Sexual dimorphism of scale keeling in *Asaccus kurdistanensis* Rastegar-Pouyani, Nilson & Faizi, 2006

Asaccus kurdistanensis Rastegar-Pouyani, Nilson & Faizi, 2006 is distinguished from other Iranian geckos of the genus by the presence of rich tuberculation in the head region as well as keeled tubercles on the dorsal body (Rastegar-Pouyani et al. 2006; Torki & Sharifi 2007; Torki et al. 2008; Torki in press). In continuation of morphological, ecological and distributional studies dealing with *A. kurdistanensis* (see aforementioned references), the author concentrates here on the extent of the keeling of the tubercular scales in different parts of the body and the distribution of the tubercles over the body surface.

Twenty-five specimens of *A. kurdistanensis* were studied; they were collected in June 2007 from a new record locality (46°16' E, 35°14'N) in the Palangan region, north of Kermanshah province in West Iran (FTHM 002900 - 002924; Farhang Torki Herpetology Museum in Farhang Torki Ecology and Herpetology Center for Researches, Nourabad City). To investigate the tubercles' degree of keeling the author followed Avolio et al. (2006a, 2006b) and used the rugosity index of an individual tubercle (TR), defined as follows: TR = LR/LT; where LR is the length of the ridge of the enlarged keeled tubercle and LT is the length of the tubercle. In each specimen sex was identified by dissection of the tailbase, snout-vent-length (SV) was measured and the keeling of 3 to 5 tubercles in seven body regions (numbers of measurements follow abbreviation) was determined: head (H, 3); neck (N, 3); fore-back (PD, 4); mid-back (MD, 5); hind-back (DD, 5); flanks (LD, 4); and proximal part of tail (PT, 3).

No significant difference is seen in the body size of males and females (*t*: 0.64; *p*: 0.52; *n* = 16+9), although the males of the sample are on the average slightly longer (59.0 mm) than the females (58.3 mm). Comparative data concerning the keeling of the tubercles in seven body regions is shown in Table 1. In all body regions except the head (*t*: 1.51; *p*: 0.14), the keeling of tubercular scales is significantly stronger in males than in females (Fig. 1). In both males and females, the carination is most pronounced in the proximal part of the tail (0.876±0.013) and least in the head region (0.107±0.004). Intensity of tubercle keeling gradually increases from the head towards the tail base. Carination on the enlarged scales of the back is strong in both sexes, with higher variability in the males. In both male and female specimens, variability in keeling is high on the neck, fore-back, mid-back and flanks, whereas it is low in the head region. The variability in the tubercle keeling of the flanks is clearly higher in males (range: 0.58) than females (range: 0.27).

Principal Component Analysis (PCA - Table 2, Fig. 2) details the sexual dimorphism in the tubercles' degree of keeling in the seven body regions studied. The PCA shows a single dominant axis (PCA 1) explaining more than 75 % of the morphological variation. The first axis shows overlaps among most characters. The second axis explains about 8 % of the variance, and the other axes even less. Although most characters overlap, sexual dimorphism in the trait studied is obvious in all of the seven body regions. The *t*-test results (at $\alpha = 0.05$) also reveal dimorphism. Based on regression analysis, the correlation of the body size and the tubercles' degree of keeling is weak in all body regions ($r^2 < 5$ %).

In terms of sexual dimorphism, the females possessed rounded, and the males more or less trihedral tubercles. In addition, the size of tubercles was larger in males than females. In a previous work (Torki & Sharifi 2007), the author compared 16 gross morphological characters of *A. kurdistanensis* among sexes and found dimorphism in body size (different from this study) and length of forelimbs as males had a larger size and longer forelimbs than their female counterparts.

The subject of scale rogosity has been discussed in some hydrophiid snakes (e.g., Avolio et al. 2006a, 2006b), where scale rugosity is more pronounced in males than in females. The present paper shows that this is also true for *A. kurdistanensis*. In general, the dorsal side of snakes is homogeneous in that it is covered by scales (rarely tubercles) only. In contrast, in various lizards species,

Table 1: The keeling (index values) of the tubercular scales in *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Comparison of eight body regions among sexes, and *t*-test results (at $\alpha = 0.05$) for gender difference. SV (mm) - snout-vent-length, H - head, N - neck, PD - fore-back, MD - mid-back, DD - hind-back, LD - flanks, PT - proximal part of tail, NM - number of tubercles measured per body region, Min - minimum, Max - maximum, SEM - standard error of the mean, * - character not significantly discriminating between sexes, ** - character significantly discriminating between sexes.

Tab. 1: Kielung (Indexwerte) der Tuberkularschuppen bei *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Vergleich von acht Körperregionen zwischen den Geschlechtern, und *t*-Test Ergebnisse ($\alpha = 0.05$) zum Geschlechterunterschied. SV (mm) - Rostro-Anal-Länge; H - Kopf, N - Hals, PD - Vorderrücken, MD - Mittelrücken, DD - Hinterrücken, LD - Flanken, PT - proximaler Schwanz, NM - Anzahl vermessener Tuberkel je Körperregion, Mean - arithmetisches Mittel, SEM - Standardfehler des Mittelwertes, Min - Minimum, Max - Maximum, Range - Spannweite, * - Merkmal nicht signifikant geschlechterverschieden, ** - Merkmal signifikant geschlechterverschieden.

Sex NM (individual)		SV (mm)*	H* 3	N** 3	PD** 4	MD** 5	DD** 5	PT** 3	LD** 4
NM (total)			27	27	36	45	45	27	36
Females	Mean	58.33	0.099	0.375	0.464	0.578	0.706	0.825	0.362
Weibchen	SEM	1.23	0.005	0.046	0.062	0.059	0.029	0.013	0.034
(n = 9)	Min	54.1	0.08	0.15	0.21	0.33	0.59	0.77	0.18
	Max	63.4	0.12	0.55	0.65	0.75	0.80	0.90	0.45
	Range	9.3	0.04	0.40	0.44	0.42	0.21	0.13	0.27
NM (total)			48	48	64	80	80	48	64
Males	Mean	59.01	0.112	0.510	0.678	0.751	0.818	0.905	0.487
Männchen	SEM	0.38	0.005	0.038	0.048	0.036	0.028	0.016	0.039
(n = 16)	Min	56.8	0.08	0.30	0.40	0.45	0.60	0.80	0.30
	Max	62.3	0.15	0.80	0.95	0.95	0.95	1.00	0.88
	Range	5.5	0.07	0.50	0.55	0.50	0.35	0.20	0.58
Total	Mean	58.76	0.107	0.462	0.601	0.689	0.778	0.876	0.442
(n = 25)	SEM	0.49	0.004	0.032	0.042	0.035	0.023	0.013	0.030
	Min	54.1	0.08	0.15	0.21	0.33	0.59	0.77	0.18
	Max	63.4	0.15	0.80	0.95	0.95	0.95	1.00	0.88
	Range	9.3	0.07	0.65	0.74	0.62	0.36	0.23	0.70
t-test	*t*	0.64	1.51	2.17	2.68	2.63	2.57	3.26	2.12
	p	0.524	0.144	0.04	0.013	0.015	0.017	0.03	0.045
Difference of means Differenz der Mitelwerte		0.679	0.012	0.135	0.213	0.172	0.111	0.079	0.125
Direction of difference Unterschiedsrichtung		M > F	M > F	M > F	M > F	M > F	M > F	M > F	M > F

both scales and tubercles are observed on the back where these two types of appendages can display a high variation in size and topography. It is reported that exogenous factors (e.g., climate and ecological conditions) and endogenous factors (e. g., physiological and hormonal agents) play important roles in the formation of keeling (e.g., KORTET et al. 2003; SHINE et al. 2004; AVOLIO et al. 2006a, 2006b); this may also be true for *A. kurdistanensis*. Both sexes live under equivalent environmental conditions, the specimens studied originated from the same locality and were sampled during the same time. Thus, the process of dimorphism in scale keeling is likely to be caused by endogenous factors, such as sex hormones (e.g., KORTET et al. 2003).

GUINEA (2003) reported that in the sea snakes studied, the rugosity underwent some change during the life cycle, in that juveniles displayed rugose scales whereas mature individuals did not. This was however doubted by AVOLIO et al. (2006a), while others believe that seasonality (i. e., exogenously modulated endogenous factors) might influence scale keeling (SHINE et al. 2004).

Distribution of tubercles over the body as well as tubercle keeling are important systematic traits in the genus *Asaccus* of the Zagros Mountains, as different species are distinguished from each other based on these characters (TORKI & SHARIFI 2007; TORKI et al. 2008). In *A. nasrullahi* Y. WERNER, 2006, keeled tubercles are absent, while *A. griseonotus* DIXON & ANDERSON,

Fig. 1: Keeling of the tubercular scales in *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006 from the region of Palangan, western Iran.
Dorsal aspect and middorsal details of male (left) and female (right) integument.

Abb. 1: Kielung der Tuberkularschuppen bei *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006 aus der Region Palangan, West Iran.
Rückenansicht und Details des Mittelrückens bei Männchen (links) und Weibchen (rechts).

1973, has weakly keeled tubercles. In *A. kurdistanensis* the keeling of the tubercles is more developed, and in *A. elisae* (F. WERNER, 1895) the tubercles are strongly keeled. Systematic significance of dermal structures may apply also to other species of *Asaccus* present in the Middle East region. In their weaker keeling, female *A. kurdistanensis* re-

Table 2: Keeling of the tubercular scales in seven body regions (for abbreviation of variables see Table 1) of *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Principal Component Analysis (PCA) of the joint measurements of males and females. Eigenanalysis of the correlation matrix.

Tab. 2: Kielung der Tuberkelschuppen in sieben Körperregionen (Abkürzungen der Variablen siehe Tab. 1) bei *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Hauptkomponentenanalyse (PCA) der gemeinsamen Meßwerte männlicher und weiblicher Tiere. Eigenanalyse der Korrelationsmatrix.

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7
H	-0.308	0.786	-0.518	-0.025	0.101	0.061	0.071
N	-0.392	0.231	0.452	0.080	-0.036	-0.715	-0.263
PD	-0.411	-0.044	0.050	-0.176	-0.639	0.423	-0.456
MD	-0.403	-0.213	-0.022	-0.487	-0.200	-0.163	0.699
DD	-0.379	-0.408	-0.327	-0.289	0.581	-0.045	-0.399
PT	-0.360	-0.322	-0.328	0.776	-0.155	-0.080	0.162
LD	-0.382	0.109	0.557	0.197	0.423	0.520	0.210
Eigenvalue	5.388	0.578	0.479	0.308	0.135	0.074	0.035
% Variance	0.770	0.082	0.069	0.044	0.019	0.011	0.005
Cumulative % Var.	0.770	0.852	0.921	0.965	0.984	0.995	1.000

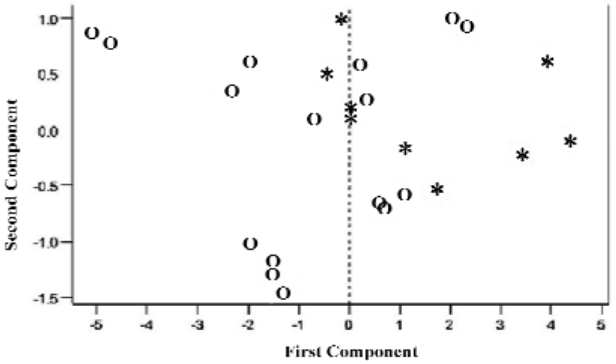

Fig. 2: Keeling of the tubercular scales in male and female *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Plot of principle components 1 and 2. ✻ - females; O - males.

Abb. 2: Kielung der Tuberkelschuppen bei Männchen und Weibchen von *Asaccus kurdistanensis* RASTEGAR-POUYANI, NILSON & FAIZI, 2006. Plot der Hauptkomponenten 1 and 2. ✻ -Weibchen; O - Männchen.

semble *A. griseonotus* whereas males exhibit considerable similarities to keeled species such as *A. elisae*.

This study revealed the effect of gender on the keeling of tubercular scales in individuals of a species of the genus *Asaccus*. Thus, tubercle keeling may not be a reliable diagnostic character within the genus, whereas the arrangement and distribution of the tubercles may turn out to be of taxonomic significance. The author believes that molecular systematic studies are needed to clarify the taxonomic position of *A. kurdistanensis* and other species of the genus.

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KEY WORDS: Reptilia: Squamata: Gekkonidae: *Asaccus*; *Asaccus kurdistanensis*, lizards, sexual dimorphism, tubercular scale rugosity, keeling, morphology, taxonomic implications, Palangan, Iran

SUBMITTED: March 10, 2008

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