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New insights on the morphology and taxonomy of the gecko *Mediodactylus ilamensis* (Reptilia: Gekkonidae)

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As a recently described species, *Mediodactylus ilamensis* is one of the least studied species of endemic reptiles of Iran. In this study a total number of 11 specimens of *Mediodactylus ilamensis* were collected from type locality (Zarin-Abad) as well as a new locality in Dinar-Kooh Preserved area, Abdanan Township approximately 27 km on an aerial line in the east of type locality. To investigate morphological variation and reveal sexual dimorphism we employed 32 metric and meristic characters. The most important morphological characteristics of this species are as follow: all scales of the body, with the exception of intermaxillaries, nasals, chin shields, and upper and lower labials, strongly keeled; postmentals absent, dorsal crossbars broad and equal to, or wider than, interspaces**;** scales of frontal and supraocular regions toward snout are multi-keeled (in some scales up to six keels) and polyhedral. Of the studied morphological characters only two are different significantly between males and females: number of active precloacal pores and ear diameter (vertical). Based on the new material, the validity of *M. ilamensis* as a full species, well distinguishable from other species of *Mediodactylus*, is confirmed. Observations on taxonomy, ecology and behavior are given.

Key words: *Carinatogecko,* Iran, Ilam, Dinarkooh.

INTRODUCTION

The naked-toed geckos are a group of gekkonid lizards, found in the Palearctic, ranging from North Africa to northern India and western China, with their greatest diversity in Iran and Pakistan (Bauer, 2013). The earliest known specimen of *Carinatogecko heteropholis*, an immature female from scrub oak firewood forest of northeastern Iraq, was first erroneously determined as *Alsophylax persicus* (Nikolsky, 1903). The same specimen (holotype) was described by Minton *et al.* (1970) as *Tropiocolotes heteropholis*. The second representative of the genus, *Carinatogecko aspratilis* (Anderson, 1973), was originally placed in *Bunopus* as *B. aspratilis*. The description was based on two tentatively immature female specimens from the southwestern Zagros foothills of Iran. These two species (*T. heteropholis* and *B. aspratilis*) were placed in a new genus named *Carinatogecko* by Golubev & Szczerbak (1981). The third representative of this genus, *C. stevenandersoni*, is distributed in Lorestan Province, western Iran (Torki, 2011) and the fourth representative, *C. ilamensis*, was described from Ilam province in 2011 (Fathinia *et al.*, 2011). A recent phylogenetic study by Cervenka *et al.* (2010) suggested that the genus *Carinatogecko* and some species of *Cyrtopodion* to be transferred to the genus *Mediodactylus*. In another phylogenetic study, the genus *Carinatogecko* was nested within the genus *Mediodactylus* (Bauer, 2013). As a recently described species, *Mediodactylus ilamensis* (Fathinia *et al.*, 2011) in one of the leats

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studied species of endemic reptiles of Iran, which was originally described from only two specimens (RUZM-GC 120.1 and RUZM-GC 120. 2; Razi University Zoological Museum). So there is not enough information about the morphological aspects of this species. Here, the morphology of this species is scrutinized based on additional specimens collected from type locality as well as a new locality in Ilam province.

MATERIAL AND METHODS

A total number of 11 specimens were collected from Ilam province in western Iran. To achieve this goal, two areas were searched using torch during night fieldworks. These areas include Dinar-Kooh Preserved area in Abdanan Township, and Zarin-Abaad in Dehloran Township, respectively (Figs. 1, 2). The specimens were identified based on Fathinia *et al.* (2011) and deposited in RUZM under museum codes GC120.1 to GC120.11 after preserving in 95% ethanol. To investigate morphological variation and also to reveal sexual dimorphism we employed 32 metric and meristic morphometric characters .including: metric characters SVL: snout-vent length; TL: Tail length; LH: Head length; HW: Head width (in widest part); ILD: Interlimb distance; NND: Nostril to nostril distance; EYED: Eye diameter (vertical); HD: Head height; HLL: Hind limb length; FLL: Forelimb length; EARD: Ear diameter (vertical); IN: interspaces between dorsal bands; meristic characters DT: number of dorsal tubercles; DB: (dorsal bands); SLar: number of righ supralabials; SLal: number of left supralabials; ILar: number of right infralabials; ILal: number of left infralabials; PPo: number of active precloacal pores (in male only); L4T: number of lamellae under 4th toe; CVS: number of transverse caudal ventral scales; VS: ventral scales (across midbody) NGBM**:** number of granular scales behind mental; DS**:** dorsal scales (across midbody); DCS: dorsal caudal scales (across midbody); DTL: number of dorsal tubercles longitudinally; TBS: scales between tubercles; SdT: number of scales around dorsal tubercles and ratio characters: CW/TW: Cloaca width to Tail Width; ML/MW: Mental length to Mental width; HLL/FLL: Hind limb length to Forelimb length; LH/HW: Head length to Head width). Morphological studies were carried out using a stereo microscope and a digital caliper to the nearest 0.01 mm. Statistical analysis was conducted with SPSS 16.0. Descriptive statistics and Independent sample t-test were used to analyze the variation between females and males.

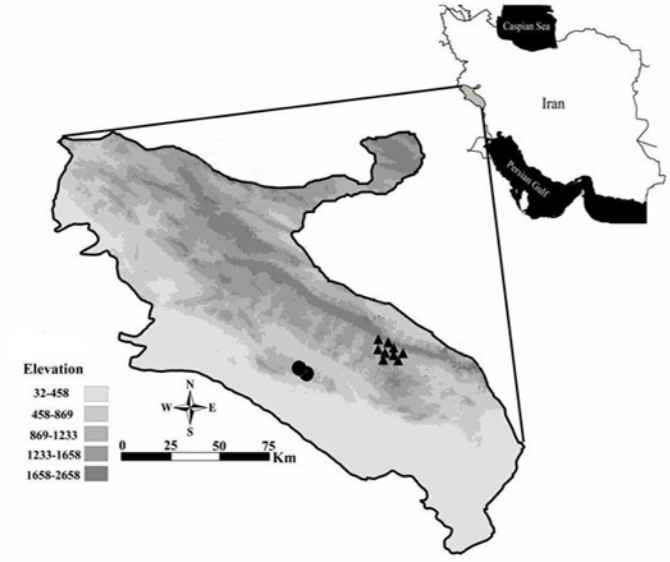

FIGURE 1. Distribution of *Mediodactylus ilamensis*; new locality (Dinar-Kooh region, Abdanan Township, Black triangles) and type locality (Zarin-Abaad, Dehloran Township, Black circles).

FIGURE 2. Long view (a) and close view (b) of habitat structure of *M. ilamensis* in Ilam Provine, Western Iran.

RESULTS

Character variation

Based on the original description (Fathinia *et al.*, 2011), we identified the collected specimens as *Mediodactylus ilamensis*. Fathinia *et al.* (2011) differentiated morphologically *M. ilamensis* from other species of the genus *Mediodactylus*. Morphological characters are presented in the Table 1. Maximum Snout-vent length of original description of *M. ilamensis* is 36.5 mm, and in this study we found a larger body sizes to 45.89 mm. the dorsal tubercle rows across midbody in holotype 10 and in paratype 9. The tubercle rows in new analyzed specimens ranges from 8 to 11. Dorsal tubercles surrounded by 8-10 smaller scales in original description vs. 8-11 in this study; 30-32 ventral keeled scales in a single transverse row in original description vs. 27-40 in this study; mental bordered by 6-7 small keeled scales in original description and 5-7 in this study. Other characters are similar to the original description as follows: scales of frontal and supraocular regions toward snout are multi-keeled (in some scales up to six keels) and polyhedral, the keels meeting towards the tip of the scale; rostral smooth and semidivided posteriorly; nine smooth supralabials; nostril surrounded by five smooth scales including rostral, first supralabial, and three postnasals; five scales between nostrils (first and fifth are smooth, the others keeled); mental smooth; no postmental; mental surrounded by seven small keeled scales posteriorly; seven smooth infralabials; all tubercles and scales of dorsum keeled, mostly blunt, a few mucronate; dorsal pholidosis heterogeneous; tubercles of dorsum extending to nape but absent in occiput; ventral scales approximately equal to dorsals in length (0.5

mm); five preanal pores; scales on dorsal side of forelimbs homogeneous and smaller than those on hindlimbs; no tubercle on forelimbs; few tubercles on hindlimbs; caudal tubercles mucronate and more prominent than tubercles on dorsum; six tubercles at the middle of each whorl; tubercles in each whorl are in contact or separated by a small scale; tubercle of each whorl separated from preceding and succeeding whorls by three rows of scales; ventral side of tail without large plate-like scales; smaller blunt, keeled scales at the base of tail just behind the vent, but becoming strongly mucronate and keeled distally. Dorsal bands in all specimens are wider than interspaces (Figs. 3a, b, d). More difference between original description and additional specimens are shown in Table 1.

Sexual dimorphism

Although body size between the sexes is not statistically significant (t = 0.32; *P* = 0.76), but males (41.09 ± 1.36; Mean ± SEM) are larger than females (39.40 ± 5.12). The tail length in males (32.68 ± 3.89) is longer than in females (30.54± 5.4), but this difference is not significant (t =0.30; *P* = 0.76).

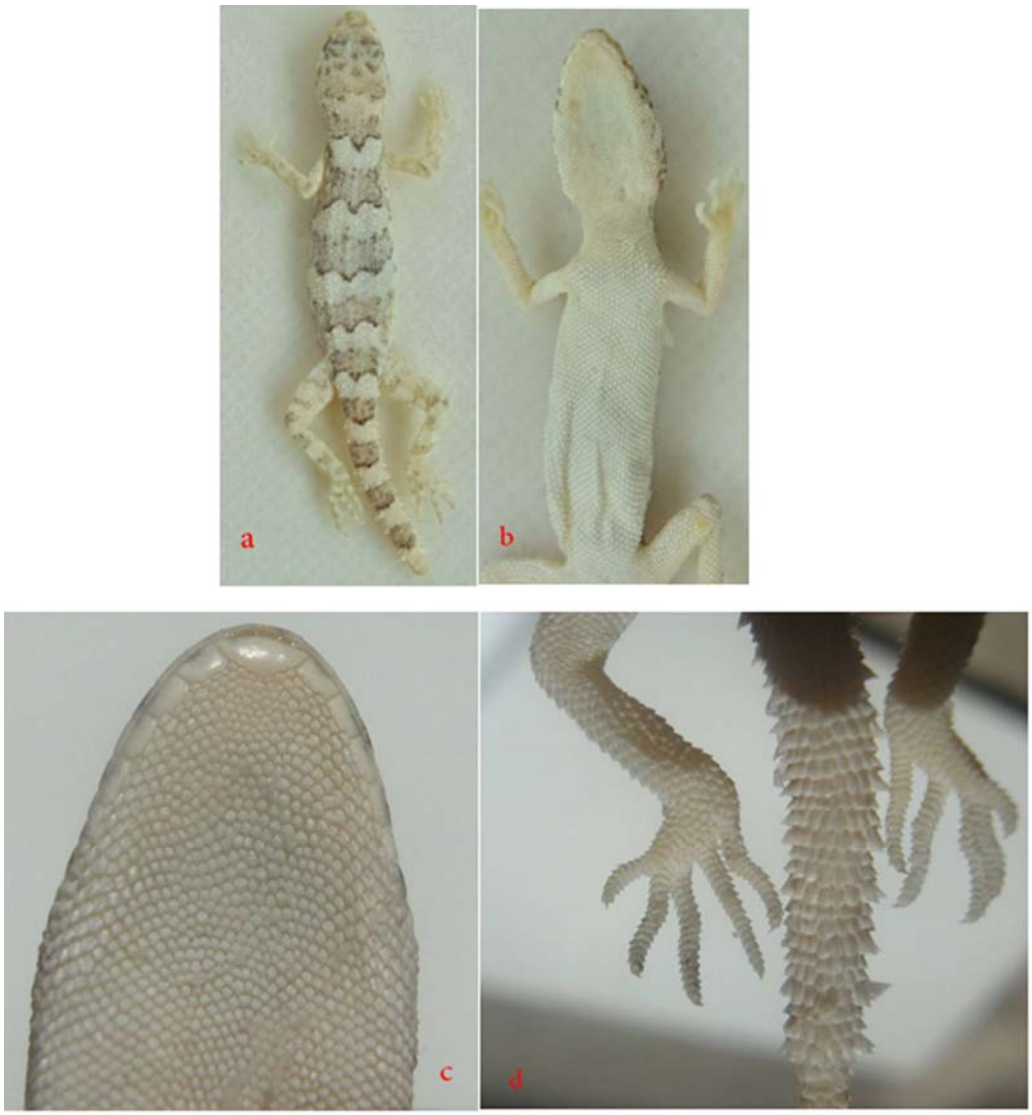

FIGURE 3. Dorsal view (a), ventral view (b), absence of postmentals (c) and keeled scales (d) on ventral part of tail and digits in *M. ilamensis*.

Of the 33 characters, we found sexual dimorphism in just two characters (Table 1): number of active precloacal pores (t = 5.61, *P* = 0.001), presenting only in males and ear diameter (vertical) (t = 2.41, *P* = 0.04) which is greater in males than in females. Forelimb length (14.78 ± 0.36) and interlimb distance (18.66 ± 0.70) in males are longer than in females, but not significantly different. Dorsal bands in females and male are approximately equal. Ratio of cloaca width to tail width in males (0.78 ± 0.03) is longer than in females (0.71 ± 0.05), but this difference is not significant (t =0.30; *P* = 0.76) (Figs. 4a, b).

TABLE 1. The variation in 32characters (in mm) in *Mediodactylus ilamensis* occurring in new localities (Dinar-Kooh region, Abdanan Township) and type locality Zarin-Abaad, Dehloran Township.

	Females (*n* = 5)				Males (*n* = 4)				Total (*n* = 9)				*t*-Test		
Character	**mean**	**S.E. M**	**Min**	**max**	**mean**	**S.E.M**	**min**	**max**	**mean**	**S.E. M**	**min**	**max**	**t**	**p**	**DD**
SVL	39.40	5.12	29.30	45.89	41.09	1.36	36.48	45.10	40.60	5.16	29.3	45.60	0.32	0.76	M > F
TL	30.54	5.42	25.12	35.96	32.68	3.89	17.72	40.19	32.07	7.83	17.72	40.19	0.30	0.76	M > F
LH	10.02	1.09	7.99	11.70	10.0	0.33	9.12	11.36	10.16	1.15	7.99	11.70	0.24	0.82	F > M
HW	7.87	1.29	5.33	9.56	8.29	0.32	6.49	9.00	8.17	1.28	5.33	9.56	0.32	0.78	M > F
DT	9.33	0.33	9.00	10.00	9.14	0.34	8.00	11.00	9.2	0.25	8.00	11.00	0.48	0.70	F > M
DB	5.67	0.33	5.00	6.00	5.14	0.14	5.00	6.00	5.3	0.15	5.00	6.00	0.12	1.57	F > M
ILD	18.44	3.13	12.27	22.47	18.66	0.70	16.04	20.78	18.60	2.97	12.27	22.47	0.07	0.95	M > F
SLar	9.67	0.33	9.00	10.00	8.71	0.36	7.00	10.00	9.00	0.94	7.00	10.00	1.58	0.15	F > M
SLal	9.00	0.58	8.00	10.00	8.85	0.26	8.00	10.00	8.90	0.73	8.00	10.00	0.81	0.25	F > M
ILar	9.00	0.58	8.00	10.00	8.43	0.43	7.00	10.00	8.60	1.07	7.00	10.00	0.75	0.47	F > M
ILal	7.33	0.33	7.00	8.00	7.57	0.20	7.00	8.00	7.50	0.52	7.00	8.00	0.51	0.66	M > F
NND	1.48	0.09	1.33	1.63	1.47	0.06	1.16	1.65	1.47	0.15	1.16	1.65	0.09	0.93	F > M
EYED	2.50	0.59	1.34	3.22	2.90	0.26	1.39	3.49	2.77	0.76	1.34	3.49	0.73	0.49	M > F
HD	4.47	0.44	3.60	5.07	4.62	0.16	4.19	5.33	4.58	0.50	3.60	5.33	0.40	0.70	M > F
HLL	7.57	3.14	11.33	21.23	19.27	0.52	17.7	20.99	18.77	2.91	11.33	21.23	0.54	0.64	M > F
FLL	12.29	2.40	7.51	15.12	14.78	0.36	13.08	16.29	14.03	2.43	7.51	16.29	1.02	0.41	M > F
PPo	0.00	0.00	0.00	0.00	3.00	0.53	2.00	5.00	2.10	1.85	0.00	5.00	5.61	0.001*	M > F
L4T	14.67	0.88	13.00	16.00	15.57	0.81	11.00	17.00	2.10	1.94	11.00	17.00	0.65	0.53	M > F
CVS	16.67	1.20	15.00	19.00	14.29	0.64	12.00	17.00	15.30	2.05	12.00	19.00	1.91	0.09	F > M
CW/TW	0.71	0.05	0.65	0.82	0.78	0.03	0.67	0.88	0.75	0.08	0.65	0.88	1.19	0.27	M > F
ML/MW	0.58	0.01	0.56	0.60	0.82	0.20	0.53	2.02	0.74	0.45	0.53	2.02	0.36	0.91	M > F
EARD	0.61	0.25	0.21	1.09	1.14	0.09	0.84	1.64	0.97	0.39	0.21	1.64	2.41	0.04*	M > F
VS	34.0	3.51	27.00	38.00	32.71	1.48	29.00	40.00	33.10	4.33	27.00	40.00	0.41	0.69	F > M
HLL/FLL	1.44	0.03	1.40	1.50	1.31	0.04	1.17	1.41	1.34	0.10	1.17	1.50	2.19	0.06	F > M
SdT	9.00	0.58	8.00	10.00	9.14	0.34	8.00	11.00	9.10	0.87	8.00	11.00	0.90	0.13	M > F
LH/WH	1.30	0.09	1.19	1.49	1.24	0.05	1.07	1.43	1.25	1.29	1.07	1.49	0.67	0.52	M > F
NGBM	6.67	0.33	6.00	7.00	6.29	0.28	5.00	7.00	6.40	0.70	5.00	7.00	0.45	0.76	F > M
DS	22.00	1.52	20.00	25.00	23.29	1.39	18.00	27.00	22.90	3.31	18.00	27.00	0.54	0.60	M > F
IN	2.32	0.44	1.44	2.86	2.75	0.43	0.99	3.95	2.61	1.01	0.99	3.95	0.59	0.57	M > F
DCS	13.00	1.00	12.00	14.00	11.29	0.36	10.00	12.00	11.66	1.22	10.00	14.00	2.08	0.08	F > M
DTL	25.00	1.53	23.00	28.00	26.00	0.72	24.00	30.00	25.70	2.05	23.00	30.00	0.68	0.51	M > F
TBS	1.67	0.33	1.00	2.00	1.86	0.14	1.00	2.00	1.80	0.42	1.00	2.00	0.63	0.55	M > F

Abbreviations SVL: snout-vent length, TL: Tail length, LH: Head length, HW: Head width (from widest part), DT: number of dorsal tubercles, DB: (dorsal bands), ILD: Interlimb distance, SLar: number of supralabials in right , SLal: number of supralabials in left, ILar: number of infralabials in right, ILal: number of infralabials in left, NND: Nostril to nostril distance EYED: Eye diameter (vertical), HD: Head depth, HLL: Hind limb length, FLL: Forelimb length, PPo: number of active precloacal pores (in male only), L4T: number of lamellae under 4th toe, CVS number of transverse Caudal ventral scales, CW/TW: Cloaca width to Tail Width, ML/MW: Mental length to Mental width, EARD: Ear diameter (vertical), VS: ventral scales (across midbody), HLL /FLL: Hind limb length to Forelimb length, SdT: number of scales around dorsal tubercles, LH/ HW: Head length to Head width, NGBM**:** number of granular scales behind mental DS**:** dorsal scales (across midbody), IN: interspaces between dorsal bands, DCS: dorsal caudal scales (across midbody), DTL: number of dorsal tubercles longitudinally, TBS: scales between tubercles, DD: direction of differences and*Significant differences between male and female.

DISSCUSSION

Mediodactylus ilamensis differs conspicuously from all other species described in this genus so far. Like the original description by Fathinia *et al.* (2011), our findings confirm the lack of postmentals (Fig. 3c) and having dark crossbars equal to or wider than their white interspaces in *M. ilamensis* and once more emphasizing the importance of this characters in identification of this species from its congeners. Like *M. ilamensis*, *M. spinicauda* also lacks postmentals, but, they differ from each other by having large keeled dorsal tubercles in *M. ilamensis* contrary to rounded ones in *M. spinicauda* and wider dorsal bands in the former than in the later. Despite lack of postmentals, *M. ilamensis* differs from *M. heterocercus*, *M. spinicauda*, *M. kotschyi*, *M. russowii*, *M. walli*, *M. amictopholis*, *M. brachykolon*, *M. narynensis* and *M. sagittifer* by having keeled subdigital lamellae.

Pattern variation

As noted before, the original description of *M. ilamensis* was based on only two specimens collected in 2011. In this work we describe the pattern coloration in more detail as follows: 5-6 brownish white crossbars on dorsum (Fig. 3a); dark stripes and spots on dorsal side of head, postorbital, frontal, infra- and supralabials; no spots are present on ventral side of body. There are more than 7-11 dark crossbars on dorsal surface of tail, width of dark bars equal to or slightly smaller than light interspaces; in some specimens, the number of these dark crossbars is equal to or more than their interspaces dark crossbars on limbs and digits (Fig. 4a). Dark transverse bars on tail, extending to lateral tail region. Ventral surfaces of head, body, forelimbs and hindlimbs are whitish (Fig. 3b).

Sexual dimorphism

Sexual dimorphism in *M. ilamensis* was pronounced in that male specimens were consistently different from females by the presence of precloacal pores. This is true for *Cyrtopodion turcmenicum* (Szczerbak, 1978) but not for most species of *Cyrtopodion* in Iran, such as *C. agamuroides* (Nikolsky, 1900), *C. scabrum* (Heyden, 1827), and *Mediodactylus heterocercum* (Blanford, 1874) where both males and females lack precloacal pores (Anderson, 1999). Males and females of *M. ilamensis* are not significantly different from each other whereas the contrary is found in many other geckos such as *C. scabrum* (males, 51 and females, 55 mm; Anderson, 1999), *M. heteropholis* (Minton *et al.*, 1970) (males, 32.5 and females, 36.3mm; Fathinia *et al.*, 2011) and some species of *Hemidactylus* such as *H. turcicus* (Linnaeus, 1758) (males, 46.0 and females, 49.2 mm; Smid *et al.*, 2013) and *H. robustus* (males, 41.8 and females, 43.6 mm; Carranza & Arnold 2012; Smid *et al.*, 2015). The only metric character with significant difference between the two sexes is ear diameter (ED). In contrast to the lack of any difference between males and females of *M.ilamensis* regarding SVL (snout-vent length), there is a significant female-biased trend in this trait between males and females of other geckonid species such as *M.heteropholis* (Fathinia *et al.*, 2011). There is no significant difference between the two sexes of *M. ilamensis* in width of vent. Greater anal width in female geckos than males are attributed to the laying of big eggs, constituting a selective advantage (Andersson, 1994; Torki, 2007a, 2010). In contrast, the larger anal width in males of many lizards than in females is attributed to an advantage for extruding hemipenes in males. Interlimb distance is a trait that favored by selective forces in terms of successful reproduction. This is a commonly female-biased character responsible for accommodating eggs/embryos in abdominal cavity. This case has been proved in many lizard species that produce numerous eggs/embryos, such as scincid, lacertid and agamid lizards (Olsson *et al.*, 2002) but not necessarily for the geckos which never develop more than one or two large eggs. Although, however, the number of eggs developing in geckos is small, the proportionate volume of these eggs is large in comparison to the clutches of lizards other than geckos (personal observations). Therefore, for holding and developing one or two large eggs, selection towards increased interlimbs distance must have occurred in the females of the gecko family as well. In fact,

the females of some geckos such as *Microgecko helenae* (Schmidtler & Schmidtler, 1972), *Asaccus kurdistanensis* Rastegar-Pouyani, Nilson & Faizi, 2006 and *Stenodactylus affinis* (Murray, 1884) possess significantly wider interlimbs distances than their males (Torki 2007a, 2010; Torki & Sharifi, 2007). But, this is not the case for female specimens of *M. ilamensis* as two sexes are not significantly different in this trait. The opposite case is very rare within lizards in general (Kratochvíl *et al.*, 2003). Among geckos, the head size of females was found to be comparatively larger than of males in *M. helenae* and *S. affinis* (Torki, 2007a, 2010). Head dimensions are not significantly different between two sexes in *M. ilamensis*. Greater head dimentions in male than females is a typical case to most other lizard families such as scincids (Olsson *et al.*, 2002). Head size plays an important role in sexual selection (Anderson & Vitt, 1990; Perry, 1996; Clemann *et al.*, 2004) which in *M. ilamensis* not favored by any of the two sexes (Fig. 4a, b).

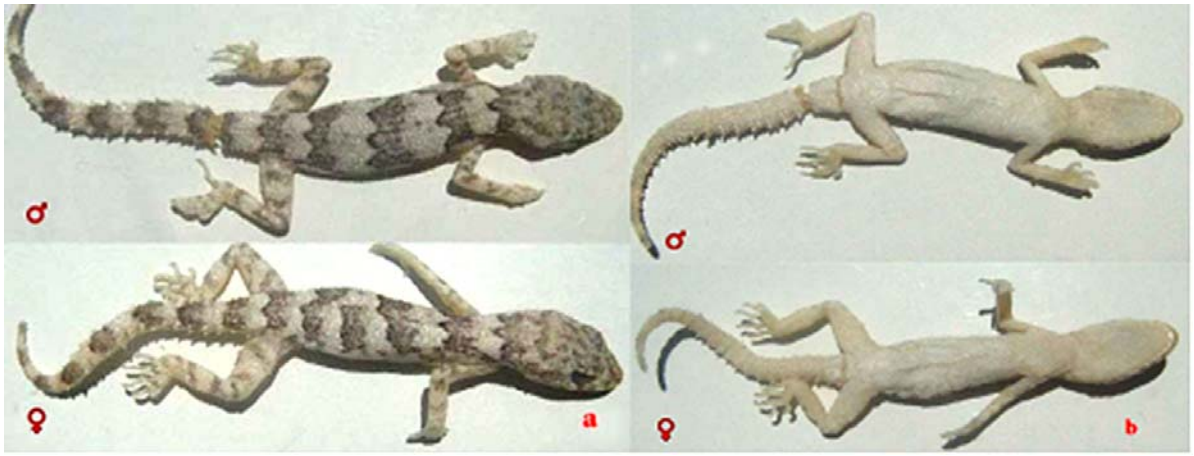

FIGURE 4. Dorsal (a) and ventral (b) views in *Mediodactylus ilamensis*.

Evaluation of taxonomic characters of Iranian species of the genus Mediodactylus

So far eight species of the genus *Mediodactylus* have been reported from Iran: *M. aspratilis*, *M. heteropholis*, *M. stevenandersoni*, *M. ilamensis*, *M. russowii*, *M.sagittifer*, *M. heterocercus* and *M. spinicauda*. They are widely distributed throughout Iran. In the following section we briefly review the important taxonomic characters that are used in their diagnoses based on previous and present studies. *Mediodactylus aspratilis* is diagnosed by having small body size, scales in middle of back distinctly larger than abdominals, caudal tubercles pointed, raised, with enlarged posterior facets, analogous dorsal tubercles present on forearms and 17-18 subdigital lamellae under the 4th toe. While *M. ilamensis* has no postmentals, width of dark bars equal to or slightly smaller than light interspaces, scales and tubercles all over the body strongly keeled (except upper and lower labials, nasals, rostral, and mental); dorsal scales heterogeneous, blunt; enlarged blunt tubercles on dorsum; mucronate tubercules on tail more prominent than tubercles on dorsum (Fathinia *et al.*, 2011). Three characters that diagnose *M. heteropholis* from remaining species are (1) two pairs of postmentals, (2) 16-17 lamellae under 4th toe and (3) nine bands on original tail (Červenka, 2010). *Mediodactylus stevenandersoni* is diagnosed by three or four pairs of postmentals (Torki, 2011). *Mediodactylus russowii* is distinguished by having dorsal tubercles oval or oval triangular, keeled, scales of tail (except tubercles) and limbs smooth. Scales of first pair of postmentals always separated from each other by one to two scales (Safaei et al., 2012). *Mediodactylus spinicauda* is distinguished from other species by having dorsal tubercles roundish (Szczerbak & Golubev, 1996; Anderson, 1999). *Mediodactylus sagittifer* is diagnosed by having dorsal tubercles oval, keeled; scales and plates of tail as well as scales of upper front surfaces of limbs with distinct keels (Szczerbak & Golubev, 1996; Anderson, 1999). *Mediodactylus heterocercus* is identified from other congeners by having dorsal tubercles oval, keeled;

scales and plates of tail as well as scales of upper front surfaces of limbs with distinct keels (Szczerbak and Golubev, 1996; Anderson, 1999). The genus *Mediodactylus* are distributed in different geographical regions of Iran: (1) *M. aspratilis* distributed in southern and south western Iran (Červenka, 2010); (2) *M. heteropholis* distributed in a few areas in the western Zagros foothills of Iran and northeastern Iraq (Červenka, 2010); (3) *M. stevenandersoni* distributed in Lorestan Province, western Iran (Torki, 2011); (4) *M. ilamensis* on the western gypsum foothills of the Zagros Mountains (Fathinia *et al*., 2011); (5) *M. russowii zarudnyi* hs been recorded in north eastern regions of the Iranian Central Deserts (Safaei *et al*., 2012); (6) *M. sagittifer* is endemic to southeastern Iran, where it is known only from the Jaz Murian Depression in Baluchistan (Anderson, 1999); (7) *M. heterocercus* from southeastern Turkey, northern and eastern Syria, Iraq and Iran (Hamadan, Kermanshahan and questionable records from Persepolis, Fars Province) (Anderson, 1999); (8) *M. spinicauda* only from the Kopet Dagh mountain range, western Badkhyz and Balkhan of northeastern Iran and southern Turkmenistan (Safaei *et al*., 2015) and *M. kotschyi* in which Anderson had given its probable occurrence in northwestern Iran during field works in western and northwestern Iran; though it has not yet been documented (Szczerbak & Golubev, 1996; Anderson, 1999).

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