Journal of Animal and Veterinary Advances 10 (21): 2874-2878, 2011
ISSN: 1680-5593

Morphological Examination of the Siberian Roe Deer *Capreolus pygargus* in South Korea

[1]Yong-Su Park, [2]Woo-Shin Lee, [3]Jong-Taek Kim and [4]Hong-Shik Oh
[1]Jangsu Endangered Species Restoration Team, Jangsu County, Jeonbuk 176-7, Korea
[2]Department of Forest Science, Seoul National University, 151-192 Seoul, South Korea
[3]School of Veterinary Medicine, Kangwon National University, 192-1 Gangwon, Korea
[4]Educational Science Research Institute, Department of Science Education,
Jeju National University, 690-750 Jeju, Korea

Abstract: This study compare the external morphological characteristics of Korean roe deer inhabit the inland and Jeju island areas and to clarify the morphological differences by the two groups. Also, total of 40 roe deer bodies were collected from road-kill, poaching and injured survey from December 2004 to June 2009. The result showed that there were significant differences between Inland and Jeju roe deer. Jeju roe deer was relatively smaller than Inland roe deer in body mass. Thus, it appeared to be a unique native species inhabited only in Jeju island in Korea. Because Jeju roe deer that inhabit the island region could be classified as a subspecies level when at least have geographically isolated for a long time and have represented significant external morphology. Therefore, Siberian roe deer in Jeju give a scientific name to *Capreolus pygargus jejuensis*. Also, body mass, hind foot length, ear length and width in morphometric analysis were identified as efficient characteristics for differentiating Inland from Jeju roe deer.

Key words: Taxonomy, morphplogy, species division, Jeju island, Siberian roe deer, Korea

INTRODUCTION

Roe deer are the most numerous wild ungulate species in Eurasia. The genus *Capreolus* presently includes two extant species. Roe deer have been classified to the smaller European roe deer (*Capreolus capreolus*) and larger Siberian roe deer (*Capreolus pygargus*). Among them, the European roe deer is widely distributed in Europe and Asia Minor (Danilkin and Hewison, 1996).

According to mitochondrial DNA sequences and the fossil record, the European roe deer and Siberian roe were subsequently isolated from the Pleistocene and 2-3 million years are known to evolve independently of each other (Danilkin and Hewison, 1996; Randi *et al*., 1998). Until now, the classification system of deer was composed most based on the external form, antler size and skull measurements in which each taxonomists show different view of categories (Bubenik and Bubenik, 1990).

Still taxonomic status of Siberian roe deer is unclear. Sokolov and Gromov (1990) analyzed the external morphology and classified the European roe as a single subspecies while Siberian deer consists of three subspecies (*C.p. manchuricus*, *C.p. pygargus* and *C.p. tianschanicus*). In addition, Wilson and Reeder (1993) classified 8 subspecies (*C.p. bedfordi*, *C.p. caucasia*, *C.p. ferghanicus*, *C.p. manchuricus*, *C.p. melanotis*, *C.p. ochracea*, *C.p. pygargus* and *C.p. tianschanicus*) and studies on the taxonomic position of Siberian roe deer compared to the European roe deer are very incomplete and status is not yet clearly established.

The taxonomic status of Siberian roe deer inhabit Korea and China especially in the Northeast and the neighboring Russian region is not clearly established (Thomas, 1908; Barclay, 1933; Tate, 1947; Koh *et al*., 1997; Koh and Randi, 2001). Also present studies on the taxonomic position of roe deer inhabit Korean Peninsula was not yet done. Furthermore, comparison analysis of external morphological characteristics between the groups of roe deer habitat on the peninsula that is known of the morphological differences between the inland and deer inhabit the Jeju island region is still rarely.

The aims of this study are to compare the external morphological characteristics of Korean roe deer inhabit the inland and Jeju island areas and to clarify the morphological differences and taxonomic characteristics between the two groups.

MATERIALS AND METHODS

Total of 40 roe deer bodies were collected from road-kill survey from December 2004 to June 2009, poaching injured roe deer in Wildlife Medical Rescue

Corresponding Author: Hong-Shik Oh, Educational Science Research Institute, Department of Science Education, Jeju National University, 690-750 Jeju, Korea

Table 1: Information of Siberian roe deer sample using in this study

Sample identity	Gender	Sampling site	Years	Sample identity	Gender	Sampling site	Years
IR01	Male	Inje	200604	JR04	Male	Jeju	200701
IR02	Male	Inje	200610	JR05	Male	Jeju	200701
IR03	Male	Inje	200610	JR06	Male	Jeju	200701
IR04	Male	Gurye	200611	JR07	Male	Jeju	200803
IR05	Male	Yanggu	200612	JR08	Male	Jeju	200803
IR06	Male	Yanggu	200612	JR09	Male	Jeju	200803
IR07	Male	Hongcheon	200705	JR10	Male	Jeju	200803
IR08	Male	Sancheong	200712	JR11	Male	Jeju	200803
IR09	Male	Chuncheon	200802	JR12	Male	Jeju	200902
IR10	Male	Sancheong	200802	JR13	Female	Jeju	200701
IR11	Female	Inje	200702	JR14	Female	Jeju	200701
IR12	Female	Inje	200703	JR15	Female	Jeju	200701
IR13	Female	Inje	200702	JR16	Female	Jeju	200803
IR14	Female	Inje	200703	JR17	Female	Jeju	200803
IR15	Female	Yanggu	200701	JR18	Female	Jeju	200803
IR16	Female	Yanggu	200701	JR19	Female	Jeju	200901
IR17	Female	Sancheong	200711	JR20	Female	Jeju	200901
JR01	Male	Jeju	200701	JR21	Female	Jeju	200901
JR02	Male	Jeju	200701	JR22	Female	Jeju	200901
JR03	Male	Jeju	200701	JR23	Female	Jeju	200901

IR: Inland Roe deer, JR: Jeju island roe deer

Fig. 1: Body dimension of roe deer showing (1) sex; (2) body mass; (3) total length (4) height at shoulder; (5) body girth; (6) body length; (7) front foot length; (8) hind foot length; (9) ear length and width; (10) neck girth (Danilkin and Hewison, 1996)

Center of Kangwon National University and collection of Zoology and morphology laboratory of Jeju National University. External morphological characteristics were measured and compared between roe deer inhabit the inland areas and the Jeju island (Table 1).

Morphological measurement and analysis: Danilkin and Hewison (1996) was used as a reference to measure the following morphological characters: sex, body mass, total length, height at shoulder, body girth, body length, front foot length, hind foot length, ear length and width and neck girth (Fig. 1). All measurements were performed two time by using a measuring tape accurate to 1 cm. In addition, the juvenile male were separated based on the development of posterior upper Molars (M3) and wear the teeth, the antler of shape and size and were excluded from measurement and analysis (Geist, 1998; Sheremetyeva and Sheremetyev, 2008).

Morphometric analysis: The statistical total length of the body parameters were equalized by standardizing the original data with subtracting the mean and dividing by the standard deviation before analysis. The standardized values (characters) lay within the range of 0-1 whatever their original scope. All statistical procedures were performed using the SPSS 12.0 program for Windows (SPSS Inc., USA).

RESULTS AND DISCUSSION

Morphological comparison between male and female of Siberian Roe deer in South Korea: Morphological comparison and analysis of Siberian roe deer between male and female in inland and Jeju island using ten characters showed a significant difference in body length only (Table 2). The body length was significant difference between male and female roe deer in inland and Jeju island. The result showed that Inland roe deer of male 53.1±5.3 cm is bigger than female 48.3±0.8 cm (t-test, $F = 5.7$, $p<0.05$) while Jeju island roe deer of male 49.6±5.7 cm is smaller than female 55.4±2.2 cm (t-test, $F = 7.3$, $p<0.05$).

Morphological comparison between mainland and Jeju island of roe deer in South Korea: The results showed significant differences of morphological characters between inland and Jeju island roe deer except for body

Table 2: Body characteristics of Siberian roe deer in mainland and Jeju island

	Mainland roe deer						Jeju roe deer					
			95% confidence interval for mean						95% confidence interval for mean			
	N	Mean±SD	Lower	Upper	Min.	Max.	N	Mean±SD	Lower	Upper	Min.	Max.
Body mass (kg)												
Male	10	32.0±2.3	30.1	33.9	29	35	12	16.4±2.7	14.8	18.0	10	22
Female	7	30.9±2.3	28.8	33.0	28	34	11	18.0±2.2	16.2	19.8	15	21
Total	17	31.5±2.3	30.2	32.7	28	35	23	17.0±2.6	15.8	18.2	10	22
Total length (cm)												
Male	10	109.0±9.1	101.4	116.6	91	119	12	95.4±5.5	92.2	98.5	86	103
Female	7	114.1±4.6	109.9	118.4	105	118	11	98.6±6.0	93.6	103.6	89	108
Total	17	111.4±7.6	107.2	115.6	91	119	23	96.5±5.8	94.0	99.1	86	108
Height at shoulder (cm)												
Male	10	67.8±5.1	63.4	72.1	60	77	12	57.0±4.2	54.6	59.4	50	64
Female	7	64.4±1.4	63.1	65.7	62	66	11	58.5±4.8	54.5	62.5	51	66
Total	17	66.2±4.1	63.9	68.5	60	77	23	57.5±4.3	55.6	59.5	50	66
Body girth (cm)												
Male	10	70.5±1.8	69.0	72.0	67	72	12	60.9±5.4	57.7	64.0	50	72
Female	7	71.9±2.9	69.2	74.5	68	75	11	60.8±3.7	57.6	63.9	56	67
Total	17	71.1±2.4	69.8	72.5	67	75	23	60.8±4.8	58.7	62.9	50	72
Body length* (cm)												
Male	10	53.1±5.3	48.7	57.6	48	59	12	49.6±5.7	46.3	52.9	41	58
Female	7	48.3±0.8	47.6	49.0	48	50	11	55.4±2.2	53.5	57.2	52	58
Total	17	50.9±4.5	48.4	53.4	48	59	23	51.7±5.5	49.3	54.1	41	58
Front foot length (cm)												
Male	10	28.6±1.1	27.7	29.5	27	30	12	22.7±1.2	22.0	23.4	20	24
Female	7	28.0±0.0	28.0	28.0	28	28	11	23.6±1.2	22.6	24.6	21	25
Total	17	28.3±0.8	27.9	28.8	27	30	23	23.0±1.3	22.5	23.6	20	25
Hind foot length (cm)												
Male	10	35.9±1.5	34.7	37.1	34	38	12	28.4±1.5	27.5	29.3	26	30
Female	7	36.0±0.0	36.0	36.0	36	36	11	29.4±1.1	28.5	30.3	28	31
Total	17	35.9±1.0	35.4	36.5	34	38	23	28.7±1.5	28.1	29.4	26	31
Ear length (cm)												
Male	10	13.3±0.9	12.5	14.0	12	14	12	9.4±0.6	9.0	9.7	8	10
Female	7	13.9±0.4	13.5	14.2	13	14	11	9.3±0.5	8.9	9.6	9	10
Total	17	13.5±0.7	13.1	13.9	12	14	23	9.3±0.6	9.1	9.6	8	10
Ear width (cm)												
Male	10	7.0±0.0	7.0	7.0	7	7	12	4.9±0.3	4.8	5.1	4	5
Female	7	7.0±0.0	7.0	7.0	7	7	11	4.9±0.4	4.6	5.2	4	5
Total	17	7.0±0.0	7.0	7.0	7	7	23	4.9±0.3	4.8	5.0	4	5
Neck length (cm)												
Male	10	31.0±4.1	27.6	34.4	27	38	12	29.9±4.5	27.3	32.6	24	40
Female	7	35.3±3.7	31.9	38.7	30	38	11	26.9±2.3	25.0	28.8	24	30
Total	17	33.0±4.4	30.6	35.4	27	38	23	28.8±4.1	27.0	30.6	24	40

*: $p<0.05$; SD: Standard Deviation

length (t-test, F = 0.3, $p>0.05$) (Table 3). Jeju island roe deer was relatively smaller than Inland roe deer in body mass.

Morphometric comparison between inland and Jeju island of roe deer in South Korea: Morphometric analysis showed that body mass (one-way ANOVA, F = 2.0, $p<0.01$), hind foot length (one-way ANOVA, F = 4.8, $p< 0.01$), ear length (one-way ANOVA, F = 0.001, $p<0.01$) and width (one-way ANOVA, F = 0.1, $p<0.01$) were significant differences between inland and Jeju island populations. Honestly significant difference of Tukey analysis showed the same result.

As a result of CANDISC analysis, the unique value of 10 characters used in this study were 80.340, 3.371. Four characters such as weight, foot length, ear length and width were identified as efficient characteristics for differentiating inland from Jeju roe deer population. In addition, a difference scatter between the two groups in the scatterplot showed there is a significant difference of morphology between the two groups (Fig. 2).

In a study on external morphology of the Siberian roe deer, male were reported to be greater than female (Danilkin and Hewison, 1996). However, since all the analyzed characters appears to be no significant difference between male and female, it is considered no morphological differences between sexes of roe deer inhabit the Korean peninsula. Because the status of the teeth and horns were determined using the measurement of adults over 2 years only if no significant morphological difference of male and female between the ages of objects.

Morphology of roe deer vary depending on several factors such as the age of deer (Hewison *et al*., 1996), qualitative differences in food resources and habitat

Table 3: Body characteristics of Siberian roe deer in mainland and Jeju island

Body characteristics	Areas	N	Mean	SD	95% confidence interval for mean		Min.	Max.
					Lower	Upper		
Body mass** (kg)	Mainland	17	31.5	2.3	30.2	32.7	28	35
	Jeju	23	17.0	2.6	15.8	18.2	10	22
Total length** (cm)	mainland	17	111.4	7.6	107.2	115.6	91	119
	Jeju	23	96.5	5.8	94.0	99.1	86	108
Height at shoulder** (cm)	Mainland	17	66.2	4.1	63.9	68.5	60	77
	Jeju	23	57.5	4.3	55.6	59.5	50	66
Body girth** (cm)	Mainland	17	71.1	2.4	69.8	72.5	67	75
	Jeju	23	60.8	4.8	58.7	62.9	50	72
Body length (cm)	Mainland	17	50.9	4.5	48.4	53.4	48	59
	Jeju	23	51.7	5.5	49.3	54.1	41	58
Front foot length** (cm)	Mainland	17	28.3	0.8	27.9	28.8	27	30
	Jeju	23	23.0	1.3	22.5	23.6	20	25
Hind foot length** (cm)	Mainland	17	35.9	1.0	35.4	36.5	34	38
	Jeju	23	28.7	1.5	28.1	29.4	26	31
Ear length** (cm)	Mainland	17	13.5	0.7	13.1	13.9	12	14
	Jeju	23	9.3	0.6	9.1	9.6	8	10
Ear width** (cm)	Mainland	17	7.0	0.0	7.0	7.0	7	7
	Jeju	23	4.9	0.3	4.8	5.0	4	5
Neck length** (cm)	Mainland	17	33.0	4.4	30.6	35.4	27	38
	Jeju	23	28.8	4.1	27.0	30.6	24	40

*: $p<0.05$, **: $p<0.01$; SD: Standard Deviation

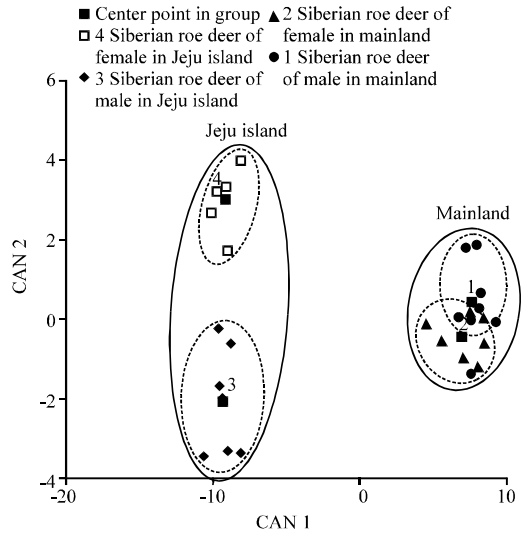

Fig. 2: Plots against the first and the second canonical varieties for body samples of Siberian roe deers in South Korea

(Danilkin and Hewison, 1996), climate and form of density dependent habitat changes (Festa-Bianchet *et al*., 1998; Toigo *et al*., 2006; Klein and Strandgaard, 2008). Especially, the adult body size could determine how long the high quality food is supplied during growth. Therefore, if populations in limited areas such as islands increase, the smaller body size is known due to reduced food resources resulting in excessive competition (Putman, 1996; Lomolino and Perault, 2007). Compared to deer inhabit the inland areas, the deer inhabit the Jeju island region is morphologically undersized as a result of long adaptation on format changes in the density dependent habitat and in a limited area such as island with special environment (Kang *et al*., 2007; Koh and Randi, 2001; Xiao *et al*., 2007). In the evolutionary ecological perspective, the species is classified if its genetically isolated and there are differences in morphological characteristics to the adjacent communities and the object with separate geographical distribution should be classified as species (Mayr, 1970; Haffer, 1986). Thus, it appeared to be a unique native species inhabited only in Jeju island in Korea. Siberian roe deer in Jeju island probably has been geologically separated from Inland Siberian roe deer in the peninsula and became significantly different in body mass.

CONCLUSION

In this study, the roe deer that inhabit the island region could be classified as a subspecies level when at least have geographically isolated for a long time and have represented significant external morphology. Therefore, Siberian roe deer in Jeju give a scientific name to *Capreolus pygargus jejuensis*. To clarify the key characteristics of weight, foot length, ear length and width characteristics confirmed by morphometric analysis are thought to be very useful traits to the two groups.

ACKNOWLEDGEMENTS

This research was supported by KIEST (052-062-039) and (1408018-1-1). Researchers wish to thank Yong-Gu Cho, Min-Chan An, Min-Ho Chang and Tae-Wook Kim for helping in sampling of Inland and Jeju roe deer.

REFERENCES

Barclay, E.N., 1933. Notes on the roe deer. Ann. Manage. Natural History, 10: 66-80.

Bubenik, G.A. and A.B. Bubenik, 1990. Horns, Proghorns and Antlers: Evolution, Morphology, Physiology and Social Significance. Springer, New York, USA., pp: 1-562.

Danilkin, A. and A.J.M. Hewison, 1996. Behavioural Ecology of Siberian and European Roe Deer. Chapman and Hall, London, UK., pp: 1-300.

Festa-Bianchet, M., J.M. Gaillard and J.T. Jorgenson, 1998. Mass- and density-dependent reproductive success and reproductive costs in a capital breeder. Am. Naturalist, 152: 367-379.

Geist, V., 1987. Bergman's rule is invalid. Can. J. Zool., 65: 1035-1038.

Geist, V., 1998. Deer of the World: Their Evolution, Behaviour and Ecology. Stackpole Books, Mechaniesburg, USA., pp: 1-432.

Haffer, J., 1986. Superspecies and species limits in vertebrates. J. Zool. Syst. Evol. Res., 24: 169-190.

Hewison, A.J.M., J.M. Angibault, J. Boutin, E. Bideau, J.P. Vincent and A. Sempere, 1996. Annual variation in body composition of deer (*Capreolus capreolus*) in moderate environmental conditions. Can. J. Zool., 74: 245-253.

Kang, M.C., S.H. Han, Y.H. Jung, J.H. Oh, G.O. Kim, J.W. Ko and M.Y. Oh, 2007. Genetic analysis of ancient bones of Cervidae animals from archaeological site in Jeju, Korea. Integrat. Biosci., 11: 147-153.

Klein, D.R. and H. Strandgaard, 2008. Factors affecting growth and body size of roe deer. J. Wildlife Manage., 36: 64-79.

Koh, H.S. and E. Randi, 2001. Genetic distinction of roe deer (*Capreolus pygargus*) sampled in Korea. Mammalian Biol., 66: 371-375.

Koh, H.S., S.K. Yoo and B.K. Lee, 1997. Analysis of external and cranial morphology of roe deer (*Capreolus pygargus bedfordi*) from Korea. Bull. Nat. Sci., 11: 99-103.

Lomolino, M.V. and D.R. Perault, 2007. Body size variation of mammals in a fragmented, temperate rainforest. Conservat. Biol., 21: 1059-1069.

Mayr, E., 1970. Population, Species and Evolution. Belknap Press of Harvard University, Massachusetts, pp: 1-453.

Putman, R.J., 1996. Competition and Resource Partitioning in Temperate Ungulate Assemblies. Springer, New York, USA., pp: 1-131.

Randi, E., M. Pierpaol and A. Danikin, 1998. Mitochondrial DNA polymor phism in populations of Siberian and European roe deer (*Capreolus pygargus* and *C. capreolus*). Heredity, 80: 429-437.

Sheremetyeva, I.N. and I.S. Sheremetyev, 2008. Skull variation in the Siberian roe deer Capreolus pygargus from the Far East: A revision of the distribution of the subspecies. Eur. J. Wildlife Res., 54: 557-569.

Sokolov, V.E. and V.S. Gromov, 1990. The contemporary ideas on roe deer systematization: morphological, ethological and hybridological analysis. Mammalia, 54: 431-444.

Tate, G.H.H., 1947. Mammals of Eastern Asia. MacMillan Company, New York, USA., pp: 336-338.

Thomas, O., 1908. The Duke of Bedford's zoological exploration in eastern Aisa-IX. List of mammals from the Mongolian Plateau. Proc. Zool. Soc. London, 1908: 104-110.

Toigo, C., J.M. Gaillard, G. Van Laere, M. Hewison and N. Morellet, 2006. How does environmental variation influence body mass, body size, and body condition? Roe deer as a case study. Ecography, 29: 301-308.

Wilson, R. and I. Reeder, 1993. Mammal of Species of the World. Smithsonian Institution Press, New York, USA., pp: 652-661..

Xiao, C.T., M.H. Zhang, Y. Fu and H.S. Koh, 2007. Mitochondrial DNA distinction of northeastern China roe deer, Siberian roe deer, European roe deer, to clarify the taxonomic status of Northeastern China roe deer. Biochem. Genet., 45: 93-102.