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What do we know about the amphibians from the Kenyan central and western highlands? A faunistic and taxonomic review[1]

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Abstract. We reviewed the pertinent faunistic and taxonomic knowledge available from literature and scientific collections on the amphibians from the central and western highlands of Kenya. Fifty-four anuran species in 19 genera and 12 families were recognized. Higher taxa are those also found in adjacent African regions. Exceptions are some genera otherwise known from extreme East Africa which, along with the order Gymnophiona, are absent from the central and western highlands of Kenya. The species *Ptychadena schillukorum, P. taenioscelis* and *Afrixalus osorioi* are reported for the first time from Kenyan territory. The taxonomy of several species is poorly resolved, underlining the need for more alpha-taxonomic effort. This should include the application of modern methods, as molecular markers to uncover cryptic species diversity. We calculated 9.04 ± 6.11 (1-30) localities per species (n = 54) and 3.98 ± 2.88 (1-25) species per locality (n = 127), showing that sampling for both species and localities is of different quality and apparently far from complete. Sampling bias due to accessibility may play a role, and more comprehensive field surveys are suggested. It may be considered that certain amphibians reach their geographic range limits just at the periphery of the Kenyan central and western highlands (e.g. "Congolian" forest taxa) or are restricted to a small distribution within that region.

Key words. Afrotropis, Anura, species list, distribution, East Africa, IUCN Red List.

Introduction

Our knowledge on tropical African amphibians is generally poor (e.g. Poynton 1999). Importantly, our data are ineffectual to understand whether they are suffering declines similar to those seen in other parts of the world (cf. Stuart et al. 2004). According to the on-going 'Global Amphibian Assessment' (GAA), about one fifth of the 948 recognized Afrotropical species (including Madagascar) is threatened with extinction (IUCN Red List categories and numbers of species are as follows: Extinct 0, Critically Endangered 31, Endangered 104, Vulnerable 100; IUCN et al. 2004).

For another fifth, no information about Red List status is available (i.e. 201 species categorized as Data Deficient; IUCN et al. 2004). One message of this finding is that for the development of conservation action plans, more information is needed from the field.

In addition, it is necessary that we expand our alpha-taxonomic research. The taxonomy of many species has not been studied since their descriptions. Others have been treated contrastingly by different authors without providing adequate evidence for the taxonomic treatment (cf. entries in Frost 2004). For many taxa, we lack information about intra- and interspecific variation and what are suitable characters to distinguish species (e.g. Lötters et al. 2004). Although the number of studies is limited, it has been shown that cryptic species diversity plays

[1] We dedicate this publication to the late Alex Duff-MacKay (1939-2003), curator of Herpetology at the National Museums of Kenya, Nairobi, from 1972 to 1995.

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an important role among the amphibians of Africa, especially when bioacoustics or molecular markers are applied (e.g. Channing et al. 2002, Vences et al. 2004, Köhler et al. in press). In other words, it is likely that IUCN Red List categories, as allocated during the GAA, for many amphibian species may be erroneous (probably not only in the Afrotropis), while others can be expected to have been overlooked (cf. IUCN et al. 2004). Only profound faunistic and taxonomic knowledge and the broad availability of such information can help to effectively protecting species from extinction (cf. Golding & Timberlake 2003).

Several authors have contributed to our knowledge on faunistic and taxonomic issues of Kenyan amphibians (cf. Howell 2000 and references listed in methods section). We have focussed on the amphibians from the central and western highlands of this country (Figs. 1, 2). It is our purpose to review the faunistic and taxonomic knowledge from this region to (1) make these data available for purposes apart from amphibian specialists (cf. Golding & Timberlake 2003) and to (2) appraise whether this region falls into the general African picture described or if our data are adequate for effective conservation issues.

Considered area and methods

Major portions of central and western Kenya include more or less continuous highlands above 1000 m above sea level (Fig. 1). Genetically and geomorphologically, this region is characterised by on-going continental drift activities for more than 30 million years (since the Oligocene), especially the formation of the Rift Valley. Altitudinal range is up to about 5000 m above sea level, reached by such volcanic peaks as Mt. Kenya and Mt. Elgon (Fig. 1). Geo-ecologically, the Kenyan central and western highlands are recent (Quaternary) landscapes, representing a transition zone between the Central African humid forests and the humid to dry savannahs in the South, East and North (cf. Ojany & Ogendo 1987). Nowadays, large portions of this region in the South and West are naturally heterogeneously structured, with a mosaic of montane forests and bush land or savannahs. The latter become more continuous towards the eastern and southern periphery. The North of the region displays savannahs and xeric grassland (e.g. WWF 1999).

The entire region, especially its forests in the West, has suffered tremendously from human impact reaching highest numbers of inhabitants per square kilometre for rural areas. As a result, only a few scattered natural or semi-natural areas remain, most of which are protected (Bennun & Njoroge 1999).

A list of species and their known distributions was compiled (Tab. 1). Data were obtained from the scientific collection of the National Museums of Kenya, Nairobi (NMK), and the following literature sources: Andersson (1911), Angel (1924), Barbour & Loveridge (1928), Loveridge (1932, 1935, 1957), Parker (1936), Keith (1968), Schiøtz (1974, 1975, 1999), Drewes (1976), Richards & Schiøtz (1977), Duff-MacKay (1980), Richards (1981), Hardy (1993), Perret (1996), Spawls (1996), Poynton (1997), Drewes & Perret (2000), Largen (2001), IUCN et al. (2004), Lötters et al. (2004), Köhler et al. (2005, in press), Schick et al. (2005), Frost (2004). In taxonomy, we follow Frost (2004) and Frost et al. (2006), unless otherwise stated. Geographical coordinates were taken from maps (Fig. 2, Appendix 1).

Results and discussion

We recognized 54 anuran species in 19 genera and 12 families (Tab. 1). Genera and families are those also found in other regions of East and adjacent Central Africa (see e.g. Loveridge 1957, Laurent 1972, Drewes & van Vindum 1991, Howell 1993, KIFCON 1995, Vonesh 2001, Harper & Vonesh 2006). An exception is the genus *Chiromantis* Peters, 1854 which is absent

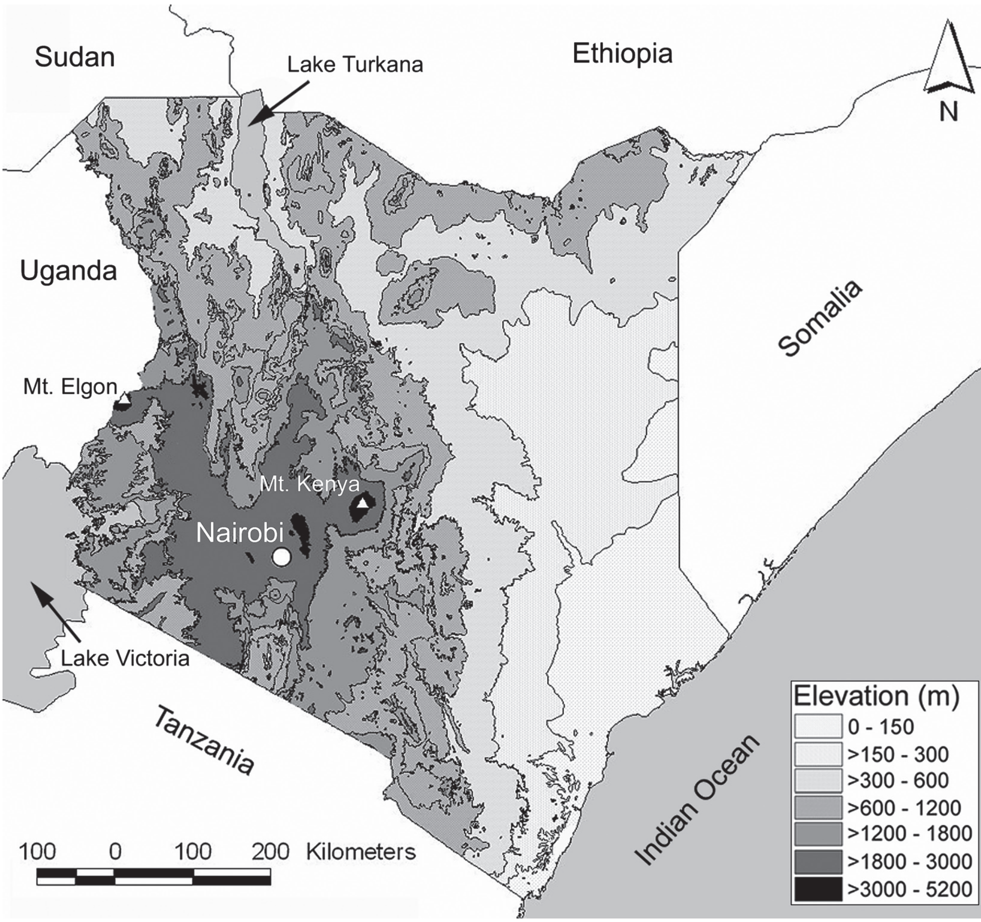

Fig. 1. Map of Kenya showing elevations above sea level and important landmarks.

from the Kenyan central and western highlands but known otherwise from adjacent Uganda as well as coastal Kenya. Anuran genera endemic to easternmost Africa (e.g. *Callulina* Nieden 1911 "1910", *Nectophrynoides* Noble, 1926, *Schismaderma* Smith, 1849) apparently do not range into the central and western highlands of Kenya except *Arthroleptides* Nieden, 1911 "1910".

No caecilians have yet been found in the highlands of central and western Kenya. Species of the genera *Boulengerula* Tornier, 1897 and *Schistometopum* Parker, 1941 are known from southern and coastal Kenya and Tanzania, but have not been reported from Uganda (cf. Frost 2004), although their occurrence there as well as in the central and western highlands cannot be excluded. Caecilians are predominantly subterranean, do not call and are frequently mistaken for earthworms, all of which means that they may easily be overlooked during amphibian surveys.

Among our findings are three anuran species here reported for the first time from Kenya (17, 33, 36 in Tab. 1; Fig. 3A). Their occurrence could have been considered likely as they are known from various localities in

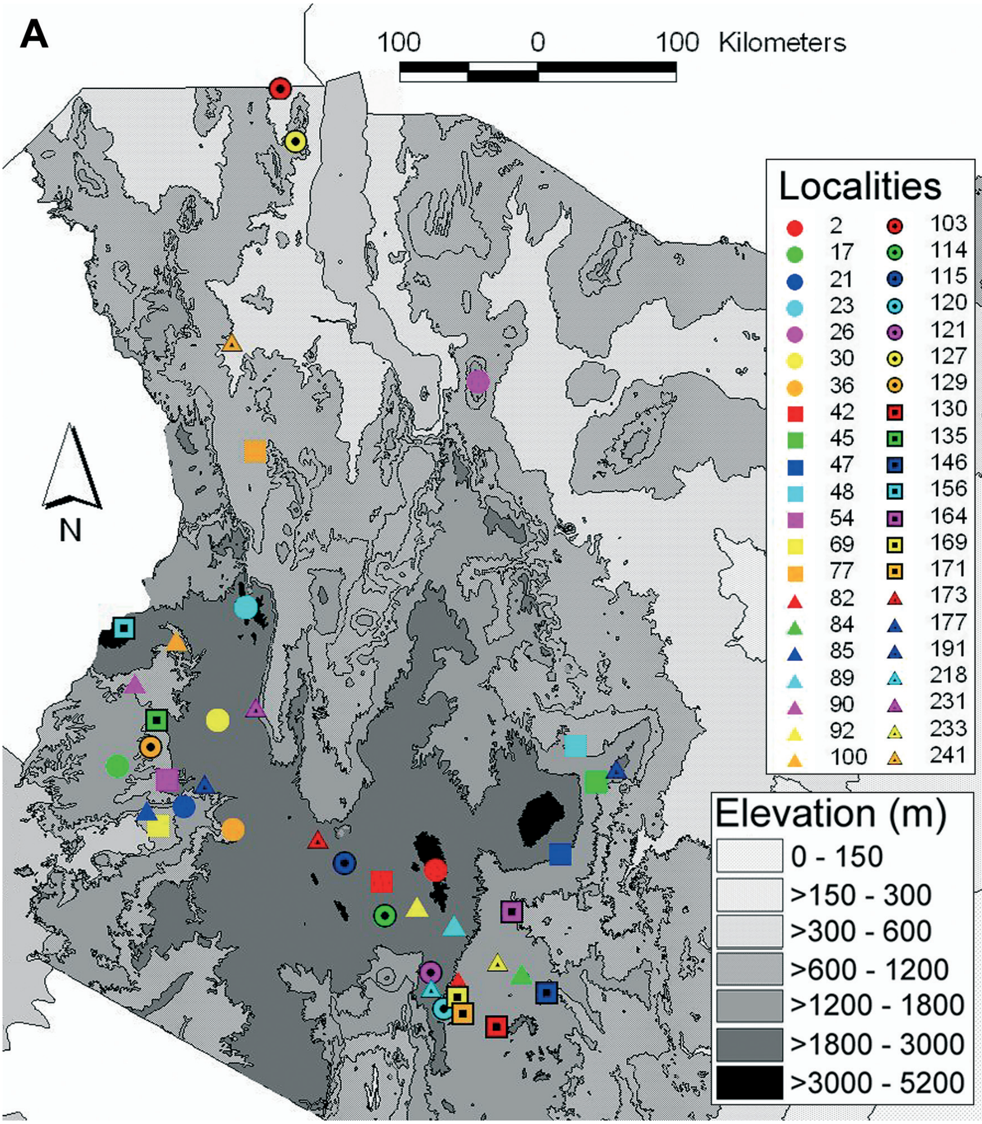

Fig. 2A. Central and western highlands (compare Fig. 1) of Kenya with part of the known amphibian localities. For locality names and coordinates see Appendix 1.

adjacent countries (cf. FROST 2004).

The number of known localities per species is 9.04 ± 6.11, 1-30 (mean ± standard deviation, range; n = 54 species, Tab. 1), while the number of species per locality is 3.98 ± 2.88, 1-25 (n = 127 localities, Fig. 2). We suggest that the large variation in these data is due to two major reasons: (1) Sampling for most localities has been sporadic (i.e. relatively short and/or one to few times) and hence is far from complete. We take the Kakamega Forest, one of the most continu-

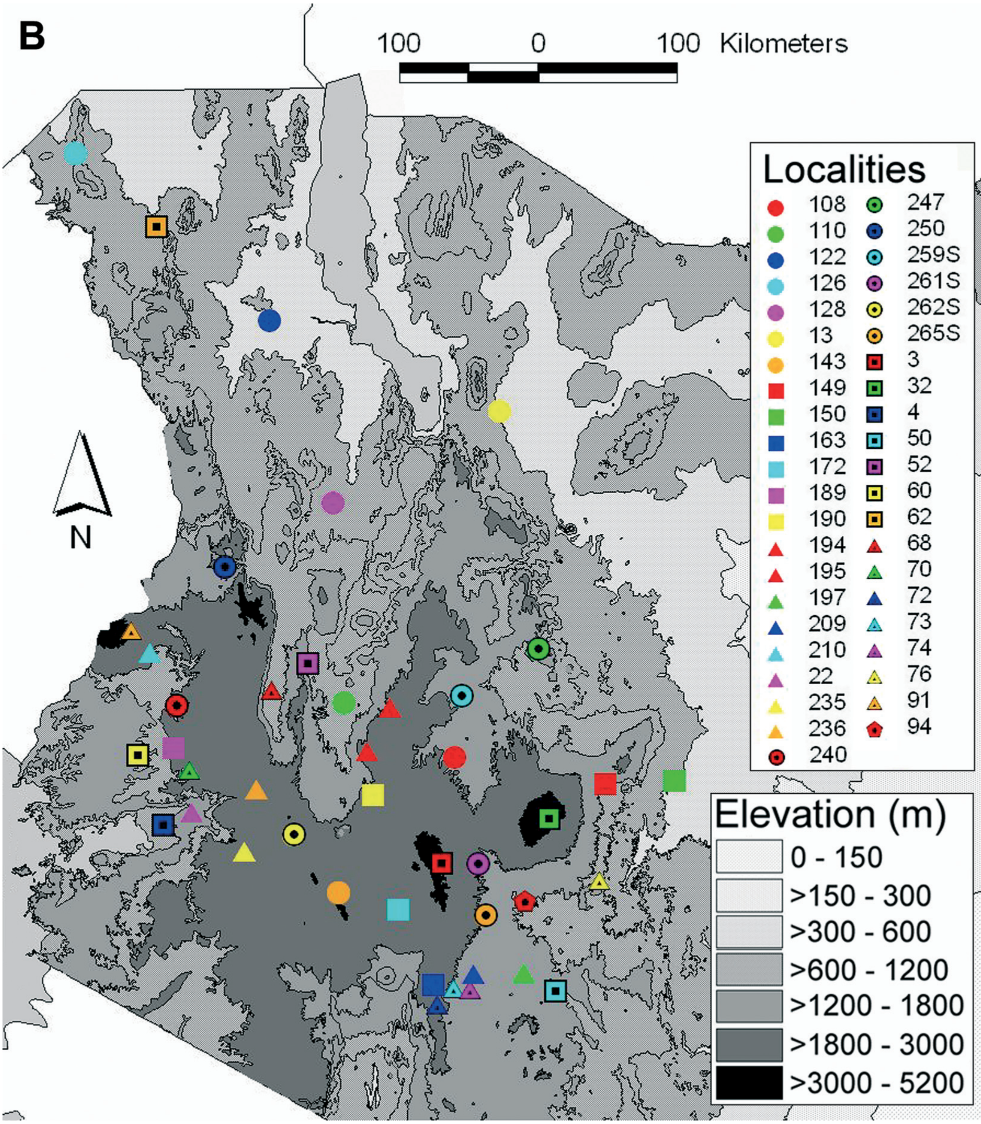

Fig. 2B. Central and western highlands (compare Fig. 1) of Kenya with part of the known amphibian localities. For locality names and coordinates see Appendix 1.

ously sampled and most species-rich sites in Kenya (e.g. Schiøtz 1975, Drewes 1976), as an example to support this view. For the first time, systematic surveys for several months were conducted in 2002 (Veith et al. 2004). Prior to this, 20 species were known, while our constant sampling resulted in the presence of an additional five species (17, 36, 44, 46, 52 in Tab. 1). (2) We expect sampling bias due to selective collecting (e.g. for nocturnal pond species only) and influence from accessibility (cf. Reddy & Dávalos 2003): as

taxon	localities
Pipidae	
1 *Xenopus borealis* Parker, 1936[1]	3, 30, 54, 70, 100, 114, 115, 143, 156, 176, 253S, 259S
2 *Xenopus* sp.[1]	30, 54, 58, 71, 72, 83, 89, 94, 96, 99, 100, 112, 114, 120, 126, 143, 144, 163, 169, 173, 176, 177, 178, 186, 187, 197, 223, 231
Bufonidae	
3 *Amietophrynus garmani* (Meek, 1897)	26, 48, 52, 78, 110, 164, 173, 247
4 *A. gutturalis* (Power, 1927	30, 51, 68, 71, 82, 110, 111, 120, 144, 169, 182, 191, 197, 253, 253S
5 *A. kerinyagae* (Keith, 1968)	42, 92, 94, 96, 112, 114, 121, 157, 172, 188, 260S, 263S, 264S, 265S, 267S
6 *A. kisoloensis* (Loveridge, 1932)	2, 21, 23, 24, 44, 47, 58, 60, 71, 76, 91, 100, 143, 144, 148, 156, 157, 176, 189
7 *A. regularis* (Reuss, 1833)	4, 50, 62, 76, 79, 110, 120, 122, 126, 127, 128, 144, 169, 191, 197, 233, 241, 250
8 *A. vittatus* (Boulenger, 1906)	76
9 *A. xeros* (Tandy, Tandy, Keith & Duff-Mackay, 1976)	48, 110
10 *A. maculatus* (Hallowell, 1854)	17, 58, 71, 76, 99, 108, 129, 135, 144, 171, 197, 206, 241
11 *Amietophrynus* sp.[2]	99, 100, 112, 114, 121, 144
12 *Mertensophryne lonnbergi* (Andersson, 1911)*[, 3]	3, 92, 121, 157, 169, 186
13 *Poyntonphrynus lughensis* (Loveridge, 1932)	62, 103, 122, 126, 128
Microhylidae	
14 *Phrynomantis bifasciatus* (Smith, 1847)	148
Hemisotidae	
15 *Hemisus guineensis* Cope, 1865	72, 87, 120, 121, 169, 171, 218, 233
16 *H. marmoratus* (Steindachner, 1863)	48, 67, 72, 99, 144, 169, 171, 191, 197, 233
Hyperoliidae	
17 *Afrixalus osorioi* (Ferreira, 1906)	58
18 *A. quadrivittatus* (Werner, 1908 "1907")[4]	58, 60, 223
19 *Hyperolius acuticeps* Ahl, 1931[5]	22, 30, 58, 100, 121, 207, 253, 253S
20 *H. cystocandicans* Richards & Schiøtz, 1977*	2, 3, 47, 89, 108, 121, 144, 148, 157, 191, 199, 234, 256S, 260S, 261S
21 *H. glandicolor* Peters, 1878[6]	2, 3, 108, 148, 169, 182, 190, 191, 200, 234, 253S, 256S, 257S, 258S
22 *H. kivuensis* Ahl, 1931[7]	54, 58, 240, 253
23 *H. lateralis* Laurent, 1940	58
24 *H. marmoratus* Rapp, 1842	73, 84, 112, 114, 121, 144, 163, 167, 169, 187, 191, 197, 233
25 *H. montanus* (Angel, 1924)*	2, 3, 24, 89, 92, 121, 148, 149, 157, 178, 186, 190, 191, 234, 235, 256S, 262S
26 *H. viridiflavus* (Duméril & Bibron, 1841)[6]	30, 44, 54, 58, 96, 100, 108, 110, 115, 120, 135, 156, 157, 173, 195, 253
27 *Hyperolius* sp. (aff. *cinnamomeoventris* Bocage, 1866)[8]	22, 58, 100, 156, 176
28 *Kassina senegalensis* (Duméril & Bibron, 1841)	45, 58, 108, 110, 121, 144, 156, 164, 173, 182, 191, 197, 207, 208, 253S
Arthroleptidae	
29 *Arthroleptis stenodactylus* Pfeffer, 1893	144, 191
30 *L. bocagii* (Günther, 1864)[9]	58, 67, 120, 144, 169, 171, 207, 233

taxon	localities
30 *L. bocagii* (Günther, 1864)[9]	58, 67, 120, 144, 169, 171, 207, 233
31 *Leptopelis* sp. [aff. *modestus* (Werner, 1898)]*[, 10]	17, 58
Ptychadenidae	
32 *Ptychadena anchietae* (Bocage, 1867)	5, 36, 48, 58, 62, 71, 73, 85, 110, 144, 173, 191, 194, 207, 240, 241, 243, 247, 253, 253S
33 *P. schillukorum* (Werner, 1908)	110
34 *P. mahnerti* Perret, 1996*	96, 121, 144, 157, 163, 186, 187, 191, 231, 235
35 *P. porosissima* (Steindachner, 1867)	58, 60, 76, 99, 190
36 *P. taenioscelis* Laurent, 1954	58
37 *Ptychadena* sp. [aff. *mascareniensis* (Duméril & Bibron, 1841)][11]	2, 3, 4, 19, 30, 44, 48, 58, 60, 69, 71, 76, 85, 99, 100, 110, 111, 114, 115, 120, 144, 156, 167, 173, 176, 197, 207, 243, 253, 253S
38 *Ptychadena* sp. [aff. *oxyrhynchus* (Smith, 1849)][12]	2, 58, 60, 169
Phrynobatrachidae	
39 *Phrynobatrachus acridoides* (Cope, 1867)	110, 126, 197, 208
40 *P. graueri* (Nieden, 1911)	21, 58, 60, 76, 157, 176, 189
41 *P. irangi* Drewes & Perret, 2000*	2, 47
42 *P. keniensis* Barbour & Loveridge, 1928	2, 23, 73, 74, 92, 94, 121, 144, 157, 163, 187, 191, 195, 199, 233, 236
43 *P. kinangopensis* Angel, 1924*	2, 3, 89, 92
44 *Phrynobatrachus* cf. *minutus* (Boulenger, 1895)[13]	5, 58, 92, 100, 150, 156, 209
45 *P. natalensis* (Smith, 1849)	44, 58, 60, 71, 78, 84, 100, 110, 111, 120, 128, 144, 146, 163, 169, 191, 197, 223, 243, 253S
46 *Phrynobatrachus* sp. (aff. *mababiensis* FitzSimons, 1932)*[?, 13]	48, 58
Petropedetidae	
47 *Arthroleptides dutoiti* Loveridge, 1935*	156
Pyxicephalidae	
48 *Amietia angolensis* (Bocage, 1866)	21, 24, 30, 48, 58, 60, 71, 89, 90, 100, 114, 143, 144, 156, 157, 169, 176, 177, 187, 189, 191, 197, 210, 236, 240
49 *A. wittei* (Angel, 1924)	2, 3, 23, 24, 32, 47, 48, 92, 150, 157, 247
50 *Cacosternum* sp. [aff. *boettgeri* (Boulenger, 1882)][14]	2, 3, 24, 92, 121, 182, 187, 197, 207, 233
51 *Tomopterna cryptotis* (Boulenger, 1907)	48, 62, 108, 120, 121, 122, 126, 128, 130, 182, 241
Dicroglossidae	
52 *Hoplobatrachus occipitalis* (Günther, 1859)	4, 44, 58, 60, 69, 71, 76, 77, 99, 110, 111, 128, 223, 241, 253
Ranidae	
53 *Hydrophylax* cf. *albolabris* (Hallowell, 1856)	54, 58, 60, 100, 240
54 *H. galamensis* (Duméril & Bibron, 1841)	4, 44, 76

Tab. 1. List of amphibians (order Anura) from the Kenyan central and western highlands and their known localities (cf. Fig. 2, Appendix 1). Taxonomy of higher taxa follows Frost et al. (2006) and of species Frost (2004) except where remarks 1-14 (see Appendix 2) are given. New country records are underlined (voucher specimens in order of appearance of species names in list below: NMK A/3927; A/395; A/39551-2). Species endemic to the region are marked by *.

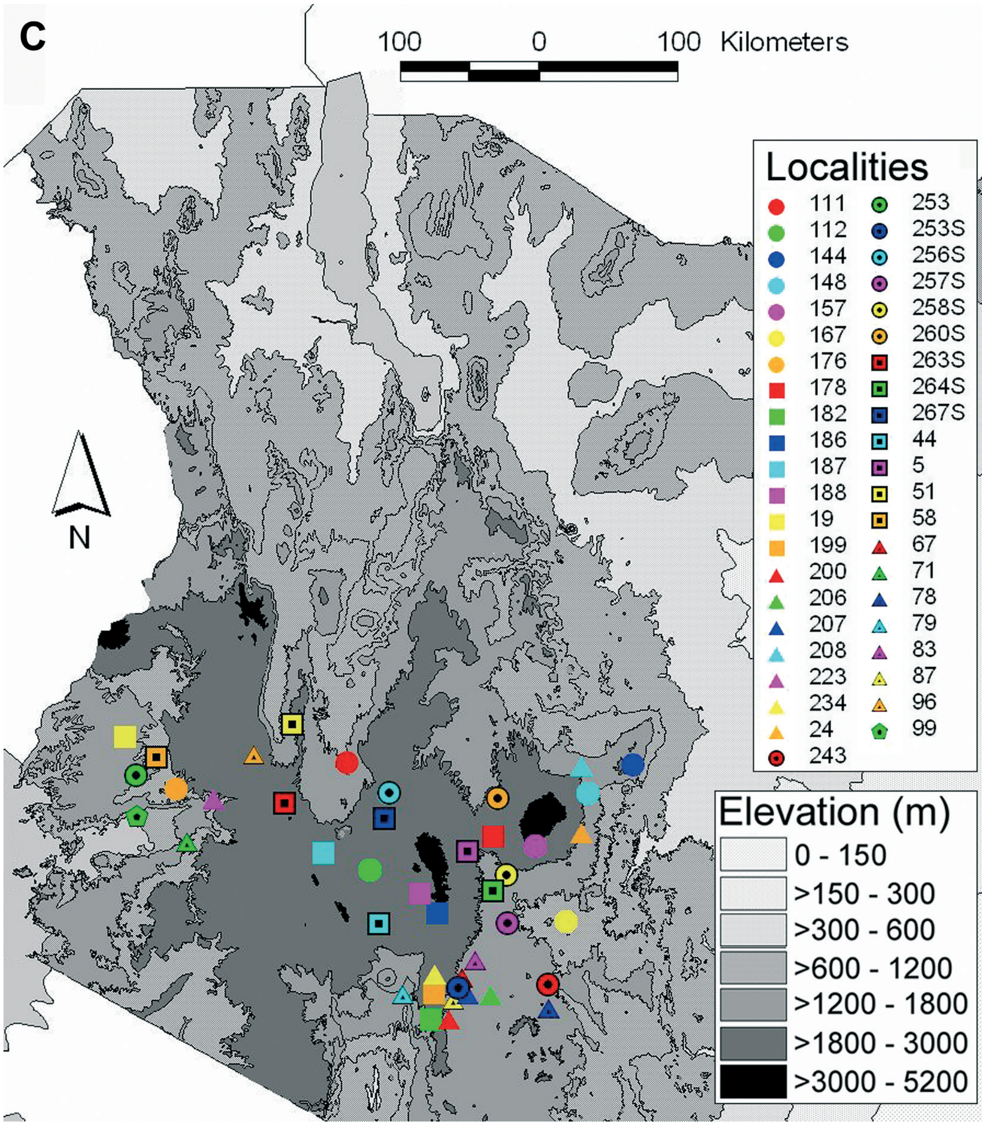

Fig. 2C. Central and western highlands (compare Fig. 1) of Kenya with amphibian localities. For locality names and coordinates see Appendix 1.

shown in Figure 2, most collecting localities are situated in the southern highland and thus comparatively easy to reach due to a close network of roads, while only few roads exist in the north (roads not shown).

It also has to be taken into account that for ecological and/or historical reasons certain species actually display restricted distributions within the central and western highlands of Kenya. There are several taxa

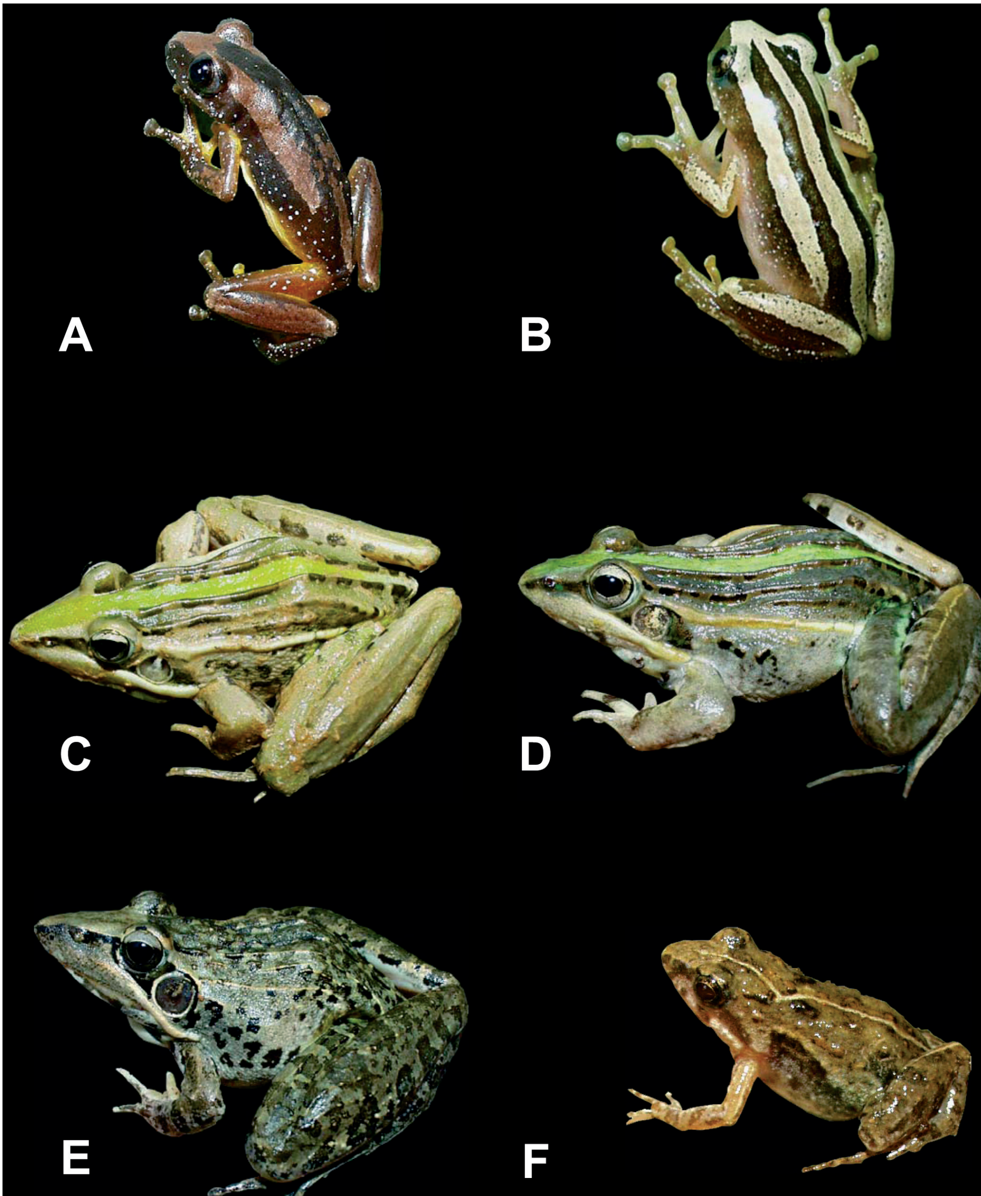

Fig. 3A. *Afrixalus osorioi* from the Kakamega Forest (specimen not collected); B: *A. quadrivittatus* from the Kakamega Forest (specimen not collected); C: *Ptychadena* sp. (aff. *mascareniensis*) from the Kakamega Forest (specimen not collected); D: *Ptychadena* sp. (aff. *mascareniensis*) from Mount Elgon (NMK A/3843); E: *Ptychadena* sp. (aff. *oxyrhynchus*) from the Kakamega Forest (specimen not collected); F: *Phrynobatrachus* sp. (aff. *mababiensis*) from the Kakamega Forest (specimen not collected). Not to scale.

which can be grouped as "Congolian" forest anurans, which are principally distributed in more humid regions west of Kenyan territory (e.g. Uganda). These species do only occur in the forested westernmost parts of Kenya, which can be understood as the periphery of their geographical ranges (e.g. 17, 18, 23, 27, 40, 53 in Tab. 1; cf. Schick et al. 2005). The same may be applicable to bush land or savannah taxa (e.g. 24, 29 in Tab. 1) – they range from east and south into the central and western highlands of Kenya but are generally absent from the humid west. A third aspect to be taken into account is species that are endemic to few localities in the Kenyan central and western highlands. They make up to about 16 % of the known species (see Tab. 1).

As mentioned above, bioacoustics and molecular markers may help to uncover cryptic species diversity. In recent times these techniques have been increasingly applied to resolve the taxonomy of amphibians from the Kenyan central and western highlands (e.g. Lötters et al. 2004, Vences et al. 2004, Köhler et al. in press). We are currently aware of several cases of cryptic species diversity (18, 27, 31, 37, 38, 44, 50 in Tab. 1).

The taxonomy of most amphibians from the region has not yet been studied using bioacoustic or molecular techniques. Therefore, it can be expected that the number of amphibian species in the Kenyan central and western highlands still includes species yet undiscovered.

Conclusion

Compared with other African countries there have been quite a number of studies dealing with amphibian species and their distributions in the Kenyan central and western highlands. Nevertheless, our analysis shows that still more research is needed on both aspects mentioned – field surveys and alpha-taxonomy – to adequately evaluate the conservation status and eventually develop conservation action plans.

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Appendix

List of localities as shown in Figure 2

Because these data were taken from a GIS database for amphibian localities throughout Kenya, numbering of localities in the central and western highlands provided here is not continuous: 2 = Aberdare National Forest Reserve (S0°27.25'/E36°40.74'); 3 = Aberdare National Park (S0°24.89'/E36°42.48'); 4 = Ahero (S0°10.00'/E34°55.00'); 5 = Amboni (S0°19.89'/E36°52.18'); 17 = Bukura, Kakamega (N0°13.11'/E34°37.27'); 19 = Bunyala (N0°25.00'/E34°40.00'); 21 = Chemisia, North Nandi (S0°2.50'/E35°3.00'); 22 = Chemelil (S0°5.10'/E35°6.13'); 23 = Cherangani Hills (N1°15.00'/E35°27.00'); 24 = Chogoria (S0°12.67'/E37°36.39'); 26 = El Kajarta (N2°43.00'/E36°57.00'); 30 = Eldoret (N0°31.00'/E35°16.00'); 32 = Ellis Lake, Mount Kenya (S0°7.50'/E37°24.00'); 36 = Fort Ternan (S0°11.25'/E35°21.98'); 42 = Gilgil (S0°31.82'/E36°19.47'); 44 = Hippo Point (S0°48.00'/E36°18.00'); 45 = Imenti Forest (N0°7.00'/E37°43.00'); 47 = Irangi, Mount Kenya (S0°21.00'/E37°29.00'); 48 = Isiolo (N0°21.00'/E37°35.00'); 50 = Kabaa (S1°14.67'/E37°26.57'); 51 = Kabarnet (N0°29.50'/E35°44.50'); 52 = Kabarsero (N0°53.00'/E35°51.00'); 54 = Kaimosi dam (N0°8.00'/E34°56.00'); 58 = Kakamega Forest (N0°16.77'/E34°52.31'); 60 = Kakamega town (N0°17.10'/E34°45.29'); 62 = Kakuma (N3°43.00'/E34°52.00'); 67 = Kamiti (S1°8.75'/E36°50.50'); 68 = Kam, Narok (N0°42.62'/E35°37.29'); 69 = Kano (S0°10.00'/E34°53.00'); 70 = Kapsabet (N0°11.86'/E35°5.48'); 71 = Kapsorok Valley (S0°16.08'/E35°4.56'); 72 = Karen's, Nairobi (S1°20.03'/E36°41.25'); 73 = Karura Forest (S1°13.43'/E36°47.38'); 74 = Kasarani (S1°13.79'/E36°53.96'); 76 = Katera (S0°31.56'/E37°43.90'); 77 = Katilo (N2°15.70'/E35°30.10'); 78 = Katitu School (S1°20.56'/E37°24.09'); 79 = Kedong Valley (S1°15.00'/E36°27.50'); 82 = Kiambu Forest (S1°10.49'/E36°49.73'); 83 = Kiambu Gachie (S1°2.20'/E36°55.72'); 84 = Kiboko (S1°7.76'/E37°14.28'); 85 = Kibos swamp (S0°4.00'/E34°48.50'); 87 = Kileleshwa (S1°17.19'/E36°46.94'); 89 = Kimande, Muranga (S0°49.00'/E36°48.00'); 90 = Kimilili Stream, Mount Elgon (N0°45.31'/E34°43.79'); 91 = Kimothon River (N1°6.25'/E34°43.25'); 92 = Kinangop plateau (S0°41.50'/E36°33.50'); 94 = Kinyagia, Nyahururu (S0°39.38'/E37°15.00'); 96 = Kipkabus (N0°18.00'/E35°30.00'); 99 = Kisumu (S0°6.00'/E34°45.00'); 100 = Kitale (N1°2.00'/E35°0.00'); 103 = Kokuro (N4°41.54'/E35°40.63'); 108 = Mpala Research Centre (N0°16.82'/E36°47.94'); 110 = Lake Baringo (N0°38.00'/E36°5.00'); 111 = Lake Bogoria (N0°15.00'/E36°6.00'); 112 = Lake Elmenteita (S0°26.50'/E36°15.00'); 114 = Lake Naivasha (S0°45.06'/E36°21.00'); 115 = Lake Nakuru (S0°24.72'/E36°5.36'); 120 = Langata, Nairobi (S1°21.17'/E36°43.74');

121 = Limuru (S1°7.00'/E36°38.50'); 122 = Lodwar (N3°7.00'/E35°36.00'); 126 = Lokichoggio (N4°12.00'/E34°21.00'); 127 = Lokitaung, Turkana (N4°16.00'/E35°46.00'); 128 = Lokori (N1°56.00'/E36°1.00'); 129 = Lubao, Kakamega (N0°20.73'/E34°49.92'); 130 = Lukenya, Machakos (S1°28.50'/E37°4.00'); 135 = Malava (N0°30.67'/E34°52.18'); 143 = Mau Hills (S0°36.00'/E36°3.00'); 144 = Maua, Nyambene Hills (N0°14.00'/E37°56.50'); 146 = Mbiuni (S1°15.43'/E37°23.39'); 148 = Meru (N0°3.00'/E37°39.00'); 149 = Meru District (N0°6.11'/E37°45.70'); 150 = Mount Meru (N0°7.31'/E38°12.32'); 156 = Mount Elgon Forest (N1°6.50'/E34°39.57'); 157 = Mount Kenya (S0°17.54'/E37°18.86'); 163 = Muguga (S1°12.18'/E36°39.40'); 164 = Muranga (S0°43.71'/E37°10.08'); 167 = Mwea (S0°46.64'/E37°30.47'); 169 = Nairobi (S1°17.00'/E36°49.00'); 171 = Nairobi National Park (S1°23.32'/E36°50.91'); 172 = Naivasha (S0°43.00'/E36°26.00'); 173 = Nakuru (S0°15.00'/E35°55.00'); 176 = Nandi Forest (N0°5.00'/E35°0.00'); 177 = Nandi Hills (N0°6.00'/E35°11.00'); 178 = Naro Moru (S0°13.74'/E37°2.03'); 182 = Ngong Hills (S1°25.00'/E36°38.00'); 186 = Njabini, South Kinagop (S0°43.78'/E36°40.52'); 187 = Njoro (S0°20.29'/E35°56.54'); 188 = North Kinangop (S0°36.00'/E36°34.00'); 189 = North Nandi Forest (N0°20.00'/E34°59.00'); 190 = Nyahururu (N0°1.97'/E36°16.03'); 191 = Nyambeni Hills (N0°12.00'/E37°51.00'); 194 = Olarabe River (N0°19.00'/E36°14.00'); 195 = Ol Ari Nyiro Ranch (N0°36.00'/E36°23.00'); 197 = Ol Doinyo Sabuk National Reserve (S1°7.44'/E37°14.55'); 199 = Ondieri swamp, Kikuyu (S1°15.00'/E36°39.50'); 200 = Ongata Rongai (S1°24.88'/E36°45.19'); 206 = Ruai (S1°15.53'/E37°1.30'); 207 = Ruaraka (S1°15.23'/E36°52.56'); 208 = Ruiri, Nyambene (N0°13.38'/E37°36.69'); 209 = Ruiru (S1°8.22'/E36°54.96'); 210 = Saboti (N0°56.98'/E34°50.17'); 218 = Sigona Golf Course (S1°13.04'/E36°39.16'); 223 = Songhor (N0°0.67'/E35°14.34'); 231 = Tambach (N0°36.00'/E35°31.00'); 233 = Thika (S1°3.00'/E37°5.00'); 234 = Tigoni (S1°7.50'/E36°40.00'); 235 = Timbilil, South-Western Mau (S0°20.50'/E35°26.50'); 236 = Timboroa (N0°4.03'/E35°31.14'); 240 = Turbo Paul Boit Dam (N0°36.68'/E35°0.62'); 241 = Turkana District (N2°57.94'/E35°21.35'); 243 = Ulani (S1°11.55'/E37°23.43'); 247 = Wamba (N0°59.00'/E37°20.00'); 250 = West Pokot District (N1°30.73'/E35°19.11'); 253 = Yala swamp (N0°10.00'/E34°44.50'); 253S = Runda (S1°12.55'/E36°48.79'); 256S = Thompson Falls (N0°3.00'/E36°22.00'); 257S = Maragua (S0°47.50'/E37°8.00'); 258S = Karatina (S0°29.00'/E37°7.50'); 259S = Laikipia National Reserve (N0°40.73'/E36°50.68'); 260S = Nanyuki (N0°1.00'/E37°4.00'); 261S = Nyeri (S0°25.00'/E36°57.00'); 262S = Molo (S0°13.42'/E35°45.64'); 263S = Maji Mazuri (S0°1.00'/E35°41.50'); 264S = Wambugu's (S0°35.00'/E37°2.00'); 265S = Fort Hall (S0°45.00'/E37°0.00'); 267S = Sabukia (Sabugo) (S0°7.00'/E36°20.00').

Appendix 2

Taxonomic remarks to Table 1

(1) Clawed frog taxonomy in the Kenyan central and western highlands is not well resolved. Our comparison of sequences of a 560 bp fragment of mitochondrial DNA of the 16S ribosomal gene (for methods see Lötters et al. 2004) revealed that specimens from the Aberdare National Park, Mau Hills and Runda are genetically almost identical [GenBank accession numbers (see http://www.ncbi.nlm.nih.gov): AY493898 (NMK A/3877/1), AY493900 (NMK unnumbered/field number SL 96), AY493901 (NMK unnumbered/field number SL 155)]. Since all these localities correspond to or are geographically close to the localities of the syntype series of *X. borealis* (cf. Frost 2004), we suggest to use this species name for these populations. However, we are aware of at least one additional species from the Kenyan western highlands. *Xenopus* from the Kakamega Forest are genetically divergent from *X. borealis* [GenBank accession number: AY493899 (NMK A/3944)]. The second species may be called *X.* (*laevis*) *victorianus* Ahl, 1924 (cf. Drewes 1976), a form originally described from the Lake Victoria basin and currently a synonym of *X. laevis* (Daudin, 1802) (see Frost 2004). However, at least the 560 bp fragment of mitochondrial DNA of the 16S ribosomal gene from Kakamega material is not identical to *X. laevis* as available at GenBank (GenBank accession number Y10943). We provisionally treat all specimens, we cannot allocate to *X. borealis* here as *X.* sp.

(2) A species we have not been able to identify. It was formerly allocated to *Amietophrynus latifrons* (Boulenger, 1900) (e.g. Duff-Mackay 1980) which appears to be a different species from western Central Africa.

(3) Poynton (1997) suggested that a species complex is hidden behind the name *Mertenso-*

phryne lonnbergi and that both or one of the forms treated as synonyms by previous authors, *M. lonnbergi nairobiensis* (Loveridge, 1911) and *M. mocquardi* (Angel, 1924) from the Kenyan central highlands, may deserve subspecific or specific status.

(4) Banana frogs, genus *Afrixalus,* with the three-line-pattern on dorsum are distributed from West to East Africa. Their taxonomic status has been controversially discussed; currently populations are regarded as conspecific under the name *Afrixalus fulvovittatus* (Cope, 1861 "1860") (see Schiøtz 1975, 1999, Frost 2004). However, not all authors hold this view (cf. Rödel 2000), underlining the need of a comprehensive revision. We have evidence from comparative analyses of DNA sequences that actually several cryptic species are included (senior author and collaborators, unpubl.). According to Frost (2004), five names, currently junior synonyms of *A. fulvovittatus,* are available: two were based on material from Liberia, one from Angola, one from Cameroon, and one was described as *Megalixalus leptosomus quadrivittatus* Werner, 1908 "1907" from "Khor Attar, Sudan" (syntypes at Naturhistorisches Museum Wien, NHMW 3723). Because Khor Attar is located only some hundred kilometres from our Kenyan record, we hereby exclude the name suggested by Werner from the junior synonymy of *Afrixalus fulvovittatus* and apply it to Kenyan material as *Afrixalus quadrivittatus* (cf. Schiøtz 1974, 1975; Köhler et al. 2005) (Fig. 3B).

(5) Channing et al. (2002), based on bioacoustics, provided evidence that *Hyperolius nasutus* Günther, 1865 "1864" comprises a complex of three species at least. The name *H. acuticeps,* as used by these authors, appears to be well applicable to populations from the central and western highlands of Kenya (cf. Lötters et al. 2004).

(6) In previous contributions, e.g. Schiøtz (1999, see also references cited therein), *Hyperolius viridiflavus* was termed a "superspecies". Wieczorek et al. (1998) used molecular markers to discriminate intra- from interspecific variation represented by the numerous forms or colour variants of *Hyperolius viridiflavus* sensu lato. According to them, two species occur in the Kenyan central and western highlands: *Hyperolius glandicolor* and *H. viridiflavus,* as used here. Apart from junior synonyms elsewhere, the following nominal species described from the Kenyan central highlands are identical with *H. glandicolor* (see Frost 2004)*: Hyperolius bergeri* Ahl, 1931; *H. coeruleopunctatus* Ahl, 1931; *H. ferniquei* (Mocquard, 1902); *H. pantherinus* (Steindachner, 1891); *H. platyrhinus* (Proctor, 1920); *H. pulchromarmoratus* Ahl, 1931; *H. symmetricus* (Mocquard, 1902). *Hyperolius viridiflavus* is also suggested to have several junior synonyms, but none of which in the Kenyan central and western highlands.

(7) *Hyperolius bituberculatus* Ahl, 1931 from Rwanda, used as a subspecific name for Kenyan *H. kivuensis* by previous authors (see Schiøtz 1975) is a junior synonym of *H. kivuensis* (Lötters et al. 2004).

(8) As mentioned by Lötters et al. (2004), the name *Hyperolius cinnamomeoventris* comprises at least two cryptic species; the one which occurs in East Africa may be *H. ituriensis* Laurent, 1943, *H. wittei* Laurent, 1943 both described from the Democratic Republic of Congo (cf. Frost 2004) or even un unnamed taxon.

(9) *Leptopelis bocagii* is suspected to comprise several cryptic species (see Schiøtz 1999, Frost 2004. Schiøtz (1975: 17) discussed without conclusion the status of a population from the Kakamega Forest, which probably deserves status as a distinct species. If so, it might be endemic to the region.

(10) As already proposed by Schiøtz (1975, 1999), *Leptopelis* populations from western Kenya which are similar to *L. modestus* represent a distinct species, as pointed out by Köhler et al. (in press), based on DNA taxonomy and bioacoustics.

(11) Using molecular markers, Vences et al. (2004) pointed out that *Ptychadena mascareniensis* is a complex of cryptic taxa. Further taxonomic revision is needed to allocate scientific names. It seems that *P. mascareniensis* sensu stricto is a species exclusively distributed on Madagascar, the Mascarenes and the Seychelles. In Kenya, two species are suggested to occur (Figs. 3C, D), one in the western (e.g. Kakamega Forest) plus another one in the central and western highlands (e.g. Aberdare National Park, Mt. Elgon Forest). According to Vences et al. (2004), the latter may most probably be called *Ptychadena nilotica* (Seetzen, 1855), while the western form may be called *P. venusta* (Werner, 1908).

(12) In a recent phylogeographic study by Vences et al. (2004), one *Ptychadena* species from the Kenyan central and western highlands was nested with *P. schubotzi* (Sternfeld, 1917) from West Africa and *Ptychadena oxyrhynchus* (Smith, 1849) from South Africa but appears to represent a distinct species. The taxonomic status of Kenyan

material (Fig. 3E) remains unclear; it is morphologically most similar to *P. oxyrhynchus*.

(13) Comparing the sequences of a 560 bp fragment of mitochondrial DNA of the 16S ribosomal gene (S. Schick et al., unpubl; for methods see Lötters et al. 2004), we have been able to identify two species of small *Phrynobatrachus* from the Kenyan central and western highlands. They are even syntopic in the Kakamega Forest. The taxonomy of these 'Little Brown Frogs' is difficult, however. Most material, based on morphology, has been assigned to *P. minutus* (originally described from Ethiopia), while Hardy (1993) for the first time applied the name *P. mababiensis* (originally described from South Africa) to Kenyan material. We here tentatively use the name aff. *mababiensis* for the material collected by Hardy (1993) and that belonging to one of the two species from the Kakamega Forest (cf. Fig. 3F), because the latter proved genetically related to but not identical with *P. mababiensis* from South Africa (S. Schick et al., unpubl.). For the remaining populations we provisionally use the name *P.* cf. *minutus*, awaiting further revision. Two unidentified species of *Arthroleptis* Smith, 1849 reported by Drewes (1976) apparently represented *Phrynobatrachus* species (R.C. Drewes, pers. comm.).

(14) According to M. Burger (pers. comm.), *Cacosternum* specimens from the Kenyan highlands studied by him and collaborators represent an undescribed species. It is related to *C. boettgeri* but distinguished in bioacoustic and morphological characters. We tentatively suspect all material from the Kenyan central highlands to belong to one species which is unnamed.

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