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Sexual Size Dimorphism of Lacertid Lizards from Korea[1]

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ABSTRACT

This study was conducted to find the sexual size dimorphism(SSD) in morphometric characters of three species , *Eremias argus, Takydromus amurensis* and *T. wolteri* in lacertid lizard from Korea. Six external traits, snout-vent length, tail length, head length, head width, forelimb length and hind-limb length were focused to compare two sexes among the each three lizards. Student's t-test was used to compare the adult SVL between the sexes for each species. For the other parts of the body, a one-way analysis of covariance(ANCOVA) with SVL as the covariate was used. In all these species, males have longer tail and head than females like general lacertid lizard. In addition, male *E. arugus* have broader head and longer forelimbs and hind-limbs than conspecific females. Likewise, male *T. wolteri* have broader head than females. In the three lacertid lizards from Korea, snout-vent length did not significantly differ between the sexes. To understand the causes for SSD in SVL, ecological information, such as the presence/absence of male-male combat and the correlation between the SVL of female and litter size, is required. Therefore, further ecological study on the three species of lacertid lizard from Korea will make it possible to explain the reason SSD is not found in SVL.

KEY WORDS: Eremias argus, Takydromus amurensis, T. wolteri, SEX, DIFFERENCE

요 약

본 연구는 한국에 서식하는 장지뱀과 3종인 표범장지뱀(*Eremias argus*), 아무르장지뱀(*T. amurensis*), 줄장지뱀(*T. wolteri*)의 외부 형질에 대한 성적 크기 차이(SSD)를 알아보기 위하여 수행되었다. 외부 형질 중 주둥이-항문 길이, 꼬리 길이, 머리 길이, 머리 폭, 앞다리 길이, 뒷다리 길이와 같은 6개 부위를 중심으로 수컷과 암컷을 비교하였다. 머리-항문 길이는 student's t 검정을, 나머지 부위는 머리-항문 길이를 공변량으로 이용하여 공분산 검정을 수행하였다. 머리 길이와 꼬리길이는 일반적인 장지뱀과의 특성과 마찬가지로 한국산 장지뱀과 3종 모두 수컷이 암컷보다 긴 것으로 나타났다. 추가적으로 표범장지뱀은 머리 넓이, 앞다리 길이, 뒷다리 길이, 줄장지뱀은 머리 넓이에서 수컷이 암컷보다 길었다. 머리-항문 길이는 한국산 장지뱀과 3종 모두 암·수 사이에서 유의한 차이가 없었다. 머리-항문 길이의 SSD의 원인을 파악하기 위해서는 수컷간의 싸움과 암컷 머리-항문 길이와 한 배 산란수의 관계와 같은 생태학적 정보가 필요하다. 한국산 장지뱀과 3종에 대한 생태학적 연구가 계속 진행된다면 SVL에서 SSD가 일어나지 않은 이유를 설명할 수 있을 것이다.

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주요어: 표범장지뱀, 아무르장지뱀, 줄장지뱀, 성, 차이

INTRODUCTION

Sexual size dimorphism(SSD) is an essential and general phenomenon where one of the sexes is characteristically larger than the other(Cox *et al*., 2003). SSD occurs in a variety of vertebrate taxa(Anderson, 1994). Male-larger SSD results from of selective pressures that favor larger males because of their advantages in a male-male combat or female choice(Anderson and Vitt, 1990). Female-larger SSD results from of selective pressures that favor larger females because of their advantages in a fecundity selection (Shine, 1992; Olsson *et al*., 2002). SSD also occurs in amphibians and reptiles such as frogs(Katsikaros and Shine, 1997), salamanders(Bruce, 1993), turtles(Aresco and Dobie, 2000) and snakes(Takiguchi and Ota, 2006) is published. SSD is also widespread in many lizards. While Some male is larger, the two sexes sometimes turn out monomorphic in size or end up in opposite patterns(Mori and Hikida, 1992). However, it is reported that male has elongated tails and limbs and longer heads but shorter trunks compared with female of the same body size(Olsson *et al*., 2002). In addition, it is reported that some species in North America show a variety of SSD among different local populations(Fitch, 1978; Stewart, 1985).

Lacertid lizards comprise a clade of about 280 species that are found throughout Africa and most of Eurasia (Arnold *et al*., 2007), and only three species, *Eremias argus*, *Takydromus amurensis* and *T. wolteri* occur in Korea. The genus *Eremias* consists of 38 species and is broadly distributed in middle latitude of Eurasia. Species of the genus mostly inhabit in sandy fields, steppes and dessert(Mozaffari and Parham, 2007). For the genus *Takydromus*, 20 species are currently recognized(Lue and Lin, 2008), and most of these species inhabit the grasslands, but others also occur shrubs and forest floors(Ziegler and Bischoff, 1999). *Eremias argus* is distributed from Russia, Mongolia, China, and Korea(Kang and Yoon, 1975; Zhao and Adler, 1993; Chang *et al*., 2006). *Takydromus wolteri* is distributed from Russia, northeastern China, and Korea. *Takydromus amurensis* is distributed from Russia, northeastern China, Tsushima Island of Japan, and Korea (Zhao and Adler, 1993; Arnold, 1997; Goris and Maeda, 2004).

This paper provides data on SSD gathered three larcertid lzards, *T. amurensis*, *T. wolteri* and *E. argus*, from Korea. We also compared SSD with other lizards.

MATERIALS AND METHODS

We collected *T. amurensis* and *T. wolteri* by hand in a natural population live in all over the country, and caught *E. argus* by hand or with a insect net in a natural population located in Baramare Beach, Taean-gun, Chungcheonnam-do, Korea. *Eremias argus*, designated as endangered category level II species by the Ministry of Environment of Korea, were measured alive and immediately released after measurement.

For morphometric data, 194 lizards were measured only adult, which include 33 *T. amurensis* specimens(11 males, 22 females), 88 *T. woteri* specimens(48 males, 40 females), and 74 *E. argus* specimens(32 males, 41 females). Specimens were examined for the following six measurements, snout-vent length(SVL), tail length(TL), head length(HL), head width(HW), forelimb length(FLL), and hind-limb length (HLL), using digital calipers(CD-15CP, MITUTOYO. Co.) to the nearest 0.01 ㎜. Tail length was measured only for specimens with intact original.

We used the SPSS(Statistical Package for the Social Science) ver. 12.0 to analyze data. Student's t-test was used to compare the adult SVL between the sexes for each species. For the other parts of the body, a one-way analysis of covariance(ANCOVA) with SVL as the covariate was used. The level of significance was set at 0.05.

RESULTS

In SVL, no significant differences were recognized between sexes in any of the lacertid lizards of Korea(*E. argus*: df=1, 71, t=-0.939, p=0.351, *T. amurensis*: df=1, 31, t=0.466, p=0.640, *T. wolteri*: df=1, 86, t=-0.486, p=0.628; Table 1). ANCOVA yielded various sexually dimorphic patterns in other morphometric characters in the

three lacertid species from Korea as below. *Eremias argus* has a significant difference between the sexes with TL(df=1, 69, F=68.789, p=0.000), HL(df=1, 71, F=-15.689, p=0.000), FLL(df=1, 71, F=10.592, p=0.002) and HLL(df=1, 71, F=21.193, p=0.000), with the exception of HW(df=1, 71, F=2.103, p=0.151). *Takydromus amurensis*

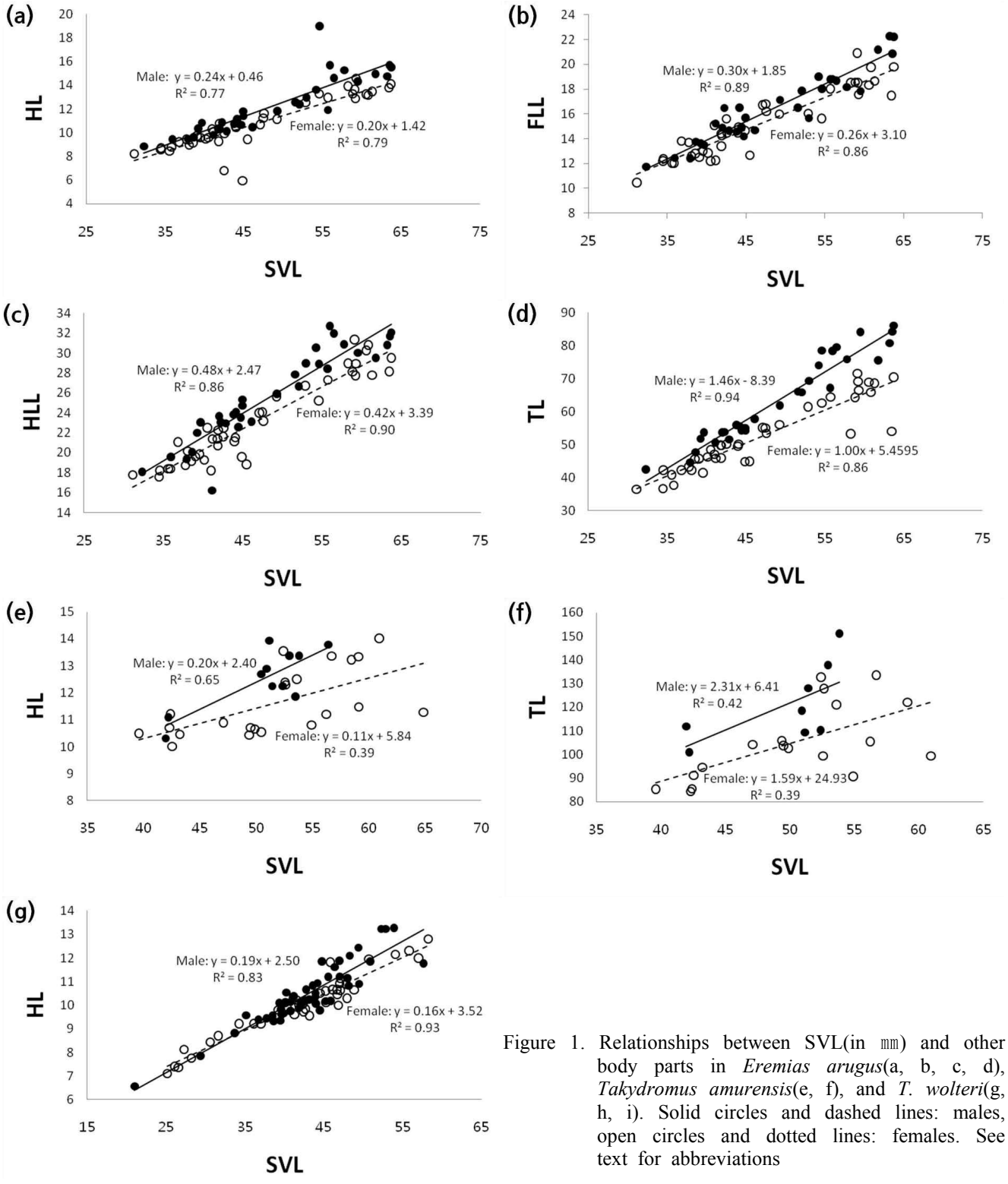

Figure 1. Relationships between SVL(in ㎜) and other body parts in *Eremias arugus*(a, b, c, d), *Takydromus amurensis*(e, f), and *T. wolteri*(g, h, i). Solid circles and dashed lines: males, open circles and dotted lines: females. See text for abbreviations

Table 1. SVL(x±SE, in mm, and followed by ranges in parentheses) and ratios to SVL for other measurements (median, followed by ranges in parentheses) in adults of the three lacertid species from Korea. n: sample size; asterisks [*] next to male values, p<0.05 after t-test or ANCOVA. See text for abbreviations

	Eremias argus		*Takydromus amurensis*		*T. wolteri*	
	Males	Females	Males	Females	Males	Females
SVL	48.68±1.56 (32.34～63.73) n=32	46.64±1.48 (31.13～63.72) n=41	50.66±1.37 (41.97～56.42) n=11	51.73±1.46 (39.61～64.87) n=22	43.03±0.90 (21.01～57.68) n=48	42.27±1.33 (25.16～58.27) n=40
TL	63.35±2.34* (42.39～86.09) n=31	52.16±1.63 (36.42～71.55) n=40	120.94±5.95* (100.94～151.08) n=8	104.98±3.81 (84.29～133.6) n=18	110.30±3.13* (72.78～152.16) n=29	102.89±4.40 (70.84～144.70) n=20
HL	12.24±0.43* (8.84～18.99) n=32	10.76±0.33 (5.95～14.6) n=41	12.53±0.34* (10.31～13.93) n=11	11.62±0.26 (10.01～14.02) n=22	10.47±0.18* (6.57～13.27) n=48	10.05±0.21 (7.10～12.80) n=40
HW	7.42±0.30 (5.39～14.16) n=32	6.82±0.20 (4.97～9.92) n=41	7.68±0.23 (6.08～8.55) n=11	7.49±0.17 (6.38～9.22) n=22	6.73±0.98* (4.03～7.95) n=48	6.42±0.13 (4.56～7.77) n=40
FLL	16.50±0.50* (11.74～22.29) n=32	15.18±0.41 (10.45～20.92) n=41	16.73±0.53 (14.33～20.40) n=11	16.03±0.34 (12.20～19.17) n=22	15.59±0.31 (8.57～19.86) n=48	14.93±0.42 (8.73～19.62) n=40
HLL	25.69±0.80* (16.22～32.73) n=32	23.11±0.66 (17.55～31.34) n=41	23.48±0.86 (18.35～28.71) n=11	22.63±0.48 (16.97～26.49) n=22	21.47±0.47 (10.34～29.04) n=48	20.60±0.73 (11.05～38.21) n=40

has a significant difference between the sexes with TL(df=1, 24, F=9.500, p=0.005) and HL(df=1, 31, F=9.422, p=0.005), with the exception of HW(df=1, 31, F=2.277, p=0.142), FLL(df=1, 31, F=3.998, p=0.055) and HLL(df=1, 31, F=3.678, p=0.065). *Takydromus wolteri* has a significant difference between the sexes with TL(df=1, 47, F=7.709, p=0.008), HL(df=1, 86, F=8.410, p=0.005) and HW(df=1, 86, F=11.846, p=0.001), with the exception of FLL(df=1, 86, F=3.867, p=0.053) and HLL(df=1, 86, F=1.600, p=0.209). TL, HL, FLL and HLL of male *E. argus* and TL and HL of male *T. amurensis*, and TL, HL and HW of male *T. wolteri* were significantly longer than females(Fig. 1).

DISCUSSION

Males of the three lacertid species from Korea, *E. argus*, *T. amurensis* and *T. wolteri*, showed longer head relative to SVL than conspecific females. It is common that in male lacertid lizard has a larger relative head size than females (Huang, 1998; Ji *et al*., 1998; Molina-Borja *et al*., 1998). Males with a larger head are in better position in male-male competitions (Anderson, 1994), thereby allowing it to take up a more spacious and better space. This explains why females tend to prefer larger size males, supporting the fact that SSD is correlated with sexual selection (Manzur and Fuentes, 1979). However the proximate mechanism requires further study that is observation on the male-male competitions of the three lacertid species from Korea. Male and female differ in energy allocation for growth, because female allocates more energy to clutch production than to growth in body parts like head, limbs and tail (Fitch, 1981; Nkosi *et al*, 2004). For example, female *T. septentrionalis* sacrifices head growth for rapid growth in SVL to realize the greater potential reproductive output from a larger body size, whereas male exhibit an increasingly rapid growth of head (Zhang and Ji, 2000). In addition, since males hold females during mating by keeping on biting their heads, necks or flanks (Svihla, 1942), male with larger head is profitable a better position to grab hold of the female (Herrel *et al*., 2001a, b; Li *et al*., 2006). Since three species of lacertid lizards from Korea are found to be grabbing the flank of female, thereby keeping the female under control while mating (Figure 2), this copulation performance apparently affects the SSD of those head.

Figure 2. A photograph of the male *Takydromus wolteri* biting the flank of the female during the mating(Chang, 2011)

TL was generally found in SSD of lacertid lizards, and it was also the case with three of lacertid lizards of Korea. In *Phrynocephalus vlangalii*, males showed a tail growth rate higher than females, which is partly related with fecundity selection acting on female (Zhang *et al*., 2005). The role of tail of male is very important because male widely move to meet superior female and constantly seek for prey owing to strong, and therefore tail of male is getting longer than female through an evolutional process.

When it comes to the length of limbs, it was only the case of *E. argus* that forelimbs and hind-limbs of males were longer than females, which was not the case with *T. amurensis* and *T. wolteri*. There was no significant difference of the daily movement distance between male and female of *E. argus* in non-breeding season, but male moved one and half times than female in breeding season(Kim, 2012). In contrast, no significant difference of movement distances between male and female of *T. wolteri* was showed in breeding and non-breeding season (Chang, 2011). We presumed that male *E. argus* moves longer distances than female comparing with male *T. wolteri* in breeding season, and it brings the result that male *E. argus* accepts high risk of being predation by enemy. Moreover, *E. argus* inhabits in coastline and dune bordering riparian(song, 2007), so it is possible to be exposed and attacked by predators when moving around comparing *T. amurensis* and *T. wolteri* that are found in thick forests or grasslands. If the relatively longer limbs of male afford them greater running speed than female, it is presumed greater success at outrunning predators may offset higher predation pressure(Nkosi *et al.*, 2004). For example, running speed in *Lacerta vivipara* increased as stride length and stride rate increased(Avery *et al.*, 1987). Accordingly, male *E. argus* are required agility to avoid from predators, so male should allocate more energy in limbs. The study of movement on *T. amurensis* is unperformed. If the study of movement for *T. amurensis* is carried out on further study, it is possible to compare the movement traits among the three species and obtain better results.

On the contrary, SVL of three species of lacertid lizard were not different between sexes, which is consistent with the results reported for other lacertid lizards such as *T. septentrionalis* (Zhang and Ji, 2000), *T. hsuehshanensis* (Huang, 1998), *E. brenchleyi* (Xu and Ji, 2003) and *E. multiocellata* (Li *et al*., 2006). SSD is assumed to evolve in lizards mainly because of between-sex differences in reproductive success relating to adult body size (Cooper and Vitt, 1989; Hews 1990; Mouton and Van Wyk, 1993). Theoretically, fecundity selection favors large female and sexual selection favors large males (Cox *et al*., 2003). The two selective pressures could cancel each other out and, consequently, result in a lack of SSD between sexes. (Ji and Du, 2000). This means that male-male combat serves as a factor contributing to the increase in size of males (Lin and Ji, 2000), and preference for a female with a greater fecundity or a larger clutch size plays a role in the increase in size of females (Ji and Du, 2000). If we want to specify the causes for the absence of sexual dimorphism in standard body size (SVL here), ecological information, such as the presence/absence of male-male combat and the correlation between the SVL of female and litter size, is required. Unfortunately, these relevant pieces of information are not yet available for the three lacertid lizards from Korea due to the paucity of ecological studies on them. Therefore, further ecological study on the three species of lacertid lizard from Korea will hopefully make it possible to explain the reason SSD is not found in SVL.

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