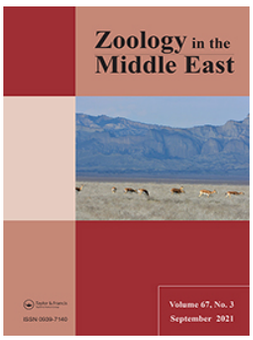

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Distribution and morphological characters of *Laudakia nuristanica* (Anderson & Leviton, 1969) from Afghanistan

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Laudakia nuristanica is one of the least-studied agamid lizards distributed in Afghanistan and Pakistan. Only 17 specimens are currently known in five museum collections from two neighbouring provinces of Afghanistan (Nuristan and Kunar) and the Chitral Valley in Pakistan. Our recent collection of agamid lizards from Afghanistan brings additional data to the species distribution. We recorded the species in north-eastern Afghanistan, particularly in the provinces of Panjshir, Parwan, and Takhar. Morphological characters presented provide additional information to the original species description.

Keywords: Central Asia; endemic species; range extension; Pakistan

Introduction

Afghanistan has an extraordinary diversity in the family Agamidae with 26 taxa which makes this country one of the main centres for agamid lizards in Central Asia (Wagner et al., 2016; Showler, 2018; Jablonski et al., 2019). Certain species of this family such as *Laudakia caucasia* (Eichwald, 1831) or *Trapelus agilis* (Olivier, 1804) are common in Afghanistan and known from many localities, while some species such as *Laudakia tuberculata* (Gray, 1827) and *L. nuristanica* (Anderson & Leviton, 1969) are known from a few localities only.

Laudakia nuristanica was described based on two specimens including an adult male (FMNH [Field Museum of Natural History, USA] 161136; Figure S1) and a female (CAS [California Academy of Sciences, USA] 115939; Figure S2), both from Kamdesh (type locality), Nuristan Province, eastern Afghanistan (Anderson & Leviton, 1969). This species was characterised by having a high number of scales around the body (more than 200) and tail, indistinct tail segmentation, and a unique pattern of scattered, enlarged conical, spinose scales over the limbs and body (Anderson & Leviton, 1969; Baig et al., 2012). It has dark grey or brown colouration with brown or silver throat with yellow or white ocelli concentrated near the tip. The underparts are pale yellow. Morphologically, this species is very close to *L. dayana* (Stoliczka, 1871) and *L. tuberculata* (Baig et al., 2012). The species is named for the type locality in Nuristan Province in eastern Afghanistan. Probably due to complicated access for herpetofaunal research in Afghanistan, only three localities and ten voucher specimens of *L. nuristanica* are currently known for the country. Thus, the species is known only from the eastern parts of the Hindu Kush mountain range (Leviton & Anderson, 1970; Baig, 1988;

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Baig et al., 2012) and it is among the least studied species of agamid reptiles in Central Asia. Based on the present study, we expand the distribution range of the species and supplemented it by morphological data from several localities of north-eastern Afghanistan.

Material and Methods

Fieldwork focused on the genus *Laudakia* in Afghanistan was conducted during the summer and early autumn of 2018 in three provinces of Afghanistan: Panjshir, Parwan and Takhar. Nine specimens were caught by hand, euthanized, photographed, and fixed in 10% formaldehyde. Specimens are currently deposited in the collections of the Pakistan Museum of Natural History (PMNH) in Islamabad and the University of Chitral (UOCH) in Chitral, Pakistan under voucher numbers PMNH 4346-47, 4349-53, and UOCH1, 2 (Figures 1, 2). Newly obtained specimens were compared with all available voucher specimens of the species from Afghanistan, deposited in museum collections of the Zoological Research Museum Alexander Koenig, Bonn, Germany (ZFMK; n=8); Field Museum of Natural History, Chicago, USA (FMNH; n=1), and the California Academy of Sciences (CAS; n=1), San Francisco, USA that were newly photographed (see Supplementary Figures S1–11). A specimen from Pakistan deposited in PMNH (Baig, 1988; PMNH 160) was also included with morphological data (Table S1).

Terminology of morphological characters mostly follows Baig (1999) and Baig et al. (2012). The following measurements and scale counts were taken: SVL = snout-vent length, TL = tail length, HL = head length from the tip of snout to angle of the jaw, HW = head width at the widest position, HH = Head height, HLL = hindlimb length from insertion to toe base, FLL = forelimb length from insertion to heel base, EyD = eye diameter, TD = tympanum diameter, SAB = number of scales around the midbody, MVR = number of midventral scale rows from shoulder to before the cloacal opening, PS = pericaudal scales, number of scales around the 9th and 10th caudal annuli, NEMD = number of enlarged middorsal scales, SL = number of supralabials on left /right sides, IL = number of infralabials on left/right sides, SDLF 3rd = number of subdigital lamellae beneath the third finger, SDLF 4th = number of subdigital lamellae beneath the fourth toe, HLT = hindlimb length from insertion to the tip of the longest toe, FLT = forelimb length from insertion to tip of the longest finger. All examined metric characters were taken to the nearest 0.1 mm by digital vernier caliper. Description of colouration in life is based on photos (Figures 1–3, S1–10) and field notes. The distribution map was prepared with QGIS 2.18.15 Development Team (2020 (http://qgis.osgeo.org).

Results

Literature and museum collection records. Kamdesh (the type locality of the species), Nuristan Province (35.409°N, 71.338°E; 1,342 m) with specimens vouchered as FMNH 161136 (holotype; Figure S1) and CAS 115939 (paratype; Figure S2) collected on 13 and 17.x.1965, respectively; Lindai-Sin Valley, Kunar Province (34.852°N, 71.103°E, 2200 m) represented by specimens ZFMK-H 8624-25 (Figures S10–S11) collected by C. M. Naumann in 1964, and no specified locality in Nuristan Province (35.016°N, 70.394°E, sensu Wagner et al. 2016) with specimens ZFMK-H 8618–23 (Figures S3-S9) collected by C. M. Naumann in 1965. Leviton and Anderson (1970: 178) also mentioned Smith's record (1935: 214–216) of *L. tuberculata* from Kabul that may refer to *L. nuristanica* (not mapped here). A published record of the species is also known from Pakistan (PMNH 160, Ziarat, Chitral district; Baig 1988) and six other vouchered specimens are stored in the collection of the University of Florida collected in the Chitral region of Pakistan (UF 82732–33, 82936–38, 88021 – not examined in this study).

New records (Figures 1–3): Dan-e-Doshakh near Tawakh, Anabah district, Panjshir Province (35.2327°N, 69.3680°E, 1774 m), ad. ♀, 10.x.2018 (PMNH 4347); Pull-e-Pajan, Salang Pass, Jabal o Siraj district, Parwan Province (35.2327°N, 69.2087°E,

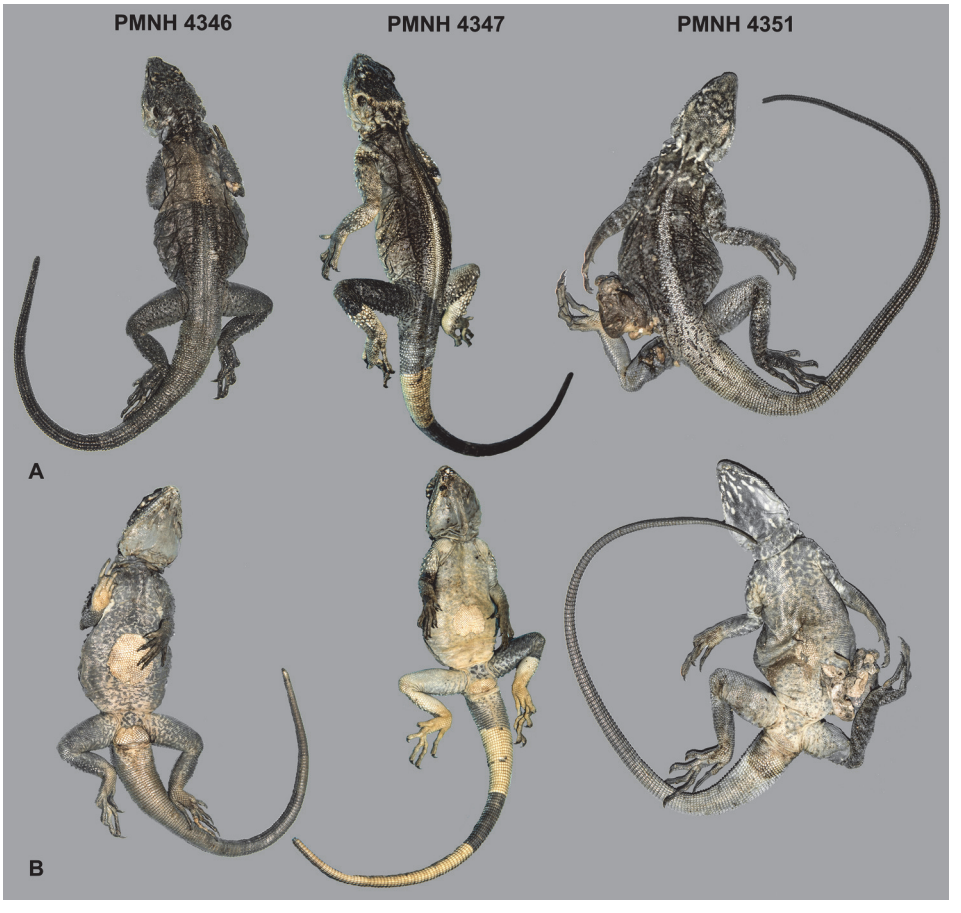

Figure 1. Adult specimens of *Laudakia nuristanica* from Parwan (PMNH 4346), Panjshir (PMNH 4347) and Takhar (PMNH 4351) provinces.

2,036 m), ad. ♀, 13.x.2018 (PMNH 4346); Sayyad, Bagram district, Parwan Province (34.9995°N, 69.3305°E, 1,478 m), ad. ♀, 14.viii.2018 (PMNH 4353, see also Jablonski et al., 2021); Shingan, Farkhar district, Takhar Province (36.6266°N, 69.8131°E, 1100 m), ad. (PMNH 4351) and subad. ♀ (PMNH 4349), 22.x.2018; Farkhar, Takhar Province (36.5773°N, 69.8675°E, 1,205 m), ad. ♂, 22.viii.2018 (PMNH 4352); Khaf Darreh, Farkhar district, Takhar Province (36.5238°N, 69.8943°E, 1,630 m), ad. ♂, 22.viii.2018 (PMNH 4350); Karbash Khana, Dan-e-Revat, Panjshir Province (35.4989°N, 69.8428°E, 2,350 m), 1 subad. (UOCH 0001, not photographed) and 1 ad. (UOCH 0002, not photographed), 9.x.2018.

Habitat and ecology. This species is known from montane areas with conifer and evergreen oak woodlands along watercourse**s** up to 2,200 m a.s.l. (Hassinger, 1968; Anderson & Leviton, 1969; Ananjeva & Tuniev, 1994; Baig et al., 2012; Wagner et al., 2016). We found the species in rocky habitats with low shrubs but without broader vegetation of oaks and conifer plants. The localities in the Farkhar district of Takhar province were situated in the hilly area of the Khanabad River Valley. The lizards were active during the day time and observed during basking on rocks between 10 am and 5 pm.

Table 1. Morphometric data of newly obtained specimens (N=17) of *Laudakia nuristanica* from Afghanistan as compared with the type specimens. All measurements in mm. Data on FMNH 161136 (holotype) and CAS 115939 (paratype) from Anderson & Leviton (1969). Abbreviations explained under "Material and Methods".

	Holotype	**Paratype**	**Range, min./max., mean, STD**
Sex	male	female	males and females
Age	adult	subadult	adults and subadults
SVL	131.0	93.0	92.0–152.0 (120.6±17.1)
TL	245.0	183.0	126.0–252.0 (215.4±32.5)
TL/SVL	1.87	1.97	1.22–2.11
HL	37.0	26.0	25.0–44.0 (32.73±5.7)
HW	-	-	17.0–36.0 (24.71±5.2)
HL/HW	-	-	1.22–1.64
HH	-	-	9.5–17.5 (13.17±2.6)
HLL	-	-	47.5–113.0 (76.03±21.7)
FLL	-	-	30.2–72.0 (50.22±14.7)
EyD	-	-	5.5–7.7 (6.53±0.7)
TD	-	-	3.4–6.2 (4.78±0.8)
SAB	-	-	212–270 (237±19.0)
MVR	-	-	118–135 (126.94±4.9)
PS	45	45	39–52 (44.0±3.9)
NEMD	-	-	8–11 (9.39±1.1)
SL	13	13	10–13/10–13 (11.33–11.50±0.8)
IL	11/12	11/12	10–13/10–13 (11.17–11.50±0.8-1.0)
SDLF 3rd	-	-	25–29 (26.86±1.3)
SDLT 4th	-	-	33–36 (34.86±1.1)
HLT	110.0	74.0	76.8–116.0 (92.7±14.0)
FLT	-	-	50.5–77.0 (62.0±9.3)

Morphology (Figures 1–2, S1–S11, Tables 1 & S1): Morphological data from nine freshly collected specimens of *L. nuristanica* and eight specimens from ZFMK collection were compared these with the two specimens from the type collection (CAS, FMNH). These data showed that the newly obtained specimens fit with the morphological data mentioned for the description of the species. A new maximum body size for the Afghan populations (SVL=152.0 mm) was taken from the specimens PMNH 4347. The following morphological characters are noticeable from the new material (see also Table S1, count in parentheses refers to the data of this species in Baig [1992] and Baig et al. [2012]): head, body and base of tail depressed; tail oval in cross-section, longer than snout-vent length; each tail segment consists of four whorls, segmentation barely distinct towards the proximal portion of tail; upper head scales heterogeneous, subequal, rugose to bluntly keeled, largest on snout; groups of enlarged spinose scales present on the neck and sides of head, especially around the tympanum; 10–13 SL (11–13; 12±0.8) and 10–13 IL (10–12; 11±1.0); 212–270 SAB (216–274; 242±15.8), 39–52 PS (43–48; 46±2); 8–11 (7–9) NEMD, not arranged in regular rows and somewhat heterogeneous in size, a few about twice as large as largest ventral scales; dorsal body, flanks and limbs with scattered, enlarged, conical and spinose scales among small granular scales: flanks without a patch of enlarged mucronate scales; ventral scales smooth, smaller than enlarged vertebral and flank scales but larger than gular and other small dorsal scales; limbs with unique scalation, covered above with strongly heterogeneous scales, numerous greatly enlarged scales among much smaller ones, the smaller almost granular; large

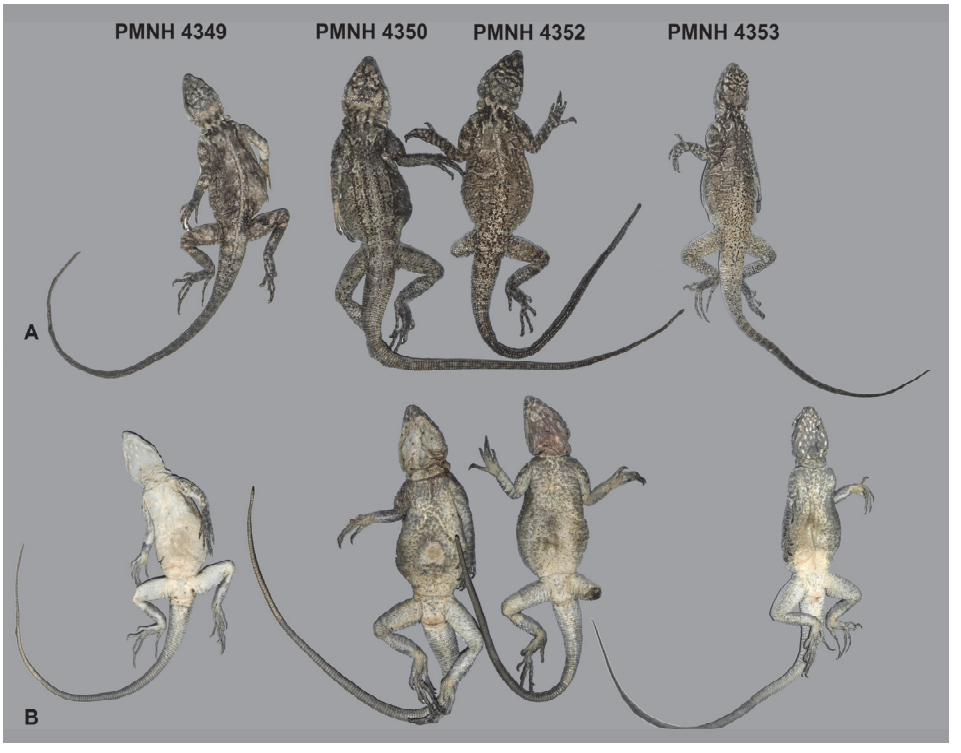

Figure 2. Adult and subadult specimens of *Laudakia nuristanica* from Parwan (PMNH 4353) and Takhar (PMNH 4349, 4350, 4352) Provinces.

scales neither grouped in patches nor imbricate, but strongly spinose; skin of neck and lateral sides loose forming gular and dorsolateral folds, respectively; callous glands present in males only, about six to seven rows in the precloacal area and a large patch at the mid-abdominal position. Additional characters of *L. nuristanica* are as follows: Apart from the TL/SVL ratio of 1.22 in PMNH 160, the range of this character is 1.50-2.11 in all other examined specimens. The HL/HW ratio varies in the range between 1.22–1.64. The MVR from behind the collar region to vent (excluding the gulars) ranges from 118–135.

The adult colour patterns conform to the original species description (Anderson & Leviton, 1969) and are displayed in Figures 1–2 and S1–S3, S5–S8, S10–S11. The colour of the subadult specimens resembles that of adults (Figures 2 and S9).

Discussion

We here present new data on the rare agamid species from completely understudied areas of Central Asia. *Laudakia nuristanica* is very similar to *L. tuberculata* but distinguished from this and other species by having the highest number of SDLF 3rd (25-32; 28±2.2) and SDLT 4th (32-39; 35.9±2.8), SAB (216-274; 242±15.8) and PS (43-48; 46±2.0) (Baig, 1992; Baig et al. 2012). We found no variations in our specimens from those reported earlier (Anderson & Leviton (1969). Except for minor variations in PS, all the present data were in the range of already known data (Table 1 & S1).

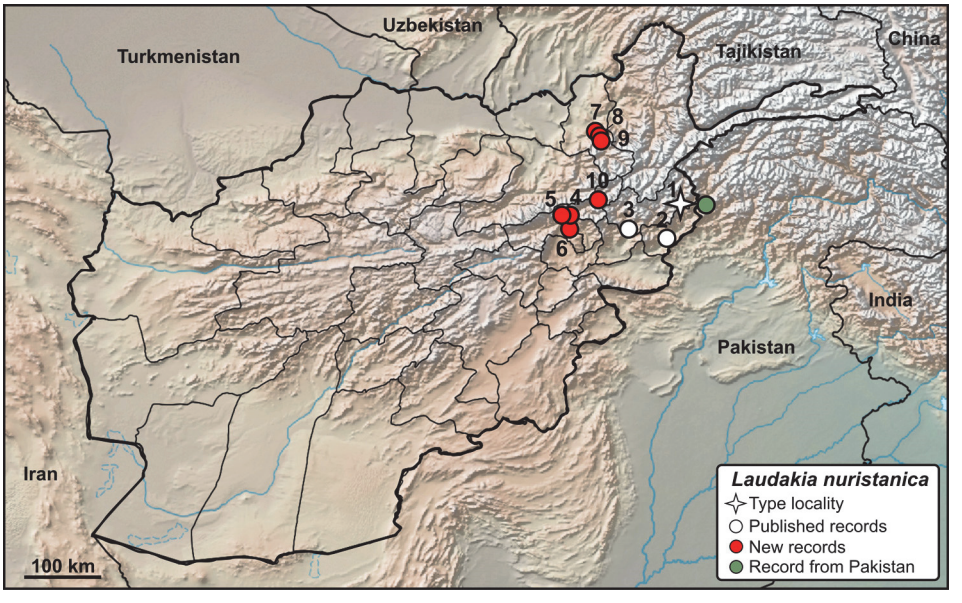

Figure 3. Distribution of *Laudakia nuristanica* in Afghanistan. 1- Kamdesh (type locality, white star), Nuristan Province (FMNH 161136, CAS 115939); 2- Lindai-Sin Valley, Kunar Province (ZFMK-H 8624-25); 3- Nuristan, Nuristan Province (ZFMK-H 8618-23); 4- Dan-e-Doshakh near Tawakh, Panjshir Province (PMNH 4347); 5- Pull-e-Pajan, Salang Pass, Parwan Province (PMNH 4346); 6- Sayyad, Bagram, Parwan Province (PMNH 4353); 7- Shingan, Farkhar, Takhar Province (PMNH 4351); 8- Farkhar, Takhar Province (PMNH 4352); 9- Khaf Darreh, Takhar Province (PMNH 4350); 10- Karbash Khana, Panjshir Province (UOCH 0001-2). The record from Pakistan (green) follows Baig (1988).

The distribution range of *L. nuristanica* is much larger than was reported earlier (Leviton & Anderson, 1970; Baig et al., 2012; Wagner et al., 2016). The range of the species reaches several other provinces, i.e. Panjshir, Parwan, and Takhar. Especially, the distribution in Takhar suggests probably continuous distribution to the northern parts of the country across the valleys of Hindu Kush. It also suggests that this species is now known from five provinces of Afghanistan with further records to be expected for Kabul, Kapisa, or Badakhshan provinces. The recorded elevation (2,350 m) from the locality Karbash Khana, Dan-e-Revat, Panjshir Province represents the highest known locality for this species. Simultaneously, the species is probably not distributed below 1,000 m, although Khan (2006) mentioned the species' occurrence in Pakistan between 500 and 600 m of elevation. Anderson and Leviton (1969) found the species in the montane area of conifer and evergreen oak woodlands with the presence of water. Similar observations are presented for the Chitral Valley, Pakistan (Baig, 1988). On the other hand, our observations come from a wider variety of habitats which suggest that the species can inhabits different niches.

Supplementary Material

Supplementary Figures (S1-S11) and Supplementary Table S1 are given as a Supplementary Annex, which is available via the "Supplementary" tab on the article's online page.

Acknowledgements

We cordially thank E. Ely and L. Scheinberg (both Californian Academy of Sciences, San Francisco, USA), M. Flecks (ZFMK, Bonn, Germany), J. Mata, A. Resetar (both Field Museum of Natural History, Chicago, USA) for providing voucher specimens and a photograph of *L. nuristanica* from Afghanistan, K. Adler (Cornell University, Ithaca, USA) for revising and improving the language of the article, and A. Javorčík and J. Poláková for their help in the lab.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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Supplementary Material to:

Distribution and morphology of a little-known agamid *Laudakia nuristanica* (Anderson and Leviton, 1969) from Afghanistan

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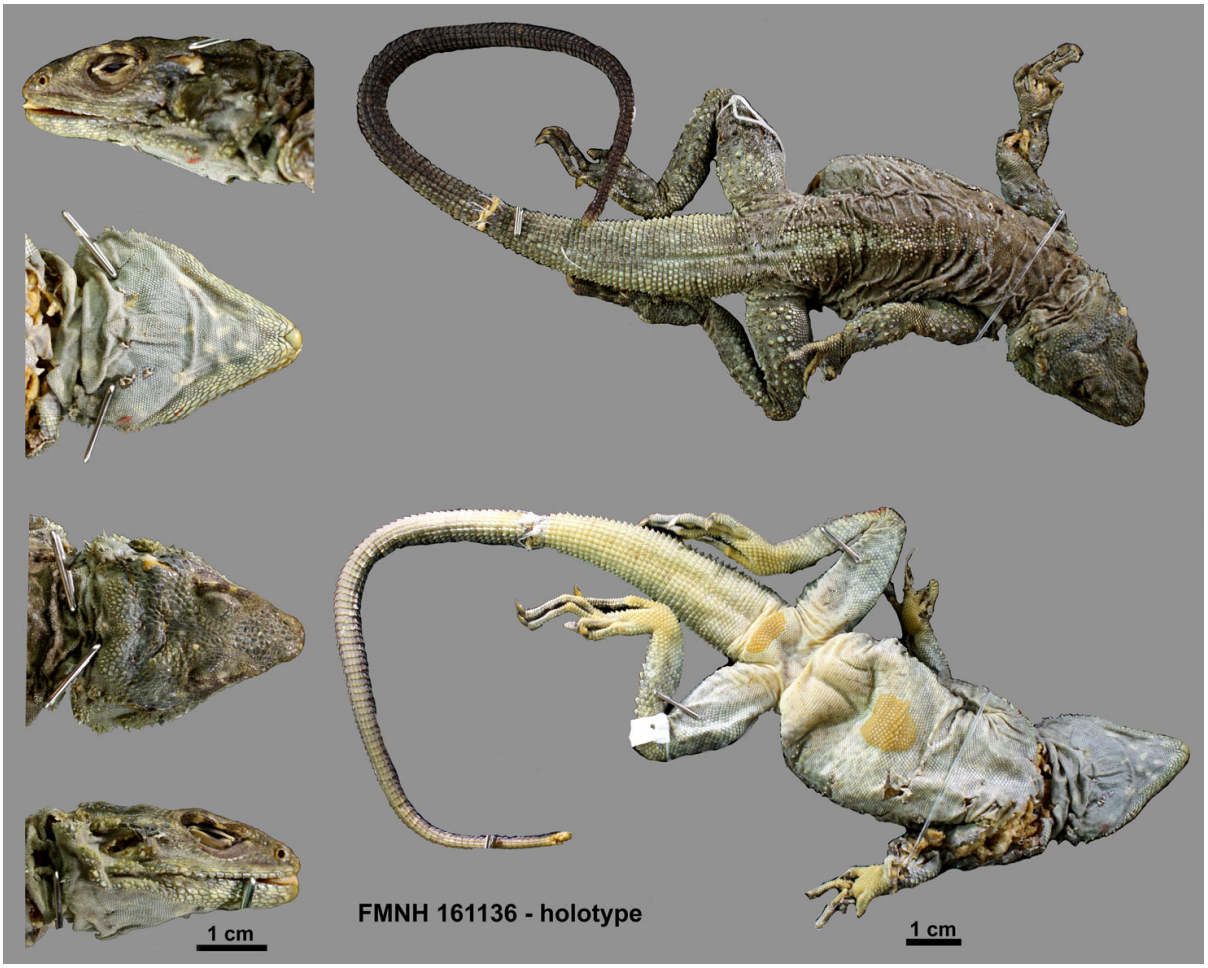
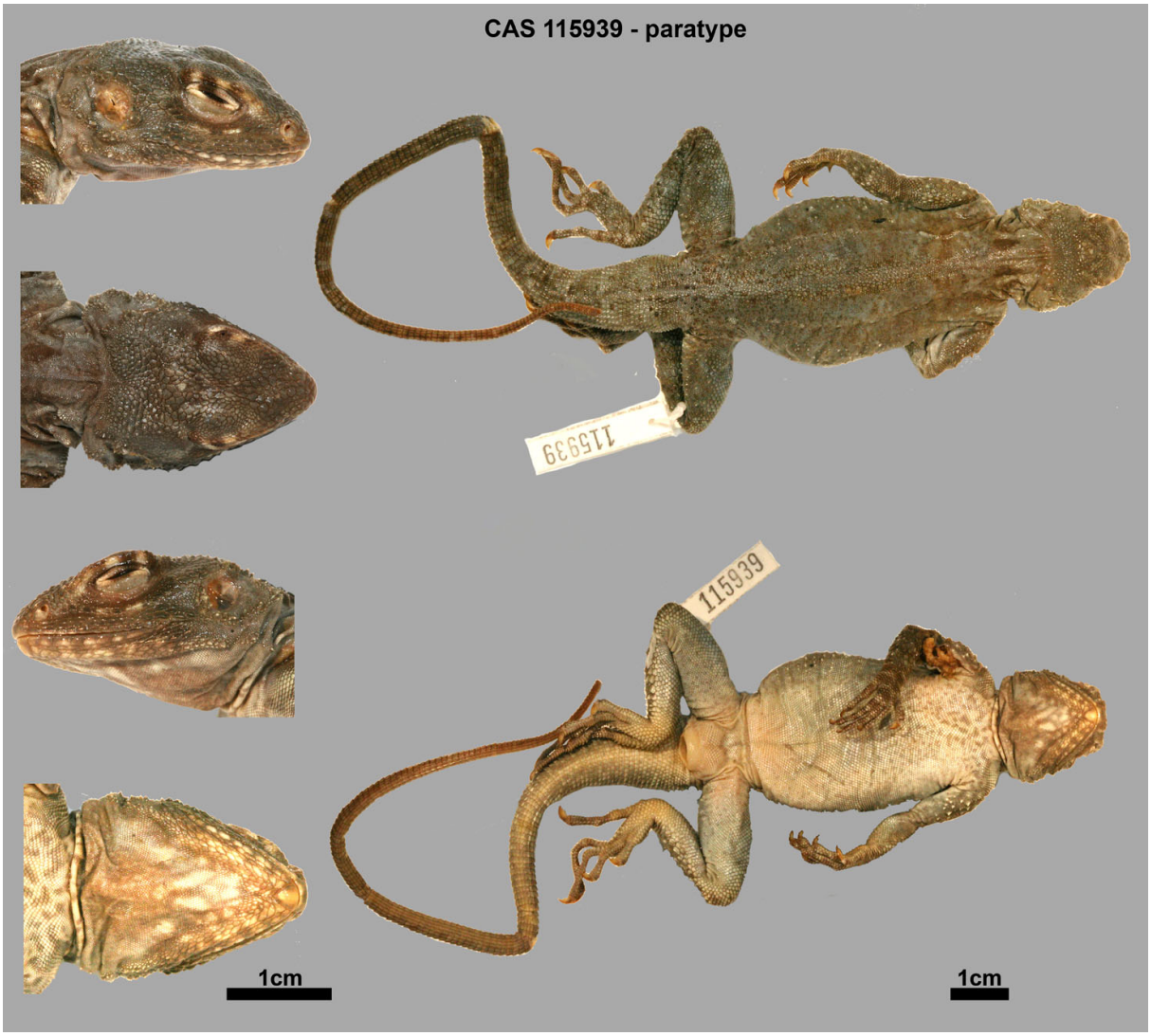
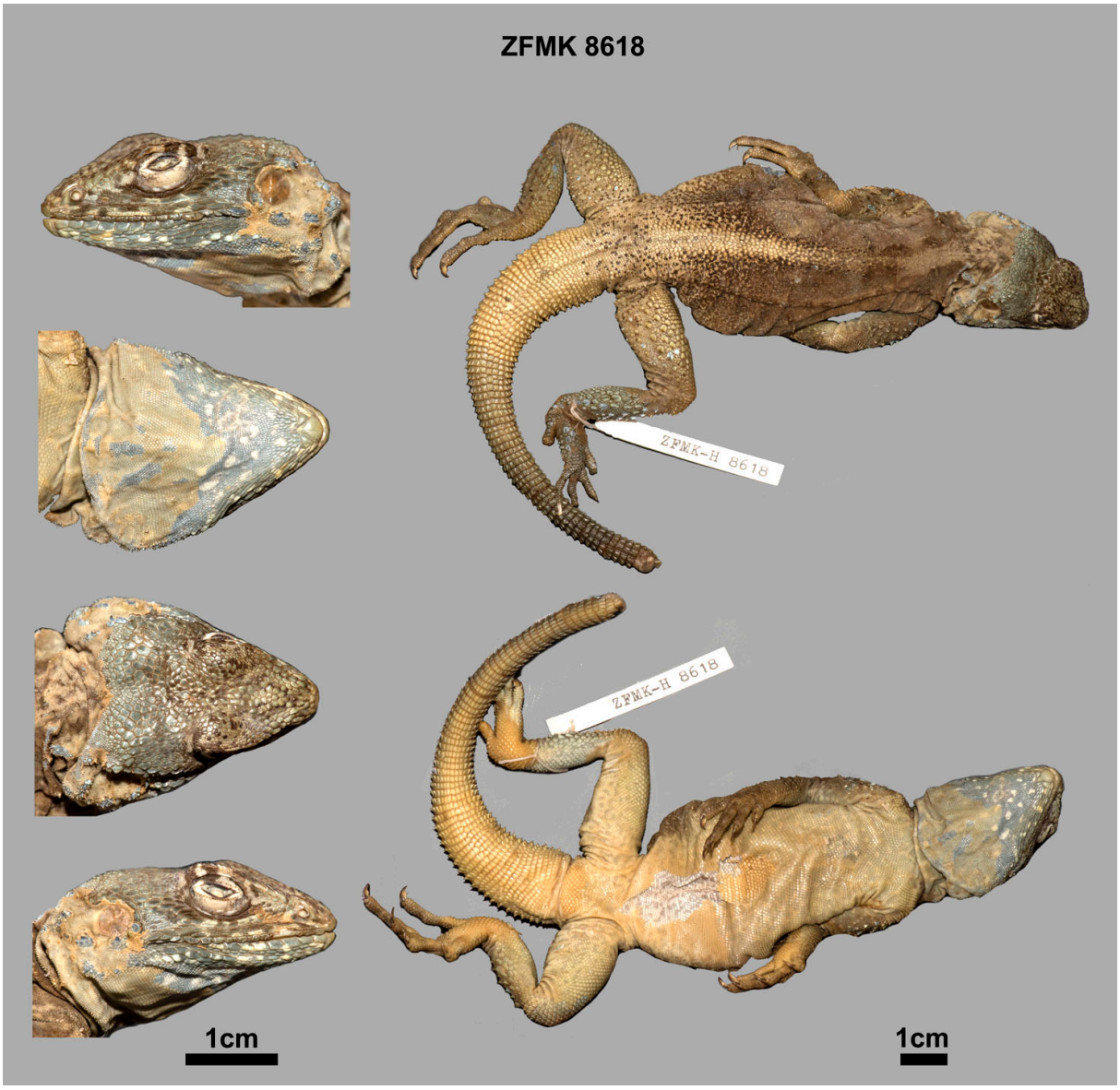


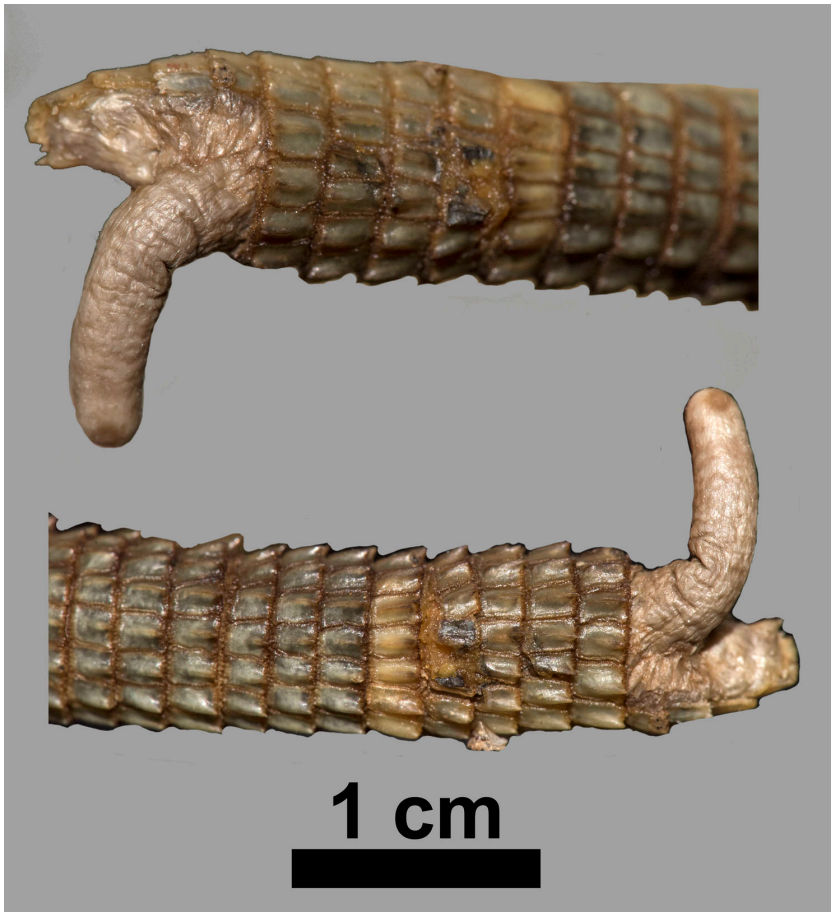
Supplementary Figure S1. Holotype of *Laudakia nuristanica* from Kamdesh, Nuristan Province.



Supplementary Figure S2. Paratype of *Laudakia nuristanica* from Kamdesh, Nuristan Province.

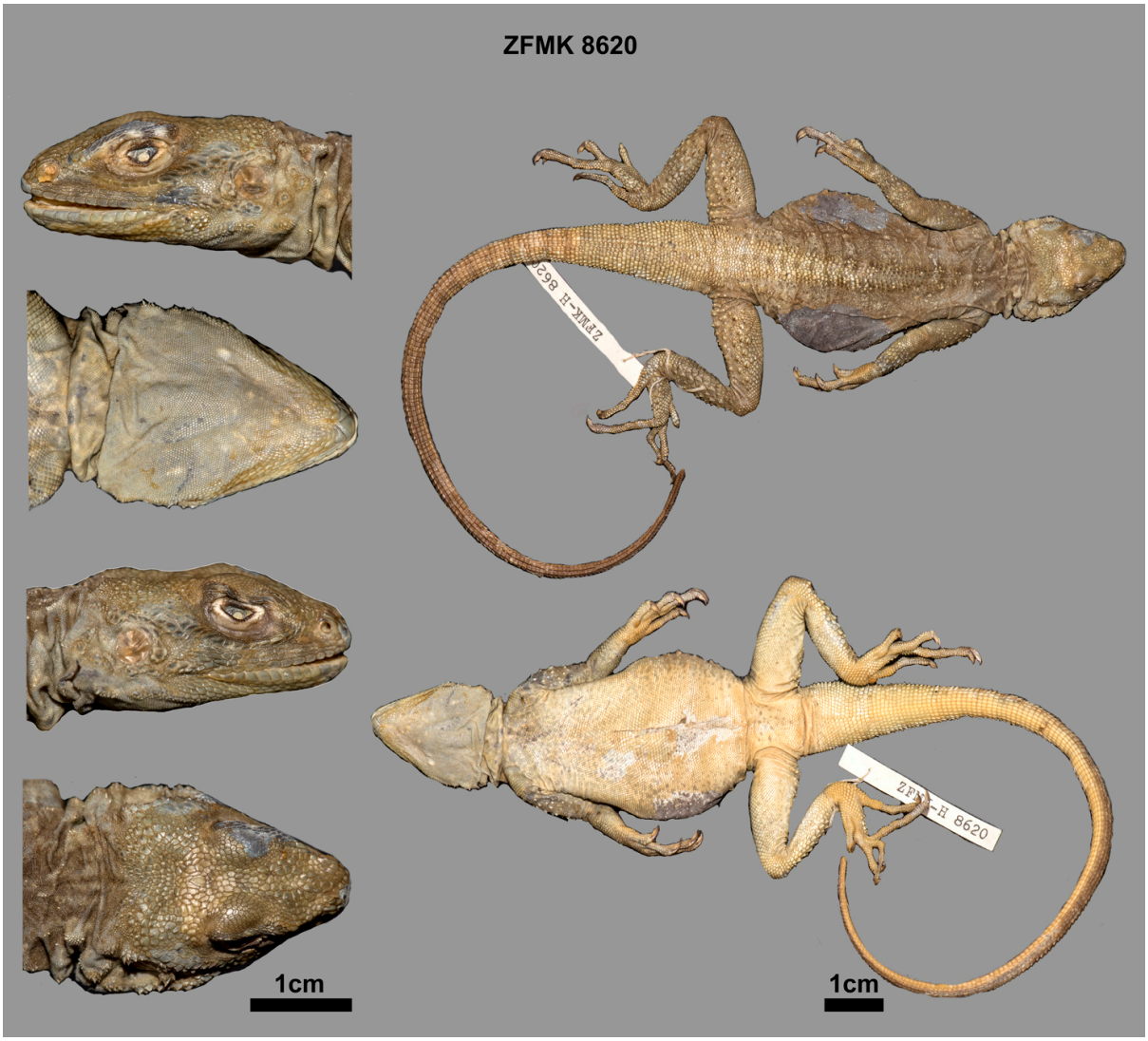


Supplementary Figure S3. *Laudakia nuristanica*, specimen ZFMK-H 8618, from an unknown locality of the Nuristan Province, Afghanistan.

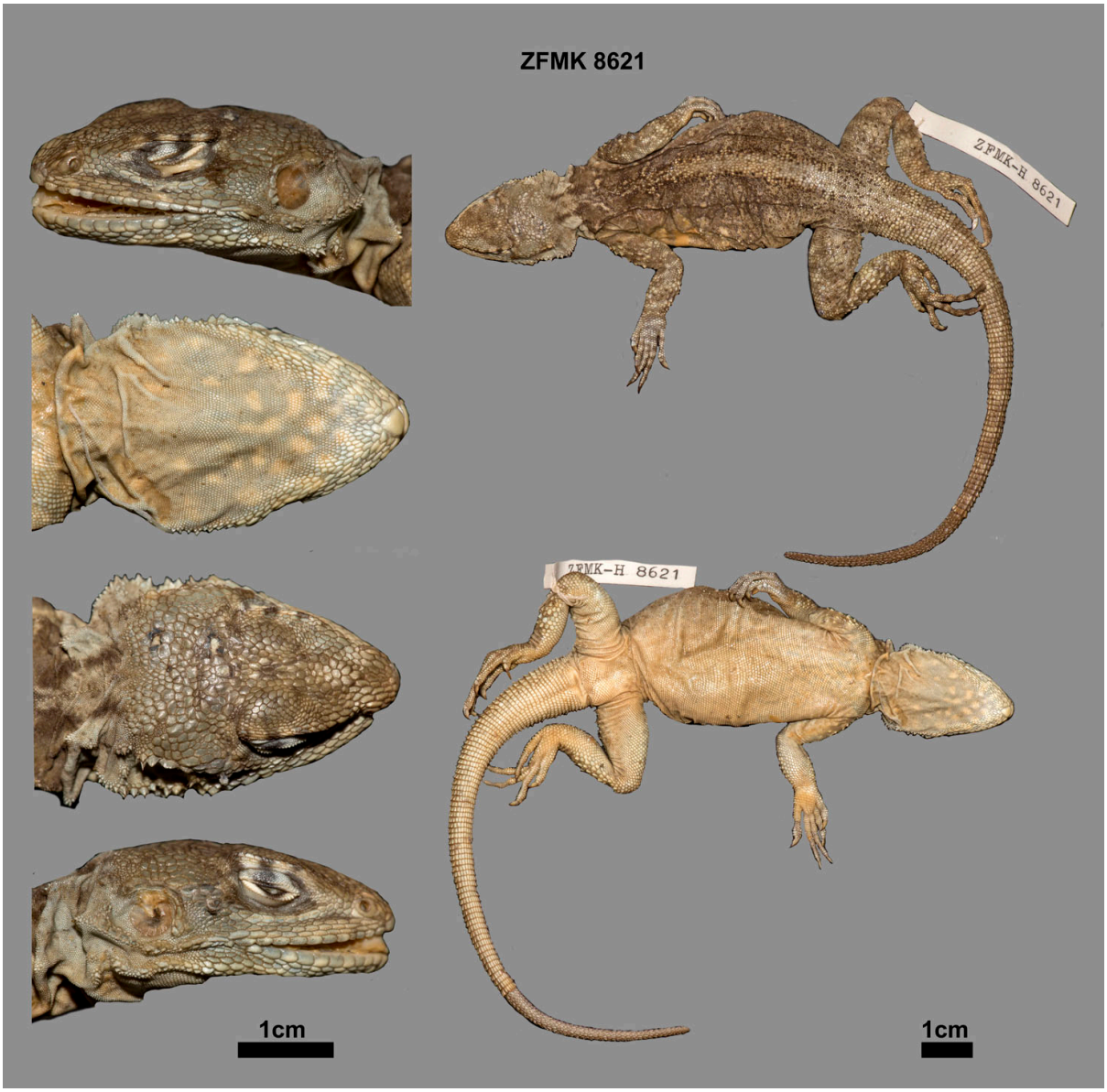


Supplementary Figure S4. The bifurcated tail of *Laudakia nuristanica* (ZFMK-H 8618) from an unknown locality of the Nuristan Province, Afghanistan.

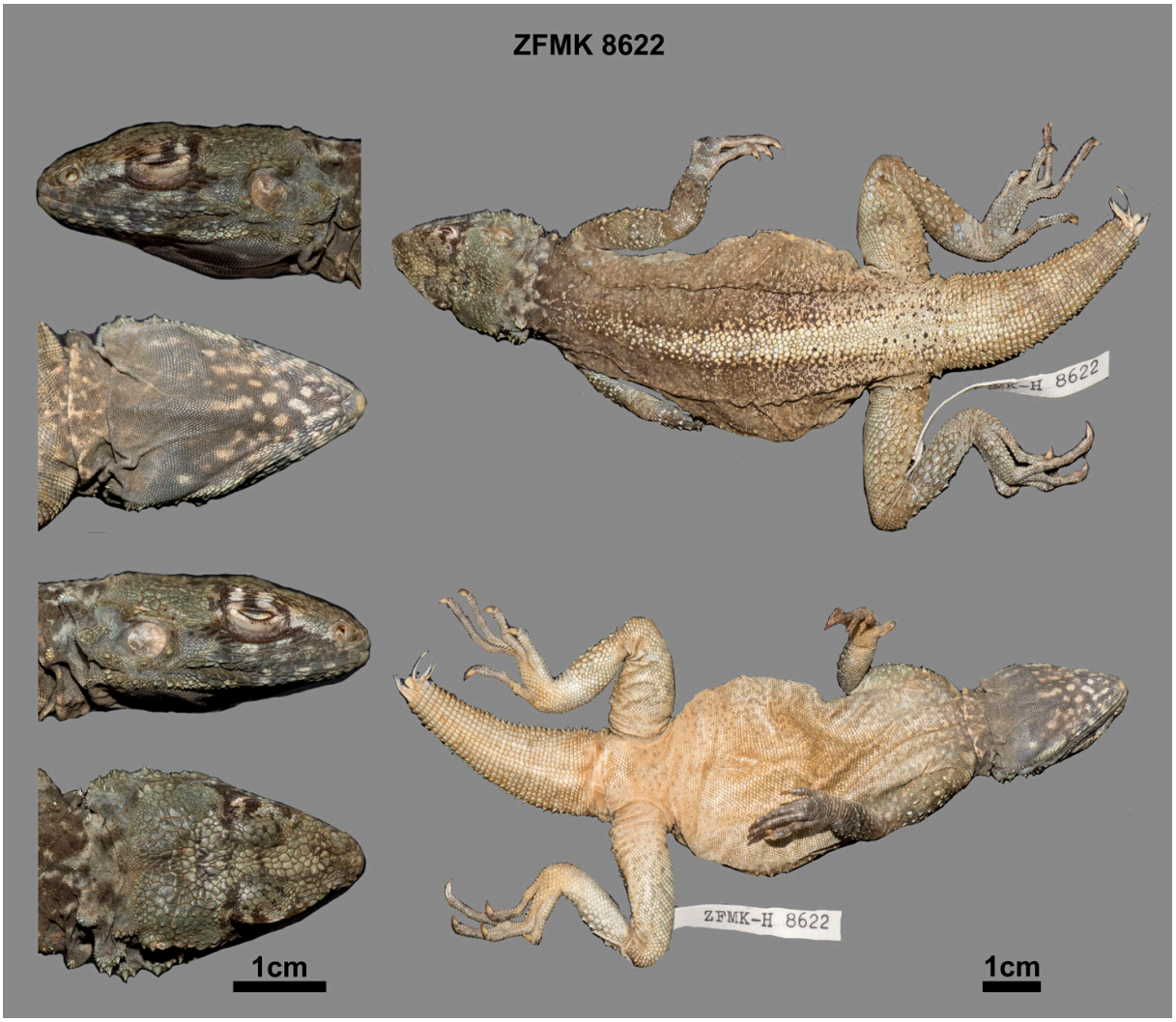
Supplementary Figure S5. *Laudakia nuristanica*, specimen ZFMK-H 8619, from an unknown locality of the Nuristan Province, Afghanistan.



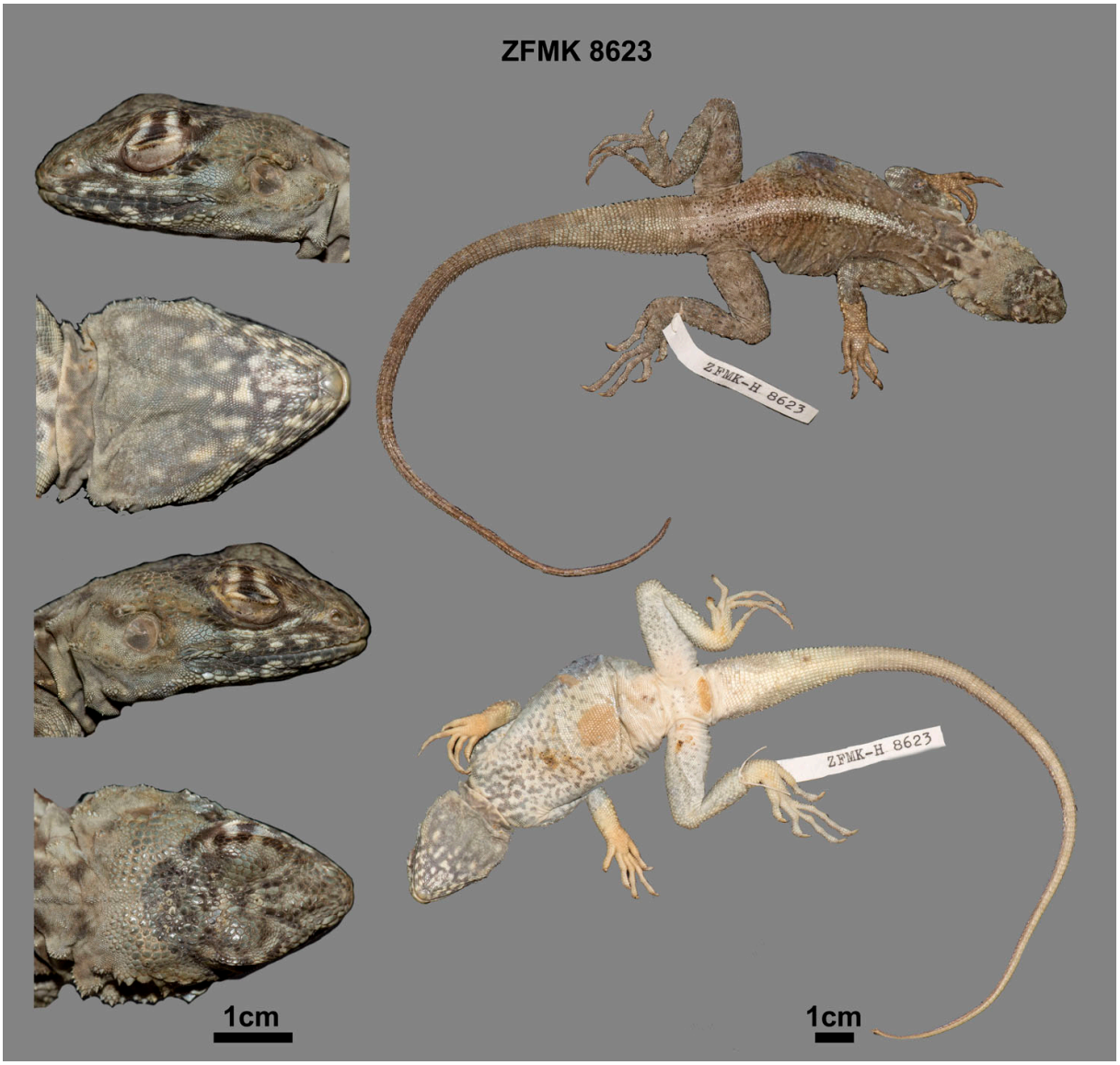
Supplementary Figure S6. *Laudakia nuristanica*, specimen ZFMK-H 8620, from an unknown locality of the Nuristan Province, Afghanistan.



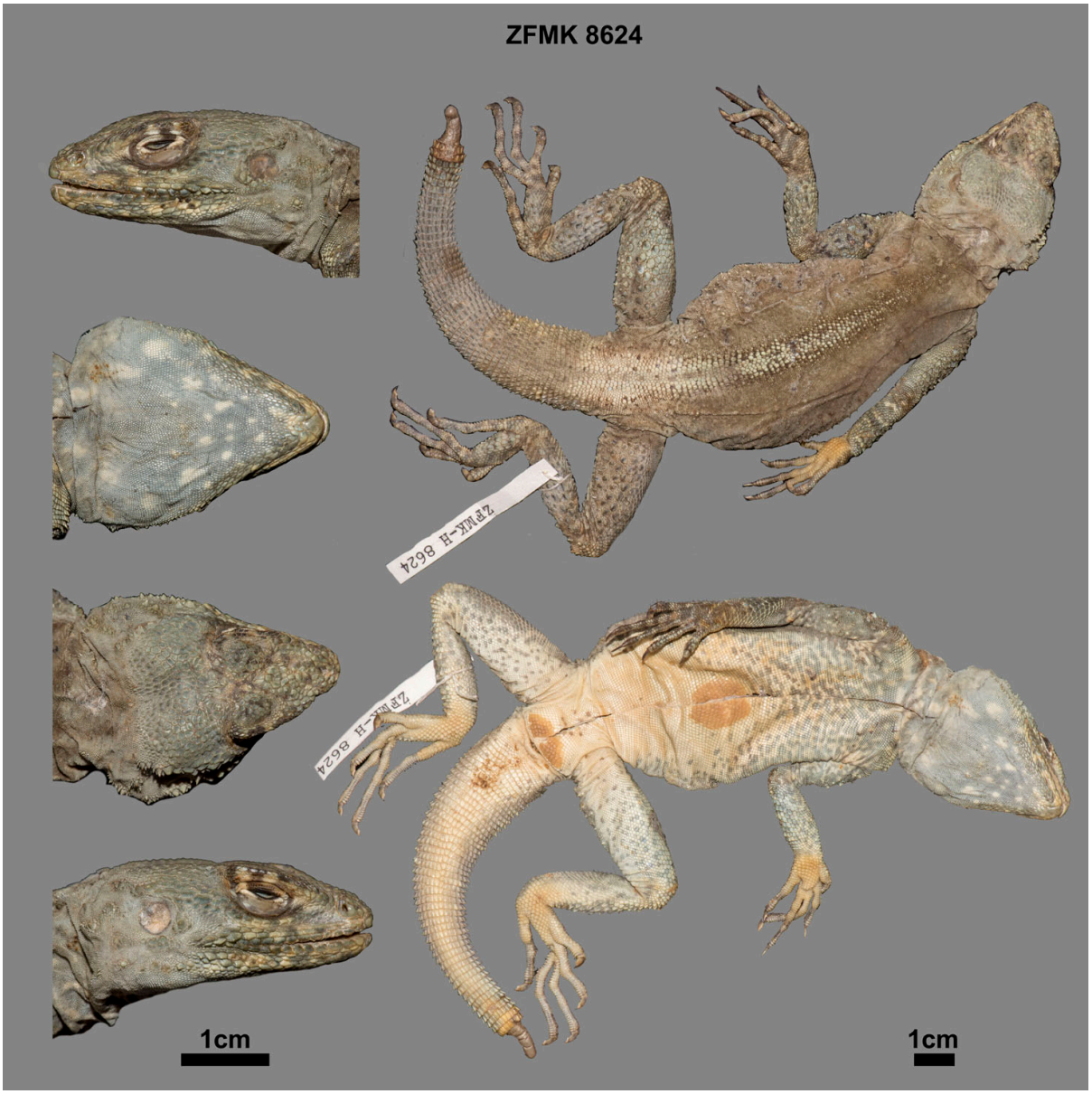
Supplementary Figure S7. *Laudakia nuristanica,* specimen ZFMK-H 8621, from an unknown locality of the Nuristan Province, Afghanistan.



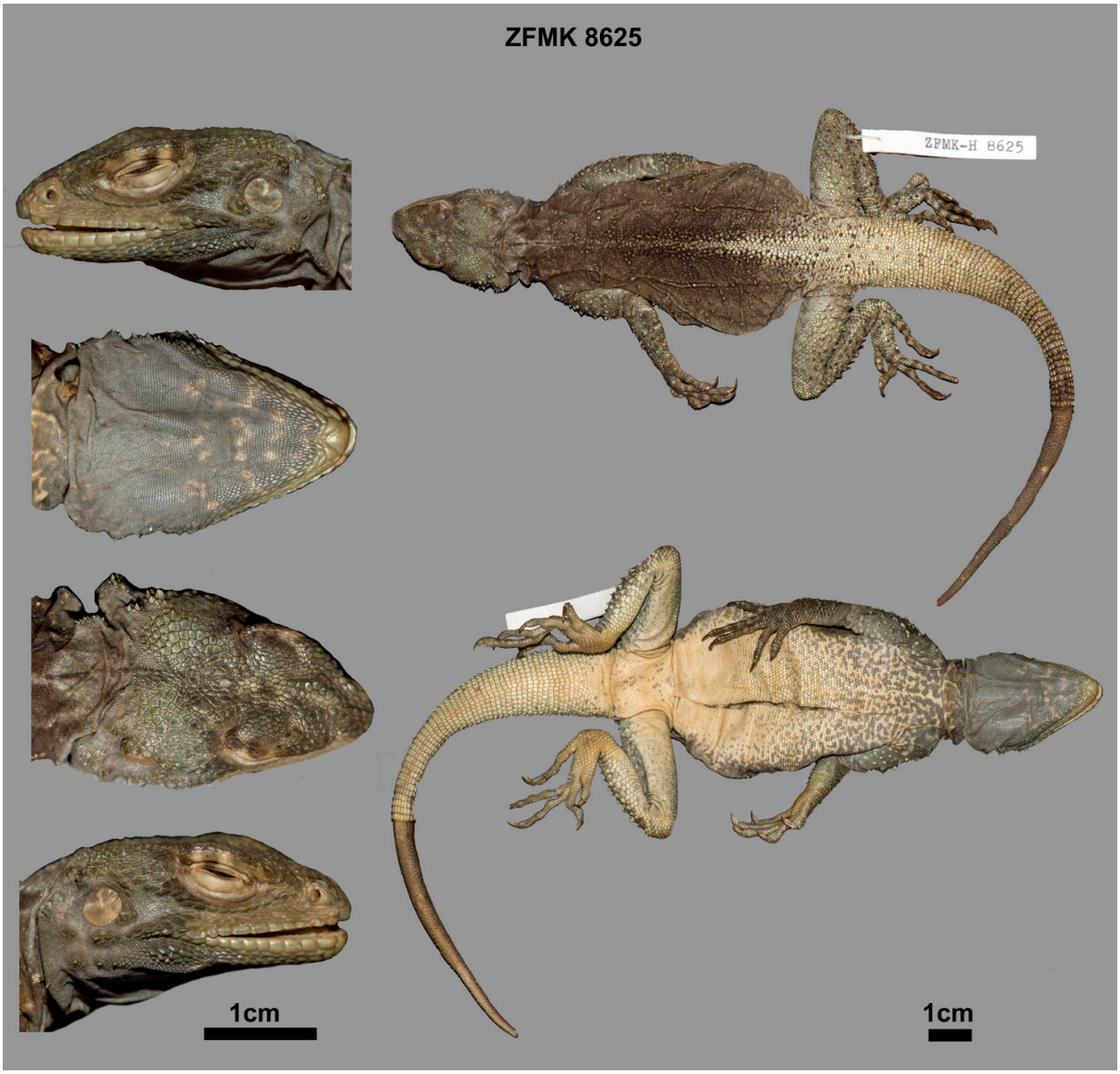
Supplementary Figure S8. *Laudakia nuristanica*, specimen ZFMK-H 8622, from an unknown locality of the Nuristan Province, Afghanistan.



Supplementary Figure S9. *Laudakia nuristanica*, specimen ZFMK-H 8623, from an unknown locality of the Nuristan Province, Afghanistan.



Supplementary Figure S10. *Laudakia nuristanica,* specimen ZFMK-H 8624, from Lindai-Sin Valley, Kunar Province, Afghanistan.



Supplementary Figure S11. *Laudakia nuristanica*, specimen ZFMK-H 8625, from Lindai-Sin Valley, Kunar Province, Afghanistan.

Table S1. Morphometric (in mm) and meristic data for the newly collected specimens of *Laudakia nuristanica* and available specimens from museum collections. For abbreviations see Material and methods. tb = tail broken. CAS = California Academy of Sciences, San Francisco, USA; FMNH = Field Museum of Natural History, Chicago, USA; PMNH = Pakistani Museum of Natural History, Islamabad, Pakistan; UOCH = University of Chitral, Chitral, Pakistan; ZFMK = Zoologisches Forschungsmuseum Alexander Koening, Bonn, Germany.

	FMNH 161136 holotype	**CAS 115939 paratype**	**PMNH 160**	**UOCH 0001**	**UOCH 0002**	**PMNH 4347**	**PMNH 4346**	**PMNH 4353**	**PMNH 4351**	**PMNH 4349**	**PMNH 4350**	**PMNH 4352**	**ZFMK-H 8618**	**ZFMK-H 8619**	**ZFMK-H 8620**	**ZFMK-H 8621**	**ZFMK-H 8622**	**ZFMK-H 8623**	**ZFMK-H 8624**	**ZFMK-H 8625**
source	Anderson & Leviton 1969	Anderson & Leviton 1969	Baig 1988 (data taken *de novo*)	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study	This study
sex	Male	Female	Female	Female	Male	Male	Male	Female	Female	Male	Male	Female	Male	Male	Female	Female	Female	Male	Male	Female
age	adult	Subad.	Subad.	Subad.	adult	adult	adult	adult	adult	adult	adult	adult	adult	adult	adult	Subad.	adult	Subad.	adult	Adult
SVL	131.0	93.0	103.0	92.0	130.0	152.0	147.5	112.5	125.8	124.5	115.0	108.0	138.0	124.0	125.0	102.0	121.0	100.0	133.0	134.0
TL	245 (tm)	183.0	126.0	114.0 (tb)	31.0 (tb)	228.0	233.0	225.0	252.0	227.0	235.0	220.0	115.0 (tb = 8.8 bifurcat-ed)	220.0	225.0	88.0 (t=43.0)	45.0 (tb=0.0)	211.0	83.0 (tb=10.5)	148.0 (tb=68.0)
TL/SVL	1.87	1.97	1.22	-	-	1.50	1.57	2.00	2.00	1.82	2.04	2.03	-	1.77	1.80	-	-	2.11	-	-
HL	37.0	26.0	29.0	28.0	44.0	36.0	36.0	25.0	29.2	30.5	27.5	25.5	40.1	37.7	33.8	28.8	31.4	29.2	41.4	38.4
HW	-	-	23.0	17.0	36.0	29.5	29.0	18.5	22.1	22.4	21.5	20.0	32.6	27.6	24.7	20.4	21.0	22.0	30.3	27.2
HL/HW	-	-	1.26	1.64	1.22	1.22	1.24	1.35	1.32	1.36	1.27	1.27	1.23	1.37	1.37	1.41	1.50	1.33	1.37	1.41
HH	-	-	10.9	12.0	11.0	17.5	17.2	10.4	11.2	11.5	9.5	10.0	16.0	14.9	13.9	13.2	12.6	12.9	16.7	15.6
HLL	-	-	51.0	71.0	80.0	75.3	67.5	50.2	54.7	56.3	50.0	47.5	98.0	102.0	103.0	71.0	88.0	87.0	113.0	103.0
FLL	-	-	31.0	68.0	48.0	47.8	44.5	30.2	36.5	36.0	32.0	32.0	71.0	65.0	61.0	51.0	60.0	56.0	72.0	62.0
EyD	-	-	5.6	5.5	6.1	7.6	7.0	6.0	6.6	6.9	5.8	5.7	7.4	7.6	6.3	5.8	6.3	6.5	7.7	7.2
TD	-	-	5.0	4.8	4.9	6.0	6.2	4.4	6.0	5.9	4.7	5.0	4.9	4.5	3.7	3.9	3.9	3.4	4.1	4.8
SAB	-	-	230	270	223	265	240	230	238	217	245	212	-	-	-	-	-	-	-	-
MVR	-	-	124	123	119	127	120	118	130	128	130	130	130	131	133	128	131	124	124	135
PS	45	45	40	50	48	44	46	48	47	52	43	45	40	40	40	39	43	39	43	45
NEMD	-	-	10	11	10	10	10	11	10	11	10	9	9	9	8	8	9	8	8	8
SL	13	13	11/11	10/11	11/11	13/12	12/11	12/12	12/13	11/11	11/11	12/11	11/11	11/12	11/13	12/12	10/11	12/12	11/12	11/10
IL	11/12	11/12	12/12	12/13	13/12	11/12	11/11	11/11	13/12	12/12	11/10	12/12	10/11	10/11	11/12	11/12	10/11	11/10	10/12	10/11
SDLF 3rd	-	-	26	-	-	27	26	26	25	27	29	28	-	-	-	-	-	-	-	-
SDLT 4th	-	-	35	-	-	35	34	34	33	36	36	36	-	-	-	-	-	-	-	-
HLT	110.0	74.0	80.0	-	-	116.0	108.8	81.7	90.2	90.0	85.4	76.8	-	-	-	-	-	-	-	-
FLT	-	-	50.5	-	-	77.0	70.2	53.3	61.9	63.0	56.5	52.5	-	-	-	-	-	-	-	-