# New country records of *Adolfus africanus* (Sauria: Lacertidae) – a rain forest lizard with disjunct distribution?

JÖRN KÖHLER, PHILIPP WAGNER, STEFANIE VISSER & WOLFGANG BÖHME

**Abstract**

The lacertid lizard *Adolfus africanus* is recorded from Kakamega Forest, western Kenya, and Imatong Mountains, southern Sudan. Both localities represent first country records for the species. Kakamega Forest constitutes the easternmost locality for *A. africanus* which was also recorded from Cameroon. The known distribution of this rain forest species is reviewed and discussed in a biogeographical context.

Key words: Reptilia: Sauria: Lacertidae: *Adolfus africanus*; Kenya; Sudan; first records; distribution; biogeography.

## Introduction

In sub-Saharan Africa lacertid lizards are represented by 12 genera. Currently, four valid species are recognised in the genus *Adolfus*. *Adolfus alleni* (BARBOUR, 1914) is a mountain endemic known only from high moor lands of Mt. Kenya, Aberdares, the Cherangani Hills and Mt. Elgon in Kenya and adjoining Uganda. In comparison, *Adolfus jacksoni* (BOULENGER, 1899) and *A. vauereselli* (TORNIER, 1902) both have a wider distribution, although their range is restricted to mid-elevations in East Africa and the easternmost Republic of the Congo. Whereas *A. jacksoni* seems to be most tolerant to human disturbance, *A. vauereselli* is considered a forest species (ARNOLD 1989, SPAWLS et al. 2002). Thus the distribution for the three species mentioned is predominantly East African. A remarkable exception is *Adolfus africanus* (BOULENGER, 1906), described from the northern shore of Lake Victoria, Entebbe, Uganda, and also known from the countries of Rwanda, eastern Democratic Republic of the Congo, Zambia and Cameroon (e. g. MERTENS 1968, BROADLEY 1991, SCHMITZ et al. 2000, SPAWLS et al. 2002). As far as known, it is the only species of *Adolfus* occurring in western Africa. Since there are no records from the central Congo basin, a disjunct distribution pattern may be assumed, although some authors suggested that *A. africanus* is likely to inhabit the area in-between (e. g. SPAWLS et al. 2002).

The purpose of this contribution is to (1) provide new distribution data for *A. africanus*, (2) re-analyse its known distribution and (3) discuss the findings in a biogeographical context.

## New records

Kenya: Zoologisches Forschungsinstitut und Museum Alexander Koenig, ZFMK 81205-07, P. WAGNER field numbers (specimens will be deposited in the National Museums of Kenya, Nairobi) PW13-14, Buyangu, 00°20'N, 34°51'E, leg. P. WAGNER, April-June 2003; ZFMK 77457, Isecheno, 00°17'N, 34°54'E, leg. W. FREUND & J. KÖHLER, 18 October 2002. All localities are within Kakamega Forest, Western Province, Kenya, approximately 1650 m a.s.l.

The specimens exhibit all typical characteristics of *A. africanus*: green coloured venter, head and a mid-dorsal band copper-bronze, lateral white round spots and a nostril separated from first upper labial (Fig. 1).

Generally, the area of Kakamega Forest constitutes of tropical highland rain forest with an annual precipitation of approximately 2000 mm (ROUND-TURNER 1994), distributed mainly in two rainy seasons (March to June and Nov./Dec.). However, heavy down-pours might occur even during the dry season. The specimen ZFMK 77457 is a subadult (body-length 31 mm) and was recorded from the southern part of Kakamega Forest. It was captured during daytime (app. 11:00 h) in disturbed rain forest under a fallen log. The forest of Isecheno is intensively used by the local population. Collection of fuel wood and small-scale logging are major factors of disturbance. However, the most striking character is an open understorey and a heavily degraded soil surface and leaf litter zone, caused by large numbers of cattle brought to the forest for grazing. The other specimens were recorded from the northern part of Kakamega Forest which has the protected status of a National Reserve. Forest utilisation is not allowed but takes place on a small scale. The degree of disturbance varies from almost not present to moderate. These specimens were caught in pitfall traps placed in small forest clearings or found perching on a leaf of a Guava tree at daytime (app. 70 cm above the ground). All individuals were recorded from places where small clearings are present and sunlight is able to penetrate the canopy.

Fig. 1. Subadult specimen of *Adolfus africanus* from Isecheno, Kakamega Forest, Kenya (ZFMK 77475).

Subadultes Exemplar von *Adolfus africanus* aus Isecheno, Kakamega Forest, Kenia (ZFMK 77475).

Sudan: ZFMK 41093, Telanga Forest, Imatong Mountains, Sharq al Istiwâ'Îyah, Sudan, 900 m a.s.l., approximately 04°00'N, 32°40'E, leg. E. WEDERKINCH, December 1980.

The Imatong Mountains, together with the Dongotona and Didinga Mountains, are almost isolated from other mountain ranges and rise up to 3180 m a.s.l. at Mount

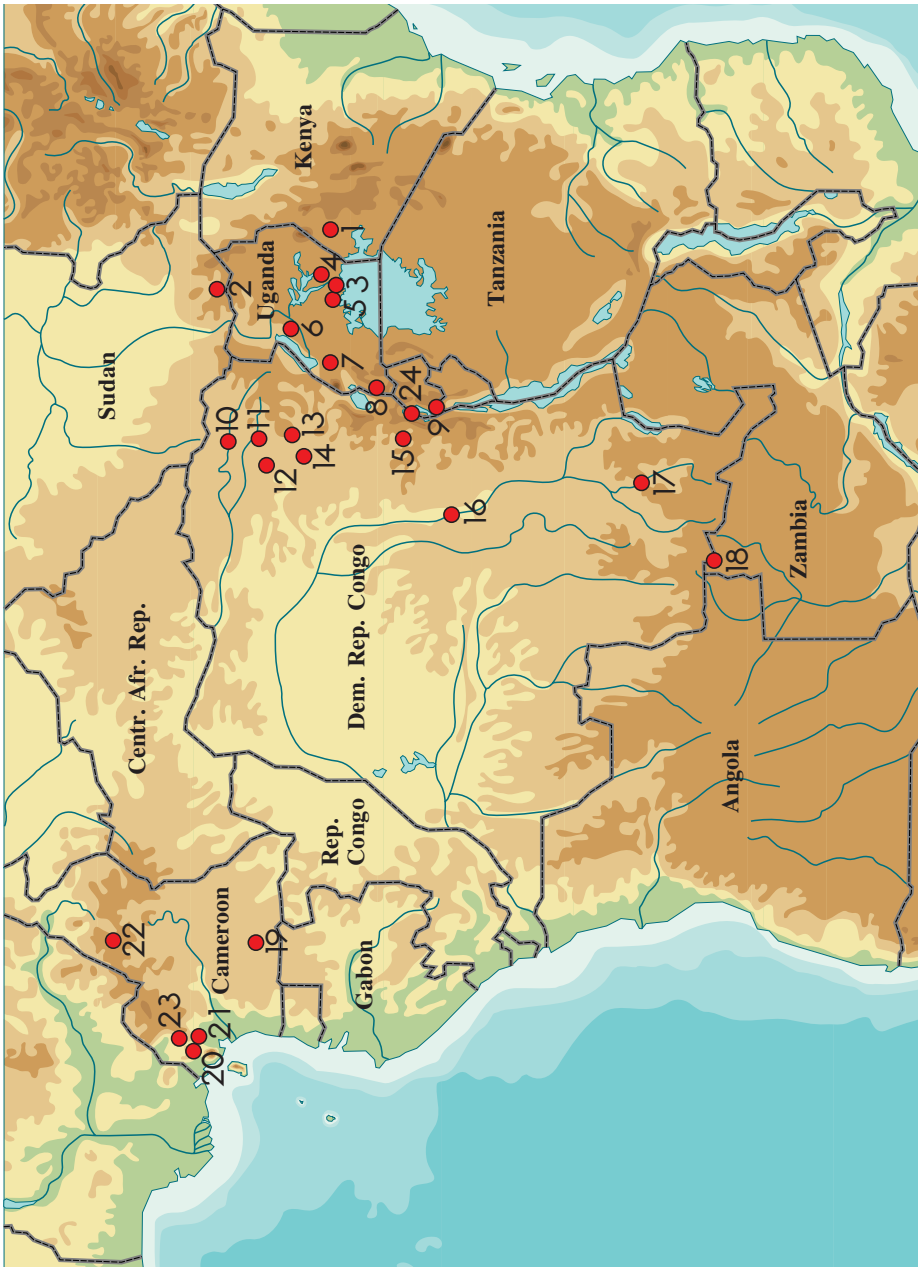


Fig. 2. Known localities for/bekannte Verbreitung von *Adolfus africanus*: 1 – Kakamega Forest; 2 – Imatong Mountains; 3 – Entebbe; 4 – Mabira Forest; 5 – Mpanga Forest; 6 – Budongo Forest; 7 – Kibale Forest; 8 – Bwindi Impenetrable Forest; 9 – Nyungwe Forest; 10 – Niangara; 11 – Penge; 12 – Medje; 13 – Itebero; 14 – Avakubi; 15 – Kahuzi-Biega, Irangi-Forest; 16 – Kindu; 17 – Mitumba Mountains; 18 – Zambezi Source; 19 – Bitye; 20 – Dikume; 21 – Mt. Kupe; 22 – Minim, Adamaua; 23 – Edib, Bakossi Mountains; 24 – Idjwi Island.

Kinyeti (Imatong). The slopes are covered with highland forest, but only at the Imatong Mountains forest cover is reaching all altitudinal zones harbouring a high diversity of species (NIKOLAUS 1987).

The presence of *A. africanus* in southern Sudan was already mentioned by BÖHME & SCHNEIDER (1987) and SCHMITZ et al. (2000) and referred to the same ZFMK specimen. However, the authors did not provide detailed information, since this was beyond the aim of the contributions and thus the Sudan record was neglected in subsequent literature (e. g. SPAWLS et al. 2002, UETZ 2002).

**Known distribution**

In addition to the new records mentioned above, we reviewed the literature and ZFMK material for known localities of *A. africanus*. The respective records are listed below and shown in figure 2. If not provided with the specimen data or in the publication, longitude and latitude were determined by using Microsoft Encarta Weltatlas 98© (if possible). Collection abbreviations follow LEVITON et al. (1985).

Cameroon: Bitye, Dja River, 03°01'N, 12°22'E (MERTENS 1968); ZFMK 5804, Dikume, Rumpi Hills, 04°55'N, 09°15'E (MERTENS 1968, GARTSHORE 1986); BMNH 1984.646-652, Rumpi Hills, 1200 m a.s.l. (ARNOLD 1989); ZFMK 67573, 68274, Edib, Bakossi Mountains, 1250 m a.s.l., 05°03'N, 09°35'E (SCHMITZ et al. 2000); Minim, Adamaoua, 06°58'N, 12°52'E (BÖHME & SCHNEIDER 1987); ZFMK 59513, Mt. Kupe, app. 950 m a.s.l., 04°49'N, 09°42'E.

Democratic Republic of the Congo: ZMB 24121, Avakubi, 01°20'N, 27°34'E (type locality of *Adolfus fridericianus* STERNFELD, 1912 [type missing according to ARNOLD 1989]); Idjwi Island, 02°10'S, 29°02'E (LOVERIDGE 1942); ZFMK 47575-76, 53435, 55656-58, Irangi Forest, Kivu Province; ZFMK 55655, Itebero, Kivu-Province, 01°43'S, 28° 06'E; ZFMK 57598, Kahuzi-Biega National Park, Kivu Province, 2200 m a.s.l.; Kindu, 580 m a.s.l., 02°58'S, 25°55'E (ARNOLD 1989); Medje, 02°23'N, 27°18'E (SCHMIDT 1919); Mitumba Mountains, Upemba National Park, 1750 m a.s.l., 09°12'S, 26°40'E (DE WITTE 1953); Niangara, 03°42'N, 27°53'E (SCHMIDT 1919); Penge, 02°48'N, 27°55'E (SCHMIDT 1919).

Rwanda: ZFMK 55767, Cyamudongo, Nyungwe Forest, 02°30'S, 29°14'E.

Uganda: Budongo Forest, app. 01°45'N, 31°35'E (SPAWLS et al. 2002); Bwindi Impenetrable National Park, app. 01°00'S, 29°43'E (SPAWLS et al. 2002); BMNH 1906.5.30.13 (holotype), Entebbe, 00°04'N, 32°28'E (BOULENGER 1906); Kibale Forest, 00°30'N, 30°25'E (SPAWLS et al. 2002); Mabira Forest, 00°30'S, 32°55'E (SPAWLS et al. 2002); Mpanga Forest, 00°08'S, 32°13'E (SPAWLS et al. 2002).

Zambia: NMZB 10723-4, Zambezi Source, Mwinilunga District, 11°22'S, 24°20'E (BROADLEY 1991).

Summarizing these findings, there is a total number of 25 localities from which *A. africanus* is known, involving seven countries. The Zambian record (11°22'S, 24° 20'E) is the southernmost one, whereas the northernmost record refers to Minim, Cameroon (06°58'N, 12°52'E). The easternmost locality refers to the Kenyan record (00°17'N, 34°54'E) and the westernmost to Rumpi Hills, Cameroon (04°55'N, 09°

15'E). All known localities are situated within mountain ranges, the East African highlands or refer at least to the upper Congo basin. ARNOLD (1989) mentioned an altitudinal range of 580 to 1750 m a.s.l. for the species which is extended to 2200 m a.s.l. by our locality account.

## Discussion

The Kakamega Forest in Kenya is quite remarkable with respect to reptile distribution. Many West and Central African reptile species seem to reach their eastern limit of distribution in Kakamega Forest, like e. g. *Lygosoma fernandi, Philothamnus carinatus, P. nitidus, Hapsidophrys lineata, Boiga pulverulenta, Pseudohaje goldii, Dendroaspis jamesoni, Atheris hispida, Bitis nasicornis, Causus lichtensteini* (SPAWLS et al. 2002). However, endemism is quite low. Therefore, Kakamega Forest should not be interpreted as a stable Pleistocene forest refuge, but most likely represents a remnant of a continuous post-Pleistocene Guineo-Congolean rain forest block more recently fragmented by natural climate change and human activities.

Concerning the habitat requirements of *A. africanus,* there is a remarkable conformity in all the published information. SCHMIDT (1919) wrote "... most of the specimens caught under fallen timber in clearings, never seen in villages ...", thus exactly the conditions where one Kenyan specimen was found recently. Several other authors stated that the species occurs in conditions where small clearings are present inside a forest (ARNOLD 1989, BÖHME & SCHNEIDER 1987, BROADLEY 1991, SCHMITZ et al. 2000, SPAWLS et al. 2002). There, *A. africanus* is basking on trunks and hunts arthropods in the leaf litter. It does not occur outside the forest like frequently described for *A. jacksoni* (e. g. SPAWLS et al. 2002, own obs.). In summary, although obviously depending on small clearings, *A. africanus* has to be considered a primary forest species. None of the records refers to secondary growth or completely open habitat. Thus, it may be assumed that the species is affected by deforestation. Replacement communities subsequent to logging such as secondary forest with dense understorey and shrub do most probably not provide appropriate conditions for its survival.

By using DNA hybridisation data to identify the ages of species, FJELDSÅ & LOVETT (1997) pointed out that some current distribution patterns are probably the result of post-speciation redistribution events during the Pleistocene. Given its habitat requirements and the fact that *A. africanus* is not known from the lower Congo Basin, it seems most resolved that the species survived dry periods of the Pleistocene in rain forest refugia, which due to a recent interpretation have occurred in areas with present-day high amounts of precipitation (e. g. FJELDSÅ 1994) and thus are mostly identical with montane areas. The mid-altitude adaptation of *A. africanus* (possibly established during the Pleistocene) obviously prevented the subsequent colonisation of the lower Congo Basin. Similar distribution patterns are known for other species (e. g. *Bufo superciliaris*), supporting this hypothesis.

To answer the question of disjunct distribution of *A. africanus* some additional aspects have to be taken into account. A disjunct present-day pattern may be the result of separation during the Pleistocene and a reduced ability of subsequent dispersal, postulating a West African and an East African lineage. If this is the case, one might expect considerable genetic and/or morphological differences between West and East African populations. Unfortunately, so far genetic analyses are lacking, but morphological comparisons of West and East African specimens were already done by MERTENS (1968), BÖHME & SCHNEIDER (1987) and ARNOLD (1989), none revealing any considerable differences. We compared the recently collected Kenyan individuals with specimens

from Cameroon, Democratic Republic of the Congo, Rwanda and Sudan. There seems to be considerable intra-specific variation concerning the head scalation. In some individuals the interparietal is connected with the occipital, in others it is not. However, this character is randomly distributed among the samples and there are no consistent differences between East and West African populations.

Therefore, another possible scenario is a continuous circular distribution pattern for *A. africanus* within the large forest block (inhabiting upper rain forest regions with exception of the low altitudes of the central Congo Basin – see above) during Quarternary moist periods (app. 6000 years BC, HAMILTON 1976). The subsequent climate change accompanied by shrinking of the rain forest block, mainly reducing its northern and southern extension, may have led to the recent range disjunction. However, very little is known and future genetic studies are required to draw more precise conclusions.

**Acknowledgements**

We are indebted to our Kenyan partners, namely the National Museums of Kenya (NMK) and the Kenya Wildlife Service (KWS) for fruitful cooperation and permissions. Special thanks to DAMARIS ROTICH (NMK) for her support. We thank all researchers, students and assistants involved in the BIOTA East Africa project for providing valuable help and logistics. Special thanks to WOLFRAM FREUND (ZFMK) for joining J.K. in the field. The BIOTA East Africa project is funded by the Federal Ministry of Education and Research (BMBF, FKZ 01LC0025). P.W. thanks the following sponsors: Deutsche Telekom, Fuji-Films, Henkel, Kodak, Siemens, Unilever, Varta and Volkswagen AG.

## Neue Ländernachweise für *Adolfus africanus* (Sauria: Lacertidae) – eine Regenwald-Echse mit disjunkter Verbreitung?

Von den vier bekannten Arten der Gattung *Adolfus* zeigen drei Arten (*A. alleni, A. jacksoni, A. vaueresselli*) eine ausschließlich ostafrikanische Verbreitung. Dagegen ist nur *A. africanus* auch aus Westafrika (Kamerun) bekannt. *Adolfus africanus* wird hier erstmalig für Kenia und Sudan nachgewiesen. Der kenianische Fundort (Kakamega Forest, Western Province) stellt gleichzeitig den östlichsten bekannten Verbreitungspunkt der Art dar. Der Nachweis aus dem Sudan (Imatong-Berge, Süd-Sudan) wurde schon zuvor in der Literatur erwähnt (BÖHME & SCHNEIDER 1987, SCHMITZ et al. 2000), jedoch in Übersichtswerken bisher übersehen (z. B. SPAWLS et al. 2002, UETZ 2002).

Eine Evaluierung von Literatur- und Sammlungsnachweisen ergab, dass zusammen mit den Erstnachweisen 25 Fundorte aus sieben Ländern bekannt sind. Die bekannte Höhenverbreitung erstreckt sich von 580 bis 2200 m ü.NN. Die Fundorte befinden sich in Gebirgen, dem ostafrikanischen Hochland und dem oberen Kongobecken – aus dem zentralen Kongobecken sind keine Nachweise bekannt.

Der Kakamega Forest kann als ein östliches Fragment eines ehemals geschlossenen guineo-kongolischen Regenwaldblocks interpretiert werden. Die Zusammensetzung seiner Reptilienfauna ist insofern bemerkenswert, als dass er die östliche Verbreitungsgrenze zahlreicher Arten darstellt. Wie eine Analyse der Literaturangaben und eigene Beobachtungen zeigen, scheint *A. africanus* auf Regenwaldhabitate angewiesen zu sein. Zwar findet sich die Art zumeist in kleinen Lichtungen innerhalb des Waldes, jedoch nie in stark degradierten Habitaten.

FJELDSÅ & LOVETT (1997) zeigten anhand von DNA-Analysen, dass derzeitige Verbreitungsmuster wahrscheinlich mit pleistozänen Wiederausbreitungs-Ereignissen bereits bestehender Arten zu erklären sind. Aufgrund seiner Habitatansprüche und der Tatsache, dass *A. africanus* im zentralen Kongobecken fehlt, kann angenommen werden, dass die Art pleistozäne Trockenperioden in Waldrefugien überdauerte. Das disjunkte Verbreitungsmuster von *A. africanus* ließe sich durch eine pleistozäne Separation in eine west- und eine ostafrikanische Linie erklären. In diesem Fall wäre eine genetische und/oder morphologische Differenzierung entsprechender

Populationen zu erwarten. Genetische Analysen liegen nicht vor, morphologische Vergleiche zeigten jedoch keine Unterschiede. Eine weitere Erklärungsmöglichkeit läge in einer post-pleistozänen Trennung des Areals der an höhere Lagen adaptierten Art durch einen natürlichen Klimawandel und der damit verbundenen Schrumpfung des ehemals größeren Regenwaldblocks (HAMILTON 1976).

Schlagwörter: Reptilia: Sauria: Lacertidae: *Adolfus africanus*; Kenia; Sudan; Erstnachweise; Verbreitung; Biogeografie.

**References**

ARNOLD, E.N. (1989): Systematics and adaptive radiation of Equatorial African lizards assigned to the genera *Adolfus, Bedriagaia, Gastropholis, Holaspis* and *Lacerta* (Reptilia: Lacertidae). – J. Nat. Hist., London, **23**: 525-555.

BÖHME, W. & B. SCHNEIDER (1987): Zur Herpetofaunistik Kameruns (III) mit Beschreibung einer neuen *Cardioglossa* (Anura: Arthroleptidae). – Bonn. zool. Beitr., **38**: 241-263.

BOULENGER, G.A. (1906): Additions to the herpetology of British East Africa. – Proc. Zool. Soc. London, **1906**: 570-573.

BROADLEY, D.G. (1991): The herpetofauna of northern Mwinilunga District, northwestern Zambia. – Arnoldia Zimbabwe, **9**(37): 519-538.

DE WITTE, G.F. (1953): Exploration du Parc National de l'Upemba, **6**, Bruxelles.

FJELDSÅ, J. (1994): Geographical patterns for relict and young species of birds in Africa and South America and implications for conservation priorities. – Biodiv. Conserv., **3**: 207-226.

— & J.C. LOVETT (1997): Geographical patterns of old and young species in African forest biota: the significance of specific montane areas as evolutionary centres. – Biodiv. Conserv., **13**: 325-347.

GARTSHORE, M.E. (1986): The status of the montane herpetofauna of the Cameroon highlands. In STUART, S.N. (ed.): Conservation of Cameroon montane forests. – Int. Counc. Bird Preserv., Cambridge, 263 pp.

HAMILTON, A. (1976): The significance of patterns of distribution shown by forest plants and animals in tropical Africa for the reconstruction of upper Pleistocene palaeoenvironments: a review. – pp. 63-97 in VAN ZINDEREN BAKKER (ed.): Palaeoecology of Africa, the surrounding islands and Antarctica 9.

LEVITON, A.E., R.H. GIBBS JR., E. HEAL & C.E. DAWSON (1985): Standards in herpetology and ichthyology: Part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. – Copeia, **1985**: 802-882.

LOVERIDGE, A. (1942): Scientific results of a fourth expedition to forested areas in East & Central Africa – IV. Reptiles. – Bull. Mus. Comp. Zool., **91**: 237-373.

MERTENS, R. (1968): Zur Kenntnis der Herpetofauna von Kamerun und Fernando Poo. – Bonn. zool. Beitr., **19**(1/2): 69-84.

NIKOLAUS, G. (1987): Distribution atlas of Sudan's birds with notes on habitat and status. – Bonn. zool. Monogr., **25**: 1-322.

ROUND-TURNER, D. (ed.)(1994): Kakamega Forest - The official guide. – Kenya Indigenous Forest Conservation Programme (KIFCON), Nairobi, 67 pp.

SCHMIDT, K.P. (1919): Contribution to the herpetology of the Belgian Congo based on the collection of the American Museum Congo Expedition, 1909-1915. – Bull. Am. Mus. Nat. Hist., **39**(2): 385-624.

SCHMITZ, A., O. EUSKIRCHEN & W. BÖHME (2000): Zur Herpetofauna einer montanen Regenwaldregion in SW-Kamerun (Mt. Kupe und Bakossi-Bergland). – Herpetofauna, **22**(124): 16-27.

SPAWLS, S., K. HOWELL, R. DREWES & J. ASHE (2002): A field guide to the reptiles of East Africa. – Academic Press, London, 543 pp.

STERNFELD, R. (1912): IV. Zoologie II. Reptilia. – pp. 197-279 in SCHUBOTZ, R. (ed.): Deutsche Zentral-Afrika Expedition, 1907-1908. – Klinkhardt & Biermann, Leipzig.

UETZ, P. (ed.)(2002): The EMBL reptile data base. – www.embl-heidelberg.de /~uetz/Living Reptiles.html

Manuscript received: 11 September 2003

Authors: JÖRN KÖHLER, PHILIPP WAGNER, STEFANIE VISSER, WOLFGANG BÖHME, Zoologisches Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany. E-Mail: j.koehler.zfmk@uni-bonn.de.