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Original Article

Comparative Craniometric Measurements of Two Sympatric Species of *Vulpes* in Ikh Nart Nature Reserve, Mongolia

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Abstract

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In Mongolia, both the red fox (*Vulpes vulpes*) and corsac fox (*Vulpes corsac*) occupy broad sympatric ranges, but despite their expansive ranges, few published details of the craniometry of either species exist in Mongolia and other parts of northern and central Asia. To determine the morphological differences between two species of foxes, we tested for morphological and morphometrical differences between the red (n = 13) and corsac (n = 11) foxes using 63 cranium measurements. All significantly different skull variables were larger for red foxes than corsac foxes. This paper reports comparison of the cranial measurements from skulls of red and corsac foxes and serves as a preliminary investigation of interspecific variation between these species.

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Introduction

Red fox (*Vulpes vulpes*) and corsac fox (*Vulpes corsac*) populations have declined over recent years in Mongolia due to over-harvesting triggered by a high demand for furs and habitat degradation (Clark *et al.*, 2006, Wingard & Zahler 2006). As a result, both species were designated under the IUCN Red List Categories and Criteria as Near Threatened regionally in 2006 (Clark *et al.,* 2006), and Least Concern globally more recently (Murdoch 2014; Hoffmann & Sillero-Zubiri 2016). Long-term conservation of Mongolian fox populations requires knowledge of the species' biology and ecology, including especially the influence of poaching on population size and structure (Murdoch *et al.,* 2010b).

The corsac fox differs in body size from sympatric congeners in the overlapping parts of their ranges. Corsac foxes may reach the body mass of the smallest red foxes, but generally corsac foxes are much smaller than red foxes, whose body mass ranges from 3-14 kg (Lariviere & Pasitschniak-Arts, 1996; Clark *et al.,* 2009, Murdoch *et al.,* 2009). Red foxes display sexual dimorphism in body weight and proportions in many areas (Kolb & Hewson, 1974; Lups & Wandeler, 1983; Wandeler & Lups, 1993; Macdonald & Sillero-Zubiri, 2004), including differences between male and female red fox skulls from several different regions (Churcher, 1960; Huson & Page, 1979; Lups & Wandeler, 1983; Fairly & Bruton, 1984; Hell *et al*., 1989; Ansorge, 1994; Lynch, 1996). Such dimorphism could complicate comparisons between red and corsac foxes. Additional research found that parasites could modify skull dimensions in other species (Demuth *et al*., 2009); however, whether or not this phenomenon occurs among foxes living in the wild, remain unknown.

Researchers have studied the morphology and craniometrics of red foxes and, to a lesser extent, corsac foxes in other parts of their ranges (Ognev, 1962; Sokolov & Orlov, 1980; Churcher, 1960; Huson & Page, 1979; Lups & Wandeler, 1983; Fairly & Bruton, 1984; Hell *et al.,* 1989; Ansorge, 1994; Lynch, 1996), but few published details exist on the cranial measurements of these species in Mongolia. Previous work found that corsac foxes demonstrated a smaller total skull length than do red foxes, whose skulls range from 140-150 mm (Lariviere & Pasitschniak-Arts, 1996, Clark *et al.,* 2009). In addition, corsac foxes have a less-developed and lower sagittal crest, a more gradually tapering rostrum, and smaller, flatter auditory bullae than do red foxes (Sokolov & Orlov, 1980; Sheldon, 1992; Clark *et al.,* 2009).

Materials and Methods

We studied red and corsac fox samples obtained from skulls found opportunistically and from radio-collared animals that died due to poaching ornatural causes during ecological research in Ikh Nart Nature Reserve in Mongolia. We collected 24 skull samples of red (n = 13) and corsac (n = 11) foxes in Ikh Nart between 2004 and 2008. The samples were stored in paper bags prior to transferring them to the Mammalian Ecology Laboratory of the Institute of General and Experimental Biology, Mongolian Academy of Sciences.

We sorted the skulls by species; cleaned them of skin, flesh, and debris (mostly soil) and stored them in plastic bags. Skulls and mandibles were then soaked in antiseptic for 2 hours before

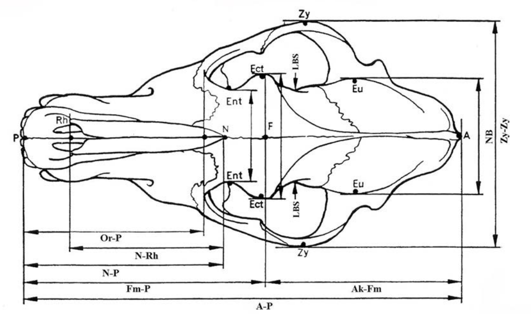

Figure 1. Measurements of the cranium of a fox (*Vulpes* spp.) skull and dorsal view. See Table 1 for definitions of the abbreviations.

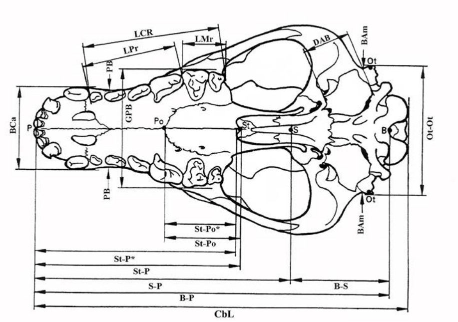

Figure 2. Measurements of the cranium of a fox (*Vulpes* spp.) skull and basal view. See Table 1 for definitions of the abbreviations.

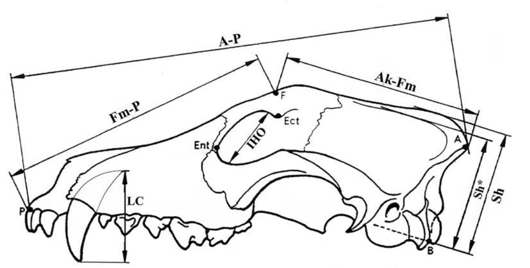

Figure 3. Measurements of the cranium of a fox (*Vulpes* spp.) skull and lateral view. See Table 1 for definitions of the abbreviations.

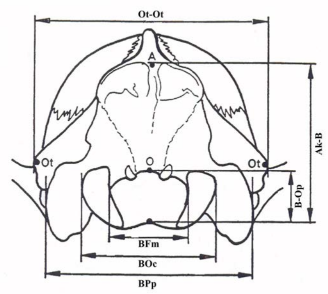

Figure 4. Measurements of the cranium of a fox (*Vulpes* spp.) skull and nuchal view. See Table 1 for definitions of the abbreviations.

collecting craniometric measurements. We used calipers for craniometry to an accuracy of 0.1 mm, following the skull measurement methods outlined by Von den Driesch (1976) and Frackowiak *et al*. (2013). We gathered data on a total of 63 metric variables (Figures 1-9). Definitions for the abbreviations of our measurements were provided in Table 1.

We also compared our results with other published data (Storm *et al*., 1976; Lynch, 1996; Temizer, 2001). Following Grue and Jensen (1973), we counted cementum layers on longitudinally sanded canine roots as our primary procedure for age determination. Degree of fusion of cranial sutures, clothing of the tooth pulp, and the wear of the occlusal surface of M1 were used to confirm age determinations. Length parameters of the red fox skulls almost reach full size by 6 months of age, but width dimensions continue increasing until the second year of life

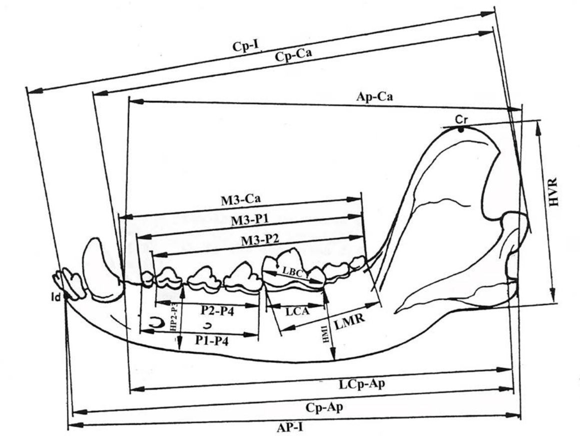

Figure 5. Measurements of the mandible of a fox (*Vulpes* spp.) skull and lateral view. See Table 1 for definitions of the abbreviations.

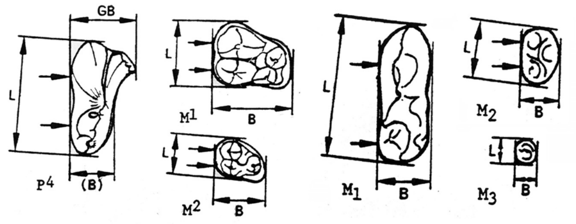

Figure 6. Measurements of the maxillary and mandibular teeth of a fox (*Vulpes* spp.) skull. See Table 1 for definitions of the abbreviations.

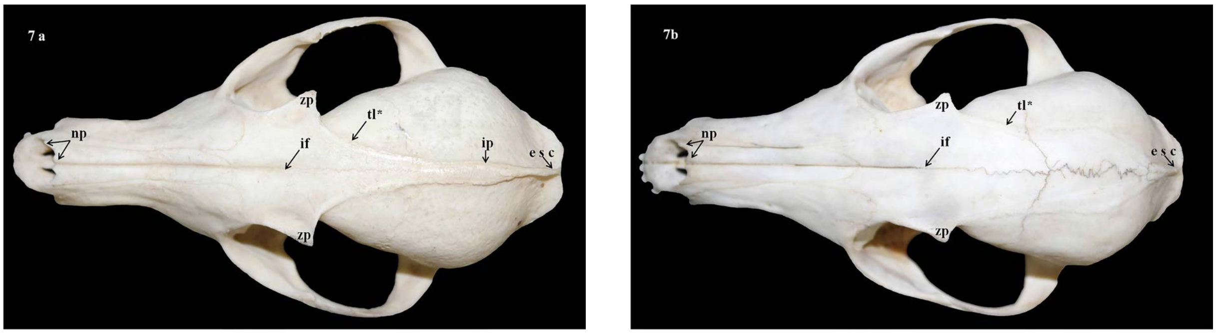

Figure 7. Dorsal view of the skull of a) red fox (*V. vulpes*) and b) corsac fox (*V. corsac*) collected in Ikh Nart Nature Reserve, Mongolia. esc – external sagittal crest, ip – interparietal suture,tl– temporal line, if – interfrontalsuture, zp – zygomatic process, np – nasal processes.

Figure 8. Nuchal view of the skull of a) red fox (*V. vulpes*) and b) corsac fox (*V. corsac*) collected in Ikh Nart Nature Reserve, Mongolia. esc – external sagittal crest, nc – nuchal crest, spo– squamous part of the occipital bone, oc – occipital condyle, pp – paracondylar process, tb – tympanic bulla, fm – foramen magnum.

Table 1. Abbreviations of measurements made on red (*V. vulpes*) and corsac (*V. corsac*) fox skulls from Ikh Nart Nature Reserve, Mongolia. Actual measurements are illustrated in Figures 1-5.

Abbreviation	Measurement description
Cranium measurements	
A-P:	Total length
Ak-Fm:	Upper neurocranium length
N-P:	Viscerocranium length
Fm-P:	Facial length
N-Rh:	Greatest length of nasals
Or-P:	"Snout" length
Zy-Zy:	Zygomatic breadth
NB:	Greatest neurocranium breadth
LBS:	Least breadth of skull
Ect-Ect:	Frontal breadth
Ent-Ent:	Least breadth between the orbits
CbL:	Condylobasal length
B-P:	Basal length
B-S:	Basicranial axis
S-P:	Basifacial axis
St-P:	Median palatal length (see Figure 2)
St-P*:	Palatal length (see Figure 2)
St-Po:	Length of the horizontal part of the palatine (see Figure 2)
St-Po*:	Length of the horizontal part of the palatine (see Figure 2)
LCR:	Length of cheektooth row
LMr:	Length of the molar row
LPr:	Length of the premolar row
BCa:	Breadth at the canine alveoli
PB:	Least palatal breadth
GPB:	Greatest palatal breadth
DAB:	Greatest diameter of the auditory bulla
BAm:	Breadth dorsal to the external auditory meatus
Sh:	Skull height
Sh*:	Skull height without the sagittal crest
IHO:	Greatest inner height of the orbit
Ot-Ot:	Greatest mastoid breadth

Abbreviation	Measurement description
Ak-B:	Height of the occipital triangle
B-Op:	Height of the foramen magnum
BPp:	Greatest breadth of the bases of the paraoccipital processes
BOc:	Greatest breadth of the occipital condyles
BFm:	Greatest breadth of the foramen magnum
Mandible measurements	
Cp-I:	Total length from condyle process
Ap-I:	Length from angular process
Cp-Ap:	Length from indentation between the condyle process and angularprocess
Cp-Ca:	Length from condyle process to the aboral border of the canine alveolus
LCp-Ap:	Length from indentation between the condyle process and angularprocess to the aboral border of the canine alveolus
Ap-Ca:	Length from the angular process to the aboral border of the canine alveolus
M3-Ca:	Length from the aboral border of the alveolus of M_3 to the aboral border ofthe canine alveolus
M3-P1:	Length of the cheektooth row
M3-P2:	Partial length of the cheektooth row
LMR:	Length of the molar row
P1-P4:	Length of the premolar row
P2-P4:	Partial length of the premolar row
LBC:	Length of the carnassials
LCA:	Length of the carnassial alveolus
LM2:	Length of M_2
LM3:	Length of M_3
HVR:	Height of the vertical ramus
HM1:	Height of the mandible behind M_1
HP2-P3:	Height of the mandible between P_2 and P_3
Tooth measurements	
L:	Maxillary and mandibular tooth length
B:	Maxillary and mandibular tooth breadth

(Ansorge, 1994). We defined age classes as: 1 to < 2 years, 2 to < 3 years, 3 to < 4 years, 4 to < 5 years, and 5 years and older. We were able to determine ages for 9 red fox skulls and 6 corsac fox skulls. An average (± SD) age of red and corsac fox skulls were 4.15 ± 1.36 and 3.17 ± 1.83 years, respectively, ranged between 1 and 5 years for both species. We pooled all measurements across all age classes for both species for comparison.

We collected basic descriptive statistics, including the mean, standard deviation (SD), and coefficient of variation (CV). We used the non-parametric Wilcoxon-Matt-Whitney U-test,

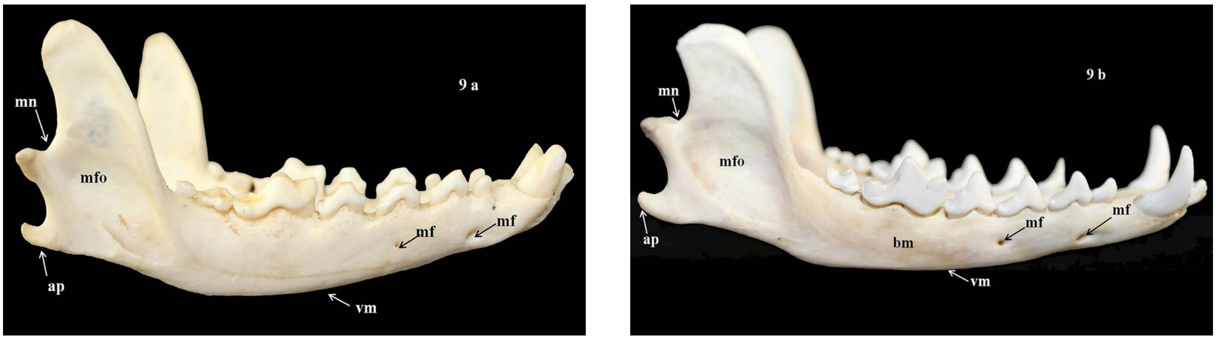

Figure 9. Lateral view of the mandible of a) red fox (*V. vulpes*) and b) corsac fox (*V. corsac*) collected in Ikh Nart Nature Reserve, Mongolia. vm – ventral margin of the body of the mandible – bm, mf – mental foramen, mfo – masseteric fossa, mn – mandibular notch, ap – angular process.

similar to a t-test for independent samples, to compare cranial measurements between species because our data did not follow a normal distribution. We analyzed data using R (R Core Team 2015) and significance was set at $P < 0.05$.

Results

We found significantly different skull measurements for most morphological features between corsac foxes and red foxes. In particular, corsac foxes demonstrated smaller, shorter and wider skulls, and with more robust canine teeth (Table 2). The corsac fox possessed a more gradually tapering rostrum and smaller, flatter auditory bullae than did the red fox (Figure 7). The external sagittal crest of the red fox arises at the junction of the temporal lines, near the interparietal bone (Figure 7a). The interfrontal and interparietal sutures in the red fox running between temporal lines were typically serrated. Low ridges extended back from the postorbital processes, with the temporal lines of the postorbital processes converging at an acute angle at the boundary of the frontal and parietal bones and forming a "V" shape on top of the skull (Figure 7a). Alternatively, in corsac foxes the temporal lines diverged from the postorbital processes, ran nearly parallel on top of the skull (with an under-developed interparietal suture), and converged near the posterior suture of the parietal bones (Figure 7b). Further, the corsac fox had a less-developed and lower external sagittal and nuchal crests than did the red fox (Figures 7 & 8).

The squamous part of the occipital bone in the corsac fox was smaller than in the red fox (Figure 7). The occipital condyles, paracondylar process and tympanic bullae in the red fox were all better developed than in the corsac fox (Figures 7 and 8). The upper side of the foramen magnum was wider and more arched of the red fox, while that of the corsac foxes was more oval (Figure 8).

Both species have two mental foramina of the mandible (Figure 9). Red foxes' masseteric fossa was deeper and wider than in corsac foxes. In addition, the mandibular notch and angular process were slightly better developed in the red fox (Figure 9). Red foxes "lower edge of the ramus curved gently back to the end of the angle, but corsac foxes" lower edge of ramus showed a distinct step, or break, just in front of the angle (Figure 9).

Skull morphological measurements confirmed these visual differences. We found significant differences in most skull measurements between two species (Table 2). In particular, measurements from the basal view (LPr, DAB, GPB), dorsal view (NB), nichal view (Ot-ot), laterial view (Hp-I, Cp-Ap, Cp-Ca, LCa-Ap, Ap-Ca, M3-Ca, LMR, LCA) and maxillary teeth (M1L) showed highly significant differences (Table 2). Similarly, most of the dental measurements of the skull and mandible revealed highly significant differences between species (Table 2). Most measurements of the length of the mandible (HP-I, Cp-Ap, Cp-Ca, LCa-Ap, Ap-Ca, M3-Ca) revealed significant differences between species (Table 2). Measurements of the posterior part of the body of mandible (LCA, HM1) revealed significant differences between species (Table 2).

Discussion

Coexistence of species that occupy similar niches generally occurs through the differential use of resources, such as food, space, and time (Schoener, 1974). Such resource partitioning

Table 2. Comparison of mean (± SD) measurements (cm) of red (*V. vulpes*) and corsac (*V. corsac*) fox skulls, mandibles, and teeth from Ikh Nart Nature Reserve, Mongolia. Differences examined Wilcox Mann Whitney U test.

View	Measurement	Red fox			Corsac fox			*W*	*P*
		N	Mean ± SD	CV	N	Mean ± SD	CV		
Dorsal view	A-P	12	14.7 ± 0.6	0.04	11	12.08 ± 1.3	0.1	126	<0.001
	Fm-P	13	8.2 ± 0.4	0.05	11	6.6 ± 0.8	0.1	134	<0.001
	Ak-Fm	12	6.8 ± 0.4	0.06	11	5.8 ± 0.3	0.05	122	<0.001
	N-P	13	6.9 ± 0.4	0.06	11	5.5 ± 0.7	0.13	132	<0.001
	N-Rh	13	5.4 ± 0.3	0.06	11	4.3 ± 0.6	0.1	120	<0.001
	Or-P	13	6.04 ± 0.4	0.07	11	4.6 ± 0.6	0.1	133	<0.001
	NB	12	4.7 ± 0.2	0.04	11	4.3 ± 0.1	0.03	122	<0.001
	Zy-Zy	8	7.6 ± 0.3	0.04	9	6.7 ± 0.5	0.08	65	<0.005
	LBS	12	2.2 ± 0.1	0.05	11	2.3 ± 0.1	0.08	50	<0.5
	Ect	13	3.5 ± 0.3	0.1	11	3.1 ± 0.3	0.1	109	<0.05
	Ent	13	2.7 ± 0.2	0.07	11	2.4 ± 0.2	0.1	109	<0.05
Basal view	CBL	12	14.04 ± 0.7	0.05	10	11.7 ± 1.3	0.1	107	<0.001
	B-P	12	12.7 ± 1.4	0.11	11	11.0 ± 1.3	0.1	105	<0.01
	B-S	10	3.6 ± 0.3	0.08	11	2.6 ± 0.4	0.1	102	<0.001
	S-P	10	9.7 ± 0.9	0.09	11	8.2 ± 0.9	0.1	92	<0.01
	St-P	12	7.2 ± 0.4	0.05	11	6.05 ± 0.7	0.1	120	<0.001
	St*-P	12	7.05 ± 0.3	0.05	11	5.8 ± 0.6	0.1	120	<0.001
	St-Po	12	2.1 ± 0.4	0.2	11	1.9 ± 0.3	0.2	108	<0.01
	St*Po	12	2.04 ± 0.1	0.08	11	1.8 ± 0.2	0.2	108	<0.01
	LCR	12	5.4 ± 0.2	0.04	11	4.5 ± 0.5	0.1	118	<0.001
	LMr	13	1.3 ± 0.1	0.1	11	1.1 ± 0.2	0.2	116	<0.01
	LPr	12	4.2 ± 0.1	0.04	11	3.6 ± 0.4	0.1	116	<0.005
	DAB	11	2.1 ± 0.06	0.02	11	1.8 ± 0.1	0.1	60	<0.001
	Ot	12	4.7 ± 0.2	0.04	11	4.1 ± 0.4	0.09	117	<0.001
	GPB	13	4.0 ± 0.2	0.06	11	3.5 ± 0.3	0.08	124	<0.005
Lateral view	Cp-I	8	9.6 ± 3.3	0.3	7	9.1 ± 0.8	0.09	47	<0.05
	HP-I	12	10.8 ± 0.5	0.04	11	8.9 ± 0.7	0.08	128	<0.001
	Cp-Ap	12	10.4 ± 0.5	0.04	11	8.8 ± 0.9	0.1	118	<0.001
	Cp-Ca	13	9.9 ± 0.3	0.03	10	8.2 ± 0.7	0.08	114	<0.001
	LCa-Ap	11	9.3 ± 0.3	0.03	9	7.8 ± 0.6	0.08	97	<0.001
	Ap-Ca	13	9.6 ± 0.4	0.05	11	8.07 ± 0.6	0.07	138	<0.001
	M3-Ca	13	6.5 ± 0.2	0.03	11	5.4 ± 0.4	0.08	136	<0.001
	M3-P1	12	5.9 ± 0.2	0.04	11	5.0 ± 0.4	0.08	123	<0.001
	M3-P2	13	5.4 ± 0.2	0.03	11	4.5 ± 0.4	0.09	136	<0.001
	LMR	13	2.6 ± 0.1	0.03	11	2.1 ± 0.1	0.09	141	<0.001
	P1-P4	13	3.5 ± 0.2	0.08	9	2.9 ± 0.2	0.07	106	<0.01
	P2-P4	12	2.7 ± 0.3	0.1	11	2.4 ± 0.2	0.08	116	<0.001
	LBC	13	1.6 ± 0.2	0.1	10	1.3 ± 0.1	0.1	116	<0.001
	LCA	13	1.3 ± 0.09	0.06	10	1.08 ± 0.1	0.1	122	<0.001
	HVR	13	3.7 ± 0.1	0.04	11	3.2 ± 0.2	0.06	137	<0.001
	HM1	13	1.4 ± 0.07	0.04	10	1.2 ± 0.1	0.1	125	<0.001
	HP2-P3	11	1.4 ± 0.2	0.1	10	1.05 ± 0.09	0.08	97	<0.005
Left side view	IHO	11	2.2 ± 0.4	0.1	10	2.2 ± 0.07	0.03	63	<0.5
	Sh	12	4.0 ± 0.3	0.08	11	3.7 ± 0.6	0.1	93	<0.1
	Sh*	12	3.7 ± 0.3	0.09	11	3.5 ± 0.5	0.1	83	<0.5

Table 2. (continued)

View	Measurement	Red fox			Corsac fox			W	P
		N	Mean ± SD	CV	N	Mean ± SD	CV		
Nichal view	Ot-Ot	11	4.8 ± 0.1	0.02	11	4.2 ± 0.3	0.08	114	<0.001
	BFm	12	1.5 ± 0.03	7.3	11	1.3 ± 0.3	8.2	115	<0.005
	BOc	12	2.5 ± 0.07	0.02	11	2.2 ± 0.3	0.1	107	<0.01
	BPp	11	4.1 ± 0.4	0.1	10	3.6 ± 0.3	0.09	91	<0.01
	B-Op	12	1.1 ± 0.05	0.05	10	0.9 ± 0.07	0.07	108	<0.001
	AK-B	12	2.5 ± 0.1	0.06	11	2.2 ± 0.2	0.09	108	<0.005
Tooth view	Max-P4L	9	1.4 ± 0.1	0.1	10	1.2 ± 0.1	0.1	84	<0.05
	Max -P4B	10	0.6 ± 0.1	0.2	10	0.5 ± 0.05	0.1	92	<0.01
	Max -M1L	11	0.9 ± 0.09	0.1	10	0.7 ± 0.2	0.2	113	<0.005
	Max -M1B	10	1.2 ± 0.08	0.06	10	1.04 ± 0.1	0.1	108	<0.01
	Max -M2L	10	0.5 ± 0.04	0.08	10	0.4 ± 0.04	0.09	86	<0.001
	Max-M2B	10	0.7 ± 0.2	0.2	10	0.7 ± 0.09	0.1	74	<0.05
	Man-M1L	8	1.5 ± 0.2	0.1	8	1.2 ± 0.1	0.1	54	<0.01
	Man-M1B	8	0.6 ± 0.08	0.1	8	0.4 ± 0.07	0.1	45	<0.5
	Man -M2L	8	0.7 ± 0.02	0.03	8	0.5 ± 0.09	0.1	52	<0.05
	Man -M2B	8	0.4 ± 0.2	0.3	8	0.4 ± 0.07	0.01	51	<0.05
	Man-M3L	6	0.3 ± 0.04	0.1	8	0.2 ± 0.03	0.1	43	<0.01
	Man-M3B	8	0.3 ± 0.03	0.1	8	0.2 ± 0.05	0.2	38	<0.05

reduces competition and may be inferred from morphological differentiation (Begon *et al*., 2006). Red and corsac foxes occur sympatrically in Ikh Nart Nature Reserve and other arid steppe regions of Mongolia (Clark *et al*., 2006), and occupy similar ecological niches (Murdoch *et al*., 2007; Murdoch, 2009; Munkhzul *et al*., 2012).

Mammalian skulls are highly informative, conservative, and adaptive structures, and therefore, represent a powerful tool for biogeographic, phylogenetic, and systematic investigations, especially in the absence of molecular investigations (Loy, 2007). The *Vulpes* skulls available in museum and private collections could reveal a mass of information related to the adaptations of these animals. A large part of the systematic structure of red foxes in the steppe area has been constructed on the grounds of these skulls, especially at the subspecies level. Researchers have identified some skull morphological differences between red and corsac foxes (Bannikov, 1954; Sokolov & Orlov, 1980), but relatively few publications compare red and corsac fox skull morphologies. Similarly, we are unaware of any studies that compare the craniums of both species. Russian and Mongolian mammalian guide books provide different guidelines for distinguishing between red and corsac foxes using skull morphology. Bannikov (1954), Dulamtseren (1970) and Batsaikhan *et al.* (2010) suggested that skulls greater than 130 mm in length come from red foxes, while skulls less than 130 mm in length come from corsac foxes. Heptner et al. (1992) stated that corsac fox skull lengths range between 95 and 112 mm and suggested if the total length of skull is >115 mm then it comes from a red fox. In addition, Sokolov & Orlov (1980) reported that the total length of red fox skulls varied between 130 and 160 mm.

In a comparative study of the skulls of red fox and arctic foxes (*Vulpes lagopus*), Frackowiak *et al*. (2013) found the most distinct morphological differences in the nasal, temporal, parietal and occipital bones. They found that the most important morphological differences occurred within craniometric measurements, especially in the nasal, occipital, and temporal bones, and the parietal, maxilla, and mandible areas.

Influences of individual age on the craniometric measurements of both species were noticeable in our study. Specifically, we observed a more developed external sagittal crest, wider

Table 3. Mean (± SE) craniometric measurements (cm) of corsac foxes (*V. corsac*) from northern Kazakhstan (Kadyrbaev and Sludskii 1981), Turkmenstan (Scherbina 1995) and Mongolia.

Measurement	Kazakhstan (n=22)	Turkmenstan (n=9)	Ikh Nart (n=11)
Skull length	10.6	10.7	12.07 ± 0.3
Zygomatic breadth	6.1	6.4	6.7 ± 0.2
Height of auditory bullae	4.2	4.4	4.6 ± 0.3
Upper row of teeth	4.0	5.2	4.6 ± 0.4

more arched foramen magnum, deeper and wider masseteric fossa, and better developed mandibular notch and angular process in red foxes than in corsac foxes. Jurgelenas *et al.* (2007) and Frackowiak *et al*. (2013) found similar patterns in their comparison of the skulls of the red fox, raccoon dog (*Nyctereutes procyonoides*; Hidaka *et al.* 1998) and arctic fox. Our study showed differences in the almost all measurements of both species particularly length of the molar row of maxilla and mandible. We also found age and species differences in the skulls of both species in Mongolia.

Craniometric comparisons of corsac foxes from Ikh Nart with animals from Kazakhstan and Turkmenistan suggest agreement with Bergmann's rule (Table 3). However, sample sizes from all three populations were relatively small and more samples, particularly from other regions, would be helpful for assessing whether latitudinal clines exist. Male corsac foxes in Ikh Nart, for example, were lighter on average than males at a more northern latitude in Kazakhstan, but heavier than those from a site to the south in Turkmenistan (Kadyrbaev & Sludskii, 1981; Scherbina, 1995; Murdoch *et al.*, 2009). Corsac foxes from Turkmenistan had longer mean body lengths with shorter mean tail lengths than those from northern Kazakhstan and Ikh Nart, contradicting Allen's Rule (Kadyrbaev & Sludskii, 1981; Scherbina, 1995; Murdoch *et al*., 2009).

Corsac fox and red fox has been a staple source of fur in Mongolia for many years (Wingard & Zahler, 2006). In 1973, concerns that harvest levels had been unsustainable for many years caused the Mongolian government to ban trade in corsac fox furs. It was never reinstated under the communist system. In the 1990, Mongolians once again started harvesting this small carnivore to sell on the international market. With the shift in government, trade went primarily south to China along with virtually all other forms of wildlife trade (Wingard & Zahler, 2006). Overhunting, coupled with habitat disturbance, has caused the corsac fox to disappear from much of its historic range (Ognev, 1962; Stroganov, 1962). The current level of trade in Mongolia has the potential to similarly impact the both species and results from our study can be used to help identify poached foxes to species level.

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