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## THE MONTANE FOREST ASSOCIATED AMPHIBIAN SPECIES OF THE TAITA HILLS, KENYA

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### ABSTRACT

The group of forested mountains known as the Taita Hills are the northern-most montane blocks of the Eastern Arc Mountains, a globally recognized biodiversity hotspot. They are surrounded by the dry Tsavo plains. Until the present study no comprehensive survey of the amphibian fauna of Taita Hills covering the entire altitudinal gradient had been conducted. In this study details on the distribution and life history of amphibians associated with montane forest are provided. The biodiversity importance of the Taita Hills lies with the number of endemics per unit of area of remaining forest, which is one of the highest among the Eastern Arc Mountains. Presented herein are data for these endemics and other amphibian species associated with montane forest based on our field surveys from 2005 to 2007. In addition we have included published data and those from previous collections housed at the National Museums of Kenya, Nairobi. The results indicate that the majority of the twenty-six amphibians species recorded from the Taita Hills are those of the widespread East African lowland fauna. Only six are those associated with montane forest, including three threatened endemics. Concern is raised for the protection of this endemic amphibian fauna associated with montane forest because of ongoing habitat degradation.

**Keywords:** Eastern Arc Mountains, *Gymnophiona*, distribution, *Anura*, life history

## INTRODUCTION

Amphibians are one of the most threatened animal groups. At least one third of the more than 6000 described species is threatened with extinction applying IUCN Red List categories and criteria (e.g. Stuart *et al.*, 2004, 2008). A major requirement of the IUCN Amphibian Conservation Action Plan (Gascon *et al.*, 2005) is to make available basic information on systematics, distribution and life history to stakeholders in disciplines relevant to conservation management. For many amphibian species, especially in species-rich tropical countries, such data are lacking.

Despite increased efforts in recent years, the diverse amphibian fauna of eastern Africa is far from being well understood (Poynton, 1999; Channing & Howell, 2006; Lötters *et al.*, 2006; Poynton *et al.*, 2007). One such area is the Taita Hills in southern Kenya which constitute the northernmost portion of the crystalline block faulted Eastern Arc Mountains (EAM) (Lovett, 1990; Newmark, 2002). Many EAM blocks have remnant montane closed forest fragments and belong to the 34 worldwide biodiversity hotspots (Myers, 2003; Mittermeier *et al.*, 2004).

Sampling effort in the EAM has been uneven. The best studied mountain blocks are East Usambara and Uluguru (e.g. Barbour & Loveridge, 1928; Loveridge, 1957). More recently the Udzungwa Mountains have received the attention of herpetologists (Menegon & Salvidio, 2005; Poynton *et al.*, 2007 plus references therein). These initial studies underscored the importance of biodiversity in the EAM, only uncovered through the most recent and extensive focus on the EAM amphibian fauna. Many of the recent studies in the EAM have recorded an amphibian diversity that is comprised of lowland and montane species including many widespread taxa (e.g. Loader *et al.*, 2004, 2006; Menegon *et al.*, 2004, 2007, 2008; Doggart *et al.*, 2006; Burgess *et al.*, 2007; Poynton *et al.*, 2007; Malonza, 2008).

The early amphibian studies in the Taita Hills were mainly restricted to montane areas (Loveridge, 1957). At that time, Mount Mbololo was the focus for collections which led to the descriptions of the endemic Gymnophiona *Boulengerula taitana* Loveridge, 1935 as well as the more widely ranging anurans *Mertensophryne taitana* (Peters, 1878) and *Hyperolius glandicolor* (Peters, 1879). Recently, *Boulengerula niedeni* Müller, Measey, Loader & Malonza, 2005 was described from Sagalla Hill, one of the isolates of the Taita Hills and *Callulina dawida* Loader, Measey, de Sá & Malonza, 2009 from Dawida and Mbololo blocks.

Lists of montane amphibian species of Taita Hills have been published by Beentje (1987), Bytebier (2001) and Burgess *et al.* (2007). In this study we examined the amphibian species of Taita Hills from the base up to the montane areas. However, the uniqueness of the Taita Hills amphibian fauna lies with its endemics that are restricted to the montane closed rainforest. We present here an updated account of the amphibians associated with montane forest in which we include descriptions of the endemics and information on distribution, life history and conservation status. New natural history information on some selected widespread species is also provided.

## STUDY AREA

The Taita Hills complex consists of the main block known as Dawida (2228 m) about 25 km north-west of Voi town and three other blocks; Mount Mbololo (1800 m), Sagalla Hill (1500 m), and Mount Kasigau (1645 m) approximately 5, 25 and 50 km respectively from Dawida (figure 1). These blocks jut out at varying elevations from the dry Tsavo lowlands.

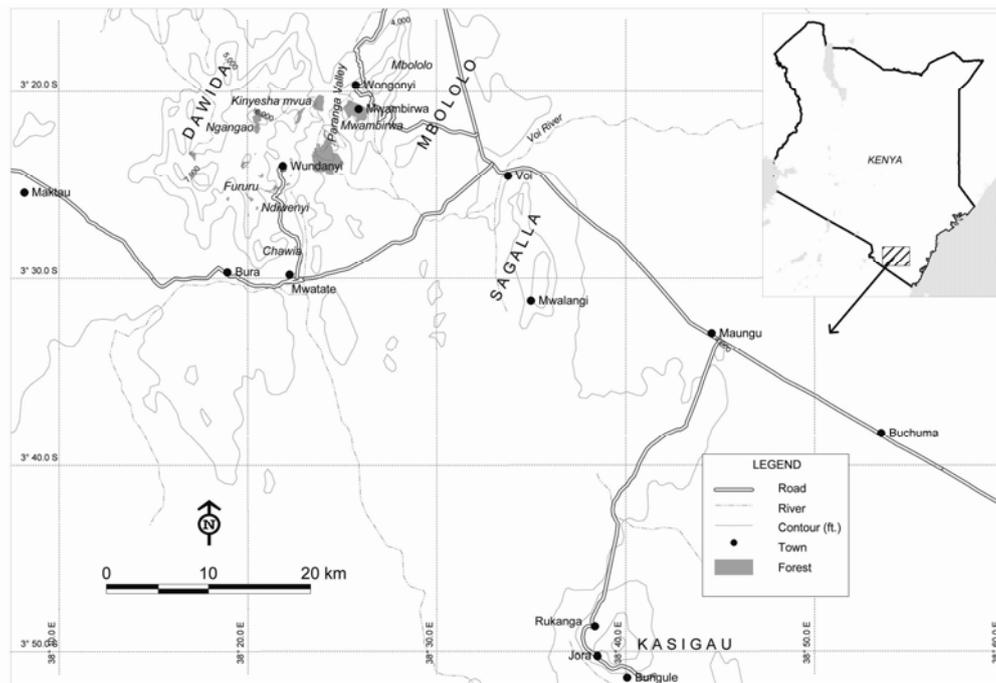


Figure 1. Map of the Taita Hills showing the main block Dawida and the three isolates of Mbololo, Sagalla and Kasigau. Inset a map of Kenya showing the location of Taita Hills.

Sagalla Hill, directly south of Voi, is separated from Dawida and Mbololo by the Voi River, while Mount Mbololo is separated from Dawida by the Paranga valley at *ca.* 900 m. Dry bushland runs up the flanks of the hills, giving way rather abruptly depending on the mountain block location at *ca.* 1200 m to forest associated habitat. Due to human disturbance and habitation there remains only a scattered group of closed montane forest fragments. These range in size between 3 and 220 ha and total less than 400 ha, which is less than 2% of the original forest (Newmark, 1998; Lens *et al.*, 1999). In addition the majority of the hilltops have exotic pine (*Pinus* spp) and eucalyptus (*Eucalyptus* spp) plantation forests.

Mean annual temperatures along an elevational gradient from 600 to 1400 m decrease from 22 to 16°C while rainfall increases (Malonza, 2008). Rainfall and temperature data were gathered from daily records for different sites from lowlands to the highlands. Temperature was taken to the nearest 1 degree using a max-min mercury thermometer while the rain was measured with a 40 mm capacity rain gauge and both were of no-name brand.

## MATERIALS AND METHODS

All data presented here are based on (i) published references as mentioned throughout the text, (ii) collections made by previous workers and housed at National Museums of Kenya, Nairobi (NMK), or (iii) collections (at NMK) and observations by PKM and GJM. Fieldwork was conducted from April 2005 to December 2007 in all four Taita Hills blocks (Dawida, Mbololo, Sagalla and Kasigau; figure 1) from the base to the top in selected sites. Amphibian sampling methods using standard pit-fall traps associated with a drift fence forming a Y-shaped array

(Heyer *et al.* 1994), rectangular 600-m transects as well as opportunistic night visual and acoustic encounter surveys (Rödel & Ernst, 2004; Veith *et al.*, 2004). Specimens were euthanized with MS222 and preserved in formalin (10% of stock solution) (Heyer *et al.*, 1994). Tissue samples for DNA analysis were taken for majority of the specimens and stored in ethanol. Material collected has been deposited in NMK and that examined is listed in the appendix.

Descriptions apply to specimens from the present study area and refer to adult specimens only, except where noted. Taxonomy follows Frost *et al.* (2006) and Frost (2008). Measurements of preserved animals were taken with dial callipers or with a string for caecilians, which was subsequently stretched along a ruler. Labial tooth row formulae in anuran larvae were determined in the manner of McDiarmid & Altig (1999). Abbreviations used: LTRF=labial tooth row formula; PA=number of primary annuli in Gymnophiona; SUL=snout-urostyle length, (frogs and toads). The range (min, max) of SUL, PA and body length of caecilians and mean $\pm$ SD (standard deviation) are provided for each taxon.

The IUCN Red List criteria details were applied (IUCN, 2001) following the IUCN Red List of Threatened Species ([www.iucnredlist.org/amphibians](http://www.iucnredlist.org/amphibians)). We carefully reconsidered the IUCN status of the Taita endemic species and make comments and recommendations in the text. The global conservation status assessment refers to the species entire world-wide geographic range. The following abbreviations were used; Critically Endangered CR; Endangered EN; Vulnerable VU and Least Concern LC.

## RESULTS AND DISCUSSION

### Taita Hills endemics

Despite having the smallest amount of natural closed forest remaining in the EAM (Newmark, 1998), Taita Hills has one of the highest numbers of mountain block endemics per unit area (see Burgess *et al.*, 2007; Malonza, 2008). Of the 26 recorded species from base to the montane areas, three (two caecilians and one frog species), are associated with montane forest and endemic to the Taita Hills (figure 2).

#### *Boulengerula niedeni* Müller, Measey, Loader & Malonza, 2005

##### *Description*

A caeciliid with male body length range from 205.7–287.0 mm (235.40 $\pm$ 29.65),  $n=10$  and female 215.0–290.0 mm (251.88 $\pm$ 20.10),  $n=25$ ; PA 140.0–155.0 (144.86 $\pm$ 3.53),  $n=35$ ; head longer than wide; snout dorsally rounded; eyes not visible externally; tentacles short and globular; body smooth but annulated. In life, dorsal colour brownish, ventral colour light brown with the dorsal head region pinkish; throat flesh pink. Juveniles show little to no pigmentation. See also Müller *et al.* (2005b).

##### *Distribution and life history*

Endemic to Sagalla Hill and found in low density in farms and patches of indigenous forests at altitudes between 1000–1504 m. In farmlands, these caecilians can be found mainly in soils rich in organic manure or under organic debris. During the dry seasons, like *B. taitana*, they can be found at the edge of water drainage channels. In indigenous forest, during the wet season, they can occur close to the surface within or under decomposing logs. Reproduction is expected to be similar to *B. taitana*, see below.



a



b



c

Figure 2. Taita Hills endemic amphibians recorded during the present study. a. *Callulina dawida*, b. *Boulengerula niedeni*, c. *Boulengerula taitana*.

#### *Conservation status*

Global: Critically Endangered (CR) B1ab (iii). There is continuing decline in its area of occupancy (AOO), extent and quality of habitat and it is restricted only to Sagalla Hill. The current estimated extent of occurrence (EOO) is less than 20 km<sup>2</sup> and area of occupancy of the fragmented sites is 7.06 km<sup>2</sup>. We therefore agree with the current listing. There is population decline, given that its suitable habitat is disappearing due to soil erosion and drying by *Eucalyptus* trees.

*Boulengerula taitana* Loveridge, 1935*Description*

Males of this caecilian are relatively longer than females; male body length range 243.0–420.0 mm ( $299.17 \pm 42.72$ ),  $n=23$ , and female 235.5–345.0 mm ( $283.96 \pm 28.47$ ),  $n=27$ ; PA 125.0–143.0 ( $135.48 \pm 3.88$ ),  $n=50$ . This concurs with Malonza & Measey (2005) who, using a larger sample size, found males to be significantly longer than females; head longer than wide; snout dorsally rounded; eyes present but covered by a translucent skin; tentacles short and globular; body smooth but annulated. In life, dorsal colour dark gloss bluish black; ventral colour is also variable from blue grey to the extent of having dark blotches or speckling; head region flesh pink; throat flesh pink. Juveniles are pigment-less. These characteristics are similar to those given by Loveridge (1957) and Nussbaum & Hinkel (1994).

*Distribution and life history*

This species is locally abundant in forests, plantation forests and farmlands in Mbololo and Dawida blocks at altitudes between 1230 m and 1859 m and much less abundant in Mount Kasigau forest from around 1000 to around 1635 m. It was previously recorded only from Mbololo and Dawida; this new isolated record from Mount Kasigau represents an important 50 km extension to the south-east of its occurrence. *Boulengerula taitana* prefers micro-habitats such as moist soils rich in organic manure in farmland and can be found under decomposing leaves and/or debris, e.g. on terrace banana, avocado and at fig tree bases. During dry seasons, it can be found deep in soils or is confined to moist sites especially alongside permanent water drainage channels. Adults can be found throughout the year (Malonza & Measey, 2005). In forests, the species occurs in loose soil with dead leaves under and within decomposing logs. On two occasions in the wet seasons an individual was found moving within leaf litter at night. During the day in Ngangao forest another individual was observed moving on the grassed forest floor. Some individuals appear only to leave their burrows when these are flooded, or when safari ants, *Dorylus molestus* Gerstäcker, 1859 raid their burrows (Measey, 2004). After such occurrences, they may then be taken in pit-fall traps.

*Boulengerula taitana* is a carnivorous generalist that mainly preys on a variety of invertebrates, including termites; dipteran larvae and earthworms (Hebrard *et al.*, 1992; Gaborieau & Measey, 2004).

*Boulengerula taitana* is a direct developing amphibian (Nussbaum & Hinkel, 1994). The membranous eggs (mean clutch size is 5 as reported by Malonza & Measey, 2005) are laid in an underground chamber. Kupfer *et al.* (2006) collected 21 females with broods of between two and nine, an indication of egg clutch size range. The hatchlings are found in January after the short rains (Malonza & Measey, 2005). The species provides parental care to its eggs and young. Eggs are guarded and the outer layer of skin of a brooding female is transformed to provide a rich supply of nutrients for the developing offspring. The young caecilians possess a specialized dentition, which they use to remove the outer layer of their mother's modified skin (Kupfer *et al.*, 2006). In contrast to their apparently seasonal reproduction, Measey *et al.* (2008) found that spermatogenesis in this species is aseasonal.

*Conservation status*

Global: Vulnerable (VU). This species has previously been recorded as Least Concern (LC) as it is abundant in both agricultural land and forest and does not appear to suffer detrimental effects from small scale farming. However, here we propose to change the level of IUCN listing, based on the following reasons: (i) This species has a limited altitudinal range (ca. 1200–1900 m) which limits the amount of moist habitat available to it in the Taita Hills; (ii) EOO is estimated to be ca. 400 km<sup>2</sup> and the AOO is 46.95 km<sup>2</sup> (Dawida 38.41 km<sup>2</sup>, Mbololo 7.69 km<sup>2</sup>, Kasigau 0.85 km<sup>2</sup>) and it does not occur in large areas of the Taita Hills of suitable

altitude because they fall within a rain shadow; (iii) soil erosion is of considerable concern in the Taita Hills, particularly at higher altitudes. This species is commonly found in dark fertile soil, but was not traceable in areas where soil erosion has occurred. Given the new data concerning the limited distribution of this species and the habitat loss due to susceptibility to ongoing soil erosion we recommend that this species be moved into a threatened category. While it qualifies for a higher threatened status than Vulnerable in terms of AOO, it is clearly able to adapt to novel habitats, *e.g.* agricultural and plantations. The IUCN listing should reflect this and category VU B2a&b (ii, iii) is recommended here.

***Callulina dawida*** Loader, Measey, de Sá & Malonza, 2009

*Description*

This is a new brevipitid species similar to the East Usambara Mountains endemic *Callulina krefftii* Nieden, 1911 (Barbour & Loveridge, 1928; Menegon, pers. comm.); it differs morphologically on the basis of the degree of digital expansion from other described *Callulina* species (see Loader *et al.*, 2009). *Callulina krefftii* has for years been considered to be a widespread Eastern Arc Mountains endemic present in about ten mountain blocks including Taita Hills (Beentje, 1988). *Callulina kisiwamsitu* de Sá, Loader & Channing, 2004 was the first to be removed from this widespread species as a West Usambara endemic (de Sá *et al.*, 2004). All the other records from the other blocks have been recognized as separate species awaiting description with some mountain blocks having more than one *Callulina* species (Menegon *et al.*, 2008).

A detailed description of *Callulina dawida* distinguishing it from the other two described *Callulina* species is given by Loader *et al.* (2009). In Taita Hills male SUL 26.36–33.30 mm (30.36±2.26), *n*=8, and female 39.55–44.97 mm (42.48±1.99), *n*=8; in life the warty dorsal colour of this frog is quite variable with shades of light yellow through orange, brown to dark brown. In majority of brown individuals, the eyebrows, flanks, hind and fore quarters are normally lighter; ventrum pale but occasionally spotted while the throat of males is slightly mottled.

*Distribution and life history*

This is a species of high elevation indigenous forest. It is only known from forests (1397–2200 m) in Mbololo and Dawida blocks (*e.g.* Ngangao, Chawia, Fururu, Vuria, Ndiwenyi, Mwachora, Boma-Wundanyi). It is believed to be absent from Sagalla and Kasigau. It is mainly nocturnal and primarily burrows under decomposing logs or debris. However, it may also be found walking on leaf litter and perched at some distance off the ground during both day and night. When disturbed, the frog inflates and arches its body, with the head tucked in and when handled it produces a sticky substance by the skin.

The phonetic call is a ‘brrr brrr brrr .....’ repeatedly made during day or night mainly from concealed sites, from June to September. In September 2007, a female was found sitting on ca. 30–40 eggs in a tight clutch (egg diameter *ca.* 2 mm). Hatching occurred after about 3 months *i.e.* end of November. It is likely, as in similar species of brevipitids, that it guards its eggs which develop directly. Majority of the juveniles were mainly found between January and May.

*Conservation status*

We suggest that this species be ranked CR B1a&b (ii, iii) due to the following reasons: (i) geographically it occurs in only two sub-populations (Mbololo and Dawida) that are severely fragmented with an estimated EOO of 168.2 km<sup>2</sup> and AOO of 4.3 km<sup>2</sup>; (ii) restricted to indigenous forests and only within certain altitudinal range (*ca.* 1400–2200 m) and (iii) its habitat quality is declining due to continuing forest disturbance and degradation (see also Loader *et al.*, 2009).

**Other montane forest associated species*****Xenopus borealis*** Parker, 1936*Description*

Taita Hills male SUL of this pipid frog range from 50.71–61.26 mm ( $n=6$ , females 54.96–80.28 mm ( $69.58\pm 10.69$ ),  $n=5$ ). General description of this species can be found in Channing & Howell (2006).

*Distribution and life history*

*Xenopus borealis* is common in the Kenyan highlands as well as parts of Tanzania (Loveridge, 1957; Lötters *et al.*, 2006). This species was found to be locally abundant in permanent ponds, swamps, streams and/or drainage channels in the Dawida block at altitudes of 1397–1814 m throughout the year. It seems likely that this species also occurs in the Mbololo block as habitat characteristics are similar but it is absent from Sagalla Hill.

Calling and mating take place in water. The male produces a slow series of trills or clacks as described by Vigny (1979). In Taita Hills, *X. borealis* has been heard calling and seen in inguinal amplexus in November when they deposit eggs singly and attached to plants or objects in water pools or ponds.

*Conservation status*

Global: LC. The species is locally abundant in permanent water bodies at high altitudes even those within highly disturbed sites.

***Arthroleptis xenodactyloides*** Hewitt, 1933*Description*

Male SUL of this arthroleptid range from 12.14–21.23 mm ( $17.75\pm 1.84$ ),  $n=28$  female SVL 17.25–23.83 mm ( $20.65\pm 1.77$ ),  $n=22$ . Other descriptive characteristics of this frog species can be found in Channing & Howell (2006).

*Distribution and life history*

An eastern Africa leaf litter anuran known from Zimbabwe, Mozambique, Malawi, Tanzania and Kenya (Blackburn & Measey, 2009). In Taita Hills, it is found during both night and day among dead leaves as well as in grassed forest glades from 1293 to 2200 m in Mbololo, Dawida and Sagalla blocks. It occurs in both indigenous and exotic forest plantations including patches within farmlands. A study on gene flow among the Taita Hills sub-populations has found gene exchanges through shared water drainage systems, even between the mountain blocks of Dawida and Mbololo (Measey *et al.*, 2007).

Breeding may take place throughout the year but with peaks during heavy rains (March, November). The call is a brief cricket-like chirp, as described by Channing & Howell (2006) and can be heard during day and night. Usually males vocalize under cover of dead leaves on the forest floor. Amplexus is axillary and occurs during both day and night. Clutches of 13–30 white eggs each within a 4 mm diameter capsule have been found under and/or on leaf litter. Our observations suggest that eggs take about 30 days to hatch directly into miniature frogs at different times until the entire eggs hatch. The size at hatching is about 3.1 mm. Diet as reported from Malawi specimens consists of small terrestrial invertebrates (Blackburn & Moreau, 2006).

*Conservation status*

Global: LC.

***Amietia angolensis*** (Bocage, 1866)*Description*

Male SUL of this pyxicephalid range 51.06–69.18 mm (58.76±5.16),  $n=13$ , female 75.41–90.49 mm (82.77±6.35),  $n=6$  (see general descriptions in Channing & Howell, 2006).

*Distribution and life history*

A widespread riparian species in sub-Saharan Africa. It is present in Dawida and Mbololo blocks at altitudes of 1187 to 1750 m within permanent water streams. It seems quite adaptable to human habitation (*e.g.* it occurs in Wundanyi town stream).

In Taita Hills, males call from the water, often floating near emergent vegetation. The call is biphasic, consisting of a series of clicks and a number of croaks, as described by Channing & Howell (2006). Axillary amplexus occurs and eggs are laid singly in shallow water. Tadpoles were found in shallow almost stagnant water on the edge of streams as well as on manmade dammed ponds for community water schemes. Tadpoles can be up to 60 mm in total length and are light brown and display LTRF 4(2–4)/3(1), but also LTRF 5(2–5)/3(1) and 6(2–6)/3(1) was found in November (Mwambirwa plantation - Mbololo block, *e.g.* NMK A/4470). The larva of this species was described by Channing (2001), reporting LTRF 4(2–4)/3(1–2).

*Conservation status*

Global: LC.

**Notes on selected widespread species*****Mertensophryne taitana*** (Peters, 1878)*Description*

A dwarf toad with SUL males 24.0–33.0 mm (28.11±2.66),  $n=5$ , females 31.63–36.0 mm (33.8±156),  $n=5$  (see also Stewart, 1967; Channing & Howell, 2006 for general description of this species).

*Distribution and life history*

Both nocturnal and diurnal, these terrestrial toads are known from drylands and savannas in eastern Africa with Taita Hills as the type locality. In Taita Hills, *M. taitana* is mainly known from the Mbololo block and two individuals collected in traps in Macha and Mwachora (Dawida) forests in 1998 and 2007, respectively. It occurs at elevations of 1236–1644 m in farmlands and forests plantations.

Axillary amplexus occurs and black eggs in strings and tadpoles have only been found during the November rains in Mbololo farmlands, *e.g.* within road puddles in Macha, Mwasange, Mchanga, Irindiyi and Kilumaluma villages. Aggregations of about 50 individuals were found breeding in the late morning. This species does not have an advertisement call *per se* as sound reception and reproduction mechanisms appears to be absent (Channing & Howell, 2006). Additional breeding details have been provided by Ngwava *et al.* (2009). This, however, reports that the species produces a certain call that draws attention of other toads in the vicinity. The tadpole has been described by Müller *et al.* (2005a) and is conspicuous by having a ‘crown’. This study shows that metamorphosis is short and completed after only 13 days.

In Taita Hills this species is locally rare with a restricted distribution and apparently absent in suitable areas. It is known to breed only during one season of the year within highly vulnerable sites.

*Conservation status*

Global: LC.

***Hyperolius glandicolor*** (Peters, 1879)*Description*

A hyperoliid with male SUL 28.99-30 mm ( $31.61 \pm 1.57$ ),  $n=27$ , that of females 29.34–34.87 mm ( $31.35 \pm 1.60$ ),  $n=23$ ; tibia length almost half SUL; horizontal eye diameter greater than the distance from nostril to anterior corner of eye; pupil horizontal; dorsal snout rounded; tympanum hidden; dorsal skin with scattered warts; foot webbing moderately expressed; subarticular tubercles well-developed, inner metatarsal tubercle small; semicircular terminal discs present in all toes and fingers; in life, females and some of the males, dorsum greatly variable pale grayish to brownish with brown marbling, yellow spots or annuli around warts, majority of males pale brownish or yellowish golden with grey blotches on lateral sides and groin; back of thighs and digits reddish or flesh pink; ventrally white except for the bright yellow gular flap in males.

*Distribution and life history:* A nocturnal frog known from Taita Hills (type locality) and its environs (Schjøtz, 1999). In the study area it is quite abundant in reed swamps and densely vegetated dams, water lily covered ponds as well as grassy water pools within farms, forests and forest plantations. The species occurs in all blocks (at ca. 839–1750 m) but yet to be recorded in Mount Kasigau. The montane population is connected to that of the lowland (e.g. Mwatate and Bura swamps) through permanent water streams. Elsewhere within the region it is present in Ngulia Hills just north of Taita Hills as well as in Lake Jipe and Kitobo forest-Taveta on the south-west of Taita Hills (NMK collection, Nairobi). Where present this frog is locally abundant and adaptable to human habitation.

*Hyperolius glandicolor* is a prolonged breeder and in Taita Hills may reproduce throughout the year with peaks during the March and November rains. Males call from a variety of sites including on the ground, rocks, tree logs, water edge, vegetation growing in or adjacent to water (reeds, sedges, weeds, grasses), on water lily leaves, rocky outcrops and various farm crops. The call is a brief xylophone-like click but males sometimes also produce a creaking aggressive call. Amplexus is axillary and the egg masses are deposited directly into water or on leaves of vegetation above water and then washed into water. The free swimming grey to dark brown tadpoles attain up to 30 mm total length and have LTRF of 1/3 (see NMK A/4352).

*Conservation status*

Global: LC.

***Hildebrandtia macrotympanum*** (Boulenger, 1912)

Morphological description of this ptychadenid is given by Balletto *et al.* (1980). In the Taita Hills, this is typically a lowland species. During this study it was recorded only on the base of Mount Kasigau. The breeding habits of this species were largely unknown (Channing & Howell, 2006). However, the available information from Taita Hills indicate that this species deposits eggs in water of seasonal dams or water holes at the onset of the March (and probably in November) rainfall peaks. Metamorphs, brown and cream in colour, were found on the water edge in Bafwe dam, Kasigau lowland farms in late April during the early hours of night. No adults were found.

*Conservation status*

Global: LC.

***Leptopelis concolor*** Ahl, 1929

General description and distribution of this arthroleptid tree frog is provided by Schjøtz (1999). In Taita Hills this species occur altitudinally from 563 to 1604 m in all the four blocks.

It breeds just after the onset of the rainy seasons in March and November in stream and/or

rock pools as well as in dams. During these periods, males have been heard and observed calling while perched on widely-spaced short shrubs, reeds, tall grass or even on various farm crops and fruit plants. Its breeding was earlier unknown (see Schiøtz, 1999; Channing & Howell, 2006). However, in early December tadpoles were found in seasonal stream rock pools in Mount Kasigau. In late April, cream and green backed metamorphs were found perched on short grass adjacent to a flowing stream at *ca.* 1100 m.

#### Other amphibians recorded in Taita Hills

The following is a list of other amphibians recorded during this study: *Amietophrynus garmani* (Meek, 1897), *Amietophrynus gutturalis* (Power, 1927), *Amietophrynus xeros* (Tandy, Keith & Duff-Mackay, 1976), *Phrynomantis bifasciatus* (Smith, 1847), *Hemisis marmoratus* (Peters, 1854), *Ptychadena anchietae* (Bocage, 1867), *Ptychadena mascareniensis* (Duméril & Bibron, 1841), *Ptychadena mossambica* (Peters, 1854), *Ptychadena schillukorum* (Werner, 1907), *Phrynobatrachus scheffleri* (Nieden, 1911), *Pyxicephalus adspersus* Tschudi, 1838, *Tomopterna cryptotis* (Boulenger, 1907), *Hyperolius tuberilinguis* Smith, 1849, *Kassina senegalensis* (Duméril & Bibron, 1841), *Chiromantis kelleri* Boettger, 1893, and *Chiromantis petersi* Boulenger, 1882.

The following species have earlier been recorded on the surrounding Taita Hills plains but were not recorded during this survey: *Hyperolius sheldricki* Duff-Mackay & Schiøtz, 1971, *Hyperolius pusillus* (Cope, 1862) and *Afrivalus septentrionalis* Schiøtz, 1974.

#### Conclusions

The results presented here demonstrate that the amphibian fauna of the Taita Hills is more diverse than has previously been realised (*e.g.* Loveridge, 1957; Beentje, 1987; Bytebier, 2001; Burgess *et al.*, 2007). *Boulengerula taitana* was previously known only from the Dawida and Mount Mbololo but its range has now been found to extend to Mount Kasigau closed montane forest. *Callulina dawida* was previously only recorded (as *C. krefftii*) on Dawida but was detected also in Mount Mbololo forest.

Species identifications offered here have removed anomalous records. The leaf litter frog *Arthroleptis xenodactyloides* is present in Taita Hills, not *Arthroleptis adolfifriederici* Nieden, 1911 as claimed by Loveridge (1957). The brevicipitid species present in Taita Hills is a new *Callulina* species (see Loader *et al.*, 2009), not the earlier reported widespread EAM endemic *Callulina krefftii* (Barbour & Loveridge, 1928; Beentje, 1988; Burgess *et al.*, 2007).

Surprisingly, certain Eastern Arc Mountains endemic genera such as *Probreviceps*, *Nectophrynoidea*, *Scolecophorus* and *Hoplophryne* are missing from Taita Hills. This could be an indication that the Taita Hills became isolated from the other forest blocks that continued sharing species by having a continuous forest block.

Apparently many of the Taita Hills species represent widespread taxa. However, the percentage of amphibians species associated with montane forest that are endemic to Taita Hills is very high (*i.e.* 50%) an aspect not yet examined in the other EAM. As has been recorded in other EAM the proportion of endemics increases linearly with elevation (see Menegon *et al.*, 2008).

The three montane forest associated species are of conservation importance. The continued survival of these species appears to hinge on the protection of indigenous forest fragments. The CR amphibians (*Boulengerula niedeni* and *Callulina dawida*) could be used to catalyze conservation action in Taita Hills as a key biodiversity area; where a “flagship species approach” is useful. We stress the importance of the protection of a network of both communally and privately owned indigenous forests with some form of connectivity. We also recommend planting of more indigenous than exotic trees on both communal and private lands. Conservation of biodiversity in fragmented habitats requires substantial ecosystem restoration

efforts (Akçakaya *et al.*, 2007). We, therefore, strongly support restoration programmes of gradually replacing exotic plantations with indigenous trees. This would increase the potential habitat area (AOO) available for the Taita Hills CR amphibians.

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**APPENDIX: MATERIAL EXAMINED**

Abbreviations: F, female; M, male; A, catalogue prefix letter for class Amphibia at NMK.

*Boulengerula niedeni* (all from Sagalla): A/4294 (F) Holotype; A/4298/7(F), A/4298/6, A/4298/1(M) and A/4298/3(M) paratypes; A/4262/2 (M), A/4262/4 (F), A/4262/3(F) - Mwalangi; A/4761(F)-Sagalla forest (UTM: S454858, E9612866, 1504 m); A/4672 (M), A/4265/2(F) - Mghange (UTM: S454848, E9614526, 1273 m); A/4261/2 (F), A/4664/12 (F), A/4265/2 (M), A/4262/1(M) - Sagalla; A/4759 (F) - Sagalla valley; A/4802/2 (M), A/4802/1 (M) - Mtangoni (UTM: S453275, E9612860, 1101 m); A/4264/14(F), A/4264/6 (F), A/4264/11(F), A/4264/9 (F) A/4264/15 (F), A/4264/7 (F), A/4264/8 (M), A/4264/10 (M) - Kanyanga (UTM: S453142, E9613034, 1080m); A/4263/1 (F), A/4263/1 (F) - Sagalla forest patch (S454596, E9612536, 1464 m); A/4484/3 (M) - Mwanjika; A/4656 (F) - Kishamba (S454282, E9612844, 1384 m); A/4803 (F) - Mashighati; A/4757/2(F) - Sagalla (UTM: S454221, E9611136, 1389 m); A/4758/1 (F) - Kizumani (UTM: S454041, E9615969, 1139 m).  
*Boulengerula taitana*: A/4335/1 (M), A/4767(M), A/4335/2 (F), A/4752 (M), A/4752 (F), A/4752 (F), A/4752/4 (M) -Ngangao forest (UTM: S426665, E9627510, 1854 m); A/4586/1 (M), A/4586/2 (F), A/4822 (F) - Sungululu plantation (UTM: S428943, E9625202, 1483 m); A/4589/1 (M) - Boma forest (UTM: S428847, E9624462, 1439m; A/4764/4(M), A/4405/3 (F), A/4764/1 (M), A/4405/3 (F), A/4405/4 (M), A/4405/2 (M), A/4405/5 (F), A/4405/1 (M) - Kasigau forest (UTM: S462435, E9577222, 1645 m); A/4336/2 (M), A/4336/1 (M), A/4142/2 (M) - Mghambonyi (UTM: S429199, E9629466, 1546 m); A/4473/3 (F), A/4473/2 (M), A/4473/3(F), A/4473/1 (F) - Mbololo forest (UTM: S438781, E9632602, 1600 m); A/4749/2 (F), A/4749/3 (F), A/4147/18 (M), A/4147/19 (F), A/4147/5 (M), A/4147/10 (M), A/4147/9 (F), A/4147/13 (F), A/4147/3 (F), A/4147/20 (F), A/4147/11 (F), A/4147/14 (F), A/4022/25 (F), A/4022/11 (M), A/4022/17 (F), A/4022/7 (M), A/4022/19 (F), A/4022/26 (F), A/4022/22 (M), A/4022/4 (F), A/4022/23 (M), A/4022/5 (F) - Wundanyi (UTM: S429291, E9624396, 1405 m).

*Xenopus borealis*: A/4536/1 (M), A/4480/2 (M), A/4480/1 (F), A/4536/2 (F)- Wundanyi (UTM: S429291, E9624396, 1405 m); A/4338/2 (M) - Ngangao forest (UTM: S426665, E9627510, 1854 m); A/4339/4 (M), A/4339/3 (M), A/4339/2 (M), A/4339/1 (F) - Mghambonyi (UTM: S429141, E9629362, 1543 m).

*Callulina dawida*: A/4344/1 (F), A/4344/1 (F), A/4344/2 (M), A/3703 (M) - Chawia forest (UTM:S426690, E9615280, 1600 m); A/3617 (F) - Fururu forest; A/4343 (F), A/4594 (F), A/4492 (F), A/4268/1(M), A/4268/2 (M), A/1499 (M) - Ngangao forest (UTM:S426665, E9627510, 1854 m); A/4684 (F) - Mbololo forest (UTM:S438781, E9632602, 1600 m); A/4645 (F) - Boma forest, Wundanyi (UTM:S428847, E9624462, 1439m); A/3647/1 (M), A/3647/5 (M) - Ndiwenyi forest; A/4267 (M) - Kiangungu forest fragment, Iyale (UTM:S426787, 962392, 1705 m).

*Arthroleptis xenodactyloides*: A/4432/4 (M), A/4544/4 (M), A/4544/3 (M), A/4544/8 (M), A/4544/10 (M), A/4544/4 (M), A/4544/1 (F) - Sagalla forest (UTM:S454858, E9612866, 1504 m); A/4538/25 (M), A/4538/26 (M), A/4538/14 (F), A/4538/13 (F), A/4538/4 (F), A/4538/22 (F), A/4538/17 (F), A/4538/23 (F) - Fururu forest (UTM:S426463, E9620811, 1710 m); A/4541 (M), A/4541/1 (M), A/4541/21 (M), A/4541/2 (M), A/4541/25 (M), A/4541/8 (M), A/4541/7 (M), A/451/20 (M), A/4541/14 (M), A/4541/3 (M), A/4541/17 (F), A/4541/9 (F), A/4541/6 (F), A/4541/5 (F), A/4541/4 (F), A/4541/15 (F), A/4538/15 (F),A/4541/15 (F) - Ngangao forest (UTM:S426665, E9627510, 1854 m; UTM:S427057, E9627713, 1774 m); A/4544/9 (M) - Sagalla plantation (UTM:S454790, E9612494, 1345 m; A/4150/1(M), A/4540/16 (M), A/4150/4 (F), A/4150/3 (F), A/3708/2 (F), A/4150/2 (M), A/4540/9 (F), A/4540/11 (M), A/4541/9 (F), A/4540/12 (F) - Mbololo forest (UTM:S43896, E9632681, 1691

m; S438781, E9632602, 1600 m); A/4543/3 (M), A/4543/2 (M), A/4543/5 (M), A/4543/5 (M) - Mwambirwa forest plantation (UTM:S436945, E9629581, 1261 m; UTM:S436945, E9629581, 1300 m); A/4537/20 (M), A/4537/5 (F), A/4537/4 (M) - Chawia forest (UTM:S426690, E9615280, 1600 m).

*Amietia angolensis*: A/4329/1 (F), A/4329/2 (F), A/4329/3 (F), A/4417 (tadpole) - Wundanyi (UTM:S429291, E9624396, 1405 m); A/4328 (F) - Mghambonyi (UTM:S429480, E9629080, 1534 m); A/4691/1(F) - Shingharo; A/3694/1 (F), A/3694/2 (M), A/3694/3 (M) - Chawia forest (UTM:S426690, E9615280, 1600 m); A/4631/1 (M), A/4631/2 (M) - Chale, Mbololo (UTM:S435541, E9631190, 1236 m); A/4637 (M) - Piringa, Mbale (UTM:S430237, E9626134, 1187 m); A/3693/1 (M), A/3693/4 (M), A/3693/2 (M), A/3693/3 (M) - Iyale forest; A/3695/1 (M), A/3695/4 (M), A/3695/3 (M), A/3695/2 (M) - Ngangao forest; A/4470 (tadpoles) - Mwambirwa plantation (UTM:S436798, E9629662, 1327 m).

*Hyperolius glandicolor*: A/4362/1 (F), A/4362/7 (F), A/4362/3 (F), A/4362/11 (F), A/4420/6 (F), A/3702/13 (F), A/3702/26 (F), A/3702/19 (F), A/3702/12 (F), A/4420/4 (M), A/4362/12 (M), A/4362/8 (M), A/3702/4 (M), A/3702/8 (M), A/3702/3 (M), A/3702/14 (M), A/3199/4 (M), A/4352 (tadpoles) - Chawia forest (UTM:S426879, E9615986, 1604 m); A/4439/3 (F), A/4570/2 (F), A/457/1 (M), - Kauze, Sagalla (UTM:S453142, E 9613032, 1081 m); A/4551/3 (F), A/4466/5 (F), A/4466/1 (F), A/4466/9 (F), A/4466/7 (M), A/4551/2 (M), A/4466/7 (M) - Wongonyi, Mbololo; A/4550/4 (F), A/4550/2 (M), A/4550/1 (M), A/4550/5 (M), A/4550/3 (M) - Kiangungu, Iyale (UTM:S426787, E962392, 1705 m); A/4472/2 (F), A/3199/2 (F), A/3199/3 (F), A/3199/1 (F), A/4472/1 (M) - Mwatate dam (UTM:S431351, E9612026, 839 m); A/1445/4 (F), A/1445/3 (M), A/1445/2 (M) - Bura (UTM:S423915, E9613546, 968 m); A/4418/2 (F) - Wundanyi (UTM:S429372, E922405, 1400 m); A/4646 (F) - Piringa, Mbale (UTM:S430237, E9626134, 1187 m); A/4360/2 (M), A/4360/3 (M), A/4360/1(M) - Ngangao forest; A/4504 (M) - Mghambonyi (UTM:S429199, E9629466, 1546 m); A/4490/2 (M), A/4169/1 (M) - Kanyanga, Sagalla (UTM:S453142, E9613034, 1080 m); A/4418/4 (M), A/4418/1 (M) – Wundanyi.

*Mertensophryne taitanus*: A/4591 (M), A/4240 (F) - Mwambirwa plantation (UTM:S436798, E9629662, 1327 m); A/4600 (M) - Mwasange, Wongonyi (UTM:S437290, E 9630988, 1309 m); A/3532 (M) - Macha forest (UTM:S428765, E9622214, 1650 m); A/4780/4 (M), A/4780/3 (M), A/4780/5 (F), A/4780/1 (F), A/4780/2 (F), A/4780/6 (F) - Kilumaluma, Wongonyi (UTM: S436519, E9632041, 1320). A/4526 (Tadpoles)-Mchanga, Wongonyi.