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Assessing the conservation status of soil-dwelling vertebrates: insights from the rediscovery of *Typhlops uluguruensis* (Reptilia: Serpentes: Typhlopidae)

Abstract Soil-dwelling amphibians and reptiles are relatively poorly studied and understood. Difficulties in sampling these taxa in their subterranean habitats might impede assessments of their conservation status. We explore this issue with a case study of the burrowing scolecophidian snake *Typhlops uluguruensis*, endemic to the Uluguru Mountains in the Eastern Arc of Tanzania. Despite recent standard faunistic surveys, there have been no reported sightings or collections of *T. uluguruensis* since the type series of four specimens was collected in 1926. Intensive replacement of forest by agriculture in the vicinity of the type locality had led to concern about the conservation status of this and other species. We report the rediscovery of *T. uluguruensis* in low intensity agriculture adjacent to human habitation, and close to the type locality. We compare the new material with the type series, and discuss the implications of this rediscovery for conservation assessments of small, soil-dwelling lower vertebrates. We advise caution in determining conservation status when, as is usually the case, no special sampling of the soil has been carried out. Additionally, relatively neglected disturbed habitats should also be given more attention. Standard sampling methods for soil-dwelling vertebrates need to be further developed and established.

Key words Africa, caecilians, Eastern Arc, Scolecophidia, Tanzania, Uluguru

Introduction

The biology of amphibians and reptiles that are endogeic, i.e. lead a dedicated soil-dwelling existence, is generally less well understood than for their above-ground relatives. Studies of their natural history and ecology are impeded by the difficulty of observing and sampling them within their environment, so that dedicated methods involving excavation are generally required for their investigation (e.g. Measey *et al*., 2003*a*, *b*). This might be expected to constrain the assessment and monitoring of their conservation status, though empirical studies are lacking.

The endogeic typhlopid scolecophidian snake *Typhlops uluguruensis* was described by Barbour & Loveridge (1928) from four specimens (not three, *contra* Spawls *et al*., 2002) collected in 1926 from Nyange in the Uluguru Mountains of eastern Tanzania. Since its description, there have been no reports of any further sightings or collections of this taxon. *Typhlops uluguruensis* is one of 16 endemic vertebrates reported from the Uluguru Mountains (Burgess *et al*., 2002). These are a component block of the Eastern Arc Mountains of Kenya and Tanzania, a World biodiversity hotspot, and area of high local and regional endemicity (e.g. Loveridge, 1942; Myers *et al*., 2000; Burgess *et al*., 2002). Recent standard faunistic surveys in the Uluguru forests (Doggart *et al*., 2001; Burgess *et al*., 2002) failed to find *T. uluguruensis* and two other probably burrowing, endemic snakes (*Prosymna ornatissima* and *Typhlops* sp. nov.), and Burgess *et al*. (2002) expressed concern about the conservation status of these apparently absent species in the context of ongoing intensive deforestation in the Uluguru Mountains. Here we report the rediscovery of *T. uluguruensis* and discuss its implications for the conservation biology of endogeic vertebrates.

Institutional abbreviations used are MCZ: Museum of Comparative Zoology, Harvard, USA; BMNH: The Natural History Museum, London, UK; MRAC: Royal Museum of Central Africa, Tervuren, Belgium.

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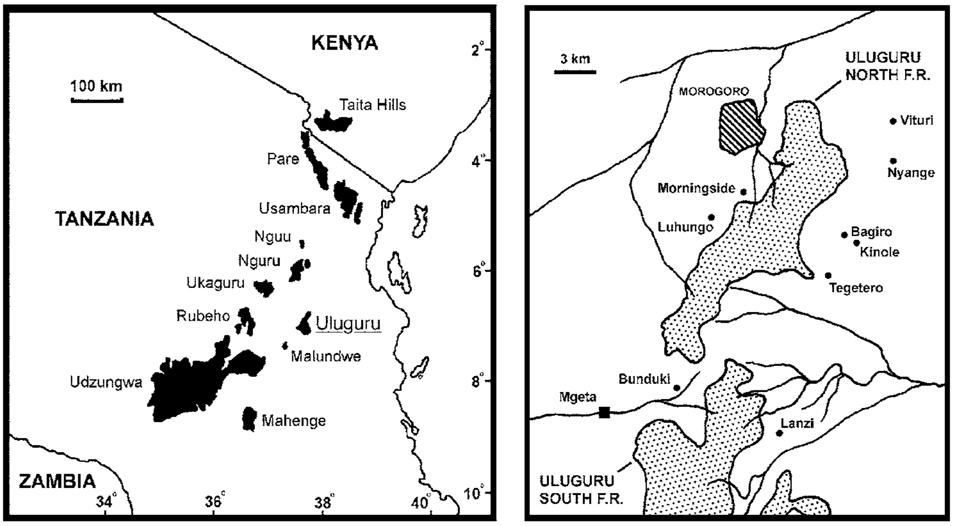

Figure 1 Maps indicating the position of the Uluguru Mountains in the Eastern Arc (left, redrawn from Wasser & Lovett, 1993: fig. 1.1) and the approximate position of localities yielding specimens of *Typhlops uluguruensis* (right). *Typhlops uluguruensis* was originally collected in 1926 from Nyange, and was rediscovered in 2002 from Tegetero Mission, which lies between Tegetero and the edge of the Uluguru North Forest Reserve. The area of forest in the northern part of the Uluguru Mountains has reduced dramatically since 1955 (Burgess *et al.*, 2002: fig. 2).

Materials, Methods and Results

The holotype (MCZ R-23080) and three paratypes (MCZ R-23081, 23082, 23083; the latter two are now MRAC R.11225 and BMNH 1946.1.10.70, respectively) of *T. uluguruensis* were collected on 6 October 1926 from the village of Nyange (Barbour & Loveridge, 1928). This is at 6°52′S, 37°46′E and an altitude of about 760 m (2500 feet; Barbour & Loveridge, 1928: 103, cf. the 850 m reported by Roux-Estève, 1974), in the northern part of the Uluguru Mountains (Fig. 1). The four specimens were found by local people in agricultural land close to forest, and "Two, at least, of the series were taken under the rotting grass roof of a collapsed hut which had been built close to the edge of the rain-forest" (Barbour & Loveridge, 1928: 105). On 21 and 22 May 2002, we made a brief visit to the Uluguru mountains as part of a purely systematic study of caecilian amphibians. On 22 May, a further four specimens of *T. uluguruensis* were excavated by local people from loose soil in mixed, low intensity agriculture interspersed among, and adjacent to, housing at Tegetero Mission (6°57′S, 37°43′E, 995 m a.s.l). Tegetero Mission is on the edge of the Uluguru North Catchment Forest Reserve in the Kitundu Hills. The reserve comprises upper montane, montane and submontane forest on steep slopes. All the brief fieldwork reported here took place at altitudes characterised by submontane forest.

Soil and leaf litter was dug with bladed hoes for approximately five person hours inside the forest above the village at Tegetero Mission, at an altitude of 1200 m. This yielded only a single specimen of the caecilian amphibian *Scolecomorphus kirkii* Boulenger and no other caecilians or snakes. Aided by photographs of conspecifics, locals at Tegetero Mission had been asked to help locate specimens of the caecilian *Boulengerula uluguruensis* Barbour & Loveridge within the village, while our searches were concurrently taking place in the forest. In less than one day, they collected 200+ *B. uluguruensis*, many earthworms, and the four specimens of *T. uluguruensis*. All are superficially similar in size, proportions and colour, and they had been dug from the upper 0.5 m, or less, of the soil in small agricultural plots in the village. Two of these most recently collected specimens of *T. uluguruensis* were preserved (BMNH 2002.49-50).

In order to verify identification of the new material, and to generate further systematic data, some meristic and morphometric features were measured for all museum specimens of *T. uluguruensis*. Vertebrae were counted from radiographs. Middorsal scales were counted between, but excluding, the rostral and posterior apical scale. Scale rows were counted at 20 midventral scales behind the mentum (anteriorly), at midbody, and at 10 midventral scales anterior of the vent (posteriorly). Circumference at midbody was measured with a piece of thread and a ruler, to the nearest mm. Total length was also measured to the nearest mm with a ruler. Midbody diameter and tail length (vent to tip of apical scale) were measured to the nearest 0.1 mm using dial callipers.

As described by Barbour & Loveridge, *T. uluguruensis* are pink in life. They are pallid, and specimens lose their colour in preservative, becoming a uniform pale yellow-brown. This colour change happened progressively from the posterior end of the body forwards in both BMNH 2002.49 and 2002.50, so that the posterior half of the body was yellowish and the anterior half a darker grey colour some 12 months after preservation. The eyes of *T. uluguruensis* have been reported as being invisible (e.g. Roux-Estève, 1974), but their position is probably indicated by darker, rather diffuse, pink spots in life. Each spot is close to the ventral margin of the large preocular scale, so that in dorsal view they are close to the lateral edges

	MCZ R-23080	MCZ R-23081	MRAC R.11225	BMNH 1946.1.10.70	BMNH 2002.49	BMNH 2002.50
Sex	(m*†)	(f†)			m	f
Total length (mm)	231 (235*, 230†)	236 (245*, 230†)	230 (240*)	218 (230*, 210†)	214	214
Tail length (mm)	6.1 (5*)	3.3 (3*)	4.9 (4*)	4.4(4*)	3.5	3.4
Midbody diameter (mm)	4.4 (4.5*)	4.2 (5*)	4.1 (5*)	3.8(4.5*)	3.8	4
Midbody circumference (mm)	14	15	16	14	15	15
Total length/midbody diameter	52.5	56.2	56.1	57.4	56.3	53.5
Tail length/total length (%)	2.64	1.4	2.13	2.02	1.64	1.59
Total vertebrae	263 (263†)	264 (263†)	267	264 (263†)	268	269
Middorsal scales	389 (389†)	379 (383†)	402	416 (414†)	380	379
Anterior scale rows	24	24	24	24	24	24
Midbody scale rows	22 (22†)	22 (22†)	22	22 (24†)	22	22
Posterior scale rows	22	22	22	22	22	22
Subcaudal scales	13	8	11	11	8	8

Table 1 Some external meristic and morphometric data and vertebral counts for all six known specimens of *Typhlops uluguruensis* Barbour & Loveridge. See text for methods, and locality details for each specimen. Data in parentheses are taken from *Barbour & Loveridge (1928) and †Roux-Estève (1974).

of the head, and slightly behind the posterior margin of the rostral. These spots become unclear in preservative.

External morphometric and meristic data and numbers of vertebrae are given in Table 1. Comparisons with the type material confirm our identification of BMNH 2002.49 and 50. Barbour & Loveridge (1928: 104) reported 20 scale rows and Roux-Estève (1974) 22 to 24 at the level of the 100th middorsal scale, but we counted 22 at midbody in all specimens. Differences in recorded lengths among our and previous studies probably reflect measurement error and/or change in the condition of preserved specimens over time. Our greater recorded tail lengths suggest that independent workers have not measured the same dimension. Barbour & Loveridge (1928: 105) described the tail of *T. uluguruensis* as "sharply pointed but not terminating in a spine". This is true of most of the available specimens, but a small, blunt spine is present in BMNH 2002.50.

Barbour & Loveridge (1928: 105) reported termites in the gut of one of their specimens. This was probably MCZ R-23081, which still contains many tens of termites. A few of these were removed, and identified by David T. Jones (BMNH) as major and minor workers of a single species of *Odontotermes* (Termitidae, Macrotermitinae), a termite that nests within soil. A brief examination of other termites remaining in the gut revealed no soldiers.

Discussion

This is the first report of *T. uluguruensis* in life for more than 75 years, despite standard faunistic surveys intended for conservation assessments having been conducted in the region of the type locality (see Burgess *et al*., 2002). Doggart *et al*. (2001) and Burgess *et al*. (2002) expressed concern that the absence of records of some endemic Uluguru vertebrates, including *T. uluguruensis*, over many decades coincided with ongoing, intensive deforestation, particularly since 1955. Burgess *et al*. (2002: 149) considered that "the process of habitat loss and species decline may be linked". However, that 200+ *Boulengerula uluguruensis* and four *Typhlops uluguruensis* were recovered from mixed agricultual plots in a short period of time indicates that these endogeic vertebrates are able to live in the current low intensity agriculture that has replaced much forest on the slopes of the Uluguru Mountains. Indeed, Barbour & Loveridge's (1928) original collections of *T. uluguruensis* were made from agricultural land on the edge of forest (see Materials, Methods and Results). Thus, at least for these two endogeic species, it is probably not generally the case that "Farmlands do not offer suitable habitat for the Uluguru endemic vertebrates" (Burgess *et al*., 2002: 144). Providing that the local agricultural practices and habitat do not change markedly, *T. uluguruensis* (and *B. uluguruensis*) may not be under immediate threat.

The presence of *B. uluguruensis* and *T. uluguruensis* in forest adjacent to agricultural land at Tegetero Mission is yet to be established. It is possible that low intensity agriculture actually allows some soil vertebrates to sustain greater abundance than in previous native forest. This is speculative, but open to testing, and high abundance of caecilians and burrowing snakes is known from soils in similar agricultural habitats elsewhere in the tropics and subtropics (e.g. Rajendran, 1985; Hebrard *et al*., 1992; Nussbaum & Pfrender, 1998; Oommen *et al*., 2000; Schleich & Kästle, 2002: 77; Measey *et al*., 2003*a*, *b*). A limited altitudinal range might explain the potential absence of these species in the remaining higher altitude forest, and this is also open to future testing. Until more is known of its distribution and abundance in forest and agricultural habitats, we suggest that the conservation status of *T. uluguruensis* should be considered "data deficient".

In light of our serendipitous rediscovery of *T. uluguruensis*, it will be of interest to determine whether the other endogeic vertebrates endemic to the Uluguru Mountains can be rediscovered at their type localities, which, following deforestation (Burgess *et al*., 2002: fig. 2), are now further from the margin of the Uluguru North Forest Reserve than the new locality reported here (Fig. 1). We agree with Burgess *et al.* (2002: 144) that for the Uluguru Mountains, as with much of Eastern Africa, "the area is yet to be adequately surveyed", and this is probably particularly true for endogeic organisms.

Doggart *et al.*'s (2001) faunal inventories were based on the most extensive quantitative biological surveys of the Uluguru Mountains ever conducted, covering an impressive range of organisms and localities in difficult terrain. Their methods were standard for such studies of vertebrate biodiversity. Doggart *et al.*'s (2001) sampling of possible *T. uluguruensis* habitat in Uluguru North forest consisted of six hours of diurnal searching of leaf litter and under rotting logs, plus possibly a small proportion of six hours of nocturnal surveys, although these were focused on locating chameleons in trees. Organisms leading a dedicated subterranean existence are very rarely encountered on the surface (including in leaf litter), and therefore might be overlooked by standard small vertebrate sampling methods, including pitfall trapping. Additionally, the discovery of *T. uluguruensis* and *B. uluguruensis* in agricultural plots indicates that some small endogeic vertebrates can be accommodated by low intensity agricultural systems – disturbed habitats that are generally considered detrimental to native species. We recommend that, where possible, digging in soil is added to faunal surveys that aim to produce complete inventories of vertebrates, and that sampling by digging should be a prerequisite of conclusions about endogeic taxa. Additionally, we recommend that disturbed habitats are assessed for their potential to support even supposedly rare and/or endangered species. In the absence of appropriate sampling, lack of discovery is not evidence of absence, and does not justify conclusions on conservation status. As discussed by Measey *et al.* (2003*a*, *b*), standard methods for quantitative surveys of endogeic lower vertebrates have yet to become established, and more work is required in this area. Measey *et al.* (2003*a*, *b*) stressed the need for viable methods in the context of quantitative ecology, but these may also become essential for accurate conservation assessments.

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