length, Head circumference, Hind foot length, Red foxes, Tail length, *Vulpes vulpes aegyptiaca*.

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Introduction

The Red Fox (*Vulpes Vulpes*) is the most widely distributed carnivore in the world and the most abundant carnivore in Egypt, it is a very adaptable animal, being able to live in a variety of habitats ranging from the arctic areas to the barren temperate deserts, and the crowded cities (Basuony et al., 2005).

In Egypt, the Red fox holds a specific role in zoonotic Medicine. World Health Organization (WHO) reports point out that rabies in red foxes is a public health problem in the Middle East, including Egypt (WHO, 1997).

Osborn and Helmy, (1980) differentiated Red fox (*Vulpes vulpes*) from Rueppell's Sand Fox (*Vulpes rueppelli*) in a darker color, back of ear being black instead of pale brown. The red fox has a blackish venter instead of white, bearing a black mark on the foreleg with larger average dimensions. The ranges of *V. vulpes* and *V. rueppelli* overlap only slightly. Rueppell's Sand Fox is known to be desert-adapted, probably due to its smaller size plus its ability to survive in dry areas. *Vulpes vulpes aegyptiaca* is a larger and darker race than *V. v. arabica* and *V. v. palaestina*.

There is little literature available on morphometric measurements of red foxes worldwide except Cavallini, 1995 in Italy, Voigt, 1987 in Canada, McIntosh, 1963 in Australia, Hatting, 1956 in the UK and Zhan et al., 1991 in Japan) and in Egypt (Osborn and Helmy, 1980) considered the cornerstone source for this aspect. Hence, the present work is aimed to present morphometric measurements in 44 free-ranging red foxes from different localities in Egypt.

Materials and methods

Experimental Work

This study was performed from February 2016 to April 2021 on forty-four (44) Red foxes (*Vulpes vulpes*) of two age categories, young (< 1-year-old) and adults (> 1 year old). Foxes were not captured during the winter months which included gestation and parturition periods to avoid stress and potential injury to pups and adults. Also, we did not sample during these periods to avoid measuring pregnant females which could have biased our results.

The age is estimated by the number of annuli in the cementum of the canine teeth of the lower jaw (Jensen and Nielsen, 1968). Foxes with non-erupted molars on the lower jaws (M3) were considered as juveniles (< 0.5-year-old; Sasakawa, 1984), and those with no annulus in the cementum of their canines as sub-adults (>0.5-year-old and < 1-year-old), Juveniles and sub-adults were grouped as young (Fig. 1)

Adults were aged by the number of annual layers on their canines. Since the dark layers in the canine tooth cementum are formed between April and August (Grue and Jensen, 1979; Sasakawa et al., 1980), the age of animals collected in this period was determined by adding one to the number of layers.

Sex was determined through the identification of external reproductive organs (22 females and 22 males). Foxes` weights ranged from 0.7 Kg to 5.4 Kg, the weight of the sampled animals measured to the nearest 0.1kg (Slavica et al., 2011).

Foxes were hunted by foot-held trap by local hunters, purchased from three governorates from Egypt (Giza, Sohag, and Qena).

According to (Stocker, 2005), better handling of animals is achieved by a typical dog grasper with quick-release noose to catch a fox and a stout pair of gloves used to protect hands if exposed, scruffing a fox then done to make it relax, rump supported with the free hand (Fig. 1).

According to (Canada Fox Breeders' Association, 2013), animals were kept in a well-ventilated room, housed in Pens of sufficient size to meet the physiological and behavioral needs of the foxes. Foxes were fed various rich components including poultry slaughter by-products, beef by-products, fish by-products and small amounts of fresh vegetables and fruits once daily, water was available continuously all the time especially in summer (Gugołek, 2011). Feed was withheld for 12 hours before anesthesia.

1.1. Experimental design

The foxes were divided into 4 groups from three locations from Egypt (Sohag, Giza, and Qena) as follow: adult males, adult females, young males and young females.

1.1.1. Inspection of foxes.

Animals were immobilized using ketamine hydrochloride (25mg/kg) injected intramuscularly in femoral or scapular body areas (Ramsden et al., 1976) before the examination (Fig. 1).

Body measurements (Tail length TL, Head & body length HBL, neck circumference NC and hindfoot length HFL were estimated according to (Foresman, 2012) Cloth tape measure was used to measure the following:

- Head and body length (HBL): Measure from tip of the nose to base of the tail at the notch of the sacrum with the animal lying recumbent on its back or stomach as with total length.
- Tail length (TaL): Measure from the base of the tail at the rump to the tip of the last caudal vertebra (Fig. 1)
- Hindfoot length (HFL): Measure from the end of the hip joint to the tip of the longest digit, not including the claw
- Neck circumference (NC): Measure around the smallest portion of the neck.

Statistical analysis

Data processing and statistical analysis were performed using PRISM software (SAS Institute Inc., Cary, NC, USA).

Values determined for different sexes and ages were compared using one-way ANOVA (SAS Version 9.2). A level of $P<0.05$ was accepted as statistically significant.

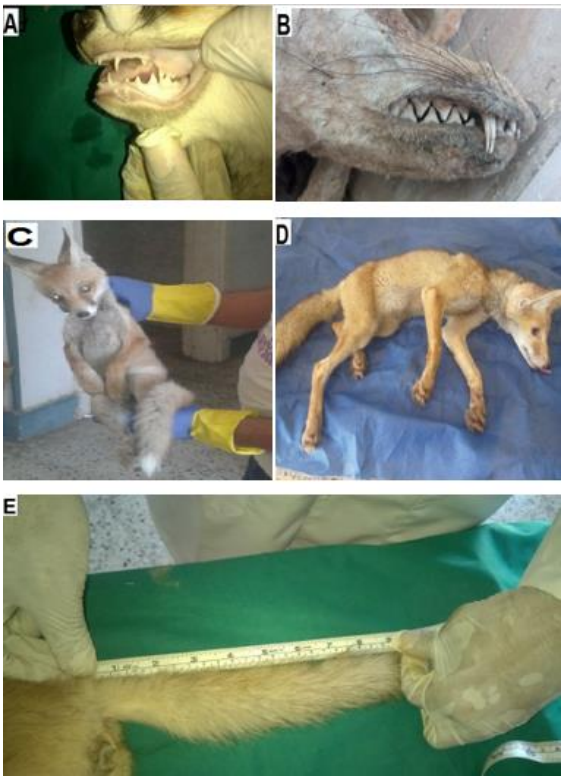

Fig. 1. A. young red fox with non-erupted molars on the lower jaws. **B.** adult red fox with complete dental formula. **C.** proper Handling of red fox according to Stocker, (2005). **D.** Young red fox anesthetized by Ketamine hydrochloride showing salivation. **E.** Tail length; measured from the base of the tail at the rump to the tip of the last caudal vertebra.

Results

The study was conducted for a period of 62 months from February 2016 to April 2021 in 44 foxes of different sexes (22 females and 22 males) for the determination of basic morphometric measurements and ages from three localities of Egypt (Table 1).

Based on this study results; head &body length, tail length, hind foot length, neck circumference and body weight in adult male red foxes were (58.26±0.44 cm, 36.21±0.25 cm, 14.41±0.14 cm, 19.54±0.18 cm, 5.26±0.15 kg) respectively, while in adult females were (55.73±0.48 cm, 34.67±0.32 cm, 13.92±0.21 cm, 19.14±0.14 cm, 4.66±0.15 kg) and these results were illustrated in (Table 2).

Results of the same parameters in young male foxes and young female foxes also were illustrated in (Table 2).

Sex variations:

Regarding the sex differences in morphometric measurements, animals were categorized into four groups; adult males and females, young males and females, and the selected parameters were; Head and body length, tail length, neck circumference, and Hindfoot length, besides body weight.

Results showed significant sexual dimorphism in body weight between adult male foxes (5.26±0.15 kg) and adult female animals (4.66±0.15 kg) with a male-female ratio 1.13 (Table 2).

The same sexual dimorphism was recorded in head and body length (in adult males 58.26±0.44 cm) and (in adult females 55.73±0.48 cm with M/F ratio 1.05) animals, and tail length (adult males 36.21±0.25 cm and adult females 34.67±0.32 cm) with M/F ratio 1.04 and these results were illustrated in (Table 2 and Fig. 2).

In the entire work, there were no significant sexual dimorphism in adult foxes regarding neck circumference nor hindfoot length (Table 2).

On the other hand, there were no significant difference between young male animals and young female animals in all morphometric measurements, and these results were illustrated in (Table 2).

Despite the male/female ratio of head & body length, tail length and bodyweight in adult group (1.05, 1.04, 1.13 respectively) is similar to that of young group (1.02, 1.03, 1.02 respectively), there were significant sexual dimorphism in adult group not young group and these results were illustrated in (Table 2).

Table 1: Distribution of locality, sex and age of animals involved in the study.

Governorate	**Giza**				**Sohag**				**Qena**			
Sex	Male		Female		Male		Female		Male		Female	
Age	A	Y	A	Y	A	Y	A	Y	A	Y	A	Y
Number	4	2	5	2	6	6	6	7	4	0	0	2

A: Adult animals, and Y: Young animals.

Table 2: Mean (±SE) of body weight and morphometric measurements of adult and young red foxes (*Vulpes Vulpes*) from Egypt showing Sex variations.

	Adult red foxes (n=25)			**Young red foxes (n=19)**		
	Male (n=14)	**Female (n=11)**	**M/F Ratio**	**Male (n=8)**	**Female (n=11)**	**M/F Ratio**
HBL (cm)	58.26±0.44**	55.73±0.48	1.05	45.44±0.18	44.55±0.66	1.02
TaL (cm)	36.21±0.25**	34.67±0.32	1.04	28.71±0.18	27.84±0.44	1.031
HFL (cm)	14.41±0.14	13.92±0.21	1.04	11.48±0.15	11.16±0.16	1.028
NC (cm)	19.54±0.18	19.14±0.14	1.02	15.6±0.14	15.2±0.28	1.026
BW (Kg)	5.26±0.15 *	4.66±0.15	1.13	2.68±0.13	2.64±0.11	1.02

** = p value is less than 0.05 ** = p value is less than 0.01 *** = p value is less than 0.001*

HBL: Head and Body length TaL: Tail Length HFL: Hind foot Length

NC: Neck Circumference BW: Body Weight M/F ratio: Male/Female ratio.

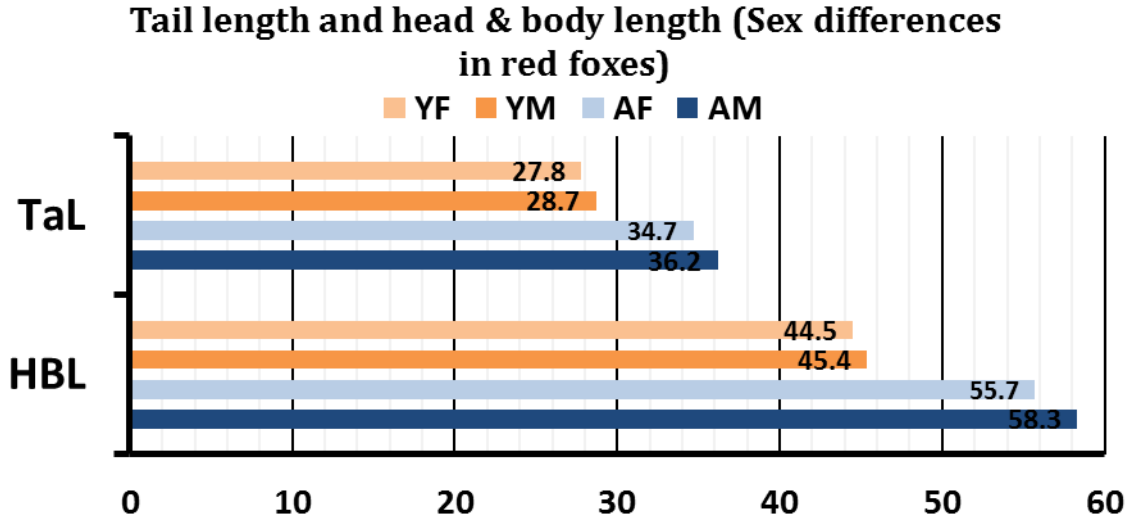

Fig. 2. Sex differences of tail length and head & body length among male and female red foxes from Egypt.

Age variations:

Regarding age differences in morphometric measurements, animals were categorized into four groups; adult and young males, adult and young females, and the selected parameters were; head and body length, tail length, neck circumference, and hindfoot length, besides bodyweight.

The current work results revealed that, the four morphometric measurements besides body weight are significantly higher in adult male animals than young male animals and the adult/young ratio in head and body length, tail length, neck circumference, hindfoot length and bodyweight were (1.28, 1.26, 1.25, 1.25, 1.96 respectively) (Table 3 and Fig. 3).

Also, the same parameters were higher in adult female animals than young female animals and the adult/young ratio in head and body length, tail length, neck circumference, hindfoot length and bodyweight were (1.25, 1.24, 1.25, 1.26, 1.76 respectively) (Table 3 and Fig. 3).

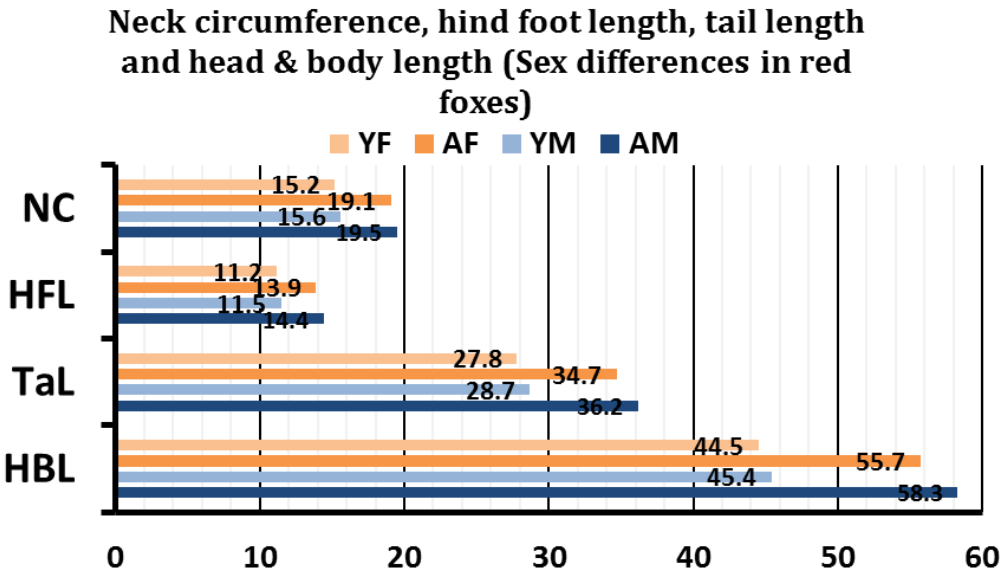

Fig. 3. Age differences of neck circumference, hind foot length, tail length and head & body length among adult and young red foxes from Egypt.

Table 3: Mean (±SE) of body weight and morphometric measurements of male and female red foxes (*Vulpes Vulpes*) from Egypt showing age variations.

	Male animals (n=22)			Female animals (n=22)		
	Adult (n=14)	**Young (n=8)**	**A/Y Ratio**	**Adult (n=11)**	**Young (n=11)**	**A/Y Ratio**
HBL (cm)	58.26±0.44 ***	45.44±0.18	1.28	55.73±0.48 ***	44.55±0.66	1.25
TaL (cm)	36.21±0.25 ***	28.71±0.18	1.26	34.67±0.32 ***	27.84±0.44	1.24
HFL (cm)	14.41±0.14 ***	11.48±0.15	1.25	13.92±0.21 ***	11.16±0.16	1.25
NC (cm)	19.54±0.18 ***	15.6±0.14	1.25	19.14±0.14 ***	15.2±0.28	1.26
BW (Kg)	5.26±0.15 ***	2.68±0.13	1.96	4.66±0.15 ***	2.64±0.11	1.76

** = p value is less than 0.05 ** = p value is less than 0.01 *** = p value is less than 0.001*
HBL: Head and Body length TaL: Tail Length HFL: Hind foot Length
NC: Neck Circumference BW: Body Weight A/Y ratio: Adult/Young ratio

Discussion

Sexual dimorphism in terms of body mass and size occurs among some canids and has been reported in the corsac fox (*Vulpes corsac*, Linnaeus, 1768) and red fox (*V. vulpes*, Linnaeus, 1758)

Based on this study results; Bodyweight, head body length and tail length in adult male red foxes were much lower than the results of (Zhan et al., 1991) in Japan, and results of (Kolb and Hewson, 1974) in Scotland, and also results of (McIntosh, 1963) in Australia, while results of male head body length and tail length were matching to (Osborn and Helmy, 1980) from Egypt (57.8 cm, 36.2 cm) and resemble the results of (Lewis and Lewis, 1968) from Lebanon (59 cm, 37 cm). and these variances could be related to geographical variations in different subspecies of red foxes.

In this work there were significant sexual dimorphism in body weight between adult male foxes (5.26±0.15 kg) and adult female animals (4.66±0.15 kg) with a male-female ratio 1.13 and those results were similar to (Takeuchi, 2010) in Japan (female;4.39±0.25 and males;5.11±0.19 with M/F ratio 1.16)

The sexual dimorphism in head and body length (in adult males 58.26±0.44 cm; adult females 55.73±0.48 cm with M/F ratio 1.05), and tail length (adult males 36.21±0.25 cm; adult females 34.67±0.32 cm with M/F ratio 1.04), was in agreement with (Takeuchi, 2010) and differs from results of (Murdoch et al., 2009) who recorded sexual dimorphism in tail length only, the difference may be due to small number of animals enrolled in (Murdoch et al., 2009).

Sexual dimorphism in body weight and morphometric measurements were in alignment with (Hattingh, 1956; McIntosh, 1963; Voigt, 1987; Zhan et al., 1991; Cavallini, 1995 and Gortazar et al., 2000) that were typically found heavier and larger male than female red foxes.

In the entire work, there were no significant sexual dimorphism in adult foxes regarding neck circumference nor hindfoot length which is matching with results of (Takeuchi, 2010) in red foxes in Japan, and (Murdoch et al., 2009) in Mongolia.

Sexual dimorphism usually evolves due to three mechanisms, including sexual

selection (i.e., when characters that confer an advantage in the competition for mates or mate choice are selected for within one sex), food competition between sexes, and intrinsic differences between the reproductive roles of males and females (i.e., the 'dimorphic niche' hypothesis) (Hedrick and Temeles, 1989).

On the other hand, there were no significant difference between young male animals and young female animals in all morphometric measurements, which is disagreeing with the results of (Zhan et al.,1997) on 9 – month Silver foxes (subspecies of red fox in Japan) which recorded significant variance in head length, body length, depth of chest and all measurements of long bones between male and female animals and this may be due to the sample selected by the author (9-months of age) which is near the adults values.

The clear significant differences in all morphometric measurements and bodyweight between adult and young foxes either in female group or male group may be referred to the obvious difference in age, as the young group almost less than 7 months old.

Generally, terrestrial mammals finish growing by the beginning of reproduction; changes in body size after maturation are slight (McNab 1971; Imaizumi 1986). In the Red fox, growth is rapid during the cub stage until 3–4 months after birth (Lloyd 1980; Sasakawa 1984). Cubs grow almost to adult size by 6 months after birth (Fairley 1970).

Subadult males disperse further and more often than females (Storm et al. 1976) to obtain early reproductive opportunities at as early as 9–10 months aged (Storm et al. 1976; Harris 1977). Not only an acquired body character giving the visual impression of largeness, but innate body characteristics may additionally promote mating success.

Conflict of interest statement

The author declares that there is no potential conflict of interest.

References

Basuony M, Saleh M, Riad A, Fathy W (2005). Food composition and feeding ecology of the Red Fox *Vulpes vulpes* (Linnaeus, 1758) in Egypt. Egyptian Journal of Biology, 7: 96-102.

Canada Fox Breeders' Association (2013). Code of practice for the care and handling of farmed fox (*Vulpes vulpes*). Canada Fox Breeders' Association and the National Farm Animal Care Council. Canada.

Cavallini P (1995). Variation in the body size of the red fox. In Annales Zoologici Fennici (pp. 421-427). Finnish Zoological and Botanical Publishing Board.

Crooks K (1994). Demography and status of the island fox and the island spotted skunk on Santa Cruz Island, California. The Southwestern Naturalist 39: 257–262.

Fairley J.S. (1970). The food, reproduction, form, growth and development of the fox, Vulpes vulpes, in north-east Ireland. Proceedings of the Royal Irish Academy 69: 103–137.

Foresman KR (2012). Carnivores in hand. In Carnivore Ecology and Conservation. Oxford University Press. Oxford University Press Inc., New York.

Gortázar C, Travaini A, Delibes M (2000). Habitat-related microgeographic body size variation in two Mediterranean populations of red fox (*Vulpes vulpes*). Journal of Zoology, 250(3): 335-338.

Grue H. and Jensen B. (1979). Review of the formation of incremental lines in tooth cementum of terrestrial mammals [age determination, game animal, variation, sex, reproductive cycle, climate, region, condition of the animal]. Danish Review of Game Biology 11(3): 1-48.

Gugołek A (2011). Nutritional recommendations and nutritional value of feed to fur animals. Collective work. Institute of Animal Physiology and Nutrition, Jabłonna, 211.

Harris S. (1977). Distribution, habitat utilization and age structure of a suburban fox (*Vulpes vulpes*) population. Mammal Review 7: 25–39.

Hattingh I (1956). Measurements of foxes from Scotland and England. Proceedings of the Zoological Society of London. 127: 191–199.

Hedrick AV and Temeles EJ (1989). The evolution of sexual dimorphism in animals: hypotheses and tests. Trends in ecology and evolution, 4(5): 136-138.

Imaizumi Y. (1986). Measurement methods for mammals and their significance. Bird and Mammal Measurements Manual (I) Special publication from the Tochigi Prefectural Museum. No. 2, pp. 59–63. Utsunomiya (in Japanese).

Jensen B and Nielsen LB (1968). Age determination in the red fox (*Vulpes vulpes*) from canine tooth sections. Danish Review of Game Biology. 5(6): 1-16.

Kolb HH and Hewson R (1974). The body size of the red fox (*Vulpes vulpes*) in Scotland. Journal of Zoology, 173(2): 253-255.

Lewis RE and Lewis JH (1968). A review of Lebanese mammals. Carnivora, Pinnipedia, Hyracoidea and Artiodactyla. Journal of zoology, 154(4): 517-531.

Lloyd, HG. (1980). The Red Fox. B. T. Bastford, London, 320 pp. Martin, R.E., Pine R. H. and DeBlase, A. F. 2001. A Manual of Mammalogy: With Keys to Families for the World, 3rd ed. McGraw-Hill Co. Ltd., New York, USA, 333 pp

Magi M, Guardone L, Mignone W, Prati MC, Macchioni F (2016). Intestinal helminths of red foxes (*Vulpes vulpes*) in north-west Italy. Helminthologia, 53(1): 31-38.

McIntosh DL (1963). Reproduction and growth of the red fox in Canberra district. CSIRO Wildlife Research. 8: 132–141.

McNab BK. (1971). On the ecological significance of Bergmann's rule. Ecology 52: 845–854.

Murdoch JD, Munkhzul T, Buyandelger S, and Reading RP (2009). Body size and sexual dimorphism among a population of corsac and red foxes in central Mongolia. Mammalia 73 (2009): 72–75

Osborn DJ and Helmy I (1980). The contemporary land mammals of

Egypt (including Sinai). Field Museum of Natural History Chicago ILL.

Ramsden RO, Coppin PF, Johnston DH (1976). Clinical observations on the use of ketamine hydrochloride in wild carnivores. Journal of Wildlife Diseases. 12(2): 221-225.

Sasakawa M (1984). Growth of the skull and eruption sequences of permanent teeth in red fox (*Vulpes vulpes).* Japanese Journal of Oral Biology, 26(4), 1210-1227 (in Japanese with English abstract)

Sasakawa M, Maekawa K, Ohtaishi, N, Nakane F (1980). Age determination from annual layers in canine tooth cementum and age variation of the canine tooth of red fox *(Vulpes vulpes).* Hokkaido Journal of Dental Science 1: 23-27. (in Japanese)

Slavica A, Dezdek D, Konjevic D, Cvetnic, Z, Sindicic M, Stanin D, Habus J, Turk N (2011). Prevalence of leptospiral antibodies in the red fox (*Vulpes vulpes*) population of Croatia. Veterinarni Medicina, 56(4): 209–213

Solberg EH (2008a). Introductory concept. In Tietz fundamentals of clinical chemistry, 6th Edition. Carl AB, Edward RA and David EB (eds.). W.B. Saunders, Philadelphia, Pennsylvania, pp. 3–30.

Stocker L (2005). Red fox. In Practical Wildlife Care. 2nd Edn. Blackwell Science. pp 224-231

Storm GL, Andrews RD, Phillips RL, Bishop RA, Siniff DB, Tester JR (1976). Morphology, reproduction, dispersal, and mortality of midwestern red fox population. Wildlife Monograph 49: 1–82.

Takeuchi M (2010). Sexual dimorphism and relative growth of body size in the Japanese red fox (*Vulpes vulpes japonica*). Mammal Study, 35(2): 125-131.

Voigt DR (1987). Red fox In Novak M, Baker JA, Obbard ME and Mallock B eds., Wild Furbearer Management and Conservation in North America, pp. 378-392. Toronto: Ontario Ministry of Natural Resources.

World Health Organization (1997). World Survey of Rabies No. 31 for Year 1995. WHO/EMC/ZOO/97.1. WHO Division of Emerging and Other Communicable Diseases Surveillance and Control, Geneva, 29 pp.

Zhan YM, Yasuda J, Too K (1991). Reference data on the anatomy and serum biochemistry of the silver fox. Japanese Journal of Veterinary Research, 39(1): 39-50.

Zhan YM, Yasuda J, Too K (1997). Reference data on the anatomy, hematology and biochemistry of 9-month-old silver foxes. Japanese Journal of Veterinary Research, 45(1): 13-19.