

## Studies on African *Agama* III. Resurrection of *Agama agama turuensis* LOVERIDGE, 1932 (Squamata: Agamidae) from synonymy and elevation to species rank

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**Abstract.** New material of *Agama agama* LINNAEUS, 1758 from Mount Hanang, Tanzania is indistinguishable from the type material of *Agama agama turuensis* LOVERIDGE, 1932, a taxon which is so far considered to be a synonym of *Agama lionotus elgonis* LÖNNBERG, 1922. Our comparative morphological study demonstrates *turuensis* is most similar to *Agama mwanzae* LOVERIDGE, 1923 and *Agama kaimosae* LOVERIDGE, 1935, and distinct from both *A. agama* and *A. lionotus* BOULENGER, 1896. *Agama turuensis* can likewise neither be assigned to *A. mwanzae* nor *A. kaimosae* but has to be rather considered as a distinct species.

Key words. Squamata, Agamidae, *Agama turuensis*, new status, Africa, Tanzania, Mount Hanang, taxonomy.

### Introduction

The genus *Agama* is endemic to Africa and its species are very widespread in the savannah regions of Africa. Currently, 34 species are recognized but the genus in general, and especially the *Agama agama* species complex and the clade including the East African are in need of a thorough taxonomic revision.

Nearly all taxa of the genus express sexual dimorphism in colouration. Displaying males show a contrasting colouration pattern, which consists of vividly coloured red or orange heads, which contrast with the always different colours of their bodies and tails. Contrary, females retain a predominantly uniform brown juvenile colouration, which is often covered by yellow spots and blotches. Most of the taxa are living in social colonies with one dominant male and several females and juveniles. Only some cryptic species like e.g. *Agama hispida* and most probably *Agama lionotus dodomae* live in pairs.

The taxonomy of the genus is still unclear. MOODY (1980) revised the family Agamidae

and subdivided the genus *Agama* into the following six genera: *Agama*, *Stellio*, *Trapelus*, *Pseudotrapelus*, *Brachysaura* and *Xenagama*. Later, JOGER (1991) identified both *Laudakia* and *Phrynocephalus* as sister taxa of *Agama*.

At present the genus can be divided into three different species groups: the *Agama agama* group which includes the West African taxa, the *Agama lionotus* group which includes the East African taxa, and the *Agama hispida* group including the South African taxa. BÖHME et al. (2005) have separated the *Agama lionotus* species complex from the *Agama agama* group because of their unique narrow blue and white banded tails.

In the course of a herpetological survey of Mt. Hanang (KRAUSE 2006) in Tanzania the second author collected a series of *Agama*, which were difficult to assign to a specific taxon. The geographically neighbouring type localities of taxa belonging to this genus were Gwa'o's, Dodoma for *A. l. dodomae* LOVERIDGE, 1923 southeast of Mt. Hanang, and the primary type locality (of the holotype) Unyanganyi, northwest of Mt. Hanang (see

map in BÖHME et al. 2005) of *A. l. turuensis*.

The species of the collective genus *Agama* are often difficult to distinguish because of the high variability of their diagnostic characters, and in particular, *A. agama* is in urgent need of a taxonomic revision. One of the most obvious and important characters is the colouration of breeding males. The importance of the colour pattern of the throat, forelimbs and tail in particular, seems to be due to sexual selection because it plays an important role in the intraspecific recognition and infraspecific communication in these lizards. Therefore, these characters are useful for distinguishing different species, at least when they are sympatric, although similar types of colour pattern may exist convergently in allopatric forms (JACOBSEN 1992, MCLACHLAN 1981, WAGNER 2007).

The present paper is part of a larger project dealing with a morphological and molecular revision of the genus *Agama* (WAGNER 2007, WAGNER et al. in press). Herein, we compare material of the ZFMK collection (see appendix for details) with representatives of the *A. agama* species group, particularly with the two taxa mentioned above, the type localities of which are relatively close to Mt. Hanang.

### Material and methods

Material of the following institutes was used (see appendix): Museum of comparative Zoology (MCZ), Harvard University, Cambridge/Massachusetts, USA; Muséum d'histoire naturelle (MHNG), Genève, Switzerland; National Museums of Kenya (NMK), Nairobi, Kenya; Zoologisches Forschungsmuseum A. Koenig (ZFMK), Bonn, Germany. Synonymy follows WERMUTH (1967). Measurements, scale counts and terminology follows GRANDISON (1968) and MOODY & BÖHME (1984) and were taken with a dial calliper to the nearest 0.1 mm.

The following abbreviations were used: SVL= Snout-vent length; HW= Head width; HH= Head height; HL= Head length; TL= Tail length; SupL= Supralabials; SubL= Sub-

labia; SaM= Scales around midbody; TS= Throat scales between corner of mouth; PP= Preanal pores; SDL= Subdigitallamellae; SEM= Scanning Electron Microscope.

The following values were used: head length, head width, head height, diameter of ear, snout-vent length, tail length, body length, tail height, tail width, pelvic height, pelvic width, tibia length, femur length, feet length, length of 4<sup>th</sup> finger and length of 4<sup>th</sup> toe.

The following values were used in ratio: head width/head height; head length/head width; head length/diameter of ear; snout-vent length/tail length; pelvic width/pelvic height.

The following scale counts were used: scale rows around midbody, longitudinal dorsal scales in one standard length, longitudinal scales on the flank in one standard length, longitudinal ventral scales in one standard length, scales of the throat from rictus to rictus, dorsal pelvic scales, scales around the tail in one standard length, scales around the tail in distance of four times the standard length, number of scales per tail segment, number of preanal pores in the 1<sup>st</sup> row, number of preanal pores in 2<sup>nd</sup> row, number of supralabial scales, number of sublabial scales, number of occipital scales, number of internasal scales, number of scales between eye and ear and number of digits on 4<sup>th</sup> toe. One standard length is the length between the gular fold and vent divided by five.

Statistical analyses were carried out with the software package 'SPSS for Windows' version 12.0.1. Differences in morphology and morphometrics were tested for significance as follows: Adult specimens were compared in four principle components (PC) and tested on significance with ANOVA and LEVANE tests ( $P=0.01$ ). If the differences were significant the TUCKEY-KRAMER test was used to identify the groups with significant differences.

For SEM images paravertebral mid-dorsal scales from the posterior half of the dorsum were used from the following specimens: *Agama kaimosae* (ZFMK 83660: Kenya: Ngoromosi), *Agama caudospinosa* (ZFMK 83667:

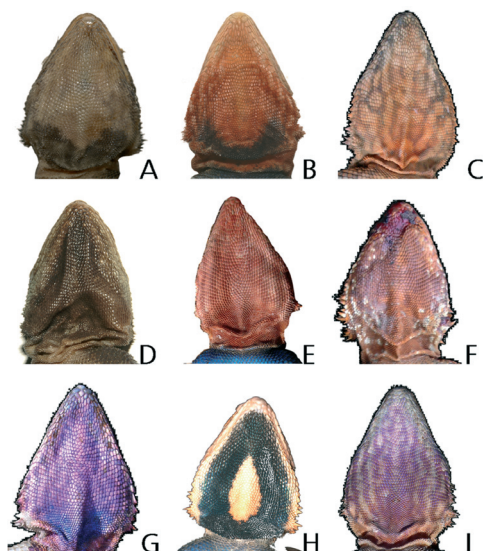


Fig. 1. Throat patterns of East African agama: **A:** *Agama turuensis* (Tanzania: Mount Hanang, ZFMK 74941); **B:** *Agama lionotus elgonis* (Kenya: Nakuru, ZFMK 82065); **C:** *Agama caudospinosa* (Kenya: Naro Moru, ZFMK 83661); **D:** *Agama lionotus ufipae* (Tanzania: Kipili, MCZ R30741); **E:** *Agama lionotus lionotus* (Tanzania: Arusha, ZFMK 66617); **F:** *Agama finchi* (Kenya: Malaba, NMK L/2716); **G:** *Agama mwanzae* (Kenya: Masai Mara, ZFMK 83657); **H:** *Agama lionotus dodomae* (Tanzania, ZFMK 83706); **I:** *Agama kaimosae* (Kenya: Ngoromosi, ZFMK L/2715).

Kenya: Kiamatongu), *Agama mwanzae* (ZFMK 83657; Kenya: Masai Mara), *Agama l. lionotus* (ZFMK 2651; Kenya: Nairobi), *Agama planiceps* (ZFMK 21961; Namibia: Koko, Werda), *Agama finchi* (ZFMK 82092; Kenya: Malaba), *Agama agama* (ZFMK 2630; Sudan), *Agama turuensis* (ZFMK 74941; Tanzania: Mt. Hanang). The images were taken with a Hitachi S-2460N in the ZFMK.

## Results and discussion

According to BÖHME et al. (2005), the *A. agama* group consists of two distinct species: *A. agama* (s. str.) and *A. lionotus*. The latter species complex can easily be distinguished from

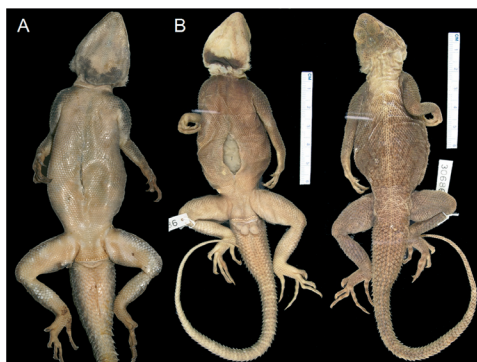


Fig. 2. (A) Preserved adult male of *Agama turuensis* (ZFMK 74941) from Mount Hanang, Tanzania in ventral view in comparison with (B) the holotype of *A. turuensis* in ventral and dorsal views. Image of the holotype: ©President and Fellows of Harvard College, other photo by PHILIPP WAGNER.

the former by their tail colouration, which consists of narrow white annuli separated by broader light bluish bands, whereas the tails are distinctly bi- or tricoloured in the taxa of the former species (including the recently described *A. finchi* BÖHME et al. 2005). Based on this colouration pattern, the Mt. Hanang series cannot clearly be diagnosed as a member of the *A. lionotus* group. Moreover, *A. l. dodomae* has a very peculiar throat pattern (fig. 1 H). Also, *A. l. elgonis* can be ruled out due to the same banded tail pattern as in *A. l. dodomae*; it has, however, a throat pattern similar to that of our Mt. Hanang series (see fig. 1 A&B).

The specimens of the Mt. Hanang series, in turn, have unicoloured tails which resemble the situation in *A. mwanzae*, *A. caudospinosa* and *A. kaimosae* (WAGNER et al. in press). These three species, however, lack the characteristic dark U-shaped crossbar on the hind margin of the throat, but the Mt. Hanang specimens cannot be identified with either of them. This crossbar on the throat resembling that of *A. l. elgonis*, likely led LOVERIDGE (1933) to synonymise his new taxon *A. turuensis* – described just one year before – with *A. l. elgonis* which has been ruled out already by us because of its typical tail pat-

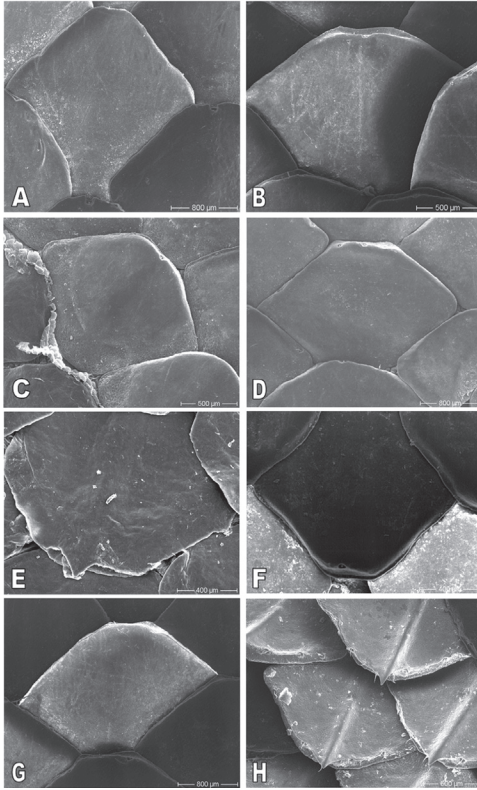


Fig. 3. Dorsal view of middorsal scales of **A:** *Agama kaimosae* (ZFMK 83660) **B:** *Agama turuensis* (ZFMK 74941), **C:** *Agama caudospinosa* (ZFMK 83667), **D:** *Agama mwanzae* (ZFMK 83657), **E:** *Agama l. lionotus* (ZFMK 2651), **F:** *Agama planiceps* (ZFMK 21961), **G:** *Agama finchi* (ZFMK 82092), **H:** *Agama agama* (ZFMK 2630).

tern (see above). In order to assess the status of *A. turuensis* we were able to compare our series with relevant photographic material (fig. 2) kindly provided to us by J. ROSADO (MCZ). Together with the original description by LOVERIDGE (1932) it is possible to assign unambiguously our series with LOVERIDGE'S name and to resurrect *A. turuensis* LOVERIDGE, 1932 as a valid species.

Differences in morphology of the used values were significant to *Agama caudospinosa*, *A. agama*, *A. mwanzae* and *A. finchi*. To the probably closest related *A. kaimosae* and to

*A. lionotus* no significant differences in morphology were found. (PC1: LEVANE  $P=0.1331$ ; ANOVA:  $F_{8.44}=3.6982$   $P<0.01$   $R^2=0.424056$ ; PC2: LEVANE  $P=0.3945$ ; ANOVA:  $F_{8.44}=33.663$   $P<0.01$   $R^2=0.859561$ ; PC3: LEVANE  $P=0.1363$ ; ANOVA:  $F_{8.44}=8.1924$   $P<0.01$   $R^2=0.598318$ ; PC4: LEVANE  $P=0.2810$ ; ANOVA:  $F_{8.44}=8.3482$   $P<0.01$   $R^2=0.602838$ ).

Our conclusion is supported by preliminary molecular results of the third author (BURMANN 2006) which clearly show our Mt. Hanang series to be genetically close to *A. mwanzae* and *A. kaimosae*, but distinct enough to recognize it as a valid species.

#### *Agama turuensis* bona species

In the following paragraph we characterise *A. turuensis* based on the data given by LOVERIDGE (1932) and by our own data (see also table 1).

*Agama turuensis* is a medium-sized agama resembling species like *A. lionotus* or *A. mwanzae*. It is characterized by the unique blue to brownish colouration of breeding males in addition to the remarkable throat pattern (see fig. 1) whereas the females and non-dominant males retain a characteristic juvenile pattern, like many taxa of the genus *Agama*.

**Morphology.** Body more or less slender, snout vent length in average 112 mm ( $n=7$ ), tail length in average 158 mm. Nostril above the canthus rostralis, pierced in the middle of the enlarged nasal scale and directed obliquely upwards. Between the nostrils with a longitudinal sharply keeled scale, followed by heterogeneous scales in the interorbital region and on the upper side of the head, head scales smooth or feebly keeled, directed forwards and to the sides, supraocular scales smooth. Parietal scale pentagonal, parietal organ visible. Ear-opening large, about the same size as the eye, tympanum superficial and visible, behind the ear with three clusters of spiny scales and single spiny scales around the ear-opening hole, additionally with a

row and a cluster of spiny scales on the nape side. Nuchal crest low. Gular scales smooth, mostly uniform in size but getting smaller towards the gular fold. Dorsals keeled to nearly smooth, keeled and extended on the sides becoming smooth towards the vertebral region, dorsal scales on the tail extremely keeled and extended, ventral scales weakly keeled, scales on the tail arranged in weak whorls which consist of three scale rings each. Ventral scales smooth, juxtaposed and slightly overlapping. One to two rows of preanal pores with an average of 16 pores. Scales on the limbs strongly keeled on the upper side, smooth on the underside, scales on the upper part of the limbs twice as large as the dorsals, becoming smaller towards the underside and the manus. 3<sup>rd</sup> and 4<sup>th</sup> fingers, 3<sup>rd</sup> and 4<sup>th</sup> toes longest, rather equal in size, digital length decreasing 2.5-1 in the fingers and 5-2-1 in the toes, subdigital lamellae with 2 to 5 keels on fingers and toes.

The fine structure of the scales (SEM) clearly shows differences between *A. turuensis* and the species groups of *A. agama* and *A. lionotus* (see fig. 3). The scales of *A. turuensis* are feebly keeled and are similar to those of *A. mwanzae*, *A. caudospinosa*, *A. kaimosae* and *A. planiceps*. All are more or less unkeeled without a spine. The scales of *A. agama*, *A. lionotus* and *A. finchi* are keeled and mucronate.

Head, neck, forelimbs and shoulders rich brick-red; back dark blue, spotted light blue; hind limbs and base of tail light blue; tail dark blue; below throat and neck brick-red, throat with a dark 'U' or '—' shaped marking at the base; belly and underside of forelimbs dark blue, underside of hind limbs and tail light blue (see figs. 1, 4).

Both females and juveniles show the typical colouration of female *Agama* lizards (see figs. 5, 6). Dorsum ground colour dark brown with a vertebral row of black framed white

Tab. 1. Ranges (mm) of selected characters of *Agama turuensis* and related taxa. SVL= Snout-vent-length; HW= Head width; HH= Head height; HL= Head length; TL= Tail length; SupL= Supralabialia on left side; SubL= Sublabialia on left side; SaM= Scales around midbody; TS= Throat scales between corner of mouth; PP= Preanal pores; SDL= Subdigitallamellae, left 4<sup>th</sup> toe; x= Average; n= number.

|      | <i>Agama turuensis</i>    | <i>Agama kaimosae</i>     | <i>Agama l. lionotus</i>  | <i>Agama l. elgonis</i>  | <i>Agama mwanzae</i>      | <i>Agama caudospinosa</i> |
|------|---------------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------|
|      | min-max (x) n<br>[mm]     | min-max (x) n<br>[mm]     | min-max (x) n<br>[mm]     | min-max (x) n<br>[mm]    | min-max (x) n<br>[mm]     | min-max (x) n<br>[mm]     |
| SVL  | 99.0–133.1<br>(112.27) 7  | 81.0–124.9<br>(108.4) 5   | 60.0–144.5<br>(101.29) 39 | 88.0–116.9<br>(100.57) 3 | 62.4–127.9<br>(104.43) 13 | 86.0–132.5<br>(110.39) 16 |
| HW   | 20.0–28.6<br>(23.21) 7    | 16.5–25.7<br>(22.14) 5    | 12.9–26.9<br>(19.65) 39   | 17.5–22.7<br>(19.63) 3   | 13.7–28.1<br>(21.65) 13   | 18.8–26.9<br>(22.42) 16   |
| HH   | 11.2–14.0<br>(12.53) 7    | 9.7–14.0<br>(12.3) 5      | 8.8–16.9<br>(12.25) 39    | 10.8–11.1<br>(11.47) 3   | 7.7–14.3<br>(11.38) 13    | 10.1–14.2<br>(12.33) 16   |
| HL   | 27.4–35.9<br>(30.13) 7    | 22.8–34.2<br>(30.36) 5    | 17.1–37.8<br>(27.11) 39   | 23.5–31.1<br>(26.63) 3   | 17.8–35.4<br>(28.65) 13   | 25.4–38.7<br>(30.85) 16   |
| TL   | 145.0–166.7<br>(158.37) 3 | 156.8–167.3<br>(162.05) 2 | 126.0–209.1<br>(153.3) 24 | 157.4–157.4<br>(157.4) 1 | 118.7–215.2<br>(173.27) 6 | 113.5–143.7<br>(126.12) 6 |
| SupL | 9–11 (10.13) 8            | 10–11 (10.5) 6            | 9–12 (10.47) 64           | 9–10 (9.6) 5             | 9–12 (9.79) 14            | 9–13 (11.1) 21            |
| SubL | 9–12 (10.25) 8            | 10–11 (10.17) 6           | 9–12 (10.1) 64            | 9–11 (10.6) 5            | 10–12 (10.36) 14          | 9–11 (9.95) 21            |
| SaM  | 71–85 (77.63) 8           | 79–82 (80) 6              | 67–91 (75.36) 64          | 79–87 (81.8) 5           | 67–82 (75.15) 13          | 74–116 (93.29) 21         |
| TS   | 47–55 (51.38) 8           | 46–55 (51) 6              | 44–64 (50.78) 64          | 53–60 (56.6) 5           | 45–55 (48.29) 14          | 49–61 (55.24) 21          |
| PP   | 11–29 (16) 4              | 11–13 (12) 5              | 10–29 (15.75) 28          | 11–24 (17.5) 2           | 12–24 (17.13) 8           | 10–21 (13.21) 19          |
| SDL  | 16–22 (20) 8              | 18–21 (19.17) 6           | 17–26 (21.5) 64           | 18–20 (18.8) 5           | 18–24 (20.14) 14          | 15–21 (17.62) 21          |



Fig. 4. Adult male of *Agama turuensis* (ZFMK 74941) from Mount Hanang, Tanzania. Photo by PATRICK KRAUSE.

longitudinal dots extending from the nape onto the tail, framing extending with scattered white dots as bars to the sides, juvenile more spotted than the adult females, gravid colouration of females is unknown but most probably different to the typical colouration, mentioned above, as in other taxa of the genus. Upper side of the head and neck with white flecks and spots, most distinct in the juvenile and becoming less expressed in the adult females. Ventrums, including the tail, creamish to white, throat with longitudinal fine lines, one female with two darker bars at the base of the throat. Limbs ground coloured pale brown with darker gray lines and bars. In all colouration patterns the juvenile is brighter than the adult female and drawings are more distinct.

**Habitat.** The collected series was found on rocks in an arid, semi-desert thorn-bush area. Additional specimens were found on the rocky ridges of the flanks of Mt. Hanang. They were found on rocky outcrops in medium to high grassland up to 2200 m a.s.l., 500 m below the forest reserve. Structured colonies, dominated by one male, could be sighted near Jorodom and Katesh villages.

**Distribution.** *Agama turuensis* is so far only known from the following Tanzanian localities: Unyanganyi, east of Singida (type



Fig. 5. Juvenile of *Agama turuensis* from Mount Hanang, Tanzania. Photo by PATRICK KRAUSE.



Fig. 6. Subadult female of *Agama turuensis* from Mount Hanang, Tanzania. Photo by PATRICK KRAUSE.

locality); Mangasini, Usandawi (paratypes) and Mount Hanang (ZFMK material). This mountain is part of a mountain massif, extending from the Kenyan Nguruman Escarpment through the Ngorongoro area to mountains in the Dodoma area in Tanzania. According to this geomorphological structure one can expect that *A. turuensis* has a wider distribution along this mountain complex from Kenya to Tanzania.

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### Appendix

#### Material examined

**Agama agama**: SENEGAL: Dakar: Bel-Air: ZFMK 73845-849; CAMEROON: ZFMK 83759-766. **Agama caudospinosa**: KENYA: Lake Elementaita: NMK L/2722/1-2; Kiamatongu: NMK L/2730/2-3, ZFMK 83667; Naro Moru: NMK L/2726/3-6, ZFMK 83661-663; Meru: Nkunga NMK L/2728/1-3, 6, ZFMK 83664-666; Nairobi (locality questionable): ZFMK 8701, 9025. **Agama finchi**: MALABA: NMK L/2716/1, 4, 6-7, 9-10, ZFMK 83652-656. **Agama kaimosae**: KENYA: Ngoromosi: NMK L/2715/1, 3-4, ZFMK 83658-660; TANZANIA: Kishapu District: Mwamalasa: MHNG 877.65; MHNG 2684.001-006. **Agama lionotus dodomae**: TANZANIA: ZMB 12980, ZFMK 83706 **Agama lionotus elgonis**: KENYA: Nakuru: NMK L/2721/1, 3, ZFMK 83637; Lake Nakuru NP: ZFMK 82064-065. **Agama lionotus lionotus**: KENYA: Cherangani Hills: Sebit: NMK L/2718/1, 3-4, 7-8, ZFMK 83634-636; Cherangani Hills: Sigor: ZFMK 82063-062; Lake Baringo: NMK L/2720; Ngong Hills: NMK L/2732/1, 3-4, ZFMK 83643; Namanga: NMK L/2733/2-4, ZFMK

83644; Nairobi NP: Masai Gate: NMK L/2724/3-5, ZFMK 83639-640; South Horr: ZFMK 70772-775; Ol Doiyo Sapuk NP: NMK L/2734/2, ZFMK 83645; Sultan Hamud: NMK L/2742/1, ZFMK 83651; Isiolo: NMK L/2727/1, 3-4, ZFMK 83641; Kindaruma: NMK L/2729/1, 3, ZFMK 83642; Kibwezi: NMK L/2740; Taita Hills: NMK L/2736; Tsavo East NP: NMK L/2735/1, 4-5, 7, ZFMK 83646-648; Tsavo West NP: NMK L/2739/1-4; Sagala Hills: NMK L/2737/1, ZFMK 83649; Rukinga Ranch: NMK L/2738/1, 3-4, ZFMK 83650. TANZANIA: ZFMK 7485; Tanga: ZFMK 44713; Arusha: ZFMK 66617-618; Mbunyan: ZFMK 77336. **Agama mwanzae**: KENYA: Masai Mara: NMK L/2723/1-3, ZFMK 83657, 82075-077. RWANDA: Mpanga: ZFMK 51195; Kibungu: Rugurama: ZFMK 55797-800; Kibungu: Nasko: ZFMK 61664; Kibungu: Ntaruka: ZFMK 61663. **Agama turuensis**: TANZANIA: Mt. Hanang: ZFMK 74930-943, 82192-194, 82324-328, 82357-360, 82278-279.

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