



## New species of *Phrynocephalus* (Squamata, Agamidae) from Qinghai, Northwest China

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### Abstract

A new viviparous species of *Phrynocephalus* from Guinan, Qinghai, China, is described. *Phrynocephalus guinanensis* **sp. nov.**, differs from all congeners in the following combination of characters: body large and relatively robust; dorsal ground color of head, neck, trunk, limbs and tail brown with weak light brown mottling; lateral ground color of head, neck, trunk and tail light black with weak white-gray mottling in adult males, and green with weak white-gray mottling in adult females; ventral ground color of tail white-gray to black in the distal part of the tail in adult males, and totally white-gray in adult females; ventral surfaces of hind-limbs white-gray; ventral surfaces of fore-limbs brick-red in adult males, and white-gray in adult females; ventral ground color of trunk and head black in the center but, in the periphery, brick-red in adult males and white-gray in adult females. *Phrynocephalus guinanensis* **sp. nov.** typically uses desert habitats, whereas *P. vlangalii*, a species closely related to the new form, uses a variety of arid and semi-arid habitats. It is the nineteenth species of *Phrynocephalus* recorded from China.

**Key words:** *Phrynocephalus guinanensis* **sp. nov.**, Agamidae, Northwest China, new species, morphological description

### Introduction

Toad-headed lizards of the genus *Phrynocephalus* Kaup (Family Agamidae), currently including more than forty species, are widely distributed in desert, arid or semi-arid regions in Central and West Asia [westwards to southern Jordan (*P. arabicus* Anderson)] and North-Northwest China [eastwards to Hebei Province (*P. versicolor* Strauch)] (Zhao 1999). Eighteen species have been found in China, twelve of which are small-sized [often smaller than 60 mm adult snout-vent length (SVL)], and the remaining six are medium or large-sized species (Zhao 1979, 1997a, 1997b, 1999; Wang *et al.* 2002; Xiong *et al.* 2005). Toad-headed lizards found in China are either oviparous or viviparous, with all the six currently known viviparous species (*P. erythrurus* Zugmayer, *P. forsythii* Anderson, *P. putjatae* Bedriaga, *P. theobaldi* Blyth, *P. vlangalii* Strauch and *P. zetangensis* Wang, Zeng & Wu) endemic to China (Zhao 1999).

During our first collecting trip to Northwest China in 2004, we collected specimens of a viviparous species of *Phrynocephalus* from sand dunes in Guinan County, Qinghai Province, which could not be assigned to any known species. The lizard is similar to *P. vlangalii* in terms of body size and shape, and has been probably included within the *P. vlangalii* species complex, including specimens of *P. putjatae* from Tianzhu and Guide (Pang *et al.* 2003). Our unpublished molecular data show that the lizard is phylogenetically closer to the *P. vlangalii* species complex than to other Chinese toad-headed lizards. However, careful examination of specimens collected since 2004, as well as morphological comparison of the unidentified lizard with *P.*

*vlangalii* has led to the discovery of considerable differences between them. We therefore suggest that the recently found viviparous *Phrynocephalus* lizard should be named as new.

## Materials and methods

We collected 209 adults (103 ♀♀ and 106 ♂♂) of the new species during May–July in 2004–2007 from sand dunes in Senduo (35°34'N, 101°05'E; altitude 3350 m ASL), Guinan County, Qinghai Province, and 390 adults (277 ♀♀ and 113 ♂♂) of *P. vlangalii* from Daotanghe (36°29'N, 101°09'E; altitude 3250 m ASL), Gonghe County, Qinghai Province. We palpated all females to assess their reproductive conditions, and paid particular attention to the smallest reproductive female of each species. Most of these lizards were released at their point of capture following the measurement of SVL.

Forty specimens (20 ♀♀ and 20 ♂♂) of the new species and 40 adults (20 ♀♀ and 20 ♂♂) of *P. vlangalii* collected in 2004 were brought to our laboratory for more detailed morphological measurements and scale counts. Measurements to the nearest 0.1 mm were taken for each lizard with Mitutoyo digital calipers following the methods of Zhao (1999) and Zhang *et al.* (2005), including SVL, tail length (TL), head length (HL, from the snout to the posterior end of the skull), head width (HW, taken at the posterior end of mandible), fore-limb length (FLL, humerus plus ulna), hind-limb length (HLL, femur plus tibia), 4<sup>th</sup> finger length (FFL), 4<sup>th</sup> toe length (FTL), claw length of the 4<sup>th</sup> finger (FCL) and claw length of the 4<sup>th</sup> toe (TCL). All type specimens of the new species were deposited in the Research Center of Herpetology, Nanjing Normal University.

Fourteen pregnant females of the new species collected from the field in mid-July 2005 were transported to our laboratory, where they were housed in a 2.5 m × 1.2 m × 0.6 m (length × width × height) cage, in an indoor animal holding facility. The cage contained a substrate consisting of 300-mm sand, with rocks and pieces of clay tiles provided as cover. During daylight hours, thermoregulatory opportunities were provided by two 200-W incandescent lamps suspended over one end of the cage; overnight temperatures followed indoor ambient temperatures (18 ± 1 °C). Food [mealworms (larvae of *Tenebrio molitor*) and house crickets (*Achetus domesticus*)] and fresh water were provided daily, so that excess food was always available in the cage. The cage was checked twice daily for newborns, and more frequently when the first female gave birth, such that newborns could be always collected and weighed within a few hours after parturition. Body mass, SVL and TL were taken for each postpartum female.

## Taxonomy

### *Phrynocephalus* Kaup (Family Agamidae)

#### *Phrynocephalus guinanensis* sp. nov.

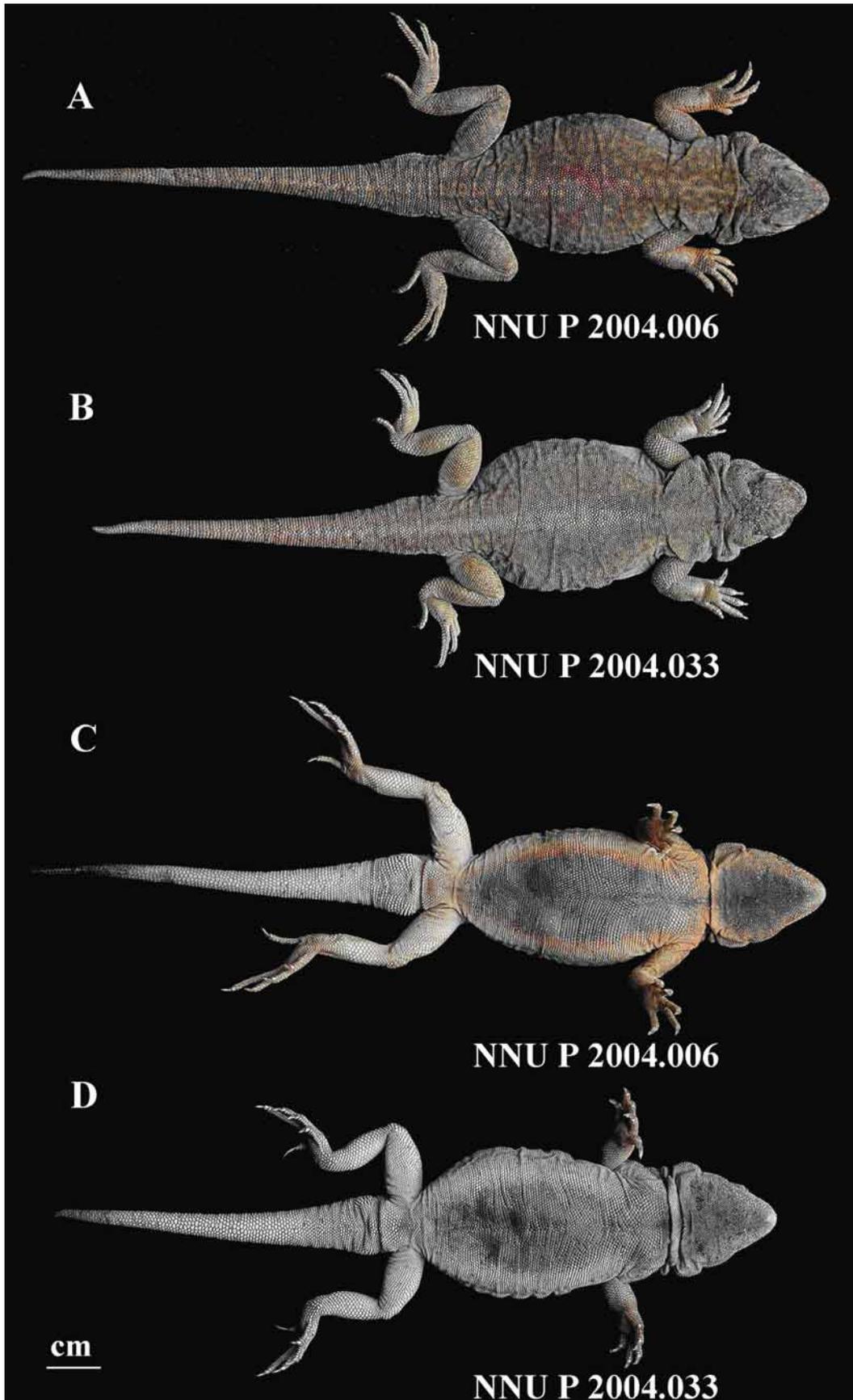
(Figure 1)

**Holotype.** NNU (Nanjing Normal University) P 2004.006, adult male (Fig. 1A, C); Senduo (35°34'N, 101°05'E; altitude 3350 m ASL), Guinan County, Qinghai Province, China; collected by Xiang Ji on 17 May 2004.

**Paratypes.** NNU P 2004.001–005, NNU P 2004.007–040, 19 adult males and 20 adult females; same data and collector as for holotype.

**Etymology.** The specific epithet is a latinization of the name Guinan County, Qinghai Province, China.

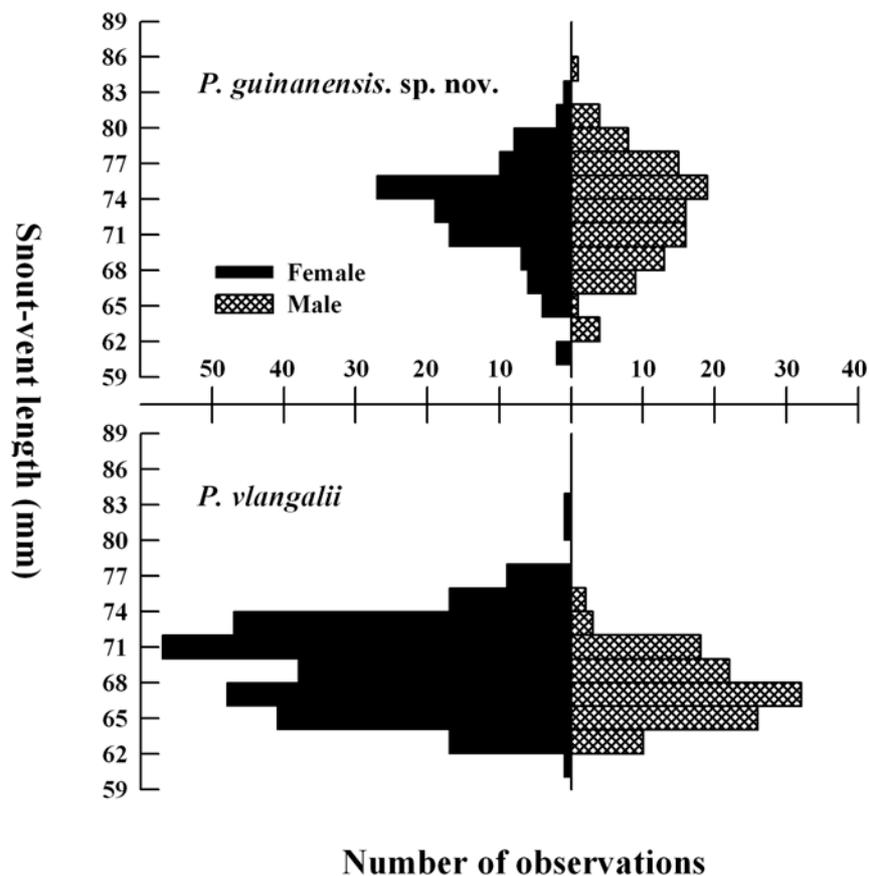
**Diagnosis.** A large viviparous species of *Phrynocephalus*, distinguishable from congeners using the following combination of characters: up to 84 mm SVL; dorsal ground color of head, neck, trunk, limbs and tail brown with weak light brown mottling; lateral ground color of head, neck, trunk and tail light black with



**FIGURE 1.** The adult male holotype (NNU P 2004.006; A: dorsal view, C: ventral view) and an adult female paratype (NNU P 2004.033; B: dorsal view, D: ventral view) of *Phrynocephalus guinanensis* **sp. nov.** from Senduo, Guinan County, Qinghai Province, China. Photo by Guo-Hua Ding.

weak white-gray mottling in adult males, and green with weak white-gray mottling in adult females; ventral ground color of tail white-gray to black in the distal part of the tail in adult males, and totally white-gray in adult females; ventral surfaces of hind-limbs white-gray; ventral surfaces of fore-limbs brick-red in adult males, and white-gray in adult females; ventral ground color of trunk and head black in the center but, in the periphery, brick-red in adult males and white-gray in adult females, and totally white-gray in adult females; 5–8 nasal scales; 5–8 internasal scales; 8–12 scales around parietal eye; 13–18 supraocular scales; 126–164 dorsal scales; 101–136 ventral scales; 144–186 scales around mid-body; 21–31 gular folds; 15–19 subdigital lamellae of the 4<sup>th</sup> finger; 22–29 subdigital lamellae of the 4<sup>th</sup> toe (Table 1).

Sexual variation in measurements and scutellation of *P. guinanensis* **sp. nov.** is presented in Table 1. It differs from *P. vlangalii* in all examined morphological traits (Table 1). Moreover, it differs from *P. vlangalii*, a species with females being the larger sex (Fig. 2;  $F_{1,388} = 25.89$ ,  $P < 0.0001$ ), in that male and female adults are monomorphic in SVL (Fig. 2;  $F_{1,207} = 0.03$ ,  $P = 0.871$ ).



**FIGURE 2.** Frequency distributions of adult SVL of two species of toad-headed lizards, *P. guinanensis* **sp. nov.** (from Senduo, Guinan County) and *P. vlangalii* (from Daotanghe, Gonghe County).

**Description of holotype.** Adult male (Fig. 1A, C); SVL 71.7 mm, TL 71.8 mm, HL 18.7 mm, HW 16.5 mm, FLL 23.6 mm, HLL 33.4 mm, FFL 6.8 mm, FTL 10.9 mm, FCL 2.1 mm, TCL 1.8 mm; 7 nasal scales; 7 internasal scales; 10 scales around parietal eye; 13 supraocular scales; 149 dorsal scales; 127 ventral scales; 170 scales around mid-body; 25 gular folds; 15 subdigital lamellae of the 4<sup>th</sup> finger; 24 subdigital lamellae of the 4<sup>th</sup> toe; head moderately long (HL/SVL 0.26), wide (HW/HL 0.77), distinct from neck; snout moderately rounded at tip; interorbital region weakly concave; tympanum opening not visible; scales on snout, forehead and dorsum of body small, granular, and nearly homogeneous; body relatively robust; fore-limbs moderately long (FLL/SVL 0.33); hind-limbs more robust and longer (HLL/SVL 0.47) than fore-limbs.

**TABLE 1.** Mensural and meristic data, expressed as mean SE and range, for the type series of *P. guinanensis* **sp. nov.** and *P. vlangalii* from Qinghai, Northwest China. Data are analyzed by using two-way ANOVA or two-way ANCOVA (with SVL as the covariate) with species and sex as the factors. PG: *P. guinanensis* **sp. nov.**, PV: *P. vlangalii*, F: females, and M: males.

	<i>P. guinanensis</i>		<i>P. vlangalii</i>		Statistical results		
	Females	Males	Females	Males	Species	Sex	Species × Sex
<i>N</i>	20	20	20	20			
Snout-vent length (mm)	71.4 ± 0.7 64.0–76.7	71.0 ± 0.9 61.6–78.0	66.2 ± 1.1 58.9–77.1	64.6 ± 0.8 57.8–72.2	$F_{1,76} = 45.14$ , $P < 0.0001$ ; PG > PV	$F_{1,76} = 1.41$ , $P = 0.239$ ; $F = M$	$F_{1,76} = 0.49$ , $P = 0.485$
Tail length (mm)	67.8 ± 0.9 56.0–76.0	73.2 ± 0.9 62.1–81.0	59.7 ± 1.0 53.3–70.2	65.7 ± 1.1 56.5–75.5	$F_{1,75} = 11.84$ , $P < 0.001$ ; PG > PV	$F_{1,75} = 179.18$ , $P < 0.0001$ ; $F < M$	$F_{1,75} = 3.14$ , $P = 0.081$
Head length (mm)	18.2 ± 0.1 16.7–19.1	18.4 ± 0.2 17.0–19.9	16.5 ± 0.2 15.0–18.5	17.0 ± 0.2 15.7–18.0	$F_{1,75} = 18.74$ , $P < 0.0001$ ; PG > PV	$F_{1,66} = 17.43$ , $P < 0.0001$ ; $F < M$	$F_{1,66} = 2.27$ , $P = 0.136$
Head width (mm)	14.9 ± 0.1 13.7–15.6	15.3 ± 0.1 14.3–16.5	14.8 ± 0.2 13.5–16.4	14.8 ± 0.2 13.6–16.2	$F_{1,75} = 5.74$ , $P = 0.019$ ; PG < PV	$F_{1,75} = 8.13$ , $P < 0.006$ ; $F < M$	$F_{1,75} = 0.76$ , $P = 0.384$
Fore-limb length (mm)	21.4 ± 0.2 19.1–23.5	22.7 ± 0.2 20.9–24.8	18.8 ± 0.3 16.2–21.0	19.0 ± 0.2 17.9–20.4	$F_{1,75} = 84.72$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 15.27$ , $P < 0.0003$ ; $F < M$	$F_{1,75} = 3.93$ , $P = 0.051$
Hind-limb length (mm)	31.8 ± 0.3 29.0–34.9	33.8 ± 0.2 31.8–35.6	27.6 ± 0.3 24.5–29.5	28.6 ± 0.3 26.3–31.6	$F_{1,75} = 137.50$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 46.74$ , $P < 0.0001$ ; $F < M$	$F_{1,75} = 2.13$ , $P = 0.149$
4 <sup>th</sup> finger length (mm)	6.4 ± 0.06 5.6–6.9	6.7 ± 0.08 5.7–7.3	5.6 ± 0.1 4.7–6.7	6.2 ± 0.1 5.4–7.1	$F_{1,75} = 19.85$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 29.05$ , $P < 0.0001$ ; $F < M$	$F_{1,75} = 6.12$ , $P = 0.016$
4 <sup>th</sup> toe length (mm)	10.0 ± 0.08 9.2–10.6	10.7 ± 0.1 9.3–11.8	7.9 ± 0.1 6.9–8.7	8.7 ± 0.1 8.0–9.3	$F_{1,75} = 239.65$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 65.57$ , $P < 0.0001$ ; $F < M$	$F_{1,75} = 0.16$ , $P = 0.693$
Claw length of the 4 <sup>th</sup> finger (mm)	2.3 ± 0.06 1.8–2.7	2.1 ± 0.06 1.7–2.9	1.8 ± 0.06 1.3–2.2	1.8 ± 0.03 1.5–2.2	$F_{1,75} = 20.91$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 2.45$ , $P = 0.121$ ; $F = M$	$F_{1,75} = 4.81$ , $P = 0.031$
Claw length of the 4 <sup>th</sup> toe (mm)	2.1 ± 0.04 1.8–2.4	2.1 ± 0.05 1.8–2.6	1.9 ± 0.04 1.5–2.2	1.8 ± 0.03 1.6–2.0	$F_{1,75} = 20.06$ , $P < 0.0001$ ; PG > PV	$F_{1,75} = 0.02$ , $P = 0.890$ ; $F = M$	$F_{1,75} = 0.57$ , $P = 0.451$
Nasal scales	6.0 ± 0.2 5–8	6.1 ± 0.2 5–8	4.1 ± 0.1 3–5	4.1 ± 0.1 3–5	$F_{1,76} = 112.61$ , $P < 0.0001$ ; PG > PV	$F_{1,76} = 0.16$ , $P = 0.688$ ; $F = M$	$F_{1,76} = 0.16$ , $P = 0.688$
Internasal scales	7.0 ± 0.2 5–8	6.9 ± 0.2 5–8	6.2 ± 0.2 5–7	6.4 ± 0.2 5–7	$F_{1,76} = 13.87$ , $P < 0.0004$ ; PG > PV	$F_{1,76} = 0.02$ , $P = 0.890$ ; $F = M$	$F_{1,76} = 0.74$ , $P = 0.393$
Scales around parietal eye	10.0 ± 0.2 8–12	9.9 ± 0.2 8–11	7.3 ± 0.2 6–9	7.6 ± 0.2 6–9	$F_{1,76} = 150.78$ , $P < 0.0001$ ; PG > PV	$F_{1,76} = 0.38$ , $P = 0.537$ ; $F = M$	$F_{1,76} = 0.75$ , $P = 0.388$
Supraocular scales	14.9 ± 0.3 13–18	14.5 ± 0.3 13–17	10.7 ± 0.3 10–14	10.4 ± 0.2 9–12	$F_{1,76} = 208.87$ , $P < 0.0001$ ; PG > PV	$F_{1,76} = 10.88$ , $P < 0.002$ ; $F > M$	$F_{1,76} = 3.05$ , $P = 0.085$
Dorsal scales	141.5 ± 2.1 128–164	141.1 ± 1.8 126–157	104.7 ± 1.5 93–118	103.0 ± 1.9 85–116	$F_{1,76} = 402.87$ , $P < 0.0001$ ; PG > PV	$F_{1,76} = 0.30$ , $P = 0.584$ ; $F = M$	$F_{1,76} = 0.11$ , $P = 0.738$

.....to be continued

TABLE 1. (continued)

	<i>P. guinanensis</i>		<i>P. vlangalii</i>		Statistical results		
	Females	Males	Females	Males	Species	Sex	Species × Sex
<i>N</i>	20	20	20	20			
Ventral scales	119.8 ± 2.0 101–131	122.7 ± 1.6 107–136	82.4 ± 1.6 71–99	83.3 ± 1.5 73–101	$F_{1,76} = 521.17$ , $P < 0.0001$ ; $PG > PV$	$F_{1,76} = 1.32$ , $P = 0.256$ ; $F = M$	$F_{1,76} = 0.37$ , $P = 0.544$
Scales around mid-body	162.6 ± 2.2 149–186	161.2 ± 2.4 144–181	128.3 ± 2.2 111–149	131.8 ± 1.5 121–147	$F_{1,76} = 224.90$ , $P < 0.0001$ ; $PG > PV$	$F_{1,76} = 0.24$ , $P = 0.622$ ; $F = M$	$F_{1,76} = 1.28$ , $P = 0.262$
Gular folds	25.4 ± 0.3 23–28	25.3 ± 0.5 21–31	21.8 ± 0.3 19–25	21.9 ± 0.4 19–25	$F_{1,76} = 69.35$ , $P < 0.0001$ ; $PG > PV$	$F_{1,76} = 0.02$ , $P = 0.890$ ; $F = M$	$F_{1,76} = 0.01$ , $P = 0.906$
Subdigital lamellae of the 4 <sup>th</sup> finger	17.0 ± 0.1 16–18	17.2 ± 0.2 15–19	14.0 ± 0.2 12–16	14.1 ± 0.2 12–17	$F_{1,76} = 209.87$ , $P < 0.0001$ ; $PG > PV$	$F_{1,76} = 0.51$ , $P = 0.478$ ; $F = M$	$F_{1,76} = 0.35$ , $P = 0.554$
Subdigital lamellae of the 4 <sup>th</sup> toe	25.4 ± 0.3 22–28	25.3 ± 0.3 24–29	17.5 ± 0.2 16–19	17.7 ± 0.2 15–20	$F_{1,76} = 826.95$ , $P < 0.0001$ ; $PG > PV$	$F_{1,76} = 0.14$ , $P = 0.711$ ; $F = M$	$F_{1,76} = 0.31$ , $P = 0.579$

**Color of holotype in life.** Dorsal ground color of head, neck, trunk, limbs and tail brown with weak light brown mottling (red coloration was not natural but a temporary mark “6” for the holotype); lateral ground color of head, neck, trunk and tail light black with weak white-gray mottling; ventral ground color of trunk and head black in the center, and brick-red in the periphery; ventral ground color of tail white-gray to black in the distal part of the tail; ventral surfaces of fore-limbs brick-red; ventral surfaces of hind-limbs white-gray.

**Color variation.** In life, adult females (NNU P 2004.021-040) differed in coloration from the holotype in the following four aspects: lateral ground color of head, neck, trunk and tail green with weak white-gray mottling; ventral ground color of trunk and head black in the center, and white-gray in the periphery; ventral ground color of tail totally white-gray; ventral surfaces of fore-limbs white-gray.

**Female reproduction.** Adult females ( $N = 14$ , 65.2–78.9 mm SVL) gave birth between late July and early August. Postpartum body mass varied from 8.3–15.2 (mean = 11.1) g, litter size from 1–4 (mean = 2.1) young, neonate mass from 0.8–1.3 (mean = 1.1) g, and litter mass (litter size × neonate mass) from 1.0–4.1 (mean = 2.2) g.

**Natural history.** At the locality where specimens of *P. guinanensis* **sp. nov.** were collected, individuals were abundant in sand dunes with very sparse vegetation consisting of *Elymus* grasses and man-planted saplings (Genera *Salix* and *Populus*). No other known *Phrynocephalus* lizards in Qinghai resemble *P. guinanensis* **sp. nov.** in habitat use. As in numerous other toad-headed lizards, burrows are used to escape predators, or to avoid extreme thermal conditions in *P. guinanensis* **sp. nov.**

## Discussion

Of the eighteen currently known species of Chinese toad-headed lizards, fourteen (*P. albolineatus* Zhao, *P. axillaris* Blanford, *P. erythrurus*, *P. forsythii*, *P. frontalis* Strauch, *P. grumgrzimai* Bedriaga, *P. guttatus* (Gmelin), *P. helioscopus* (Pallas), *P. immaculatus* Zhao, *P. koslowi* Bedriaga, *P. mystaceus* (Pallas), *P. przewalskii* Strauch, *P. theobaldi* and *P. vericolor*) have no more than four internasal scales (Zhao 1997b, 1999). *Phrynocephalus guinanensis* **sp. nov.** differs from these species in that it has 5–8 internasal scales (Table 1), and can be therefore easily distinguished from them. Moreover, except for *P. mystaceus* (up to 89 mm SVL; Zhao 1999), these species are smaller than *P. guinanensis* **sp. nov.** The remaining four named

species of Chinese toad-headed lizards (*P. nasatus* Golubev & Dunayev, *P. putjatae*, *P. vlangalii* and *P. zetangensis*) all have a minimum of four internasal scales (Zhao 1997b, 1999), but they differ from *P. guinanensis* **sp. nov.** in measurements, scutellation, coloration and/or reproductive mode (Wang *et al.* 1996, 1999, 2002; Zhao 1999). For example, both *P. nasatus* and *P. zetangensis* are small-sized lizards (< 60 mm SVL), with the former being an oviparous species (Wang *et al.* 1996; Zhao 1999). Dorsal scales (128–164) outnumber ventral scales (101–131) in *P. guinanensis* **sp. nov.** (Table 1). On the contrary, ventral scales (82–90) outnumber dorsal scales (79–84) in *P. zetangensis* (Wang *et al.* 1996).

The type territory of the new species is situated within the area where *P. putjatae*, *P. reldae* Bedriaga and *P. vlangalii* were described. The former two were described by Bedriaga in 1909 based on specimens from two neighboring counties, Guide (*P. putjatae*) and Gonghe (*P. reldae*) both of which are very near Guinan (Zhao 1997b). *Phrynocephalus reldae* is widely believed to be a synonym of *P. vlangalii* (Pope 1935; Huang 1988). *Phrynocephalus putjatae* was recently reported to be a valid species primarily because it lacks heteromorphic sex chromosomes that can be seen in *P. vlangalii* (Wang *et al.* 2002). It worth noting, however, that *P. putjatae* is morphologically much more similar to *P. vlangalii* (Wang *et al.* 2002; Jin & Liu 2008) than to *P. guinanensis* **sp. nov.**

Morphological comparisons show considerable differences between *P. guinanensis* **sp. nov.** and the closely related *P. vlangalii*, including the pattern of sexual dimorphism in body size. Although reproductive mode (viviparity) and means for neonate mass (~1.1 g for both species) do not differ between the new species and *P. vlangalii* (Zhang *et al.* 2005), fecundity (mean of 2.1 versus 3.6 young) and reproductive output (mean of 2.2 versus 3.7 g) are both smaller in *P. guinanensis* **sp. nov.** than in *P. vlangalii* (Zhang *et al.* 2005). *Phrynocephalus guinanensis* **sp. nov.** typically uses desert habitats, whereas *P. vlangalii* uses a variety of arid and semi-arid habitats at elevations ranging from 2200–4600 mm (Jin *et al.* 2006). These differences suggest that *P. guinanensis* **sp. nov.** should be regarded as a species distinct from *P. vlangalii*, and named as new. With the description of *P. guinanensis* **sp. nov.**, the genus *Phrynocephalus* includes nineteen species from China.

*Phrynocephalus guinanensis* **sp. nov.** is currently known only from Guinan, Qinghai, Northwest China. No other species of *Phrynocephalus* in Qinghai has been known to use the same habitats as *P. guinanensis*. Given the high endemism of the viviparous Chinese toad-headed lizards (Zhao 1999; Pang *et al.* 2003), endemism of *P. guinanensis* is not unexpected. Geographically more intensive sampling of the lizard is warranted to better understand its distributional range.

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