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Sexual Size and Shape Dimorphism in an Agamid Lizard

Sitana Ponticeriana (Sauria: Agamidae)

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Abstract The fan-throated lizard, *Sitana ponticeriana*, is a medium-sized ground living agamid distributed throughout India, preferably in dry and more or less open country habitats. A total of each of 80 males and females were collected from Konark-Balukhand Wildlife Sanctuary area and subjected to various morphometric measurements to investigate the sexual size and shape dimorphism of the species. Sexually immature individuals were much less dimorphic than the adults. All body parts of males were larger than those of females. Both the sexes also differ in allometry of all head characters with body size, with males showing a disproportionate increase of head size and dimensions and head shape changed with increasing head size. Similarly, the foot (front and hind) of both sexes differs in length. The hind foot was double in length than that of the front. Males had larger hind foot (1.68cm) than females (1.56cm). A strong positive relatioship (r =0.8) was observed between SVL and HFL in females. Analysis of variance at $p<0.05$ level of significance was done foe several variables. The head was twice longer than width. The HL and HW showed positive allometry in males and females.

Keywords *Sitana Ponticeriana,* Sexual Dimorphism, Morphological Characters

1. Introduction

Sexual dimorphism in size, shape, colour and behaviour is a widespread phenomenon in animal kingdom [1]. Most species are dimorphic rather than monomorphic [1-3]. Morphological differences between the two sexes; however, have two aspects: size and shape. Sexual size dimorphism (SSD) describes the situation in which the two sexes differ in measured values of certain morphological traits. SSD has extensively been described in reptiles [1]. Early studies of SSD in reptiles focused on overall body size and used single traits (body weight or snout-to-vent-length in most cases) to stand for overall body size [4].

Sexual dimorphism can be explained by both proximate (growth patterns) and ultimate (evolutionary payoffs) causes, and both have been extensively studied, particularly the latter [4,5]. Much insight can be gained by the integrated study of both the proximate and ultimate perspectives of sexual dimorphism [6-8].

The major morphometric data available for most of the lizards is the size, which sometimes provides answer to separation of mature individuals of some species. Review of growth studies in reptiles indicate that size at first reproduction and growth thereafter and both are potentially important determinates of adult size [9,10] while age and size in adult reptiles are often poorly correlated [11]. Fitch [12] Mitchell and Zug [13] reported sexual dimorphism in body length of some gekkonids. However, there are confusions between size and sexual dimorphism in gecko, *H. flaviviridis* where size does not depend on sex, but almost entirely on age and the amount of food intake. Also hypotheses have been published to explain the evolutionary basis for sexual size dimorphism in lizards [14,15].

Three agamid lizards (*Calotes versicolor, Psammophilus blanfordanus and Sitana ponticeriana)* are found in Odisha and of the three, *Calotes versicolor* is the most common. *Sitana ponticeriana* is found throughout the state, but they are most abundant in the casurina plantation areas near sea beaches, especially near Konark-Balukhand wildlife sanctuary. It is a ground-dwelling, diurnal agamid, common in open sandy scrub. A fast and graceful runner occasionally adopts a bipedal gait when hard pressed. It rests in the shade of bushes and other cover and may climb these for basking [16]. Data on size analyses of the species and SSD is not available. The present paper describes the SSD of the species.

2. Materials and Methods

The study was carried out during winter months (November – February) for two seasons in the Balukhand-Konark Wildlife Sanctuary (71.7 km2 area on a sandy tract along the east coast of India) in the District of Puri, Odisha state (Latitude 19^0 48' to 19^0 54', Longitude 85^0

52' and 86^0 14' East]) (Fig. 1). The canopy composition includes primarily *Casuarinas* sp.,Tamarind (*Tamarindus indica), Anacardium* sp., Karanja (*Pongamia glabra*), Polanga (*Calophylluminophyllum*), Neem (*Azadirachta indica*), *Eucalyptus* sp., and *Acacia* sp. The fauna includes Striped Hyena (*Hyaena hyaena*), Jungle Cat (*Felis chaus*), Spotted Deer (*Axis axis*), Blackbuck (*Antilope cervicapra*), and several species of birds. The lizard fauna includes *Lygosoma punctatus, Mabuya bibroni, Mabuya macularia* and *Calotes versicolor*. The maximum air temperature is 40^0C during May-June. Maximum surface soil temperature ranges from 40^0C in the shade to in excess of 45^0C in areas with full sun. Minimum winter temperature is 10^0C.

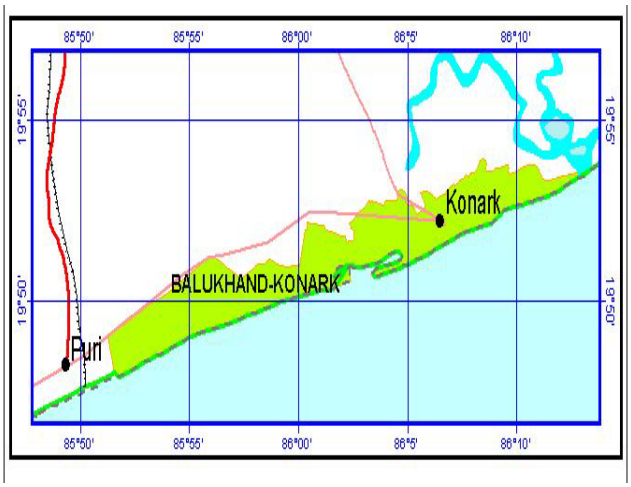


Figure 1. Map showing the study area (Konark-Balukhand wildlife sanctuary)

3. Specimens and Measures

The specimens, collected through several field trips, were given a unique number on the back using water-insoluble paint as a temporary mark and toe clipped in a unique combination as a permanent mark. A total of 80 males and 80 females of various size ranges were examined for the present study. A total of 13 morphological variables were measured out of which snout-to-vent length (SVL), right front foot length (FFL) and right hind foot length (HFL) were measured to the nearest 1cm. Ten morphometric traits such as head length (HL), head width (HW), snout length (SL), snout to nostril length (SNL), nostril to anterior eyelid commissure length (NECL), inter-narial distance (IND), eye diameter (ED), inter-canthal distance (ICD), tympanum diameter (TD), eye to tympanum length (ETL) relating to head region were measured using a digital dial caliper to the nearest 0.01mm. The existence of significant differences between the sexes was tested by one-way analysis of variance (ANOVA).The F values were evaluated at $p<0.05$ significance level to determine the significance difference of each morphometric variables of both the sexes.

4. Results

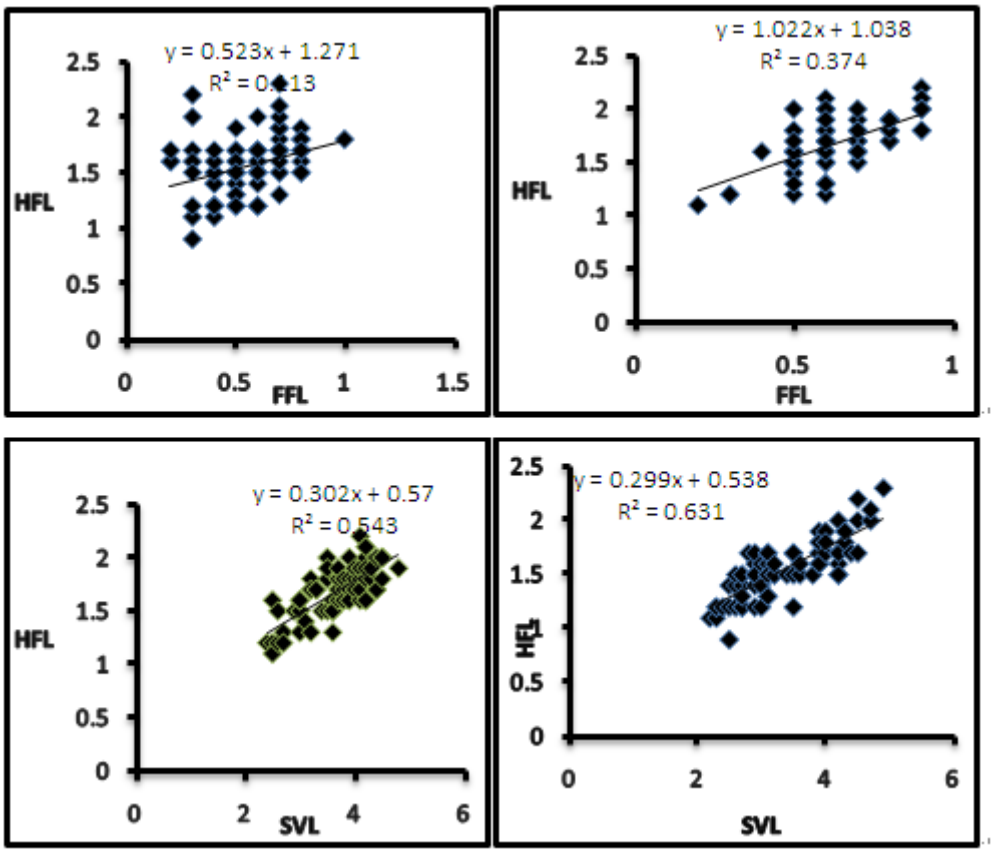
The specimens were collected during different months spreading over two years. However, the data are arranged in an ascending order because specimens of different size ranges were captured each time.

4.1. Morphometry of Males

The morphometric measurements of males (and females) are presented in Table 1 and Figure 2. The snout-vent length of males varied from 2.4cm to 4.8cm with a mean value of 3.68±0.56cm. The front foot length ranged from 0.20cm to 0.90cm, the average being 0.63±0.14. Similarly, the average hind foot length (minimum 1.10cm, maximum 2.20cm) was 1.68±0.23cm. In general, the HFL is double in length than that of the FFL of male. A positive relationship ($r = 0.6$) was observed between the front and hind foot lengths. Analyses of variance for both males and females are presented in Table 2. SVL and HFL recorded an F value of 861.71 at $P < 0.05$ level and has positive relationship ($r = 0.7$). Similarly, SVL and FFL recorded the F value of 2326.41 at the same level of significance. The F value was 1223.20 ($P< 0.05$) when compared between HFL and FFL. The mean head length and head width were 10.85±1.44mm and 6.62±0.95mm, respectively. Like foot length, head was also double in length to that of its width. One way ANOVA of head length and head width at $P<0.05$ revealed an F value of as 476.67 with an appreciable positive relationship ($r = 0.6$). The mean value of snout length was 4.70±0.63mm, where as the mean value of snout to nostril length was 2.04± 0.46mm. NECL and IND ranged from 1.12mm to 3.96mm and 1.38mm to 2.98mm with mean values of 3.17±0.85mm and 2.35±0.28mm, respectively. These two traits were less varied between the sexes. The eye diameter ranged between 2.02mm to 4.38mm with an average of 3.42±0.52mm, where as the inter-canthal distance (ICD) had ranged from 3.16mm to a 6.92mm in size, with an average of 4.93± 0.78mm. Tympanum diameter (range; 1.40mm to 2.22mm, 1.33±0.25) and eye to tympanum length (ETL) (range: 2.08mm to 4.98mm, 3.39±0.71) were also not much variable. The study revealed that increase in size of the individuals is accompanied by an increase in all the morphomtric variables examined. Thus, increase in size is a function of an increase in all the variables.

Table 1. Morphological variables (range, mean, standard deviation and standard error) of male and female *Sitana ponticeriana* (N = 80).

Parameters	Males (N = 80)			Females (N = 80)			t value
	Range	Mean±SD	SE	Range	Mean±SD	SE	
SVL (cm)	2.4− 4.8	3.68±0.56	0.06	2.2− 4.9	3.41±0.70	0.08	4.61
FFL (cm)	0.2− 0.9	0.63±0.14	0.02	0.2 −1.0	0.55±0.17	0.02	2.7
HFL (cm)	1.1−2.2	1.68±0.23	0.03	0.9−2.3	1.56±0.26	0.03	3.21
HL (mm)	6.98−12.92	10.85±1.44	0.16	7.38 −2.28	10.1±1.32	0.15	3.11
HW (mm)	5.02−8.92	6.62±0.95	0.11	4.12 − 8.68	6.26±1.15	0.13	3.05
SL (mm)	3.08−5.98	4.70±0.63	0.07	2.26 −7.76	4.43±0.95	0.11	3.14
SNL (mm)	1.04−2.94	2.04±0.46	0.05	1.06 −2.98	1.94±0.54	0.06	1.22
NECL (mm)	1.12−3.96	3.17±0.85	0.09	1.14 −3.98	2.78±0.73	0.08	3.1
IND (mm)	1.38−2.98	2.35±0.28	0.03	1.26 −3.52	2.25±0.49	0.05	1.54
ED (mm)	2.02−4.38	3.42±0.52	0.06	2.08 −4.92	3.16±0.70	0.08	2.10
ICD (mm)	3.16−6.92	4.93±0.78	0.09	3.02 −7.44	4.32±0.98	0.11	4.32
TD (mm)	1.04−2.22	1.33±0.25	0.03	0.76 −2.96	1.42±0.42	0.04	2.13
ETL (mm)	2.08−4.98	3.39±0.71	0.08	1.22 −4.94	2.80±0.87	0.1	3.86



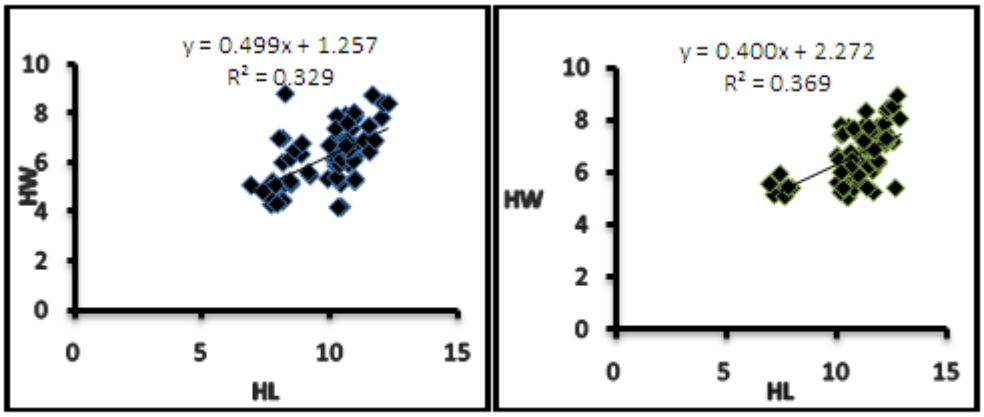


Figure 2. Relationship between various body parameters in male and female *Sitana ponticeriana* (N=80)

Table 2. One way ANOVA of various body parameters of male and female *Sitana ponticeriana* (N=80).

Source of Variation	Male						Female					
	SS	df	MS	F	P-value	F crit	SS	df	MS	F	P-value	F crit
SVL and HFL												
Between Groups	159.60	1	159.60	861.71	0.05	3.90	136.53	1	136.53	485.76	0.05	3.90
Within Groups	29.26	158	0.18				44.40	158	0.28			
Total	188.86	159					180.93	159				
SVL and FFL												
Between Groups	371.27	1	371.27	2326.41	0.05	3.90	326.32	1	326.32	1252.80	0.05	3.90
Within Groups	24.89	156	0.15				41.15	158	0.26			
Total	396.16	157					367.48	159				
FFL and HFL												
Between Groups	44.31	1	44.31	1223.20	0.05	3.90	40.70	1	40.70	823.24	0.05	3.90
Within Groups	5.72	158	0.036				7.81	158	0.049			
Total	50.03	159					48.51	159				
HL and HW												
Between Groups	716.09	1	716.09	476.67	0.05	3.90	561.90	1	561.90	363.31	0.05	3.90
Within Groups	237.36	158	1.50				244.35	158	1.54			
Total	953.45	159					806.25	159				

4.2. Morphometry of Females

The morhometric measurements of the females are presented in Table 1 and Fig. 2. The snout-vent length of females varied from 2.2cm to 4.9cm (mean of 3.40 ± 0.70mm). The front foot length (0.63 ± 0.16cm) was larger than the hind foot (0.56 ± 0.26cm). Analysis of foot length (FFL and HFL) revealed a low positive relationship (r = 0.3), where as a strong positive relationship (r =0.8) was recorded for snout-vent length and hind foot length. The F value of one way ANOVA at P< 0.05 level were 485.76, 1252.80 and 823.24 for SVL and HFL, SVL and FFL and FFL and HFL, respectively. The head length was greater than the head width which also recorded a similar trend in ANOVA (F value = 363.31 at p<0.05). A positive relationship was recorded between the head length and head width (r =0.5). The snout length ranged from 2.26mm to 7.76mm with a mean of 4.43 ± 0.95mm. The snout to nostril length was 1.06 1.94 ± 0.54mm. NECL and IND recorded the averages of 2.78 ± 0.73mm and 2.25 ± 0.49mm, respectively. Comparing the mean value of eye diameter (3.16 ± 0.70mm) and inter-canthal distance (4.32 ± 0.98mm), ED size slightly differed from that of the ICD. Tympanum diameter varied from 0.76mm to 2.96mm with a mean value 1.44 ± 0.41. Eye to tympanum length ranged from1.22mm to 4.94mm, average beings 2.90 ± 0.87mm.

4.3. Sexual Dimorphism in Morphometry

The study clearly indicated sexual dimorphism in the morphometry of both the sexes of *Sitana ponticeriana* (Table 2). The males had greater values of all measured variables of morphological traits and, therefore, were also greater in size. The SVL of males is 7.33% greater than that of the females. Similarly, the FFL of males are 12.69% larger than that of the females. However, maximum variation has been observed in the arrangement of two of the variables, ICD (12.37%) and NECL (12.30%) on head of the species. In most other variables, the males are 5-7% larger than the females. Tympanum diameter is the only exception among all the variables i.e. the females have greater tympanum than the males.

5. Discussion

Sexual size dimorphism (SSD) is believed to evolve in lizards mainly owing to intersexual differences in reproductive success related to adult body size [17]. Theoretically, two selective pressures-fecundity selections (favouring of large males via male competition) could cancel each other out and consequently result in a lack of SSD between males and females [18]. From a proximate perspective, shape dimorphism of a given body part can arise through different allometric patterns between the two sexes under two conditions [8]. First, sexual shape dimorphism arises because the two sexes differ in the degree of allometry. Alternatively, sexual shape dimorphism can result from two sexes growing to different asymptotic size, when allometric growth is present in both sexes, the relative length of that body part increases with body size, and relative length of that body part in the sex with a smaller asymptotic size will also be smaller. On the contrary, when a body part exhibits negative allometry in both sexes, the relative length of that body part will decrease as body size increase and the relative length of that body part in the sex with a smaller asymptotic size will be longer [19]. The two most universal patterns of shape dimorphism found in many lizard species are males had relatively larger heads and females relatively larger inter limb lengths. Males possessing relatively larger heads have been reported in major lizard clades (Agamidae [20], Gekkonidae [21], Iguanidae [8], Lacertidae [22], Scincidae [23]. Gould [24] proposed an alternative and non-adaptive explanation for sexual shape dimorphism. Differences in shape can arise as an indirect consequence of selection on body size if the body parts under examination exhibit allometric growth [19]. The two most universal patterns of shape dimorphism found in many lizard species are males had relatively larger heads and females relatively larger inter limb lengths.

Several studies reported size analyses of Indian agamids [25-27]. In the present study, males had absolutely (size) and relatively (shape) higher values than females in several attributes. The hind foot length was larger in size than that of the front foot length in both males and females. The study concludes that *Sitana ponticeriana* is dimorphic in both size and shape, which can be explained by different growth patterns between the two sexes. It was found that all the morphometric variables showed positive allometry among them in both males and females. The results further give evidence for a considerable morphological modification of the species studied in a relative period of time, resulting in a change in SD patterns.

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