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Original article

A new species of Running Frog, (*Kassina*, Anura: Hyperoliidae) from Unguja Island, Zanzibar, Tanzania

CHARLES A. MSUYA[1], KIM M. HOWELL[1], AND ALAN CHANNING[2]

[1]*PO Box 35064, Department of Zoology & Wildlife Conservation, University of Dar es Salaam, Dar es Salaam, Tanzania*
[2]*Biodiversity and Conservation Biology Department, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa*

Abstract.—A new species of *Kassina* is described from Unguja Island, Zanzibar, East Africa. It is distinguished from other species in its genus by an advertisement call that is pulsed, frequency modulated, and with a longer duration than that of *K. senegalensis* or *K. maculata*, and its grey and white reticulated colour pattern. The gular strap, like that in *K. senegalensis*, is continuous with the thick, pleated skin of the vocal pouch, but unlike *K. senegalensis*, it is rounded and truncated posteriorly. In contrast, the gular gland of *K. maculata* is rounded and free at its posterior end. The finger and toe tips are not distinct disks, but are only very slightly rounded and truncated when viewed from above. In lateral view, the tips are noticeably flattened.

Key words.—Africa, Tanzania, new species, *Kassina*, Zanzibar, Jozani-Chwaka National Park

The Running Frogs (*Kassina* spp.) are members of the Hyperoliidae, a family that is restricted to sub-Saharan Africa. In eastern Africa several species of *Kassina* have been recorded (Channing & Howell 2006). *K. maculata* Duméril 1853 is known from the coastal lowlands of Kenya, south through the tropical eastern coast of South Africa, and is also recorded from Zanzibar. *K. senegalensis* Duméril & Bibron 1841 is a species known from arid and moister habitats through much of sub-Saharan Africa from sea level to about 2500 m, but it is not known from Zanzibar.

Although summary information exists on the amphibian fauna of Zanzibar (Pakenham 1983; Channing & Howell 2006) only *K. maculata* has been recorded on Unguja, the largest of the islands. For vertebrates generally, the insular fauna of Zanzibar is depleted in comparison to that of the mainland coast opposite (Moreau & Pakenham 1941; Pakenham 1983). The only distinctive endemic mammal on Zanzibar, the Zanzibar Red Colobus, has been considered a separate species by some authors (Corbet & Hill 1991), however, it is currently given only sub specific status as *Procolobus pennantii kirki* (Wilson & Reeder 1993; Burgess *et al.* 2000). No species of amphibian, reptile or bird is currently recognized as endemic solely to Zanzibar (Mlingwa *et al.* 2000; Broadley & Howell 2000; Poynton 2000; Nahonyo *et al.* 2002).

Recent field surveys on Unguja Island conducted prior to establishing the Jozani-Chwaka National Park revealed the presence of a frog in the genus *Kassina* that differs from all known species and, based on current knowledge, is endemic to Zanzibar. We describe it below.

MATERIALS AND METHODS

The new species was discovered at the Jozani-Chwaka Proposed National Park (JCPNP). Biogeographically the flora of Zanzibar belongs to the Zanzibar-Inhambane regional center of endemism (UNEP 2001), which extends from Somalia to the Mozambique coast. Detailed descriptions of the vegetation of Jozani are given in Pikkarainen (1991), Mohammed (1999) and Nahonyo *et al.* (2002). A ground-water forest occupies the central part of the reserve and is surrounded by cultivation, coral rag forests, bushland, derived wooded grassland and mangroves to the north and south.

The Jozani forest is mainly comprised of Quaternary geologic formations. The surrounding areas are predominantly limestone formed during the Quaternary through to the Miocene. The soils in much of the Jozani area are shallow and at some localities coral rag is emergent. Within the ground water forest the soils are mostly clay loams with black colouration due to humus. In the Quaternary parent rock areas the laterites, alluvials and colluvials are predominant with some areas covered with marine, fluviatite sands and sandstone.

The climate of Jozani is determined by its geographical location and seasonal changes that arise from the general circulation of air over the Indian Ocean. The monsoons have the dominant influence on wind direction and strength, temperature and rainfall. The northwest monsoon (*kaskazi*) prevails from November to February and is characterized by high air temperatures of greater than 30°C and weaker winds. The southeast monsoon (*kusi*) lasts from April to September and is marked by lower air temperatures, approximately 25°C, with stronger winds. Generally, Zanzibar receives some rain almost all year round and no month completely lacks rainfall. There are two wet seasons, with the long rains (*masika*) starting from mid-March to the end of May and the short rains starting from mid-October to the end of December. Zanzibar receives an average of about 1565 mm of rainfall annually (UNEP 2001).

Animals were collected in June and July 2002 in coral rag thickets and plantations of *Cassia* spp. No vocalizations were heard during this time. A second visit was made to the area during the long rainy season in April 2004. One pitfall line was established in coral rag thicket, and vocalizing animals were traced. Tadpoles of the new species have not yet been observed and collected. Frogs were narcotized with MS 222 and preserved in 70% ethanol. A single specimen was cleared and stained with Alizarin red.

Vocalizations of males calling in the field were recorded using a Marantz PMD 222 tape recorder with a Sennheiser K3-V microphone. Advertisement calls recorded at 24°C were analyzed using Raven 1.2.1 (Charif *et al.* 2004).

All measurements were taken on preserved material using a vernier caliper accurate to 0.01 mm. Measurements were rounded to 0.1 mm.

Characters for a phylogenetic analysis were derived from the cleared and stained specimen, using the characters of Drewes (1984). The phylogeny was estimated using maximum parsimony in PAUP* (Swofford 2002).

In April 2004, calling adult males that measured between 38.5 mm and 42.2 mm snout-urostyle length (SUL) were collected from pools in the ground water forest. The largest female measured 38.1mm in length. The largest calling male was selected as the holotype.

Comparative material examined is listed in the Appendix.

SYSTEMATICS

(Amphibia: Anura: Hyperoliidae)
Kassina jozani Msuya, Howell & Channing
sp. nov.
(Fig.1).

Holotype.—The holotype is an adult male, collected by C.A. Msuya on 17 April 2004 at 19.30 hrs, near the newly constructed guesthouse close to the proposed Jozani-Chwaka National Park offices (06° 16.273' S; 39° 25.102' E, 50 m), and deposited in the Natural History Museum, London, (BMNH 2005.1576). The animal was calling from the edge of a small temporary pond in farmland at the edge of Jozani Forest.

Paratypes.—A single adult male BMNH 2005.1577 was collected at the same place and on the same date as the holotype. The two smaller paratypes BMNH 2005.1578 and BMNH 2005.1579 were taken in pitfall traps with drift fences set in Jozani forest, July 2002.

Other Material.—Duplicate specimens collected at the same locality are deposited in the collection of the Department of Zoology & Wildlife Conservation, University of Dar es Salaam.

Diagnosis.—This species is distinguished from *K. senegalensis* and *K. maculata*, other members of the genus found along the coastal strip of eastern Africa, by its reticulated dorsal colour pattern in grey with white edging, and a quiet, pulsed, low pitched advertisement call. The call has a mean duration of 0.2 s, with 8 pulses, rising in frequency from 461 Hz to 1345 Hz. The advertisement call of *K. senegalensis* from Beira is of shorter duration (0.1 s), not pulsed, and rising in frequency from 964 Hz to 2290 Hz. The call of *K. maculata* has a faster rise time than either that of *K. senegalensis* or *K. jozani*, and is of shorter duration.

The new species has the tips of its digits only very slightly rounded, but extremely flattened in side view. This differs from *K. senegalensis*, in which the tips of the digits are somewhat more rounded, and from *K. maculata* in which the tips of the digits are rounded and bear distinct discs.

The gular flap in the new species is similar to that of *K. senegalensis* in that it is continuous with the skin of the vocal pouch, but its sides are more rounded than in the former species and it is truncated at its point of attachment to the skin of the vocal pouch. In contrast, the gular strap in *K. maculata* is free posteriorly (see Schiøtz 1975, 1999).

The eyes of the new species are large, their diameter is between 10 and 13% of SUL. In life their bulging appearance is especially noticeable and they appear to protrude more in the new species than in either *K. senegalensis* or *K. maculata*.

The widespread *Kassina senegalensis* is similar in morphology to the new species, but has a dorsal colour pattern of dark brown stripes or spots on a pale brown background. *Kassina maculata* is a larger, more robust frog, with red patches on the sides of the lower abdomen and hind limbs that are never present in the new species.

Description of holotype.—A male, BMNH 2005.1576, SUL 42.2. Body typically kassinoid in shape, with slender limbs and a large head (Fig. 1). Nostrils situated on the side of the canthus, not raised or projecting. Tympanum slightly ovate, longer vertically than horizontally, located at the posterior commissure of the jawline. The eyes are large with vertical pupils, typical of the genus. The jaw is rounded when viewed from below. The width of the head at the angle of the jaw is equal to the length of the tibia. Eye diameter equals distance between eye and nostril.



Figure 1. *Kassina jozani* **sp. nov.** from Zanzibar

Fingers have no webbing; subarticular tubercles are well-developed, single, and the palmar tubercles are elongated and rounded (Fig. 2). The finger tips are not distinctly expanded into discs and are only slightly rounded in dorsal view. In lateral view, the extreme tips of the digits are flattened. Relative finger lengths are 2<1<4<3. The third finger including the palmar tubercle is about 25% of the SUL. Both the inner and outer metatarsal tubercles are rounded and slightly elongate. The inner is slightly longer than the outer.

Webbing is present only slightly at the base of the toes (Fig. 3). The tips of the toes resemble those of the fingers. The fourth toe, including the outer metatarsal tubercle is longer than the tibia.

The skin is smooth on the dorsum and on the limbs. The gular gland and the gular folds are granular. The gular strap is attached at its posterior margin to the skin of the vocal sac. Its posterior end is rounded but narrows and truncates medially. The belly is granular to the vent.

Major measurements are: SUL 42.2, head width at angle of jaw 15.3, horizontal eye 5.0, tympanum 2.6, tympanum to eye 1.4, eye to nostril 4.8, internostril 2.5, distance between anterior corners of eyes 6.8, tibia 15.4, fourth toe including outer metatarsal tubercle 16.1, third finger including carpal tubercle 10.0.

Colouration.—In life, the dorsum is covered by black to slate-grey blotches separated by thin, pale grey lines. This reticulated pattern is carried through to the limbs, where the pale grey becomes cream. Eyelids are dark with a pale grey line on each, merging between the eyes and extending to the nostrils. Forearms and thigh with dark olive barring separated by cream bands. Ventrally, the throat is darkly pigmented with black to dark grey, as is the vocal sac and the folds of skin that extend on either side to the forelimbs. The remainder of the ventral surface is cream, but the undersurface of limbs has a yellow wash, which fades after preservation. In breeding males a darkly pigmented mid-ventral patch is very obvious in life, but also disappears in alcohol.

Paratype variation.—The paratypes are similar to the holotype. The gular strap of the only adult male among the paratypes, CAM 1595, is less clearly truncated at its posterior than that of the type. For details, see Table 1. The subarticular tubercles of the larger paratype are of

the same size and shape as those of the holotype, but those of the smaller, subadult paratypes (BMNH 2005.1579) are smaller and less well developed.

Advertisement call.—Chorusing males were recorded from concealed positions at the edge of flooded water pools in and at the edge of Jozani Forest during the long rainy season in April 2004. The call was analyzed using a discrete Fourier transform of 256. The sound spectrogram (Fig. 4) compares a typical call of *K. jozani* with *K. senegalensis* and *K. maculata*. The call is a soft, pulsed, rising note. The following description is based on an analysis of 10 calls, one from each of 10 different males. Calls have a mean duration of 0.2 s (0.17-0.23) SD 0.00. The call has a mean of 8 pulses (6-9), starting at an emphasized mean frequency of 501 Hz (461-557) SD 36.2, rising to 1199 Hz (1061-1345) SD 94.5. Mean low frequency is 501 Hz, SD 36.2; mean high frequency is 1199.9 Hz, SD 94.5; mean call mid-frequency is 850 Hz, N = 10). Fig. 4 also shows a typical call of *K. senegalensis* (Lukwe, Malawi) and *K. maculata* (Beira, Mozambique).

Distribution.—This species is presently only known from the type locality in Jozani Forest on Zanzibar (Fig. 5). It has been recorded around pools in ground water forest, where it breeds (Fig. 6) and in surrounding terrestrial habitats (Fig. 7). Jozani Forest is within the Proposed Jozani-Chwaka Bay National Park (PJCNP) covering an area of 57.7 km2 located on the main Zanzibar Island (Unguja) some 35 kilometers south of Zanzibar town. It is situated between 6° 16'S; 39° 34' E and 6° 28' S; 39° 45' E. At 31 m asl., Jozani forest and vicinity is one of the lowest points on Zanzibar Island.

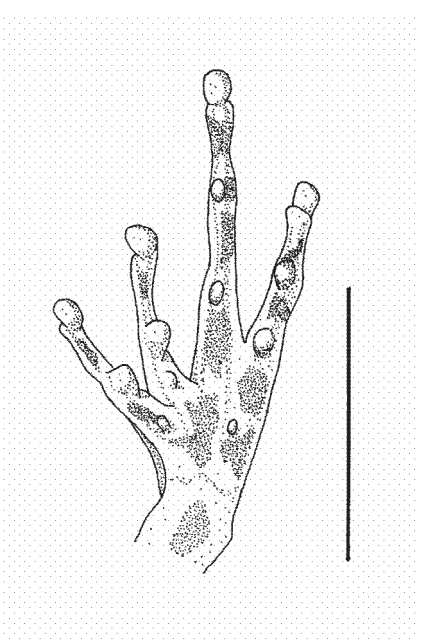


Figure 2. Ventral surface of the left hand of *Kassina jozani* **sp. nov.**

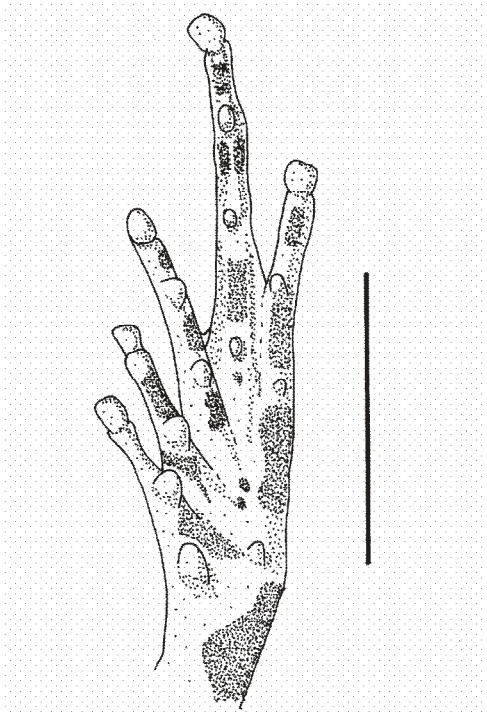


Figure 3. Ventral view of the right foot of *Kassina jozani* **sp. nov.**

Table 1. Measurements of types (mm). The holotype is CAM 1594.

	CAM 1594	CAM 1595	CAM 1409	CAM 1410
SUL	42.2	38.5	26	23
Head width at angle with jaw	15.3	14	10	09
Horizontal eye	5.0	4.1	3.0	3.0
Tympanum	2.6	2.4	2.4	2.1
Tympanum to eye	1.4	1.5	1.4	1.4
Eye to nostril	4.8	4.2	2.8	2.3
Internostril	2.5	2.0	2.6	1.5
Distance between anterior corner of eyes	6.8	4.8	4.2	4.0
Tibia	15.4	13.6	11.8	9.0
4th toe including outer metatarsal tubercle	16.1	11.1	9.7	9.9
3rd finger including carpal tubercle	10	8.5	8.0	7.0

Relationships.—The informative characters used in the data matrix, scored from the cleared and stained specimen were as follows (character numbering and scoring after Drewes 1984):

1. The dorsal exposure of the sphenethmoid is more than 0.6 the length of the frontoparietals - state 3.

2. The ventral configuration of the sphenethmoid consists of two unfused elements - state 1.

3. Quadratojugal contacts the maxilla anteriorly and is not enlarged dorsally - state 0.

4. Prevomerine odontophore and associated teeth absent - state 1.

7. Relative length of vertebral column 2.6 - state 1.

8. Transverse process almost perpendicular to longitudinal axis - state 0.

14. Tip of third finger bifurcated - state 3.

17. Ratio of caudal margin of metasternum to anterior margin between 1.5 and 3.0 - state 1.

18. Gular gland straplike, vocal pouch present - state 7.

26. Carpals fused - state 1.

The phylogeny was estimated using *Phlyctimantis leonardi* and *P. verrucosus* as an outgroup, with the ingroup including *Kassina cassinoides*, *K. cochranae*, *K. parkeri*, *K. jozani*, *K. fusca*, *K. kuvangensis*, *K. lamottei*, *K. mertensi*, *K. senegalensis* and *K. maculata*, taken from the matrix of Drewes (1984; Appendix B). *Kassina decorata* was omitted as it was scored the same as *K. cochranae* in this small dataset. Only skeletal characters were used, so only a subset of Drewes (1984) data was incorporated into the matrix. The character states were treated as unordered, with three equally parsimonius trees resulting from a branch-and-bound search. The strict consensus tree (Fig. 8) shows that *K. jozani* is the sister group to the West African clade of *K. cassinoides*, *K. cochranae* (and/or *K.decorata*) and *K. parkeri*. This relationship needs to be tested using a comprehensive molecular dataset.

Etymology.—This species is named for the Jozani Forest, the largest and only protected area on Unguja Island, Zanzibar. The species name is a noun in apposition.

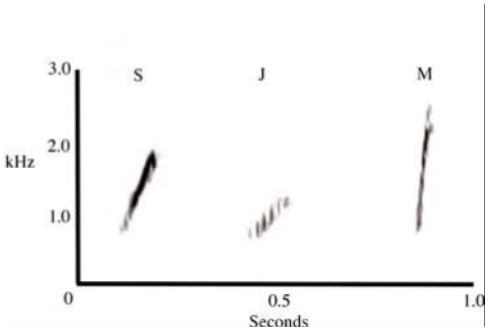


Figure 4. Sound spectrogram of the advertisement calls of *Kassina senegalensis* (S), *K. jozani* (J), and *K. maculata* (M). Calls were analysed simultaneously.

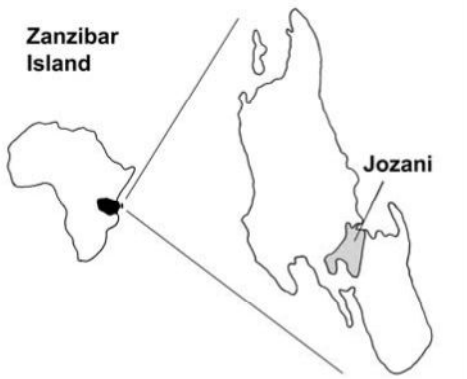


Figure 5. Map showing the locality of Jozani Forest on Zanzibar. Co-ordinates are given in the text.



Figure 6. Photograph of breeding site of Kassina jozani in ground water forest at Jozani Forest on Unguja.



Figure 7. Photograph of the type locality at the edge of Jozani Forest on Unguja Island.

DISCUSSION

It has long been recognized that the vertebrate fauna of Zanzibar is relatively depauperate and contains no endemic species (see review of coastal forest fauna in Burgess & Clarke 2000).

Zanzibar is believed to have been separated from the mainland of Tanzania no longer ago than in the Late Pleistocene, perhaps 100,000-10,000 years BP (see discussion in Pakenham, 1979). Until the discovery of *Kassina jozani*, this isolation was not known to have been sufficient for species formation to have occurred. Clarke *et al.* (2000) have pointed out that there are low rates of floristic endemism on Zanzibar while Burgess & Clarke (2000) record no endemic vertebrates.

Although the call was recorded during the long rainy season, no females were found at that time, suggesting that the pattern of breeding of the new species follows that of *K. senegalensis* and most other ground dwelling species on the coast of East Africa that breed during the

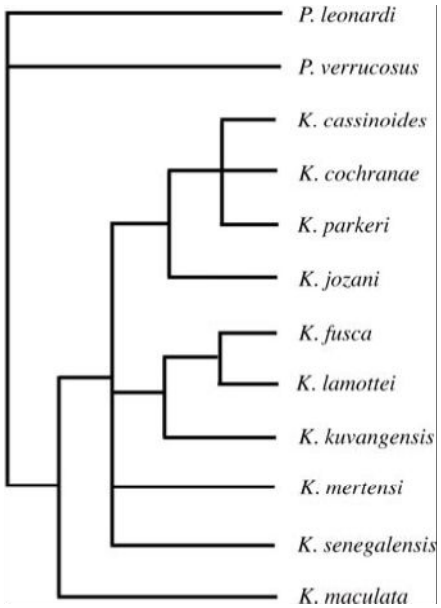


Figure 8. Strict consensus of three equally parsimonius trees, showing the relationships of *Kassina jozani*.

short rainy season between October and December (Msuya, 2001).

Juveniles and sub-adults were found between June and July 2002 in coral rag thickets and plantation forest areas that were up to 3 km away from depressions within the Jozani forest, which are the most likely breeding locations. The new species appears to be a seasonal visitor to ephemeral breeding sites, but can disperse to distant areas.

Once the proposed Jozani Chwaka National Park is gazetted, the largest known suitable breeding site for the new species will be included within a formally protected area. However, there is a need to establish how far individuals disperse into other habitats such as coral rag thicket after breeding, and to ensure that dry season refugia also receive suitable protection to ensure the survival of the species. A wider-ranging survey for the presence/absence of this species on Zanzibar is also needed to provide more information about its conservation status.

The discovery of a strikingly patterned frog, easily recognized as distinct from others in an area commonly visited by tourists and in which considerable research has been conducted (see Nahonyo *et al.* 2002 for a summary) suggests that further detailed study will reward inquisitive biologists on the island.

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LITERATURE CITED

BROADLEY, D.G. & K.M. HOWELL. 2000. Section 4.4 Reptiles. Pp. 191-199. *In* Burgess, N.D. and Clarke, G. P., (eds). Coastal Forests of Eastern Africa. IUCN, Cambridge, UK.

BURGESS, N.D. & G.P. CLARKE (EDS). 2000. Coastal Forests of Eastern Africa. IUCN, Cambridge, UK.

BURGESS, N.D., D. KOCK, A. COCKLE, C. FITZGIBBON, P. JENKINS, & P. HONESS. 2000. Section 4.3 mammals, pp. 173-190. In Burgess, N.D. and Clarke, G. P., (eds). Coastal Forests of Eastern Africa. IUCN, Cambridge, UK.

CHANNING, A. & K.M. HOWELL. 2006. Amphibians of East Africa. Cornell Univesity Press, Ithaca, New York.

CHARIF, R.A., C.W. CLARK, & K.M. FRISTRUP. 2004. Raven 1.2 User's Manual. Cornell Laboratory of Ornithology, Ithaca, NY.

CLARKE, G.P., K. VOLLESEN, & L.B. MWASUMBI. 2000.

Section 4.1 Vascular Plants. Pp. 129-147. *In* Burgess, N.D. & G.P. Clarke (Eds). Coastal Forests of Eastern Africa. IUCN, Cambridge, UK.

CORBET, G.B. & J.E. HILL. 1991. A World Checklist of Mammalian Species (third edition). Natural History Museum Publications and Oxford University Press, London and Oxford.

DREWES R.C. 1984. A Phylogenetic Analysis of the Hyperoliidae (Anura): Treefrogs of Africa, Madagascar, and the Seychelles Island. California Academy of Sciences Occasional paper No.130.

MLINGWA, C.O.F., E.M. WAIYAKI, L.A. BENNUN, & N.D. BURGESS. 2000 Chapter 4.2 Birds. Pp.149-171. In Burgess, N.D. & G.P. Clarke (eds). Coastal Forests of Eastern AFRICA. IUCN, CAMBRIDGE, UK.

MOHAMMED, S.M. 1999. The ecology and socioeconomy of Chwaka Bay, Zanzibar. Federal Ministry for Economic Co-operation and Development of Germany (BMZ).

MOREAU, R.E. & R.H.W. PAKENHAM. 1941. The land vertebrates of Pemba, Zanzibar and Mafia: A Zoo-Geographical Study. Proceedings of the Zoological Society of London, Series A. Vol. 110 Parts 3 and 4.

MSUYA, C.A. 2001. Habitats, distribution and feeding of amphibians in Zaraninge Forest Reserve, Tanzania. Ph.D thesis, University of Dar es Salaam.

NAHONYO C.L., L.B. MWASUMBI, S. ELIAPENDA, C. MSUYA, C. MWANSASU, T. M. SUYA, B.O. MPONDA & P. KIHAULE. 2002. Jozani - Chwaka Bay proposed National Park biodiversity inventory report. Submitted to Care Tanzania and Department of Commercial Crops, Fruits and Forestry, Serikali ya Mapinduzi, Zanzibar.

PAKENHAM, R.H.W. 1979. The Birds of Zanzibar and Pemba. British Ornithologists' Union, B.O.U. Check-list No.2. London.

PAKENHAM, R.H.W. 1983. The reptiles and amphibians of Zanzibar and Pemba islands (with a note on freshwater fishes). Journal of the East African Natural History Society 177: 1- 40.

PIKKARAINEN, T. 1991. Inventory of Jozani and Ngezi Forests: Results. Forestry Department, Zanzibar. FINNIDA, Kuopio. Pp 201-209.

POYNTON, J.C. 2000. Amphibians. Pp. 201-209. *In* Burgess, N.D. & G.P. Clarke (eds). Coastal Forests of Eastern Africa. IUCN, Cambridge, UK.

SCHIØTZ, A. 1975. Treefrogs of eastern Africa. Steenstrupia, Copenhagen.

SCHIØTZ, A. 1999. Treefrogs of Africa. Edition Chimaira, Frankfurt am Main.

SWOFFORD, D.L. 2002. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4. Sinauer Associates, Sunderland, Massachusetts.

UNEP. 2001. Eastern Africa Atlas of Coastal Resources: Tanzania. UNEP, Directorate for International Cooperation (DGIC) Belgium, United Republic of Tanzania.

WILSON, D.W. & D. REEDER (EDS). 1993. Mammal species of the world, a taxonomic and geographic reference, 2nd ed. Smithsonian Institution Press, Washington, DC.

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APPENDIX 1

Comparative material examined. UDSM - the reference collection of the Department of Zoology & Wildlife Conservation, University of Dar es Salaam)

Kassina senegalensis:

Males: Ifakara UDSM 86; Tatanda UDSM 257, 1258; Arusha National Park UDSM 1624, 1625.

Females: Zaraninge Forest Reserve UDSM 1879-1881; Biharamulo Forest Reserve UDSM 1883; Usangu Plains UDSM 2173-2177.

Kassina maculata:

Males: Zaraninge Forest Reserve UDSM 1793, 1794, 1800, 2249.