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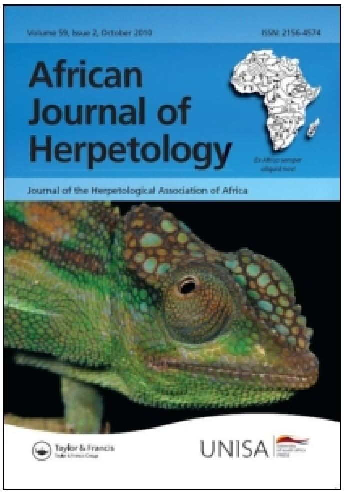

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*Original article*

# A new species of chameleon (Sauria: Chamaeleonidae: *Nadzikambia*) from Mount Mabu, central Mozambique

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**Abstract.**—*Nadzikambia* is a monotypic genus described to accommodate the Mulanje chameleon, *N. mlanjensis.* During herpetological surveys of isolated mountains in Mozambique a population of chameleons was discovered on Mount Mabu. It is referable to the genus *Nadzikambia*, but features of scalation, colouration and genetic divergence distinguish this population from *N. mlanjensis.* It is described as a new species, *Nadzikambia baylissi*, and represents the second species in the genus and the first record of the genus in Mozambique. Notes on reproduction in *N. mlanjensis* are appended. The discovery of the new species in a mid-altitude evergreen forest remnant on Mount Mabu emphasises the high conservation importance of the region, previously signalled by the discovery of a new species of forest viper (*Atheris mabuensis*), and a number of undescribed butterflies and freshwater crab species in the region.

**Key words.**—Chamaeleonidae, *Nadzikambia*, new species, Mount Mabu, Mozambique

Studies on chameleon systematics have proliferated in recent years, stimulated both by increasing access to remote areas and to technological innovations in the analysis of species boundaries and phylogenetic relationships (Townsend & Larson 2002; Matthee *et al.* 2004; Mariaux & Tilbury 2006; Tilbury *et al.* 2006; Tolley *et al.* 2006). It has become increasingly evident that high chameleon diversity is often associated with montane forest habitats (Mariaux & Tilbury 2006; Raxworthy & Nussbaum 2006; Tolley *et al.* 2008), which also face increasing threats from anthropogenic pressure and from predicted climate change.

A suite of small chameleons from East and South Africa, once placed together in the genus *Bradypodion* (Klaver & Böhme 1986), have recently been partitioned, with *Bradypodion* retained for the South Africa radiation and the new genus *Kinyongia* erected to accommodate species from the Eastern Arc mountains of Tanzania and other montane forests associated with the Albertine Rift, Mount Kenya and associated highlands (Tilbury *et al.* 2006). For both of these genera, new species are still being uncovered during faunal surveys to poorly-known areas (Menegon *et al.* 2009; Nečas 2009; Nečas *et al.* 2009; Tilbury & Tolley 2009), and there is increasing insight into their phylogenetic relations and biogeography (Tolley unpub. data). Another small chameleon, *Nadzikambia mlanjensis*, occurs on Mount

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Mulanje, south east Malawi (Broadley 1965), and was previously placed with *Bradypodion* (Klaver & Böhme 1986). It has since been shown not to be closely related to either *Bradypodion* or *Kinyongia* and was placed in a monotypic genus, *Nadzikambia* (Tilbury *et al.* 2006). It remains both a phylogenetic and zoogeographic enigma.

The montane inselbergs of Mount Namuli, Mount Mabu, Mount Chiperone, and Mount Inago occur in Zambezia Province, Mozambique, adjacent to Mount Mulanje (Fig. 1), and all rise over 1500 m a.s.l. Although the herpetofauna of Mount Mulanje is relatively well-known (Broadley 2001; Stevens 1974; WRB pers. obs; M. Cunningham pers. comm. 2006), and includes numerous endemic or near-endemic amphibians and reptiles (WRB pers. obs; M. Cunningham pers. comm. 2006), the reptiles and amphibians of the montane inselbergs of central and northern Mozambique remain largely unstudied. Recently, Branch & Ryan (2001) reported the discovery on Mount Namuli of two lizards, the gecko *Lygodactylus rex* and the leaf chameleon *Rhampholeon platyceps*, that were previously considered endemic to Mount Mulanje, highlighting the possible biogeographic affinities between these neighbouring massifs.

As part of a Darwin Initiative, formal biodiversity surveys of the montane isolates of central Mozambique were initiated (J.R. Timberlake pers. comm. 2009). Mount Mabu (16°17′56″ S, 36°23′44″ E) is an inselberg rising to 1710 m a.s.l., situated in the Zambezia Province of central Mozambique, close to Malawi (Fig. 1). It lies 90 km to the south-east of the much larger massif of Mount Mulanje (3002 m a.s.l.) in adjacent Malawi, and the main peak comprises a granite dome and a few other granitic formations that rise above an undulating forest of between 60–70 km$^2$. Most of the forest lies at medium altitudes, mainly between 1000–1400 m a.s.l., with smaller patches reaching approximately 1 650 m a.s.l. The foothills are clothed in dense transitional woodland and riparian forest to at least 300 m a.s.l., except where replaced by cultivation for tea and eucalyptus plantations (F. Dowsett-Lemaire & R.J. Dowsett pers. comm. 2008).

Although the herpetofauna was not specifically targeted during these surveys, reptiles and amphibians were collected opportunistically, particularly by Julian Bayliss, and forwarded to Port Elizabeth Museum for identification. An early discovery in the forest on Mount Mabu was a new species of forest viper, *Atheris mabuensis* Branch & Bayliss 2009, a genus that had never previously been recorded from Mozambique and which, moreover, represented a substantial southern range extension for the genus. In addition to a new population of *Rhampholeon* sp., an additional chameleon was photographed during the botanical survey of the mountain. This chameleon could not be assigned to any known species, and an additional short trip was made to Mount Mabu in May 2009 to collect material for study. This proved successful and the results of the analysis of this new material are presented below.

# MATERIALS AND METHODS

## Material Examined

In addition to the Mount Mabu material the following specimens were examined from the herpetological collections of Bayworld (formerly Port Elizabeth Museum, PEM) and Transvaal Museum (Pretoria, TM): *Nadzikambia mlanjensis*: PEM R5746, Little

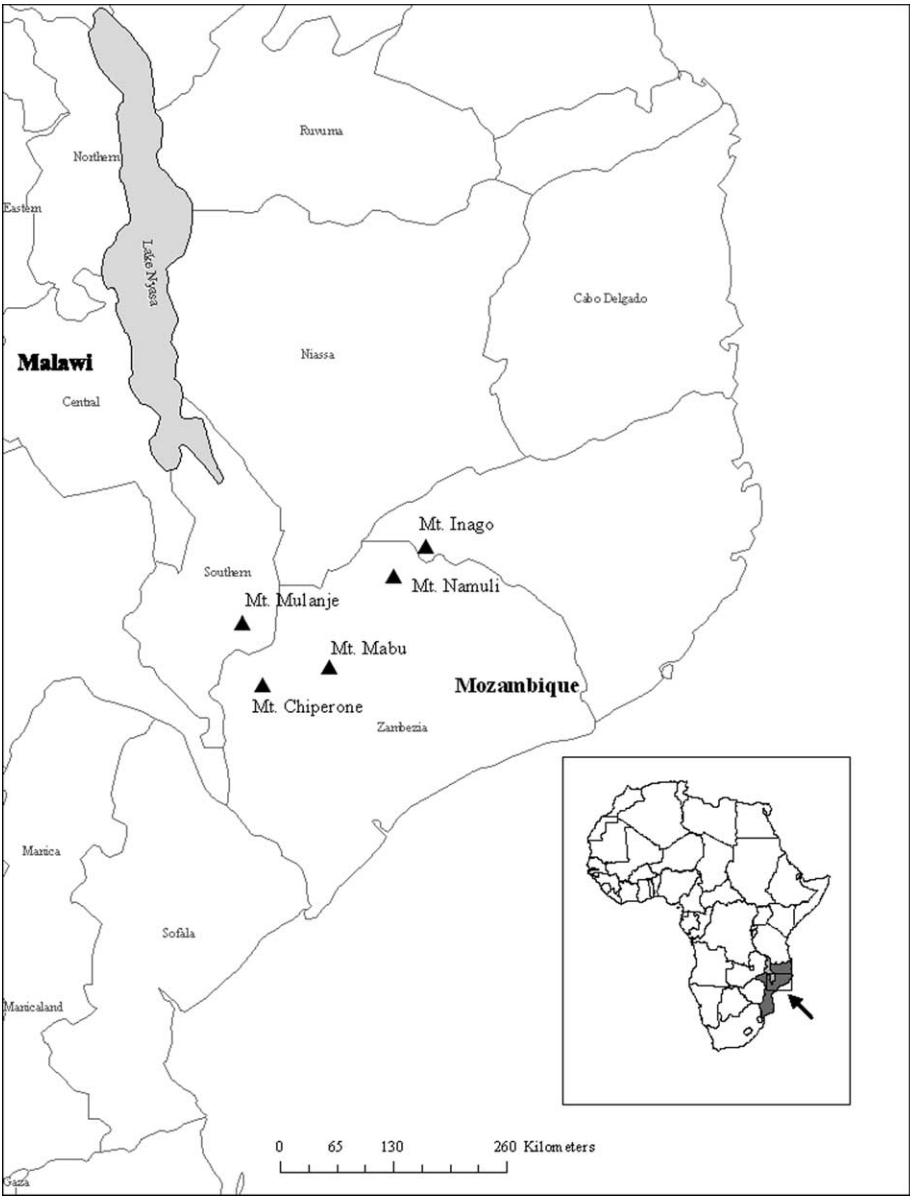

Figure 1. Map showing the location of Mount Mabu, Mozambique and adjacent montane isolates in southern Malawi.

Ruo Gorge, Mount Mulanje, Malawi (1535DC, 15°58′S, 35°41′E), 17 February 1998, C. Tilbury; PEM R16293–94, R16315–16, Lichenya Hut, Mount Mulanje, Malawi (15°58′28″ S, 35°33′02″ E, 1 858 m a.s.l.), M. Cunningham and J. Marais, 18 January 2005; PEM R18142–44, Lichenya Hut, Mount Mulanje, Malawi (15°56′09″ S, 35°35′17″ E), J. Bayliss, 6 July 2009; TM 81523 (previously NMZB-UM29228), Chisambo, Mount Mulanje, Malawi, R.A Stevens, November 1968.

## Morphological Analysis

The following measurements were recorded: snout-vent length (SVL): tip of the snout to the anterior edge of the cloaca; tail length (Tail): tip of tail to posterior edge of the cloaca; total length (TL): combined SVL and tail length; head length (HL): from the tip of the casque to the tip of the snout; head width (HW): width of head (usually just behind eye); head height (HH): rictus of mouth to tip of casque; mouth length (ML): tip of rostral to rictus; casque-eye (CE): diagonal distance from posterior margin of orbit to tip of the casque; snout length (SL): from tip of snout to anterior margin of orbit; eye diameter (ED): horizontal width of orbit; cranial crest gap (CC): width across crown between raised cranial crests at mid-eye; inter-limb length(IL): distance between axillary and inguinal regions; forelimb length (FL): from elbow to wrist; hindlimb length (HL): from knee to heel.

The following scalation details were recorded: upper labials (UL) and lower labials (LL); mid-lateral body scalation (scale shape, whether flattened or tubercular, and whether separated by granules or abutting); scales on crown between cranial crests (whether tuberculate or flattened). Upper and lower labial counts were compared between species using a two-tailed t-test.

Terminology of hemipenial morphology follows Klaver & Böhme (1986).

## Molecular Analysis

To determine the taxonomic placement of the individuals found on Mount Mabu, a phylogenetic analysis was conducted using Bayesian, parsimony and likelihood methods. The analysis included representatives of all other genera in the Chamaeleonidae, except *Calumma*. The outgroup consisted of individuals from the Malagasy genus *Brookesia*, as this has been shown to be sister to all other genera (Townsend & Larson 2002). Sequences from 43 of these individuals have been published previously (Table 1), with the new samples from Mount Mabu (n = 3) sequenced for this study. DNA extraction, PCR amplification, and cycle sequencing of two mitochondrial gene fragments were carried out following standard procedures using the following primers for ND2: L4437b (Macey *et al.* 1997a) and H5934 (Macey *et al.* 1997b), and 16S: L2510 and H3080 (Palumbi 1996). A fragment of the nuclear gene RAG1 was sequenced using primers F118 and R1067 (Matthee *et al.* 2004). Standard PCR and sequencing were followed for this gene fragment, with PCR annealing temperature at 57°C. New sequences have been deposited in GenBank, and matching voucher specimens deposited in the Port Elizabeth Museum (Table 1).

The phylogenetic analyses were run on 46 individuals (including the outgroup) with a combined total of 2167 characters (16S 472bp, ND2 856bp, RAG 821bp). The partition homogeneity test was run in PAUP*4.0b10 (Swofford 2002), and indicated no conflicting signal between the mitochondrial and nuclear markers, so the entire dataset was run simultaneously. Bayesian inference was used to investigate optimal tree space using MrBayes 3.1.0 (Huelsenbeck & Ronquist 2001; Ronquist & Huelsenbeck 2003). The model used included seven data partitions with uniform priors for all parameters with six rate categories: a single partition for 16S (although

Table 1. Sample numbers, collecting localities, voucher accession numbers (PEM, Port Elizabeth Museum; CAS, California Academy of Sciences; ZFMK, Zoologisches Forschungsmuseum A. Koenig), and GenBank accession numbers (16S, ND2, RAG1) for chameleons used in this study. Sequences from 43 individuals were downloaded from GenBank, and three were sequenced for the present study (indicated by *). N/A, no information.

| Genus | Species | Sample ID | Voucher | 16S | ND2 | RAG1 |
|---|---|---|---|---|---|---|
| *Bradypodion* | *damaranum* | KTH145 | N/A | AY756653 | AY756703 | DQ996646 |
| *Bradypodion* | *melanocephalum* | CT016 | PEM R5693 | AY289813 | AY289869 | DQ996647 |
| *Bradypodion* | *pumilum* | KT062 | N/A | AY756639 | AY756689 | DQ996648 |
| *Bradypodion* | *ventrale* | KTH153 | N/A | AY756654 | AY756704 | DQ996649 |
| *Brookesia* | *brygooi* | N/A | N/A | AF121953 | AF448774 | N/A |
| *Brookesia* | *peyrierasi* | N/A | N/A | AF121954 | AF448777 | N/A |
| *Brookesia* | *thieli* | N/A | N/A | N/A | AF448780 | AY662577 |
| *Chamaeleo* | *gracilis* | CT088 | N/A | FJ717748 | FJ717798 | FJ746587 |
| *Chamaeleo* | *gracilis* | PEM R2304 | PEM R2304 | DQ923819 | EF014303 | DQ996658 |
| *Chamaeleo* | *dilepis* var. *quilensis* | CT024 | PEM R5890 | DQ923817 | EF014301 | DQ996656 |
| *Chamaeleo* | *dilepis* var. *quilensis* | CT025 | PEM R5891 | DQ923818 | EF014302 | DQ996657 |
| *Chamaeleo* | *senegalensis* | CT087 | PEM R16627 | FJ717752 | FJ717797 | FJ746590 |
| *Furcifer* | *antimena* | M38 | N/A | FJ717753 | N/A | FJ746591 |
| *Furcifer* | *antimena* | M39 | N/A | FJ717754 | FJ717814 | FJ746592 |
| *Furcifer* | *verrucosus* | M01 | N/A | FJ717755 | FJ717813 | FJ746593 |
| *Kinyongia* | *adolfifriderici* | CAS201593 | CAS201593 | DQ923820 | EF014304 | DQ996659 |
| *Kinyongia* | *carpenteri* | CT345 | PEM R16572 | DQ923821 | EF014305 | DQ996660 |
| *Kinyongia* | *excubitor* | CT209 | PEM R16571 | DQ923823 | EF014307 | DQ996661 |
| *Kinyongia* | *fischeri* | CT201 | PEM R16559 | DQ923827 | EF014311 | DQ996664 |
| *Kinyongia* | *oxyrhina* | CT192 | PEM R16569 | DQ923831 | EF014315 | DQ996669 |
| *Kinyongia* | *tavetana* | CT113 | PEM R5736 | DQ991233 | FJ717801 | DQ996671 |
| *Kinyongia* | *tavetana* | CT207 | PEM R16563 | DQ923833 | EF014317 | DQ996672 |
| *Kinyongia* | *tenuis* | CAS 168917 | CAS 168917 | EF014318 | DQ923834 | N/A |
| *Kinyongia* | *xenorhina* | CT350 | PEM R16570 | DQ923838 | EF014322 | DQ996676 |
| *Nadzikambia* | *baylissi* sp. nov.* | PEM R10854 | PEM R10854 | HM582314 | HM582317 | HM582320 |
| *Nadzikambia* | *baylissi* sp. nov.* | PEM R10855 | PEM R10855 | HM582315 | HM582318 | HM582321 |
| *Nadzikambia* | *baylissi* sp. nov.* | PEM R10856 | PEM R10856 | HM582316 | HM582319 | HM582322 |
| *Nadzikambia* | *mlanjensis* | CT055 | PEM R5746 | AY289860 | AY289918 | DQ996681 |
| *Nadzikambia* | *mlanjensis* | PEM R16294 | PEM R16294 | DQ923841 | EF014325 | DQ996679 |
| *Nadzikambia* | *mlanjensis* | PEM R16315 | PEM R16315 | DQ923842 | EF014326 | DQ996680 |
| *Rhampholeon* | *boulengeri* | Rboulen24 | CAS 201682 | AY524877 | AY524915 | N/A |
| *Rhampholeon* | *marshalli* | Rmarshalli15 | PEMR 16244 | AY524871 | AY524909 | AY524947 |
| *Rhampholeon* | *moyeri* | Rmoyeri29 | MTSN001TA | AY524876 | AY524914 | AY524952 |
| *Rhampholeon* | *platyceps* | Rplatyceps11 | PEMR 16251 | AY524879 | AY524917 | AY524954 |
| *Rhampholeon* | *spectrum* | Rspectrum20 | CAS 207683 | AY524863 | AY524900 | AY524938 |
| *Rhampholeon* | *temporalis* | Rtemporalis3 | PEMR 16255 | AY524867 | AY524905 | AY524943 |
| *Rhampholeon* | *uluguruensis* | Rulugurensis31 | ZMB 48421 | AY524896 | AY524934 | N/A |
| *Rieppeleon* | *brachyurus* | Rbrachyurus5 | PEMR 16264 | AY524899 | AY524937 | N/A |
| *Rieppeleon* | *brevicaudatus* | Rbrevicaudatus4 | PEMR 16257 | AY524888 | AY524926 | AY524963 |
| *Rieppeleon* | *kerstenii* | Rkerstenii23 | CAS 169939 | AY524890 | AY524928 | AY524965 |
| *Trioceros* | *affinis* | CT020 | ZFMK 63063-65 | FJ717756 | FJ717787 | FJ746594 |
| *Trioceros* | *affinis* | CT021 | ZFMK 63063-65 | FJ717757 | FJ717788 | FJ746595 |
| *Trioceros* | *goetzei* | CT050 | N/A | FJ717768 | FJ717791 | FJ746603 |
| *Trioceros* | *herannae* | CT023 | ZFMK 63059-62 | FJ717772 | FJ717790 | FJ746606 |
| *Trioceros* | *johnstoni* | CAS201596 | CAS 201596 | DQ923812 | EF014298 | DQ996650 |
| *Trioceros* | *rudis* | CAS201716 | CAS 201716 | DQ923811 | EF014297 | DQ996653 |

47 bases were removed due to poor alignment) and independent partitions for each codon of the two coding genes ND2 and RAG1. The models were based on a preliminary examination of the dataset using Modeltest 3.6 (Posada & Crandall 1998), whereby both the AIC test specified the most complex model (GTR + I + G) for the combined dataset and for each marker independently. To confirm that this model was not over-parameterised, additional runs were made with only three partitions (one for each marker). To ensure the results converged on the same topology, each MCMC was run twice in parallel for 10 million generations each, with trees sampled every 1000 generations. For all the runs, the first 3 million generations (3000 trees) were removed as burn-in, after examination of the average standard deviation of split frequencies ( $<0.005$), the convergence diagnostic (PSRF values $\sim 1.0$) as well as the log-probabilities and the values of each parameter for stabilisation. The ESS values were checked for all parameters in using Tracerv1.4.1 (Rambaut & Drummond 2007) to ensure the effective sample sizes exceeded 200. The remaining 7000 trees were used to construct a 50% majority rule tree and nodes with $\geq 0.95$ posterior probability were considered supported.

A parsimony analysis was run in PAUP*4.0b10 (Swofford 2002) using the same dataset as in the Bayesian analysis. A heuristic search was run with 1000 random replicates and 100 trees saved each replicate. One thousand bootstrap replicates were run to evaluate confidence in the nodes (100 random addition replicates, saving 50 trees per replicate). In addition, a maximum likelihood (ML) search was run in GARLI (Zwickl 2006), using the GTR model indicated by Modeltest for the combined dataset, with all parameters estimated, and a random starting tree. This analysis was run three times to ensure that independent ML searches produced the same topologies. Nodes with bootstrap support $\geq 70\%$ were considered supported in both these analyses.

## Results

### Morphology

The conservative morphology and body proportions of the Mount Mabu chameleon are very similar to those of *N. mlanjensis*, and few scale counts or meristics differ greatly between the two chameleons. The small number of specimens available (4 from Mount Mabu, 13 *N. mlanjensis* from Mount Mulanje) precludes detailed statistical treatment.

**Crown scalation.**—The scales on the crown as well as those of the cranial crests are raised and tubercular in *N. mlanjensis* (Fig. 2A), unlike the smooth crown scales and reduced cranial crests of the Mount Mabu chameleon (Fig. 2B).

**Labial counts.**—The upper and lower labial scales of *N. mlanjensis* (Fig. 2C) are both significantly larger than those of the Mount Mabu chameleon (Fig. 2D), resulting in significantly higher labial counts in the latter (Table 2).

**Body scalation.**—The lateral body scales of *N. mlanjensis* comprise conical, subcircular scales that are usually separated by granules (Fig. 2E), unlike the abutting, squarish, non-tubercular body scales of the Mount Mabu chameleon (Fig. 2F).

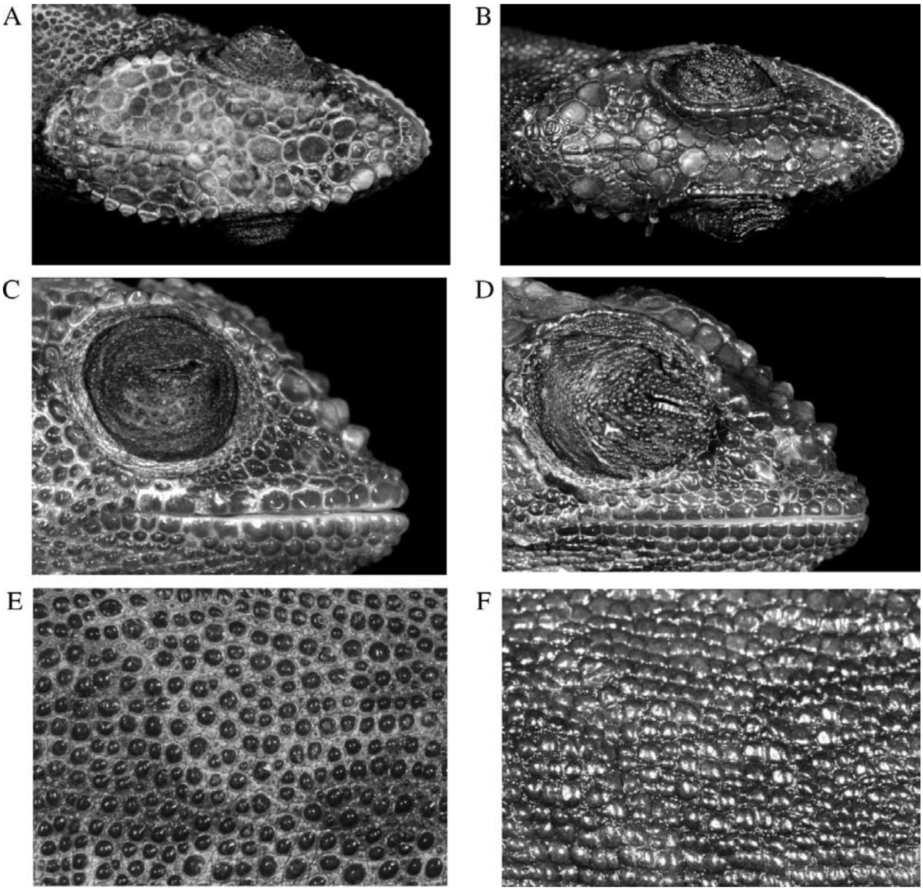

Figure 2. Scalation in *Nadzikambia* (after preservation) for *N. mlanjensis* (male PEM 18445, Lichenja Hut, Mount Mulanje, Malawi), and *N. baylissi* (holotype, PEM 18054), Mount Mabu, Mozambique). (A) dorsal head scales, *N. mlanjensis*, (B) dorsal head scales, *N. baylissi*, (C) labial scales, *N. mlanjensis*, (D) labial scales *N. baylissi*, (E) lateral body scalation, *N. mlanjensis*, and (F) lateral body scalation, *N. baylissi*.

**Tail length.**—Although sample sizes are too low at present to examine tail length differences statistically, it is possible that the Mount Mabu chameleon has a slightly longer tail ratio; TL/SVL: Mount Mabu, mean 1.16, range 1.05–1.25, $n = 3$ (hatchling excluded); *N. mlanjensis*, mean 1.03, range 0.90–1.13, $n = 10$.

**Hemipenes (Fig. 3).**—The everted hemipenes of the Mount Mabu chameleon (PEM R18055) has a short, unadorned pedicel and the asulcal surface of the organ is covered in shallow, non-papillate calyces that are only slightly transversely enlarged and number 8–9 in longitudinal series. The sulcus drains into a large shallow sub-triangular 'cup' on the distal sulcal surface, whilst the sulcal folds are unadorned proximally. Two large, subconical bulges occur mid-truncus on the sulcal surface at the point where the sulcal folds flare to form the distal sub-triangular 'cup'. There are no rotulae or enlarged papillate flaps (sensu Klaver & Böhme 1986). The hemipenis of *Nadzikambia*

Table 2. Sample sizes (N), labial counts and associated statistics for *Nadzikambia mlanjensis* and *Nadzikambia baylissi*. Significance values (*P*) for comparison of labial counts are given.

| | *N* | Range | Mean | Variance | *P* |
|---|---|---|---|---|---|
| Upper labials | | | | | |
| *N. mlanjensis* | 13 | 13–16 | 14.35 | 0.807 | |
| *N. baylissi* | 4 | 16–18 | 17.13 | 0.729 | $<0.001$ |
| Lower Labials | | | | | |
| *N. mlanjensis* | 13 | 15–18 | 16.08 | 0.494 | |
| *N. baylissi* | 4 | 17–19.5 | 17.87 | 1.395 | $<0.01$ |

*mlanjensis*, based on published descriptions (Broadley 1971; Klaver & Böhme 1986) and the everted hemipenes of PEM R18144 (Fig. 3A) and PEM R18445, has a similar shape to that of the Mount Mabu chameleon but it is characterised by two enormous papillate lobes, with the largest papillae grouped on the distal margin (cf. "apical 'wings' with scalloped edges", Broadley 1971, p. 1; see fig. 10, Klaver & Böhme 1986), smaller papillae at the centre of the lobes, and a small group of enlarged papillae at the proximal border of each lobe. The position of the two papillate structures on the apex is similar to that of the rotulae of other chameleons but much more pliable (Klaver & Böhme 1986). Hemipenial morphology differs between the two chameleons in several important features. The hemipenis of *N. mlanjensis* is characterised by paired large apical papillate lobes (absent in the Mount Mabu chameleon), whilst in the latter a pair of subconical bulges border the sulcus (absent in *N. mlanjensis*). These differences are unlikely to be due to season influences on hemipenial development as both the PEM Lichenya chameleons have similar hemipenes despite being collected in different seasons (January and July), whilst the Mount Mabu male was collected in the same season (late May) as one of the Lichenya males.

## Molecular Analysis

The phylogenetic analyses showed that the individuals from Mount Mabu form a well-supported monophyletic lineage, sister to *Nadzikambia mlanjensis* from Mount Mulanje (Fig. 4). Bayesian posterior probabilities for supported nodes and tree topologies were essentially identical for the two models. Overall, both the parsimony and likelihood trees (trees not shown) had the same topology and supported nodes (>75% bootstrap) as the Bayesian analysis. However, in some cases the likelihood search produced higher support values than the parsimony search, which were more on par with the Bayesian analysis. The parsimony analysis produced three equally parsimonious trees (3934 steps, CI 0.41, RI 0.56) that differed only in terminal branch swapping. Although sequence divergence values should not be the sole qualifier for species boundaries (Ferguson 2002), values between the Mount Mabu specimens and *N. mlanjensis* from Mount Mulanje are comparable (*c.*2% 16S, 4% ND2, <1% RAG) to that observed between other chameleon species (e.g. Menegon *et al.* 2009; Tilbury & Tolley 2009).

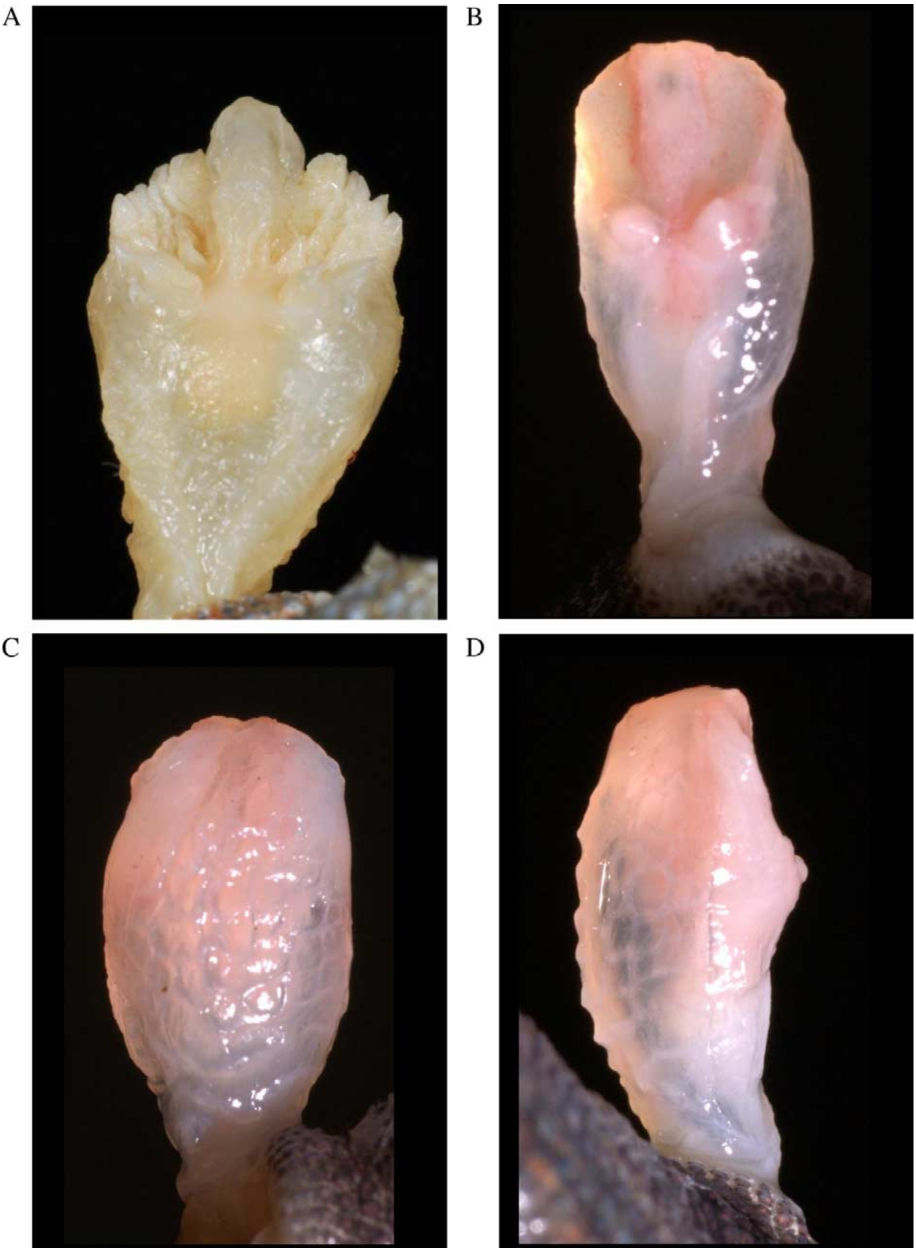

Figure 3. Hemipenes of (A) *Nadzikambia mlanjensis* (PEM R18144, after fixation; sulcal surface). *Nadzikambia baylissi* (male holotype PEM R16365, before fixation), (B) sulcal surface, (C) asulcal surface, and (D) lateral surface.

## Conclusion

The Mount Mabu chameleon can be referred to *Nadzikambia* by possessing a short hemipenis that lacks apical rotulae, a red cap in females, lacking gular and ventral crests, and by genetic monophyly with *N. mlanjensis.* It differs from *N. mlanjensis* in a

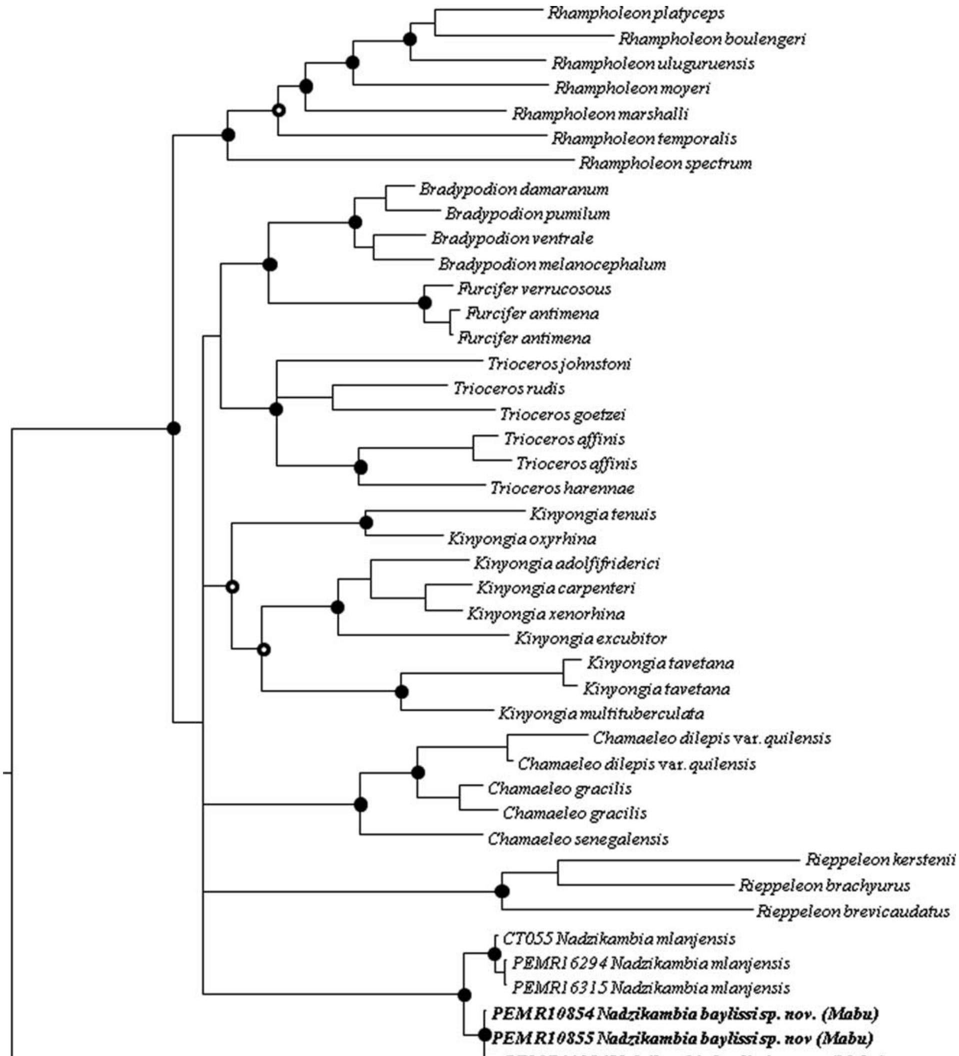

Figure 4. Bayesian majority-rule consensus phylogram for the combined data set for the family Chamaeleonidae, including samples from Mount Mabu (in bold) and Mount Mulanje (*Nadzikambia*). Supported nodes are indicated with circles (filled circles indicate ≥0.95 posterior probability and ≥75% parsimony/likelihood bootstrap, open circles indicate ≥0.95 posterior probability and ≥75% likelihood bootstrap).

number of morphological features, including body and head scalation, labial counts and hemipenial morphology. The phylogenetic tree indicates that chameleons from Mount Mabu are separate to those from Mount Mulanje, but also show sequence divergence values that are comparable to those observed between species in other chameleon genera (Tolley & Burger 2004; Tolley *et al.* 2006; Menegon *et al.* 2009; Tilbury & Tolley 2009). We conclude that the Mount Mabu chameleon is a valid species and take this opportunity to describe it below.

## Systematics

Squamata: Sauria: Chamaeleonidae
*Nadzikambia baylissi* Branch and Tolley **sp. nov.**

**Type material.**—The type series comprises four specimens. The three adult specimens have small ventral incisions where liver tissue was excised for genetic studies; they were fixed in formalin and are currently stored in 50% propanol. A hatchling is undamaged and stored whole in 75% ethanol.

**Holotype.**—An adult male (PEM R18055; Fig. 5A,B) with everted hemipenes, collected by W.R. Branch, J. Bayliss and W. Conradie, 30 May 2009, at the forest base

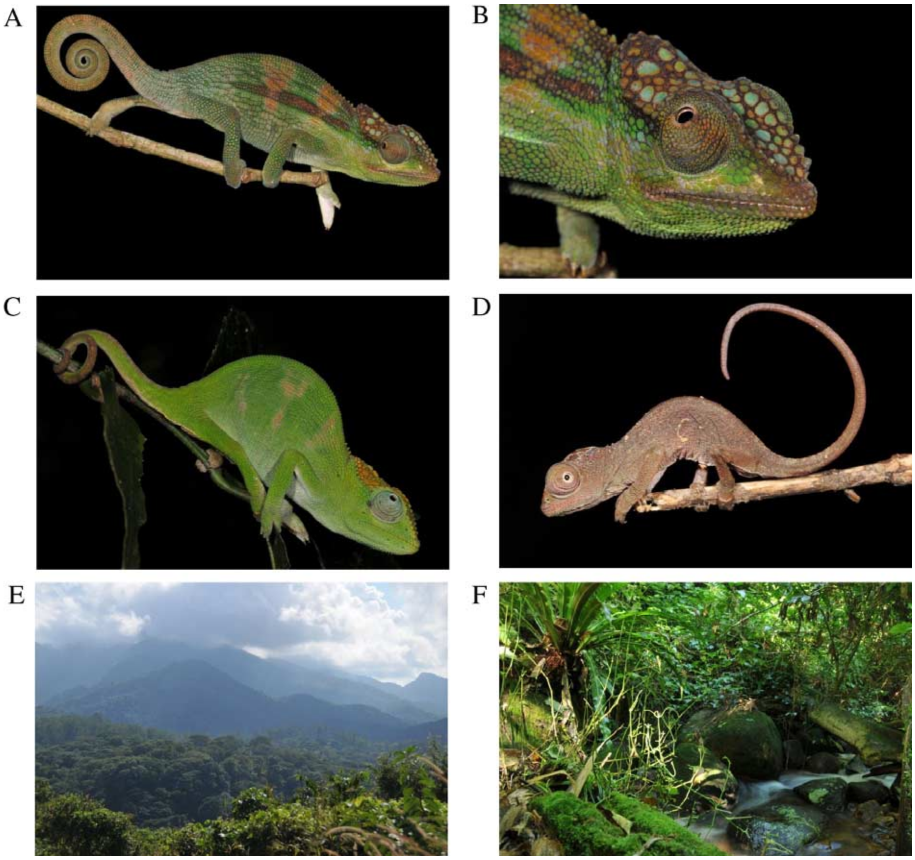

Figure 5. *Nadzikambia baylissi* colour in life, male holotype PEM R18055, (A) whole body, (B) head, (C) female allotype PEM R18054, (D) hatchling paratype PEM 18053, (E) habitat, closed canopy mid-altitude rain forest, and (F) bank of forest stream where the hatchling paratype was collected.

camp in the extensive, mid-altitude forest that nestles under the eastern face of Mount Mabu, Zambézia Province, Mozambique (16°17′10.1″ S, 36°24′02.2″ E, ca. 967 m a.s.l.).

**Allotype.**—An adult female (PEM R18054; Fig. 5C), collected by J. Bayliss, W.R. Branch and W. Conradie, 29 May 2009, same locality details as holotype.

**Paratypes.**—Two specimens, comprising a hatchling (PEM R18053, Fig. 5D), collected by W. Conradie, W.R. Branch and J. Bayliss, 27 May 2009, same locality details as holotype, and an adult female (PEM R18056, collected by J. Bayliss, W.R. Branch and W. Conradie, 2 June 2009, same locality details as holotype.

**Diagnosis.**—The new species can be distinguished from *N. mlanjensis* by its lateral body scalation that comprises often abutting, squarish, non-tubercular body scales (lateral body scales conical, subcircular, and usually separated by granules in *N. mlanjensis*, Fig. 2E); by generally having a higher number of labials, particularly on the upper lip (Fig. 2, Table 2); in having generally smooth scales on the crown of the head (Fig. 2) with a reduced parietal crest (cranial scales rugose and with well-developed parietal crest in *N. mlanjensis*); by having a simple hemipenis with reduced apical ornamentation (a pair of large apical papillate lobes present in *N. mlanjensis*, Fig. 3.), and by monophyly with high support using two mitochondrial and one nuclear marker. Male body colouration may also differ, although this requires confirmation with additional material.

**Description of holotype.**—Adult male, hemipenes everted, a single ventral incision in the chest region. Casque slightly elevated and elongated, rounded behind; crown centrally depressed, surrounding a reduced parietal crest that comprises three enlarged, moderately raised, distinctly keeled scales that increase in size towards the rear; crown demarcated on sides by raised tubercles of the orbital and lateral crests, and to the rear by the casque; temporal crest absent; lateral crest composed of raised, irregular tubercular scales, arising from the mid-upper edge of orbit and deflecting upwards around the casque; orbital crest continuing from lateral crest at the upper posterior quadrant of orbit and forward over eye onto snout, composed of a series of raised, circular, tubercular scales (4) on snout, and as elongate scales (10 right, 9 left) around upper margin of orbit, which are lowest and only partially keeled above the eye; scales of crown flattened, abutting with few interspersed granules, largest in the midline of snout, adjacent to the parietal crest, and alongside the orbital crests above the eye. Body scales relatively homogenous and flattened, abutting and forming rosettes on the lower flanks but separated by fine granular on upper flanks; scales smallest on belly, largest and squarish along flanks and sides of backbone; gular and ventral crests absent; scales on tail homogenous, flattened, squarish, juxtaposed and only slightly larger on dorsal surface than below; scales on limbs homogenous, rounded, separated by minute granules, and largest on outer surface of calf and forearm; tail-length longer than snout-vent length. Nostril rhombic, posteriorly directed, positioned halfway between tip of snout and front of eye, and separated from upper labials by two rows of granules, those adjacent to labials much larger; no enlarged rostral or mental scale; upper labials, 18 (right) and 17 (left), subequal in size; lower labials, 19 on right, 17 on left, subequal in size; scales bordering to lower labials subhexagonal and subequal in size to lower labials; throat grooves fine and inconspicuous.

In life, body basically green with bluish infusion over the sacral region, and with two diffuse orange triangular bars on each flank, the first at the level of the forelimb insertion, and the second just behind midbody; a reddish band extends from behind the eye along mid-flank, petering out on the hind-body, and being partially obscured by the two orange bands; the tail is greenish with orange infusions, particularly on the dorsal surface; venter, inner surfaces of limbs and soles of feet, light blue green. Throat and lower surfaces of head (snout and temporal region) bright lime green with scattered light blue scales, particularly on the temporal region; large flat scales on the crown usually sky blue with dark brown, usually diffuse, borders; scales of eye turrets green, but orange where the red stripe that extends from the flank onto the temporal region, continues diffusely through the eye; snout green-brown (Fig. 5A).

After preservation, total head and body very dark, almost purple-black, all normal colouration lost, except for a very faint thin mid-ventral white line; a pale ring encircles the injection site, and is an artefact of euthanasia.

**Variation.**—Description of allotype (as for holotype, unless noted): adult female with viscera exposed by a single, ragged ventral incision and liver tissue excised for DNA analysis. Scalation similar, differing only on minor details; 3 enlarged scales of parietal crest only weakly keeled; upper labials, 18 on both sides; lower labials, 19 on right, 20 on left. In life (Fig. 5C), body, legs, throat and lower surfaces of head lime green, with belly, inner surfaces of limbs and soles of feet light blue-grey and with a thin white mid-ventral line; flank bars reduced to irregular diffuse orange blotches; upper surface of tail suffused with dirty red-orange, scales covering eyes blue green; crown of head orange-red. In preservative, total head and body very dark, almost purple-black, all normal colouration lost, except for the thin mid-ventral white line.

Description of paratypes (as for holotype, unless noted): PEM R18056, upper labials and lower labials 16 on both sides; PEM R18053, upper labials and lower labials 17 on both sides. In life the hatchling (Fig. 5D) has a uniform, grey-purple colouration. After preservation a prominent mid-ventral white line is present in both the adult female PEM R18056 and the hatchling (PEM R18053).

Measurements for the type series of *Nadzikambia baylissi* are summarised in Table 3. Maximum sizes (SVL + Tail = TL): PEM R18055 (male holotype), 70.5 + 84.0 = 154.5 mm; PEM R18054 (female allotype) 64.7 + 68.0 = 132.7 mm. The hatchling (23.4 + 34 mm) has a proportionately longer tail (tail length/SVL = 1.45; mean 1.16, range 1.05–1.25 in 3 adults). It is possible that *N. mlanjensis* grows to a larger size (largest male (PEM R18445) 83 + 87 = 190 mm, largest female (PEM R5746) 80 + 73 = 153 mm), but larger series are required to confirm this.

Whilst the type series is limited in number, there is little indication of sexual dimorphism, both in colouration and in head ornamentation. The two adult females had prominent red crowns that were not observed in the male. A red crown has been observed in both sexes in *N. mlanjensis*. Broadley (1965, p. 2) noted that in the adult male type of *N. mlanjensis* the "distance between the commissure of the mouth and the extremity of the casque is shorter than the length of the mouth". However, mature males lack an obvious elevated casque in both species of *Nadzikambia*, and the ratio HH/ML is an inconsistent feature with no obvious difference between the sexes: *N. baylissi*: mean 1.04, range 0.93–1.15, n = 3; *N. mlanjensis*: mean 1.07, range 0.93–1.20, n = 9.

**Etymology.**—The patronym honours the outstanding contributions of Dr Julian Bayliss, field organiser of recent surveys undertaken under the auspices of the

Table 3. Measurements (mm) for the type series of *Nadzikambia baylissi.*

| | Museum number (PEM) | | | |
|---|---|---|---|---|
| | R18055 Holotype | R18054 Allotype | R18056 Paratype | R18053 Paratype |
| Sex | M | F | F | Hatchling |
| Snout-vent length | 70.5 | 64.7 | 64.0 | 23.4 |
| Tail length | 84.0 | 68.0 | 80.0 | 34.0 |
| Total length | 159.00 | 132.7 | 144.0 | 57.4 |
| Head length | 22.3 | 19.7 | 19.2 | 6.7 |
| Head width | 10.5 | 9.5 | 10.0 | 3.6 |
| Head height | 14.4 | 11.5 | 12.4 | 5.0 |
| Mouth length | 13.7 | 12.4 | 10.8 | 4.6 |
| Casque-eye | 9.9 | 8.5 | 8.1 | 4.2 |
| Snout length | 6.9 | 6.8 | 6.3 | 2.5 |
| Eye diameter | 7.5 | 6.4 | 5.7 | 3.1 |
| Cranial crest gap | 5.5 | 4.9 | 5.4 | 2.6 |
| Inter-limb length | 40.1 | 38.7 | 38.6 | 15.4 |
| Forelimb length | 12.6 | 11.7 | 11.7 | 4.7 |
| Hindlimb length | 12.1 | 12.3 | 10.7 | 4.8 |

Darwin Initiative to montane isolates in central Mozambique, and which have considerably increased our knowledge of the regional herpetofauna.

**Distribution.**—Restricted to the type locality in evergreen forest on Mount Mabu, Zambézia Province, central Mozambique.

**Habitat.**—All specimens were collected in evergreen mid-altitude wet forest at approximately 1000 m a.s.l. (Fig. 5E). The hatchling paratype (PEM R18053) was collected at night on a small shrub only 15 cm above the forest floor, approximately 10 m from a forest stream (Fig. 5F). It is possible that it had recently emerged from the egg chamber. All three adults were collected from 2.0–3.5 m above ground on small trees. The habitat comprises closed-canopy forest, except for small gaps caused by tree-falls and along stream gullies. Tall trees (up to 40–45 m height) emerge from the canopy, with *Strombosia scheffleri* dominant and others including *Newtonia* sp., *Chrysophyllum gorungosanum*, *Maranthes goetzeniana*, *Ficus thonningii*, *Blighia unijugata*, and *Funtumia africana*. Smaller trees in the understory include *Allophylus* sp., *Canthium* sp., *Oxyanthus speciosus*, *Rawsonia lucida*, *Tabernaemontana ventricosa*, *Vepris stolzii*, and small saplings of *Cola greenwayi*, *Drypetes* sp. and *Maranthes* sp. Canopy lianas are dominated by *Millettia lasiantha* (F. Dowsett-Lemaire & R.J. Dowsett pers. comm. 2008).

**Reproduction.**—Both the female allotype and paratype were collected in late autumn and neither have indication of enlarged embryos or oviductal eggs. *N. mlanjensis*, and thus probably *N. baylissi*, is oviparous. Three adult female *N. mlanjensis* (PEM R16315–16, 13294, SVL 70–78 mm) collected near Lichenya Hut on 18 January 2005 were all heavily gravid, with mature oviductal eggs ready for laying, as was another heavily gravid female (PEM R5746, SVL 80 mm) from Little Ruo Gorge, collected on 17 February 1998. Clutch size for these females averaged 7.5 (n = 4), and the oviductal eggs (n = 19) measured on average 14.9 × 7.3 mm.

**Conservation.**—The species is currently known from a very small area in moist mid-altitude evergreen forest habitat on Mount Mabu that is not formally protected. The forest therefore remains under obvious environmental threats due to habitat destruction following revitalisation of the surrounding tea estate and from adjacent rural shambas. The forest is currently exploited for both subsistence bushmeat and local timber use. It is estimated that c. 7 000 ha of forest remain on Mount Mabu forest and could be threatened by local stochastic events. Concern has already been expressed at the loss of low and mid-altitude forests on Mount Namuli for some bird species of conservation concern, e.g. Cholo Alethe (J.R. Timberlake pers. comm. 2009). According to current IUCN criteria (IUCN 2001) the species should be considered Vulnerable due to its very restricted area of occupancy. Other species of conservation concern in the Mount Mabu forest include the endemic forest viper *Atheris mabuensis* (Branch & Bayliss 2009), a new pygmy chameleon (*Rhampholeon* sp. WRB, KAT pers. obs.; J. Bayliss pers. comm.), and a number of undescribed invertebrates, including freshwater crabs and butterflies (J. Bayliss pers. comm.).

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