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CHAPTER 3
REDUNCINE ANTELOPE OF THE ZAMBEZI BASIN

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3.1 INTRODUCTION

The Reduncini (also known as reduncine antelopes) is a tribe of large to medium sized antelopes found only within Africa. It comprises a diversity of waterbuck, reedbuck, puku, lechwe and kob. According to the established taxonomy (Ansell 1971), at least ten species encompassing numerous subspecies have been described to science. Two genera are recognized, namely *Redunca* and *Kobus*. With one exception, all extant reduncine antelopes share a predilection for wetlands in the African tropics: these wetlands are all located within the savanna biomes of south-central and northern Africa. Reduncines are reliant on surface water, and so do not occur far from perennial water bodies. These antelopes have evolved distinct adaptations to an aquatic life, exemplified by the elongated hooves of lechwe. They are entirely grazers and are gregarious, living in small family units (waterbuck and reedbuck) or large herds (lechwe and kob).

An especially high diversity of reduncine antelopes is centred in and around the Zambezi Basin. Several endemic populations of lechwe are restricted to within certain Zambezian wetlands: well known populations occur on the Kafue Flats, Bangweulu Basin and Okavango Delta. At least 16 distinctive populations affiliated to complexes of four species of lechwe occur within the modern limits of the region. The origins of this high diversity deserve detailed study but this has yet to be carried out. Until recently, very large herds of lechwe and equally large collective populations of waterbuck, puku and reedbuck occurred within suitable habitats in the Zambezi Basin. Numbers and distributions of all these populations have shrunk radically in recent decades. The role of these antelopes in the ecology of the wetlands, where a high biomass of herbivores concentrated, was likely to have been profound.

The huge herds of charismatic lechwe and kobs on open sunlit wetlands has repeatedly been marveled at, written about, and also exploited. A popular public image is of herds of lechwe plunging through the shallows of a central African wetland – as depicted on the cover of *Okavango: Sea of Land, Land of Water* (Johnson & Bannister 1977). Lechwe and kobs have become firmly established as flagship species for conservation. This began before the Second World War in the then Northern Rhodesia, where the colonial Game Management authorities were concerned over the future of the black lechwe around Lake Bangweulu, a concern heightened in the 1950s with the rapid decline in populations of Kafue and black lechwe. A major catalyst in conservation was the activities and advocacy of an NGO, the Game Preservation Society of Northern Rhodesia (that later became the Wildlife Society of Zambia). Indeed, the official journal of the Wildlife Society of Zambia was named "Black Lechwe", and the research journal of the Zambian Department of National Parks was named *The Puku.* This focus on these single species symbolized concern about the future of Zambia's formerly rich wildlife.

3.1.1 Geographical and taxonomic scope

The focus of this review is on the evolution, diversification and current status of the Reduncini. This is the crux of the knowledge of a taxon regarding properties of biodiversity. With respect to the attributes of biodiversity knowledge, information pertaining to evolutionary biology and biogeography has been reviewed rather than the larger assemblage of detailed information published about the behaviour and ecology of the Reduncini in the Zambezi Basin and elsewhere in Africa.

The extent of the Zambezi Basin recognized in this review extends beyond its modern watersheds. It includes the entire modern drainage of the Zambezi as well as the Okavango Delta and its tributaries; and the Bangweulu and Mweru basins (northern Zambia). It also considers the Upemba and Rukwa depressions in the Democratic Republic of Congo (DRC) and Tanzania, respectively. This region encompasses much of Malawi, eastern Angola, southern Shaba Province of the DRC, central Mozambique, northeastern Botswana, and northern Zimbabwe. All of Zambia is included. This coverage is essential to account for the evolution of the Zambezi and neighboring drainage systems, and the biota therein, which have changed considerably over the past five million years since the Miocene.

The Bohor reedbuck (including a total of seven subspecies recognized by Ansell 1971) is excluded from this review because there is no evidence of the species occurring in the Zambezi Basin, nor in Malawi or Zambia, but it does extend into the Rovuma Valley of northern Mozambique and perhaps further south. Mountain Reedbuck, *R. fulvorufula*, does not occur within the Zambezi Basin; three subspecies have been described, the populations of which are restricted to suitable mountainous habitat in southern Africa (*R. f. fulvorufula*), north-east Africa (*R. f. chanleri*), and a relict population on Mount Adamua in Cameroon (*R. f. adamuae*). The Nile lechwe, *Kobus megaceros* is not specifically reviewed given its restricted distribution in southern Sudan and adjacent western Ethiopia. The Kob, *K. kob,* formerly widely distributed across the Guinean savannas of North Africa, is excluded for a similar reason. It is pertinent to note that *K. kob* (of which several allopatric populations have been described as subspecies) in equatorial Africa and the northern, Guinean savannas is very closely related to the pukus (*K. vardoni* and *K. senganus*), whose distribution centres on Zambia.

3.2 PHYLOGENETIC ORIGINS AND PALAEONTOLOGICAL BACKGROUND

3.2.1 Taxonomic preamble

With the exception of painstaking palaeontological research into various fossil beds in Africa (for example, Gentry 1990, Vrba 1979, Vrba *et al*. 1994) the study, and most especially resolution, of the systematics of reduncine antelopes has not kept pace with more utilitarian attention to their exploitation and conservation. Comparatively little has been published about the taxonomic status of the many described populations of the Reduncini, and the few available tend to focus on the lechwes (Ansell 1964, 1971, Ansell & Banfield 1980, Barclay 1933). Apart from Vrba *et al*. (1994), no systematic research of the Reduncini has employed the modern techniques and philosophy of modern systematics. This is unfortunate. It is difficult to state unequivocally how many species of reduncine antelopes occur within the Zambezi Basin or within Africa overall. Lack of data, and more especially its synthesis by modern phylogenetic systematists, is one cause of this deficiency. Another allied reason is that an objective concept of the species (one which objectively interprets mammalian diversity) has yet to be applied to the Reduncini, and indeed most other mammals.

The establishment of objective criteria to identify a reduncine species is obviously a prerequisite to study any aspect of its biology and generate reliable knowledge. Some discussion is devoted to this problem, given its impacts on scientific knowledge and biodiversity conservation. An underlying premise of this review is that the study of the ecology and behaviour of any aspect of an organism's biology must be founded on accurate taxonomy. Such taxonomy must seek to "carve nature at its historical joints" and discover species and their historical relationships – to objectively identify real species, that is relevant evolutionary products of diversification. This procedure must unearth cryptic species yet avoid descriptions of artificial taxa. It is precisely this knowledge that is a prerequisite to

frame scientifically-sound knowledge to conserve organismal biodiversity (Cracraft 1997, Dimmick *et al*. 1999, Soltis & Gitzendanner 1999). Indeed, the application of a more objective perspective on what species are (their ontology) confers profound implications on how the Reduncini are classified, and this in turn provides important lessons to the understanding of biogeography and biodiversity in the Zambezi Basin. The Reduncini constitute an important case study for the scientific study of biodiversity and its conservation in Africa and elsewhere. The perspective gained from understanding reduncine diversity is especially relevant to wetlands.

3.2.2 **Evolution**

The Reduncini evolved over 15 million years ago. The oldest known fossils are 11 million years old from East Africa. The group formerly occurred in Asia, as of 5 million years ago. It has been suggested that this dispersal out of Africa corresponded with mesic conditions that facilitated their dispersal down the Nile Valley. Diagnostic characters of reduncine antelopes are transverse ridges on their horns (only present in males), a large maxillary tuberosity, comparatively small cheek teeth, and no less than three other diagnostic characters of the lower and upper molar teeth (Gentry 1990, Kingdon 1982).

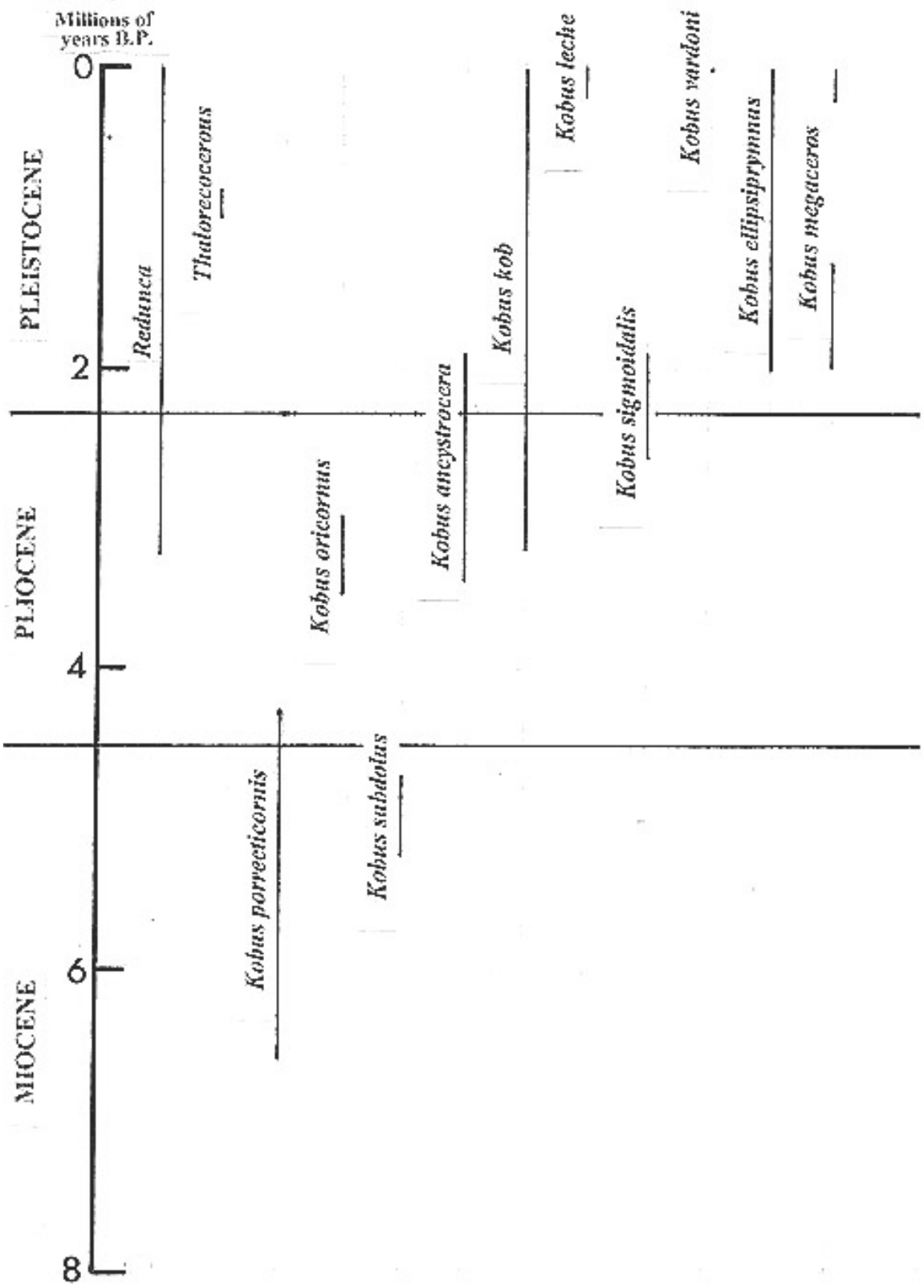
Reduncine fossils have been collected from many of Africa's fossil beds in Quaternary and Tertiary formations in Kenya, Ethiopia, Tanzania and South Africa. The earliest known fossils are assigned to *Kobus porrecticornis* (7-4.5 Million years ago [Mya]) and *K. subdolus* (5 Mya). A pulse of diversification of *Kobus* occurred in the late Miocene and early Pleistocene (Figure 3.1; Gentry 1990). Noteworthy records are that the lineage of "waterbuck", *K. ellipsiprymnus* and "Ugandan Kob", *K. kob* can be traced back to 2 and 3 Mya, respectively. The fossil reduncines assigned to "Red lechwe" *K. leche* and "Nile Lechwe" *K. megaceros* are far more recent – tens of thousands of years old.

The genus *Redunca* appears over 3.0 Mya. No less than three sympatric species have been discovered from the dolomite strata of northern South Africa, including examples of the extant *arundinum* and *fulvorufula*, and the extinct *R. darti* (McKee 1995). Exploration of geological formations likely to hold fossils in Zambia and northern Zimbabwe has yet to be carried out.

Nevertheless, the identity of the immediate ancestors of the Reduncini and their extant relatives is unclear. This uncertainty is evident in how inferences of higher level phylogeny have influenced classifications of the Bovidae. Vrba (1979) concluded that the Reduncini diverged from a clade which ultimately formed the Neotragini (stenbuck, suni, royal antelope and grysbucks). This treatment was followed by Meester *et al*. (1986) and Skinner & Smithers (1990). Neotragines are considered to be primitive antelopes, as exemplified by *Raphicerus sharpei* (Sharpe's grysbuck). Evidence for this relationship can be seen in puku, which possess a vestigial preorbital gland common to all neotragines. Additional evidence is represented in the ontogeny of horn growth in waterbuck, lechwe and reedbuck. Primitive swept back horns (a shared neotragine trait) in juveniles proceeds to the large, lyrate horns of the adult reduncine. Indeed, reduncine evolution has involved elaboration of horns and scent glands (Kingdon 1982).

In a different taxonomic treatment, Gentry (1990) placed the tribe Reduncini alongside its sister tribe Hippotragini (oryx, sable, roan and allies) to form the subfamily Hippotraginae, but acknowledged understanding of bovid relationships at this level (above the genus) to be poor. One derived character which Gentry considered shared among these antelopes is the enlarged basioccipital (where an enlarged longus capitis muscle inserts on the skull). This adaptation permits powerful and rapid downward head movements, and occurs in alcelaphines, hippotragines and reduncines: nevertheless, as Kingdon (1982)

Figure 3.1. Geological time scale showing the approximate durations of certain morphospecies of the Reduncini as established from the African fossil record since the late Miocene (modified from Gentry 1990).



argues, its possession does not necessarily infer common ancestry. Separate fossils from Langebaanweg, South Africa and Pinjor, Siwaliks, even suggest that Reduncini as currently recognized might be paraphyletic. In this respect, Gentry (1990) notes that the genus *Ourebia* (currently recognized as a neotragine) possesses certain characters more typical of reduncines than neotragines. This is apparent in the considerable similarity of the subauricular glands of oribi, *Ourebia ourebi*, and mountain reedbuck, *Redunca fulvorufula* (Kingdon 1982, Vrba *et al*. 1994). The inclusion of *Ourebia* in the Reduncini is also supported by dependence of oribi on mesic habitats and their need for surface water, and their loud whistling call reminiscent of reedbucks. Conversely, most other neotragines are adapted to dry forests, savannas and deserts, with one species occurring in moist forest. Given its resemblance to neotragines, but also reduncine affinities, the extant *Ourebia ourebi* could be a primitive reduncine.

3.2.3 **Adaptation to aquatic habitats and environmental disturbance**

The lechwe are unique among the reduncine antelopes in being able to live permanently in wetlands. Their adaptations represent extreme specialization. Kingdon (1982) has suggested that a neotragine ancestor of the Reduncini occupied tropical valleys and its descendants diversified to exploit valley grasslands, followed by adaptation to aquatic conditions in mesic environments. Nevertheless, wetlands are characterized by frequent disturbance, and the exploitation and associated specialization required to exploit wet grasslands exposed reduncines to such disturbances as diseases, parasites, fluctuating water levels associated with climatic extremes (floods to droughts), fires and predation.

Very recently (on a palaeoecological time scale), humans have become a dominant agent of disturbance in reduncine habitats, either through direct depredation, or habitat modification (especially through fire and hydrological developments), or by competition with livestock. However, disturbances has not all been caused by humans. Climate and tectonic-driven changes to wetlands appear to have had a major impact on reduncine diversity. These have caused dramatic and recent changes in the distribution and diversification of reduncine antelopes. In particular, comparatively recent disturbances (on an evolutionary time scale) to Zambezian wetlands are of considerable interest. The details and implications of these phenomena are considered in the final section of this review.

Some even more recent changes in distribution have also occurred. Fluctuations in the distribution of *K. leche* in northern Botswana since the mid-19th century exemplify the susceptibility of these antelopes to habitat change. David Livingstone during his search for Lake Ngami in 1849 collected the first specimens of *Kobus leche* known to science from its vicinity (Spinage 1994), while Andersson (1856) recorded hundreds of this species on the Taoghe Delta on the edge of Lake Ngami. This area was then perennial swamp. Today, the landscape supports open, semiarid grassland and the Taoghe river is dry. The lechwe of Lake Ngami are extinct. The nearest lechwe only occur in the Okavango, over 60 km to the north (Smithers 1971, Spinage 1994). This example illustrates how vagaries of changes in habitats have modified the distributions of these antelopes within very short time periods.

3.3 SOCIAL ORGANISATION AND BEHAVIOUR

3.3.1 Sociality and adaptation to open, mesic habitats

The social organization of nearly all currently recognized species of reduncines has been well studied, and is characterized by high levels of competition amongst males for mates. Only a minority of males secure territorial tenure and thus matings. These social systems have evolved in response to the comparative uniformity of the grassland and aquatic habitats exploited by reduncines, where high densities of antelopes congregate (Nefdt 1995, 1996, Rosser 1987). All reduncine antelopes live in herds, which reach their highest extremes in density and size in the kobs and lechwes. The behavioural organization of lechwe (Nefdt 1995, 1996, Thirgood *et al*. 1992), waterbuck (Hanks *et al.* 1969, Herbert 1972, Melton 1978, Spinage 1982), reedbuck (Howard 1986a, 1986b) and puku (de Vos 1965, de Vos & Dowsett 1966, Rosser 1987) have been studied in detail, focussing especially on social organization and mating systems.

The lek breeding system – based on territorial defence where only a minority of dominant males secure matings – are exemplified in certain lechwe, puku and kob. Significantly, the first record of lek breeding in a mammal was recorded in the Reduncini (*K. kob*, Buechner 1961). These social systems have evolved in response to high densities of antelopes in specific habitats. Territorial and other disputes between individuals are frequent and follow highly ritualized behavioural repertoires (Leuthold 1977). Lechwe exhibit significant diversity in breeding systems: *K. kafuensis* and *K. leche* (in the Linyanti) defend and mate on leks, but *K. smithemani* does not (Thirgood *et al*. 1992). These social systems of reduncines are correlated with their morphological adaptations. Chief amongst these are the scent glands and robust horns. Scent marks are important in denoting information about reproductive and social status (Kingdon 1982), thus the social organization of reduncines is dominated by olfactory cues. All reduncines have a strong musky odour from secretions of the sebaceous glands – waterbuck (*K. ellipsiprymnus*) are noted for their strong "turpentine-like" odour, and strong odours also characterize reedbuck and lechwe. It appears that reduncine scents are species-specific and are involved in recognition of conspecifics in territoriality and mate choice. A semiochemical function of scent marks has been demonstrated for two species of lechwe (Deustch & Nefdt 1992). A diversity of specialized scent glands in reduncines include subauricular, pedal and inguinal glands, and the scented fur is maintained by an oily secretion into the fur from the sebaceous glands (Kingdon 1982). Territorial, sexually active puku males have a glandular secretion on the neck (Rosser 1987).

Only male reduncines have horns. The evolutionary trend has been toward enlargement of horns, which has reached its extreme in lechwe and waterbuck. Large horns function as signalling devices and are used in ritual sparring among males over status, territories and mates. A key adaptation has evolved to allow the powerful and violent head movements of males, manifest in the thick necks of puku, lechwe and kob. Sexual dimorphism renders this trait especially noticeable in males. The conspicuous evidence of this adaptation has been hypertrophy of the longus capitis muscle underlying the spinal column, which contracts the neck and lowers the head. Enlargement of this muscle is associated with larger processes of the cervical vertebrae and the basioccipital processes at the base of the reduncine skull (Kingdon 1982).

3.3.2 Ecological relevance

A common trait of Reduncini is close association with aquatic habitats, and all are dependent on surface water. Lechwe, in particular, have a predilection for floodplains, a dependency that appears to be physiological and is presumably primitive in its evolution, being manifest throughout extant reduncines (Kingdon 1982) including Mountain Reedbuck, *Redunca fulvorufula* (Smithers 1971).

Several authors (Schuster 1976, 1980) have emphasized the impact of lechwe on floodplains, especially the Kafue and Bangweulu. Here, dense concentrations of lechwe represent an extreme manifestation of the phenomenon.

The dominant role of reduncine antelopes in the ecology of aquatic landscapes in Africa has been largely inferred. Williamson (1981) notes that grazing by lechwe in the Linyanti has had a major impact on the sward, reducing large areas to closely-cropped lawns. Apart from calculations of biomass, there has been no quantitative demonstration of the impacts of these antelopes on nutrient flux or effects on other populations (invertebrates, fishes and waterbirds). It is equally valid to infer that the specific habitat selection by reduncine antelopes will have a marked impact through their trampling of the substrate. This would especially apply to seasonal concentrations of these antelopes when breeding. In this respect, *K. smithemani* and *K. kafuensis* appear to hold a keystone role in certain aquatic landscapes, such as the Bangweulu and Kafue floodplains, due to trampling of the floodplain and participating in nutrient cycling. The biomass of Kafue lechwe has been recorded as the highest known carrying capacity for large mammals (11,000 kg/km^2), although this figure fluctuated with seasonal flooding regimes (Schuster 1980).

3.4 POPULATION STATUS AND HISTORICAL DECLINES

This section summarizes the status of Reduncini in significant areas within the Zambezi Basin, with a focus on the principal wetlands. The definitive source is East's (1989a, 1989b) multi- authored survey of the status and conservation of antelopes in southern and south-central Africa, which includes country reports and a regional review. Where possible, evidence for changes within the basin is included. The earliest records are from the writings of David Livingstone, who explored the Zambezi and some of its tributaries in the mid-19th century. Important records have been summarized by Benson (1974). Additional information can be obtained in the writings of later explorers and hunters, notably F.C. Selous (Selous 1881, 1908).

3.4.1 **Barotseland**

Populations of waterbuck and lechwe have declined within the region (Figures 3.2 and 3.3), as concluded from historical records since the early 20th century (Ansell 1960a, 1978). Waterbuck do not occur west of the Zambezi. Reedbuck appear widespread where human depredation is not excessive (East 1989a).

3.4.2 **South eastern and central Angola**

Populations of red lechwe and waterbuck extend from the Upper Zambezi valley within western Zambia into southern Angola (Figures 3.2 and 3.3). The status of waterbuck along the Cubango, Luiana and Okavango (Kavango) rivers is unknown, but they are suspected to have declined. Given the decline of the Namibian population, the overall status of this population (believed to be *penricei*) could be precarious. It is noteworthy that an isolated population of puku occurs in the Luando National Park in C Angola. Red lechwe occur along the Zambezi in E Angola and the Cuando in the south east within the Luiana and Mavinga Reserves (East 1989a). Red lechwe are considered rare in Angola (East 1989a) and their current status cannot be established. This situation is unsettling, as the taxonomic status of these populations (especially the widely separated populations of the Cubango, Luiana and Kavango rivers) is unclear.

Figure 3.2. Distribution of two species of waterbuck (*Kobus crawshayi, K. ellipsiprymnus*) in the Zambezi Basin (after Ansell 1978, Ansell & Dowsett 1988, East 1989a,b, Griffin & Joubert 1991, Rodgers 1984, Skinner & Smithers 1990). Distributions of *K. kondoensis* and *K. penricei* are not mapped in detail, being subject to future biogeographical and phylogenetic refinement. Hatched areas depict approximate distributions summarized by East (1989a,b) where specimen data could not be located. Open symbols are localities of historical occurrence.

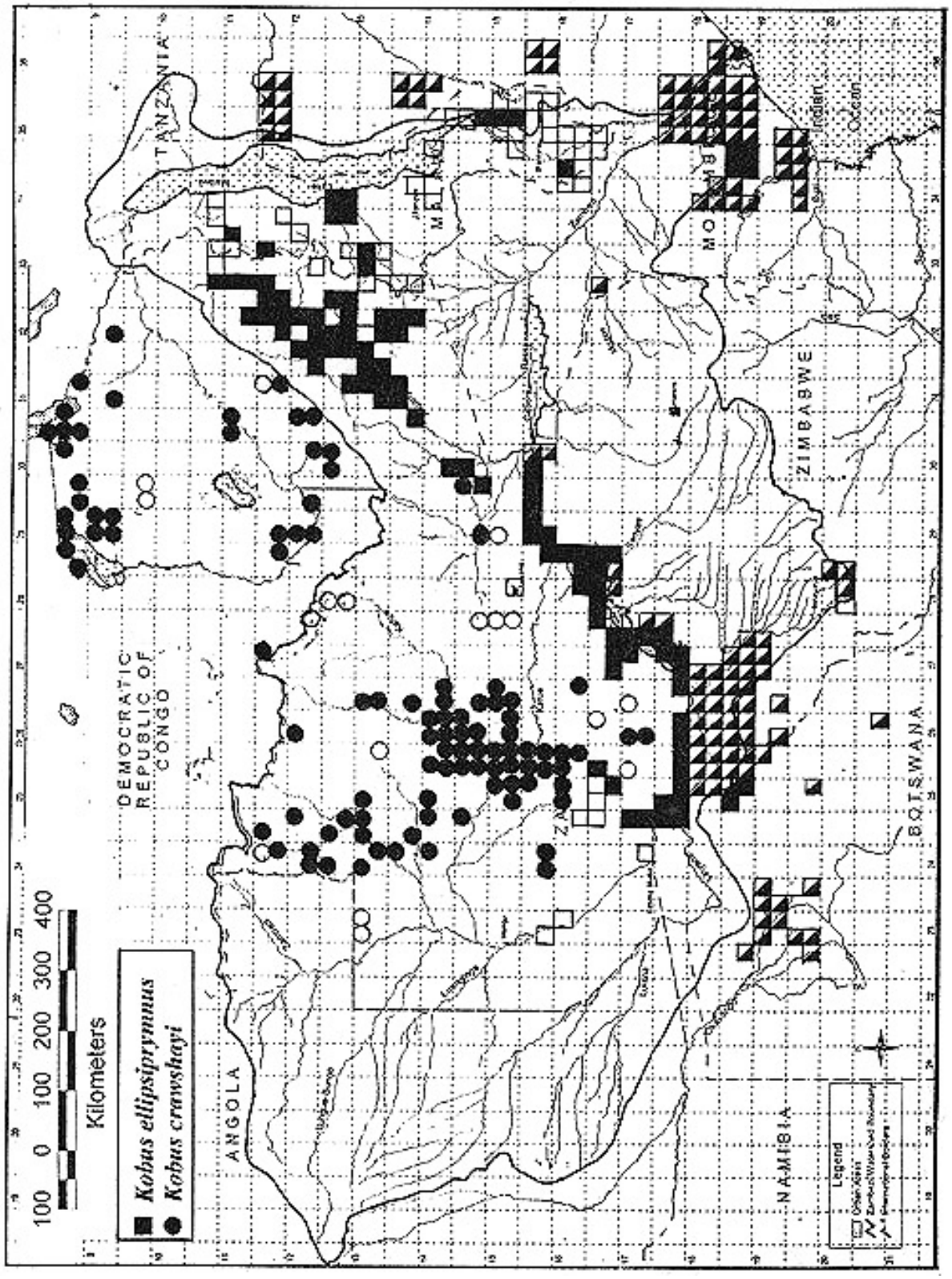
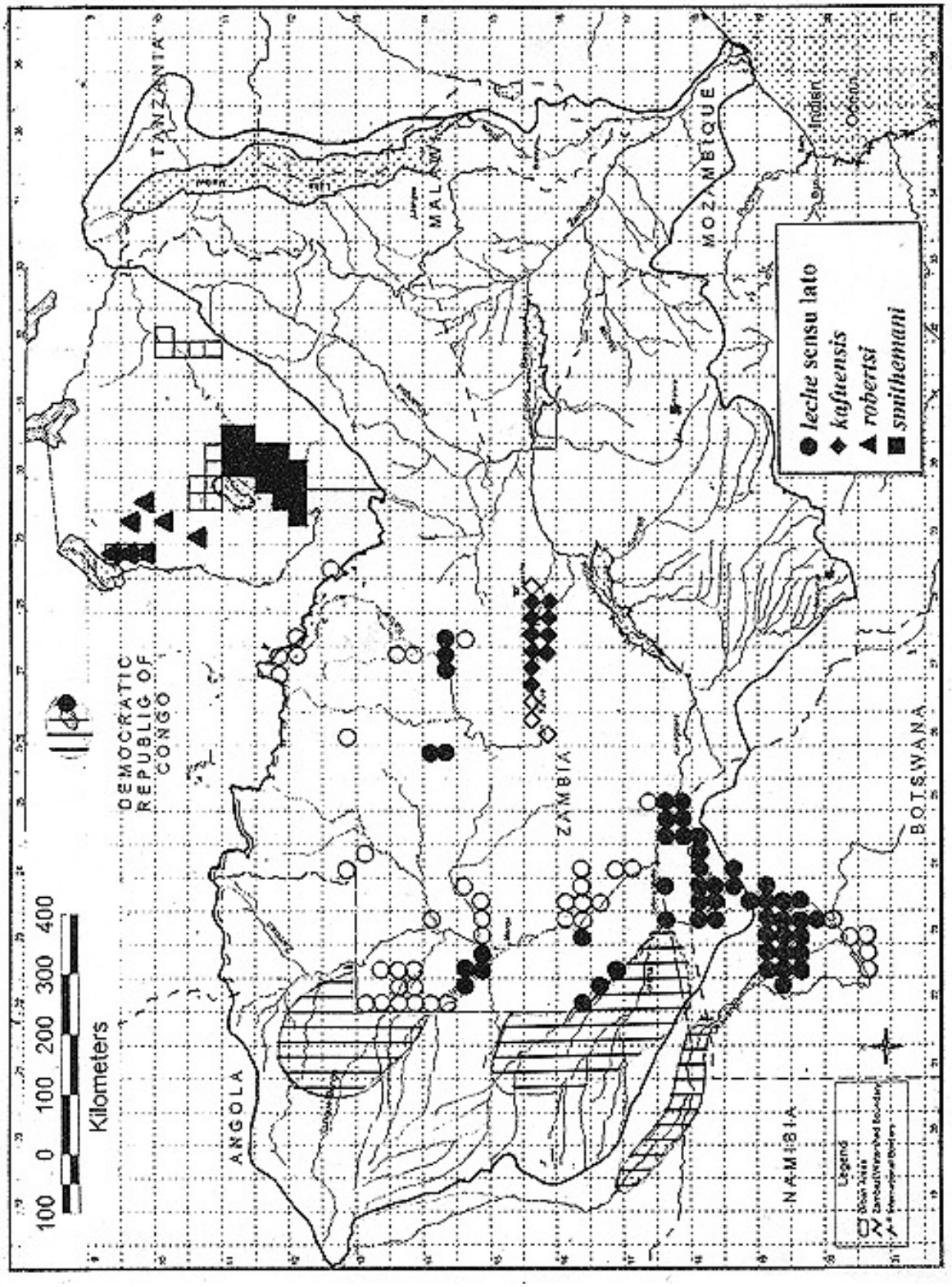


Figure 3.3. Distribution of four "subspecies" of lechwe (*Kobus l. leche* sensu lato, *K. l. kafuensis, K. l. robertsi*, *K. l. smithemani*) in the Zambezi Basin (data from Ansell 1978, Ansell & Dowsett 1988, Dollman 1921, East 1989a,b, Griffin & Joubert 1991, Smithers 1971, Skinner & Smithers 1990). Distributions of outlying allopatric populations of *K.* "*leche*" are also depicted which include *K. notatus* and *K. amboellensis*. Hatched areas depict approximate distributions summarized by East (1989a,b) where specimen data could not be located. Open symbols are localities of historical occurrence.



3.4.3 **Caprivi and Chobe/Linyanti**

Overall, reduncine populations have declined in the western Caprivi and certain species apparently occur marginally (East 1989a). Over the past 100 years, puku have declined greatly in the eastern Caprivi (East 1989a, Smithers 1983), and their status is marginal and precarious in Namibia (Figure 3.4). As of the 1980s, a relic population of approximately 50 animals persisted on the Chobe floodplain in Botswana (East 1989a, Smithers 1983). F.C. Selous first visited the Puku Flats in 1874, when puku were very numerous, but they were greatly disturbed by dense settlement in 1876 by refugees following political turmoil in Barotseland. They have never recovered from this human impact (Dollman 1921). Puku also declined to extinction on Impalila Island in the Caprivi after its settlement in 1958 (Child 1968).

It has been suggested that the total population of reedbuck within Namibia is approximately 50 individuals (East 1989a). Griffin & Grobler (1991) noted sightings of waterbuck in the eastern Caprivi between 1983 and 1987 but none since, and record a decline of waterbuck along the Kwando floodplain. Red lechwe are the exception. As of the late 1980s, a population of over 4300 occurred in the eastern Caprivi, and 150-200 in the western Caprivi. It has been estimated that several thousand red lechwe occur in the Linyanti area of Botswana, and these migrate seasonally into the Chobe floodplain (Williamson 1981, East 1989a).

3.4.4 **Okavango Delta**

Populations of reduncine populations appear healthy where human settlement has not excluded or depleted their populations. This includes stable populations of waterbuck (the Botswana national population of 900 is largely concentrated within the Okavango), reedbuck (small) and red lechwe. Over 20 000 red lechwe are estimated to occur in the Okavango.

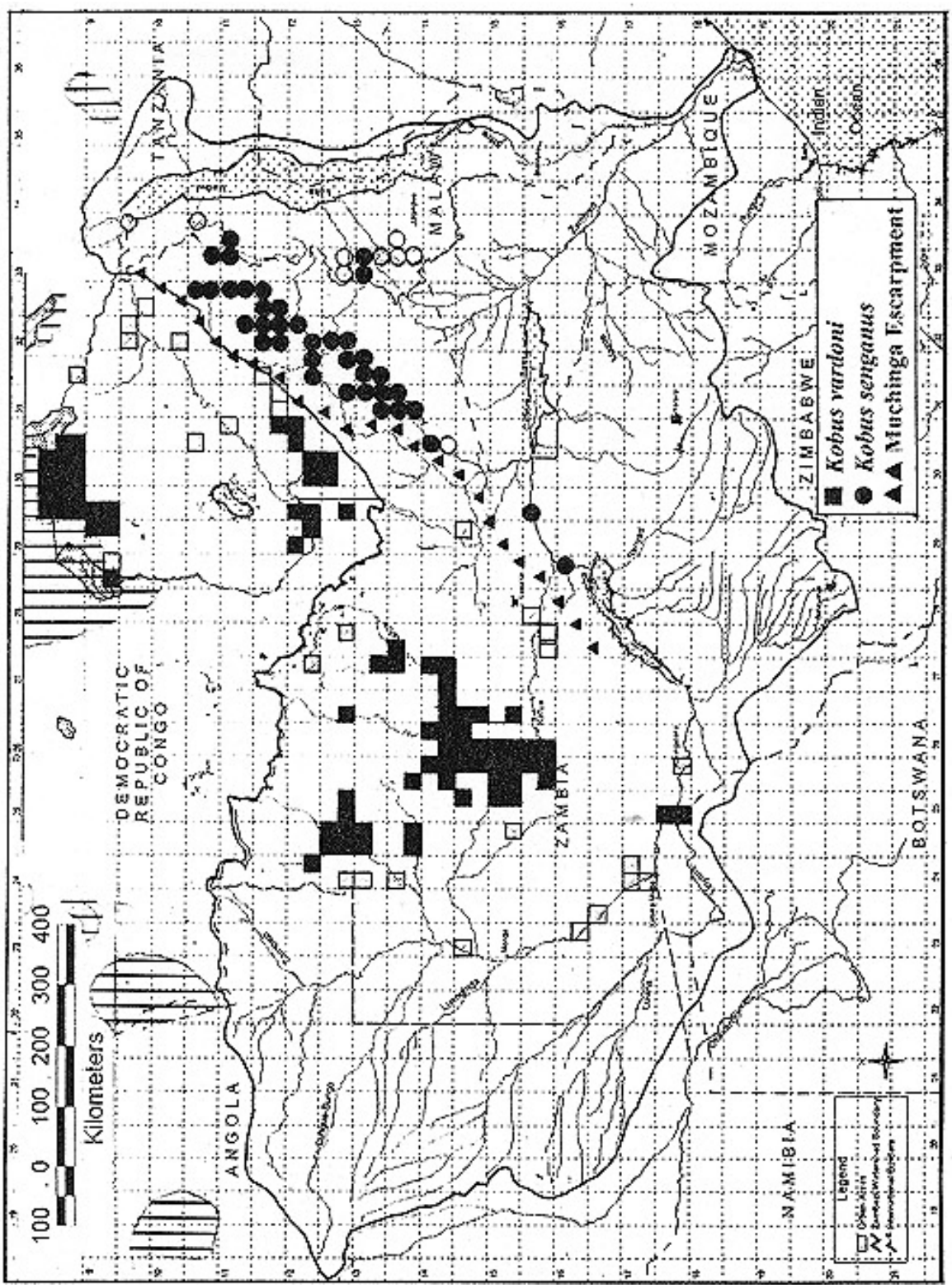
Smithers (1971) discusses the local extinction of lechwe from Lake Ngami since the last century. They were not encountered by the Vernay-Lang Kalahari expedition which crossed Lake Ngami in May 1930, and which went on to collect 10 red lechwe from the vicinity of the Kwaai River from 6-28 May 1930 (Hill 1942).

3.4.5 **Bangweulu Flats**

Black lechwe formerly occurred in their hundreds of thousands in the Bangweulu Basin in the early part of the 20th Century (Allen 1963, Ansell 1978, Bell & Grimsdell 1973, Howard *et al*. 1984, Hughes 1933, Letcher 1910, Thirgood *et al*. 1994). The biology and status of black lechwe and their environment has been the subject of a comprehensive report (Grimsdell & Bell 1975). The population has since undergone a dramatic decline both in its range and abundance. This extirpation elicited considerable concern and much subsequent study.

The major cause of the decline of *K. smithemani* has been accelerated human depredations – much of it driven by commercial poaching to supply protein demands on the Copperbelt. This commercialization of exploitation changed what had previously been a localized economy of subsistence hunting by the resident people (Batwa, Baunga and Bisa tribes). Modern technology – in the form of firearms for hunting, and vehicles for transportation – aided and accelerated these depredations (Grimsdell & Bell 1976). An added mortality agent was predation by the abundant lion, *Panthera leo*, population in the Mpika District of Lake Bangweulu in the mid-20th century. Following a drastic decline in the prey populations of the miombo savannas surrounding the wetland, these lions modified their hunting behaviour to a semi-aquatic existence, successfully hunting Black Lechwe (Allen 1963).

Figure 3.4. Distribution of two species of puku (*Kobus senganus* and *K. vardoni*) in the Zambezi Basin (data from Ansell 1978, Ansell & Dowsett 1988, Griffin & Joubert 1991, Rodgers 1984, Skinner & Smithers 1990, Smithers 1971). The taxonomic status of the isolated populations in Tanzania are not known. The cross-hatched line approximates the Muchinga Escarpment. Hatched areas depict approximate distributions summarized by East (1989a,b) where specimen data could not be located. Open symbols are localities of historical occurrence.



It is noteworthy that an abnormally high flood after 1936 significantly depleted numbers of *K. smithemani*, which dropped from at least 150,000 to 40-60,000 individuals. The raised water level squeezed the population into the remaining habitat, where they were also more susceptible to intense hunting that began with poaching for meat rations during the Second World War, and was commercialized thereafter. Numbers declined to about 16,000 in 1969.

This episodic flooding illustrates the comparative susceptibility of a large herbivore with specific habitat requirements, although in the case of lechwe it is offset by their high reproductive potential. Grimsdell & Bell (1976) estimated a population increase approximating 25% from 16,000 in 1969 to 30,000 in 1976. Based on repeated censuses from 1988 to 1991, the latest report (Thirgood *et al.* 1994) records the population of *K. smithemani* in the southern Bangweulu to have recovered to approximately 30,000 individuals. It remains threatened by poaching and improved access to the area (especially in the west). Thirgood *et al.* (1994) emphasize the importance of securing the Chimbwi Plain as a dry season refuge for the population.

3.4.6 **Lake Mweru**

I have not been able to obtain reports which focus directly on the reduncines occurring on the margins of Lake Mweru and its tributaries. This is unfortunate. Ansell (1974) paid some attention to the taxonomic position and status of the Luena lechwe, *K. robertsi* – concluded to be extinct (Figure 3.3).

3.4.7 **Busanga Flats, Kafue National Park**

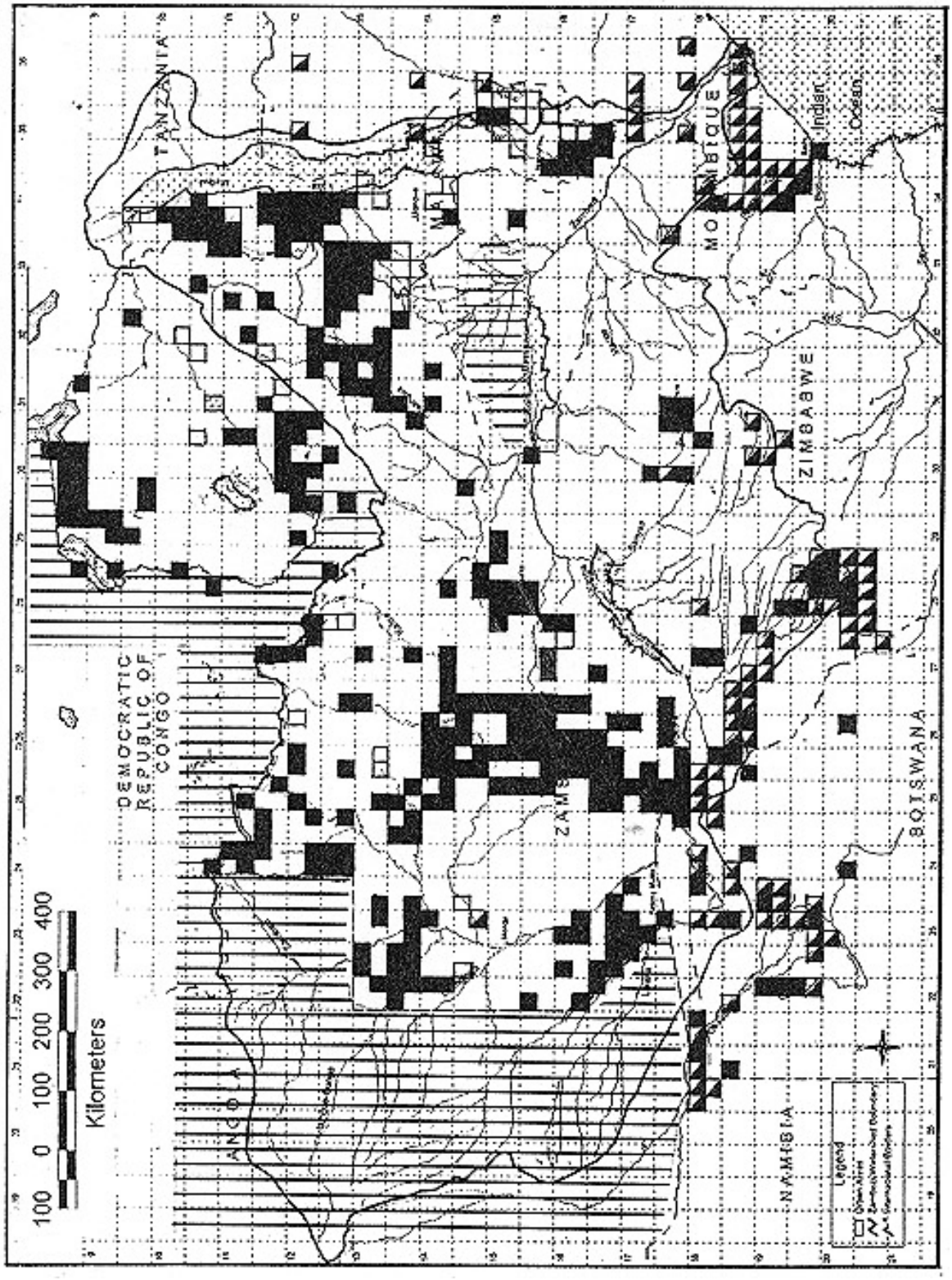
Rapid recovery of lechwe populations has been recorded in the northern region of the Kafue National Park (Figure 3.3), where the red lechwe population had recovered from an estimated 71 animals in October 1948 to 1163 in July 1971 (Grimsdell & Bell 1972). The most recent report estimated that this population numbered 3400 in 1985 (Howard & Chabwela 1987). The latter census covered both wet and dry seasons.

3.4.8 **Kafue Flats**

The Kafue Flats are of significant conservation status as the endemic Kafue lechwe is entirely restricted to this locality (Figure 3.3). The formerly widespread population is now restricted to Blue Lagoon and Lochinvar National Parks. Construction of hydroelectric schemes (centered on the Kafue Dam) were predicted to cause major disruptions to the Kafue Flats and its biota. Alteration of the flooding regime was particularly expected to affect Kafue lechwe by impacting on their social behaviour (Schuster 1980). Numbers declined by 50% between 1972 and 1981, but their total distribution has not changed significantly. Long term affects of this acute hydrological perturbation on the Kafue biota have still to be established (East 1989a, Sheppe 1985). The leks of Kafue lechwe are restricted to a remarkably small area (Nefdt 1996). Nonetheless, the reproductive seasonality of Kafue lechwe has since changed with a modification in timing of floods released from impoundments upstream. The primary cue that initiates mating appears to be rising flood waters: young born seven months later benefit nutritionally from exposed forage as waters recede from the floodplain (Nefdt 1996). Nefdt (1996) records that although Kafue lechwes mate and conceive throughout the year, a significant peak in births occurs in periods of maximal forage availability (over a period of one to two months), especially when water levels on the floodplain are receding and exposing nutritious forage.

A recent visit to Lochinvar National Park in October 1999 and discussions with local authorities revealed that commercial poaching of *K. kafuensis* is rife, especially in Blue Lagoon National Park, where depredations are unsustainable.

Figure 3.5. Distribution of southern and northern reedbuck (*Redunca arundinum* and *R. occidentalis*) in the Zambezi Basin (data from Ansell 1978, Ansell & Dowsett 1988, East 1989a,b, Griffin & Joubert 1991, Skinner & Smithers 1990). No attempt has been made to distinguish between distributions of the two populations. Hatched areas depict approximate distributions summarized by East (1989a,b) where specimen data could not be located. Open symbols are localities of historical occurrence.



3.4.9 **Lower Shire and Malawi**

Waterbuck and reedbuck (Figures 3.2 and 3.5) originally occurred throughout the Lower Shire in suitable habitat (Ansell & Dowsett 1988). These populations were virtually extirpated with widespread settlement by rural human populations and associated development. They only persist in the Liwonde and Majete Reserves. Reedbuck still occur in certain protected areas, notably Nyika National Park (East 1989a). Elsewhere in Malawi, waterbuck only survive in protected areas such as Liwonde National Park and Nkhotakhota and Majete Game Reserves. It appears to be declining in the Kasungu National Park and is believed extinct in the Vwaza Marsh Game Reserve (Ansell & Dowsett 1988). Puku have always had a very restricted distribution in Malawi (Ansell & Dowsett 1988, Lyell 1913; Figure 3.4).

3.4.10 **Middle Zambezi Valley**

Healthy populations of waterbuck persist within the protected areas across the middle Zambezi Basin, including Matusadona, Mana and Zambezi National Parks, and where human settlement has not reduced their numbers in suitable habitat (East 1989a). Reedbuck appear to be absent from large parts of the middle Zambezi Valley, and occur locally in northwestern Zimbabwe upstream of Victoria Falls. Reedbuck appear to have declined within the region, possibly due to increased aridity. Large numbers of waterbuck and reedbuck were extirpated in the Sebungwe and Urungwe regions of Zimbabwe during Tsetse Control operations into the 1960s – a total of 16,644 reedbuck and 10,371 waterbuck were shot between 1933 and 1958 – the majority from the Middle Zambezi Valley. The falling proportion of these reduncines' contribution to total kills through this period suggests a significant impact on the population (Child & Riney 1987).

3.4.11 **Zambezi Delta and Gorongosa**

Important populations of reedbuck and waterbuck persisted in Sofala Province and southern regions of the Zambezi Delta into the 1980s, but experienced major depredations thereafter. The northern region of Sofala Province (including Gorongosa and Marromeu) was estimated to support 90% of the vulnerable waterbuck population in Mozambique (East 1989a).The first census in 1968 suggested a population of 4300 waterbuck, concentrated in south and central Marromeu (Tinley 1969). A survey in June 1994 revealed that intact populations of reedbuck occurred in Gorongosa National Park, but comparatively few were seen in Marromeu. Previously, the waterbuck population in Marromeu was of the order of 50,000 in the late 1970s, but the 1994 census estimated that only between 33 and 230 animals had survived (Cumming *et al.* 1994). Given the localized, apparently allopatric range of this waterbuck population (Figure 3.2), its taxonomic status requires investigation. Originally, reedbuck were widespread and common where human depredations are not excessive, with Marromeu-Gorongosa being the stronghold of the species in Mozambique. They also appear to have benefited from a partial drying out of the Marromeu floodplain during the 1980s. Chambal (1989) suggested that very few reedbuck (21) existed in Marromeu in 1988, and Cumming *et al.* (1994) estimated the total population of central Marromeu at a meagre 10 individuals. These figures appear to be underestimates as Anderson *et al.* (1990) estimated the population of the ecotone and floodplains (admittedly a larger area) at 260. Nonetheless, reedbuck have declined catastrophically since the 1970s. Recent catastrophic crashes in these reduncine populations (and other large mammals) have obviously created a conservation crisis in the region. Most recently (July 1999), the population of reedbuck appears to be recovering.

3.5 TAXONOMY AND STATUS OF REDUNCINE POPULATIONS

I have attempted to identify each significant population of the reduncine antelopes that have been recognized by taxonomists at the subspecific level or higher, and/or have been recognized as discrete populations with definite geographical boundaries. Thus the following species accounts apply the species category loosely and would be better labelled "population accounts". They provide short reviews of the taxonomy and distribution of each discrete population (selected mainly on subspecific criteria), with a synopsis of the current status of each. The accounts form an introductory framework to review the diversity of the Reduncini in more detail to elucidate a more accurate taxonomy. Conservation status is derived from East (1989a, 1989b).

I place particular emphasis on the evolutionary distinction of a species. This recognizes most allopatric populations as full species, and is in direct conflict with the traditional orthodoxy of the Biological Species Concept (BSC) with its firm reliance on reproductive isolation. A significant departure from this orthodoxy is that the concept of subspecies is not applied (see Cracraft 1997 for further discussion). The differences, and especially the implications and impacts for conservation, of this two philosophies are important, and are discussed in detail in the next section.

REEDBUCK

Southern Reedbuck, *Redunca arundinum*

Taxonomy and Distribution

R. arundinum is sympatric with the Bohor reedbuck, *R. redunca* in W Tanzania in the drainage of the Ugalla and Moyowosi rivers. Key characters distinguishing these species include the number of inguinal pouches, pelage and horn shape (Ansell 1971).

Two subspecies were recognized by Ansell (1971), who notes that *thomasinae* Sclater, 1900 (from the Songwe River separating Tanzania and Malawi) has priority over usage of *occidentalis*, should the northern race prove separable:

R. a. arundinum (Boddaert,1785) includes *eleotragus* Schreber,1787; *coerulescens* Link,1795; *arundinacea* Bechstein,1799; *cinerea* Bechstein,1800; *isaellina* Afzelius,1815; *oleotragus* Desmoulins,1822; *multiannulata* Fitzinger,1869; *caffra* Fitzinger,1869; and *algoensis* Fitzinger, 1869.

The southern reedbuck was formerly widely distributed in the Zambezi Basin in all the riparian states, wherever suitable habitat occurs.

Status

Status of this widely distributed species varies from Vulnerable to Least Concern. Southern reedbuck have declined within large parts of their former range due to human settlement and depredations. They still persist along dambos within the southern catchment of the Middle Zambezi, but have declined in W Zimbabwe apparently due to increasing aridity. The large population of C Mozambique appears Near Threatened in Gorongosa and is Endangered in Zambezi Delta (Marromeu floodplain) based on a catastrophic decline since the 1970s (Cumming *et al.* 1994).

Northern Reedbuck, *Redunca occidentalis* Rothschild, 1907

Taxonomy and Distribution

Widely distributed through Gabon, N Angola, DRC, Zambia, Tanzania, and possibly N Mozambique and N Malawi. The taxonomic treatment by Ansell (1971) is provisional and it is uncertain where

the two taxa (*arundinum* and *occidentalis*) actually occur in the Zambezi Basin, particularly in the southern regions. In all respects, *Redunca arundinum* (*sensu lato*) is an antelope associated with the southern savannas – a distributional pattern which distinguishes it from *R. redunca*, the Bohor reedbuck.

In conclusion, the available evidence suggests that two different populations of reedbuck occur within the Zambezi Basin; their exact distributions and taxonomic status await elucidation. Lydekker & Blaine (1914) differentiated between the two taxa on the greyer fur of the neck and grey tail of *occidentalis* compared with *arundinum*. It remains to be ascertained whether this character represents a geographical cline across Africa, or represents discontinuous variation. Overall status is Vulnerable. Reedbuck have declined in parts of Zambia, and especially in Malawi (Figure 3.5).

Table 3.1. Comparison of taxonomic units recognizing by lumping or splitting reduncine taxa at the population level within the genera *Kobus* and *Redunca* that occur within the Zambezi Basin. *K. ellispsiprymnus* in the central (and particularly NE) Zambezi Basin could be specifically distinct from the topotypical population of N South Africa and S Botswana. It is unclear whether the Tanzanian population of puku in the Rukwa and Kilombero valleys is *vardoni* or *senganus*.

Biological species	**Subspecies**	**Evolutionary species**
R. arundinum	R. a. arundinum	R. arundinum
	R. a. occidentalis	R. occidentalis
K. ellipsiprymnus	K. e. ellipsiprymnus	K. "ellipsiprymnus"
	K. e. crawshayi	K. crawshayi
	K. e. kondoensis	K. kondoensis
	K. e. penricei	K. penricei
K. leche	K. l. leche	K. leche (restricted to Okavango Delta)
	K. l. amboellensis	K. amboellensis
	K. l. notatus	K. notatus
		K. "leche - Busanga"
		K. "leche - Upemba"
		K. "leche - Luando"
	K. l. smithemani	K. smithemani
	K. l. robertsi	K. robertsi
	K. l. kafuensis	K. kafuensis
K. vardoni	K. v. vardoni	K. vardoni
	K. v. senganus	K. senganus
		K. "vardoni - Tanzania"
		K. "vardoni - Luando"
Relevant populations **4**	**14**	**19+**
Total species **4**	**4**	**19+**

WATERBUCK

Common Waterbuck, *Kobus ellipsiprymnus*

Taxonomy and Distribution

Two broad divisions within *K. ellipsiprymnus sensu lato* have been traditionally recognized by taxonomists. These are the *defassa* group (discussed below) and *ellipsiprymnus* group. The major character distinguishing the two forms is the elliptical ring of pale fur on the rump (*ellipsiprymnus*) versus a pale patch (*defassa*). Haltenorth (1963), followed by Ansell (1971), recognized eight subspecies under the vaguely defined *defassa* group.

It appears that the majority of waterbuck within the Zambezi Basin belong to the nominate *ellipsiprymnus*. These two species groups (*defassa* and *ellipsiprymnus*), formalized by Ansell (1971) for *K. ellipsiprymnus sensu lato*, have been recognized in later treatments (Meester *et al.* 1986), but the situation remains confused. Most importantly, the exact geographical and taxonomic relationship of *ellipsiprymnus* with *penricei, crawshayi* and *kondoensis* awaits elucidation. The relationship between *kondoensis* and *ellipsiprymnus* along the northeastern edge of the latter's range is equally unclear. The distribution of *kondoensis* centres on C and E Tanzania, but its southern limits (bordering *ellipsiprymnus*) and northern limits (bordering *thikae* (Matschie, 1910)) are unknown.

Status

Endangered in C Mozambique. Elsewhere, waterbuck are widely distributed within the southern and eastern portion of the Zambezi Basin where suitable habitat occurs and human impacts are not excessive. Ansell & Dowsett (1988) and East (1989a) do not state which taxon occurs in Malawi, but it is thought to be *ellipsiprymnus* (C. Dudley, pers. comm.)

Kondo Waterbuck, *Kobus kondoensis* (Matschie, 1911)

Taxonomy and Distribution

The distribution of the Kondo waterbuck is centred in S Tanzania, but the southern and northern limits to this population have yet to be established. It has been classified in the *ellipsiprymnus* group – apparently closely related to the nominate race (Ansell 1971). I draw attention to this population, because its possible occurrence within the northeastern margin of the Zambezi Basin needs to be considered. Here it would occur parapatrically, or perhaps sympatrically, with *ellipsiprymnus* and/or *crawshayi*.

Status

Indeterminate. This situation that can only be resolved by a thorough systematic study of this population and its allies. The population of waterbuck extending west of Lake Tanganyika to Lake Mweru could represent this *K. kondoensis* (Figure 3.2).

Crawshay's Waterbuck, *Kobus crawshayi* P. L. Sclater, 1894

Taxonomy and Distribution

Typically classified as *K. defassa crawshayi*, the distribution of Crawshay's waterbuck is centred on the southern Congo Basin west of the Muchinga Escarpment. It also has a scattered distribution across south eastern Tanzania, where its relationship with *kondoensis* is uncertain. The Muchinga Escarpment forms a significant southwestern boundary to its distribution. In a localized area along the Lusemfwa River, *crawshayi* occurs sympatrically with *ellipsiprymnus*, and hybridization has been recorded (Ansell 1978). Ansell (1982) also describes hybrids of these waterbucks near Ngoma in Kafue National Park, but no progeny appeared to survive.

In Zambia, Crawshay's waterbuck has often been called the Defassa waterbuck, *K. defassa* (for example, Hanks *et al.* 1969, De Vos & Dowsett 1966). This is strictly speaking incorrect as true Defassa waterbuck only occur in S and C Ethiopia (Ansell 1971).

Status
Vulnerable. Endangered locally within its formerly wide range. Its exact status requires elucidation of the northern extent of its distribution. Populations have been established on private game ranches in S Zambia (A. Middleton, *pers. comm*. 1990). Griffin & Grobler (1991) record the occurrence of a few individuals, which they designate *K. e. crawshayi*, in the Zambezi area of the Caprivi between 1983-1987. These are perhaps better allocated to *K. penricei*.

Penrice's Waterbuck, *Kobus penricei* Rothschild, 1895
Taxonomy and Distribution
The distribution of Penrice's waterbuck is centred in S and C Angola in the drainage of the Okavango, Upper Cunene and Kwando rivers, and the population extends marginally into the Caprivi. The type specimen was collected "from Bongo, Kuvali River, 100 miles (approx.) S.E. of Benguella" (Shortridge 1934: 528). This distribution was noted by Shortridge (1934) who, citing D.G. Lancaster (*in litt.*), mapped the range of *penricei* eastwards along the Chobe River in Angola to Shesheke in SW Zambia. In this context, *crawshayi, penricei* and *ellipsiprymnus* exhibit a parapatric distributional pattern across the region of E Caprivi and the Chobe-Zambezi confluence, a situation not followed by Ansell (1978). It remains to be established whether historical records of waterbuck along the Upper Zambezi (Ansell 1978) are referable to *penricei* or *ellipsiprymnus*.

This uncertainty is reflected in recent reviews of southern African mammals (Smithers 1983, Skinner & Smithers 1991) which do not cite the occurrence of *K. penricei* in southern Africa (the W Caprivi) and only recognize *K. ellipsiprymnus*. Nevertheless, the authoritative *Classification of Southern African Mammals* (Meester *et al*. 1986) recognizes both *ellipsiprymnus* and *penricei* as occurring in southern Africa. Here, *penricei* is listed provisionally, based on the occurrence of vagrant individuals in the Caprivi from Angola. In a final word on its status, Meester *et al.* (1986) quote W.F.H. Ansell (*in litt.*) that *ellipsiprymnus* and *defassa* (including *penricei*) form parts of a superspecies.

As with the other populations of waterbuck, the status of *penricei* is difficult to ascertain, especially with respect to *crawshayi*. Lydekker & Blaine (1914) distinguished between the darker- furred *penricei* and lighter-furred *crawshayi*. It is perhaps pertinent to note that Letcher (1910) distinguishes two varieties of "*defassa*" waterbuck – a paler-furred population south of Lake Mweru and west of the Muchinga Escarpment "in eastern Northern Rhodesia", and a darker-furred variety he only encountered and shot in the western part of the country.

Although Ansell (1971) lists *penricei* as also occurring in the southwestern DRC and S Gabon, it is unlikely that this vast area is inhabited by only a single waterbuck taxon. As with the other described populations occurring within the basin, similar taxonomic problems apply to *penricei*, a problem that can only be resolved by a thorough systematic review.

Status
Vulnerable and likely Endangered in Angola. Its exact status requires elucidation of the overall distribution of *K. penricei*, especially along its northern and eastern margins. The population of waterbuck has declined on the Kwando floodplain in Namibia. No individuals were recorded in the Kavango, Linyanti or Zambezi areas, but reasons for this decline are unknown. Some individuals,

attributable to either *crawshayi* or *penricei* were recorded from the Zambezi area of Namibia (E Caprivi) between 1983 and 1987, but have not been resighted (Griffin & Grobler 1991).

LECHWE

Black Lechwe, *Kobus smithemani* (Lydekker, 1900)

Taxonomy and Distribution

The taxonomic distinctiveness of the smaller, darker coloured lechwe in N Zambia was recognized early in the 20th century, although queried by Barclay (1933). Male black lechwe had long been sought after as trophies (Lyell 1913), so this antelope was unquestionably recognized as distinct. Ansell (1964) recognized this, which had previously been unquestioned by conservation authorities. This taxonomic distinctiveness, exhibited in darker colouration and shorter horns of *smithemani*, was conclusively demonstrated by Ansell & Banfield (1980). Black lechwe formerly occurred along the northern shores of Lake Bangweulu, and also in the upper reaches of the Chambeshi River (Ansell 1978), but these populations were extirpated in the early part of this century.

Kobus smithemani only occurs along the southern and eastern margins of Lake Bangweulu, where the population migrates seasonally as water levels fluctuate. The core area used by black lechwe focuses on Chikuni Island, which only becomes isolated during high water levels (Grimsdell & Bell 1975).

Status

Vulnerable. The numbers of *K. smithemani* have recovered from a radical decline through the 1950s. The majority of this population is concentrated in the southern Bangweulu floodplain, and the localized extent of this habitat means that the population is at risk of disease (such as anthrax and rinderpest) and political unrest. A recent visit to the Bangweulu Flats in October 1999 revealed large herds in the vicinity of Chikuni Island and its surrounds. Black lechwe herds were encountered over 10 km west and 5 km east of Chikuni Island. Subsistence poaching continues as shown by the abundance of skulls a few months old on the floodplain. The population of *K. smithemani* in the western reaches of the Bangweulu Flats is exposed to commercial poachers who exploit improved access from the tarred Mansa-Serenji road (R. Nefdt, *pers. comm.* 1999).

Kafue Lechwe, *Kobus kafuensis* Haltenorth, 1963

Taxonomy and Distribution

The population of lechwes confined to the Kafue Flats of S Zambia had flippantly been described as "red lechwe" into the 1960s. The Kafue lechwe was only described as taxonomically distinct in 1963, although this had previously been suspected and even tacitly acknowledged (see Ansell 1964). *K. kafuensis* is larger than other lechwe, with larger horns (Ansell 1964). The morphology of the inguinal glands also differ from other lechwe (Ansell 1960b). *K. grandicornis*, Ansell 1964 is a synonym of *kafuensis*.

Status

Endangered. Although, the numbers of Kafue lechwe have recovered from a radical decline through the 1950s, they have not recovered to former densities or range. The majority of this population occurs in the Lochinvar National Park (with a smaller population in Blue Lagoon National Park), but is dependent on resources outside of the protected area on commercial farms and densely settled areas (East 1989a). The leks, essential for breeding, are remarkably localized in their number and location – only five existed between 1990 and 1991 within the entire range of this species on the south bank of the Kafue Flats. Despite intensive surveys, no other leks were located (Nefdt 1996). The localized extent of this habitat means that the population is at risk of disease (perhaps anthrax

and rinderpest) and human depredations. A recent visit to Lochinvar in October 1999, and discussions with resident biologists and safari operators in Zambia, revealed that commercial poaching of *K. kafuensis* is rampant, especially in Blue Lagoon National Park. This situation appears to be severe and requires drastic action if the species is not to decline to extinction.

Red Lechwe, *Kobus leche* (Gray, 1850)

Taxonomy and Distribution

Based on the entrenched taxonomic classification, reduncine antelopes affiliated to the nominate race of the red lechwe are believed to exhibit an extensive, albeit scattered, distribution across the modern Zambezi Basin, with outliers in SE and C Angola, and southern Shaba province of the DRC (Ansell 1971, East 1989a, 1989b, Shortridge 1934). Red lechwe also occurred in the southern DRC in the Upemba National Park (Ansell & Banfield 1980, Schouteden 1947). An important population of lechwe occurs in S Angola, centred along the Kavango (Okavango) River and extending into the western Caprivi: the name *amboellensis* (Sokolowsky 1903) is available, with the type locality in S Angola at approximately 16º20'E and 19º30'E (Shortridge 1934). The eastern Caprivi (Linyanti) population was described as *notatus* (Matschie, 1912) and would appear to extend into SE Angola along the Luiana and Cuando rivers. The specimens noted by Ansell (1978) along the Angola-Zambian border in SW Zambia are probably from this population.

It is currently impossible to elucidate the precise taxonomic and distributional status of this complex of populations of "red" lechwes, not least because they have not been adequately studied and several appear to be extinct. Few museum specimens appear to be available. Currently allocated to *K. l. leche*, the taxonomic status of the Namibian, Angolan and DRC populations require elucidation.

Barclay (1933) concluded that no subspecific divisions were warranted in *K. leche*, but his conclusions were weakened by reliance on patterns and colour of pelage. A facile attempt at a taxonomic review by Howard & Sidorowicz (1976) concluded that all lechwe formed one species, and only two subspecies were valid. The mistakes, weaknesses and overall failure of their analysis was subsequently demonstrated, not least in being based on a false sample of *K. leche* (Ansell & Banfield 1980). The latter study focussed on the differences between *smithemani*, *robertsi* and *kafuensis* and demonstrated that *smithemani* and *leche* are the most similar in skull proportions and size, with *kafuensis* the most distinct. Given the recent diversification of lechwes (evident in *kafuensis, robertsi* and *smithemani*), it is likely that *K. l. leche* is actually a polyphyletic taxon. Radical declines in the historical range of unrecognized taxa (to extinction in *K. robertsi*), indicates that special attention should be paid to the actual taxonomic and conservation status of the plethora of populations currently attributed to *Kobus leche* (Figure 3.3).

Williamson (1994) summarized a detailed study of the lechwe in the Linyanti area of Botswana focusing on territorial and reproductive behaviour. His data demonstrated significant differences between the reproductive behaviour of this Linyanti population of "*leche*" and *kafuensis* in the timing of breeding, and other significant behavioural differences. The Linyanti lechwe are sedentary and occur at a lower density than *kafuensis*. They also defend territories of a larger size continuously through the year, and breeding adults in Linyanti differ markedly in size and colouration from *kafuensis* (Williamson 1994).

Status

Locally Endangered. Any attempt at an assessment of the status of "red lechwe" is handicapped by an inadequate taxonomy. Child (1975) records the decline of *K. leche* in the E Caprivi, which was especially noticeable on the Chobe floodplain. Here a minimum of 2500 individuals were counted

in 1962 but had declined over eight years to 5% of this. Other populations of "red lechwe" are thriving (East 1989a). These include the nominate population (definitely *K. leche*) of the Okavango Delta and Caprivi, assuming these form a contiguous population. The population (possibly *K. amboellensis*) in Namibia (W Caprivi) along the Okavango River had increased from 1400 individuals in 1985 to 2000 in 1990 (Griffin & Grobler 1991). As with all lechwe, the formerly extensive range of the "red lechwe" has experienced a major shrinkage, especially within Angola and Zambia. They were formerly widely distributed across the Upper Zambezi in suitable habitat. A huge reduction in numbers and range has occurred within the Barotse floodplain, with few remnant populations persisting (Ansell 1978). The status of "red lechwe" in Angola and southern DRC requires urgent study – these are most likely Critically Endangered. Unequivocal understanding of the conservation status of the "red lechwe" is contingent on a thorough systematic review of all extinct and extant populations across their entire historical range.

Roberts' Lechwe, *Kobus robertsi* Rothschild, 1907

Taxonomy and Distribution

Only acknowledged as distinct in the late 1970s, this taxon is represented by only one population with a localized distribution in N Zambia. *Kobus robertsi* originally occurred within the Pambashye Swamps on the Luongo-Kalungwishi drainage north of Lake Bangweulu (Ansell 1978), and is certainly the most poorly known of the Reduncini, if not of all African bovids. Very few scientific specimens are known. Lydekker & Blaine (1914) listed only two specimens in the British Museum (Natural History), stating the type to be in the Rothschild Museum, Tring, and accepted *robertsi* as valid:

> "As this lechwe occurs in company with the true lechwe, it must be regarded - if anything more than a melanistic phase - as a species rather than a race." (Lydekker & Blaine 1914: 249).

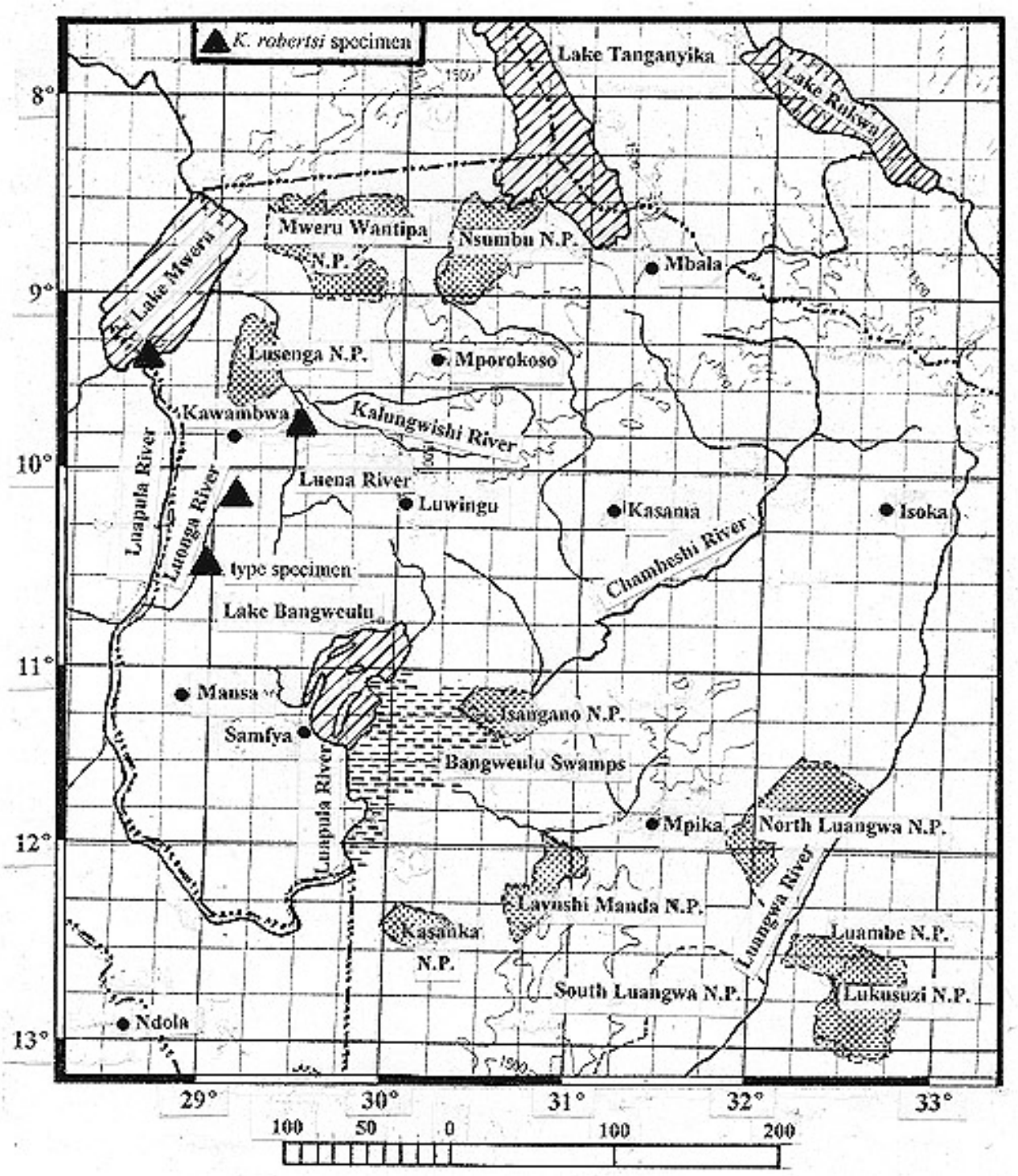
The taxon was described on the basis of only two specimens (Rothschild 1907), which were subsequently lost (Ansell 1974). Ansell (1974) allocated BM 13.11.27.1 as the neotype of *Kobus robertsi*. This was collected on the Luongo River (10º35'S; 28º59' E) on 7 October 1913. Two other specimens are known from the Luongo River (10º10'S; 29º05'E) and the Luena River (9º45'S; 29º25'E) south of its confluence with the Kalungwishi (Figure 3.6).

The type locality was restricted to the Luongo River (10º35'S; 28º59'E) by Ansell (1974). Two specimens (previously reported by Ansell 1974 as of indeterminate status) were recently reexamined in the mammal collection, Natural History Museum, Bulawayo (out of a total of 187 specimens of *K. leche sensu lato*); both specimens are in a reasonable condition. Their cranial measurements agree with that of the neotype of *robertsi* published by Ansell & Banfield (1980), and shown to be distinct from all other lechwe. These two specimens consist of a single skull (NMZB 2753 %), and skin and skull (NMZB 2751 &); both were collected from Chisenga Island (9º22'S; 28º37'E; Figure 3.6) in 1947. Situated in the south of Lake Mweru, this is north of the above mentioned localities – some 150 km northwest of the type locality of *robertsi* and the Luongo and Luena rivers (Figures 3.3 and 3.6). In total, it appears that only five specimens of *K. robertsi* are known.

Status

Extinct. Should any individuals persist they are Critically Endangered. Ansell (1974, 1978) and Ansell & Banfield (1980), followed by East (1989a), inferred *K. robertsi* to be extinct in the Pambashye Swamps and on Chisenga Island. No recent published investigation is known that has attempted to investigate the status of lechwe in northern Zambia, aside from considerable attention paid to *K. smithemani*. The relationships between collecting localities and protected areas in N

Figure 3.6. Detailed distribution of *Kobus robertsi* in northern Zambia (data from Ansell 1974, 1978, and reexamination of two specimens in the Natural History Museum of Zimbabwe) in relation to the network of protected areas. The type locality is shown.



Zambia is depicted in Figure 3.6. Virtually nothing is known about the ecology, behaviour and general biology of the Luena lechwe, aside from what can be discerned from a paucity of museum specimens and anecdotal reference in the form of very few publications. Prior to Ansell & Banfield (1980), most authorities had concluded that *robertsi* was *incertae sedis*, and glossed over its existence.

PUKU

Puku, *Kobus vardoni* (Livingstone, 1857)

Taxonomy and Distribution

Puku (*K. vardoni sensu lato*) are restricted to a limited area of the southern savanna zone, an area within the catchment of the Upper Zambezi and Luapula rivers in Zambia. The taxonomic status of the allopatric populations of pukus in Rukwa and Kilombero, S Tanzania (Rodgers 1984) and C Angola (East 1989a) is unknown. Ansell (1971) recognized two subspecies, whose distributions are separated by the Muchinga Escarpment:

> "*K. v. vardoni* (Livingstone, 1857) occurs in southern Congo basin, Angola, north eastern Botswana and Caprivi and western Zambia. It was originally described from Libonda, Barotseland by David Livingstone - where puku no longer occur."

This population also occurred eastwards along the Upper Zambezi River to the Victoria Falls (Ansell 1971, Selous 1908; Figure 3.4).

Ansell (1971) suggested that *K. vardoni* and *K. senganus* comprise a superspecies together with the Ugandan Kob, *K. kob*. Other authorities have considered the former populations to be subspecies of *K. kob*. These antelopes are morphologically uniform with similar habitat requirements, which suggests their divergence was recent (Ansell 1971). Important differences occur in the morphology of the inguinal and pedal glands between kobs and puku (Ansell 1960b).

Status

Endangered in parts of its range; elsewhere Vulnerable. Ansell (1978) emphasized that puku had declined significantly since the early 20th century. *K. vardoni* has declined significantly in NE Botswana over the past 100 years. Selous (1881) recorded the species as numerous on the Pookoo Flats, where herds of 50 were common. Puku occurred for approximately 112 km along the south bank of the Chobe upstream of the Chobe-Zambezi confluence. They also occurred at the Victoria Falls on the south bank of the Zambezi in 1874, where one was shot by Selous's colleague J. L. Garden (Dollman 1921, Selous 1908), but these were probably vagrants. More recently, Child (1968) estimated that less than 100 individuals occurred between Kasane and Simwanza along the Chobe River. Smithers (1971) reiterated that a radical reduction had occurred at the southwestern edge of their range, and this was first recorded by F.C. Selous (Dollman 1921). Ansell (1978) also noted that *K. vardoni* had undergone a significant reduction within its former range across western and northern Zambia. No information appears to be available on the Angolan populations, only on their existence (East 1989a, Machado 1969). Under adequate protection, puku populations recover rapidly. This has occurred over the past decade in Kasanka National Park in NE Zambia (Cotterill, *pers. obs*. 1999). Populations of puku introduced on to game ranches in S Zambia and into the Middle Zambezi Valley (in Zambia in the 1990s) are increasing (I. Bruce-Miller, *pers. comm*. 1999)

Senga Puku, *Kobus senganus* Sclater &Thomas, 1897

Taxonomy and Distribution

Kobus senganus occurs widely in the Luangwa Valley and eastwards into parts of Malawi (where its range has undergone significant reduction), and the Rukwa and Kilombero valleys of Tanzania (Rodgers 1984). There were recently two isolated records from the Middle Zambezi Valley in Zimbabwe, which are referable to *K. senganus*. A sighting of an adult female was recorded by Dunham & Tsindi (1984) from the Mana Pools floodplain near the Sapi-Zambezi Confluence (15°40'S; 29°35'E). Another individual (NMZB 67049 &) was collected by the Department of National Parks and Wildlife Management of Zimbabwe near Chirundu (16°02'S; 28°51'E) on 13 August 1984.

Status

Locally Endangered. The population in Zambia's Luangwa Valley appears healthy. Ansell and Dowsett (1988) concluded their status within Malawi to be precarious, with populations still persisting in the Kasungu National Park. Extirpated from large areas, but some have been reintroduced (Ansell & Dowsett 1988). Lyell (1913) emphasized that puku only occurred in C Malawi in the catchment of the Bua River. Ansell & Dowsett (1988) identified other localities north of here (Figure 3.4). The individuals recorded from the Zambezi Valley in Zimbabwe appear to be vagrants, and their persistence contingent on the establishment of a viable population – there are no previous records of the occurrence of puku in the area.

3.6 WHAT ARE THE SPECIES OF REDUNCINE ANTELOPES?

3.6.1 Defining the problem

The above overview demonstrates that the taxonomy of the Reduncini is complicated by controversies over the taxonomic status of most taxa, their unambiguous identity, and precise distributions. The current taxonomy is obsolete in its dependence on vague classifications of morphospecies within which a plethora of subspecies are subsumed. This has seriously influenced studies of reduncines and applications of biological knowledge. For example, Hanks *et al.* (1969) argued that individual waterbucks referable to both *crawshayi* and *ellipsiprymnus* occurred together in the Kafue National Park. In another example, Howard & Sidorowicz (1976) concluded that *Kobus leche* was a monotypic species with only two valid subspecies, with *kafuensis* merely a form of *K. l. leche*. More recent authorities such as Kingdon (1982, 1997), avoided major problems in reduncine taxonomy, simply by not mentioning the existence of controversial subspecies, notably in *K. ellipsiprymnus*. This is surprising because Kingdon devotes deserving attention elsewhere to the many cryptic species of primates and other mammals. A serious attempt to resolve this problem needs to briefly consider the history of mammalian taxonomy and how the entrenched taxonomy of reduncine antelopes was constructed. This provides a setting from which to understand patterns of diversification of Zambezian Reduncini more objectively.

Prior to the Neo-Darwinian Synthesis in evolutionary biology (Mayr & Provine 1980), typological perspectives often dominated taxonomy and were the *modus operandi* in mammalian taxonomy (as in many biological subdisciplines) before the biological species concept became widely adopted (Corbet 1997). Cognisance of this historical situation is important. The majority of vertebrates described and classified up until the Second World War were based on remarkably little material, and the reduncine antelopes were no exception. Rothschild (1907), for example, described *K. robertsi* as a specific taxon distinct from *Kobus leche* on the basis of only two specimens with scant

comparison with other populations. The situation was exacerbated by reliance on pelage characters which vary considerably, even within localized populations.

The principal characters employed to describe species and subspecies of reduncine antelopes were pelage patterns and colouration. These formed the criteria by which taxonomists (including Lyddeker, Matschie, Rothschild and Schwarz) described numerous subspecies and species of waterbucks, reedbucks, kobs, and lechwes. The study by Ansell & Banfield (1980) is an exception in its use of cranial measurements, which justified subspecific divisions of lechwe populations subsumed under *K. leche*. With very few exceptions, all taxa of extant reduncines were described by taxonomists working before the Neo-Darwinian Synthesis had hardened. This watershed in biology more or less coincided with the Second World War, and particularly with the publication of a seminal book "*Systematics and the Origin of Species*" in 1942 by the German ornithologist Ernst Mayr, then at the American Museum of Natural History in New York (Mayr 1942). Today acknowledged as the eminent evolutionary biologist of the 20th century, Mayr provided abundant evidence that new species evolved as a result of divergence of parent populations. The key lesson of this review was that "population thinking" is essential to carefully quantify and evaluate the variation within populations in order to identify taxonomic boundaries (O'Hara 1997). Influence of population thinking on taxonomic mammalogy was apparent by the early 1950s (for example, Ellerman *et al*. 1953), but considerable research remained to be done to cope with the challenges of elucidating mammalian diversity in Africa, and indeed all biodiversity. This challenge remains, and African bovids, exemplified by the Reduncini, are not exempt. Ansell (1971) tried to resolve the taxonomy of the Reduncini (and extant African Bovidae in its entirety) by applying Mayr's methods and philosophy of microtaxonomy, relying on the biological species concept (BSC) and, in certain cases, its derivative, the superspecies. The superspecies concept applied to waterbuck and puku to try and surmount complex taxonomic problems was not successful.

Resolution of such taxonomic problems requires objective identification of the real evolutionary products that comprise the Reduncini. This must focus on the genetically divergent populations of these semi-aquatic antelopes and further reconstruct the patterns of their diversification in space and time. The taxonomic overview given in the previous section has separated the reduncine antelopes into the smallest divisible units recognizable on the basis of morphospecies, originally described as species and subspecies. Its resolution hinges on the thoroughness with which reduncines have been scrutinized by mammalian taxonomists, and what future, more refined, analyses will reveal of other real evolutionary products in the Reduncini, especially its more cryptic taxa. My treatment obviously tends toward a splitting of taxa, as opposed to the converse treatment of extreme lumping (Table 3.1).

3.6.2 **What is a species?**

Further elucidation of reduncine taxonomy requires attention to the ontology of species, because the solution to the species problem in biology and conservation lies largely within the domain of the philosophy of science. The ontology of the entity "species" has to do with what a species actually is in terms of biological theory. Considerable controversy surrounds the species concept, and is probably unmatched by any other controversy in biology. An unambiguous species definition is very hard (if not impossible) to obtain – quite possibly one of the toughest tasks in contemporary evolutionary biology. This controversy is grounded in different perspectives on how to recognize and measure biodiversity. One approach, perhaps idealistic, has been to strive for a universal species concept, applicable to all organisms, bacteria, fungi, animals and plants; irrespective of whether they reproduce sexually or asexually. Hull (1988) has pointed out that at least two thirds of populations in the entire biosphere comprise asexually reproducing organisms, and this has been so

through the geological history of life since its inception. For this reason alone (a primary dichotomy between how organisms make more organisms) a universal species concept is very difficult to obtain. This endorses a pluralistic approach to species concepts, with at least one for plants, another for arthropods, yet another for vertebrates, and more for microbes. This dichotomy between sexual and asexual reproduction need concern us no further, as all mammals reproduce sexually. We can progress to review applications of the BSC to the Reduncini.

I now devote some attention to the characterization of reduncine species. This must begin with some consensus as to what it is about species we recognize in distinguishing between diverse reduncine populations. As stated above, the impetus for attention to what species are actually lies in an oft-quoted adage that "species are the currency of conservation". Resolution of the species problem is critical to any objective assessment of organismal biodiversity and its sound study and management. The mandate for objectivity does not make this a simple exercise. The place to start is to establish deficiencies in the existing taxonomy, and then build on these through two stages to resolve the problem. I begin with an examination of the biological species concept as applied to the Reduncini and other vertebrates.

3.6.3 **The biological species concept as applied to Reduncini: superspecies or subspecies?**

The established taxonomy of the Reduncini (Ansell 1971, followed by Meester *et al*. 1986 and Grubb 1993) rests on the biological species concept (BSC). The first step before attempting an improvement of reduncine taxonomy (with a focus on the Zambezi Basin) is to review the details of how science has tried to characterize and classify populations of these antelopes. Each of the several species recognized clearly encompasses different, but frustratingly similar, populations. The latter were characterized as subspecies, or allospecies – parts of superspecies. This modification of the BSC recognized the superspecies as:

> "...consists of a monophyletic group of entirely or essentially allopatric species that are morphologically too different to be included in a single species. The principal feature of the superspecies is that geographically it presents essentially the picture of a polytypic species, but that the allopatric populations are so different morphologically or otherwise that reproductive isolation between them can be assumed." (Mayr, 1963: 499)

The superspecies concept has been widely applied to Afrotropical birds (Hall & Moreau 1970, Snow 1978 for numerous examples). Grubb (1978) inferred that a large percentage of extant Afrotropical mammals are superspecies (Table 3.2). Application of the superspecies solution to reduncine antelopes in the Zambezi Basin recognizes three superspecies comprising a total of at least twelve allospecies. These superspecies are *K. leche, K. ellipsiprymnus* and *K. kob*. This is tentative as a thorough review of the 12 populations traditionally recognized as subspecies might not elevate all to allospecies rank according to criteria of the BSC. Furthermore, following the terminology of Haffer (1986), allopatric members of a superspecies (for example, *K. leche*) are termed allospecies, while parapatric populations (*K. crawshayi* and *K. ellipsiprymnus*) are termed paraspecies (Figure 3.2).

Table 3.2. Tabulation of superspecies of African mammals as a proportion of total diversity (after Grubb 1978).

Taxa	No. species	No. superspecies	No. (and proportion) of species that are allospecies	Species/superspecies ratio
Carnivores	70-76	59	24-33(0.34-0.43)	1.2-1.3
Artiodactyls	85-96	64	36-52(0.42-0.52)	1.3-1.5
All ungulates	95-112	72	39-63(0.41-0.56)	1.4-1.7
Primates	45-69	30	25-49(0.56-0.71)	1.5-2.3
Squirrels	37	26	17(0.46)	1.3

While numerous cases of recent evolutionary divergence in African antelopes have traditionally been viewed as representing subspecific differences (and/or superspecies, Grubb 1978), recent evidence suggests that this is a superficial interpretation of the divergence that actually has occurred in these clades of recently-speciated antelope populations. Previously unsuspected divergences in some Afrotropical bovids have recently been revealed by analysis of molecular characters – in this case mitochondrial DNA of certain antelopes in East Africa. Examples include two populations of blue wildebeest, *Connochaetes* "*taurinus*" separated by the Rift Valley in East Africa. Unprecedented genetic divergence was also discovered in waterbucks, *K.* "*ellipsiprymnus*" and impalas, *Aepyceros* "*melampus*" in the same region (Arctander *et al*. 1996). It appears that future studies are likely to reveal hitherto unsuspected genetic divergence in such apparently "good" species. These developments prescribe unprecedented revision of these clades of bovids as molecular characters are incorporated into systematic revisions.

Although the biological species concept became a bastion in taxonomic zoology, its ubiquity has been widely challenged over the past two decades. The concept was originally developed for sexually-reproducing vertebrates, especially birds. The BSC has been modified and stretched in attempts to recognize species in other phyla, including invertebrates and plants, but it has encountered serious problems.

The problem with allospecies versus paraspecies or subspecies to populations, such as those of reduncines, is in the subjectivity of its application, such that some authorities might describe these reduncine taxa as semispecies given their allopatric distributions. A pertinent example is the treatment of *K. senganus*, *K. kob* and *K. vardoni* as either allospecies of one superspecies or merely subspecies of *K. kob* (Ansell 1971). In terms of the BSC (on which the superspecies concept has been built) these populations must be reproductively isolated to qualify as species. Reproductive isolation is not a prescriptive criterion for recognition of a species. Many divergent species (such as eland *Taurotragus oryx* and greater kudu, *Tragelaphus strepsiceros*) hybridize. Hybridization is not uncommon between different populations which are relevant products of evolutionary divergence. Furthermore, concern over hybridization is actually a side issue when it comes to evaluating species as divergent products of evolutionary processes. Reproductive isolation actually has only a partial role in the conceptualization of species as evolutionary lineages. This is a major danger in the interbreeding criterion of the BSC which fosters misleading interpretations of evolutionary lineages (Frost & Hillis 1990, Zink & McKitrick 1995).

The prescription by the BSC that species be reproductive isolates places a prerequisite on sympatry if a "good species" is to be unequivocally diagnosed. This is another weakness of the BSC. Ultimately, taxonomic status under the BSC hinges on geographical relationships, which are often dynamic and further subject to biases in surveys which tend to under-represent rarer taxa. Other weaknesses are that the BSC ignores some evolutionary significant entities, and does not rigorously define the ranges of species it recognizes (Cracraft 1997). An important argument against the BSC by Patterson (1985) defines a species as a population possessing a distinct SMRS (Specific Mate Recognition System). An SMRS (see below) is shared property of a population of interbreeding organisms and is subject to strong stabilising selection acting on individual organisms. A species defined by its SMRS is created entirely differently from the isolation mechanisms postulated by Mayr to maintain the distinctiveness of a biological species. According to Patterson, speciation is an effect of adaptations that evolve to support successful matings in sexually reproducing organisms. So, application of these philosophical criteria of evolutionary causation identifies yet another critical weakness in how the BSC is formulated, which limits the ability of the BSC to characterize biodiversity (Patterson 1985).

3.6.4 **Reduncine species distinguished by the Recognition Species Concept**

Given these deficiencies of the BSC, a possible solution is to apply the Recognition Species Concept (RSC) defined by Patterson (1985):

> "A species is that most inclusive population of individual, biparental organisms which share a common fertilization system." (Paterson 1985: 21)

This has particular merit in elucidation of sympatric species, especially cryptic or morphologically similar species. The SMRS of reduncine antelopes is evident in the horns and pelage patterns of the different populations. These include the facial and leg markings of different lechwes, and the different dorsal patterns of the waterbucks. Equally important are ritualistic behavioural repertoires associated with territory establishment and defence, and courtship, where visual cues are important. Olfactory cues specific to species are equally if not more important in the Reduncini (Kingdon 1982), but have only been investigated in *K. kafuensis* and *K. kob thomasi* – chemicals in female urine deposited in the soil of leks influence the reproductive behaviour of other females (Deustch & Nefdt 1992). The morphology of scent glands could be equally important traits of an SMRS, as Ansell (1960b) demonstrated for *kafuensis* and "*leche*", *kob* and *vardoni*.

Distinctly different traits distinguish species-specific SMRS of two reduncine populations traditionally characterized as representatives of two subspecies (Ansell 1971, 1974, Ansell & Banfield 1980) or two allospecies (Grubb 1978). These are *K. smithemani* and *K. kafuensis*, which differ in pelage colouration, horn morphology, skull morphology (Ansell 1974, Ansell & Banfield 1980) and semiochemistry (Deustch & Nefdt 1992). I hypothesize that evolution of a distinct SMRS has occurred in various species of waterbuck, kob and puku, and perhaps reedbuck. Elucidation of the SMRS is integral to applying the RSC to different populations of reedbuck and waterbuck.

A similar divergence is illustrated in the reproductive behaviours of *kafuensis* and the Linyanti population of "*leche*" (see above, Williamson, 1994). I infer these differences to represent a different SMRS in these two populations. Published studies of "*leche*" in the Okavango (Joubert 1972, Lent 1969) do not present data sufficient to compare with those of Schuster (1976, 1980) and Nefdt (1996) or Williamson (1994) for *kafuensis* and the Linyanti population of "*leche*". Nevertheless, the outline of divergences between the SMRS of certain reduncines can be summarized in Table 3.3.

Table 3.3. Comparison of some semio-chemical, behavioural and morphological traits documented for certain populations of the Reduncini of the genus *Kobus* indicative of a Specific Mate Recognition System. The emphasis is on comparison of differences with closely related species of lechwe, kob and waterbuck. Data obtained from Allen (1963), Ansell (1960b, 1964, 1974), De Vos & Dowsett (1966), Grimsdell & Bell (1975), Hanks *et al*. (1969), Kingdon (1982), Lent (1969), Leuthold (1977), Nefdt (1995, 1996), Robinette & Child (1964), Rosser (1987), Schuster (1976), Skinner & Smithers (1990), Smithers (1983), Thirgood *et al*. (1992) and Williamson (1994).

Taxon / Trait	smithemani	leche - Linyanti	leche - Kasempa	kafuensis	kob	vardoni	crawshayi	ellipsiprymnus
Mating system	polygamous territories	aseasonal lek	?	temporary lek	seasonal lek	resource defence mating system	polygamous territories	polygamous territories
Scent	?	?	?	specific?	specific?	?	?	"turpentine" tainted fur
Pedal glands	?	?	?	?	?	vestigial	?	?
Inguinal glands	?	?	open anteriorly	open laterally	open ventrally	open anteriorly	?	?
Coloration	black pelage in adults	dark stripe on foreleg	?	foreleg stripe, patch on neck	black forelegs	rufous forelegs	pale rump patch, dark neck & flanks	pale ring on rump
Body size	smallest	intermediate	intermediate	largest	_	_	_	_
Horns	smallest	intermediate	intermediate	largest	_	_	_	_

Although the RSC appears to confer major strengths to characterize reduncine species, its major weakness is its non-historical limitations (as for the BSC). It cannot recognize the temporal dimension of species – that they are lineages. Neither the RSC nor BSC recognize that species – reduncine antelope or other – are lineages with a birth (speciation) and a death (extinction). These problems have received the attention of phylogenetic systematists since the early 1980s as part of the spread of historical perspectives through systematics, culminating in widespread adoption of cladistic philosophy and its methods in recognizing and classifying taxa. This philosophy – termed tree thinking (O'Hara 1997) – has radical implications for how we conceptualize species (Ghiselin 1997).

Speciation can be caused by many different processes driven by different determinants of disturbance and selection. An important commonality to speciation is that most species are believed to form in geographical isolation – in allopatry. An important set of processes results in vicariance – the disruption of populations' ranges in a geographical context. In terms of the RSC, the primary change in speciation in a sexually reproducing population as in mammals) is the formation of a new SMRS. Thus a mammalian species has a birth and death, with the overall temporal pattern being the origin and extinction of its SMRS.

3.6.5 **Recognizing that Reduncine species have an evolutionary dimension**

Complementary to population thinking, tree thinking conceptualizes extant individuals of a species not just as populations occupying some geographical zone, but also as the living parts of a historical

lineage. Cognisance of a temporal, as well as a spatial, attribute of species has generated a number of historical species concepts. A major impetus for recognizing a temporal dimension to species concepts was the widespread adoption of phylogenetic perspectives in systematics (Baum 1992). Although both developed through the 1980s, phylogenetic treatments of species have scarcely interacted with the parallel development of the Recognition Species Concept. Distinct allopatric populations are distinct lineages, and thus phylogenetic species, but may still maintain the same SMRS.

Atemporal deficiencies of the BSC and RSC can be overcome if we consider the evolutionary divergence of populations. Tree thinking recognizes a commonality to all episodes of speciation with respect to the underlying pattern. Species result when a population exhibiting continuous variation has diverged to produce two or more populations exhibiting a pattern of discontinuous variation. Thus, the patterns of horn shape and size, skull morphology and pelage colour in *K. kafuensis* and *K. smithemani* exhibit a classic example of discrete variation, although the traits used as taxonomic characters vary continuously within each population.

Mayr (1957) originally distinguished between primary and secondary concepts of species. With the notable exception of Mayden (1997), this key distinction has been ignored in the plethora of publications seeking to resolve the species problem in evolutionary biology. The only concept that qualifies as a primary species concept is the Evolutionary Species Concept (ESC) originally proposed by Simpson (1951, 1961) and developed subsequently (Mayden 1997, Wiley 1978). No matter the mechanisms underlying its formation, any species (plant, microbial or animal) is an evolutionary species. A primary property of any species – whether comprised of sexual or asexual organisms – is that it persists as a lineage through time. This property underpins the primary species concept as articulated in the Evolutionary Species Concept (Mayden 1997, Simpson 1961):

> "...an entity composed of organisms which maintains its identity from other such entities through time and over space, and which has its own independent evolutionary fate and independent tendencies." (Wiley & Mayden 1997, quoted in Mayden 1997: 395).

3.6.6 **Characterization of the evolutionary species of Reduncine antelopes**

The stated objective to cleave nature at its historical joints so as to identify real evolutionary entities, is to ensure that no distinct biodiversity falls through the cracks in the conceptual maps we construct of its patterns of divergence. Fissured taxonomies (exemplified by artificial treatments such as adherence to the typological belief that all lechwes are "red lechwes") are inaccurate and prevent characterization of real evolutionary products. Complete and rigorous characterization of a species needs to apply the Evolutionary Species Concept (ESC) as the primary concept of species applicable to all biodiversity. In practice, this exercise encounters a severe hurdle.

The ESC is not operational, and secondary concepts are required to recognize a species depending on whether the population is sexual or asexual, and whether it has (or does not have) fossilized representatives of its extinct parts. In philosophical terms, application of the ESC as the primary species concept, using secondary species concepts to recognize evolutionary lineages applies a combination of monism and pluralism (Mayden 1997), a strategy followed by Dimmick *et al*. (1999). A pluralistic solution uses secondary species concepts (notably recognition, RSC, and phylogenetic, PSC) to discover species. Following Baum & Donoghue (1995), a similar strategy has been employed by Soltis and Gitzendanner (1999) in characterizing botanical diversity using a historical application of the phylogenetic species concept. This approach is revolutionary, and the conservation lessons and implications are extreme (Dimminck *et al*. 1999, Soltis & Gitzendanner

1999); because it objectively elucidates the actual products and patterns of diversification. A similar conclusion is drawn by de Queiroz (1998), who emphasizes that the RSC is more fine-grained and identifies smaller-scale properties of species, whilst the PSC takes a broader-scale view of a species in considering its entire lineage.

Nevertheless, characterization of evolutionary species is difficult, especially where fossil data are scarce or non-existent (as with the Reduncini). To move beyond the deficiencies of the current reduncine taxonomy based on the biological species concept, I see the only solution is to apply both the RSC and PSC. This means that in applying a pluralistic conceptualization of species to the Reduncini and other mammals we must define a species as:

> an interbreeding population that has diverged from related species and possesses a common specific mate recognition system (SMRS). This unique lineage of sexually-reproducing organisms experiences a birth and death and exists as a genetically exclusive population.

3.6.7 **Diversification in Reduncine species using the phylogenetic species concept**

The application of a phylogenetic species concept (PSC) is not without its difficulties and controversies. The PSC has gathered major support and revolutionized perspectives of biological diversity in several groups, especially birds (Cracraft 1997, Martin 1996). Attempts to overcome deficiencies of the BSC have fuelled much of the impetus for phylogenetic and historical perspectives to define species and their properties. An example of the application of a phylogenetic species concept is a recent revision of African tree frogs (Schiotz 1999), which reveals considerable biodiversity previously unrecognized. Another is the application of a phylogenetic species concept to extant birds (Cracraft 1997) in which hitherto hidden biodiversity is revealed. The implications of this refined knowledge in conservation are extreme (Peterson & Navarro-Siguenza 1999, Soltis & Gitzendanner 1999).

It is important to realize that many versions of the PSC have been proposed (as emphasized by Baum 1992, Baum & Donoghue 1995, Mayden 1997, Soltis & Gitzendanner 1999). Their derivation and application falls into one of two philosophies of systematics - pattern cladistics or phylogenetic systematics. Their differences have important implications for how a particular PSC characterizes biodiversity. Based on pattern cladism, a widespread application of the PSC is diagnostic, as originally stated by Cracraft in 1983:

> "...the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent." (Cracraft 1983: 170)

The major problem with any diagnostic PSC is its subjectivity in recognizing diagnosable groups. They fail to define genetically-exclusive populations. A population perspective is an imperative requirement of a robust species concept. This was attempted by the BSC, is a strength of the RSC, and a failure of the diagnostic PSC. Nevertheless, all these concepts fall short in either reproductive inclusiveness (diagnostic PSC) or historicity (recognizing the species as a lineage - BSC and RSC). An important and recent development in phylogenetic systematics has been to recognize and quantify the historical dimension of species, focusing on their exclusivity (Baum 1992, De Queiroz & Donoghue 1990). This would seek out genetically-exclusive populations for objective characterization (*sensu* Baum & Donoghue 1995), and recognize their existence as historical lineages by describing them as phylogenetic species. Baum & Donoghue (1995) emphasize the importance of genetic exclusivity in applying a phylogenetic species concept to populations. This ideally requires elucidation of gene trees using molecular characters, but exclusivity of a lineage can

be established from comparisons of morphological and behavioural characters. It cannot be overemphasized that this "history-based" approach is fundamentally different from the diagnostic PSC advocated by Cracraft (1983, 1997) and pattern cladists (e.g. Nixon & Wheeler 1990). Baum & Donoghue (1995: 566) define species under a history-based PSC as ".as basal, exclusive taxa; that is, taxa containing within them no subgroups that are themselves exclusive.", such that a species is:

> "a basal group of organisms all of whose genes coalesced more recently with each other than with those of any other organisms outside the group." (Baum & Donoghue 1995: 567)

This theoretical framework of this species concept focuses on the genealogical history of populations rather than on the presence or absence of characters as applied in diagnostic PSC. Characters are used to characterize history-based phylogenetic species, but are fallible evidence for the existence of a species, rather than its defining attributes. Ideally, reconstructions of gene coalescence are needed to characterize species using this concept, but morphological characters can equally be used (Baum & Donoghue 1995).

The first step toward an objective characterization of reduncine species applied the RSC (in actual fact a secondary species concept - Mayr 1957, Mayden 1997) to the fine-scale properties of a species in a time-limited context. This focused on characterization of Specific Mate Recognition Systems (SMRS). The characters associated with these in a reduncine population are likely to be associated with genetic exclusivity of particular lineages. Nevertheless, through vicariance, evolution of a genetically exclusive population of reduncines may occur without modification of the SMRS. Characterization of evolutionary lineages in the Reduncini requires a species concept that accommodates an entity extended through time. Here, application of a historical PSC (following Baum & Donoghue 1995) that utilizes molecular and morphological characters of reduncines would characterize exclusive populations in terms of their phylogenetic relationships.

3.6.8 **Conclusions and recommendations**

(a) In any taxonomy (applying the BSC or a more biologically-appropriate species concept), the taxonomic status of the reedbucks is currently too unclear to recognize unequivocal divisions between the northern or southern reedbucks (*R. occidentalis* and *R. arundinum*, respectively). This problem is compounded by the hazy understanding of exact ranges of the two populations within the Zambezi Basin. This particular problem can only be resolved by thorough review of museum specimens. This also applies to certain waterbuck populations – *crawshayi* and *penricei* are recognized as species distinct from the "*ellipsiprymnus*" in Zimbabwe and E Zambia. The precise status of the latter population, and those elsewhere in the Zambezi Basin requires review, as does that of *kondoensis*.

(b) In this phylogenetic context the ESC (Mayden 1997), rendered operational by the historical PSC and the RSC, recognizes at least 18 extant species of Reduncini within the Zambezi Basin (Table 3.1). Application of the PSC characterizes all allopatric populations of lechwe as distinct species. Equally, *senganus* and *vardoni* are kob species separated by the Muchinga Escarpment. It is most important to emphasize that this figure is tentative – it is especially weakened by dependence on morphospecies. Characterization of the true identities of the phylogenetic species in the Reduncini requires deeper understanding of their biogeography and phylogeny. It is likely that the figure is higher if other unstudied populations within the basin and surrounding wetlands are considered. This uncertainty particularly applies to lechwe, and waterbuck, puku and reedbuck populations in E Angola. In particular, the localized populations of *K.* "*leche*" and *K.* "*vardoni*" in C Angola are singled out for urgent study.

(c) Possible divergence between the "red" lechwe in the drainage systems of the Okavango and Linyanti deserves consideration. I hypothesize that *K. amboellensis* in the Cubango (extending into W Caprivi) and *K. notatus* in the Linyanti (and higher up the Luiana and Cuando rivers) could be distinct from topotypical *K. leche* of the Okavango Delta, each evolved allopatrically within its respective drainage system. Although these populations might appear contiguous, this may not have been so in the recent geological past considering tectonic modifications.

(d) The database of characters and specimens for Reduncini available to me is too incomplete to revise the Reduncini at present. Given the scope and complexity of this problem, it has only been possible to carry out a tentative overview of the reduncine populations – as summarized above – to attempt some synthesis of the patterns of their diversity within the Zambezi Basin, and so account for its origin.

(e) Recalling the imperative to "carve nature at her historical joints", and so reveal relevant evolutionary products, the need to resolve the taxonomy of all extinct and extant Reduncini requires an exhaustive revision. This will need to include morphological, behavioural and (especially) molecular characters at a continental scale with recourse to the type material of all described taxa. Nothing short of a thorough systematic review can solve the current uncertainties and complexities. The key in such an investigation may prove to be the use of molecular characters in cladistic analyses to resolve a phylogeny, especially for parapatric and sympatric species. The sitatunga populations, extending from the Okavango-Caprivi through Barotseland and across N Zambia to Lakes Bangweulu and Mweru (with an isolated population in C Angola occurring with puku and lechwe), also deserve the scrutiny of the philosophies and practices of modern systematics.

3.7 EVOLUTION OF REDUNCINE ANTELOPES IN THE ZAMBEZI BASIN

3.7.1 Evolutionary changes and vicariance

Integral to an objective characterization of biodiversity is to characterize the processes that have driven speciation. Speciation is an effect – a consequence – of processes that caused populations to diversify into distinct evolutionary lineages. New species form through different mechanisms, which include vicariance, sympatric speciation (perhaps driven by sexual selection) and genetic drift within certain demes in a population. In the case of reduncine antelopes, the mechanism of speciation has most likely involved changes in the SMRS of fragmented populations caused by directional selection. The most likely explanation is that a combination of climatic change and tectonic movements caused vicariance of reduncine populations across the basin. The greatest degree of vicariance has occurred on the African peneplain where the drainage of the Upper Zambezi has shifted dramatically through the Tertiary and Quaternary. Equally importantly, natural and sexual selection operated within these populations in allopatry (and parapatry) to result in the evolution of specific SMRS in different populations.

As an agent of reduncine evolution, the impact of vicariance can be singled out. The shared genetic composition of a population would have been changed by natural selection and been sorted by environmental changes. Climate-induced changes, especially arid periods, would have shrunk a contiguous wetland (such as N Zambia and the southern portion of Shaba Province) into isolated fragments of aquatic habitat. Natural selection, within separated habitats under different environmental conditions, could have driven the evolution of species-specific adaptations for mating. Perhaps a major agent of such change would be sexual selection operating within the

polygynous mating system of reduncine antelopes. A different SMRS – and thus species – could evolve as an effect of organismal reproduction in geographically isolated populations under the influence of directional selection. The overall result of vicariance was the origin of new populations – each persisted as a distinct species.

Environmental change through the late Tertiary and Quaternary has long been postulated as responsible for diversification of African vertebrates. Recent reviews of evolution in African mammals (Grubb 1978, 1982, 1983) have benefited from a far more complete biogeographical database then was available to researchers in the 1920s who first suggested that environmental changes drove diversification (e.g. Ruxton & Schwarz 1929). These more complete data have allowed recent authors to draw more comprehensive conclusions about other faunas (e.g. Carcasson 1964, Crowe & Crowe 1982, Hall & Moreau 1970, Moreau 1966, Snow 1978). Consideration of the expansions and contractions of forest, savanna and semiarid habitats across Africa, before and through the Pleistocene, has been central to all these reviews of biotic evolution in the Afrotropical realm. As discussed above, Grubb (1978) provided a thorough overview of Afrotropical mammals at a continental scale, and applied the biological species concept to distinguish superspecies. A refined analysis is still required that needs to utilize thorough, fine-grained biogeographical datasets in conjunction with molecular data to reconstruct gene trees and more robust phylogenies, using an evolutionary species concept.

3.7.2 **Evolution of wetlands through the late Tertiary**

These previous reviews (with partial exception of Ansell 1960a) adopted a rather coarse-grained approach at a continental scale, and have also tended to focus on forests (Grubb 1978, 1982, 1983, Robbins 1978, Kingdon 1981). The evolution and biogeography of semi-aquatic mammals possibly differs from forest-dwelling and other terrestrial populations, that have primarily been influenced by climatic changes. The vicariance of aquatic habitats in Africa with respect to mammal evolution has received comparatively little attention, and the Reduncini are exceptional in their predilection for aquatic habitats. Equalling, if not exceeding, the climatic changes in impacts, there is considerable evidence that Africa's drainage systems and basins have been altered repeatedly. This has been caused by geomorphological agencies, including tectonic activity and capture of headwaters, and is especially true of the African erosion surface across what is today Zambia, Tanzania, E Angola, Botswana, N Mozambique and southern DRC. Situated on the ancient African plateau, the hydrology of the Zambezi and associated tributaries has changed repeatedly and radically (Partridge & Maud 1987, Thomas & Shaw 1988, 1990).

The African surface is ancient when considered in a geomorphological context – the African peneplain was established early, soon after Gondwanaland had split up. Its formation began in the Mesozoic, and has been partially eroded through two Post-African events for at least 35 million years. The drainage across the continent exploited zones of crustal weakness surrounding the cratons of more ancient rocks (Partridge & Maud 1987). Slight alterations of this comparatively level surface by tectonic events has radically modified drainage patterns across the subcontinent across a range of spatial scales (Main 1992, Skelton 1994, Thomas & Shaw 1988, 1990).

Burgeoning data point to the importance of vicariance in having generated a significant portion of global biodiversity. The resultant biogeographical pattern is frequently associated with allopatric populations exhibiting little morphological divergence (Dimmick *et al*. 1999). This is true of the Reduncini and other Afrotropical mammals where numerous allopatric populations (traditionally and variously interpreted as super- or subspecies) have evolved since the Pleistocene. These biogeographic patterns deserve wider and more detailed attention and their elucidation is critical

to understand the evolutionary processes which generated the region's biodiversity. The implications for conservation decisions and activities cannot be over emphasized.

3.7.3 **Evidence from other Zambezian mammal species**

The Zambezian drainage has been radically altered over the past five million years (Main 1992). Two major events can be singled out. Firstly, the connection between the Upper Zambezi and Limpopo was closed by the end of the Pliocene (5 Mya), as concluded by Thomas & Shaw (1988, 1990). Their respective fish faunas vary more than that of an equivalent comparison of the Upper Kafue, Upper Zambezi and Okavango, the fish faunas of which are very similar (Skelton 1994). This would not have influenced reduncine evolution, given recent speciation. Secondly, the capture of the Upper Zambezi, Upper Kafue and other Upper Zambezi tributaries by the Middle Zambezi, which is the more likely agency of reduncine evolution.

Notable patterns exhibited in the distributions of Reduncini within the Zambezi Basin parallel those of other large mammals. (Figure 3.7, Table 3.4). The predominant pattern is one of vicariant species distributions – this especially applies to organisms whose capabilities of dispersal were minimal during vicariant disturbances. The common consequence for such populations would have been widespread extinction with local persistence of fragmented populations. Within the Zambezi Basin, additional patterns of divergence and disjunct distributions are exemplified in several populations of closely related populations of mammals (Figure 3.8). Particularly pertinent are certain endemic mammals of the Luangwa Valley, including Thornicroft's Giraffe, *G. thornicrofti* and Cookson's Wildebeest, *C. cooksoni*. Other large herbivores, including two closely related sable antelopes (*Hippotragus niger* and *H. anselli*), exhibit a similar biogeographical pattern (Groves 1983). The distributions of the two sun squirrels, *Heliosciurus mutabilis* and *H. gambianus*, are also divided by the Muchinga Escarpment (Ansell 1978).

Also noteworthy is that a distinct population of Tsessebe, *Damaliscus lunatus* is restricted to the Kasanka Flats and Mpika area south of Lake Bangweulu (Ansell 1978, Bell and Grimsdell 1973). This population is separated by hundreds of kilometres from a southwestern population (occurring from N Botswana, through W Zambia (west of the Upper Zambezi) into E Angola). The Bangweulu population of *D. lunatus* is perhaps more closely related to *D. l. jimela* (Matschie, 1892) of East Africa (where it is commonly called the topi). I hypothesize that vicariance between the Bangweulu and west Barotse populations of *D. lunatus* followed the alteration of Upper Zambezi drainage – a portion of the original Chambeshi and other south easterly flowing rivers were captured by the Kafue and Lusemfwa, the latter being tributaries of the Middle Zambezi and Luangwa, respectively. This event followed either tectonic activity or headwater capture, or both Tsessebe exploit the ecotone between savanna and floodplain; and would have been distributed along the course of the Chambeshi-Upper Kafue to its confluence with the Zambezi. It is pertinent to record that the distinctly allopatric distribution of *Damaliscus lunatus* (*sensu lato*) across the Upper Zambezi-Kafue-Chambeshi cannot be easily discounted as the result of a historical decline.Without exception, historical evidence (Dollman 1921, Grimwood *et al*. 1958, Knowles Jordan & Ansell 1959, Letcher 1910) all emphasizes (and indeed puzzles over) the anomalous distribution of tsessebe across what can now be recognized as the Upper Zambezi, Upper Kafue and Chambeshi-Luapula axis.

Further evidence lies in the distributions of primates. A distinct biogeographical pattern can be singled out for baboons and forest guenons, with two assemblages separated across an axis extending from the Chambeshi to Shesheke and Okavango (hereafter the Chambeshi-Okavango axis). This axis follows a NE-SW trend, and in Zambia coincides with the drainage of the

Figure 3.7. Proposed evolution of the drainage systems across the Upper Zambezi Basin and its environs, and the resultant vicariance of lechwe antelopes. Hatching depicts possible zones where populations have diverged into their present allopatric distributions. Recent historical declines are not depicted. Evolutionary species of lechwes are depicted by numbers:
1 *leche* (Okavango Delta); 2 *amboellensis*; 3 *notatus*; 4 "leche – busanga"; 5 "leche – Upemba"; 6 "leche – Luando"; 7 *smithemani*; 8 *robertsi*; 9 *kafuensis*.

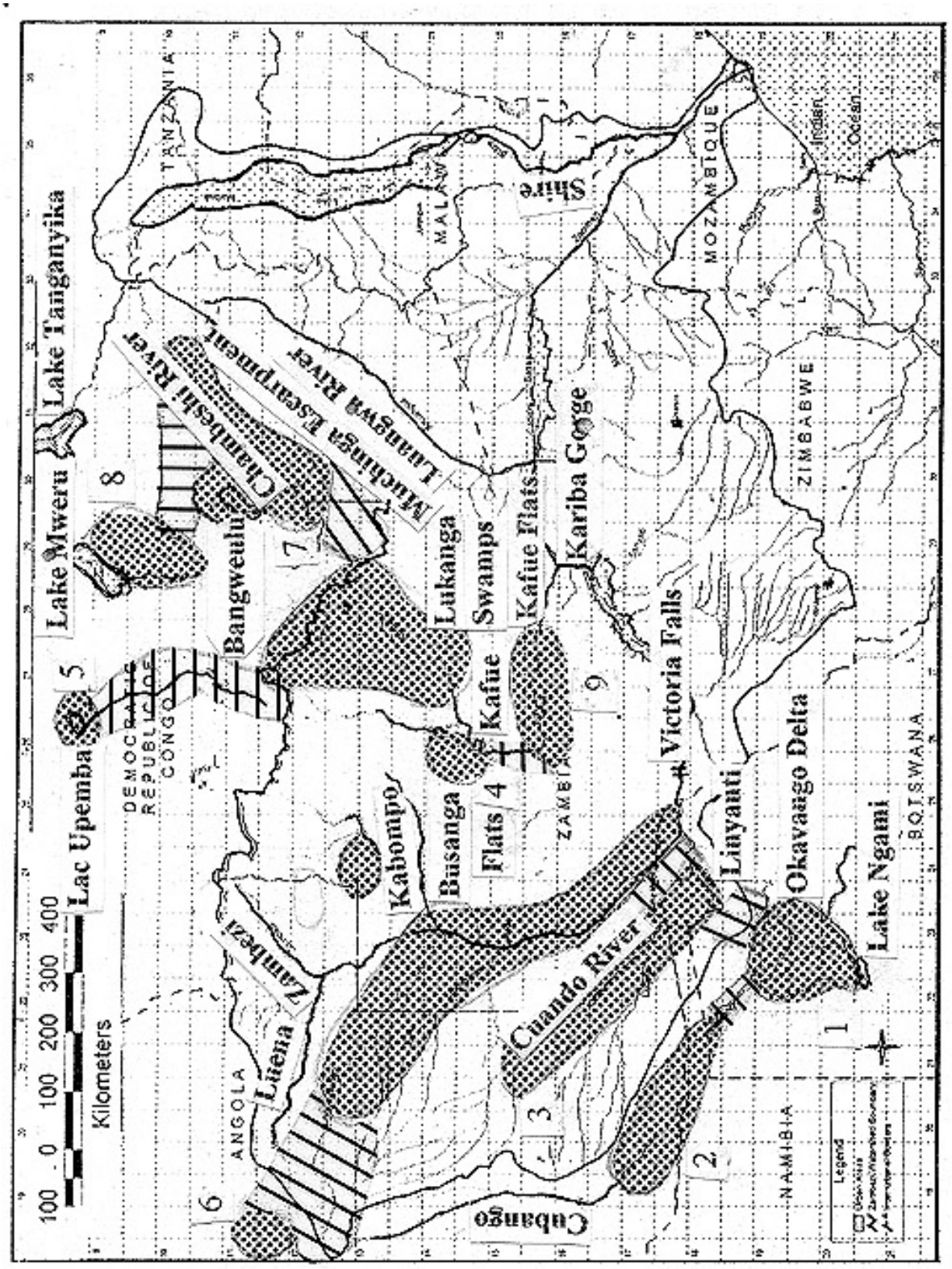


Table 3.4. Checklists of wetland antelopes occurring in the principal wetlands of the Zambezi Basin and its environs. Although not strictly adapted to wetlands, tsessebe, giraffes and oribi are included as their biogeography correlates closely with that of reduncines
(X - taxon occurs in locality; ? - occurrence uncertain; E? - occurrence uncertain, but if present then endangered).

Category	Bangweulu	Mweru	Barotse	Okavango	Chobe/ Linyanti	Kafue Flats	Lower Shire	Luangwa Valley	Zambezi Delta
Reduncines									
Redunca arundinum Southern Reedbuck	?	?	?	?	?	?	?	?	?
R. occidentalis Northern Reedbuck	X	X	X	?	?	?	?	?	?
Kobus crawshayi Crawshay's Waterbuck	X	X	X		?	X			
K. ellipsiprymnus Common Waterbuck				X	X	X	X	X	?
K. kondoensis Kondo Waterbuck	?	?						?	
K. penricei Penrice's Waterbuck				?	X				
K. kafuensis Kafue Lechwe						X			
K. leche Red Lechwe			X		X				
K. robertsi Roberts' Lechwe		X							
K. smithemani Black Lechwe	X								
K. senganus Senga Puku							E?	X	
K. vardoni Puku	I	I	I		I	I			

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Category	Bangweulu	Mweru	Barotse	Okavango	Chobe/ Linyanti	Kafue Flats	Lower Shire	Luangwa Valley	Zambezi Delta
Other Species									
Giraffae thorncrofti Thorncroft's Giraffe								X	
G. angolensis Angolan Giraffe			X	X	X				
Damaliscus lunatus Tsessebe			X	X	X				
D. "*lunatus*"-bangweulu Bangweulu Tsessebe	X								
Tragelaphus spekei Sitatunga	X	X	X	X	X				

Figure 3.8. Distributions of certain species of large herbivores: wildebeest (*Connochaetes taurinus* and *C. cooksoni*), tsessebe (*Damaliscus lunatus*), giraffe (*Giraffae angolensis* and *G. thornicrofti*). Information compiled from Ansell (1978) and Ansell & Dowsett (1988). Historical declines are not distinguished.

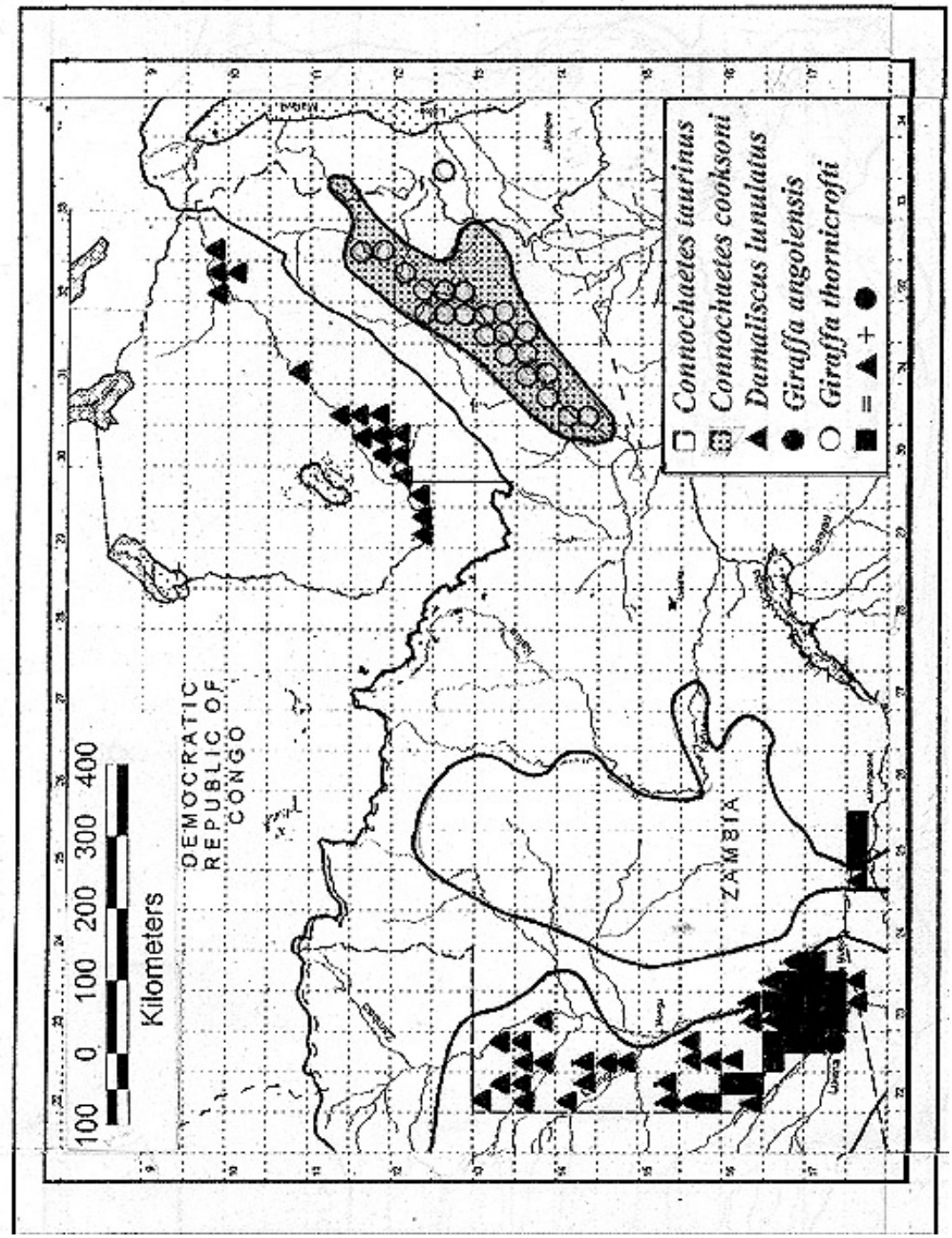
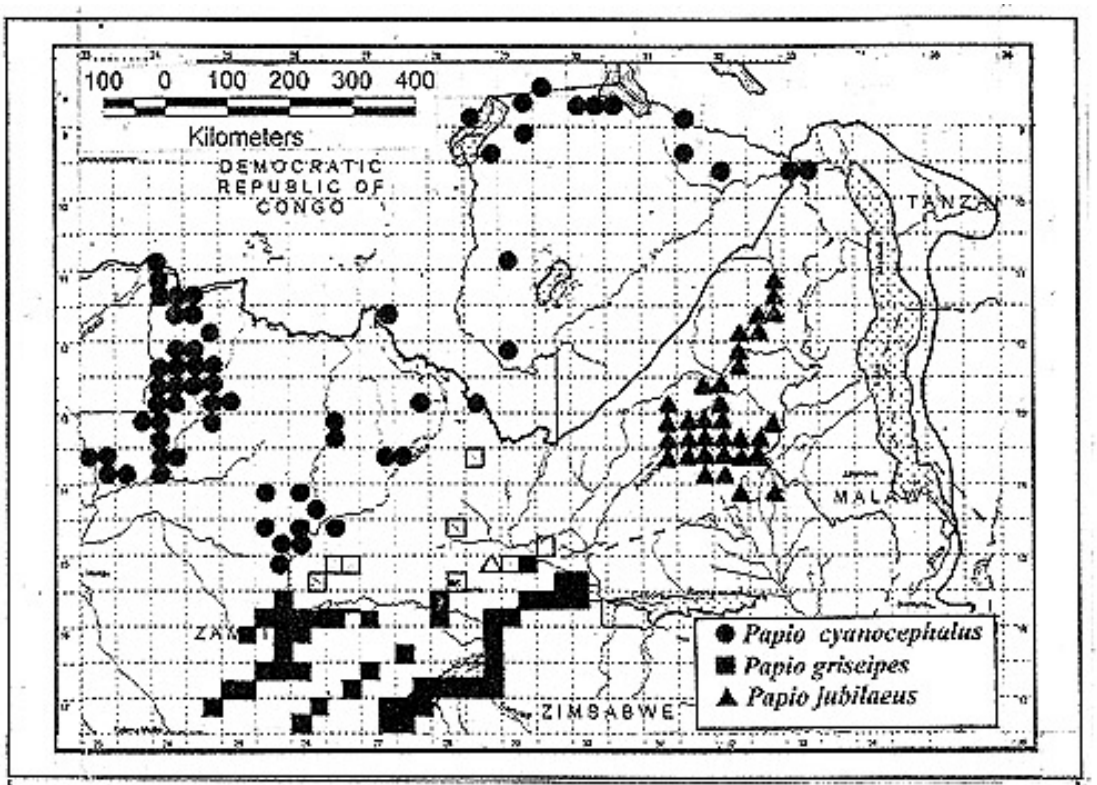
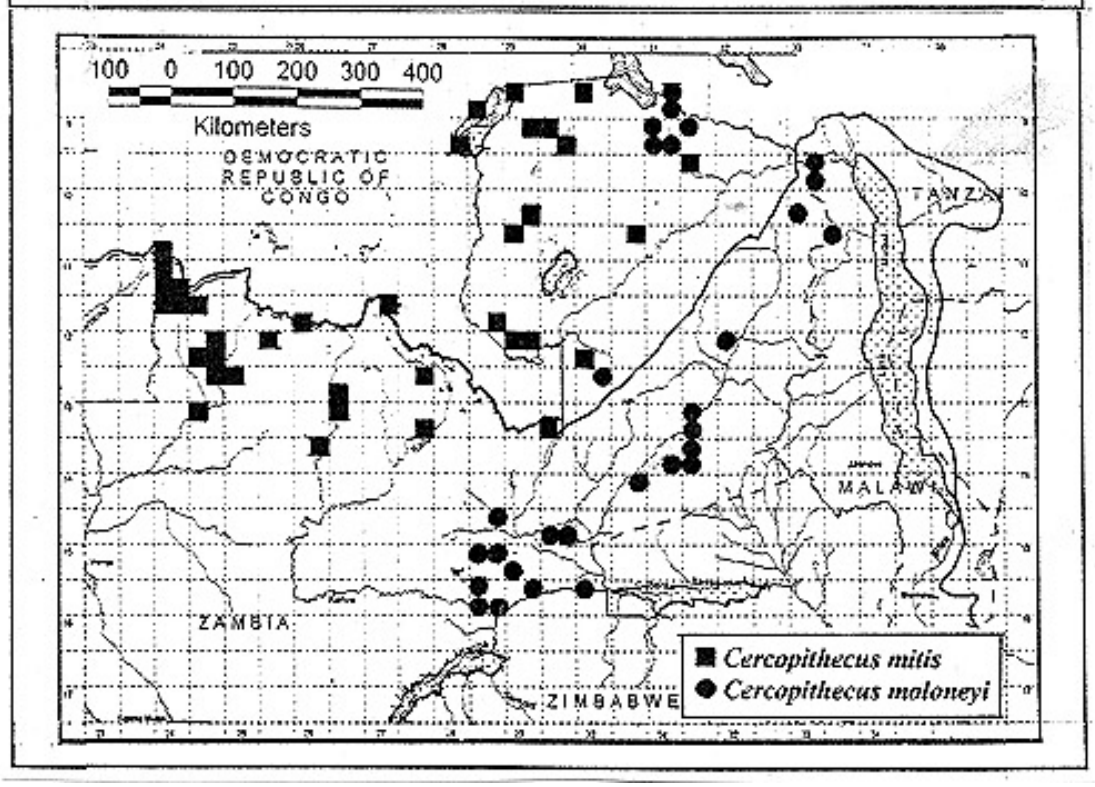


Figure 3.9. Distributions of three evolutionary species of (a) baboon (*Papio cynocephalus*, *P. griseipes* and *P. jubilaeus*) and (b) two evolutionary species of forest monkey (*Cercopithecus mitis* and *C. moloneyi*) demonstrating allopatric distributions (data from Ansell 1978). While *P. jubilaeus* only occurs east of the Muchinga Escarpment, *P. griseipes* and *C. moloneyi* are separated from related populations by the former course of the Upper Zambezi and Chambeshi drainage systems. Open symbols represent localities for which the species identity is in doubt.

a)



b)



Chambeshi and Upper Kafue rivers. Blue monkey, *Cercopithecus opisthostictus* Sclater, 1893 and yellow baboon, *Papio cynocephalus* (Linnaeus, 1766) occur to the north, and chacma baboon, *P. ursinus* (Kerr, 1792) and *C. moloneyi* (Sclater, 1894) are restricted to the south of this Chambeshi-Okavango axis (Figure 3.9). This relationship is also seen in the speciation pattern of *K. kafuensis* (see below, and Figure 3.3), separated from more northerly lechwe populations of the Upper Kafue (Busanga and Lukanga Swamps). Significantly, the divergence between *Papio griseipes* and *P. jubilaeus* – two allopatric populations of baboons (both occurring south of the Chambeshi-Okavango axis) – occurs along the Muchinga Escarpment (Figure 3.9a).

These major changes in Africa's mammal fauna are parallelled to a lesser extent in the divergences represented in many species of extant mammals occurring in and around the modern Zambezi Basin. The Upper Zambezi, notably the Barotse floodplain, appears to be a major geographical barrier (not only to many large mammals, but amphibians and reptiles too) between mesic and xeric species. Pertinent examples are *Connachaetes taurinus*, *Giraffae angolensis,* and *D. lunatus* (Figure 3.8), as well as *K. crawshayi* and *K. vardoni* (Figures 3.2 and 3.4). The contemporary annual flooding regime may prevent lateral dispersal, but it does not explain why dispersal did not occur during arid periods in the late Pleistocene – only tens of thousands of years ago. The existence of apparently recently-diverged taxa (exemplified by tsessebe) suggests that some dispersal has occurred and/or vicariance has been recent. The likely mechanism is that tectonic activity altered the geographical pattern of drainage across an axis extending from the Bangweulu-Chambeshi drainage system into the modern Okavango-Makgadikgadi. The Chambeshi and Upper Zambezi are hypothesized to have flowed into this inland lake – the Makgadikgadi. Several mammals with a predilection for open savanna (such as alcelaphine antelopes) and/or aquatic grasslands (reduncine antelopes) would then have exhibited a more continuous distribution.

As with reduncines, these resultant products of this diversification have been typically interpreted as superspecies (Grubb 1978). The situation is obviously ripe for a radical revision of these zoogeographical patterns using the refined concepts and methods of phylogenetic systematics. Although the pattern of speciation has been traditionally termed allopatric (or parapatric), the more appropriate term is dichopatric (following Cracraft 1984) in order to recognize that the major process of diversification for evolution of reduncines and other large mammals across the Zambezi Basin has resulted from vicariance, and not competitive exclusion.

3.7.4 **Diversification of Reduncine antelopes in the Zambezi Basin**

The divergence exhibited among extant representatives of the Reduncini strongly suggests that speciation was not simply caused by a single disturbance event, and neither were these disturbances a simple result of one agency. It appears that several species originated across a shifting mosaic of islands of wetland in a sea of predator-rich savanna. A similar pattern of allopatric speciation is exemplified by the giraffe, wildebeest and tsessebe, large herbivores of open savanna. The resultant pattern of diversity in modern reduncines is today a fragmented mosaic. In historical times, much of this biogeographic mosaic of reduncines within the Zambezi Basin has been destroyed by human depredations and impacts over the past two centuries. Preliminary scrutiny of the lechwes reveals that at least four species occur within Zambia alone, and possibly the populations of Barotseland, Busanga Flats, Caprivi and the Okavango are genetically distinct. There are also populations (designated as *K. l. leche*, Ansell 1978, Ansell & Banfield 1980) represented by specimens in the Royal Museum of Central Africa, Tervuren, Belgium from the Shaba Province of the DRC. These are mainly from the environs of Lake Upemba (Schouteden 1947). Their precise taxonomic status has yet to be established (Ansell & Banfield 1980; see species accounts above).

The marked difference between the distributional patterns of lechwe versus waterbuck in modern Zambia suggests one of two scenarios regarding diversification (Figure 3.10): (a) populations of these two groups diverged in response to two separate episodes of vicariance, or (b) the founder population(s) responded differently to the same environmental changes. Examples illustrate the possible role of these processes in the major vicariant events hypothesized:

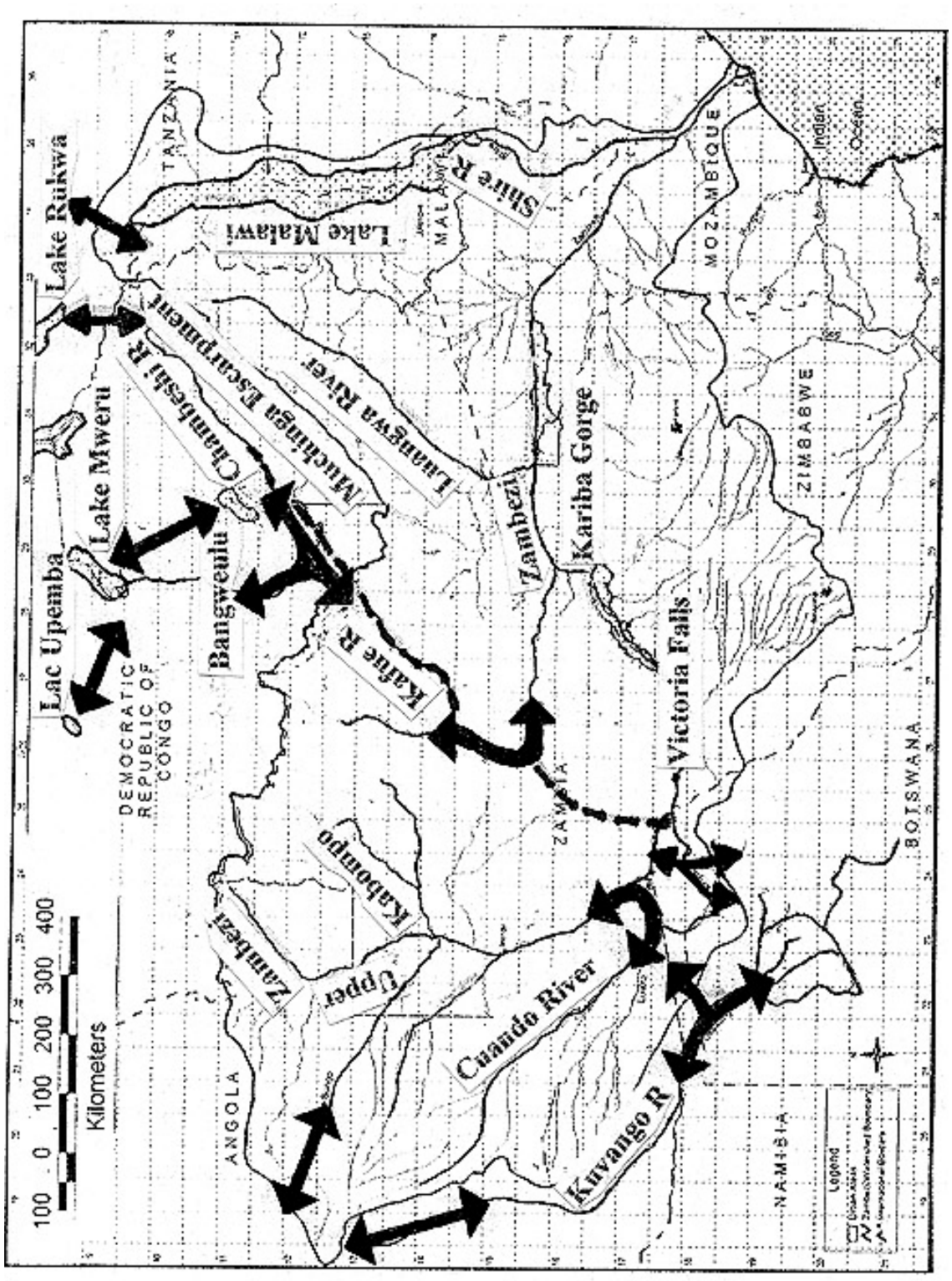
(a) Allopatric speciation followed on formation of the Muchinga Escarpment. This probably resulted in divergence of distinct pairs of species, including *K. crawshayi* and *K. ellipsiprymnus*; *K. vardoni* and *K. senganus*. Modern distributions of Zambian waterbuck suggests that their speciation was comparatively recent – *K. crawshayi* occurs across northern Zambia and southern DRC, but not west of the Zambezi, while *K. ellipsiprymnus* is confined to southern and eastern Zambia, the Luangwa and Middle Zambezi valleys. The two populations are marginally sympatric along the Lusemfwa River, a tributary of the Luangwa (Figure 3.2). The Muchinga Escarpment forms a significant boundary between the larger part of these populations (Ansell 1978, see below).

(b) *Kobus kafuensis* appears to be an allopatric isolate from a more wide-ranging population of *K.* "*leche*", whose descendants today occur only in the Busanga Flats and parts of the Upper Zambezi. In fact, *K. kafuensis* is the only lechwe that occurs marginally south of the present Upper Zambezi drainage system. Its divergence occurred long after capture of the Upper Kafue River by the Middle Zambezi (during the Miocene, Skelton 1994) and most likely as the Kafue Flats became established comparatively recently. A preliminary analysis of lechwe morphometrics (Ansell & Banfield 1980) suggested that *kafuensis* is the most derived, and thus most recent, taxon. Its large horns especially point to the origin of a unique SMRS. As for other populations, the taxonomic status of the Busanga and more westerly populations of *K.* "*leche*" require objective characterization.

(c) The Luapula River captured the Upper Chambeshi in the Pliocene (Dixey 1955, Skelton 1994) and the Bangweulu Basin formed thereafter, but the subsequent timing of changes in drainage patterns in N Zambia is unclear. It was then that *K. smithemani* and *K. robertsi* evolved in N Zambia with the evolution of a distinct SMRS in parapatric or allopatric populations. A likely physical agent of vicariance was tectonic changes across the Mweru and Bangweulu basins (and associated drainage systems) that perhaps influenced the Upemba region of the southern Congo Basin. This caused vicariance of a more contiguous lechwe population(s). It remains to be established which is the daughter species of these populations. The smaller size of *smithemani*, compared to *leche, robertsi* and *kafuensis*, suggests that it is more derived and evolved from an ancestor similar to *robertsi* or *leche*.

(d) There is circumstantial evidence, based on patterns of extant Reduncine diversity, that a separate vicariance event occurred in the E Caprivi across the Chobe, Linyanti, Luiana and Upper Zambezi, perhaps extending beyond north of Sesheke and east of Kazungula. This region corresponds to the boundary between distributions of *vardoni, crawshayi* and *penricei*, and the occurrence of an isolated population of *vardoni*. The taxonomic status of lechwe in the Linyanti and Cuando, as possibly distinct from topotypical *K. leche* in the Okavango Delta and *K. amboellensis* of the Cubango, adds additional, albeit tenuous, evidence. The edges of distributions of species of birds, reptiles and amphibians also correspond to this region. Most pertinently, the biogeographical patterns of reduncine diversity in this region points to the existence of a hotspot of evolutionary divergence.

Figure 3.10. Geographical depiction of the two principal agents hypothesized to have driven diversification of the reduncine antelopes across the Zambezi Basin and its environs since the late Pliocene (~2 Mya). Cross-hatching depicts the Muchinga Escarpment; arrows represent zones of allopatric speciation; thick dashed line represents approximate course of former Chambeshi-Upper Kafue tributary of the Zambezi.



(e) Compared to lechwe, reedbuck and waterbuck are less susceptible to vicariant disturbances as they are not so rigidly dependent on their aquatic habitats. An interesting attribute of the behaviour of puku could be relevant to their biogeography. These antelopes often disperse long distances (Ansell 1978, Ansell & Dowsett 1988), whilst the range of established populations are remarkably stable (as along the Chobe floodplain). Possibility of gene flow across the respective ranges of *vardoni* and *senganus* could have diluted and even obviated vicariant changes to ancestral populations. This behaviour may have camouflaged divergent evolution within these populations, a situation which can only be resolved with genetic studies. It is also significant that Howard (1986a) records long distance dispersal by southern reedbucks in Natal, South Africa.

(f) As already emphasized, it is not possible to distinguish unequivocal divisions between the northern and southern reedbuck (*R. occidentalis* and *R. arundinum*, respectively), should these forms withstand close scrutiny. This problem is compounded by hazy understanding as to where the two forms actually occur within the Zambezi Basin. It is, nonetheless, noteworthy that the boundary between the two forms corresponds (as recognized by Ansell, 1971) to the Zambian plateau where *Kobus* and other clades of vertebrates exhibit recent and considerable diversification. The zone of possible vicariance in *Redunca* may lie in northern Zambia and neighbouring Tanzania, across the headwaters of the Luangwa and Chambeshi rivers extending into the Rukwa depression, where *R. thomasi* (of uncertain taxonomic status) was described from the Songwe River.

(g) Although evidence is vague, a zone of biological diversification across the northeastern edge of the Zambezi Basin is analogous to the E Caprivi. As judged from incomplete data on antelope distributions, this zone would encompass the headwaters of the Luangwa and Chambeshi rivers, and extend north east across the East African rift system into the Rukwa depression. The Rukwa Valley is noted for the occurrence of *K. vardoni*, typically associated with the Upper Zambezi Basin, and both *R. arundinum* and *R. redunca*, at the southern limits of the latter's distribution. An isolated population of lechwe (believed to have been *K. smithemani*) occurred in this area at the northern margin of the Luangwa Valley (Lyell 1913), but is now extinct (Ansell 1971). This complex of reduncine populations likely resulted from recent vicariance associated with tectonic activity in the East African rift.

I suggest that this diversification resulted from a combination of determinants – tectonic events, with these geological and geomorphological processes interacting with climatic changes during the Pleistocene. One candidate is the capture of the Upper Zambezi at Katombora, associated with which were modifications of the drainage of the Chobe and associated system. This had formerly drained southwards into the central Kalahari but was now captured by the Middle Zambezi immediately west of Kazungula. The late Pleistocene was also a time of aridification, when regional climate was cooler and drier. Thus, at least two physical agents likely drove reduncine speciation, and positive feedback could have occurred. The drying-out of wetlands on the Zambezian-Congo Plateau (the African erosion surface) may have activated movement in existing fault systems and so initiated local tectonic activity. In consequence, this may have altered drainage patterns. The result would have contributed to vicariance of wetland biota.

The overall pattern exhibited in reduncine diversification approximates the evolutionary model of punctuated equilibria (Eldredge & Gould 1972). Originally proposed by Eldredge (1971), the punctuated equilibrium model is actually an elaboration, as a temporal analogue, of Mayr's allopatric model of speciation. Following rapid speciation in small vicariant populations, reduncine

populations have persisted comparatively unchanged within their ranges. The fossil data available for *Kobus* and *Redunca* also support this model of stasis punctuated by allopatric speciation (Figure 3.1). Following Erwin (1991), the Reduncini are a clade of evolutionarily vibrant lineages that have recently evolved and whose evolution could persist if lineages are not extirpated by human agencies. Their habitats are sites of significant conservation concern given their recent evolution, which has quite possibly involved other biota.

The diversification of Zambezian Reduncini appears to have occurred comparatively recently during the late Pleistocene (Figure 3.1), with their extant diversity resplendent in many closely-related populations (traditionally termed superspecies, Grubb 1978). This is especially true of the lechwes. Their allopatric distributions are possibly a consequence of these antelope's high fidelity to floodplains. I suggest the model that best describes the evolution of Zambezian reduncines is one of species stasis rapidly altered by environmental changes which caused vicariance. This hypothesis is similar to the Turn Over Pulse Hypothesis, which has been used to explain mammal diversification across the continent somewhat earlier in the Tertiary and at much larger scales (Vrba 1985, 1992). Evidence for this is also abundantly represented in fossil record of pigs and primates (including hominids). These corresponded to global fluctuations in climate at the Miocene-Pliocene (5Mya) and Pliocene-Pleistocene (~2Mya) boundaries.

A more detailed model for evolution of Zambezi reduncines is still required, integrating more precise information about geomorphological changes through the Pleistocene into the Holocene. Existing models (notably Skelton 1994 on evolution of fish faunas) are too coarse-grained in their spatial and temporal dimensions, and treat the history of evolutionary change across the Zambezi Basin as proceeding through three linear stages. It was probably not that straightforward, given influences of arid periods and finer-grained vicariance of drainage systems, but this can only be tested with more precise biogeographical analyses using genetic studies of indicator species. Reduncines, especially lechwes are special candidates for finer-grained analysis of this more recent evolution in the region. Studies of their divergence need to be correlated with data pointing to fluctuations in extinct wetlands and those still existing across the basin. I suggest data from carbon deposits in sediments and pollen cores, allied with other palaeoecological research, might aid elucidation of where major lechwe habitats occurred in the comparatively recent geological past.

The susceptibility of reduncine antelopes to these physical modifications of the African erosion surface that forms the Zambezian plateau can only be surmised today. The high habitat fidelity of these aquatic antelopes suggests that the consequences were radical. The response of *K. smithemani* to an abnormal flooding of the Bangweulu area in 1936-1938 illustrates the susceptibility, especially of lechwe, to disruption of their habitats, a susceptibility that introduces the possibility of extinctions. Since species turnover is a function of both extinction and diversification, it is not unlikely that many populations of reduncines declined to extinction when tumultuous events modified wetland habitats. An extremely poor fine-grained fossil record - and remote chances of fossilization - render elucidation of this history difficult from morphological characters. Molecular characters, including construction of gene trees, are the obvious solution, but no matter how complete, can only paint a partial historical chronicle. In this respect, I predict that more detailed studies of the genetic parameters of reduncine diversification will reveal even greater extant diversity than has been pointed out in this review.

3.8 CONSERVATION

Conservation of reduncine antelopes in the Zambezi Basin involves at least three issues. One is the challenge and practice of recognizing and conserving healthy representatives of reduncine species in the region. Much attention has already been paid to this in the review. The second involves the application of scientific knowledge about reduncines to make informed conservation decisions, where reduncine species and the patterns of their evolution are used to indicate sites which support important biodiversity and/or are zones of recent and continuing evolution. Third is the relevance and value of using certain populations of reduncines to support and implement conservation activities. In this latter role, reduncines are flagship or umbrella species. It is important not to confuse these three issues (Caro & O'Doherty 1999). Two or more of these issues might be complementary in a particular conservation project, but they must be teased out and recognized so as to avoid confusion and inappropriate applications.

The reduncines have experienced huge reductions in their population through the 20th century as a result of human depredations. The historical decline of puku in Zambia exemplifies the problem, which has reached its extreme in the extinction of allopatric populations of lechwe (most notoriously *K. robertsi*). Hughes (1933) concluded that puku formed "a thin red line" along the edges of Zambian wetlands, especially vulnerable to hunting, and emphasized that these populations were already suffering major depredations in the early decades of the 20th century. In drawing attention to Hughes' admonition, Vesey Fitzgerald (1961) emphasized that it is these antelopes dependent on open grasslands that are especially prone to human depredation, and cites puku, lechwe and tsessebe as showing huge declines in the ranges and densities of their populations. The case of Kasanka dambo in Kasanka National Park demonstrates that "a thin red line" of puku can be restored with adequate protection.

3.8.1 Maintenance of populations

The crux of conserving any species *in situ* is to maintain sufficient habitat. This is the first and obvious step. Any management plan must address the maintenance of viable populations which are not subject to excessive depredation. The disturbance regime (for example the Kafue Flats, Schuster 1980) must be maintained to provide the appropriate cues which determine reproductive and other behaviour. The critical requirements are to reduce human depredation and excessive competition with domestic herbivores. In practice, protected areas of reduncine habitats are essential. As in southern Bangweulu (Thirgood *et al.* 1994), hunting must be prohibited in such core zones, but managed in surrounding buffer and utilization zones.

An important management tool in conservation programmes in Africa is to develop community-based conservation projects, where humans living in and around conservation areas benefit directly from the wildlife therein. It is important to acknowledge that existing programmes remain experiments, and their longevity appears precarious considered against threats of alternative land use practices, and especially unsustainable trends in human population levels.

Kingdon (1982) has emphasized the potential of reduncine antelopes for utilization, as have other authors (East 1989a, 1989b, Grimsdell & Bell 1975). The recovery of lechwe on the Busanga Flats, Caprivi and Bangweulu demonstrate that reduncine antelopes, especially lechwe, can recover rapidly from comparatively low populations. This reproductive potential needs to be considered in conservation management plans for any wetland where they occur, and testifies to considerable chances of success, but only if unsustainable exploitation, unsuitable land use and deleterious habitat modification can be halted.

Research and monitoring has demonstrated that *K. smithemani*, and *K.* "*leche*" on the Busanga Flats (Bell & Grimsdell 1973, Howard & Chabela 1987), have a remarkably high intrinsic rate of population growth. A major determinant of this life history variable is the very high survivorship of neonates coupled with a relatively young age of first reproduction in females. To this high population increase can be added the productive habitat exploited by lechwe (Ansell 1957, Bell & Grimsdell 1972, Grimsdell & Bell 1976, Robinette & Child 1964). Female puku also reproduce at a young age; 66% of calves marked in a study conceived in their first year (Rosser 1987). Howard (1986b) records that fecundity of female southern reedbuck is increased by a post-partum oestrus.

Although many authorities have repeatedly suggested that reduncines, especially lechwe, are suitable for sustainable exploitation, caution is advisable in implementing such programmes. In past centuries, certain African tribes exploited lechwe on a regular basis. Many of these were characterized by coordinated hunts where the antelope were driven with beaters and speared, or captured with dogs. If this historical offtake was sustainable, it is no longer following the introduction of modern hunting technology, national communication systems, and a massive, burgeoning population of rural humans. The consequences have been catastrophic. The exponential declines of lechwe populations in the Caprivi, Kafue Flats and Bangweulu in the past decades speak for themselves. So does the acute reduction in ranges of puku and "red" lechwes from large areas of the Upper Zambezi.

Exploitation of any population can only succeed in the long term if it is tightly managed, such that quotas are adhered to, and the resource is monitored to detect changes and trends in populations. This adds significant costs in the form of skilled personnel and aerial census. It is worth emphasizing that signatories to the Convention on Biological Diversity (to which the riparian states are party) are beholden to perform these activities in the long term within their countries. The large, unique wetlands more than justify this expenditure toward biodiversity conservation. The crux is the commitment and policing of such policies, despite inevitable political changes and burgeoning human demands. Ideally, exploitation of populations of reduncines needs to be coupled with tourism, and with more integrated and thus productive land use. Zambezian wetlands supporting unique reduncine species are especially suited to exclusive, high-paying tourism given the aesthetic attributes of the landscape and other charismatic species, such as Shoebills, in northern Zambia. Alongside sitatunga and shoebills, reduncines are flagship species to attract and maintain conservation support and interest, and in so doing aid development of their habitats as exclusive, international tourist destinations. Economic benefits could be considerable if the resource and the ecological integrity of the landscape is maintained.

3.8.2 **Reduncines as indicator species**

The patterns of diversification exhibited in the reduncine antelopes of the Zambezi Basin provide sober lessons for the assessment of biodiversity. The major part of this review has tried to elucidate the evolution and current taxonomic status of the various populations. The existence of these isolated populations points to the existence of significant wetlands which have persisted through, and also been formed by, significant climatic and tectonic changes. They open up questions about other evolutionary species, especially invertebrates and fishes currently unknown but restricted to the same areas.

The previous section has emphasized that the Reduncini form an evolutionarily vibrant clade of species that might still continue to diverge. Their existence points to a conservation priority in defining conservation areas for Zambezian biodiversity which focus not only on the representation of pattern, but equally on the maintenance of representative landscapes which generated (and

continue to maintain) the biodiversity of which reduncine antelopes are part. As Cowling *et al*. (1999) emphasize, the consideration of evolutionary and ecological processes in conservation planning is vital but very challenging, not least because we know so little about these processes.

3.8.3 **Reduncines as "umbrella" species in conservation**

Like many large mammals, it would appear that a reduncine antelope requires a relatively large ecological neighbourhood in which it can obtain ecological resources to survive and reproduce. This requires designation and maintenance of extensive landscapes. Certain reduncines are popular flagships for conservation in the region. These include the reedbuck of Marromeu and especially the black and Kafue lechwe of Zambia.

The use of any umbrella, or flagship, species needs to be kept within the context of the reality of the overwhelming adversity facing all biodiversity conservation projects. There is a risk that conservation of the target species becomes an overriding rationale for conservation activities and funding. The reality is that the ecological integrity (undeniably a slippery definition in its own right) holds precedence to maintain the habitats where both charismatic and less apparent organisms have evolved and persist. Conservation of reduncine antelopes requires two major investments. One hinges on maintaining their aquatic and surrounding habitats. The second requires reducing human depredations on populations of these antelopes. Ultimately, this requires the synergistic management of all biodiversity and the drainage systems where these biota have evolved.

3.9 CONCLUSIONS AND RECOMMENDATIONS

1. The vicariant patterns of recent diversification in reduncine antelopes render them useful indicators to identify important biodiversity in the Zambezi Basin and further afield. Examples are the occurrence of *K. robertsi* and *K. smithemani* in N Zambia and *K. kafuensis* in the Kafue Flats, both likely to be correlated with recent geomorphological evolution within the Upper Zambezi drainage. Indication of recent evolution and rapid changes in the gradient of biodiversity across certain landscapes are highlighted by changes in reduncine distributions in at least two regions of the Zambezi Basin – the include the E Caprivi and Kazungula, and possibly the headwaters of the Chambeshi and Luangwa extending into the Rukwa Valley of SE Tanzania.

2. The Reduncini comprise a clade of evolutionarily vibrant populations. Their biogeography pointst to zones of recent and on-going evolution. Objectively applied, knowledge of their biogeography and evolution can identify representative and significant landscapes in the Zambezi Basin where evolutionarily significant populations have evolved. As they currently illustrate, the occurrence of fragmented and parapatric populations of reduncines across a large portion of the basin indicates sites for priority assessment and maintenance of aquatic biodiversity in areas where the different species occur. Overall, the pattern and timing of reduncine evolution across the Zambezi Basin indicates that a pulse of diversification has occurred across south-central Africa with special impacts on wetland biodiversity. Available evidence points to this pulse having been recent, rapid and geographically extensive in its occurrence across the Upper Zambezi. Whether caused by tectonic and geomorphological changes, climatic fluctuations, or both, the implications for biology and conservation of a knowledge of its history are profound. The more detailed analysis should be expanded into a search for historical changes in significant wetlands across the modern Upper Zambezi, Chambeshi and Kafue systems and adjacent catchments. Nevertheless, this use of large vertebrates as indicators and surrogates must be applied cautiously in biodiversity conservation

given the gravity of conservation decisions. It is critical to involve other datasets, including those for herpetofauna, fish and especially invertebrates, in a synthesis.

3. Considering their charismatic status and associated public attention, it is indeed surprising that considerable scientific work remains to elucidate the taxonomy of many large Afrotropical herbivores. This deficiency is exemplified in the Reduncini, whose phylogenetic status also requires clarification. A detailed review of the systematics of the Reduncini is required in order to assess and structure conservation planning for all genetically distinct populations. Such a study should include field assessments of existing populations to obtain tissue samples and complete gaps in museum collections.

4. Recent and radical declines, extinctions and growing threats to reduncine antelopes across the Zambezi Basin illustrate an acute conservation crisis. The impacts on most of these large mammals have been extreme, with a sweeping loss of biodiversity across the Upper Zambezi during the 20th century. As exemplified by the lechwe, reduncine antelopes have been lost from huge areas of their original habitats, which have become increasingly dominated by humans and developed for agriculture. It is especially noteworthy that at least one significant population – Roberts' Lechwe, *Kobus robertsi* – has become extinct; an inaccurate taxonomy no doubt contributed to its decline (*K. robertsi* was originally dismissed as an aberrant form of *K. leche*.) The lesson from this example is salutary. Given the great diversity represented among extant reduncine antelope of south central Africa, all discrete populations should be treated as full species with respect to conservation management until their phylogenetic status is conclusively resolved.

5. A field survey of critically threatened reduncine populations is required. This should focus on the southern Congo Basin, eastern and central Angola and, especially, northern Zambia (north of Lake Bangweulu). These surveys cannot exclude the southern Congo Basin and neighbouring Tanzania, and should include an exploration of the former range of *Kobus robertsi* and attempt to establish whether any individuals still persist. The need for this survey is urgent.

6. The potential of reduncine antelopes for controlled exploitation has barely been explored (despite the case of *K. smithemani*). This potential is characterized by their rapid growth rates and high reproductive potential. An adult reduncine antelope yields tasty meat and valuable hides. Males of all species are sought after by trophy hunters. Any such scheme needs to be properly designed and managed by professional ecologists, with conservation of at least one core source area where no cropping occurs. Such schemes are unlikely to succeed in marginal aquatic habitats, or where reduncines compete heavily for forage with other large herbivores.

7. This review has only presented preliminary conclusions. These are actually hypotheses based on incomplete datasets, correlated with equally incomplete historical evidence to provide partial answers to questions of what species of Reduncini occur where, their taxonomy and evolution. Comprehensive and detailed data about reduncine biogeography and diversity (collected and analysed as suggested above) will be invaluable to evaluate and map Afrotropical biodiversity in the continent's wetlands – in the Zambezi Basin, its environs, and elsewhere. These data on such charismatic vertebrates must be meshed with more taxonomically-representative knowledge of the region's biodiversity. The need to understand reduncine diversification and the processes which caused these antelopes and other populations to evolve is important. It points to evolutionary and ecological processes which need to be

maintained, and conceptual tools and datasets to identify representative components of extant biodiversity in the wetlands and other landscapes of Africa.

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CHAPTER 4
SMALL MAMMALS OF THE ZAMBEZI WETLANDS

Fenton Cotterill

4.1 INTRODUCTION

Small mammals make up a significant proportion of the mammal fauna of the Zambezi Basin. With the exception of the poorly known otter-shrew, *Potamogale velox* (known only from Mwinilunga District in NE Zambia), there are no specialized mammals occurring in the basin that are entirely dependent on wetlands. Yet wetlands are important habitats for small mammals; floodplains support fluctuating populations of rats and mice, as do riparian forests and woodlands, and shrews exploit the abundance of invertebrates found there. Bats are particularly well-adapted to exploit insect prey foraging over floodplains and open water, provided roosts are available on wetland margins.

The small mammal fauna of the Zambezi Basin is incompletely known. This deficiency applies to all groups (bats, insectivores and rodents). Most wetland habitats have been poorly surveyed, if at all. The main information available is limited to distributions and taxonomy, with very little known of different species' natural history and ecology. Knowledge of the small mammals of Barotseland is based primarily on specimens collected (mostly by W.F.H. Ansell) through the 1940s and into the 1970s. This taxonomic and biogeographical data for small mammals was included in Ansell's *Mammals of Zambia* (Ansell 1978). Smithers and Tello (1976) compiled an analogous treatment for Mozambique, the mammal fauna of which is one of the least known of all African countries. This deficiency of information is exemplified by the Zambezi Delta. Pioneering studies of African mammals were initiated on the lower Zambezi by R.H. Peters in the mid-19th century. Many larger mammals, together with some bats and rodents, were described to science by him. Examples include the porcupine (*Hystrix africaeaustralis*), Lichtenstein's hartebeest (*Sigmoceros lichtensteinii*), and the red squirrel (*Paraxerus palliatus*). Nevertheless, there have been no further scientific studies of small mammals of the Lower Zambezi and its delta. Small mammals were surveyed in some protected areas in Mozambique through the 1960s and early 1970s. This activity did not extend to Marromeu, where research was limited to monitoring of large mammals (summarised in Cumming *et al*. 1994) in the Marromeu Buffalo Reserve and surrounding hunting areas (coutadas).

This chapter presents the results of two surveys of important wetlands in the Zambezi Basin – Barotseland and the Zambezi Delta. The contributions of these new data to improved knowledge of the small mammal faunas of these areas are discussed in a national and regional context.

4.2 BAROTSELAND SMALL MAMMALS SURVEY

4.2.1 Introduction

As part of the Biodiversity Foundation for Africa/Zambezi Society wetlands biodiversity assessment project, a field survey of the small mammals of some of the wetlands of Barotseland, Western Zambia was carried out between 2-12 November 1998. The author was accompanied by Mr Aleck Ndlovu, technician in the Department of Mammals, Natural History Museum in Bulawayo. The trip was done in conjunction with a wetland bird survey (see Appendix 5.1).

Mammalian nomenclature follows Wilson and Reeder (1993), except for *Pipistrellus* where Hill and Harrison (1987) are followed.

4.2.2 **Methodology**

Owing to vehicle problems, only two sites were sampled – both dambos. The first site was 7 km west of Ndanda School, north of Mongu in a lower drainage valley classified as a wet riverplain R2 by Jeanes & Baars (1991). The woodlands near settlements had been modified, but extensive and dense tall stands of miombo occurred to the south. The second site was Litoya dambo next to a village near a large permanent pool also situated in a wet riverplain. The margins of the dambo were densely settled and cultivated; few livestock were seen. Woodlands near villages exhibited considerable modification with much regrowth and evidence of felling. This last site provided many bats but few terrestrial mammals.

4.2.3 **Results**

Total number of species collected was 26 (Table 4.1), representing a collecting effort of 43 net nights and 14 harptrap nights. The majority of bats were netted, with 34 bats captured in harptraps. Only five terrestrial mammals were collected, using snap traps baited with peanut butter and rolled oats, over 300 trap nights in eight days, while two rodents were collected in the pitfall trap arrays. Some invertebrates (insects, spiders and scorpions) and over 50 specimens of frogs and reptiles were also collected in the pitfalls and in swamps and pools near Ndanda School. All this material has been deposited in the Bulawayo Natural History Museum.

4.2.4 **Discussion**

Western Zambia has been poorly collected with respect to small mammals (Ansell 1978). Nonetheless, the occurrence of all these species is not unexpected. The bat fauna, as judged by captures in nets and harptraps, is dominated by vespertilionids and molossids. I suspect these bats roost in hollows and crevices in trees and under exfoliating bark in the tall woodlands bordering the Litoya and Ndanda dambos. The success in sampling of bats was the focus on permanent water bodies around which the bats congregated to drink and forage. This sampling strategy has also proved successful in Zimbabwe, especially during the hot, dry season in October and November. The high abundance of *C. pumila* at Litoya may reflect the occurrence of a large colony in a building in the vicinity, perhaps at the school.

The series of *Chaerephon chapini*, *Mops niveiventer*, *Laephotis botswanae, Pipistrellus anchietai* and *Scotoecus albigula* are of significant scientific taxonomic importance as such series are uncommon. The former, Africa's smallest molossid bat, is not common, with the Ndanda collection being the third recorded locality in Zambia. *M. niveiventer* and *L. botswanae* are known from a few scattered localities in Zambia and E Angola, with *L. botswanae* known from further south (Cotterill 1996).

House bats of the genus *Scotoecus* include some of Africa's most poorly known bats. Too few specimens have been collected to establish species boundaries with confidence. For example, *S. albofuscus* is only known from three specimens from the southern African subregion; two individuals from Zinave in central Mozambique (Smithers & Tello 1976) and one specimen collected near St Lucia in South Africa (Kearney & Taylor 1997). The series of *Scotoecus albigula* secured on this expedition is quite possibly the largest available from any single locality. These new specimens have been compared with the three specimens preserved in Bulawayo. Cranially, they are identical to a specimen of *S.* cf. *albigula* from the Luangwa Valley and conform to the key and

data in Hill (1974). As far as I am aware, the photographs obtained are also the first taken of this species. No further conclusions can be drawn on their taxonomic status until the specimens in the UK are examined. A similar situation applies to the unidentified specimens of *Pipistrellus* and *Scotophilus*.

Table 4.1. List of mammals collected in western Zambia, November 1998, by collecting site.

Species	Litoya	Ndanda	Remarks
Family Pteropididae			
Epomophorus dobsoni		X	
Epomophorus gambianus	X	X	
Family Molossidae			
Mops midas Midas free-tailed bat	X		locally common
Mops condylura Angola free-tailed bat	X	X	common
Mops niveiventer White-bellied free-tailed bat	X	X	locally common
Chaerephon chapini Long-crested free-tailed bat		X	rare
Chaerephon pumila Little free-tailed bat	X	X	common
Chaerephon nigeriae Nigerian free-tailed bat	X	X	locally common
Family Vespertilonidae			
Scotophilus borbonicus Lesser house bat	X	X	common
Scotophilus dinganii Yellow house bat		X	common
Scotophilus sp.	X		undescribed species, also known from SE Zimbabwe
Scotoecus albigula		X	rare
Laephotis botswanae Botswana long-eared bat		X	rare
Pipistrellus capensis Cape pipistrelle	X	X	common
Pipistrellus melckorum Melck's pipistrelle		X	rare
Pipistrellus somalicus Somali pipistrelle	X	X	common
Pipistrellus anchietai Anchieta's pipistrelle	X	X	locally common
Pipistrellus rusticus Rusty bat	X	X	common
Pipistrellus kuhli Kuhl's pipistrelle		X	rare
Pipistrellus nanus Banana bat		X	common
Pipistrellus sp.	X	X	
Glauconycteris variegata Butterfly bat		X	
Family Rodentia			
Cryptomys damarensis Damara molerat	X	X	common on Kalahari sand
Dasymys incomtus Water rat		X	
Saccostomys campestris Pouched mouse		X	
Tatera leucogaster Bushveld gerbil		X	

Overall, the significance of these new biogeographical data can be judged from the distribution maps given in Ansell (1978). In addition, important life history data was obtained for many of the species of bats collected – most females had recently given birth and were lactating, or births were imminent.

The molerats were collected from colonies which occur along the edges of the dambos: their burrows extended into the open grassland. These specimens were trapped with modified Hickman traps (Hickman 1979) baited with potato, and were identified as Damara molerat, *Cryptomys damarensis*, which is widespread on Kalahari sands in south central Africa. This species was encountered at both Litoya and Ndanda. Fresh mounds, presumed to have been dug by *C. damarensis*, were seen elsewhere in Mongu District and between Senanga and Shesheke on the west bank of the Zambezi.

The paucity of rodents and insectivores encountered during the survey is an interesting result. I suggest that their absence is the result of human depredations and activities such as fire. The sampling period may also have coincided with dispersals and/or declines in rodent populations.

It is obviously difficult to assess the representativeness of data collected during this survey. Although only the eastern margins of the Barotse floodplain were sampled, I am confident that the two localities of Litoya and Ndanda represent the landscapes along the eastern extent of the floodplain. I suspect that the insectivorous bats in the region roost in woodlands and forage and drink over the neighbouring floodplain and dambos. Further surveys are required, especially within the floodplain proper and in the northern part of Barotseland.

4.2.5 **Other observations**

The Lozi farmers living along the Ndanda and Litoya dambos confirmed the lack of small mammals. They said these are frequently hunted for food. Evidence of springhares was seen.

Little evidence of large mammals was seen. Droppings of reedbuck, *Redunca arundinum*, were noted in the Ndanda dambo approximately 8 km west of Ndanda School. We were told about the occurrence of lechwe along the Luena Flats and also further west along the Litoya dambo near the Zambezi, but this could not be confirmed.

4.3 ZAMBEZI DELTA SMALL MAMMAL SURVEY

4.3.1 **Introduction**

This report provides details of a collection of 15 species of small mammals from the Marromeu District of central Mozambique made between 24 July and 7 August 1999. The author was accompanied by Mr Alec Ndlovu of the Natural History Museum in Bulawayo. The mammal survey team constituted part of a larger multidisciplinary party.

Little information is available on the mammals of the Marromeu District. Pioneering studies of African mammals were initiated in the environs of the lower Zambezi by R.H. Peters in the mid-19th Century: many of the more conspicuous larger mammals, together with some bats and rodents, were described to science by him as a result. Examples include the porcupine (*Hystrix africaeaustralis*), Lichtenstein's hartebeest (*Sigmoceros lichtensteinii*) and the red squirrel

(*Paraxerus palliatus*). Little further in the way of scientific studies of terrestrial mammals occurring along the Lower Zambezi and its delta has occurred since.Surveys of small mammals were completed for some protected areas in Mozambique some years ago, but did not include Marromeu. The major authority remains the *Mammals of Moçambique* (Smithers & Tello 1976) which collated existing knowledge at that time. With the exception of some monitoring of large mammals (summarised in Cumming *et al*. 1994) in the Marromeu Buffalo Reserve and surrounding hunting areas (coutadas), no scientific collections of small mammals had previously been made in the environs of the Zambezi Delta and Marromeu floodplain.

4.3.2 **Methods**

Small mammals were collected in the Marromeu district of central Mozambique from two sites, supplemented by some work in the town of Marromeu itself. One site was in Coutada 11 on the western edge of the floodplain. The bulk of collecting was carried out within a 2 km radius of the base camp on the ecotone between floodplain, palm savanna and forest. The second site was near the administrative centre of Malingapansi in the southern section of the delta along the Rio Micelo (18º40'36"S / 36º06'17"E). This is situated in an agro-ecolandscape in which remnants of fringing riparian forest and palm savanna had persisted.

A collapsible harp trap and standard 4 tier mistnets (12 x 2 m) were used for bats. These were set near the ground, and also suspended higher in the canopy in attempts to intercept flying bats. Snap traps, baited with peanut butter and rolled oats, were set in microhabitats (near grass tussocks, holes, hollow trees, under fallen logs etc). A total of 45 snap traps were deployed. Modified Hickman traps (Hickman 1979) were used to capture mole rats.

Pitfall trap arrays were set in two sites to trap rodents and shrews, as well as amphibians, small reptiles and invertebrates. Each array consisted of 20 litre PVC plastic buckets set in the ground, and interconnected by barriers of plastic sheeting. Plastic sheets were held in place with steel pegs and the bottom edge of the plastic buried in the soil. Some invertebrates (insects, spiders and scorpions) were collected in the pitfalls and have been deposited in the Natural History Museum of Zimbabwe.

Nomenclature follows Wilson & Reeder (1993), except in the case of *Pipistrellus* which follows Hill & Harrison (1987).

4.3.3 **Results**

Specimens collected

Specimens of 15 species were collected from the Marromeu wetland and Zambezi Delta (Table 4.2). All represent significant new locality records in Mozambique. The special significance of two species of fruit bats are discussed below. Nevertheless, these results are disappointing given the sampling effort. A total of only five terrestrial mammals were collected from Coutada 11. This was despite a trapping effort over nine days of 45 snaptraps (405 trap nights). These snap traps only captured one four-toed elephant shrew (*Petrodomus tetradactylus*) and one rodent. Similarly, the use of two pitfall arrays over eight nights collected a total of one shrew and one rodent. Trapping success was even lower near Malingapansi, where the majority of rodents were collected by the local community. These results were disappointing considering the sampling effort in apparently mammal rich habitat.

Captures of bats were also disappointing despite a sampling effort of 40 net nights, with the harp trap operating for seven nights. The large collection of molossids (notably *Mops condylura*) was taken in Marromeu, where large colonies of *M. condylura* and *Chaerephon pumila* have colonized the roofs of houses. *M. condylura* typically roosts in hollow trees, as evident in five specimens collected by a member of the local community in Coutada 11 from their daylight roost in a large tree.

Table 4.2. Small mammal species collected in Marromeu District, Mozambique between 24 July and 7 August 1999.

Taxon	Marromeu	Coutada 11	Malingapansi
Order Insectivora (Shrews)			
Crocidura luna, Dollman, 1910 Grey-brown musk shrew		X	
Order Chiroptera (Bats)			
Eidolon helvum (Kerr, 1792) Straw-coloured fruit bat	X		
Epomophorus crypturus Peters, 1852 Peters' epauletted fruit bat		X	X
Epomophorus wahlbergi (Sundevall, 1846) Wahlberg's epauletted fruit bat		X	X
Lissonycteris angolensis goliath Bergmans, 1997 Harrison's fruit bat		X	
Pipistrellus somalicus (Thomas, 1901) Somali pipistrelle		X	
Pipistrellus nanus (Peters, 1852) Banana bat		X	
Mops condylura (A. Smith, 1833) Angolan free-tailed bat	X	X	
Chaerephon pumila (Cretzschmar, 1830) Little free-tailed bat	X		
Order Rodentia (Squirrels, Rats and Mice)			
Cryptomys darlingi (Thomas, 1895) Darling's mole rat		X	
Mastomys natalensis (A. Smith 1834) Natal Multimammate mouse			X
Mus minutoides A. Smith, 1833 Pygmy mouse		X	
Aethomys chrysophilus (de Winton, 1897) Red veld rat		X	X
Rattus rattus (Linnaeus, 1758) House rat			X
Order Macroscelidea (Elephant Shrews)			
Petrodomus tetradactylus Peters, 1846 Four-toed elephant shrew		X	

A brief pulse of activity occurred near the base camp in Coutada 11, but lasted approximately one hour. Very few bats were captured despite erection of nets into the canopy. The harp trap only captured one *Pipistrellus somalicus*. More success was obtained with fruit bats, especially in the vicinity of fruiting trees: both at Malingapansi and Coutada 11. Nevertheless, capture should have been much higher overall.

A series of four-toed elephant shrews (*Petrodomus tetradactylus*) were collected by the local community further inland (near the headquarters of Coutada 11). Local inhabitants also said that this elephant shrew occurred in the vicinity of Malingapansi, but none were seen. The preferred habitat of this species is the understorey of dry, evergreen forest. *P. tetradactylus* is widely distributed across coastal Mozambique, extending eastwards where suitable habitat is available.

Several colonies of molerats were encountered in Coutada 11. Sustained trapping over several days near the base camp yielded two specimens with two others being captured by members of the local community. Although provisionally identified as *Cryptomys darlingi*, these might represent a taxonomically distinct population, for which the name *bierai* is available. Molecular studies (including mitochondrial DNA and karyology) are necessary to resolve this possibility.

Visual records of mammals

Specimen-based records were supplemented by records for 14 species based on either direct sightings or identification of spoor or scats (Table 4.3). Spoor of some antelope species was recorded in Coutada 11. Visual records were also obtained for warthog (*Phacocheorus aethiopicus*), bushbuck (*Tragelaphus scriptus*), buffalo (*Syncerus caffer*), oribi (*Ourebia ourebi*) and reedbuck (*Redunca arundinum*). Spoor and scats were also seen of Lichtenstein's Hartebeest (*Sigmoceros lichtensteinii*), red duiker (*Cephalophus natalensis*) and water mongoose (*Atilax paludinosus*).

Troops of samango monkey (*Cercopithecus mitis erythrarchus*) were seen and heard in Coutada 11 near the base camp on the floodplain and near the main hunting camp. A troop of this species was also seen near the mouth of the Zambezi Delta in mangrove forests approximately 2 km inland from the Indian ocean (W.R. Branch, *pers. comm*.). Troops of vervet monkey (*Cercopithecus aethiops*) were seen approximately 3 km SE of Malingapansi in a patch of mixed palm forest, including mango trees.

The calls of thick-tailed bushbaby (*Otolemur crassicaudatus*) were heard near the base camp in Coutada 11. A smaller galago (presumed to be *Galagoides zanzibaricus*, Grant's nightape) was also observed in the vicinity. A red squirrel (*Paraxerus palliatus*) was observed in forest edge along the base camp in Coutada 11.

In addition, the safari operator in Coutada 11 reported the occurrence of elephant (*Loxodonta africana*), sable (*Hippotragus niger*), suni (*Neotragus moschatus*) and blue duiker (*Cephalophus monticola*) in the hunting area. Details of visual records of larger mammal species are maintained in a log book by hunters.

Table 4.3. Mammals for which visual records were obtained in Marromeu District, Mozambique between 24 July and 7 August 1999.

Taxon	Coutada 11	Delta area
Order Primata (Primates)		
Otolemur crassicaudatus (E. Geoffroy, 1812) Thick-tailed bushbaby	X	X
Galagoides zanzibaricus granti (Thomas & Wroughton, 1907) Grant's nightape	X	_
Cercopithecus mitis erythrarchus (Peters, 1852) Samango monkey	X	X
Cercopithecus aethiops (Linnaeus, 1758) Vervet monkey	_	X
Order Carnivora (Carnivores)		
Atilax paludinosus (G. Cuvier, 1829) Water mongoose	X	X
Panthera pardus (Linnaeus, 1758) Leopard	X	_
Order Tubulidentata (Antbears)		
Orycteropus afer (Pallas, 1766) Antbear	X	_
Order Ungulata (Antelopes, Pigs)		
Phacochoerus aethiopicus (Pallas, 1766) Warthog	X	_
Syncerus caffer (Sparrman, 1779) Buffalo	X	_
Redunca arundinum (Boddaert, 1785) Southern Reedbuck	X	_
Ourebia ourebi (Zimmermann, 1783) Oribi	X	_
Sigmoceros lichtensteini (Peters, 1849) Lichtenstein's hartebeest	X	_
Order Rodentia (Squirrels, Rats and Mice)		
Paraxerus palliatus (Peters, 1852) Red squirrel	X	_
Hystrix africaeaustralis (Peters, 1852) Porcupine	X	_

4.3.4 Significance of collected specimens

The mammal fauna of Mozambique is poorly known. The most up-to-date review remains Smithers & Tello (1976). Although, J. Tello, K. Tinley and colleagues collected small mammals from some protected areas in Mozambique through the 1960s into the early 1970s, these surveys concentrated on Gorongosa and Zinave National Parks. Few specimens, if any, were collected from the Zambezi

Delta and Marromeu. The nearest collecting activities to the delta were by R.H. Peters in the middle of the 19th century. In 1908, Austin Roberts (later the famous curator in Transvaal Museum) and F. Vaughan Kirby collected some mammals north west of Chinde and near Quelimane in 1908 (Brain 1998). These were mostly from the vicinity of Vila Pereira and Nhamacurra, some distance north of the Lower Zambezi.

The results of this expedition to Marromeu were disappointing. Far higher returns on mistnetting for bats and trapping for small terrestrial mammals were expected. This is probably because mammal activity had not re-commenced after the dry season with the rise in ambient temperatures. Nonetheless, some of the specimens obtained represent significant contributions to scientific knowledge of the species they represent. These are discussed in turn.

Harrison's Fruit Bat, *Lissonycteris angolensis goliath*

The single specimen of the fruit bat, *Lissonycteris angolensis goliath*, collected in Coutada 11 is an interesting record. This is a significant range extension from the Eastern Highlands in eastern Mozambique near the Zimbabwe border. The taxonomic distinctiveness of this population was only recently established (Bergmans 1997). The identity of this specimen is not in doubt as it has been compared with the holotype and paratypes in the Natural History Museum, Bulawayo. Few specimens are known of this recently-described fruit bat. This is the second known locality of the species from Mozambique, which has previously only been recorded from the vicinity of Chimoio. The only other known specimens have been collected in eastern Zimbabwe (Gleneagles, Nyanga and the Haroni-Rusitu forest). Although originally described as a subspecies, the allopatric distribution of this population suggests that full specific status is likely. *L. a. goliath* is significantly larger than fruits bats of the topotypical population restricted to west Africa. The specific status of *L. goliath* is conferred if an evolutionary species concept (recognising the phylogenetic distinctiveness of the allopatric population as an evolutionary lineage) is applied.

Straw-coloured Fruit Bat, *Eidolon helvum*

The permanent occurrence of *Eidolon helvum* in the town of Marromeu is of significant interest. The bats, estimated to number in their hundreds, roost in a large mango tree near the sugar refinery in eastern Marromeu close to the south bank of the Zambezi. The large, adult mammal collected was sexually active, and considerable fighting over roost space was observed. This strongly suggests that the colony was reproductively active. Small, permanent colonies of *Eidolon helvum* have been reported in Malawi (Ansell & Dowsett 1988). The Marromeu colony has been in residence at least since 1978 (B. Chande, pers. comm.). To the best of my knowledge, this is the only permanent colony of *Eidolon helvum* in southern Africa. Its conservation is of obvious importance. This large bat is migratory, and its range is centred on moist forests of west and central Africa. Individuals migrate widely from this region, and range across the subcontinent. It was previously believed that reproduction only occurred in equatorial regions, and only migratory individuals occurred in southern Africa (Smithers 1983).

Paucity of Small Mammals

The most likely explanation for the paucity of terrestrial mammals noted in this survey is the phenology of the environment. The floodplains may only provide suitable habitats for rodents once flooded grasslands have receded. This would occur later in the year (September through December) with populations continuing to increase through the wet season. In this case, populations would be localized and reduced by the end of the wet season.

Some evidence for this situation is illustrated in the characteristics of rodents captured near Malingapansi, notably multimammate mice (*Mastomys natalensis*). A large series of *M. natalensis* was collected by members of the local community in the environs of Malingapasi. This species is commensal with humans, and especially abundant in agroecolandscapes. Mice of the genus *Mastomys* are capable of high fecundity, and their rapid growth rates and early age of breeding account for population explosions. Many of these specimens captured in Malingapansi were juveniles and subadults, which suggest that a population explosion of *Mastomys* was underway in the area. In addition, 4 subadult specimens of the commensal house rat, *Rattus rattus* was collected in newly completed buildings in Malingapansi.

Based on experience in Zimbabwe and southern Zambia, most bats exhibit a seasonal decline in activity. Highest captures occur during the warmer months of the hot, wet season (September-April) when bats are reproductively active. During the cool, dry season (May-August) insectivorous bats tend to forage intermittently, and their metabolic demands are lower compared to when breeding.

4.3.5 Conclusions and suggestions

There remains considerable potential to improve scientific knowledge of the small mammals of the Marromeu wetland and Zambezi Delta, as for all the region's biodiversity. This will only accrue through further surveys. The most suitable season to survey small mammals in the Marromeu District is most likely in November, or possibly later during the summer months. Sampling through November into December will most likely provide the highest returns on sampling effort. Captures of rodents and shrews should also improve at this time.

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CHAPTER 5
WETLAND BIRDS OF THE ZAMBEZI BASIN

Peter Mundy

5.1. INTRODUCTION

A wetland bird (or waterbird), as defined here, is one that is ecologically dependent on water and/or marshy habitats, i.e. it is a wetland species that spends its life in and around these habitats for feeding (e.g. Osprey), breeding (e.g. Carmine Bee-eater), or both (e.g. Long-tailed Wagtail) (Latin names can be found in Table 5.1 - see page 217 - and Table 5.2 - see page 226). Unfortunately, there is some confusion among ornithologists as to the definition of a waterbird. The very recent publication by Underhill *et al*. (1999) uses the families from Pelecanidae to Laridae and defers to Rose & Scott (1997) for their definition. These latter authors use a "family" or "whole-taxa" approach, from Gaviidae to Rynchopidae (32 families), while admitting to the "minor anomalies" that this produces of omitting a "few wetland birds" such as kingfishers and raptors. Nevertheless, Rose & Scott (1997) repeat the Ramsar Convention definition of water*fowl* ("birds that are ecologically dependent upon wetlands"), but restrict it to the above-mentioned families. Meanwhile Maclean (1993: li-lii) adds wagtails to his grouping of "waterbirds", and the African Waterfowl Census (Dodman *et al*. 1997: 244-247) adds birds of prey, including owls, to the Rose and Scott list.

The accurate approach, of course, is to look at the individual species themselves, whatever family they may belong to. In this way, species from otherwise waterfowl families may not be waterbirds, e.g. Cattle Egret and White Stork which in the main are dry grassland species, and species from non-waterfowl families may be waterbirds, e.g. Fish Eagle and Swamp Boubou. Thus water*birds* include all water*fowl,* but not vice versa. This distinction seems clear and sensible to me, but has been blurred by the above authors.

Quite likely there will be some disagreement over any chosen list of the waterbirds of the Zambezi Basin because the list depends on how one 'weighs' or categorises the potential species. For example, some might want to include the Black-rumped Buttonquail and Grimwood's Longclaw (K. Hustler, pers. comm.), whereas I consider these as being not closely enough connected with water. I have therefore taken a 'strict' approach to a species when deciding whether or not to define it as a waterbird. My list now contains 178 species from 40 families, and is a revised version of that to be found in the Phase 1 Final Report (Timberlake 1998), which contained 167 species. From that earlier list I have deleted nine species which are mainly birds of dry grassland, and have added 20 others, for example the White-cheeked Bee-eater (which had previously been overlooked) and various warblers.

Clearly then, a waterbird as defined here is a *fresh*water bird. By definition, seabirds (or birds dependent on salt water) have been omitted. Again, a few species may be controversial. For example, the Lesser Black-backed Gull is included because it is sometimes found inland on freshwater, but the Sooty Tern is excluded because it is only (and rarely) found inland when blown there by cyclones in the Mozambique channel (Couto & Jana 1999). In principle, of course, seabirds are excluded because the Zambezi Basin is a freshwater habitat.

A 'strict' approach has also been taken to the boundaries of the Zambezi Basin, using the current watershed delimitations (Matiza *et al.* 1995: 2). Thus the Okavango and Bangweulu Swamps are omitted.

This chapter deals with certain aspects of the wetland birds (178 species) of the Zambezi Basin. It should be noted in passing, however, that to date 570 bird species have been identified in the four main wetlands, and the basin as a whole probably supports about 800 species (K. Hustler, pers. comm.). Many of these are forest and woodland birds, some are aerials, etc. Several species are, or should be, the subject of taxonomic investigation. But such aspects are not considered where they concern non-waterbirds. Following a review of the rather limited previous work on the waterbirds of the Zambezi Basin and a brief look at certain aspects of zoogeography, detailed checklists of wetland birds and their distribution are presented. There follows a consideration of species and areas of conservation interest; a broader remit of grassland birds in general is included because of south-central Africa's significance in this regard. Finally, several conclusions are suggested. The chapter finishes by highlighting the conservation status of species that are of particular interest.

For the sake of completeness, it should be mentioned that waterbirds in the Zambezi Basin will of course use other wet habitats in addition to the large wetlands of particular interest to this project. For example: (a) Zimbabwe, and to a lesser extent Malawi and Zambia, hold many (indeed thousands, ALCOM/FAO database) artificial dams of one hectare or more in extent, including lakes Kariba (Donnelly & Donnely 1983) and Cabora Bassa; (b) there are countless dambos or vleis within the basin which, at least in Zambia and Zimbabwe (e.g. Whitlow 1985), add up to a considerable extent of wetland, unfortunately much threatened by damming and agriculture; (c) there are also many temporary pans, usually lasting for less than a year, which are havens for breeding waterbirds such as ducks (Godfrey 1992); and (d) there are many rivers and streams flowing into the Zambezi itself, the riverine fringes of which are particularly important to species such as African Finfoot and Half-collared Kingfisher.

5.2. REVIEW OF PREVIOUS WORK

An older generation of ornithologists has mapped most of the species of sub-Saharan Africa in terms of specimens collected (Hall & Moreau 1970, Snow 1978), and these near-continental maps include the Zambezi Basin. However, for the passerines (Order Passeriformes, with waterbirds in six families – small perching-and-singing birds) only "resident" species were mapped, all palaearctic migrants being excluded (Hall & Moreau 1970). In addition, the maps were compiled from "specimens and from literature" and from a "few well-authenticated sight-records". For the non-passerines (many orders, with waterbirds in 33 families – generally larger birds) mapping was restricted to those species "known to breed" (Snow 1978). Several "purely or predominantly" marine families were excluded, resulting in species such as Crab Plover and African Skimmer being omitted, as were all palaearctic migrants. However, for the non-passerines, "sight records [were] freely admitted for large and conspicuous species". Thus these atlases excluded 47 species of waterbirds that are included on the list for the Zambezi Basin (Table 5.1, page 217). Finally, at the map scale used of 1:36 million each symbol covers about one-half of a degree square; a resolution which today is generally considered to be too coarse.

Nevertheless, these two atlases were pioneering achievements and remain essential to biodiversity assessments. They heralded the modern passion for atlases of countries (e.g. Penry 1994) or regions (Harrison *et al.* 1997 is unique in this regard). The first such atlas of the new genre was for Natal

in South Africa (Cyrus & Robson 1980). Such atlases, it must be emphasised, almost entirely use sight and call records due to the greatly improved identification skills of bird watchers over the last two decades, brought about both by field guides (for example, in our region, Aspinwall & Beel 1998, Newman 1996, Newman *et al.* 1992 and Sinclair *et al.* 1997) and by audio tapes of calls. Various of these atlases also indicate months of occurrence, breeding, and an index of abundance. But to this day none uses all the field data collected that could be presented, i.e. distribution, seasonality (dates), breeding, abundance (actual numbers), and age structure where possible.

In January 1991 the African Waterfowl Census (AWC) was launched and several countries participated. The aims were to count waterfowl (not all waterbirds!) at wetlands annually in January and July. By 1997, counts were being made in 28 countries on the African mainland (Dodman *et al.* 1997); included were all the countries in the Zambezi Basin except for Angola. Families of birds from grebes to the African Skimmer, including birds of prey and the Marsh Owl, were counted. Thus the AWC list excluded no less than 44 species which are considered to be waterbirds in the Zambezi Basin. It should be clear that the main problems with the AWC are the extreme difficulty of having observers at all important wetlands, and of the observers counting all the birds (even just the conspicuous ones) at any one large wetland. Nevertheless it is a start, and three of the aims are: (a) to provide a monitoring scheme, (b) to describe distributions, and (c) to learn of seasonal changes in distribution and numbers. Parts of the Kafue Flats consistently produce large numbers of waterbirds. Incidentally, one should note in passing that an earlier scheme in South Africa – the African Waterfowl Enquiry (Anon. 1954, 1972) – fell away years before the AWC was started. Some information from the AWC was used in a duck atlas (Scott & Rose 1996) and will be used in a forthcoming wader atlas.

Perhaps as part of the original Enquiry, there was a great deal of waterfowl ringing done in southern Africa, but most of it was "decades ago" (Underhill *et al.* 1999). For example, this recent review notes that 13,189 Sacred Ibis had been ringed, of which 96% were ringed by 1973 – several of the ringed birds were recovered (i.e. found dead) in the Zambezi Basin. Ringing of waterbirds, such as waders (plovers and sandpipers), terns and warblers, still continues, albeit at a low ebb.

Ornithologists in South Africa also made many studies on waterfowl, particularly ducks. There has been much less interest further north, though studies in Zambia by Douthwaite (1977, 1978), in Zimbabwe by Jarvis (1984), Hustler (1996, 1997) and Hustler & Marshall (1996), and in areas to the south by Borello *et al.*(1998), Stowe & Becker (1992) and Tree (1979), are examples. There is in fact tremendous scope for biological studies on the waterbirds of the Zambezi Basin, and not just in terms of distribution and numbers, but in the equally intriguing aspects of food, micro-habitat preferences and sympatry. Detailed surveys along most of the Zambezi have been done for the Rock Pratincole (Williams *et al*. 1989) and African Skimmer (Coppinger *et al*. 1988) and within Zimbabwe for the Carmine Bee-eater (Mundy *et al*. 1994), and on certain wetlands for the Wattled Crane (e.g. Howard & Aspinwall 1984). These surveys also considered the impacts of various threats on the species.

5.3. ASPECTS OF ZOOGEOGRAPHY

Information on waterbirds in the Zambezi Basin must still be regarded as incomplete due to the difficulty of fully exploring the extensive wetlands. This caveat also applies historically – some species which are being increasingly recorded, such as the European Marsh Harrier and Black-tailed Godwit (K. Hustler, pers. comm.), may genuinely be increasing or may not have been noticed in the

past. In addition, the Chobe-Linyanti and Lower Shire areas are well investigated, and certainly better known than the Barotse floodplain and Zambezi Delta. Whereas many of the larger non-passerine waterbirds can be confidently seen from the air (e.g. Beilfuss & Allan 1996 for the Zambezi Delta), and even have their populations estimated in the manner of large mammals (e.g. Wattled Crane), this is impossible for the smaller birds. There is much to be learned of the distributions of all the waterbirds across all the wetlands of the Zambezi Basin, and this must especially apply to Angola which contains 18% of the basin.

Of perhaps greater interest are the occurrence of 'isolated' populations of particular species, restricted to certain areas or wetlands. All these need taxonomic investigation as to their specific or subspecific status. The Ethiopian Snipe, for example, which is widely distributed, has a longer bill (by one-third) than its counterpart further south, and the Red-shouldered Widow, also widespread in the basin, may be specifically distinct from the southern type (K. Hustler, pers. comm.). It seems possible too that the Black-backed Cisticola of the Barotse floodplain is a separate species.

Particularly striking instances are provided by two other cisticola warblers. The Cloud Cisticola is a bird usually of grasslands in South Africa, but has an isolated population in the plains (floodplain?) grassland of the Upper Zambezi and over the watershed in Angola (Hall & Moreau 1970). The Levaillant's or Lesser Black-backed Cisticola also has an isolated population in Barotseland as well as elsewhere in the basin such as on the Zimbabwe highveld. Its taxonomic status is under investigation (K. Hustler, pers. comm). Indeed the cisticolas or grass warblers as a group surely offer a most interesting perspective on bird evolution, especially in view of their apparent morphological uniformity. All but one of the 40 species live in Africa (Garcia 1985). The group was last examined nearly a century ago (Lymes 1930) and is therefore ready for a modern treatment. Not known to be migrants, or even nomads, these little brown birds have evolved into habitat specialists with a wide range of calls and displays.

That a few species of waterbird (e.g. Slaty Egret, Maccoa Duck) are quite restricted in their wetlands of choice comes as something of a surprise in view of birds' obvious mobility due to flight. Most waterbirds, as expected, are widely distributed, being able to move from one wetland to another with ease; flamingos and Wattled Cranes are conspicuous examples. Most waterbird species also undertake movements of some sort (see Underhill *et al.* 1999) and these must be related to the state of the habitat and depth of water. After rain in the catchment and flooding, shoreline habitat disappears and waders (plovers and sandpipers) must move. Conversely, other species arrive into the flooded grassland, especially secretive ones such as bitterns, rails and flufftails. The palaearctic migrants that occur in the basin during the austral summer presumably have the widest tolerances, because they are not breeding and can therefore move whenever necessary. The Corncrake is one such example (Stowe & Becker 1992). The selective factor at work on all waterbird species, then, is one of being able to move and search – perhaps over long distances – in the wake of habitat loss due to drying-out or flooding.

5.4 DETAILED CHECKLISTS

A revised list of the waterbirds of the Zambezi Basin is presented in Table 5.1. There are 178 species in 40 families, with a few having many species: Ardeidae (17 species), Anatidae (18), Rallidae (15), Charadriidae (13), Scolopacidae (21, all but one being palaearctic migrants) and Sylviidae (12). These are the waterbird families *par excellence*.

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Table 5.1 Checklist of wetland bird species recorded in wetlands of the Zambezi Basin: Barotse floodplains (Bar), Chobe-Linyanti swamps (Cho), Lower Shire marshes (LSh), Zambezi Delta (ZD), and in any other areas (Other). Family names are indicated in heavy type.

* = threatened species, either globally or regionally

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
Podicipedidae						
Dabchick (Little Grebe)	*Tachybaptus ruficollis*	X	X	X	X	X
Great Crested Grebe	*Podiceps cristatus*					X
Pelecanidae						
White Pelican	*Pelecanus onocrotalus*	X	X	X	X	X
Pink-backed (Grey) Pelican	*Pelecanus rufescens*	X	X	X	X	X
Phalacrocoracidae						
Reed (Long-tailed) Cormorant	*Phalacrocorax africanus*	X	X	X	X	X
White-breasted Cormorant	*Phalacrocorax carbo*	X	X	X	X	X
Anhingidae						
African Darter	*Anhinga melanogaster*	X	X	X	X	X
Ardeidae						
Grey Heron	*Ardea cinerea*	X	X	X	X	X
Goliath Heron	*Ardea goliath*	X	X	X	X	X
Purple Heron	*Ardea purpurea*	X	X	X	X	X
Great White Heron (Egret)	*Egretta alba*	X	X	X	X	X
Little Egret	*Egretta garzetta*	X	X	X	X	X
Yellow-billed Egret	*Egretta intermedia*	X	X	X	X	X
Black Egret	*Egretta ardesiaca*	X	X	X	X	X
Slaty Egret *	*Egretta vinaceigula*	X	X			X
Squacco Heron	*Ardeola ralloides*	X	X	X	X	X
Madagascar Squacco (Pond) Heron *	*Ardeola idae*			X		X
Rufous-bellied Heron	*Butorides rufiventris*	X	X	X	X	X
Green-backed Heron	*Butorides striatus*	X	X	X	X	X
Black-crowned Night Heron	*Nycticorax nycticorax*	X	X	X	X	X
White-backed Night Heron	*Gorsachius leuconotus*	X	X	X		X
Little Bittern	*Ixobrychus minutus*	X	X	X	X	X
Dwarf Bittern (Rail Heron)	*Ixobrychus sturmii*	X	X	X	X	X
Bittern	*Botaurus stellaris*	X				X
Scopidae						
Hamerkop	*Scopus umbretta*	X	X	X	X	X
Balaenicipitidae						
Shoebill Stork *	*Balaeniceps rex*					X

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
Ciconiidae						
Black Stork	*Ciconia nigra*		X	X	X	X
Woolly-necked Stork	*Ciconia episcopus*	X	X	X	X	X
Open-billed Stork	*Anastomus lamelligerus*	X	X	X	X	X
Saddle-billed Stork	*Ephippiorhynchus senegalensis*	X	X	X	X	X
Marabou Stork	*Leptoptilos crumeniferus*	X	X	X	X	X
Yellow-billed Stork (Wood Ibis)	*Mycteria ibis*	X	X	X	X	X
Plataleidae						
Sacred Ibis	*Threskiornis aethiopicus*	X	X	X	X	X
Glossy Ibis	*Plegadis falcinellus*	X	X	X	X	X
Hadeda Ibis	*Bostrychia hagedash*	X	X	X	X	X
African Spoonbill	*Platalea alba*	X	X	X	X	X
Phoenicopteridae						
Greater Flamingo	*Phoenicopterus ruber*	X	X	X	X	X
Lesser Flamingo *	*Phoenicopterus minor*	X		X	X	X
Anatidae						
White-faced Duck	*Dendrocygna viduata*	X	X	X	X	X
Fulvous Duck	*Dendrocygna bicolor*	X	X	X	X	X
White-backed Duck	*Thalassornis leuconotus*					X
Egyptian Goose	*Alopochen aegyptiacus*	X	X	X	X	X
Yellow-billed Duck	*Anas undulata*	X	X	X		X
African Black Duck	*Anas sparsa*			X		X
Cape Teal	*Anas capensis*	X	X			X
Hottentot Teal	*Anas hottentota*	X	X	X	X	X
Red-billed Teal	*Anas erythrorhyncha*	X	X	X	X	X
Pintail	*Anas acuta* (PM)		X		X	
Garganey	*Anas querquedula* (PM)			X	X	
European Shoveller	*Anas clypeata* (PM)					X
Cape Shoveller	*Anas smithii*		X		X	X
Southern Pochard	*Netta erythrophthalma*	X	X	X	X	X
Pygmy Goose	*Nettapus auritus*	X	X	X	X	X
Knob-billed Duck	*Sarkidiornis melanotos*	X	X	X	X	X
Spur-winged Goose	*Plectropterus gambensis*	X	X	X	X	X
Maccoa Duck	*Oxyura maccoa*		X			X
Accipitridae						
African Fish Eagle	*Haliaeetus vocifer*	X	X	X	X	X
European Marsh Harrier	*Circus aeruginosus* (PM)			X		X
African Marsh Harrier	*Circus ranivorus*	X	X	X	X	X

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
Pandionidae						
Osprey	*Pandion haliaetus* (PM)	X	X	X		X
Phasianidae						
Harlequin Quail	*Coturnix delegorguei*	X	X	X	X	X
Blue Quail	*Coturnix adansonii*			X	X	X
Gruidae						
Wattled Crane *	*Bugeranus carunculatus*	X	X		X	X
Grey Crowned Crane	*Balearica regulorum*	X	X		X	X
Rallidae						
African Water Rail	*Rallus caerulescens*	X	X	X	X	X
Corncrake *	*Crex crex* (PM)					X
African Crake	*Crex egregia*	X	X	X		X
Black Crake	*Amaurornis flavirostris*	X	X	X	X	X
Spotted Crake	*Porzana porzana* (PM)		X			X
Baillon's Crake	*Porzana pusilla*					X
Striped Crake	*Aenigmatolimnas marginalis*					X
Red-chested Flufftail	*Sarothrura rufa*	X	X		X	X
Streaky-breasted Flufftail	*Sarothrura boehmi*					X
White-winged Flufftail *	*Sarothrura ayresi*					X
Purple Gallinule (Swamp Hen)	*Porphyrio porphyrio*	X	X	X	X	X
Lesser Gallinule	*Porphyrula alleni*	X	X	X	X	X
Moorhen	*Gallinula chloropus*	X	X	X		X
Lesser Moorhen	*Gallinula angulata*	X	X	X	X	X
Red-knobbed Coot	*Fulica cristata*	X	X	X		X
Heliornithidae						
African Finfoot	*Podica senegalensis*		X	X		X
Jacanidae						
African Jacana (Lily-trotter)	*Actophilornis africanus*	X	X	X	X	X
Lesser Jacana	*Microparra capensis*	X	X	X	X	X
Rostratulidae						
Painted Snipe	*Rostratula benghalensis*	X	X	X		X
Haematopodidae						
European Oystercatcher	*Haematopus ostralegus* (PM)				X	
Charadriidae						
Ringed Plover	*Charadrius hiaticula* (PM)	X	X	X	X	X
White-fronted Plover	*Charadrius marginatus*	X	X	X	X	X
Chestnut-banded Plover	*Charadrius pallidus*		X			X
Kittlitz's Sandplover	*Charadrius pecuarius*	X	X	X	X	X

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
Three-banded Plover	*Charadrius tricollaris*	X	X	X	X	X
Mongolian Plover (Lesser Sandplover)	*Charadrius mongolus* (PM)					X
Sand Plover (Greater Sandplover)	*Charadrius leschenaultii* (PM)					X
Caspian Plover	*Charadrius asiaticus* (PM)	X	X	X		X
Grey Plover	*Pluvialis squatarola* (PM)	X	X	X	X	X
Blacksmith Plover	*Vanellus armatus*	X	X	X	X	X
White-crowned Plover	*Vanellus albiceps*	X	X	X	X	X
Senegal Wattled Plover	*Vanellus senegallus*	X	X	X	X	X
Long-toed (White-winged) Plover	*Vanellus crassirostris*	X	X	X	X	X
Scolopacidae						
Ruddy Turnstone	*Arenaria interpres* (PM)	X				X
Terek Sandpiper	*Xenus cinereus* (PM)	X		X		X
Common Sandpiper	*Tringa hypoleucos* (PM)	X	X	X	X	X
Green Sandpiper	*Tringa ochropus* (PM)	X		X	X	X
Wood Sandpiper	*Tringa glareola* (PM)	X	X	X	X	X
Spotted Redshank	*Tringa erythropus* (PM)			X		
Redshank	*Tringa totanus* (PM)			X		
Marsh Sandpiper	*Tringa stagnatilis* (PM)	X	X	X	X	X
Greenshank	*Tringa nebularia* (PM)	X	X	X	X	X
Knot	*Calidris canutus* (PM)					X
Curlew Sandpiper	*Calidris ferruginea* (PM)	X	X	X	X	X
Little Stint	*Calidris minuta* (PM)	X	X	X	X	X
Sanderling	*Calidris alba* (PM)	X		X	X	X
Ruff/Reeve	*Philomachus pugnax* (PM)	X	X	X	X	X
Great Snipe *	*Gallinago media* (PM)	X		X		X
Ethiopian Snipe	*Gallinago nigripennis*	X	X	X	X	X
Black-tailed Godwit	*Limosa limosa* (PM)					X
Bar-tailed Godwit	*Limosa lapponica* (PM)			X		X
Curlew	*Numenius arquata* (PM)	X				X
Whimbrel	*Numenius phaeopus* (PM)			X	X	
Grey Phalarope	*Phalaropus fulicarius* (PM)					X
Recurvirostridae						
Avocet	*Recurvirostra avosetta*	X	X	X		X
Black-winged Stilt	*Himantopus himantopus*	X	X	X	X	X
Dromadidae						
Crab Plover	*Dromas ardeola* (PM)				X	
Burhinidae						
Water Dikkop	*Burhinus vermiculatus*	X	X	X	X	X

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
Glareolidae						
Red-winged Pratincole	*Glareola pratincola*	X	X	X	X	X
Rock (White-collared) Pratincole *	*Glareola nuchalis*		X			X
Laridae						
Lesser Black-backed Gull	*Larus fuscus* (PM)	X		X		X
Grey-headed Gull	*Larus cirrocephalus*	X	X	X	X	X
Gull-billed Tern	*Gelochelidon nilotica* (PM)					X
Caspian Tern	*Hydroprogne caspia*	X	X		X	X
Lesser Crested Tern	*Sterna bengalensis* (PM)				X	
Whiskered Tern	*Chlidonias hybridus*	X	X	X	X	X
White-winged Tern	*Chlidonias leucopterus* (PM)	X	X	X	X	X
Rynchopidae						
African Skimmer *	*Rynchops flavirostris*	X	X	X	X	X
Cuculidae						
Black Coucal	*Centropus bengalensis/grillii*	X	X	X		X
Coppery-tailed Coucal	*Centropus cupreicaudus*	X	X			X
White-browed Coucal	*Centropus superciliosus*	X	X	X	X	X
Tytonidae						
Grass Owl	*Tyto capensis*				X	X
Strigidae						
Marsh Owl	*Asio capensis*	X	X	X	X	X
Pel's Fishing Owl	*Scotopelia peli*		X	X		X
Caprimulgidae						
Natal (Swamp) Nightjar	*Caprimulgus natalensis*	X	X			X
Alcedinidae						
Pied Kingfisher	*Ceryle rudis*	X	X	X	X	X
Giant Kingfisher	*Ceryle maxima*	X	X	X	X	X
Half-collared Kingfisher	*Alcedo semitorquata*		X		X	X
Malachite Kingfisher	*Alcedo cristata*	X	X	X	X	X
Mangrove Kingfisher	*Halcyon senegaloides*				X	
Meropidae						
Olive Bee-eater	*Merops superciliosus*		X	X		X
Blue-cheeked Bee-eater	*Merops persicus* (PM)	X	X	X	X	X
Southern Carmine Bee-eater *	*Merops nubicoides*	X	X	X	X	X
White-fronted Bee-eater	*Merops bullockoides*	X	X	X	X	X
White-cheeked Bee-eater	*Merops variegatus*	X				X
Hirundinidae						
Wire-tailed Swallow	*Hirundo smithii*	X	X	X	X	X

Family/Common names	Scientific name	Bar	Cho	LSh	ZD	Other
European Sand Martin	*Riparia riparia* (PM)	X	X	X		X
African (Brown-throated) Sand Martin	*Riparia paludicola*	X	X	X	X	X
Banded Martin	*Riparia cincta*	X	X	X		X
Sylviidae						
Basra Reed Warbler	*Acrocephalus griseldis* (PM)			X	X	
European Reed Warbler	*Acrocephalus scirpaceus* (PM)	X		X		
Sedge Warbler	*Acrocephalus schoenobaenus* (PM)	X	X	X	X	X
Cape Reed (Lesser Swamp) Warbler	*Acrocephalus gracilirostris*	X	X	X	X	X
Greater Swamp Warbler	*Acrocephalus rufescens*	X	X			X
African Sedge (Little Rush) Warbler	*Bradypterus baboecala*	X	X	X	X	X
Moustached Warbler	*Melocichla mentalis*			X	X	X
Pale-crowned Cisticola	*Cisticola brunnescens*	X				X
Red-faced Cisticola	*Cisticola erythrops*	X	X	X	X	X
Black-backed Cisticola	*Cisticola galactotes*	X	X	X	X	X
Chirping Cisticola	*Cisticola pipiens*	X	X			X
Levaillant's Cisticola	*Cisticola tinniens*	X				X
Motacillidae						
African Pied Wagtail	*Motacilla aguimp*	X	X	X	X	X
Long-tailed Wagtail	*Motacilla clara*	X		X		X
Pink-throated Longclaw	*Macronyx ameliae*	X	X			X
Malaconotidae						
Swamp Boubou	*Laniarius bicolor*	X	X			
Marsh Tchagra	*Tchagra minuta*			X	X	X
Ploceidae						
Yellow Weaver	*Ploceus subaureus*			X	X	X
Brown-throated Weaver	*Ploceus xanthopterus*	X	X	X	X	X
Red-headed Quelea	*Quelea erythrops*			X	X	X
Red Bishop	*Euplectes orix*	X	X	X	X	X
Golden Bishop	*Euplectes afer*	X	X			X
Red-shouldered Widow	*Euplectes axillaris*	X	X	X	X	X
Estrildidae						
Common Waxbill	*Estrilda astrild*	X	X	X	X	X
Orange-breasted Waxbill	*Sporaeginthus subflavus*	X		X	X	X
Totals	178 species	133	129	132	118	166

N.B. Water*fowl* are generally considered to be all those families up to and including the African Skimmer, whereas water*birds* include any that are ecologically dependent on water.
(PM)= Palaearctic Migrant; i.e. a species that breeds (in the northern summer) in Europe, Russia and Asia, but spends the northern winter in Africa as a non-breeding migrant. There are 43 in this list.

In a list of this nature, no distinction has been made between common and rare species, or between residents and intra-African migrants. Each is simply recorded as present, whether from only one sighting or from many. It should be emphasised that the lists are almost entirely made up of *sightings* of birds rather than specimens. Birds can be easily identified both by sight and call by an experienced observer, and usually there is no need to take specimens. A list like this in fact unduly emphasises the *vagrant* species, because bird watchers can be relied upon to document the unusual rather than the commonplace. A vagrant can be defined as a species that is totally unexpected in an area – such as the Sooty Tern. By contrast, the Lesser Black-backed Gull, which can be expected, is in fact *rare*. It should be obvious that there is a big difference between rarity and vagrancy.

The list of waterbirds in Table 5.1 shows their distribution among the four IUCN wetland sites, and a fifth column indicates occurrence in any other wetland in the Zambezi Basin. It will be seen that there is a surprisingly similar number of species recorded (so far) in the four main wetlands: moving downstream these are 133, 129, 132 and 118 species, respectively. For the first three the checklists are at about 80% of the total waterbird total for the basin (one presumes that the list for the Zambezi Delta is likely to improve), but the lists do differ in their specific composition. It can certainly be said that the Lower Shire hosts nothing of importance (including threatened species) that cannot also be found in one or other of these wetlands. It should also be said that while the palaeartic migrants show differences in species distributions across the basin, none of these can be viewed as significant. A few are marine (e.g. Crab Plover) and therefore are expected to occur only in the Zambezi Delta, some are secretive (e.g. Bittern) and their supposed absence from an area may not be real, and many are simply nomadic on their wintering grounds in Africa and could simply turn up anywhere given enough time. The important differences should be looked for among the residents. Thus several species show a 'patchy' distribution, for example Slaty Egret, Rock Pratincole, Coppery-tailed Coucal, Mangrove Kingfisher, a few cisticola warblers, Swamp Boubou and Marsh Tchagra.

In terms of families, five species of ducks are also patchily distributed – for them, no one of the selected study sites hosts them all, although they are probably all found on the Kafue Flats. No general pattern among the waterbirds can be perceived; each of the major wetlands supports a slightly different species composition. Nevertheless, the Barotse floodplain, the Chobe-Linyanti swamps and the Zambezi Delta are all important in their own right both for biodiversity and for threatened species, such that all warrant protection (and further exploration).

5.4.1 **Barotse Floodplains**

The list was compiled by Peter Leonard with an additional few species by Kit Hustler from his visit in November 1998 (Appendix 5.1) and others from the visit in March and August 1999 by Paul Van Daele and Bob Stjernstedt (Appendix 5.2). It is based on the Zambian Bird Atlas project (R.J. Dowsett & D.R. Aspinwall, in prep.), which uses half-degree-squares of 30' by 30' in size. Greater resolution is not possible at this stage (see also Aspinwall & Beel 1998). Such an HDS measures c. 53 km x 56 km, an area of nearly 3000 km^2. According to Leonard, the Barotse floodplains and Luena Flats are contained within the six HDS (1422D, 1423C, 1522B, 1523A, 1523C, 1623A). Hustler also visited a seventh HDS (1423D), which is correct according to Aspinwall & Beel (1998).

A total of 133 species of wetland birds has been recorded so far. Of these, the Slaty Egret, Lesser Flamingo, Wattled Crane and Great Snipe are in a threatened category (Collar *et al.* 1994).

5.4.2 **Chobe-Linyanti Swamps**

The list was compiled by Wendy Borello, who used Borello & Borello (1997), Harrison *et al.* (1997) and Penry (1994) as her sources. In addition, other species have been added from Koen (1988) and Branfield (1990). The swamps and floodplains are along the border areas of the Caprivi Strip, between Botswana and Namibia. The Kwando/Linyanti/Chobe swamps, from 18°S: 23°15'E through to the Ngoma bridge at 17°55'S: 24°45'E, occur in twelve quarter-degree squares (QDS) (1823A2, A4, B2, B3, B4, C4; 1724C4 [Lake Liambezi], D3; 1824A1, A2, A3, B1). In this region a QDS measures c. 27 x 27 km, an area of 740 km^2. On the Namibian side bird distribution was mapped according to QDS, but in Botswana HDS were used, both by the southern African atlas (Harrison *et al.* 1997) and by Penry (1994).

A total of 129 species has so far been recorded for this area. Of these, only the Slaty Egret and Wattled Crane are in a threatened category.

5.4.3 **Lower Shire Marshes**

The list was compiled by Dale Hanmer. These marshes – Elephant, Bangula and Ndinde – run south along the Shire River from Chikwawa at about 16°S: 34°45'E, for 135 km to the Mozambique border. They occupy part of seven QDS (1634B2, B4; 1635A3, C1, C2, C4; 1735A2).

A total of 132 species are wetland-dependent. Of these, the Madagascar Squacco Heron, Lesser Flamingo, Great Snipe and Basra Reed Warbler are in a threatened category.

5.4.4 **Zambezi Delta**

The list was compiled using Beilfuss & Allan (1996), Clancey (1996), Hall & Moreau (1970), Hanmer (1976), Singini (1996) and Snow (1978). The basic list was taken from Hanmer (1976), who lived upstream from the delta proper at Mopeia on the Cuacua distributary. In addition to these authors, Carlos Bento added 12 species from observations on waterbirds in the period 1995-1999, Appendix 5.3), and Bill Branch added seven more from his visit in July-August 1999. Altogether the checklist now comprises 358 species. It is presumed that the delta offers exciting possibilities for further discoveries.

No precise localities exist for the birds on the list, certainly not within a specified QDS. But accurate atlas work is beginning in this region by Vincent Parker working on the second stage of his Mozambique bird atlas which will cover the area between the Save and Zambezi Rivers, and by Carlos Bento beginning a study of Wattled Cranes in the delta itself. All recorded species are from the 'mainland', but presumably there are seabirds that fly and even fish close to and perhaps within the delta, for example the Sooty Tern. As yet there are no records for these species, save general maps such as in field guides; Newman (1996), for example, indicates that at least 11 species occur offshore from the delta. The costal parts of the delta no doubt have brackish water in varying degrees, which presumably encourage seabirds to forage inland from time to time.

A total of 118 species are wetland-dependent (and more are expected). Of these, Lesser Flamingo, Wattled Crane and Basra Reed Warbler are in a threatened category.

There is a huge area of papyrus in the northern part of the delta, and this habitat raises the possibility of the Shoebill or Whale-headed Stork occurring there. The species is known to "occasionally wander further south" from Bangweulu (Aspinwall & Beel 1998), and therefore into the Zambezi Basin, and there is "one confirmed record for the Nyika Plateau" (Newman *et al.* 1992).

5.4.5 **Museum collections**

The collection at the Natural History Museum (Bulawayo) was examined by Audrey Msimanga and Boneface Magwizi for specimens of water-dependent species. A list of 429 specimens of 82 species was prepared, of which 221 specimens of 61 species are from the Zambezi Basin *sensu stricto*. Other specimens may be found from the four specific wetlands in the Gaborone, Livingstone and Maputo museums, and perhaps even further afield in the British Museum.

5.5 CONSERVATION STATUS

South-central Africa has large areas of grassland and much of this is on "seasonally waterlogged soils" (White 1983) forming the dambos, floodplains and Kalahari pans that we call the wetlands of the Zambezi Basin. By virtue of flight, grassland or wetland birds may have many areas that they can visit and therefore there are few serious constraints on their distributions within the basin. This biome of grassland (i.e. no trees or bushes), which becomes wetland when waterlogged, comprises grass and sedge species, including reeds, bulrushes, and even papyrus in places. It is likely that birds adapt mostly to the physiognomic features of a habitat, i.e. short or long grass, dry or wet, rather than to the vegetation composition as such. This probably applies very much to the palaearctic migrants, which are spending their (northern) winter in sub-Saharan Africa, in their non-breeding season. Birds such as the Corncrake and Great Snipe, for example, could arrive anywhere in suitable wet habitat. As it is the austral summer and rainy season, marshy habitats are very widespread.

5.5.1 **Species of conservation concern**

In the moist southern savannas of Africa the grassland biome is said to be the "richest grassland avifauna" in the world (M.P.S. Irwin, pers. comm.). Table 5.2 (overleaf) lists 95 species of birds of both dry and wet grasslands, of which the larks (six species), warblers (19 species, with 11 cisticolas or grass-warblers), motacillids (ten species) and weavers (14 species, with eight being bishops and widows) comprise one-half. Eight species are regional (i.e. south-central African) endemics, and all occur in the Upper Zambezi zone (see Timberlake 1998: 9-15). Nearly all these "grassland" species are in that zone (90), with lesser numbers being found in the Middle Zambezi (71) and even less in the Lower Zambezi (60). The grasslands and wetlands of the upper zone, upstream of the Victoria Falls but mostly from the source of the Zambezi to the Barotse floodplains, therefore host a considerable – and significant – avian biodiversity. When distinct populations of widespread species are also included, such as the Black-backed Cisticola (K. Hustler, pers. comm.), the Cape Wagtail (Hustler 1993) and the Long-tailed Widow (Craig 1993), then clearly the significance is increased.

There are eight globally threatened waterbird species which occur in the Zambezi Basin, and three regionally threatened species (Table 5.3 - see page 229). All such species deserve attention, but as argued above, the two palaearctic migrants (Corncrake and Great Snipe) cannot claim any serious concern due to the problem of not knowing where they might be from day to day. The Corncrake, at least, is threatened by mechanized agriculture in Europe (Crockford *et al*. 1996) rather than anything in the Zambezi Basin. In addition, the Lesser Flamingo has its residency outside the basin and only moves through it to and from Mozambique, and perhaps to East Africa (Borello *et al*. 1998), while the Madagascar Squacco Heron is an intra-African migrant that is said not to breed on the mainland. The White-winged Flufftail, the only globally Endangered species in the list, is a presumed vagrant to the basin (to the best of our knowledge so far) from its stronghold in South Africa, so little if anything can as yet be done for this species.

Table 5.2 Grassland (including wet grassland) bird species of south-central Africa.

* = south-central Africa endemic; PM = palaearctic migrant
† = species occurring as isolated populations

Common Name	Scientific Name	Upper/Middle/ Lower Zambezi		
Red-wing Francolin	*Francolinus levaillantii*	UZ		
White-throated Francolin †	*Francolinus albogularis*	UZ		
Common Quail	*Coturnix coturnix*	UZ	MZ	LZ
Harlequin Quail	*Coturnix delegorguei*	UZ	MZ	LZ
Blue Quail	*Coturnix adansonii*	UZ	MZ	LZ
Kurrichane Buttonquail	*Turnix sylvatica*	UZ	MZ	LZ
Black-rumped Buttonquail	*Turnix hottentota*	UZ	MZ	LZ
Red-chested Flufftail	*Sarothrura rufa*	UZ	MZ	LZ
Long-toed Flufftail	*Sarothrura lugens*		MZ	LZ
Streaky-breasted Flufftail	*Sarothrura boehmi*	UZ	MZ	LZ
White-winged Flufftail	*Sarothrura ayresi*		MZ	
African Rail	*Rallus caerulescens*	UZ	MZ	LZ
Corncrake (PM)	*Crex crex*	UZ	MZ	LZ
African Crake	*Crex egregia*	UZ	MZ	LZ
Striped Crake	*Aenigmatolimnas marginalis*	UZ	MZ	LZ
Lesser Moorhen	*Gallinula angulata*	UZ	MZ	LZ
Purple Gallinule	*Porphyrio porphyrio*	UZ	MZ	LZ
Lesser Gallinule	*Porphyrula alleni*	UZ	MZ	LZ
Denham's Bustard	*Neotis denhami*	UZ	MZ	
White-bellied Korhaan †	*Eupodotis senegalensis (cafra*)	UZ		
Black-bellied Korhaan	*Eupodotis melanogaster*	UZ	MZ	LZ
Wattled Plover	*Vanellus senegallus*	UZ	MZ	LZ
Crowned Plover	*Vanellus coronatus*	UZ	MZ	LZ
Ethiopian Snipe	*Gallinago nigripennis*	UZ	MZ	LZ
Great Snipe (PM)	*Gallinago media*	UZ	MZ	LZ
Temminck's Courser	*Cursorius temminckii*	UZ	MZ	LZ
Yellow-throated Sandgrouse †	*Pterocles gutturalis*	UZ	MZ	
Coppery-tailed Coucal *	*Centropus cupreicaudus*	UZ	(MZ)	LZ
Grass Owl	*Tyto capensis*	UZ	MZ	LZ
Marsh Owl	*Asio capensis*	UZ	MZ	LZ
Natal Nightjar	*Carimulgus natalensis*	UZ		
White-cheeked Bee-eater	*Merops variegatus*	UZ		

Common Name	Scientific Name	Upper/Middle/ Lower Zambezi		
Angola Lark *	*Mirafra angolensis*	UZ		
Rufous-naped Lark	*Mirafra africana*	UZ	MZ	LZ
Red-capped Lark	*Calandrella cinerea*	UZ	MZ	LZ
Pink-billed Lark †	*Spizocorys conirostris*	UZ		
Chestnut-backed Finch-lark	*Eremopterix leucotis*	UZ	MZ	LZ
Grey-backed Finch-lark	*Eremopterix verticalis*	UZ	MZ	
Banded Martin	*Riparia cincta*	UZ	MZ	LZ
Red-breasted Swallow	*Hirundo semirufa*	UZ	MZ	LZ
Black-and-rufous Swallow *	*Hirundo nigrorufa*	UZ		
Grey-rumped Swallow	*Pseudhirundo griseopyga*	UZ	MZ	LZ
White-rumped Babbler †	*Turdoides leucopygius*	UZ	MZ	
Capped Wheatear	*Oenanthe pileata*	UZ	MZ	LZ
Sooty Chat	*Myrmecocichla nigra*	UZ		
Stonechat	*Saxicola torquata*	UZ	MZ	LZ
African Marsh Warbler	*Acrocephalus baeticatus*	UZ	MZ	LZ
Cape Reed Warbler	*Acrocephalus gracilirostris*	UZ	MZ	LZ
Greater Swamp Warbler	*Acrocephalus rufescens*	UZ		
European Sedge Warbler (PM)	*Acrocephalus schoenobaenus*	UZ	MZ	LZ
European Reed Warbler (PM)	*Acrocephalus scirpaceus*	UZ		LZ
African Sedge Warbler	*Bradypterus baboecala*	UZ	MZ	LZ
Broad-tailed Warbler	*Schoenicola brevirostris/platyura*	UZ	MZ	LZ
Moustached Warbler	*Melocichla mentalis*	UZ	MZ	LZ
Fan-tailed Cisticola	*Cisticola juncidis*	UZ	MZ	LZ
Desert Cisticola	*Cisticola aridula*	UZ	MZ	
Cloud Cisticola †	*Cisticola textrix*	UZ		
Ayres's Cloud Cisticola	*Cisticola ayresii*	UZ		
Pale-crowned Cisticola †	*Cisticola brunnescens*	UZ	MZ	
Black-backed Cisticola	*Cisticola galactotes*	UZ		LZ
Levaillant's Cisticola †	*Cisticola tinniens*	UZ	MZ	
Croaking Cisticola	*Cisticola natalensis*	UZ	MZ	LZ
Chirping Cisticola *	*Cisticola pipiens*	UZ	(MZ)	
Black-tailed Cisticola *	*Cisticola dambo*	UZ		
Stout Cisticola	*Cisticola robusta*	UZ		
Swamp Flycatcher	*Muscicapa aquatica*	(UZ)		
Cape Wagtail *	*Motacilla capensis (simplicissima)*	UZ		
Yellow Wagtail	*Motacilla flava*	UZ	MZ	LZ

Common Name	Scientific Name	Upper/Middle/ Lower Zambezi		
Grassveld Pipit	*Anthus cinnamomeus*	UZ	MZ	LZ
Buffy Pipit	*Anthus vaalensis*	UZ	MZ	LZ
Plain-backed Pipit	*Anthus leucophrys*	UZ	MZ	LZ
Short-tailed Pipit	*Anthus brachyurus*	UZ	MZ	
Yellow-throated Longclaw	*Macronyx croceus*			LZ
Pink-throated Longclaw	*Macronyx ameliae*	UZ	MZ	LZ
Fulleborn's Longclaw *	*Macronyx fuelleborni*	UZ	(MZ)	
Grimwood's Longclaw *	*Macronyx grimwoodi*	UZ		
Swamp Boubou	*Laniarius bicolor*	UZ		
Brown-throated Weaver †	*Ploceus xanthopterus*	UZ		LZ
Masked Weaver	*Ploceus velatus*	UZ	MZ	LZ
Thick-billed Weaver †	*Amblyospiza albifrons*	UZ	MZ	LZ
Red Bishop	*Euplectes orix*	UZ	MZ	LZ
Golden Bishop	*Euplectes afer*	UZ	MZ	
Red-shouldered Widow	*Euplectes axillaris*	UZ	MZ	LZ
White-winged Widow	*Euplectes albonotatus*	UZ	MZ	LZ
Red-collared Widow	*Euplectes ardens*		MZ	LZ
Long-tailed Widow †	*Euplectes progne*	UZ		
Yellow-backed Widow	*Euplectes macrourus*	UZ	MZ	LZ
Marsh Widow	*Euplectes hartlaubi*	UZ	MZ	
Red-headed Quelea	*Quelea erythrops*	UZ		LZ
Cardinal Quelea	*Quelea cardinalis*		MZ	
Cuckoo Finch	*Anomalospiza imberbis*	UZ	MZ	LZ
Orange-breasted Waxbill	*Sporaeginthus subflavus*	UZ	MZ	LZ
Quail Finch	*Ortygospiza atricollis*	UZ	MZ	
Locust Finch	*Ortygospiza locustella*	UZ	MZ	LZ
Black-chinned Quailfinch	*Ortygospiza gabonensis*	UZ		
	Totals	**90**	**71**	**60**

Adapted from M.P.S. Irwin, pers. comm.
Note: Entries in brackets indicate very restricted distributions in that zone.

Table 5.3 Globally and regionally threatened waterbird species in the Zambezi Basin.

Species	**Pop.** [1]	**Category**[2]	**Threats** [4]	**Status**
White-winged Flufftail	V	End	agriculture	?
Slaty Egret	RB	Vul	reed cutting	OK
Wattled Crane	RB	Vul	agriculture, hunting, flood regime, (poisons)	OK ?
Corncrake	PM	Vul	agriculture	?
Madagascar Squacco Heron	IM (V)	Nt	?	?
Shoebill [5]	RB	Nt	agriculture, hunting	OK ?
Lesser Flamingo	N	Nt	?	?
Great Snipe	PM (V)	Nt	?	?
Black-winged Pratincole	PM	Nt	?	?
Rock Pratincole	IMB	regional [3]	flood regime	OK
African Skimmer	IMB	regional	flood regime, hunting	negative
Carmine Bee-eater	IMB	regional	flood regime, hunting	OK ?

Notes:
1. Population status: resident breeder (RB), intra-African migrant breeder (IMB), palaearctic migrant (PM), nomad (N) and vagrant (V).
2. Global categories are: Endangered (End), Vulnerable (Vul) and Near-threatened (Nt).
3. Regional = major population in south-central Africa.
4. Pollution is assumed to occur in the basin, in terms of agriculture and sewage run-offs, as well as pesticides. The possible impacts are unknown on any of these species, though all must surely encounter pollutants.
5. The Shoebill Stork has been seen in the Zambezi Basin *sensu stricto* only as a wanderer to central Zambia (Aspinwall & Beel 1998). It occurs in the Bangweulu swamps, but not in the Okavango swamps (as erroneously mapped by Maclean 1993).

This leaves us with six threatened species which need attention, all of which are in fact conspicuous and relatively easy to count and monitor. Their distributions are:

Slaty Egret	south-west part of the basin.
Wattled Crane	most major wetlands, and some minor dambos.
Shoebill	Bangweulu Swamps, occasionally to the south-west.
Rock Pratincole	Zambezi River, on rock stacks.
African Skimmer	Zambezi River, sandy islands and bars.
Carmine Bee-eater	Zambezi River and some tributaries, on 'cliffs' of river banks.

It is clear from Table 5.3 that the Wattled Crane is vulnerable to the most threats, in fact it suffers from all likely threats. There are five: (a) agriculture of one sort or another (including cattle grazing, subsistence agriculture such as market gardens, reed cutting, water usage); (b) hunting or poaching for food or the possible trade in live birds; (c) changes in flood regime caused by the dams on the Zambezi and Kafue River which alter water levels; (d) pollution (though so far no impacts are yet

known on these species); and (e) poisoning from pesticides, invariably by accident. This is why the Wattled Crane was highlighted in Timberlake (1998) as a 'flagship' species. If attention is focused upon it, then other species are likely to benefit as a result.

Only the African Skimmer is believed to be in decline. Its chicks are hunted as bait for fishing; nesting is disturbed by tourism; and changed flood regimes (generally lower water levels) allow the sandy islands to become overgrown by trees and bushes, especially *Faidherbia albida*. This can be seen on the Zambezi River below Kariba gorge. However, the Carmine Bee-eater may also be in decline (Feather 1997) as will be the Rock Pratincole if the proposed Batoka dam goes ahead (Childes & Mundy 1998). The impact of the various major dams (Kariba, Cabora Bassa), as far as the birds are concerned, is felt almost entirely by those three species that are riverine in their habitat (i.e. the last three listed above). The Wattled Crane suffers this impact only on the Kafue Flats, which are downstream of the Itezhi-Tezhi dam, and in the Zambezi Delta.

It is possible to help these species, inasmuch as flood-gates can be opened in particular relation to the birds breeding season, but probably only in years with high inflow to the dams. This was requested in 1999 from the Kariba dam (L. Maasdorp, pers. comm.), though little water release took place. However, the gates were opened on 25 February 2000. It can be stated categorically, however, that the Rock Pratincole, African Skimmer and Carmine Bee-eater will have problems in surviving along the Zambezi River downstream of the Kariba dam wall. Indeed, both the skimmer and bee-eater will certainly have declined due to the effects of the dam in reducing river flow; the skimmer will be left 'high and dry' and the bee-eater will have its breeding places under-cut (Mundy *et al*. 1994). The Wattled Crane is certain to be affected due to the lower water levels and unnatural fluctuations in level – there is presumably a lesser area inundated these days by the Zambezi and the Kafue rivers, and therefore a lesser food supply for the cranes. Also the lower water levels will limit the area available for crane nesting in both floodplains. For successful conservation of these species detailed attention must be paid to new flood regimes from periodic opening of the dam floodgates (see Appendix 5.3 and also Volume IV Chapter 2).

The other group of species that requires particular attention in the Zambezi Basin is that group which is restricted to the basin by virtue of being endemics (see Table 5.2) or by being present as isolated populations. Species of interest and concern in this last group are: White-throated Francolin, White-bellied Korhaan, Yellow-throated Sandgrouse, Pink-billed Lark, White-rumped Babbler, Cloud Cisticola, Pale-crowned (Pectoral-patch) Cisticola, Levaillant's Cisticola, Brown-throated Weaver, Thick-billed Weaver, Long-tailed Widow, Lemon-breasted Canary and Lesser Seed-cracker. The total number of species of conservation concern now totals 27, comprising six "threatened" species (RB and IMB in Table 5.3), eight "regional endemics" (Table 5.2), and 13 "isolated-populations" of wider ranging species. Of course there are other threatened species found in forest, woodland or montane habitats within the Zambezi Basin (see Collar *et al.* 1994), but these have been excluded, as have others of purely taxonomic interest.

5.5.2 **Areas of conservation interest**

Some waterbirds are easy to monitor, as indicated by the success of the biannual African Waterfowl Censuses, but there are also those species that inhabit marshes and flooded tall grassland which can be almost impossible to detect. That is the enigma with this group of birds. So far it is known, as stated above, that the highest diversity resides on the Barotse floodplains and upstream. At the same time it is also known that the greatest abundances of waterbirds in terms of sheer numbers reside on the Kafue Flats (e.g. Dodman *et al*. 1997). Such floodplain and marsh areas are far richer in bird numbers and in bird diversity than are the open waters of the lakes and dams in the basin (Lakes

Malawi, Kariba and Cabora Bassa). The Kafue Flats also support hundreds to thousands of Wattled Cranes on a regular basis, unlike the Zambezi Delta.

In this regard of "important bird areas", the Southern African Bird Atlas (Harrison *et al.* 1997) is of fundamental importance. It altogether superseded an earlier one for Botswana alone (Penry 1994). At the same time, it is very much to be regretted that the promised atlases for Zambia (R.J. Dowsett & D.R. Aspinwall, in prep.) and Malawi (R.J. Dowsett, in prep.) are not yet to hand. Both have been promised for years. Fortunately, atlas work in Mozambique is progressing well, that for the southern third of the country having just been published (Parker 1999). Vincent Parker has now shifted his attention to the central third of the country, i.e. the region between the Save and Zambezi Rivers. By contrast, Angola remains a big blank.

Again, southern Africa has led the way (with Ethiopia) in producing an atlas of important bird areas (Barnes 1998). Ten of the areas listed fall within the Zambezi Basin, with seven of them being wetlands or having wetlands in them. In Namibia, the eastern Caprivi wetlands have high bird diversity (Simmons *et al.* 1998), while nearby in Botswana, the Linyanti Swamp area holds probably the same diversity (Tyler & Bishop 1998). In Zimbabwe, the four important wetland areas are the middle Zambezi valley, Batoka Gorge, Lake Chivero, and the seasonal pans in the Hwange National Park (Childes & Mundy 1998).

From the perspective of birds, then, the Barotse floodplain and the Chobe-Linyanti swamps are the most important for biodiversity, especially when considering endemics, whereas Kafue Flats seems to be the most significant for sheer numbers. The Zambezi Delta is somewhat of an unknown so far. The Lower Shire marshes show a high diversity in Table 5.1, but host nothing that does not occur elsewhere; the area has greatly deteriorated due to sugarcane cultivation practices. As yet, firm opinions cannot be made for all the wetlands in the Zambezi Basin until the Zambia, Malawi and central Mozambique atlases are published. It would therefore, at this stage, be worthwhile to put effort into publishing these atlases rather than into surveying more wetlands.

5.6. CONCLUSIONS

(a) Mapping of waterbird distributions in the Zambezi Basin will be greatly aided when the atlases for Zambia, Malawi, and central Mozambique are published. The definition of 'waterbird' must be properly comprehensive, but the literature shows that it must be carefully drafted.

(b) Large wetlands in the shape of floodplains and swamps allow bird diversity to evolve. The Barotse wetland is the most important in this respect. The Zambezi Delta adds a few species that like brackish conditions.

(c) By and large the palaearctic migrants that depend on wetlands can look after themselves – having flown to south-central Africa from the north they can easily move from one wetland to another because they are not breeding.

(d) Important habitat for the diversity of small birds and for populations of threatened species is provided by three of the large wetlands, i.e. Barotse floodplains, Chobe-Linyanti and the Zambezi Delta, and also by the Kafue Flats for the Wattled Crane. The Lower Shire is dispensable in this respect.

(e) The basin is very important for grassland birds in general. Several species, such as the Black-rumped Buttonquail, will move between dry and wet grasslands, thus blurring the distinction between the two in terms of these birds.

(f) Several species at least (Ethiopian Snipe, Cloud Cisticola, Black-backed Cisticola, Levaillant's Cisticola, Cape Wagtail and Red-shouldered Widow) need to be the focus of taxonomic investigation so as to determine their true status.

(g) Due to their mobility because of flight, and driven by habitat change from fluctuating water levels, many waterbirds are widespread in the basin. Mobility is clearly one of their methods of survival.

(h) Rather few biological studies (outside of distribution and movements) have been done on waterbird species.

(i) For threatened species (and their wetlands) particular attention should be given to improving the flood regimes from the dams (i.e. releasing water) in an effort to improve conditions for the Rock Pratincole, African Skimmer, Carmine Bee-eater and also the Wattled Crane.

(j) The 'flagship' bird species for the Zambezi Basin are the Wattled Crane (around 90% of its population is thought to live in south-central Africa) and Slaty Egret (endemic to the basin plus the Okavango Swamps).

5.7 ACKNOWLEDGEMENTS

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CHAPTER 5 : APPENDIX 1
BIRD SURVEY OF THE BAROTSE FLOODPLAIN, NOVEMBER 1998

Kit Hustler

1. INTRODUCTION

This report provides details of a field trip undertaken from 2-12 November 1998 to the Mongu District of western Zambia. The itinerary of sampling and data collected are detailed. During the trip I was accompanied by Vincent Katanekwa, Director of the Livingstone Museum and an ornithologist.

Surveys were carried out at two sites: Ndanda dambo (14°56'23" S / 23°42'59" E) northeast of Mongu and Litoya dambo (15°40'12" S; 23°20'00" E) south of Mongu. Ndanda dambo was in a lower drainage valley (classified as a Wet River Plain (R2) by Jeanes & Baars 1991). The woodlands near settlements in this area have been modified but were quite extensive and dense away from habitation. Litoya dambo is classified as the same vegetation type. The margins of this dambo are intensively settled with patches of cultivation within the dambo itself.

2. METHODOLOGY

Field observations were made with 10 x 40 binoculars and all birds sighted in the observation areas were recorded. Data were collected by walking along and in the drainage lines and actively searching for the birds that might have been there. Tape recordings were used in some instances in an attempt to attract certain species closer to us either to confirm their occurrence in the area and to obtain good views of the bird or to collect a specimen. Night birds were recorded on the basis of their vocalisations, as were a number of the pipits, larks and cisticolas. Tape recordings were made of some of the species for later analysis, but familiarity with the songs of some of the more cryptic species was used to detect their presence in the field.

In all cases observations were made within 3 km of the co-ordinates given for the localities of specimens collected, which are Ndanda (14°54'39"S / 23°38'15"E and 14°56'23"S / 23°42'59"E) and Litoya (15°40'12"S / 23°20'00"E).

3. RESULTS

3.1 Species sighted

Birds seen during the survey are listed in Table 1. During the exercise, a number of new species were added to the Zambian Atlas square lists; these are indicated with asterisks in the table.

3.2 Specimens collected

Few birds were collected as we had limited ammunition of the correct type and we had limited time to skin and prepare those specimens we did collect. Those that were collected were obtained for a specific purpose or if an unexpected opportunity arose. All bird specimens collected are housed in the Livingstone Museum. Specimens are described below.

Cisticola tinniens – An unknown and undescribed population of this species occurs in the wet dambos that flow into the Zambezi in western Zambia. Initially discovered by Dylan Aspinwall during field work for the Zambian Bird Atlas, there are no specimens in any of the regions museums from this population. A pair was collected at Ndanda, but unfortunately the male bird was not recovered from the rank vegetation into which it flew. No more specimens were collected. Fieldwork on this species concentrated on determining densities of the birds, getting representative recordings of their vocalisations and the location of a nest.

Cisticola galactotes – This species is in the process of being described as a full species (*luapula*) and is essentially an upper Zambezi endemic. Tape playback experiments were initiated, density estimates calculated for a number of dambos and a nest was located. One bird was collected at Ndanda.

Cisticola pectoralis – This species occurred in some numbers in the wet dambos and is the subject of some taxonomic debate. A male was collected and genetic material recovered for future analysis. The songs of these birds were identical to those given on commercially available tapes of the bird songs of the region. One interesting facet of the behaviour of some of these birds was territorial males calling from the ground on a short perch. Normally this species undertakes an extended aerial display. One bird was collected at Ndanda.

Euplectes axillaris – A female bird was collected and the specimen shows some interesting plumage differences from more southerly populations. There is a suggestion that the central African populations are not *axillaris* but something else, and it is hoped that the genetic material collected will some way to solving this argument. One bird was collected at Ndanda.

Anthus leucophrys – A recently fledged chick still being fed by its parents was collected at 14º54'39" S / 23º38'15" E. The juvenile plumage of this species is undescribed and a good sequence of the song of a displaying bird was recorded. This bird was collected.

Caprimulgus europeus and *C. mossambicus* – Both species were caught in nets set for bats over a pool of water at Ndanda. There are few records of *europeus* from Zambia.

Apus sp. – Two swifts from a large flock were collected at Litoya, and genetic material retained from both of them. They are assumed to be European Swifts *Apus apus*, on migration, but this is subject to confirmation.

4. DISCUSSION

Valuable data were obtained on the densities and ecological separation of four cisticolas in the wet dambo habitats we visited, and will form part of a submitted paper in due course.

New information was obtained on the behaviour of the Swamp Nightjar (*Caprimulgus natalensis*) and a male bird was followed for an extended period during a moon-lit night. During this time, good tape recordings were obtained of his calls and he was observed to run away from us on the ground. This species has long legs for a nightjar and it has been speculated that it moves well on the ground, although never proven until now.

At one of the dambos we examined a large flock of Black-winged Pratincoles (*Glareola nordmanni*) which appeared just on midday and had disappeared by the following morning. The estimated number is between 10-15,000 birds. There were so many that it looked like quelea at some stages, with large numbers of birds sitting on the ground and then getting airborne when they were disturbed. Large numbers of birds spiralled up in the thermals like vultures and were in flocks of up to 2000 individuals. The birds seemed to leave in large groups but arrived in loose flocks. Large concentrations of birds have been seen in Zambia before (an estimated 1 million birds; Aspinwall & Conant 1977) but it has undergone a contraction of range in South Africa in recent times (MacLean & Herremans 1997). One estimate of the global population is of 20,000 individuals (Rose & Scott 1994), but a large flock estimated at between 250,000 and 750,000 birds was seen in South Africa in 1991 (du Plessis 1995).

Conspicuous by their absence were the game birds (francolins and guineafowl) and doves. While I have no data to support these assertions, it is likely that these groups have been largely eliminated by the local population in this area. The only guineafowls seen were semi-domesticated birds with the characteristic pale head.

From a bird point of view, the diversity of habitats is staggering. On the floodplain itself, the number of oxbow lakes of different sizes, depths and vegetation structure alone make for a large number of different habitats which would suit different bird species preferentially. The presence/absence of fish, *Phragmites* and papyrus reedbeds further adds to the complexity of habitats that are suitable for birds. The distance away from water and the proximity of water to the surface of the wetlands is also important, and provides different habitats at different times of the year. The water level is determined by the level of the flood water and it is known that there are large-scale movements of birds associated with water as it rises and falls, and this would affect the presence/absence of a large variety of water birds and other species which are associated with the

floodplain. This gives a large permutation of different habitats in which birds could be found. Given their mobility, a large number of different permutations of these habitats should be visited before the attached lists given here could be considered as being close to complete. The intervening woodlands are also interesting and are an integral part of the factors determining the diversity of birds that occur in this area. They should also be investigated more thoroughly if the bird list for the area is going to be considered as anything close to complete.

The flood regime of the Zambezi on the wetlands is a very important factor and some birds are only present as the water begins to subside, but leave when the water gets too low or become restricted to areas of suitable habitat only. If these habitats are not visited and properly searched, then the species concerned will not be found. Likewise, some species arrive and breed in the suitable habitats created immediately after the floods, and then disperse widely across the continent. For this aspect of the avifauna to be properly censussed, an aircraft is needed to locate the breeding colonies quickly. A boat would then be needed to reach them in order to collect breeding data.

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Appendix 5.1 Table 1 List of birds associated with dambos of the Mongu area recorded in each HDS visited during the November 1998 survey. The first list is derived from the unpublished Zambian Bird Atlas (ZBA) with the adjacent list having the birds seen during the current survey (BFA). Records with an asterisk (*) indicate a new record for the square, those with a double asterisk (**) indicate a new record for the area. Nomenclature follows Benson *et al.* (1971).

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Reed Cormorant *Phalacrocorax africanus*	1		1		1	1	1 bird seen once at a pool
Great White Egret *Egretta alba*			1	1	1		3 birds seen at the rice growing scheme
Grey Heron *Ardea cinerea*	1		1	1	1	1	occasional birds seen fishing in pools
Black-headed Heron *Ardea melanocephala*			1		1	1	one bird seen flying over
Purple Heron *Ardea purpurea*			1	1	1	1	scarce, but probably overlooked
Little Egret *Egretta garzetta*		1	1	1	1		occasional birds seen fishing in pools
Yellow-billed Egret *Egretta intermedia*		1	1	1	1		seen on 2 occasions
Cattle Egret *Ardeola ibis*	1	1	1	1	1	1	widespread
Rufous-bellied Heron *Butorides rufiventris*		1*	1	1	1		scarce, but probably overlooked
Black-crowned Night Heron *Nycticorax nycticorax*			1		1	1	one heard at night
Abdim's Stork *Ciconia abdimii*	1		1	1			small flock close to rice scheme
Hottentot Teal *Anas hottentotta*		1*	1		1		2 birds seen at pool in dambo
Spur-winged Goose *Plectropterus gambensis*	1	1	1		1	1	widespread, but in small numbers
Secretarybird *Sagittarius serpentarius*			1			1*	one seen feeding on dambo
Yellow-billed Kite *Milvus migrans*	1	1	1	1	1	1	frequently seen overhead
Black-shouldered Kite *Elanus caeruleus*	1	1	1		1	1	regularly seen hovering over dambos
Cuckoo Hawk** *Aviceda cuculoides*		1*		1*		1*	seen flying over every dambo
Tawny Eagle *Aquila rapax*			1			1*	1 bird hunting a dove on dambo
Wahlberg's Eagle *Aquila wahlbergi*	1	1	1	1	1	1	frequently seen soaring overhead

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Brown Snake Eagle *Circaetus cinereus*	1	1	1		1	1	frequently soaring overhead or perched
Black-breasted Snake Eagle *Circaetus pectoralis*	1	1	1		1	1	frequently soaring overhead or perched
Bateleur *Terathopius ecaudatus*	1	1	1	1	1	1	occasionally seen soaring overhead
Steppe Buzzard *Buteo vulpinus*	1	1	1		1	1	frequently seen soaring or perch hunting in a dambo
Lizard Buzzard *Kaupifalco monogrammicus*	1	1	1	1	1		heard calling from the woodland edge
Ovambo Sparrowhawk *Accipiter ovampensis*		1*	1				one bird hunting finch-larks
Black Sparrowhawk *Accipiter melanoleucus*		1*	1				one bird flying overhead
African Marsh Harrier *Circus ranivorus*		1*	1	1	1	1	regular in all dambos surveyed
Lanner Falcon *Falco biarmicus*			1		1	1	hunting doves drinking in the dambo
European Hobby *Falco subbuteo*	1	1	1			1*	frequently seen overhead
Blue Quail *Coturnix chinensis*		1*	1				two birds only flushed
Helmeted Guineafowl *Numida meleagris*	1	1	1	1	1	1	only the domesticated form seen
Kurrichane Buttonquail *Turnix sylvatica*		1*	1			1*	single birds flushed from two dambos
African Rail *Rallus caerulescens*		1*	1		1		one bird heard
Purple Gallinule *Porphyrio porphyrio*		1*	1				one bird heard
Black-bellied Korhaan *Eupodotis melanogaster*	1	1					one male displaying
African Jacana *Actophilornis africanus*	1	1	1		1		scarce, two birds seen in one dambo
Crowned Plover *Vanellus coronatus*		1*	1		1		small group on dry dambo
Wattled Plover *Vanellus senegalensis*	1	1	1		1		frequently encountered on all dambos
Wood Sandpiper *Tringa glareola*	1	1	1		1		frequently encountered on all dambos
Greenshank *Tringa nebularia*		1*	1		1		one bird seen
Temminck's Courser *Cursorius temminckii*	1	1	1		1		group of 3 on a dry dambo

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Red-winged Pratincole *Glareola pratincola*	1	1	1		1	1	frequently encountered on dambos and overhead
Black-winged Pratincole** *Glareola nordmanni*						1*	large flock on one dambo
Red-eyed Dove *Streptopelia semitorquata*	1	1	1	1	1		scarce; drinking from pools in dambos
Cape Turtle Dove *Streptopelia capicola*	1	1	1	1	1	1	scarce; drinking from pools in dambos
Namaqua Dove *Oena capensis*	1	1	1		1	1	scarce on two dambos
Green-spotted Dove *Turtur chalcospilos*	1		1	1	1		heard in woodland adjacent to dambos
Green Pigeon *Treron australis*	1	1	1				once heard in woodland by dambo
Cape Parrot *Poicephalus robustus*	1		1		1	1	once heard in woodland by dambo
Meyer's Parrot *Poicephalus meyeri*	1	1	1		1	1	heard in woodland adjacent to dambos
African Cuckoo *Cuculus gularis*	1	1	1	1	1	1	heard in woodland adjacent to dambos
Red-chested Cuckoo *Cuculus solitarius*	1	1	1	1	1	1	heard in woodland adjacent to dambos
Great Spotted Cuckoo** *Clamator glandarius*						1*	once seen in tree in middle of dambo
Black Cuckoo *Cuculus clamosus*	1	1	1		1		heard in woodland adjacent to dambos
Striped Cuckoo *Clamator levaillantii*	1	1	1		1		seen in stunted woodland in dambo; also heard in woodland adjacent to dambos
Jacobin Cuckoo *Clamator jacobinus*		1*	1				heard in woodland adjacent to dambos
Thick-billed Cuckoo** *Pachycoccyx audeberti*		1*					once heard in woodland
Klaas's Cuckoo *Chrysococcyx klaas*	1	1	1	1	1		often seen in stunted woodland in dambos; also heard
Black Coucal *Centropus grilli*		1*			1		one bird seen in rank vegetation in dambo
Coppery-tailed Coucal *Centropus cupreicaudus*	1	1	1		1	1	frequently seen in rank vegetation in dambos
Barn Owl *Tyto alba*			1	1	1	1	heard at night
Wood Owl *Ciccaba woodfordii*	1	1	1				heard at night
White-faced Owl *Otus leucotis*	1	1	1	1		1*	heard at night

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Spotted Eagle Owl *Bubo africanus*	1	1	1		1		heard at night
Giant Eagle Owl *Bubo lacteus*	1		1	1		1*	heard at night
Marsh Owl *Asio capensis*	1		1		1	1	flushed from rank vegetation in dambo
European Nightjar** *Caprimulgus europeus*		1*					caught in net set over a pool in middle of dambo
Rufous-cheeked Nightjar *Caprimulgus rufigena*	1	1	1	1	1	1	heard calling from dambos
Swamp Nightjar** *Caprimulgus natalensis*		1*				1*	heard calling from dambos
Mozambique Nightjar *Caprimulgus fossii*	1	1	1	1	1	1	heard calling and caught in net set over pool in middle of dambo
Pennant-winged Nightjar *Macrodipteryx vexillarius*	1	1	1	1		1*	seen displaying over a dambo
European Swift *Apus apus*	1	1	1		1	1	scarce; large flocks seen drinking at pools in dambos
Little Swift** *Apus affinis*						1*	one flock drinking at pool in dambo
Pied Kingfisher *Ceryle rudis*	1	1	1		1	1	frequently seen at pools in dambos
Malachite Kingfisher *Alcedo cristata*	1	1	1		1	1	frequently seen at pools in dambos
Pygmy Kingfisher *Ispidina picta*	1	1	1				seen on dambo edge in woodland
Woodland Kingfisher *Halcyon senegalensis*	1	1	1		1		heard in woodland
European Bee-eater *Merops apiaster*	1	1	1	1	1	1	frequently seen over dambos
Blue-cheeked Bee-eater *Merops persicus*	1	1	1		1	1	frequently seen over dambos
Carmine Bee-eater *Merops nubicus*			1		1	1	scarce; one group over a dambo
White-fronted Bee-eater ** *Merops bullockoides*		1*					one group seen over a dambo
Little Bee-eater *Merops pusillus*	1	1	1		1		widespread in dambos
White-cheeked Bee-eater *Merops variegatus*	1	1	1		1		scarce; few birds in one dambo only
Swallow-tailed Bee-eater *Merops hirundineus*	1	1	1		1		occasionally over dambos but mainly on woodland edge
Lilac-breasted Roller *Coracias caudata*	1	1	1	1	1	1	frequently encountered in dambos

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Purple Roller *Coracias naevia*		1*	1		1		encountered once on dambo
Broad-billed Roller *Eurystomus glaucurus*	1	1	1		1	1	frequently seen over dambos
Red-billed Woodhoopoe *Phoeniculus purpureus*	1	1	1		1		heard in woodland
Pale-billed Hornbill *Tockus pallidirostris*	1	1	1		1	1	seen overhead dambos and heard in woodland
Grey Hornbill *Tockus nasutus*	1	1	1		1		seen overhead dambos and heard in woodland
Crowned Hornbill *Tockus alboterminatus*	1	1				1*	seen overhead dambos and heard in woodland
Ground Hornbill *Bucorvus cafer*	1		1		1	1	heard once only
Yellow-fronted Tinkerbird *Pogoniulus chrysoconus*	1	1	1	1	1	1	often heard in woodland
Crested Barbet** *Tachyphonus vaillantii*				1*			once heard in woodland
Brown-backed Honeyguide *Protodiscus regulus*			1	1			once in woodland edge of dambo
Golden-tailed Woodpecker *Campethera abingoni*		1*	1		1		once heard in woodland
Rufous-naped Lark *Mirafra africana*	1	1	1	1	1	1	frequent on dambos
Flappet Lark *Mirafra rufocinnamomea*	1	1		1		1*	often heard in woodland
Fawn-coloured Lark *Mirafra africanoides*			1	1	1		few birds on a dambo
Chestnut-backed Finchlark *Eremopterix leucotis*		1*	1		1		small flock on a dambo
European Swallow *Hirundo rustica*	1	1	1	1	1	1	frequently seen in large flocks overhead dambos
White-throated Swallow *Hirundo albigularis*		1*	1				in mixed swallow flocks overhead dambos
Wire-tailed Swallow *Hirundo smithii*		1*	1		1		in mixed swallow flocks overhead dambos
Pearl-breasted Swallow *Hirundo dimidiata*		1*	1		1		in mixed swallow flocks overhead dambos
Mosque Swallow *Hirundo senegalensis*	1	1	1		1		in mixed swallow flocks overhead dambos
Lesser Striped Swallow *Hirundo abyssinica*	1	1			1		in mixed swallow flocks overhead dambos
South African Cliff Swallow *Hirundo spilodera*	1					1*	one bird in mixed swallow flock overhead dambo

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
House Martin *Delichon urbica*	1	1	1		1		in mixed swallow flocks overhead dambos
European Sand Martin *Riparia riparia*	1		1		1	1	in mixed swallow flocks overhead dambos
Banded Martin *Riparia cincta*		1*	1		1	1	in mixed swallow flocks overhead dambos
Black Cuckooshrike *Campephaga phoenicea*	1	1	1		1		often heard in woodland
Fork-tailed Drongo *Dicrurus adsimilis*	1	1	1	1	1	1	frequent on woodland edge and on trees in dambos
Black-headed Oriole *Oriolus larvatus*	1	1	1	1	1		often heard in woodland
Pied Crow *Corvus albus*	1	1	1	1	1	1	occasionally overhead dambos
Miombo Grey Tit *Parus griseiventris*	1	1	1		1		once in woodland on dambo edge
White-rumped Babbler *Turdoides leucopygius*		1*	1		1		one flock in rank vegetation of dambo
Black-eyed Bulbul *Pycnonotus barbatus*	1	1	1	1	1	1	frequent in woodland edge and on trees in dambos
Kurrichane Thrush *Turdus libonyana*	1	1	1		1		occasionally heard in woodland
Capped Wheatear *Oenanthe pileata*	1	1	1	1			few birds on drier portions of dambos
Arnot's Chat** *Thamnolaea arnoti*						1*	two birds in open on a dambo
Stonechat *Saxicola torquata*	1	1	1	1	1	1	frequent in moister ranker sections of dambos
Heuglin's Robin *Cossypha heuglini*	1	1	1		1		occasionally heard in woodland
White-browed Robin *Erythropygia leucophrys*	1	1	1		1		often heard in woodland
Central Bearded Robin *Erythropygia barbata*	1	1					once heard and seen in woodland
Cape Reed Warbler *Acrocephalus gracilirostris*		1*			1		one bird in rank vegetation in dambo
African Sedge Warbler *Bradypterus baboecalus*		1*	1				frequent in rank vegetation in dambo
Broad-tailed Warbler *Schoenicola platyura*	1	1	1		1		two birds displaying over rank vegetation in dambo
Icterine Warbler** *Hippolais icterina*		1*		1*			heard and seen in woodland twice
Garden Warbler *Sylvia borin*	1	1			1		once heard and seen in woodland

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Willow Warbler *Phylloscopus trochilus*	1		1	1	1	1	often heard in woodland
Yellow-breasted Apalis *Apalis flavida*	1	1	1				often heard in woodland
Long-billed Crombec *Sylvietta rufescens*	1	1	1	1	1		often heard in woodland
Green-capped Eremomela *Eremomela scotops*	1	1	1	1	1		often heard in woodland
Bleating Warbler *Camaroptera brachyura*	1	1	1	1	1		frequent on woodland edge and dry rank vegetation in dambos
Fan-tailed Cisticola *Cisticola juncidis*	1	1	1		1	1	frequent on drier margins of dambos
Desert Cisticola *Cisticola aridula*	1	1	1		1	1	occasional on drier margins of dambos
Pale-crowned Cisticola *Cisticola pectoralis*	1	1	1		1	1	frequent on wet short grass of dambos
Red-faced Cisticola** *Cisticola erythrops*		1*					one heard in rank vegetation on dambo
Black-backed Cisticola *Cisticola galactotes*	1	1	1		1	1	frequent in wet rank vegetation on dambos
Levaillant's Cisticola *Cisticola tinniens*	1	1					localised and restricted to short grass/ rank vegetation ecotone on dambo
Croaking Cisticola *Cisticola natalensis*	1	1	1		1	1	frequent in rank vegetation of dambos
Tawny-flanked Prinia *Prinia subflava*	1	1	1		1	1	frequent in rank vegetation of dambos
Blue-grey Flycatcher *Muscicapa caerulescens*	1	1			1		one party seen on woodland edge
Spotted Flycatcher *Muscicapa striata*	1	1	1	1	1		frequent in woodland and on edge
Pallid Flycatcher *Bradornis pallidus*	1	1	1	1	1		frequent in woodland and on edge
Chinspot Batis *Batis molitor*	1	1	1		1		occasionally heard in woodland
Paradise Flycatcher *Terpsiphone viridis*	1	1	1	1	1	1	often heard in woodland
Cape Wagtail *Motacilla capensis*	1	1	1		1		frequent in wet situations in dambos
Grassland Pipit *Anthus novaeseelandiae*	1	1	1		1	1	frequent on drier sections of dambos
Miombo Pipit *Anthus nyassae*	1	1	1	1	1		frequent on woodland edge
Dark Plain-backed Pipit *Anthus leucophrys*	1	1	1		1	1	frequent on dambos in dry and wet situations

Species	1423D		1523A		1523C		Abundance/Habitat
	ZBA	BFA	ZBA	BFA	ZBA	BFA	
Buffy Plain-backed Pipit *Anthus vaalensis*	1	1	1	1	1		frequent on drier sections of dambos
Fulleborn's Longclaw *Macronyx fuelleborni*	1	1	1	1	1	1	frequent on drier sections dambos
Pink-throated Longclaw *Macronyx ameliae*	1	1	1		1		frequent on wet short grass sections of dambos
Lesser Grey Shrike *Lanius minor*	1	1	1	1	1	1	frequently perched on dambos
Red-backed Shrike *Lanius collurio*	1	1	1		1		occasionally seen perched on dambos
Fiscal Shrike *Lanius collaris*	1	1	1		1		occasionally seen perched on dambos
Puffback *Dryoscopus cubla*	1	1	1		1		often heard in woodlands
Brubru *Nilaus afer*	1	1	1		1		often heard in woodlands
Black-crowned Tchagra *Tchagra senegala*		1*	1		1	1	often heard in woodlands
Grey-headed Bush Shrike *Malaconotus blanchoti*	1	1	1		1		often heard in woodlands
Wattled Starling *Creatophora cinerea*			1	1	1		flock seen in dry part of dambo
Plum-coloured Starling *Cinnyricinclus leucogaster*	1	1	1		1		often heard and seen in woodland
Yellow-billed Oxpecker** *Buphagus africanus*		1*					one group seen on cattle in a dambo
Coppery Sunbird *Nectarinia cuprea*		1*	1		1		two pairs in rank vegetation in a dambo
Marico Sunbird *Nectarinia mariquensis*		1*	1	1	1	1	occasionally seen on woodland edge
Shelley's Sunbird** *Nectarinia shelleyi*				1*			one bird seen on woodland edge
White-bellied Sunbird *Nectarinia talatala*	1	1	1	1	1	1	frequently heard and seen on woodland edge
Scarlet-chested Sunbird *Nectarinia senegalensis*	1	1	1	1	1	1	frequently seen and heard on woodland edge
Black Sunbird *Nectarinia amethystina*	1	1	1		1	1	frequently seen and heard on woodland edge
Collared Sunbird *Anthreptes collaris*	1	1					pair seen on woodland edge
Yellow White-eye *Zosterops senegalensis*	1	1	1		1	1	frequently seen and heard on woodland edge
Southern Grey-headed Sparrow *Passer griseus*		1	1			1*	occasional on woodland edge

Species		1423D		1523A		1523C		Abundance/Habitat
		ZBA	BFA	ZBA	BFA	ZBA	BFA	
Thick-billed Weaver *Amblyospiza albifrons*			1*	1		1		small group of birds in rank vegetation of dambo
Spectacled Weaver *Ploceus ocularis*			1*			1		once heard and seen in isolated trees growing in dambo centre
Spotted-back Weaver *Ploceus cucullatus*		1	1	1		1		heard and seen at nests in isolated tree growing in dambo centre
Golden Weaver *Ploceus xanthops*		1	1	1		1		heard and seen in isolated trees growing in dambo centre
Red-billed Quelea *Quelea quelea*		1	1	1		1	1	frequently seen in small flocks on dambos
Red-shouldered Widow *Euplectes axillaris*		1	1	1		1	1	frequently seen in small groups in rank vegetation of dambos
Red-billed Firefinch *Lagonosticta senegala*		1	1	1	1	1		uncommon in dambos
Common Waxbill *Estrilda astrild*		1	1	1		1	1	uncommon in dambos
Quailfinch *Ortygospiza atricollis*			1*	1		1	1	uncommon in dambos
Red-billed Quailfinch *Ortygospiza gabonensis*			1*	1				one small flock seen in dambo
Orange-breasted Waxbill *Amandava subflava*			1*	1		1		one small flock seen in rank vegetation of dambo
Bronze Mannikin *Lonchura cucullata*		1	1	1		1	1	frequently seen on woodland edge
Pin-tailed Whydah *Vidua macroura*		1	1	1		1	1	occasionally seen in rank vegetation in dambos
Yellow-eye Canary *Serinus mozambicus*		1	1	1	1	1		often seen drinking in dambos
Black-throated Canary *Serinus atrogularis*		1	1	1		1		often seen drinking in dambo
Golden-breasted Bunting *Emberiza flaviventris*		1	1	1	1	1	1	frequent on woodland edge and drinking in dambos
Cinnamon-breasted Rock Bunting *Emberiza tahapisi*			1*			1		small group in middle of dry dambo
TOTAL	**190**	129	161	162	62	146	90	

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CHAPTER 5 : APPENDIX 2
BIRD SURVEYS OF THE BAROTSE FLOODPLAINS

Paul Van Daele & Bob Stjernstedt

1. INTRODUCTION

This report presents data on bird distribution collected from 23-28 March and 25-29 August 1999 in the Bulozi Plains area of Barotseland. The first survey was conducted by Bob Stjernstedt and Paul Van Daele for the Biodiversity Foundation for Africa, and the second survey by Paul Van Daele alone. Sites visited are shown in Table 1.

Appendix 5.2 Table 1 Sites visited and locations.

Site	Latitude (S)	Longitude (E)
Ndau School	15°35'	22°57'
Simunyange Plain	15°26'58"	22°55'36"
Lui School	15°27'36"	23°51'12"
Litawa School	15°39'59"	23°35'00"
Silita Pan	15°20'36"	23°37'30"
Litoya Village	15°40'08"	23°19'57"
Lake Makapaela (Makakaela on map)	15°03'20"	23°13'20"
Mongu-Lealui	15°15'00"	23°03'10"
Lake Nalulao	15°03'20"	23°20'20"
Lake Liangandu	15°03'06"	23°20'06"
Lake Ngame	15°02'36"	23°19'15"
Ikabako Plain	15°08'18"	23°17'20"
Nangili School	14°52'34"	23°04'29"
Likapayi Village	14°49'22"	23°01'40"
Sandbanks near Nalonde (+7km N from there)	14°46'18"	23°01'31"
Nasange Village	14°51'22"	23°01'30"
Imwinda "harbour" branch of Zambezi	14°51'08"	23°01'03"
Chipela branch of Zambezi	14°50'21"	23°00'42"
Moolo stream (E point)	14°45'22"	23°05'28"
Moolo stream (W point) - Yanjoko Village	14°47'05"	23°02'51"
southern Barotse Plain	14°14'00"	23°15'00"

2. METHODOLOGY

In an attempt to produce comparable data, abundance of the species observed was written down on a daily basis per site. Table 2 shows the frequency categories.

2.1 March survey, including Ndau School transects

Field workers who want to repeat the effort in the future and collect data to monitor changes in bird numbers in the Ndau area should preferably include an abundance notation as shown in Table 2. During the March 1999 survey the water was relatively high. Good rains left the shoreline of the floodplain 20 m from the Ndau School ablution blocks. Data were collected along five routes (half-day excursions):

(a) Walk south from the Ndau School along the shoreline for about 3 km.
(b) Walk north from the Ndau School for about 1 km.
(c) Make a boat trip around the peninsula straight east (with mango trees) from the Ndau School to the first oxbow lake and explore an area further east of there for about 1 km.
(d) Make a boat trip to the dry season village straight east from the Ndau School and closest to it.
(e) Take the path straight west from the Ndau School to the Simunyange plain and follow the shoreline of that plain for about 1 km to the south.

Appendix 5.2 Table 2 Frequency categories used during the surveys.

Category	Code	No. of sightings
Abundant	A	30+
Common	C	36492
Frequent	F	6-10
Occasional	O	2-5
Rare	R	1

2.2 **August survey**
The August survey was in five half-day excursions, described below. Bird species seen were noted for each area along with an indication of abundance. Woodland species were not recorded.

(a) Drive 8 km in plain, from Mongu in direction of Lealui.
(b) Walk eastern shore of Lake Nalulao.
(c) Walk western shore of Lake Liangandu.
(d) Drive along Zambezi from near Nalondo (see coordinates) 7 km to the north.
(e) Drive along Moolo stream.

The southern Barotse Plain was recorded birds for one hour from the coordinates given above.

3. RESULTS

3.1 **March survey**
A checklist of the birds recorded from the area during the March 1999 survey is given as Table 3. Species seen are marked on a daily basis by locality. A total of 159 species were noted, 125 species alone in the Ndau sector. The total number of individual birds seen was low. Several factors may have played a role – logistical problems resulting in a low number of areas visited, poor weather conditions and high water levels.

Taking the poor observation circumstances into account, it is our view that the Ndau and possibly Mongu sectors do not have an exceptionally rich avifauna compared to the rest of the Barotse floodplain. Reports were given to us about "important" waterbird breeding colonies active at other times of year in or outside the Ndau/Mongu sectors. It seems advisable to conduct an aerial survey to pinpoint these waterbird sites and breeding areas prior to further research on the ground.

The woodlands between the Simunyange Plain and Ndau School were found to be rather poor in numbers and species of birds. It was only on the third day that the first Fork-tailed Drongo was recorded.

The Lui Valley was visited with a view of its possible conservation importance. It was explored from Lui School to Litawa School, about 90 km further north. Few waterbirds were seen and the whole area is heavily populated. We would suggest that conservation action in the Lui Valley has low priority.

East of the Barotse Floodplain the woodlands are dotted with pans, which are a particular feature of the Western Province Kalahari sands. The area could be a refuge for some species (several pans are renowned for their population of Great Crested Grebes, a restricted-range species in Zambia). Three pans were visited (Silita, Lushi and Lusiana). Only the Silita Pan contained water and was properly explored. It was found that livestock heavily utilizes these pans. We feel that the pans warrant further investigation of general biodiversity (e.g. waterbirds, amphibians, dragonflies) earlier in the year.

Appendix 5.2 Table 3 Bird data from the Bulozi Plains survey, March 1999 (Paul Van Daele & Bob Stjernstedt).

C Common F Frequent O Occasional R Rare
Nd Ndau School Mg Mongu Sim Simunyange Plain
Lui Lui Valley Sil Silita Plain Lit Litoya

English Name	Species	Date (March 1999)								
		23 Mg	27 Mg	24 Nd	25 Nd	26 Nd	26 Sim	27 Lui	27 Sil	27 Lit
Reed Cormorant	*Phalacrocorax africanus*	F	O	C	C	C				O
Black-crowned Night Heron	*Nycticorax nycticorax*	R								
Common Squacco Heron	*Ardeola ralloides*	F		C	C	C				
Rufous-bellied Heron	*Ardeola rufiventris*		R							
Cattle Egret	*Bubulcus ibis*	C		C	C	C		C		O
Green-backed Heron	*Butorides striatus*			R	F					
Black Egret	*Egretta ardesiaca*			R						
Little Egret	*Egretta garzetta*				R					
Great White Egret	*Egretta alba*	F		F						
Purple Heron	*Ardea purpurea*	R		O	R	O				
Grey Heron	*Ardea cinerea*	R		O						
Black-headed Heron	*Ardea melanocephala*	F		C	C	C		O		
Openbill Stork	*Anastomus lamelligerus*	C		O	C	O				
Abdim's Stork	*Ciconia abdimii*								R	
Fulvous Whistling Duck	*Dendrocygna bicolor*							O		
White-faced Whistling Duck	*Dendrocygna viduata*	F		F	F			O		
Spur-winged Goose	*Plectropterus gambensis*		A		F			O		
Knob-billed Duck	*Sarkidiornis melanotos*			R	O					
African Pygmy Goose	*Nettapus auritus*				R					
Red-billed Teal	*Anas erythrorhyncha*	O								
Southern Pochard	*Netta erythrophthalma*			O						
Honey Buzzard	*Pernis apivorus*									R
Black/Yellow-billed Kite	*Milvus migrans*				R					
African Fish Eagle	*Haliaeetus vocifer*			O	O					
Short-toed Eagle	*Circaetus gallicus*								R	
Bateleur	*Terathopius ecaudatus*				R				R	R
African Marsh Harrier	*Circus ranivorus*			F	F	F		O		O
Dark Chanting Goshawk	*Melierax metabates*									R

English Name	Species	Date (March 1999)								
		23 Mg	27 Mg	24 Nd	25 Nd	26 Nd	26 Sim	27 Lui	27 Sil	27 Lit
Gabar Goshawk	*Melierax gabar*			R	R					
Wahlberg's Eagle	*Aquila wahlbergi*				O		R			
Lesser Spotted Eagle	*Aquila pomarina*			R						
Long-crested Eagle	*Lophaetus occipitalis*				R					
Lesser Kestrel	*Falco naumanni*									O
Common Kestrel	*Falco tinnunculus*			R						
Red-billed Francolin	*Francolinus adspersus*			F						
Helmeted Guineafowl	*Numida meleagris*			O			O			
Red-chested Flufftail	*Sarothrura rufa*			R	R					
Black Crake	*Amaurornis flavirostris*			F	F					
Lesser Moorhen	*Gallinula angulata*			O	C	F				
Red-knobbed Coot	*Fulica cristata*	R								
African Jacana	*Actophilornis africanus*	C		C	C	C				
Kittlitz's Plover	*Charadrius pecuarius*								F	
Senegal Wattled Plover	*Vanellus senegallus*			F	F	F				C
White-crowned Plover	*Vanellus albiceps*	F								
Blacksmith Plover	*Vanellus armatus*			F	F	F				
Ethiopian Snipe	*Gallinago nigripennis*									R
Greenshank	*Tringa nebularia*								O	
Wood Sandpiper	*Tringa glareola*								O	
Grey-headed Gull	*Larus cirrocephalus*				R					
White-winged Black Tern	*Chlidonias leucopterus*			R						
African Mourning Dove	*Streptopelia decipiens*			C						
Cape Turtle Dove	*Streptopelia capicola*			F						
Red-eyed Dove	*Streptopelia semitorquata*			F						
Emerald-spotted Wood Dove	*Turtur chalcospilos*			F						
Schalow's Turaco	*Tauraco schalowi*			R						
Jacobin Cuckoo	*Clamator jacobinus*			R	O					
Striped Crested Cuckoo	*Clamator levaillantii*				R					
Emerald Cuckoo	*Chrysococcyx cupreus*				R					
Didric Cuckoo	*Chrysococcyx caprius*			R						
Coppery-tailed Coucal	*Centropus cupreicaudus*			C						
Senegal Coucal	*Centropus senegalensis*			O						
Burchell's Coucal	*Centropus superciliosus*			O						
African Scops Owl	*Otus senegalensis*			O	O					
Pearl-spotted Owlet	*Glaucidium perlatum*			R						
Barred Owlet	*Glaucidium capense*				R					
Fiery-necked Nightjar	*Caprimulgus pectoralis*				F		R			
Gaboon Nightjar	*Caprimulgus fossii*				C					

English Name	Species	Date (March 1999)								
		23 Mg	27 Mg	24 Nd	25 Nd	26 Nd	26 Sim	27 Lui	27 Sil	27 Lit
African Palm Swift	*Cypsiurus parvus*			F						
European Swift	*Apus apus*				O					
Malachite Kingfisher	*Alcedo cristata*			C						
Senegal Kingfisher	*Halcyon senegalensis*				R					
Giant Kingfisher	*Megaceryle maxima*			R						
Pied Kingfisher	*Ceryle rudis*			C						
Little Bee-eater	*Merops pusillus*			C						
White-cheeked Bee-eater	*Merops variegatus*								O	
Blue-cheeked Bee-eater	*Merops persicus*			F						
European Bee-eater	*Merops apiaster*				O		O			
Southern Carmine Bee-eater	*Merops nubicoides*			O			O			
Lilac-breasted Roller	*Coracias caudata*				O		O			
African Grey Hornbill	*Tockus nasutus*			O			C			
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*			O						
Black-collared Barbet	*Lybius torquatus*			R			O			
Cardinal Woodpecker	*Dendropicos fuscescens*			R			R			
Rufous-naped Lark	*Mirafra africana*						R			
Red-capped Lark	*Calandrella cinerea*								C	
Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*								O	
European Sand Martin	*Riparia riparia*			F						
African Sand Martin	*Riparia paludicola*			O						
Grey-rumped Swallow	*Pseudhirundo griseopyga*				O		O			
Red-breasted Swallow	*Hirundo semirufa*				R					
Wire-tailed Swallow	*Hirundo smithii*			F	R					
European Swallow	*Hirundo rustica*				O		C		F	F
Mountain Wagtail	*Motacilla clara*			F						
Richard's Pipit	*Anthus richardi*				O					
Fnlleborn's Longclaw	*Macronyx fuellebornii*									O
Rosy-breasted Longclaw	*Macronyx ameliae*									O
Black Cuckoo-shrike	*Campephaga flava*						O			
Common Bulbul	*Pycnonotus barbatus*			C			F			
Heuglin's Robin	*Cossypha heuglini*				C					
White-browed Scrub Robin	*Erythropygia leucophrys*				C					
Stonechat	*Saxicola torquata*			C						
Little Rush Warbler	*Bradypterus baboecala*			R						
Sedge Warbler	*Acrocephalus schoenobaenus*			C						
Reed Warbler	*Acrocephalus scirpaceus*						R			
Great Reed Warbler	*Acrocephalus arundinaceus*			O						
Greater Swamp Warbler	*Acrocephalus rufescens*			F						

English Name	Species	Date (March 1999)								
		23	27	24	25	26	26	27	27	27
		Mg	Mg	Nd	Nd	Nd	Sim	Lui	Sil	Lit
Icterine Warbler	*Hippolais icterina*			R			R			
Long-billed Crombec	*Sylvietta rufescens*			F			C			
Willow Warbler	*Phylloscopus trochilus*			F	R					
Garden Warbler	*Sylvia borin*			O	R		R			
Pale-crowned Cisticola	*Cisticola cinnamomeus*									F
Fan-tailed Cisticola	*Cisticola juncidis*			C					F	F
Desert Cisticola	*Cisticola aridulus*						F		O	O
Rattling Cisticola	*Cisticola chiniana*				O		C			
Greater Black-backed	*Cisticola galactotes*			F	F					
Chirping Cisticola	*Cisticola pipiens*			C	C					
Tawny-flanked Prinia	*Prinia subflava*			C						
Yellow-breasted Apalis	*Apalis flavida*			C			O			
Bleating Bush Warbler	*Camaroptera brachyura*			C			C			
Spotted Flycatcher	*Muscicapa striata*			R			O			
Chinspot Batis	*Batis molitor*			O			C			
Paradise Flycatcher	*Terpsiphone viridis*			O	O		O			
White-rumped Babbler	*Turdoides leucopygius*			C	C					
Collared Sunbird	*Anthreptes collaris*			O						
Amethyst Sunbird	*Nectarinia amethystina*						O			
White-bellied Sunbird	*Nectarinia talatala*			O			C			
Purple-banded Sunbird	*Nectarinia bifasciata*						R			
Coppery Sunbird	*Nectarinia cuprea*				O		O			
Yellow White-eye	*Zosterops senegalensis*						R			
African Golden Oriole	*Oriolus auratus*						O			
Eastern Black-headed Oriole	*Oriolus larvatus*						C			
Lesser Grey Shrike	*Lanius minor*			R						
Southern Puffback	*Dryoscopus cubla*						C			
Brown-headed Tchagra	*Tchagra australis*			O			O			
Black-crowned Tchagra	*Tchagra senegala*			O						
Swamp Boubou	*Laniarius bicolor*			O						
Orange-breasted Bush Shrike	*Malaconotus sulphureopectus*			O						
Grey-headed Bush Shrike	*Malaconotus blanchoti*			O						
White Helmet Shrike	*Prionops plumatus*						C			
Fork-tailed Drongo	*Dicrurus adsimilis*						O			
Pied Crow	*Corvus albus*			C						
Greater Blue-eared Starling	*Lamprotornis chalybaeus*			O	F					
Wattled Starling	*Creatophora cinerea*				F					
Grey-headed Sparrow	*Passer griseus*			O						
Spectacled Weaver	*Ploceus ocularis*			F						

English Name	Species	Date (March 1999)								
		23 Mg	27 Mg	24 Nd	25 Nd	26 Nd	26 Sim	27 Lui	27 Sil	27 Lit
Large Golden Weaver	*Ploceus xanthops*			F						
African Masked Weaver	*Ploceus velatus*			C	C					
Red Bishop	*Euplectes orix*			C						
Red-shouldered Whydah	*Euplectes axillaris*			C						
Brown Firefinch	*Lagonosticta rufopicta*			O						
Common Waxbill	*Estrilda astrild*			F						
Quail Finch	*Ortygospiza atricollis*			O			C			
Bronze Mannikin	*Lonchura cucullata*				O					
Village Indigobird	*Vidua chalybeata*			O	O					
Pin-tailed Widow	*Vidua macroura*			R	O					

Note: Sequence and nomenclature follows Dowsett & Forbes-Watson (1993), Checklist of the Birds of the Afrotropical and Malagasy Regions.

3.2 **August survey**

A checklist of the birds recorded from the area during the August 1999 survey is given as Table 4. Species seen are marked on a daily basis by locality. A total of 98 species were seen from all habitats, 69 species alone in the Luena sector.

In the Mongu sector big *Acacia* trees served as roosts for Great White Egret, Little Egret, Openbill Stork and Black Egret. The puddles and wet depressions attract a number of waterfowl, notably Wattled Crane (and ten Slaty Egrets on 22 Aug 1998).

Lake Makapaela, Lake Nalulao, Lake Liangandu and Lake Ngame were all visited with a view to establishing the importance of the remaining pans and to check on the current presence of the Great Crested Grebe (*Podiceps cristatus*) in the area. The grebes may have disappeared from the area east of Limulunga. Villagers confirmed there were no other wet pans north of the Lusaka-Mongu road. The area south of this road was explored in March and no grebes were found there either.

Lake Nalulao held only 700 White-faced Whistling Ducks (not shown in Table 4). The lake gives the impression of a gravel pit with no floating vegetation and barely any vegetation along the shoreline. The nearby twin Lake Liangandu is by far the most interesting of the lakes visited, including open water, floating vegetation and waterlilies, shallow grassy marsh, some *Typha* beds along southern shore, muddy areas, etc. A diversity of habitats may be found with a diverse avifauna. However, the lake was quite difficult to explore and all observations were made from the shoreline. There seem to be no threats to the birds, although fishermen are quite active on this lake and all cattle from the area come here to drink.

Several consecutive droughts had a severe impact on Lake Makapaela, Lake Ngame and several other pans in the area. Since 1983 water levels have gone down gradually. The lakes used to hold water for the whole year, but now Lake Makapaella and Lake Ngame are only partially filled in January-February. By August the lakes are dry again, in spite of good rains during the last two years.

The Luena sector holds an interesting combination of wetland birds. Relative to the rest of the Barotse floodplain, the sandbanks, lagoons and oxbows form a rich combination of habitats with an equally diverse avifauna. Skimmers, White-crowned Plover and Blacksmith Plovers were all found breeding in numbers. Most exciting was a possible breeding record of the Avocet (*Recurvirostra avocetta*). This constitutes only

the second record for Zambia. No eggs or young were seen, but it seemed clear one bird was sitting on eggs while the other one was chasing intruders.

It may safely be concluded that the western area of the Luena flats sector is disturbed by human activities during the drier part of the year. Although cattle are an important asset for the people of Barotseland, cattle ranching has had a clear impact on the plains ecosystem. Overgrazing, burning and, to a lesser extent, subsistence farming have all added to the degradation of wet and dry habitats. The Zambezi River edge seems to be the most valuable and vulnerable part in this sector. Therefore, conservation and education activities should concentrate on the islands and sandbanks in the Zambezi (which are breeding and feeding grounds for several species of waterfowl, including Avocet) and on lagoons along the Zambezi. From a conservation point of view, it would seem advantageous to concentrate cattle in certain areas and limit access to certain lagoons or specific access points. Although it is difficult to see how one would implement any measures taken, the matter needs to be looked at carefully if conservation of the river and lagoon habitats and ecological communities is to be achieved.

The eastern parts of the Luena Flats sector (the Luena Flats properly speaking) should be a priority for future exploration. This sector could well be the most exceptional in terms of birds, dragonflies and plants. Observations to date along the edges are promising. Furthermore, the physico-chemical conditions should warrant rare combinations of plants and animals. The area is difficult or impossible to access by boat or car during the greater part of the year – mid-September until November should be the best time. It is advisable to take a local guide along from the villages north of the Luena Flats.

Appendix 5.2 Table 4 Bird survey results from the West Bank, Barotseland, August 1999 (Paul Van Daele).

C Common F Frequent O Occasional R Rare
Mk Lake Makapaella Mg Mongu-Lealui Li Lake Liangandu
LNg Lake Ngame Lp West Luena - dry plains Ll West Luena - lagoons/oxbows
WL West Luena Z Zambezi islands/sandbanks SB S. Barotse plain

English Name	Species	Date (August 1999)								
		25	25	27	27	27	27	28	28	29
		Mk	Mg	Li	LNg	Lp	Ll	WL	Z	SB
Little Grebe	*Tachybaptus ruficollis*			F						
Reed Cormorant	*Phalacrocorax africanus*						C		A	C
Black-crowned Night Heron	*Nycticorax nycticorax*		R				F			
Common Squacco Heron	*Ardeola ralloides*		C				C		F	
Rufous-bellied Heron	*Ardeola rufiventris*		C						C	
Cattle Egret	*Bubulcus ibis*						C			
Black Egret	*Egretta ardesiaca*		C							
Little Egret	*Egretta garzetta*	F	A						O	O
Great White Egret	*Egretta alba*	F	C	F	F				F	
Purple Heron	*Ardea purpurea*			F						R
Grey Heron	*Ardea cinerea*		O						O	
Black-headed Heron	*Ardea melanocephala*		O	F					F	
Yellow-billed Stork	*Mycteria ibis*								O	
Openbill Stork	*Anastomus lamelligerus*		A							C
Marabou Stork	*Leptoptilos crumeniferus*					O				
Glossy Ibis	*Plegadis falcinellus*		F							

English Name	Species	Date (August 1999)								
		25	25	27	27	27	27	28	28	29
		Mk	Mg	Li	LNg	Lp	Ll	WL	Z	SB
Fulvous Whistling Duck	*Dendrocygna bicolor*	C	F	C			F			
White-faced Whistling Duck	*Dendrocygna viduata*			A						
Spur-winged Goose	*Plectropterus gambensis*			C						
Knob-billed Duck	*Sarkidiornis melanotos*			O						
Red-billed Teal	*Anas erythrorhyncha*	O							F	
Hottentot Teal	*Anas hottentota*			F					O	
Southern Pochard	*Netta erythrophthalma*			C						
Black-shouldered Kite	*Elanus caeruleus*			O						
Black/Yellow-billed Kite	*Milvus migrans*	F								F
African Fish Eagle	*Haliaeetus vocifer*			O					O	O
White-backed Vulture	*Gyps africanus*									R
Bateleur	*Terathopius ecaudatus*			O						F
African Marsh Harrier	*Circus ranivorus*		F	F						
Martial Eagle	*Polemaetus bellicosus*						R			
Lanner Falcon	*Falco biarmicus*					R				
Blue Quail	*Coturnix chinensis*							O		
Kurrichane Buttonquail	*Turnix sylvatica*								R	
Black-rumped Buttonquail	*Turnix hottentotta*			R						
Wattled Crane	*Grus carunculatus*		C							
African Jacana	*Actophilornis africanus*			C			F			
Black-winged Stilt	*Himantopus himantopus*								F	
Avocet	*Recurvirostra avosetta*								F	
Temminck's Courser	*Cursorius temminckii*					O		O		
Common Pratincole	*Glareola pratincola*							F	F	C
White-fronted Sand Plover	*Charadrius marginatus*								F	
Senegal Wattled Plover	*Vanellus senegallus*							O	F	
White-crowned Plover	*Vanellus albiceps*								C	
Blacksmith Plover	*Vanellus armatus*	R			O		C		C	
Crowned Plover	*Vanellus coronatus*							O		
Marsh Sandpiper	*Tringa stagnatilis*								R	
Greenshank	*Tringa nebularia*		O						A	
Wood Sandpiper	*Tringa glareola*	R							O	
Common Sandpiper	*Actitis hypoleucos*								O	
Sanderling	*Calidris alba*								O	
Little Stint	*Calidris minuta*								O	
Curlew Sandpiper	*Calidris ferruginea*								O	
Ruff	*Philomachus pugnax*								O	
Grey-headed Gull	*Larus cirrocephalus*								C	F
African Skimmer	*Rynchops flavirostris*								A	

English Name	Species	Date (August 1999)								
		25	25	27	27	27	27	28	28	29
		Mk	Mg	Li	LNg	Lp	Ll	WL	Z	SB
Laughing Dove	*Streptopelia senegalensis*							F		
Cape Turtle Dove	*Streptopelia capicola*							F		
Grey Lourie	*Corythaixoides concolor*							F		
Coppery-tailed Coucal	*Centropus cupreicaudus*			F			C			
Marsh Owl	*Asio capensis*						R		R	
Gaboon Nightjar	*Caprimulgus fossii*								C	
Pied Kingfisher	*Ceryle rudis*	F	F				F			
Little Bee-eater	*Merops pusillus*			C				F		
Swallow-tailed Bee-eater	*Merops hirundineus*							F		
Southern Carmine Bee-eater	*Merops nubicoides*									C
Rufous-naped Lark	*Mirafra africana*							O		
Red-capped Lark	*Calandrella cinerea*		O					O		F
African Sand Martin	*Riparia paludicola*								R	F
Grey-rumped Swallow	*Pseudhirundo griseopyga*									C
Lesser Striped Swallow	*Hirundo abyssinica*									C
White-throated Swallow	*Hirundo albigularis*									F
Richard's Pipit	*Anthus richardi*	F	C	C						F
Plain-backed Pipit	*Anthus leucophrys*					O				O
Rosy-breasted Longclaw	*Macronyx ameliae*			R						
Common Bulbul	*Pycnonotus barbatus*							F		
Stonechat	*Saxicola torquata*				C					F
Capped Wheatear	*Oenanthe pileata*									F
Little Rush Warbler	*Bradypterus baboecala*							F	F	
Lesser Swamp Warbler	*Acrocephalus gracilirostris*								F	
Long-billed Crombec	*Sylvietta rufescens*							F		
Fan-tailed Cisticola	*Cisticola juncidis*		O	R					C	F
Desert Cisticola	*Cisticola aridulus*									F
Greater Black-backed	*Cisticola galactotes*			R				F		O
Chirping Cisticola	*Cisticola pipiens*									O
Tawny-flanked Prinia	*Prinia subflava*									F
White-rumped Babbler	*Turdoides leucopygius*					F		F		
Marico Sunbird	*Nectarinia mariquensis*							R		
Swamp Boubou	*Laniarius bicolor*							F	F	O
Orange-breasted Bush Shrike	*Malaconotus sulphureopectus*							O		
Grey-headed Sparrow	*Passer griseus*							O		
Red-billed Quelea	*Quelea quelea*							F		
Red-shouldered Whydah	*Euplectes axillaris*							F		O
Red-billed Firefinch	*Lagonosticta senegala*							F		
Common Waxbill	*Estrilda astrild*									F

English Name	Species	Date (August 1999)								
		25 Mk	25 Mg	27 Li	27 LNg	27 Lp	27 Ll	28 WL	28 Z	29 SB
Blue Waxbill	*Uraeginthus angolensis*							F		
Locust Finch	*Ortygospiza locustella*							O		
Quail Finch	*Ortygospiza atricollis*			A						
Pin-tailed Widow	*Vidua macroura*							F		

Note: Sequence and nomenclature follows Dowsett & Forbes-Watson (1993), Checklist of the Birds of the Afrotropical and Malagasy Regions.

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CHAPTER 5 : APPENDIX 3
WETLAND BIRD SURVEY OF THE ZAMBEZI DELTA

Carlos Bento

1. INTRODUCTION

The delta of the Zambezi River where it spreads out before reaching the sea is internationally renowned for its species richness and productivity, and provides breeding, feeding and wintering grounds for many species of national and international concern. It supports at least 14 distinct vegetation communities ranging from papyrus swamps to *Borassus* palm savanna to dry forest. The delta is also vital to the Mozambican economy, providing a lucrative shrimp fishery, sugar production, transportation and many natural resources. Both the ecology and the economy of the delta are intricately linked to the flooding cycles of the Zambezi River.

Unfortunately, historical information on the diversity and abundance of waterbirds in the Zambezi Delta prior to 1990 is limited to a few observations recorded during aerial wildlife surveys, and anecdotal accounts from ecologists working in the study area. Maugham (1910) compiled a list of bird species observed during his travels up the Zambezi from Chinde. His observations include a large number of waterbirds, including the Grey Crowned Crane (*Balearica regulorum*), Saddlebilled Stork (*Ephipiorhynchus senegalensis)*, White Pelican *(Pelicanus onocrotalus*) and a variety of egrets and herons. There is only cursory information on waterbird abundance from riverside observations, however, and several questionable species records (e.g. the Blue Crane, endemic to South Africa and Namibia, is listed, perhaps mistakenly for the Wattled Crane) (Bento & Beilfuss 1999).

Early aerial surveys of the Marromeu Buffalo Reserve and surrounding coutadas or hunting areas (Tinley 1969, Tinley & Sousa Dias 1973) carefully recorded the distribution and abundance of mammal species but did not record waterbird observations, with the exception of large flocks of cattle egrets in association with buffalo herds. According to ecologist Paul Dutton (pers. comm. 1999), waterbird populations were so abundant in the 1960s and 1970s that even cursory counts could not be conducted in conjunction with mammal surveys. The Marromeu floodplains were abundant in waterfowl and fish-eating birds such as White Pelicans and Pink-backed Pelicans (*Pelecanus rufescens)* and several species of storks. Dutton participated in the final surveys of the delta following the large flooding event of March 1978 and prior to the advent of civil war, but no observations of bird species were reported (Tello & Dutton 1979).

During the height of civil war in Mozambique from 1980-1990, there were no wildlife surveys in the Zambezi Delta with the exception of a limited and inconclusive survey by Chambal (1989). There is thus no information on waterbird diversity or abundance for the first fifteen years after closure of Cabora Bassa Dam in 1975. The incredible decimation of wildlife populations during this period (Anderson *et al*. 1990), however, suggests that large edible waterbird species were likely to have been heavily persecuted during this period (Bento & Beilfuss 1999).

The present study provides information which could be used as support for the wise use of the natural resources of the delta, while maintaining its biological diversity.

1.2 Objectives

The principal objectives of the study were to: (a) compile annotated checklists of waterbirds from various representative sites in the Zambezi Delta; (b) present a report giving techniques used and evaluating the findings; and (c) indicating particular species or sites of interest.

As we were involved in a similar study looking at potential impacts of dam construction (described in Bento & Beilfuss 1999), many of the findings and sections are common to both reports.

2. STUDY AREA

The Zambezi Delta covers an area of about 18,000 km^2 from its apex at Chupanga to its 120 km front with the Indian Ocean coast from Quelimane southwest to Machesse. There are two distinct climatic seasons, a summer rainy season (approximately November to April), during which the climate is subhumid and hot, and a dry winter period (May to October), during which the climate is subarid and warm. The mean annual rainfall increases from 1000 mm near Chupanga to about 1200 mm at the coast, but there is considerable variation in its inter-annual and seasonal distribution. Evaporation is high, and for only a few months of the rainy season does rainfall approach or equal potential evapotranspiration. The most important influence on the hydrology of the delta is the seasonal floodwaters of the Zambezi River and its distributor channels, and perennial runoff from streams draining the Cheringoma plateau from the west.

3. METHODOLOGY

The species list has been compiled from observations made over 1995, 1996, 1997 (Beilfuss & Allan 1996) and from observations made in 1998 and 1999. Three methods have been used: (a) aerial surveys, (b) ground surveys (in coutadas 11, 10), and (c) boat surveys from Marromeu to Chinde along the Zambezi River in 1998 and 1999. We also include a checklist from observations made over 10 days in the Marromeu coastal area.

The aerial survey covered the entire Marromeu Buffalo Reserve and surrounding coutada floodplains (the Marromeu Complex) with 4 km-width transects running parallel to the coastline in an attempt to generate a complete count of large birds species in the area. During the survey, the team also noted large breeding colonies of White Pelicans, egrets and several species of storks. All species noted during the ground and boat surveys were noted.

For the terrestrial survey, more then four hours were spent each day for five days recording waterfowl on the Coutada 10 and 11 floodplains. Various species were not possible to identify owing to difficulties such as grass height and accessibility. Such species as Crake's Rail's and Flufftails were not recorded due to difficulties in walking over the floodplain to flush them.

Four boat surveys along the Zambezi (from Marromeu to Chinde) were carried out in October 1998 and July 1999, with recording from mid-morning to mid-afternoon. During these surveys several expected species were not noted, possibly owing to the extent of the area surveyed and limited vision with binoculars. At Pambane on Chinde island in July 1999 we surveyed several small channels among the mangroves for 3.5 hours using a small canoe. Possibly many waterbird species were missing from our observations owing to the difficulties of walking in this habitat.

For questionable bird calls, a recorded tape cassette (Common Birds Calls of Southern Africa) was used for confirmation.

4. SPECIES ACCOUNTS

Each species account provides follows the Robert's number, the English and scientific names, and details on status and numbers. South Africa Red Data Book status is also mentioned. A list of species seen at each locality is given in Table 1.

Appendix 5.3 Table 1 Lists of waterbird species seen at various localities in the Zambezi Delta.

Locality 1: Nhamagote Lake (Coutada 11), 18E25.08' S / 35E33.70' E, 20 June 1999
Locality 2: Nhamagote Lake (Coutada 11), 18E15.30' S / 35E42.49' E, 21 June 1999
Locality 3: Inhagoia, Nhapacue River (Coutada 11), floodplain, 18E33.87' S / 35E39.21' E, 26 & 28 June 1999
Locality 4: Missocossa River (Coutada 10), floodplain, 18E43.43' S / 35E42.45' E, 26 & 30 June 1999.

Species	**Locality**			
	1	2	3	4
Dabchick (*Tachybaptus ruficollis*)		X		
White Pelican (*Pelecanus rufescens*)				X
Reed Cormorant (*Phalacrocorax africanus*)			X	
Darter (*Anhinga melanogaster*)				X
Blackheaded Heron (*Ardea melanocephala*)			X	X
Goliath Heron (*Ardea goliath*)			X	X
Purple Heron (*Ardea purpurea*)	X			X
Great White Egret (*Casmerodius albus*)			X	X
Yellowbilled Egret (*Egretta intermedia*)	X		X	X
Cattle Egret (*Bubulcus ibis*)			X	
Squacco Heron (*Ardeola ralloides*)			X	X
Rufousbellied Heron (*Butorides rufiventris*)			X	
Little Bittern (*Ixobrychus sturmii*)				X
Hamerkop (*Scopus umbretta*)			X	X
Woolynecked Stork (*Ciconia episcopus*)	X		X	
Openbilled Stork (*Anastomus lamelligerus*)			X	
Saddlebilled Stork (*Ephippiorhychus senegalensis*)			X	X
Marabou Stork (*Leptoptilos crumeniferus*)				X
Yellowbilled Stork (*Mycteria ibis*)			X	
Sacred Ibis (*Threskiornis aethiopicus*)			X	
Hadeda Ibis (*Bostrychia hagedash*)			X	X
African Spoonbill (*Platalea alba*)				X
Whitefaced Duck (*Dendrocygna viduata*)				X
Hottentot Teal (*Anas hottentota*)	X			
Pygmy Goose (*Nettapus auritus*)	X			
Spurwinged Goose (*Plectropterus gambensis*)			X	X
Bateleur (*Terathopius ecaudatus*)			X	
Palmnut Vulture (*Gypophierax angolensis*)			X	
African Fish Eagle (*Haliaeetus vocifer*)			X	X
Wattled Crane (*Bugeranus carunculatus*)				X
Crowned Crane (*Balearica regulorum*)				X

Species	Locality			
	1	2	3	4
Lesser Gallinule (*Porphyrula alleni*)	X			
Lesser Moorhen (*Gallinula angulata*)		X		
African Jacana (*Actophilornis africanus*)	X	X		X
Lesser Jacana (*Microparra capensis*)	X			X
Blacksmith Plover (*Vanellus armatus*)			X	
Whitecrowned Plover (*Vanellus albiceps*)			X	X
Longtoed Plover (*Vanellus crassirostris*)			X	
Great Snipe (*Gallinago media*)				X
Blackwinged Stilt (*Himantopus himantopus*)				X
Pied Kingfisher (*Ceryle rudis*)			X	X
Malachite Kingfisher (*Alcedo cristata*)	X			X

49. White Pelican *Pelecanus onocrotalus*

Common resident and breeds in the delta. Nests in large, conspicuous colonies in the coastal mangrove and are very sensitive to disturbance (Dennis & Tarboton 1993). Dutton observed large numbers of this species feeding in the Zambezi Delta floodplains during the 1960s and 1970s. In recent years they have abandoned the dry floodplains of the Zambezi Delta and now feed on Lake Urema of Gorongosa National Park, but they continue to roost and breed in the coastal parts of the delta. The aerial surveys of March 1995, July 1996 and May 1997 show local movements into the delta (Beilfuss & Allan 1996). The White Pelican is listed in the South African Red Data Book as Rare (Brook 1984).

50. Pinkbacked Pelican *Pelecanus rufescens*

Uncommon resident and breeds in the delta. Dutton observed large numbers of this species feeding on the Zambezi floodplains during the 1960s and 1970s. In the recent years they have abandoned the dry floodplains of the Zambezi Delta and now feed in Lake Urema of Gorongosa National Park, but they continue to roost and breed in the coastal delta. A flock of up to 55 birds was recorded on sandbanks in the Zambezi close to Luabo during the boat survey in July 1999. The aerial surveys of March 1995, July 1996 and May 1997 show local movements into the delta (Beilfuss & Allan 1996). The Pinkbacked Pelican is listed in the South African Red Data Book as Rare (Brook 1984).

55. Whitebreasted Cormorant *Phalacrocorax carbo*

This species is common and resident in the delta, and has been seen flying along the Zambezi and at the coast in Chinde. Normally, single birds were seen, but flocks ranging from 20 to 30 individuals were recorded roosting on tidal sandbanks along the main channel of the Zambezi.

58. Reed Cormorant *Phalacrocorax africanus*

At least three large breeding colonies of this species were recorded on the Marromeu floodplain in reedbeds along small rivers. It is a common and resident bird and feeds in ponds and calm rivers in the delta.

60. Darter *Anhinga melanogaster*

During the boat survey from Marromeu to Chinde (October 1998) this species was very common in areas along the Zambezi influenced by the tide. Up to 700 birds were counted. Few individuals were recorded during the July 1999 boat survey, suggesting migratory movements to elsewhere in southern Africa (probably to the breeding grounds).

62. Grey Heron *Ardea cinerea*
Normally, solitary birds were recorded on coastal and inland shallow waters, also on floodplain pans and lagoons. In coastal areas during high tide they roost on mangroves.

63. Blackheaded Heron *Ardea melanocephala*
Few birds were recorded on open grassland floodplains feeding on fish and frogs.

64. Goliath Heron *Ardea goliath*
Common resident and breeds on the Zambezi floodplain. It often occurs singly, even in the breeding season. It is widespread in river reedbeds on the floodplain.

65. Purple Heron *Ardea purpurea*
Occurs solitary and is a common resident. Breeds in areas with dense reedbeds and other aquatic vegetation on the floodplain and along the Zambezi.

66. Great White Egret *Egretta alba*
A common and resident species in the Zambezi Delta. Breeds in dense reedbeds and papyrus vegetation. Several colonies (up to 80 pairs) were recorded along floodplain streams covered by vegetation. For most records they were associated with other egret species feeding on fish or frogs in ponds and large lagoons (some in woodlands).

67. Little Egret *Egretta garzetta*
Common resident species of the delta breeding in reedbeds. Feeds along small streams, perching in mangrove branches, and on shores of inland and marine waters. Large colonies (up to 100 individuals) of roosting birds were recorded at Pambane (Chinde) in mangroves during high tide.

68. Yellowbilled Egret *Egretta intermedia*
Common resident usually associated with other egrets in the breeding and feeding grounds on the floodplain, ponds and lagoons of the delta. In the mixed flocks of Little Egret, Great Egret and Cattle Egret (flock size 257 birds) in Coutada 11 (Inhagoia), 65 Yellowbilled Egrets were counted.

69. Black Egret *Egretta ardesiaca*
Although this species is considered common in the tropics (Maclean 1993), only two birds were observed during the May 1997 aerial survey.

71. Cattle Egret *Bubulcus ibis*
Common and resident in the delta. During the 1995, 1996 and 1997 aerial surveys, thousands of Cattle Egrets were recorded associated with buffalo and elephant herds (Beilfuss & Allan 1996).

72. Squacco Heron *Ardeola ralloides*
Very common resident in the delta. Is usually associated with reed or papyrus vegetation. They are easily mistaken for Little Egrets during the aerial surveys.

74. Greenbacked Heron *Butorides striatus*
Usually solitary at the Zambezi estuary, along mangroves and in the intertidal mud flats at Pambane and Chinde. Feeds on crustaceans.

76. Blackcrowned Night Heron *Nycticorax nycticorax*
Few birds were recorded on the Zambezi floodplain and large lagoons in the woodland area. A bird ringed in Romania was recovered in Mozambique (Maclean 1993), which suggests that some non-breeding Palaearctic migrants reach Mozambique and the delta.

81. Hamerkop *Scopus umbretta*
Usually solitary along the Zambezi and on the floodplains. During the March 1995 aerial survey, two birds were recorded (Beilfuss & Allan 1996). During the boat survey (Marromeu-Chinde) in 1998, eight birds were counted.

84. Black Stork *Ciconia nigra*
Uncommon on the Zambezi floodplain. Six birds were recorded during the March 1995 aerial survey (Beilfuss & Allan 1996). This species is listed in the South African Red Data Book as Rare (Brook 1984). Breeds in mountainous regions (Maclean 1993).

85. Abdim's Stork *Ciconia abdimii*
Uncommon non-breeding intra-African migrant. A flock of 30 birds were recorded on the Zambezi floodplain during the March 1995 aerial survey (Beilfuss & Allan 1996).

86. Woollynecked Stork *Ciconia episcopus*
Uncommon resident bird on the Zambezi floodplain and inter-tidal area. A flock of 12 birds were recorded during the boat survey. On the floodplain the they are usually seen following fires to feed on insects. Only 6 and 3 birds were recorded during the 1995 and 1996 aerial surveys, respectively, and 69 birds in 1997 (Beilfuss & Allan 1996). This species is listed in the South African Red Data Book as Rare (Brook 1984).

87. Openbilled Stork *Anastomus lamelligerus*
Common and resident in the Zambezi Delta. Large numbers concentrate in sandbars feeding on freshwater snails and mussels in the Lower Zambezi during the dry season (Beilfuss & Bento 1997). They feed in the shallow freshwater lakes in the coastal mangrove zone during the wet season (Bento 1999). During the 1995, 1996 and 1997 aerial surveys, 1896, 1500 and 534 birds, respectively, were recorded on the floodplain. During the boat surveys from Marromeu to Chinde along the Zambezi thousands of birds were counted. This species is listed in the South African Red Data Book as Rare (Brook 1984).

88. Saddlebilled Stork *Ephippiorhynchus senegalensis*
Common resident and breeds on the Zambezi floodplain and large lagoons in the woodlands. Usually they were observed in pairs, or a pair with chick. Sometimes flocks ranging from 4 to 7 birds were observed on the floodplain. During the 1995, 1996 and 1997 aerial surveys, 36, 7 and 31 birds, respectively, were recorded (Beilfuss & Allan 1996). This suggests local movement of the species in the delta. This species is listed in the South African Red Data Book as Rare (Brook 1984).

89. Marabou Stork *Leptoptilos crumeniferus*
Locally common and resident in the delta. Mostly in pairs on the floodplain, but were also seen gregarious in coutadas 11 and 14 around carcasses of mammals during the hunting season. During the aerial surveys of the Marromeu Complex, 52 birds were recorded in 1995 and 56 in 1997. Local people often confuse this species with the Wattled Crane. This species is listed in the South African Red Data Book and is considered a rare and vagrant species in South Africa (Brook 1984).

90. Yellowbilled Stork *Mycteria ibis*
Common resident and breeds in the delta. Approximately 500-1000 pairs were observed in a large breeding colony (Beilfuss & Bento 1997). Out of the breeding season, the species is widespread all over the floodplain and perched on trees in small flocks ranging from 2 to 5 birds. It is also common to see solitary birds feeding in the lagoons. In the 1995, 1996 and 1997 aerial surveys, 41, 14 and 96 individuals, respectively, were recorded. This species is listed in the South African Red Data Book as Rare (Brook 1984).

91. Sacred Ibis *Threskionis aethiopicus*
Common resident and usually seen in association with flocks of egrets in the southwest part of the floodplain during the ground survey. Hundreds of breeding pairs have been recorded in the Marromeu Complex (Beilfuss & Bento 1997). After the breeding season, the species is widespread within the delta and other areas. During the 1995, 1996 and 1997 aerial surveys, 35, 40 and 14 birds were observed.

93. Glossy Ibis *Plegadis falcinellus*
This species is common in the delta, usually observed in the wet grassland. Feeding flocks were associated with Spurwinged Goose in the Marromeu Complex. During the aerial surveys 73 birds were recorded in 1995, and 244 in 1997.

94. Hadeda Ibis *Bostrychia hagedash*
Very common and resident in the delta, often gregarious in groups of 2 to 7 birds. During the ground survey in Coutada 10, up to 900 birds were seen early in the morning travelling from roosting trees in woodland to the feeding grounds in the grassland area.

95. African Spoonbill *Platalea alba*
Common resident and breeds in the delta. Hundreds of breeding pairs have been recorded in the Marromeu Complex. During the aerial survey only 10 birds were recorded in 1997. This species might be underestimated because it can be easily mistaken with egrets from the air. A flock of up to 25 birds was observed during the boat survey from Marromeu to Chinde in July 1999. A few feeding birds were recorded on the floodplain in Coutada 10 in July 1999.

96. Greater Flamingo *Phoenicopterus ruber*
Common in the coastal areas of the delta. A flock of up to 900 flamingos was recorded during the inter-tidal survey at Chinde in October 1998 and in July 1999. More than 300 birds were recorded during the ground survey in Pambane near Chinde. 100 birds were counted during the boat survey (October 1998) from Marromeu to Chinde in a big lagoon along the main Zambezi River around 6 km from Chinde. During the aerial survey flamingos were not recorded because the flights did not cover the inter-tidal area. Fortunately, in 1999 we flew the inter-tidal area and a flock of around 1000 birds were observed.

97. Lesser Flamingo *Phoeniconaias minor*
Common in the coastal areas of the delta, normally associated with Greater Flamingos. More than 150 birds were counted in Chinde District. The population of Lesser Flamingos might be underestimated because of the difficulty in distinguishing the Greater from Lesser Flamingo when they are far away.

99. Whitefaced Duck *Dendrocygna viduata*
Common resident of the Zambezi floodplain. During the 1995, 1996 and 1997 aerial surveys, 57, 400 and 58 birds, respectively, were counted on the floodplain (Beilfuss & Bento 1997). Usually they are associated with small floodplain lagoons together with Fulvous Duck and Spurwinged Goose. Hundreds of Whiteface Duck were counted during the boat survey along the Zambezi River from Marromeu to Chinde in July 1999. The flocks range from 20 to 60 birds. More birds were recorded on the floodplain behind the mangroves (Bento 1999).

100. Fulvous Duck *Dendrocygna bicolor*
Common resident in the delta. During the 1995, 1996 and 1997 aerial surveys, 4, 15 and 230 birds, respectively, were counted on the floodplain (Beilfuss & Bento 1997). These numbers might be underestimated owing to difficulties in differentiating this species from Whitefaced Duck.

101. Whitebacked Duck *Thalassornis leuconotus*
Uncommon resident in the small lagoons protected by mangroves on the way to Pambane (Chinde). Six dispersed pairs were recorded feeding during the ground survey.

102. Egyptian Goose *Alopochen aegyptiacus*
Common and resident in the small lagoons on the Zambezi floodplains. During the aerial surveys only one individual was recorded due to difficulties in identifying the bird from the air. During the Marromeu-Chinde boat survey a group of 11 birds were recorded crossing the main river channel from the south to north banks.

108. Redbilled Teal *Anas erythrorhyncha*
Two birds were recorded during the November 1997 aerial survey. It is probable that the population was underestimated owing to difficulties in distinguishing the bird from the air. Three pairs were counted in Pembane (Chinde) along the small lagoons behind the mangroves.

113. Southern Pochard *Netta erythrophthalma*
Two pairs of this birds were observed diving in small lagoon on the Coutada 11 floodplain during the 1999 ground survey.

114. Pygmy Goose *Nettapus auritus*
It is a common and resident bird in the Zambezi Delta. Was only recorded from the ground survey in small floodplains lagoons and lagoons behind the Mangroves in Chinde. A total of 30 birds were recorded, usually in small flocks ranges from 2 to 4 birds (always in pairs). This species belongs to South African Red Data Book and is considered a Rare species (Brook 1984).

115. Knobbilled Duck *Sarkidiornis melanotos*
A common waterbird in the delta, nevertherless it disappears in certain seasons. During the aerial surveys 7 birds were counted in March 1995, and 3 in May 1997 (Beilfuss & Allan 1996).

116. Spurwinged Goose *Plectropterus gambensis*
A common and resident on the Zambezi floodplains including the riverine areas along the Zambezi River. During the aerial surveys made over the Marromeu Complex in 1995, 1996 and 1997, 101, 14 and 172 birds, respectively, were observed. Along the Zambezi sandbanks flocks ranging from 10-50 were observed.

146. Bateleur *Terathopius ecaudatus*
Common and resident on the Zambezi floodplain. Feeds on catfish in almost dry small lagoons. During the ground survey 15 birds were counted in Coutada 10. This species is listed in the South African Red Data Book as Vulnerable (Brook 1984).

147. Palmnut Vulture *Gypohierax angolensis*
Common on the floodplain boundary. A flock of 11 birds were recorded on palm trees in Coutada 10 during the ground survey. This species is listed in the South African Red Data Book as Rare (Brook 1984).

148. African Fish Eagle *Haliaeetus vocifer*
Common in the delta, particularly on the floodplain and by large lagoons where trees are available to perch on. In the coastal areas (Chinde) they are also common and perch on the mangroves. On large highly productive lakes in coutadas 11 and 10, more then two pairs of African Fish Eagle were counted.

165. African Marsh Harrier *Circus ranivorus*
Common resident usually observed on the floodplain. During the ground survey 17 birds were counted within a range of 4 km on the Coutada 11 floodplain.

207. Wattled Crane *Bugeranus carunculatus*
Common and resident on the Zambezi floodplain. During the 1995, 1996 and 1997 aerial surveys, 156, 60 and 179 birds, respectively, were recorded (Beilfuss & Allan 1998). Usually they are seen in pairs, or pair with a chick during the breeding season. This species is sensitive to human disturbance and its presence is used by the Maputo Museum and International Crane Foundation as an indicator for habitat changes in the delta. This species is listed in South African Red Data Book as Endangered (Brook 1984).

209. Crowned Crane *Balearica regulorum*
Common and resident on the Zambezi floodplain, normally on dry grassland. Usually they occur in pairs and are very territorial. During aerial surveys 25, 44 and 50 birds were counted in 1995, 1996 and 1997, respectively.

210. African Rail *Rallus caerulescens*
Common resident on medium and large lagoons in the woodland area and floodplains of the delta. During the ground survey 13 birds were counted, but the population is underestimated because the species is often hidden. They were more often heard than seen.

213. Black Crake *Amaurornis flavirostris*
Common resident on medium and large lagoons in the woodland area and on floodplains. The best time to count them was early in the morning before sunrise. During the ground survey 105 birds were counted in two lagoons in Coutada 11.

240. African Jacana *Actophilornis africanus*
Common resident in the lagoons and pans of the Zambezi floodplain. None of these birds were counted from the air during the aerial survey owing to their small size. From the ground a total of 1000 birds were counted in Coutadas 10 and 11.

241. Lesser Jacana *Microparra capensis*
The Lesser Jacana is common in areas where there is a less human disturbance, including fishing. On the floodplain 35 birds were counted, although this number might be an underestimate owing to its small size This species is listed in the South African Red Data Book as Rare (Brook 1984).

246. Whitefronted Plover *Charadrius marginatus*
Common resident in the coastal area on sand along the inter-tidal zones. In Chinde we counted 175 birds in 1998, and 670 birds in 1999. Usually they are in flocks of up to 7 but less than 30 individuals. They are gregarious at high tide and the flock size ranges from 100-250.

249. Threebanded Plover *Charadrius tricollaris*
Common resident in the coastal areas, with a few records on ponds on the floodplain. During the ground survey at Chinde, 23 birds were counted at low tide. The numbers are probably an underestimate.

254. Grey Plover *Pluvialis squatarola*
Common non-breeding Palaearctic migrant species. More then 350 birds were counted at Chinde from Pembane to Villa do Chinde. They are widespread in the inter-tidal area during low tide.

258. Blacksmith Plover *Vanellus armatus*
Common resident on small ponds in the floodplain. Usually in pairs or small flocks ranging from 3 to 5 birds. Also seen in burned grassland.

259. Whitecrowned Plover *Vanellus albiceps*
This species is associated with the larger river floodplains. On the road along the Zambezi towards Malingapanse 12 birds were recorded, and 25 on the Coutada 11 floodplain. This species is listed in the South African Red Data Book as Rare (Brook 1984).

260. Wattled Plover *Vanellus senegallus*
Common resident on the Zambezi floodplain. More then 70 birds were recorded during the ground survey on the coutada 10 and 11 floodplain. During the 1997 aerial survey 13 birds were counted.

261. Longtoed Plover *Vanellus crassirostris*
Common resident of the Zambezi floodplain. During the ground survey 6 pairs were counted and one pair in the lake near the Mungari Camp. During the 1995, 1996 and 1997 aerial surveys, 21, 3 and 4 birds were counted.

264. Common Sandpiper *Actitis hypoleucos*
Common non-breeding Palaearctic migrant. Solitary individuals were recorded along the Zambezi and streams in the floodplain and pans. Total count during the ground survey was 75 birds.

270. Greenshank *Tringa nebularia*
Common non-breeding Palaearctic migrant. Usually seen in the inter-tidal area in Chinde and sometimes in the estuary along branches of the Zambezi. In Chinde 560 birds were counted.

272. Curlew Sandpiper *Calidris ferruginea*
Common non-breeding Palaearctic migrant. Mainly occurs on mudflats. In Chinde 1050 birds were counted. Usually they feed in flocks ranging from 15 to 50 mixed with Sanderlings.

281. Sanderling *Calidris alba*
Common non-breeding Palaearctic migrant, observed in the inter-tidal area. A flock of 750 birds were counted in Chinde during high tide.

290. Whimbrel *Numenius phaeopus*
Common non-breeding Palaearctic migrant. The numbers are very high during the summer in the inter-tidal area and on muddy flats in mangroves. More then 900 birds were recorded in the coastal area of Chinde. Few birds overwinter in the delta in flocks ranging from 5 to 7 birds.

295. Blackwinged Stilt *Himantopus himantopus*
Common resident and breeds on the Zambezi floodplains. Flocks range from 2 to 6 birds. During the aerial survey in 1997 four birds were recorded from the air.

298. Water Dikkop *Burhinus vermiculatus*
Common resident in the delta, particularly along the small meanders in the mangrove. During the night we heard calling from the pans. Up to 25 birds were recorded by walking along the river edge to the mangroves in Pambane. A few birds were noted doing the short flight to the grassland close nearby.

304. Redwinged Pratincole *Glareola praticola*
A migrant species common at certain times of the year in the delta. During the 1998 boat survey 25 birds were counted roosting on the sandbanks along the Zambezi, while during the 1999 boat survey more then 2000 birds were observed feeding in the air along the river from the area called Bento to Luabo. This species is sensitive to water regime changes. It is listed in the South African Red Data Book as Rare (Brook 1984).

315. Greyheaded Gull *Larus cirrocephalus*
A common species especially in the coastal and estuarine area. Three birds were recorded during the aerial surveys in 1995, and 23 in 1997 (Beilfuss & Bento 1997). During the boat survey from Marromeu to Chinde up to 70 birds were counted. Usually this species is associated with fishery activities and follows fishermen's boats.

322. Caspian Tern *Hydroprogne caspia*
A flock of 13 birds was recorded in the Zambezi estuary during the inter-tidal waterbird survey along the Chinde coastline. This species is listed in the South African Red Data Book as Rare (Brook 1984).

324. Swift Tern *Sterna bergii*
Few individuals (around 10) were observed fishing along the Chinde coastline. It is considered common and resident.

332. Sooty Tern *Sterna fuscata*
Common resident in the delta coastal area. More then 10,000 birds were counted in Puga-Paga Island (Nampula-Angoche), where this species breeds. The presence of the Sooty Tern in the Zambezi Delta suggests that the species moves south after the breeding season.

338. Whiskered Tern *Chlidonias hybridus*
Common along the coastline of the Zambezi Delta. This species is nomadic and moves according to rainfall (Maclean 1993). A few flocks ranging from 5 to 7 birds were recorded on the floodplain along the Zambezi.

343. African Skimmer *Rynchops flavirostris*
Common intra-African migrant bird along the Zambezi and Pungue rivers. During aerial surveys 10 birds were counted in 1997, but none were seen during the boat surveys from Marromeu to Chinde. In South Africa this bird is considered Threatened.

428. Pied Kingfisher *Ceryle rudis*
Common resident all over the Zambezi Delta. During the boat survey from Marromeu to Chinde 55 birds were recorded. From the ground survey in coutadas 10 and 11, 17 birds were recorded. Two birds were counted from the air in 1997. They usually breed along the Zambezi.

429. Giant Kingfisher *Megaceryle maxima*
During the whole trip by boat (October 1998) from Marromeu to Chinde only 3 birds were counted. In following year, on the similar boat survey (July 1999), none were recorded.

431. Malachite Kingfisher *Alcedo cristata*
A total of 12 birds were recorded during the ground survey in coutadas 10 and 11 on floodplain ponds and small streams.

434. Mangrove Kingfisher *Halcyon senegaloides*
Common resident and breeds in the delta mangroves. During the ground survey (October 1998) 100 birds were counted at Chinde. This species is listed in the South African Red Data Book as Vulnerable (Brook 1984).

5. STATUS OF WATERBIRDS IN THE ZAMBEZI DELTA

A total of 73 species of waterbirds were observed during the aerial and ground surveys (Table 2). The aerial survey counts in March 1995 gave 33 waterbird species totalling approximately 5905 individuals. Counts of July 1996 gave 4399 individuals of 25 waterbird species, and 14,960 individuals of 42 waterbird species in May 1997. Aerial counts in 1998 and 1999 focused on accurate counts of the species of international concern and did not record total counts for the more abundant species such as egrets and herons.

The combined surveys reveal that the Zambezi Delta supports numerous Vulnerable and Threatened species of Global Concern, including the Wattled Crane, Grey Crowned Crane, African Skimmer (*Rynchops flavirostris*), White Pelican, Pinkbacked Pelican, Woolynecked Stork (*Ciconia episcopus)*, Openbilled Stork (*Anastomus lamelligerus)*, Saddlebilled Stork, Yellowbellied Stork (*Mycteria ibis)*, Black Stork (*Ciconia nigra)*, Redwinged Pratincole (*Glareola pratincola)* and Caspian Tern (*Sterna caspia)*. The delta supports colonies of thousands of pairs of White Pelicans among the coastal mangroves in the southeastern Marromeu Complex, one of the largest breeding colonies recorded in Southern Africa (Goodman 1992a, Beilfuss & Allan 1996). Three immense breeding colonies of storks and herons were also observed during the wet season surveys on the central Marromeu floodplains. The largest colony supports hundreds of pairs of Openbilled Stork, Yellowbellied Stork, Sacred Ibis (*Threskiornis aethiopicus*), African Spoonbill (*Platalea alba*) and three species of egrets (*Egretta* spp). Large breeding colonies of Reed Cormorant (*Phalacrocorax africanus)*, Squacco Heron (*Ardeola ralloides)*, Grey Heron (*Ardea cinerea)* and Blackheaded Heron (*Ardea melanocephala)* were also recorded (Beilfuss & Bento 1997). Large groups of migrant Abdim's Storks (*Ciconia abdimii*) utilize the delta grasslands in the wet season.

During the boat surveys from Marromeu to Chinde, thousands of Openbilled Stork (in groups ranging from 200-1000 individuals) were recorded in association with Glossy Ibis (*Plegadis falcinellus*) and Sacred Ibis on small sandbank islands along the main channel of the Zambezi. Large numbers of Reed Cormorants, African Darters (*Anhinga melanogaster*), Lesser Flamingoes (*Phoenicopterus minor*), Goliath Herons (*Ardea goliath*), Purple Herons (*Ardea purpurea*), African Spoonbills, White Pelicans, Pinkbacked Pelicans, Spur Winged Geese (*Plectropterus gambensis*), Sandwich Terns (*Sterna sandvicensis*) and Redwinged Pratincoles were observed. Many of these species were under-represented in the aerial surveys because of their small size or similarity to other species (for example, the comparison of aerial and boat surveys of Lake Urema,

Gorongosa National Park in Beilfuss *et al.* 1998). This is especially true for several duck species, including Whitefaced Ducks (*Dendrocygna viduata*) and Fulvous Ducks (*D. bicolor*), that typically did not flush during aerial surveys and could not be accurately counted.

Whimbrels (*Numenius phaeopus*), Greenshank (*Tringa nebularia*), Grey Plovers (*Pluvialis squatarola*), Curlew Sandpipers (*Calidris ferruginea*), Sanderlings (*C. alba*) and other migratory shorebirds were common on the coast near Chinde. A large flock of Lesser Flamingos was also observed. Whitebreasted Cormorants (*Phalacrocorax carbo*), Mangrove Kingfishers (*Halcyon senegaloides*) and Pygmy Kingfishers (*Ispidina picta*) were widespread in the coastal mangroves.

6. IMPACT OF WATER RESOURCES DEVELOPMENT ON THE ZAMBEZI DELTA

Over the past half-century, water resources development projects have greatly altered the hydrology of the Zambezi Delta. Prior to the construction of Kariba Dam on the Middle Zambezi River, peak floods inundated a mosaic of habitats in the 18,000 km^2 Zambezi Delta – flooding an area at times comparable in size to the Okavango Delta in Botswana (White 1993, Coppinger & Williams 1994). Maximum flow in the Lower Zambezi occurred in March-April, several months after maximum precipitation in the Upper and Middle Zambezi Basin. Low-lying floodplains were inundated with floodwaters for up to nine months of the year, and many areas were saturated throughout the dry season (SWECO 1983). With the closing of Kariba, the third largest dam in Africa, in 1959, approximately 54% of the total Zambezi runoff became regulated. The vast Lake Kariba reservoir now captures the transient minor flood (known locally as "gumbura") generated by local rainfall in the Middle Zambezi catchment, and effectively reduces and regularizes the major annual inundation ("murorwe") from the Upper Zambezi catchment area (Davies 1986). These hydrological impacts are further exacerbated by the damming of the Kafue River, the most important Zambezi tributary below Kariba Dam. More than 90% of the total Zambezi catchment runoff is now controlled by Kariba and Itezhi Tezhi Dams (RPT 1979, SWECO 1983).

Appendix 5.3 Table 2 Waterbird species numbers observed in the Zambezi Delta (categories Common and Uncommon follow Maclean 1993).

	no. species
Total waterbird species observed	73
Common species	45
Uncommon species	8
Rare species	20
Breeding species (confirmed)	28
South Africa Red Data Book species	17
Endangered species, breeding (confirmed)	11
Non-breeding palaearctic species	7

Despite these changes in the Zambezi's hydrological regime, the sheer volume of floodwaters reaching the Lower Zambezi continued to seasonally inundate the floodplains of the delta until the construction of the massive Cabora Bassa dam in 1975. With the closing of Cabora Bassa, the last vestiges of the ancient floodcycles of the Zambezi River have been nearly eliminated. Only four significant tributaries enter the Zambezi below Cabora Bassa dam, and of those, only the Shire River is perennial. Flooding events in the Zambezi Delta, when they occur, are now dependent upon local rainfall within the Lower Zambezi sub-catchment, or unplanned (possibly catastrophic) water releases from Kariba Dam (RPT 1979). The timing, magnitude, duration and sediment deposition of these floods now differ greatly from natural flooding conditions (Suschka & Napika 1990, Beilfuss & Davies 1999).

These hydrological changes are further exacerbated by the construction of dykes along the Lower Zambezi to protect the Sena Sugar plantations at Marromeu and Luabo. Dykes were set at the elevation of the 1924 flood peak and prevent floods of less than 12,000 m^3/s from inundating the Marromeu floodplains (Bolton

1983). Prior to that time, floods of 5000 m^3/s or more inundated the Marromeu Complex on an annual basis (RPT 1979). The railway line constructed between Marromeu to Inhaminga, and the road between Marromeu and Chupanga further impede drainage through several important distributor channels in the northwestern portion of the delta or Solane depression. The cumulative impact of these developments is a dramatic reduction in flooding on the south bank of the Zambezi during moderate flood years. The north bank sector of the delta has also undergone considerable drying since the 1960s, and is much drier than the south bank sector (Tinley 1994).

Over the past 23 years, overbank flooding of the Zambezi Delta has occurred only a few times, and the western portion of the Marromeu Complex is now fed primarily by silt-free runoff from local rainfall on the Cheringoma Plateau. Anderson *et al.* (1990) observed that the complex is much drier at the end of the dry season than under natural conditions, with a reduction in wetland and open water areas, infestation of stagnant waterways with exotic vegetation, and intrusion of saltwater. Beilfuss & Allan (1996) observed the Lower Zambezi River more than 2 m below bankful discharge in the delta during the period when peak floods historically occurred. The desiccation of the floodplain opened the area to aggressive poaching of wildlife species with a more than 90% reduction in buffalo, zebra, waterbuck, reedbuck, hippo and other important grazing species (Anderson *et al.* 1990). Grassland fires now consume more than 90% of the Zambezi Delta grasslands during the dry season.

Prior to the closing of Cabora Bassa dam, Tinley (1975) and Davies *et al.* (1975) predicted that the hydrological changes imposed by the dam would result in reduced fisheries productivity, reduced silt deposition and nutrient availability, salt water intrusion, replacement of wetland vegetation by dryland species, failure of vegetation to recover from grazing, and disrupted or mis-timed reproductive patterns for wildlife species. A few years later, Bernacsek and Lopez (1984) lamented:

> "It is clear that in the case of Cahora Bassa there was no serious attempt to ecologically optimize the dam prior to construction... furthermore, after dam closure, proposals put forward by the ecological assessment team were not implemented and there has been no regular monitoring of the dam's downstream effects during its lifespan. As a result, Cahora Bassa has the dubious distinction of being the least studied and possibly least environmentally acceptable major dam project in Africa."

In recent years, several studies have been initiated to assess aspects of these potential changes on the ecology of the Zambezi Delta (e.g. GERFFA's Gorongosa-Marromeu Mountain to Mangrove Project, GEMA's Mangrove Assessment Project and the International Crane Foundation–Museu de Historia Natural Zambezi Delta restoration project). Among the most significant and obvious changes observed over the past 40 years are the mass invasion of young *Borassus* palms into the open grassy floodplain, and the invasion of *Acacia* woodland into the older palm savanna associations. These changes are quantified elsewhere (Beilfuss, Vol 3 Chapter 13 of this report), and clearly have important implications for the waterbirds of the Zambezi Delta.

7. IMPACT OF HYDROLOGICAL AND ECOLOGICAL CHANGES ON WATERBIRDS

Although we lack historical data on the abundance and distribution of most waterbirds in the Zambezi Delta, it is clear that water resources development on the Zambezi River is resulting in widespread changes in the quantity and quality of many key waterbird habitats. These changes are especially significant for the many species that either depend on natural flooding cycles to meet their reproductive requirements (e.g. Wattled Cranes), depend on natural low flow periods in the Zambezi River for breeding (e.g. African Skimmer) or feeding (e.g. Openbilled Stork), or depend on the annual recruitment of fish prey in the delta floodplains (e.g. pelicans, many storks). Case studies of these species are presented below.

If present trends continue, species requiring vast expanses of open floodplain, seasonally flooded marshland or brackish mangrove are also vulnerable to the further dessication of the delta. At present, very few waterbird species occur in the northwestern portion of the south bank of the delta where the combined effects of dams and dykes are most marked. There are also very few waterbirds in the drier north bank portion of the

Zambezi Delta. The great majority of waterbirds are clumped in the southeast corner of the Delta where seasonal runoff from the Cheringoma escarpment still inundates the floodplains on an annual basis. There is very limited waterbird utilization of the active and abandoned agricultural and livestock grazing fields around Marromeu and Luabo villages. This may be due, in part, to local hunting pressures.

These changes to important waterbird habitats are exacerbated by other ecological changes in the delta, particularly the decrease in grazing species (e.g. buffalo, waterbuck, zebra) and wallowing species (e.g. hippo), and the increased frequency of grassland fires. Further expansion of the Sena Sugar Estates into reclaimed wetland areas also threatens disturbance-sensitive waterbird species.

8. SPECIES OF SPECIAL CONCERN

8.1 Wattled Crane

The Wattled Crane (*Bugeranus carunculatus*) is a Globally Endangered resident of sub-Saharan Africa, with a total population estimated at no more than 13,000-15,000 birds (Urban 1996). The vast majority (more than 95%) of the population occurs in south-central Africa in the floodplains and dambos of the Zambezi, Lower Zaire and Okavango River basins.

Goodman (1992b) estimated there were 2570 Wattled Cranes in the Marromeu floodplain during September 1990, one of the largest populations of Wattled Cranes ever reported. The birds were observed in pairs across the floodplain, although family groups were not reported. Repeating these survey routes during March 1995, we observed 156 Wattled Cranes in the Marromeu floodplain, including 58 pairs (74%) on territories. Only two observations were made of Wattled Cranes on nests, and no juveniles were observed in the population. Surveys during the normal time of peak Wattled Crane breeding yielded similar results. We observed 20 pairs and no juveniles in July 1996 and (with an expanded survey) 60 pairs and no juveniles in May 1997. Winter surveys in 1998 and 1999 revealed numerous pairs of Wattled Cranes with chicks in the southwest corner of the delta near the Cheringoma Plateau, and very few Wattled Cranes and no chicks in the core Marromeu floodplains affected by Zambezi flooding. Large non-breeding flocks were also observed in the southwestern coastal floodplains of the Marromeu Complex. Later in 1999 20 pairs of Wattled Cranes with nearly full-grown chicks were seen in this area. Although cranes are present in large numbers, repeated surveys have yielded no evidence of breeding success in the Wattled Crane population of the Zambezi floodplains. Only where natural hydrological conditions are maintained by Cheringoma runoff are the cranes successfully breeding.

In undisturbed floodplain systems elsewhere in Africa, the breeding cycle of Wattled Cranes is intimately linked to the natural flood cycles of rivers. Wattled Crane pairs are “triggered” to nest as floodwaters begin receding after peak flooding. Nesting in deep, open water after the major flood peaks ensures that nests will be protected from predators and wildfires but will not be drowned by further rising floodwaters. As floodwaters slowly recede, Wattled Cranes raise their single chick on the pulse of exposed plant and insect life (Konrad 1981).

With the present erratic and mis-timed flooding of the Lower Zambezi system, Wattled Crane pairs may not be induced to initiate nesting. Where nesting is attempted, unanticipated water level rises can drown nests and food sources. Rapid water level drawdown in the floodplains may expose nests to wildfires and predators and limit food availability. Observations from other disturbed systems support this explanation. On the Kafue Flats, Douthwaite (1974) observed that whereas 40% of Wattled Crane pairs attempt to breed in a year of normal flooding conditions, only 3% of all pairs breed in a year of negligible flooding conditions due to drought. When the hydrological regime of the Kafue Flats was altered by the Itezhi Tezhi Dam, Konrad (1981) predicted a dramatic reduction in Wattled Crane nesting sites and feeding area. Dodman (1996) observed limited breeding activity on the Kafue Flats in 1992 (a drought year) and 1993 (normal precipitation year). Based on these and other observations, and on our findings in the Lower Zambezi system, we anticipate a significant decline in the ageing Wattled Crane population of the Marromeu Complex unless hydrological conditions in the Lower Zambezi system are improved.

8.2 **African Skimmer**

The African Skimmer (*Rhynchops flavirostris*), now extinct in South Africa and restricted to a few river basins in southern Africa, occurs in small numbers in the Lower Zambezi. Two small flocks totalling 10 Skimmers were observed over Marromeu during aerial surveys in 1997, but no individuals were seen during boat surveys of the Lower Zambezi during 1998 and 1999. A census of the Upper and Middle Zambezi River yielded only 1428 birds. The global population is estimated at less than 10,000 birds (Zusi 1996).

The survival of the African Skimmer depends in large part on the rise and fall of water levels in large rivers such as the Zambezi (Coppinger *et al.* 1988). In large, unregulated rivers, water levels rise many metres during floodstage, conveying heavy loads of suspended silt from upstream. As floodwaters recede, the silt is deposited and sandbars are formed. African Skimmers nest and roost on these exposed, open sandbars. At present the sediment load of the Zambezi is trapped by Kariba and Cabora Bassa dams, and floodwaters in the delta are primarily derived from the silt-free rainfall runoff from the Cheringoma Plateau (Davies 1986). The sandbars used as nest sites for Skimmers and other species are no longer deposited downstream. Over time, older sandbars may become vegetated and abandoned by nesting waterbirds (Dennis & Tarboton 1993).

In the Middle Zambezi, this loss of sandbar habitat is exacerbated by unseasonable water releases from Lake Kariba. When water is released during the dry season, a metre high wave surges downstream, sweeping away nests of any birds using the low islands (Coppinger *et al*. 1988). In the Lower Zambezi, erratic water releases from Cabora Bassa are probably affecting populations in the Marromeu Complex as well. There were no observations of Skimmer nesting activity during dry season surveys. In addition, proposed dam development on the Pungwe River threatens the only other population of African Skimmers in Mozambique.

The African Skimmer, with its strong dependence on the ebb and flow of the Zambezi and its sediments, is an excellent indicator for the myriad of species that depend on the natural hydrological fluctuations of the Zambezi. The Redwinged Pratincole, with similar habitat requirements, is probably also threatened by river management.

8.3 **Openbilled Stork**

Openbilled Storks (*Anastomus lamelligerus*) concentrate in large numbers to feed on freshwater snails and mussels on the exposed sandbars of the Lower Zambezi during the dry season (Beilfuss & Bento 1997), and feed in shallow freshwater lakes in the coastal mangrove zone during the wet season. Regulation of the river has reduced flood peaks and increased dry season flows, resulting in fewer seasonally exposed sandbars and more permanently vegetated sandbar islands. At present, Openbilled Storks appear to be thriving in the Lower Zambezi system relative to other wetland areas in Africa (Dodman *et al.* 1998). However, further attempts to stabilize the Zambezi flow regime will greatly diminish the availability of sandbar habitats and threaten one of the largest populations of Openbilled Storks reported in Africa.

8.4 **White and Pink-backed Pelicans**

White Pelicans (*Pelecanus onocrotalus*) nest in large, conspicuous colonies in coastal mangroves and are very sensitive to disturbance (Dennis & Tarboton 1993). Floodwaters discharged from Cabora Bassa dam do not carry or deposit sufficient alluvial sediments to maintain the coastal delta in balance with the forces of coastal erosion, resulting in extensive seaward die-off of mangroves (Hughes & Hughes 1992). The shrinking density of coastal mangroves increases the susceptibility of pelicans to disturbance and will eventually force abandonment of the nesting colonies.

Dutton (pers. comm. 1999) observed large numbers of White and Pink-backed Pelicans feeding in the Zambezi Delta floodplains during the 1960s and 1970s. In recent years, pelicans have abandoned the dry floodplains of the Zambezi Delta and now feed in Lake Urema of Gorongosa National Park, although they continue to roost and breed in the coastal delta.

8.5 **Other waterbird species**

The fates of other waterbird species in the Marromeu Complex are also linked to hydrological changes in the Lower Zambezi. These impacts of these changes include the degradation of breeding habitats for some

species and the impoverishment of feeding grounds for others. As with pelicans, Saddlebilled Storks (*Ephippiorhynchus senegalensis*), Goliath Herons (*Ardea goliath*) and many other piscivorus waterbird species depend on concentrations of laterally migrating fish that are trapped in shallow floodplain depressions as floodwaters recede. Saddlebilled Storks nest at the end of the wet season, and fledge their chicks during the dry season when food is concentrated and easy to obtain (Hancock *et al.* 1992). Goliath Herons feed on large fish in lake edges and shallow waterbodies of the floodplain (Hancock & Kushlan 1984). Such species are now unable to utilize the vast areas of the Marromeu Complex that no longer receive overbank flooding sufficient for fish to migrate to floodplain spawning grounds from the main channel.

9. INDIRECT IMPACTS ON WATERBIRD SPECIES

In addition to changes in the quality and quantity of waterbird habitat, hydrological changes in the Zambezi system have also contributed to the decrease in grazing and wallowing mammals, and the increase in hot dry season fires across the delta. The dramatic decrease in the previously widespread buffalo, zebra, waterbuck and other grazing species has led to greatly reduced grazing pressure on the grassy floodplains (Tinley 1969, Anderson *et al*. 1990). Many species of waterbirds feed preferentially in recently grazed floodplains, and are unable to utilize the rank grasslands of large portions of the delta that remain ungrazed during the dry season. Wattled Cranes, for example, are closely associated with areas grazed heavily by lechwe in the Kafue Flats and Bangweulu Basin in Zambia (Konrad 1981, Kamweneshe 1996). Similarly, several species of ducks feed on waste seed and rhizomes in heavily grazed areas. The near elimination of hippo from the Zambezi Delta has also resulted in a loss of open water habitat maintained by wallowing activity. In the 1960s and 1970s, hippo were vital in maintaining open water conditions in many of the small distributor channels of the delta (Tinley 1977). These channels have been subsequently choked with floating and emergent vegetation, and no longer provide open water habitat for piscivorus birds. The desiccation of the delta has also resulted in increased fire frequency during the dry season. The traditional mosaic pattern of burned dry areas and unburned wet areas has given way to extensive fires across the grasslands (Anderson *et al*. 1990) which threaten grassland birds that nest in the standing vegetation (e.g. egrets, reed cormorants). The reduction in above-ground biomass resulting from widespread fires, however, may perhaps offset some of the waterbird habitat losses caused by low grazing pressure. There is no data available to quantify the impact of these indirect effects on waterbird diversity and abundance in the Zambezi Delta.

10. THE RAMSAR CONVENTION

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, known as the Ramsar Convention, was adopted in 1971. This convention provides a framework for international cooperation in the conservation of wetlands and the communities that serve, in part, as waterbird habitat. Nations that ratify the Convention agree to designate at least one wetland for inclusion in the List of Wetlands of International Importance, to promote the wise use of all wetlands and their resources, to stem the loss of wetlands where possible, and to promote the training of personnel in wetland management. The Ramsar Convention defines the wise use of wetlands as "sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem" (David 1993).

Wetlands are selected as Wetlands of International Importance on the basis of sound ecological, botanical, zoological, limnological and hydrological criteria. There are currently 893 wetlands in 104 nations worldwide on the list, with a total area of over 66.8 million ha (Dwight Peck, pers. comm. 1998). In Africa, 25 nations have ratified the Convention, including Zambia, Botswana, Tanzania, Malawi and South Africa. Within the Zambezi catchment, only the Okavango Delta and the Kafue Flats are designated Wetlands of International Importance.

The Zambezi Delta easily meets the criteria as a Wetland of International Importance under the Ramsar Convention. It supports at least 17 species of global concern, including the endangered Wattled Crane, endangered African Skimmer, White Pelican, Pinkbacked Pelican, Woolynecked Stork, Openbilled Stork, Sanddlebilled Stork, Yellowbellied Stork, Black Stork, Redwinged Pratincole and Caspian Tern. Eleven of the endangered species breed in the delta (Table 1). The delta also supports Globally Important breeding

colonies of resident pelicans, storks, herons and egrets, and provides summer feeding grounds for palaearctic migrant shorebirds and the inter-African migrant Abdim's Stork. At least seven palaearctic species and 28 breeding species have been recorded (Table 1), while other breeding species are still to be confirmed.

From among the many coastal wetlands of Mozambique, the Zambezi Delta is of the highest ecological value. The Inkomati, Limpopo, Sabie and Pungwe coastal floodplains are all vitally important for ducks and other waterbirds in Mozambique, but the size and diversity of the Zambezi Delta is unparalleled. It is an excellent example of the wetlands characteristic of the coastal zone of Mozambique, and it is part of a complex of high quality wetland habitats ranging from floodplain grasslands and papyrus swamps to mangrove estuaries. The Zambezi Delta has a substantial hydrological, biological and ecological role in the functioning of the Zambezi Basin and coastal system, and is a wetland of great socio-economic and cultural value. It is also part of the extensive Sofala Bank system, the most important prawn fishery in Mozambique. The fisheries sector contributes significantly to Mozambique's economy, accounting for 40% of GNP and US$55.4 million in revenue from the prawn fishery alone in 1996 (MICOA 1998).

The nomination of Marromeu as a Wetland of International Importance creates new opportunities for international awareness and ecotourism development, particularly in conjunction with ongoing efforts to link management and sustainable utilization of the Marromeu area with Gorongosa National Park to create an immense protected area system (DNFFB 1994). It creates a conservation network linking the Zambezi Delta with other major wetlands of the Middle and Upper Zambezi system, including the Okavango Delta and Kafue Flats and enables Mozambican resource managers to gain better access to training in wetland management and monitoring and funding for research.

11. CONCLUSIONS

The Zambezi Delta supports 73 species of waterbird, including numerous Vulnerable and Threatened species of Global Concern, large breeding colonies of several waterbird species, and numerous palaearctic and intra-African migrant species. There are 17 species that are considered Endangered in South Africa and 11 of them breed in the delta.

Total waterbird numbers in the Zambezi Delta have probably undergone a significant decrease over the past 30 years due to changes in the hydrological regime of the Zambezi River. Widespread changes in the quality and quality of waterbird habitat have been observed. The breeding success of endangered Wattled Cranes, an indicator species for natural flooding conditions, is very low in the Zambezi Delta relative to other floodplain wetlands in Africa. Piscivorus waterbirds such as pelicans and storks occur in very low numbers in the floodplains most affected by water resources development.

The Zambezi Delta qualifies as a Wetland of International Importance under the Ramsar Convention, and is of great socio-economic and cultural value to Mozambique.

12. SURVEY CONSTRAINTS

Because of the inaccessibility of the core swamp grassland areas of the Marromeu Buffalo Reserve, ground surveys were limited to the surrounding coutadas (10, 11 and 14), the riverine corridor from Marromeu to Malingapansi, and the coastline at Chinde. We were unable to gain access on foot to shallow marsh areas in the Delta to flush and expose species such as bitterns, small herons, rails, crakes and flufftails, many of which are of critical conservation concern. However, observations in wetland pans of the miombo woodland adjacent to the Zambezi Delta revealed Africa Rail (*Rallus caerulescens*), Lesser Jacana (*Micropara capensis*) and Black Crake (*Amaurornis flavirostris*), suggesting that these species are likely to be present in the shallow depression wetlands of the delta as well.

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CHAPTER 6
THE HERPETOFAUNA OF THE ZAMBEZI BASIN WETLANDS

Donald G. Broadley

6.1 INTRODUCTION

Herpetofauna – that is tortoises, lizards, snakes, crocodiles, amphisbaenians and amphibians – are a comparatively well studied group within the Zambezi Basin. A review of our knowledge on the distribution of those species considered to be always or frequently associated with wetlands will help towards an understanding of biogeographic patterns across the basin. Such a review is presented here as part of the BFA/Zambezi Society project on the assessment of wetland biodiversity of the Zambezi Basin for IUCN.

There are relatively few fully aquatic reptiles and amphibians, the principal ones being the crocodiles, terrapins, clawed frogs or platannas, and a few snakes which feed on fish and frogs. Many more species inhabit reed beds, swamps, floodplains and river banks, while others utilize dry floodplains and retreat to termitaria and adjacent woodland to escape rising floodwaters. There are three categories of wetland reptiles or amphibians that can be recognised:

a) Aquatic species like the terrapins, a few water snakes and the clawed frogs (*Xenopus*).
b) Species that inhabit stream banks, dambos or floodplains.
c) Widespread savanna species that move onto the floodplains as they dry out and retreat to emergent termitaria or the peripheral woodlands when the floodwaters return.

These criteria result in the recognition of 179 species in the wetlands of the Zambezi Basin proper. The only groups strictly excluded are rupicolous reptiles and amphibians and those amphibians that do not need open water for breeding purposes, i.e. *Probreviceps, Breviceps* and *Arthroleptis*.

Figure 6.1 (see page 333) shows the composite nature of the modern Zambezi Basin, a result of complex geological events during the Cainozoic era. The palaeo-Upper Zambezi formerly flowed south through the Kalahari to join the Limpopo River, and it was not until the late Pliocene or early Pleistocene that the Middle Zambezi captured the Upper Zambezi. The principal wetland areas are either along the Upper Zambezi and its former tributary, the Kafue–Chambeshi (including the Lake Bangweulu swamps), or on the Lower Zambezi and its major tributary, the Shire River. The Okavango Delta still has a tenuous link with the Upper Zambezi via the Magwegqana Spillway and the Linyanti/Chobe rivers, while the Pungwe Flats represent the old lower course of the Zambezi River.

6.2 MATERIALS AND METHODS

The taxonomy of the reptiles and amphibians has been revised, as far as possible, using the theoretical Evolutionary Species Concept (Mayden 1997), with the Phylogenetic Species Concept as the most important secondary concept. A phylogenetic species is defined as "the smallest population or group of populations within which there is a parental pattern of ancestry and descent and which is diagnosable by unique combinations of character states" (e.g. Cracraft 1997). In

practice this requires careful re-examination of currently recognised subspecies. Some of these prove to be segments of clines. For example, the snake taxon *Xenocalamus mechowii inornatus* Witte & Laurent was erected on the basis of its uniform black dorsum and high ventral scale count.

In a revision of the genus (Broadley 1971a), I pointed out that the colour pattern was very variable in this species, but retained *X. m. inornatus* as a southern subspecies on the basis of its higher ventral counts in both sexes, although intermediates were recorded from northwestern Zambia. As there seems to be gene flow throughout the extensive range of this species, I no longer recognise a subspecies *inornatus*. On the other hand, a proto-*Xenocalamus bicolor* colonised the southern Mozambique plain alluvium via the Limpopo Basin, and the eastern population was isolated by the subsequent erosion of the Kalahari sand cover from eastern Botswana. It was originally described as a "variety" *lineatus* Roux, based largely on colour pattern, but it also differs from *X. bicolor* in its very depressed narrow head and slender build. It is clearly a good evolutionary species.

Most of the available herpetological material from the Zambezi Basin has been examined by myself (reptiles) or John Poynton (amphibians). The collections involved are indicated by the following acronyms: AMNH – American Museum of Natural History New York; BMNH – British Museum (Natural History), London; FMNH – Field Museum of Natural History, Chicago; IRSNB – Institut Royal des Sciences Naturelles de Belgique, Brussels; MCZ – Museum of Comparative Zoology, Harvard; MNHN – Museum National d'Histoire Naturelle, Paris; MRAC – Musee Royal de l'Afrique Centrale, Tervuren; NMZB – Natural History Museum of Zimbabwe, Bulawayo; PEM – Port Elizabeth Museum; SMF – Senckenberg Museum, Frankfurt am Main; TM – Transvaal Museum, Pretoria; SMWN – National Museum of Namibia, Windhoek; USNM – United States National Museum of Natural History, Washington, DC; ZMB – Zoologisches Museum, Berlin.

Checklists of the herpetofauna have been compiled for 16 sites within the greater Zambezi Basin, and another four peripheral sites that demonstrate faunal links with the basin (Fig. 6.1 - page 333; Table 6.1- page 319 and Table 6.2 - page 281). To evaluate the intensity of sampling that has been carried out at these sites, the major collections and relevant literature are summarised below.

Zambezi Headwaters

An important collection of amphibians made in the Mwinilunga District of Zambia by Rolanda Keith was deposited in the AMNH and has been examined (Poynton & Broadley 1985-91). The first comprehensive collection of reptiles from the area was made in 1991 and deposited in the NMZB (Broadley 1991). The list of herpetofauna is still incomplete: for example, no pythons have been recorded. It is possible that the Northern African Python (*Python sebae*) crosses the watershed from the Congo Basin as it has been recorded about 50 km from the Zambian border.

Barotse Floodplains

Roux (1907) listed a few Barotseland specimens deposited in the Neuchâtel Natural History Museum and described the endemic species *Typhlacontias gracilis*. The French missionary Ellenberger collected material for the MNHN, which was reported on by Angel (1920, 1921). The most important collections were made by Richard Japp west of the Zambezi during the period 1962-1966. These were initially sent to the FMNH and subsequently to NMZB. These were included in the Zambian reptile checklist (Broadley 1971b). Table 6.1 suggests that Barotseland has the richest aquatic/flood plain herpetofauna in the Zambezi Basin with 89 species so far recorded. Recent fieldwork by the BFA in the area added nine species to the list (one new to science), and there may be others still to be found.

Table 6.2. Summary of species richness for reptiles and amphibians of wetland areas of the Zambezi Basin and outside (areas as in Table 6.1).

Wetland areas: Zhw - Zambezi headwaters; Bar - Barotse floodplains; Cho - Chobe/E Caprivi; Oka - Okavango Delta; Ban - Bangweulu swamps; Kaf - Kafue Flats; Kar - Lake Kariba; Chv - Lake Chivero; Nya - Nyanga National Park; MRP - Misuku/Rungwe/Poroto mountains; Nyk - Nyika Plateau; Mal - Lake Malawi shoreline; Mul - Mulanje Mountain; Chi - Lake Chilwa; LSh - Lower Shire valley; Del - Zambezi Delta; Pun - Pungwe Flats; Upe - Upemba swamps & environs; Mwe - Lake Mweru & Mweru Wantipa; Map - Maputaland; ZB - present-day Zambezi Basin total.

GROUP	**AREA**																				
	Zhw	**Bar**	**Cho**	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	**LSh**	**Del**	Pun	Upe	Mwe	Map	ZB
CHELONII (terrapins/tortoises)	2	**3**	**4**	3	2	4	3	4	1	0	0	6	0	2	**6**	**4**	4	3	3	6	10
SAURIA (lizards)	13	**19**	**13**	12	6	11	12	11	8	6	3	15	9	9	**14**	**12**	13	14	9	13	30
AMPHISBAENIA (worm-lizards)	1	**4**	**4**	2	1	1	3	1	0	0	0	0	0	0	**2**	**0**	2	1	1	0	9
SERPENTES (snakes)	22	**30**	**24**	22	21	18	22	20	21	10	3	27	22	15	**24**	**22**	25	17	22	26	55
CROCODYLIA (crocodiles)	0	**1**	**1**	1	1	1	1	10	0	0	0	1	0	1	**1**	**1**	1	1	2	1	1
AMPHIBIA (frogs & toads)	20	**32**	**28**	20	9	24	14	22	19	8	16	33	26	18	**26**	**22**	28	20	11	32	74
TOTAL	58	**89**	**74**	60	40	59	55	59	49	24	22	82	57	45	**73**	**61**	73	56	48	78	179

Chobe/Eastern Caprivi
The first specimens recorded from this area were obtained by V. FitzSimons on the Vernay-Lang Kalahari Expedition in 1930 (FitzSimons 1935). Additional material from the Caprivi accumulated in the TM, but major contributions were made by Richard Japp, who obtained long series of burrowing reptiles turned up by bulldozers working along the Caprivi/Zambia border west of Katima Mulilo. This material was sent to the Mutare Museum and subsequently transferred to the NMZB. Recently collected material is being channelled to the SMWN via the Directorate of Wildlife Conservation and Research.

Okavango Delta
Apart from a few specimens collected at Lake Ngami, the first herpetological collection from this region was made by V. FitzSimons in 1930 (FitzSimons 1935). A fair amount of material has accumulated in the NMZB, TM and USNM, and distributions have been mapped by Auerbach (1987).

Bangweulu Swamps
A small collection was made at Nsombo at the northern end of Lake Bangweulu by F. Haas in 1931 and deposited in the SMF. It was reported on by Mertens (1937), who described *Limnophis bangweolicus* from two specimens. Captain Charles Pitman collected in the southeastern swamps between the Lulimala and Lukulu Rivers during his faunal survey of Northern Rhodesia (Pitman 1934) and specimens were deposited in the BMNH. Pike (1964) recorded the Nose-horned Viper (*Bitis nasicornis*) and Jameson's Mamba (*Dendroaspis jamesoni*) from this area, but unfortunately the voucher specimens were destroyed in a fire. Only 40 species have been recorded from the Bangweulu swamps and floodplains, but as this region is a link between the Upemba and Kafue swamp/floodplain complexes, it is estimated that at least another 40 species should be present.

Kafue Flats
Material collected at Lochinvar by B.L. Mitchell in the 1950s is deposited in the NMZB. A provisional checklist of the herpetofauna of this national park was published by Simbotwe and Patterson (1983), voucher specimens being deposited in the Livingstone Museum. It is unfortunate that hardly anything has been collected from the Busango floodplain and Lukanga swamps north of the Kafue Flats, which may show links between the latter and the Bangweulu swamps.

Lake Kariba
Good samples of the herpetofauna were obtained when the lake was rapidly filling up in 1959, mainly by B.L. Mitchell on the Zambian side and Peter Taylor on the Zimbabwean side, the material being deposited in the NMZB. Reptile records for the Zimbabwean national parks bordering the lake were subsequently published (Broadley & Blake 1979). The Middle Zambezi is depauperate as regard to wetlands. The small floodplain habitat at Mana Pools is in decline due to the damming of the Zambezi at Kariba gorge, and the peripheral floodplains of the man-made lakes Kariba and Cabora Bassa are too young to have developed a herpetofauna typical of this habitat.

Lake Chivero
Being close to Harare, the herpetofauna of this Recreational Park has been quite well sampled since the dam was completed in 1952, most of the material being deposited in the NMZB. A checklist of the reptiles has been published (Broadley & Blake 1979) while the amphibians were covered by Poynton & Broadley (1985-1991).

Nyanga National Park
The first small collection from this area was reported on by FitzSimons (1958), the specimens being deposited in the TM. Subsequently material was collected by National Parks staff, R. Kroon and myself, the material being deposited in the NMZB (Broadley 1962). A checklist of the reptiles was subsequently published (Broadley & Blake 1979).

Misuku–Rungwe–Poroto Mountains
The earliest herpetological collections from the Misuku Mountains and Fort Hill [Chipata] were made by Alexander Whyte and presented to the BMNH by Sir H.H. Johnston (Boulenger 1897). In 1929 Mr & Mrs Rudyerd Boulton were attached to the Straus Central African Expedition and collected reptiles and amphibians on Rungwe Mountain, which were deposited in the AMNH; the snakes were reported on by Bogert (1940). These included the second specimen of *Lycodonomorphus whytii*. In 1930 Loveridge collected in the Ukinga, Rungwe and Poroto Mountains for the MCZ (Loveridge 1933) and in 1948 he spent a month camped at the edge of the Matipa Forest on the Misukus and made another important collection (Loveridge 1953a, 1953b). In 1970 an Umtali Museum expedition camped in the Mugesse Forest on the Misukus and made a comprehensive collection from the area (Broadley 1971c).

Nyika Plateau
The first collections from this area were made by Alexander Whyte and presented to the BMNH by Sir H.H. Johnston (Boulenger 1897), although many species listed for "Nyika Plateau" were probably taken at lower altitudes. In 1948-49 Loveridge made an important collection for the MCZ (Loveridge 1953a, 1953b). Further large collections made on both Malawian and Zambian sectors of the Nyika in 1962-64 were deposited in the NMZB (Stewart & Wilson 1966). An Umtali Museum expedition collected additional material on the plateau in 1970 (Broadley 1971c).

Lake Malawi Shoreline
Apart from a few specimens from Cape Maclear, the first significant collection from "Lake Nyassa" to arrive at the BMNH came from Alexander Whyte from the northwest coast between Nkhata Bay and Karonga (Boulenger 1897). In 1930 Loveridge spent 10 days collecting around Mwaya at the northern tip of the lake (Loveridge 1933) and in 1949 he spent a month collecting at Mtimbuka at the southern end (Loveridge 1953a, 1953b). In 1963-64 Margaret Stewart collected amphibians throughout Malawi, including the lake margins (Stewart 1967). In 1970 an Umtali Museum expedition collected herpetological material from Nkhata Bay northwards (Broadley 1971c).

Mulanje Mountain
The first herpetological collections from the "Shire Highlands" (Mts Zomba and Mulanje) were made by Alexander Whyte and sent to the BMNH by H.H. Johnston (Günther 1893, 1894). A few specimens were collected by the Vernay-Nyasaland expedition of 1946 and deposited in the AMNH, while larger collections made by Loveridge in 1948-49 went to the MCZ (Loveridge 1953a, 1953b). In 1962 and 1970 Umtali [Mutare] Museum expeditions to Malawi made important collections on Mulanje (Broadley 1963a, 1971c). Subsequently the local herpetofauna was well sampled by Andrew Stevens, who was based at the Chisambo Tea Estate close to the Mozambique border (Stevens 1974).

Lake Chilwa
Some Lake Chilwa specimens, especially *Pelusios castanoides,* were sent to the Albany Museum by B.L. Mitchell and have subsequently been transferred to the PEM. *P. sinuatus* probably does not

occur in the lake. The herpetofauna of the swamps and floodplain of Lake Chilwa is covered in the annotated checklists by Stevens (1974) and Dudley (1978).

Lower Shire Valley

The first specimens collected in this area were obtained by Dr Kirk while on the Livingstone expedition (Günther 1864). A collection made by the Berner-Carr Entomological Survey of the Shire valley in 1952 was deposited in the AMNH and reported on by Loveridge (1953c). The snakes of this area were covered by Sweeney (1961). Stevens (1974) subsequently published an annotated checklist covering the herpetofauna of southeastern Malawi.

Zambezi Delta

There are a few specimens in the BMNH collected by the Livingstone Expedition in 1858-63 at the "Zambezi mouth", but most of the material lacks precise locality data. During his Mozambique Expedition of 1843-47, Wilhelm Peters collected mainly along the coast and the Zambezi River upstream to Tete. Material from Quelimane, Boror and Chupanga, deposited in the ZMB, came from the margins of the delta. Unfortunately, many of Peters' specimens now lack precise locality data and are only catalogued as "Mossambique", while in other cases locality data appear to have been transposed (Peters 1854, 1882). A collection from the Zambezi Delta was made by the Zoological Society of London's Zambezi Expedition of 1927. Many specimens were sent back alive to the zoo, but some voucher specimens were deposited in the BMNH (Cott 1934, 1935). Despite a recent BFA expedition to the area, its herpetofauna remains poorly known.

Pungwe Flats

A few specimens from Beira are scattered in various museums, but the first important collections from the floodplain were made in November 1963 when two Umtali Museum expeditions collected many reptiles and amphibians from the open oil pipeline trench between Muda and Lamego and near Xiluvo (Broadley 1963b, 1964).

Upemba Swamps and Environs

These swamps are partially included in the northwestern sectors of the Upemba National Park, where an enormous collection of herpetological material was made by the "Mission G.F. de Witte" in 1946-49 and deposited in the IRSNB (Witte 1953, Laurent 1957, Schmidt & Inger 1959). This coverage provides a baseline sample of the wetland herpetofauna of the southeastern Congo Basin.

Lake Mweru and Mweru Wantipa

The alkaline swamps and floodplains of the Mweru Wantipa may have formerly been linked to the Bangweulu swamps via tributaries of the Chambeshi River. This area has a diversity of habitats because, while Lake Mweru has herbaceous swamps to the south of it, the Mweru Wantipa depression has halophytic swamps and floodplains. Important collections were made in the Mweru Wantipa by H.J. Bredo while Director of the International Red Locust Control Service at Mbala. These were deposited in the IRSNB with a few specimens going to the PEM. Bredo's snake collection was studied by Broadley & Pitman (1960). Subsequently more material was collected by D.F. Vesey-FitzGerald and donated to the BMNH, MCZ and NMZB. Material from the western shore of Lake Mweru deposited in the IRSNB and the MRAC was listed by Witte (1953).

Maputaland

This area of northern KwaZulu-Natal represents the southern limit of the Mozambique plain, limited by the Lebombo Range to the west and terminating at the St. Lucia Estuary. In this restricted area most of the East African savanna species reach the southern limit of their range. Annotated

checklists of the amphibia (Poynton 1980) and reptiles (Bruton & Haacke 1980) have been published, most of the voucher specimens have been deposited in the TM.

6.3 ZOOGEOGRAPHY

The investigation of the biodiversity of the wetlands of the Zambezi Basin has to take cognisance of the palaeogeography of the basin. The deposition of the Kalahari sands during the Tertiary and their subsequent erosion and redeposition on the east coast was responsible for the evolution and dispersal of amphisbaenians and various other burrowing reptiles. The palaeo-Upper Zambezi originally had a major tributary rising in northeastern Zambia, incorporating the present Chambeshi River and the Kafue River upstream of the Kafue Flats. This then joined the palaeo-Upper Zambezi via the Nanzhila and Sichifula rivers (Fig. 6.1). The palaeo-Zambezi was originally linked to the Limpopo Basin via the Motloutse River (Main 1987, Thomas & Shaw 1988, 1991), but the tectonic uplift of the Zimbabwe-Kalahari axis broke this connection and resulted in the formation of palaeo-Lake Makgadigkadi during the Pliocene. Lake Bangweulu was apparently formed when a tectonic uplift blocked the course of the Chambeshi; the lake itself was than captured by the Luapula River.

The basic approach to a zoogeographical study of the herpetofauna of the Zambezi Basin wetlands is that used by Poynton & Broadley (1991) in dealing with the amphibians of the Zambesiaca area. This requires the identification of discrete clusterings of species ranges using a quarter-degree grid (c.27 km on a side) for plotting distributions. Although the distributional data is now comprehensive enough to permit the general application of an evolutionary species concept (Mayden 1997), in some "difficult" groups, e.g. the *Hyperolius viridiflavus* complex, it is useful to retain the subspecies category pending the availability of more molecular data. Many 'subspecies' are either geographically well isolated or show very limited hybridisation where they are in contact, consequently these are now recognised as full species.

Twenty-three range clusters were identified. These are described below.

6.3.1 **Eastern Escarpment Range Clusters**

Five of the range clusters represent subdivisions of an Eastern Escarpment group, as follows:

Eastern Escarpment – South

Two species inhabit the well-watered temperate zone of South Africa, with relict populations on the eastern highlands and central watershed areas of Zimbabwe: the water snake *Lycodonomorphus rufulus* (Fig. 6.16) and the frog *Strongylopus fasciatus* (Fig. 6.24).

Eastern Escarpment – Zimbabwe

Two frogs, *Rana inyangae* and *Hyperolius swynnertoni broadleyi*, are endemic to the eastern highlands of Zimbabwe; the former has a sister species on Mulanje Mountain north of the Zambezi.

Eastern Escarpment – Trans-Zambezi

One water snake, *Lycodonomorphus mlanjensis*, occurs on the lower slopes of Mulanje Mountain and on the eastern highlands of Zimbabwe (Fig. 6.16), probably indicating a recent connection via riparian forest during a wetter climatic period.

Eastern Escarpment – Malawi

Five forms are near-endemic to the Malawi highlands. A snake, *Dipsadoboa flavida* (Fig. 6.17) and a frog, *Rana johnstoni,* are endemic to Mount Mulanje and the latter has a vicariant species on the

Nyanga highlands. A skink, *Eumecia johnstoni* (Fig. 6.8), and a sedge frog, *Hyperolius quinquevittatus mertensi,* are endemic to the Nyika Plateau. Another sedge frog, *Hyperolius marginatus albofasciatus,* has a wide range on the Shire Highlands of south Malawi, but also extends eastwards across the Niassa Platform in Mozambique.

Eastern Escarpment – North

Three species occur on the Malawi highlands, but are also found on the highlands of southwestern Tanzania. They are the water snake *Lycodonomorphus whytii* and the frogs *Strongylopus fuelleborni* (Fig. 6.24) and *Hyperolius pictus.*

Hyperolius spinigularis is at present known only from the foot of Mulanje Mountain and Amani in the eastern Usambaras, both areas with an exceptionally high rainfall. The species may eventually be found elsewhere in the Eastern Arc mountains, as the extensive Udzungwe range is poorly known.

6.3.2 Kalahari Sand Range Clusters

The next group of range clusters are associated with the Kalahari sands, which were deposited during the Tertiary period. They extended north to the Congo Basin, south to the Orange River and east to cover most of Zambia, Zimbabwe west of the Save River and the Northern Province of South Africa (Fig. 6.2 & Broadley 1978). As these sands were eroded away by the Zambezi, Save and Limpopo Rivers and their tributaries, the sand was redeposited as alluvium on the Mozambique Plain, forming an enormous bulge in the coastline between Beira and Maputo. While the palaeo-Upper Zambezi was linked to the Limpopo River, various amphisbaenians and their fossorial snake predators extended their ranges eastwards via the Limpopo riverine alluvium and became established in the coastal alluvium. The subsequent tectonic uplift of the Zimbabwe-Kalahari axis and the erosion of the Kalahari sand cover from eastern Botswana severed the connection between eastern and western populations, which have subsequently vicariated to become sister species.

Kalahari Fauna

There are three terrestrial species: the lizards *Mabuya punctulata, Gerrhosaurus auritus* (Fig. 6.9), and the snake *Naja anchietae,* which occur on the Barotse floodplain. The fossorial forms consist of a small skink *Typhlosaurus rohani* (Fig. 6.7), three amphibians, *Zygaspis quadrifrons* (Fig. 6.11), *Monopeltis mauricei* (Fig. 6.12) and *Dalophia pistillum* (Fig. 6.13), and two back-fanged snakes which are specialised predators on amphisbaenians, i.e. *Amblyodipsas ventrimaculatus* and *Xenocalamus bicolor* (Fig. 6.15). There are three vicariant species in the Mozambique Plain alluvium, extending back into the Limpopo basin, i.e. *Zygaspis vandami arenicola* Broadley, *Monopeltis sphenorhynchus* Peters (Fig. 6.12) and *Xenocalamus lineatus* Roux (Fig. 6.15). A large toad, *Bufo poweri*, is the only amphibian representative.

Barotse Endemics

Two fossorial skinks, *Typhlacontias gracilis* (Fig. 6.7) and *Typhlosaurus jappi* have vicariant species in the Kalahari, i.e. *T. rohani* (sympatric at Kalabo) and *T. lineatus* Boulenger respectively. The attenuated amphisbaenian *Dalophia ellenbergeri* is a near-endemic, with a single record from southeastern Angola (Fig. 6.13). *Rhamphiophis acutus jappi* is perhaps a specialized flood plain form: the typical form extends through miombo woodlands along the southern rim of the Congo Basin. The fossorial frog *Hemisus "barotseensis"* sp. nov. is a near-endemic, with a single record from the Kafue National Park.

Caprivi Near-endemics
The large amphisbaenian *Dalophia longicauda* has a restricted distribution centred on the Kalahari sands of the Caprivi Strip. It appears to be a sister species of *D. pistillum*, but the two forms are now sympatric in the Caprivi and the Hwange District of Zimbabwe (Fig. 6.13). *Ptychadena mapacha* is only known from the Katima Mulilo area.

Kafue Flats Endemics
Zygaspis kafuensis is only known from the margins of the Kafue Flats (Fig. 6.11) and *Hyperolius pyrrhodictyon* is a true endemic.

Palaeo-Upper Zambezi Fauna
An arboreal dwarf gecko, *Lygodactylus chobiensis*, is widespread in the Upper Zambezi area, but has extended its range into the middle Zambezi valley and its tributaries, reaching the eastern limit of its range at Tete (Fig. 6.6). A terrapin, *Pelusios bechuanicus* (Fig. 6.3), and two snakes, *Limnophis bangweolicus* (Fig. 6.19) and *Crotaphopeltis barotseensis* (Fig. 6.17) occur throughout the swamps, while the three amphibians, *Bufo lemairii* (Fig. 6.23), *B. kavangensis* and *Kassina kuvangensis* (Fig. 6.29) breed on the floodplains.

6.3.3 Savanna Range Clusters

The next group of range clusters involves wide-ranging savanna species.

Pan-African South of the Sahara
Six species occur throughout both tropical and temperate savannas from West Africa often to the southwestern Cape: the terrapin *Pelomedusa subrufa,* the monitor lizard *Varanus niloticus,* and the snakes *Bitis arietans, Crotaphopeltis hotamboeia*, *Dispholidus typus* and *Dasypeltis scabra.* Two other reptiles do not occur in temperate regions – the snake *Philothamnus semivariegatus* and the crocodile *Crocodylus niloticus.*

Northern Savanna
Twelve species range from the Sudanese savanna of West Africa south to the Zambezi Basin – the snakes *Naja nigricollis, Natriciteres olivacea* (Fig. 6.18) and *Dromophis lineatus* (Fig. 6.20), and the amphibians *Bufo maculatus, Hylarana galamensis* (Fig. 6.25), *Ptychadena oxyrhynchus, P. mascareniensis* (Fig. 6.26), *P. pumilio, P. schillukorum* (Fig. 6.26), *Phrynobatrachus acridoides, P.natalensis* and *Kassina senegalensis.*

Western Savanna
Eight species inhabit the lowland and plateau savannas of Angola and Namibia, with a subtraction margin eastwards. Many reach Malawi and the western Mozambique pedicle (to Tete), but rarely the Mozambique plain, often being replaced by a vicariant species. They are the lizards *Mabuya wahlbergii* and *Gerrhosaurus nigrolineatus* (Fig. 6. 9), the snakes *Rhinotyphlops schlegelii* (reaches the south Mozambique plain and Maputaland), *Philothamnus angolensis* (Fig. 6.21) and *Thelotornis oatesii,* and the frogs *Phrynomantis affinis, Tomopterna cryptotis* and *Hyperolius benguellensis.*

Southern Savanna
The frogs *Xenopus laevis* and *Pyxicephalus adspersus* have their centre of distribution in temperate South Africa, but have extensive subtraction margins in plateau areas to the north.

Central Plateau Savanna

Twelve taxa have distributions centred on the plateau and highland areas of central Africa: the tortoise *Kinixys spekii,* the lizards *Mabuya megalura* (Fig. 6.7), *Lygosoma sundevallii, Panaspis* "*maculicollis"* sp. nov. and *Ichnotropis capensis*, the snakes *Psammophylax variabilis* and *Philothamnus heterolepidotus* (Fig. 6.22), and the frogs *Rana angolensis, Cacosternum boettgeri, Leptopelis bocagii* (Fig. 6.28), *Hyperolius alborufus* and *Hyperolius kivuensis*.

East African Savanna

One third of the taxa recorded from the Zambezi Basin wetlands belong to a relatively young fauna, which in many cases inhabits the coastal plain from southern Somalia to Maputaland, with a variable subtraction margin westwards. These consist of three terrapins – *Pelusios subniger* (Fig. 6.3), *P. castanoides* (Fig. 6.4) and *P. sinuatus* (Broadley 1981); the tortoise – *Kinixys belliana*; 14 lizards – *Acanthocercus atricollis, Agama mossambica, A. armata, Chamaeleo dilepis, Lygodactylus capensis, Hemidactylus mabouia, Mabuya boulengeri, M. varia, M. striata, Lygosoma afrum, Panaspis wahlbergii, Gerrhosaurus major, G. flavigularis,* and *Latastia johnstoni,* one amphisbaenian – *Chirindia swynnertoni*; 23 snakes – *Rhinotyphlops mucruso, Leptotyphlops scutifrons, Python natalensis, Causus rhombeatus, C. defilippii, Amblyodipsas polylepis, Aparallactus lunulatus, A. capensis, Elapsoidea boulengeri, Naja annulifera, N. mossambica, Lycophidion c. capense, Dipsadoboa aulica, D. flavida broadleyi* (Fig. 6.17)*, Psammophylax tritaeniatus, Rhamphiophis a. acutus; R. rostratus, Psammophis mossambicus, Meizodon semiornata* (Fig. 6.19), *Prosymna stuhlmannii, Philothamnus hoplogaster, P. punctatus* and *Thelotornis mossambicana*; and 26 amphibians – *Xenopus muelleri, Bufo gutturalis, B. garmani, Phrynomantis bifasciatus; Hemisus marmoratum, Pyxicephalus edulis, Tomopterna marmorata, Hildebrandtia ornata, Ptychadena anchietae, P. porosissima, P, uzungwensis* (Fig. 6.27)*, P. mossambica, Phrynobatrachus mababiensis, P. parvulus, Chiromantis xerampelina, Leptopelis mossambicus* (Fig. 6.28)*, Kassina maculata* (Fig. 6.29), *Afrixalus brachycnemis, A. crotalus, A. fornasinii, Hyperolius tuberilinguis, H. argus, H. mitchelli, H. pusillus, H. nasutus* and *H. marmoratus taeniatus*.

Angolan Highlands Eastwards

The 26 taxa in this group have ranges centred on the Angolan highlands, with an eastwards subtraction margin which extends into southeastern Tanzania. There is a terrapin – *Pelusios nanus* (Fig. 6.3); five lizards – *Lygodactylus angolensis, Mabuya ivensii* (Fig. 6.12)*, Eumecia anchietae* (Fig. 6.8), *Chamaesaura miopropus* (Fig. 6.10) and *Gerrhosaurus bulsi* (Fig. 6.9); two amphisbaenians – *Zygaspis nigra* (Fig. 6.11) and *Dalophia angolensis* (Fig. 6.13); seven snakes – *Causus bilineatus, Elapsoidea semiannulata* (Broadley 1998), *Lycophidion multimaculatum* (Broadley 1996), *Natriciteres bipostocularis* (Fig. 6.18), *Limnophis bicolor* (Fig. 6.19), *Rhamphiophis a. acutus* and *Philothamnus ornata* (Fig. 6.22); and 11 amphibians – *Xenopus petersii, Hemisus guineensis microps, Hylarana darlingi, H. lemairei, Ptychadena subpunctata* (Fig. 6.25), *P. grandisonae, P. upembae, P. guibei, Leptopelis parbocagii* (Fig. 6.28), *Hyperolius q. quinquetaeniatus* and *H. angolensis*.

Congo Basin

Seven species have ranges centred on the savannas of the southern Congo Basin. They are the lizard – *Tetradactylus ellenbergeri* (Fig. 6.10); three snakes – *Xenocalamus mechowii* (Fig. 6.15), *Grayia ornata* and *G. tholloni*; and three amphibians – *Ptychadena obscura, Afrixalus wittei* and *Hyperolius melanoleucus.* The Slender-snouted Crocodile, *Crocodylus cataphractus,* can be included here, but it also extends through the forested areas of the Congo Basin and West Africa.

East African Coastal Forest
Two frog-eating snakes are more or less restricted to forested or formerly forested areas of the Mozambique plain. The marsh-snake *Natriciteres sylvatica* (Fig. 6.18) is very common on tea estates and *Philothamnus natalensis* (Fig. 6.22) survives the destruction of forest and coastal bush. The Forest Cobra, *Naja melanoleuca,* has a wider range and occurs throughout equatorial forests from West Africa to Kenya and south to Maputaland; it is often semi-aquatic. The two amphibians, *Leptopelis flavomaculatus* and *Hyperolius puncticulatus*, are more restricted to a forest habitat and ascend to quite high altitudes on the eastern escarpments.

Lower Zambezi
Six taxa have distributions centred on the Lower Zambezi. These are the Flap-shelled Turtle *Cycloderma frenatum* (Fig. 6.5); two snakes – *Proatheris superciliaris* (Fig. 6.14) and *Lycodonomorphus obscuriventris* (Fig. 6.16); and three frogs – *Hemisus guineensis broadleyi, Leptopelis broadleyi* and *Afrixalus delicatus.* An undescribed species of *Dromophis* (Branch, in prep.) from the north Mozambique coast may belong here, if its proves to be present in the Zambezi Delta.

Pungwe Flats Near - Endemic
Leptotyphlops pungwensis is only known from the Pungwe Flats (Broadley & Wallach 1997) and the distribution of *Lycophidion nanum* seems to be centred on this area (Broadley 1996).

Middle Zambezi
Monopeltis zambezensis is endemic to the Middle Zambezi Valley (Fig. 6.12). *Bufo beiranus* has a strange distribution, apparently centred on the mid-Zambezi Valley but extending west to the Barotse floodplains and east to the Pungwe Flats and southern Malawi. *Hyperolius m. marginatus* also has a distribution centred on the mid-Zambezi Valley, but extends up the Luangwa Valley into western Malawi and Mozambique.

Lake Malawi North Shoreline
A single reed frog, *Hyperolius nyassae*, is endemic to this region, being replaced southwards by *H. m. marginatus*.

6.4 HERPETOFAUNA DESCRIPTIONS

Below are given brief annotated accounts of the species found in the wetlands of the Zambezi Basin.

REPTILIA
TESTUDINES
PELOMEDUSIDAE
Pelomedusa subrufa (Bonnaterre 1789) Helmeted Terrapin
This species occurs throughout sub-Saharan Africa and southwestern Arabia [PAN]. In South Africa it occurs in permanent rivers and grows to a large size, but throughout the rest of its range, due to competition with *Pelusios* spp., it is restricted to swamps and ephemeral pans, stunted in size and buries itself in the mud to aestivate. It is omnivorous, but feeds mainly on insects, tadpoles and frogs.

Pelusios nanus Laurent 1956 Dwarf Hinged Terrapin
This is the smallest species of hinged terrapin (the anterior portion of the plastron is hinged and can be raised to protect the laterally withdrawn head and the forelimbs). Its distribution extends from the Angolan Highlands round the southern rim of the Congo Basin to Lake Tanganyika and northern Zambia (Fig. 6.3) [ANG]. It is an inhabitant of small clear water streams.

Pelusios subniger (Bonnaterre 1879) Pan Hinged Terrapin
This is an 'old' species which is represented by populations on Madagascar and a sister species on the Seychelles. It has a wide range in southeast Africa, extending north to Burundi and Tanzania, south to northern KwaZulu-Natal and west to the Okavango Delta (Fig. 6.3) [EAS]. Like *Pelomedusa*, this small species is an inhabitant of swamps and ephemeral pans.

Pelusios bechuanicus FitzSimons 1932 Okavango Hinged Terrapin
This large species is endemic to the clear waters of the palaeo-Upper Zambezi system (Fig. 6.3) [PUZ] but has a sister species, *P. upembae* Broadley 1981, just across the Zambezi-Congo watershed. The very large head has diagnostic yellow markings. The diet includes invertebrates and fish.

Pelusios castanoides Hewitt 1931 Yellow-bellied Hinged Terrapin
This is another 'old' species with populations on Madagascar and a sister species on the Seychelles. It inhabits the lagoons of the Mozambique plain from southern Kenya south to Maputaland, extending inland to Lake Chilwa and the lagoons and swamps bordering Lake Malawi (Fig. 6.4) [EAS]. It feeds largely on aquatic snails.

Pelusios rhodesianus Hewitt 1927 Zambian Hinged Terrapin
The distribution of this moderate-sized species seems to be centred on the southern rim of the Congo Basin, but extends north to Uganda and south to E Zimbabwe (Fig. 6.4) [PUZ]. There are also relict populations in Maputaland and on Durban Bluff, evidence for the former link between the palaeo-Upper Zambezi and the Limpopo. This species inhabits swamps and weed-choked lakes, being common in Lake Chivero near Harare.

Pelusios sinuatus (A. Smith 1838) Serrated Hinged Terrapin
This is the largest species of the genus, attaining a shell length of 46.5 cm in Lake Tanganyika. It has a wide range in E Africa from Somalia south to KwaZulu-Natal and west to the rift valley [EAS]. It is common in the Middle and Lower Zambezi and their tributaries, but above the Victoria Falls it seems to be restricted to muddy backwaters, while *P. bechuanicus* occurs in the mainstream Zambezi. It is not known upstream from Kazungula. This species feeds mainly on snails and molluscs and is preyed upon by crocodiles.

TRIONYCHIDAE

Cycloderma frenatum Peters 1854 Zambezi Flap-shelled Turtle
This large species (females can attain a shell length of 56 cm) occurs in rivers and lakes of East Africa from the Rufiji system in Tanzania south to the Save River in Mozambique. It is particularly abundant in the shallow waters of southern Lake Malawi (Fig. 6.5) [LZ] and fossil remains have been found in N Malawi. Its upstream distribution in the Zambezi River is blocked by the Cabora Bassa rapids. It feeds largely on bivalves and snails and could profitably be introduced into the man-made lakes of Kariba and Cabora Bassa. Both eggs and adults are eaten by man.

TESTUDINIDAE

Kinixys spekii Gray 1863 Speke's Hinged Tortoise

In this genus the rear portion of the carapace is hinged and can be closed down to protect the hind legs and tail. This species has a wide range on the central African plateau from S Kenya south to the northern provinces of South Africa (Broadley 1992) [CPS]. It has a depressed shell, which enables it to take shelter in rock crevices. It is usually active in the early morning, late afternoon or after rain. Its catholic diet consists largely of millipedes, snails and carrion.

Kinixys belliana Gray 1831 Bell's Hinged Tortoise

This species has a relatively domed shell with a black radial pattern on each carapacial shield. It occurs on the East African coastal plain from Somalia south to KwaZulu-Natal, and extends westwards through Uganda and Cameroon to Senegal. It also occurs in southern Malawi and SE Zimbabwe (Broadley 1992) [EAS]. Although occurring in moister habitats, the ecology is similar to that of the previous species.

SQUAMATA

AGAMIDAE

Acanthocercus atricollis (A. Smith 1849) Southern Tree Agama

This large arboreal agama has a wide range throughout East African savannas from Ethiopia south to KwaZulu-Natal [EAS]. The usual habitat is the trunks of large trees, including palms. Its diet includes a wide range of insects and its habit of descending to the ground to feed on alate termites makes it vulnerable to predators.

Agama mossambica Peters 1854 Mozambique Agama

This moderate-sized agama is found from Tanzania south to central Mozambique, extending inland to Malawi and eastern Zimbabwe [EAS]. It is often found foraging on the ground, but is most often seen basking on the trunks of palms and other trees.

Agama armata (Peters 1854) Tropical Spiny Agama

This small, terrestrial agama inhabits savannas from Tanzania south to KwaZulu-Natal and west to Zambia, the Caprivi and E Botswana [EAS]. It is cryptically coloured and is easily overlooked unless it moves. It may climb into low bushes or low down on tree trunks to bask, but it takes refuge in burrows. The diet consists largely of ants.

CHAMAELEONIDAE

Chamaeleo dilepis Leach 1819 Flap-necked Chameleon

This common chameleon has an enormous range throughout East Africa, south to N Namibia, Botswana and northern parts of South Africa [EAS]. Its main habitat is savanna woodland, where it feeds on grasshoppers and other insects, but also moves into reedbeds and papyrus. It is heavily preyed upon by raptorial birds and snakes, especially the boomslang and vine snake.

GEKKONIDAE

Lygodactylus angolensis Bocage 1896 Angolan Dwarf Gecko

This species has a patchy distribution in WC Africa and is the common species around Lake Kariba, where it often shares house walls with *L. chobiensis* [ANG].

Lygodactylus capensis (A. Smith 1849) Cape Dwarf Gecko
This is the common species of dwarf gecko throughout most of SE Africa (Pasteur 1964) and its range is constantly being expanded by accidental transportation in the form of eggs stuck in crevices of packing crates, furniture or caravans [EAS]. It is basically arboreal, but may also be found in reedbeds.

Lygodactylus chobiensis FitzSimons 1932 Chobe Dwarf Gecko
This is a relatively robust dwarf gecko, the males having forward directed black chevrons on the throat (sometimes solid black). They are common on trees and house walls in the Okavango Basin and along the Zambezi from Barotseland downstream to Tete (Fig. 6.6) [PUZ]. It is the southernmost species of the *L. picturatus* complex and appears to be a derivative of the widespread West African species *L. gutturalis* (Bocage), which ranges south through the eastern DRC to the Upemba National Park and Pweto at the northern end of Lake Mweru (Pasteur 1964).

Hemidactylus mabouia (Jonnés 1818) Tropical House-Gecko
This moderate-sized arboreal gecko has a cosmopolitan distribution covering most of East Africa, Madagascar and the east coast of C and S America [EAS]. Because it has become a commensal of man it is rapidly expanding its range through accidental transportation of eggs. It emerges at night onto house walls to feed on insects.

SCINCIDAE
Typhlacontias gracilis Roux 1907 Barotse Burrowing Skink
This small limbless skink lives beneath leaf litter in Kalahari sand regions of Barotseland northwards to Kabompo (Fig. 6.7) [BAR]. It largely replaces *T. rohani* on the Barotse floodplain.

Typhlacontias rohani Angel 1923 Kalahari Burrowing Skink
This small skink is hard to distinguish from the previous species, and they are sympatric at Kalabo (Haacke 1997). It occurs in NE Namibia, N Botswana, NW Zimbabwe, SE Angola and adjacent Zambia west of the Zambezi (Fig. 6.7) [KAL]. This sand swimmer forages just below the surface of the sand at night, when it is relatively cool, feeding mainly on termites and beetle larvae.

LYGOSOMATINAE
Mabuya boulengeri Sternfeld 1911 Boulenger's Skink
This slender long-tailed skink inhabits savannas from S Tanzania south to C Mozambique and E Zimbabwe (Fig. 6.7) [EAS]. It may bask on tree trunks, but is more frequently found on horizontal logs, in leaf litter (especially bamboo), in reeds along streams or climbing around in long grass (Broadley 1974). Oviparous.

Mabuya ivensii (Bocage 1879) Ivens' Skink
This large elongate skink has a restricted range, extending from the Angolan highlands to the headwaters of the Zambezi (Fig. 6.12) [ANG]. It lives along streams and may take to the water to elude predators. The diet consists largely of beetles and grasshoppers (Branch & Haagner 1993).

Mabuya megalura Peters 1878 Grass Skink
This slender long-tailed skink ranges from Ethiopia south to C Mozambique (Fig. 6.7) [CPS]. The only specimen from south of the Zambezi was found asleep at night clinging to long grass in the middle of a dambo. Viviparous.

Mabuya punctulata (Bocage 1872) Speckled Skink
This small terrestrial skink has a distribution centred on the Kalahari, but extends west across Namibia to SW Angola, north to Barotseland and east through the Limpopo Basin to S Mozambique [KAL]. They may have burrows at the bases of bushes or take refuge under logs. In some parts of the range they are rupicolous (Broadley 1975). Viviparous.

Mabuya varia (Peters 1867) Variable Skink
This moderate-sized terrestrial skink has a wide range from the Sudan south to the E Cape Province and west to Namibia [EAS]. It is common from sea level to mountain top and takes refuge under rocks and logs or in thick vegetation. Most populations are viviparous.

Mabuya striata (Peters 1844) Striped Skink
This medium-sized arboreal skink ranges through East Africa from Ethiopia south to KwaZulu-Natal [EAS]. It is a commensal of man and rapidly moves onto bridges and buildings soon after construction. It feeds mainly on insects, but small lizards are sometimes devoured. Viviparous.

Mabuya wahlbergii (Peters 1869) Wahlberg's Skink
This form replaces *M. striata* in savannas west of Tete, its range including Zambia, N Zimbabwe, N Botswana, most of Namibia and S Angola [WS]. It is particularly common on mopane trees.

Eumecia anchietae Bocage 1870 Anchieta's Skink
This large, elongate, and very long-tailed skink has a range extending from the Angolan highlands around the southern rim of the Congo Basin to W Kenya (Fig. 6.8) [ANG]. There are only two or three digits on the vestigial forelimb and three on the hindlimb. This species uses serpentine locomotion to traverse its swamp or dambo habitat. Viviparous.

Eumecia johnstoni (Boulenger 1897) Johnston's Skink
This skink is known only from the holotype, collected on the Nyika Plateau by Alexander Whyte (Fig. 6.8) [EEM]. It differs from the previous species in having only one toe on the forelimb and two on the hindlimb, and also lacks the distinctive striped body pattern of *E. anchietae*.

Lygosoma afrum (Peters 1854) Mozambique Writhing Skink
This large skink has a range extending from the S Sudan and Ethiopia south to Inhambane in Mozambique [EAS]. The vestigial limbs are pentadactyle. It is found under detritus on sandy soils. Oviparous.

Lygosoma sundevallii (A. Smith 1849) Sundevall's Writhing Skink
The distribution of this moderate-sized skink seems to be centred on the Kalahari, extending west to S Angola and N Namibia, east to W Mozambique and north to Kenya [CPS]. They shelter under rocks and logs on sandy soils feeding on small insects, especially termites. Oviparous.

Panaspis wahlbergii (A. Smith 1849) Wahlberg's Snake-eyed Skink
This small species ranges through East Africa from Ethiopia south to KwaZulu-Natal [EAS]. Breeding males are bright orange below. This skink is common in leaf litter in moist savanna and feeds largely on termites. Oviparous.

Panaspis "maculicollis" sp. nov. Spotted-neck Snake-eyed Skink
This very small skink replaces the previous species throughout W Mozambique, most of Zimbabwe, Botswana, the Caprivi and W Zambia [CPS]. Males have a black patch on the side of the neck

bearing several white spots, in the breeding season the orange ventral colouration is restricted to chin and throat. The species usually inhabits dry savanna and is found under rocks and logs.

Typhlosaurus jappi Broadley 1968 Barotse Blind Legless Skink
This robust legless sand swimmer is endemic to Barotseland west of the Zambezi [BAR]. It is yellow with two broad black dorsal stripes which fade out on the tail. The type series was exposed by graders during road construction.

CORDYLIDAE
Chamaesaura miopropus Boulenger 1894 Zambian Snake-Lizard
This serpentiform lizard has vestigial monodactyl fore- and hind-limbs and ranges from Angola east through S DRC, N Zambia and Malawi to S Tanzania (Fig. 6.10) [ANG]. It usually inhabits montane grassland, but three gravid females were caught in a few square metres of thick grass on the banks of a small tributary of the Kafue River near Chingola.

GERRHOSAURIDAE
Gerrhosaurus major Duméril 1851 Rough-scaled Plated-Lizard
This large robust lizard (up to 56 cm in total length) ranges from S Ethiopia south to KwaZulu-Natal and west to the Hwange District of Zimbabwe [EAS]. It is tawny above, with or without black streaks which become more pronounced posteriorly, and bright yellow below. This lizard takes refuge in burrows, derelict termitaria or rock crevices. Omnivorous, the diet includes soft fruits and flowers, insects, millipedes and smaller lizards. Oviparous.

Gerrhosaurus nigrolineatus Hallowell 1857 Black-lined Plated-Lizard
This large, but more slender, species ranges from Gabon south to N Namibia and eastwards to Uganda, Kenya, Tanzania, Malawi, W Mozambique, Zimbabwe and the northeastern provinces of South Africa (Fig. 6.9) [WS]. It is often sympatric with *G. flavigularis* in the eastern portion of its range. Reddish brown above with black-bordered yellow dorso-lateral stripes, the flanks are suffused with bright orange. These big lizards take refuge in rodent burrows or termitaria. The diet consists largely of grasshoppers, beetles and millipedes.

Gerrhosaurus auritus Boettger 1887 Kalahari Plated-Lizard
This large species inhabits the Kalahari, extending west into N Namibia, east to the Hwange National Park and north to Barotseland (Fig. 6.9) [KAL]. Juveniles show ragged dorso-lateral stripes like the previous species, but these fade out in the adults. The ecology is similar to that of the previous species.

Gerrhosaurus bulsi Laurent 1954 Spiny-tailed Plated-Lizard
This large robust species (up to 56 cm in total length) is distinguished by the very spinose scales on the tail. Juveniles have similar colouration to the previous species, but adults are uniform grey-brown. This species ranges from NE Angola to SE DRC (Fig. 6.9) [ANG]. These lizards are abundant in the N Mwinilunga District of Zambia, where they take refuge in burrows.

Gerrhosaurus flavigularis Wiegmann 1828 Yellow-throated Plated-Lizard
This lizard has an enormous range from the Sudan and Ethiopia to the SW Cape and west to E Namibia [EAS]. This relatively small slender species is readily distinguished by the smooth soles of the feet. It has a pair of black-bordered yellow dorso-lateral stripes like *G. nigrolineatus*, but the dorsum is olive brown and the flanks darker, sometimes with irregular yellowish vertical bars

(flanks sometimes orange in eastern specimens). It is common along streams and will take to the water to escape predators.

Tetradactylus ellenbergeri (Angel 1922) Ellenberger's Long-tailed Seps
This small serpentiform species ranges from the Angola highlands through S DRC and N Zambia to SW Tanzania (Fig 6.10) [COB]. It seems to frequent rank vegetation on floodplains and dambos.

LACERTIDAE
Latastia johnstoni Boulenger 1907 Malawi Long-tailed Lizard
This sand lizard ranges from C Tanzania through SE DRC, E Zambia and Malawi to the western Mozambique pedicle, it inhabits dry savanna and floodplains [EAS].

Ichnotropis capensis (A. Smith 1838) Cape Rough-scaled Sand Lizard
This medium-sized sand lizard ranges from southern Angola and NE Namibia to Zambia, S DRC, Botswana, Zimbabwe, northeastern parts of South Africa and S Mozambique [CPS]. It lives in burrows under bushes on sandy substrates. This is an 'annual' species – eggs are laid in November/December and hatch in January/March; few adults survive into their second year.

VARANIDAE
Varanus niloticus (Linnaeus 1766) Nile Monitor
This is the largest African lizard and it is ubiquitous throughout the savannas [PAN], being replaced in the rainforests by *V. ornatus* (Daudin). An aquatic species, its diet consists largely of crabs and mussels, but also includes insects, millipedes, and any vertebrate that it can catch, together with the eggs of crocodiles and terrapins, which are dug out of the nests.

AMPHISBAENIA
These blind burrowing reptiles construct burrow systems in sandy soils and feed on small invertebrates that fall into them.

AMPHISBAENIDAE
Zygaspis kafuensis Broadley & Broadley 1997 Kafue Round-snouted Worm-Lizard
This moderate-sized species is only known from the margins of the Kafue Flats (Fig. 6.11) [KAF].

Zygaspis nigra Broadley & Gans 1969 Black Round-snouted Worm-Lizard
This large and robust species occurs in E Angola, Zambia west of the Zambezi and the E Caprivi (Fig. 6.11) [ANG]. Most specimens have been exposed by bulldozers or graders working in Kalahari sand. This species is sympatric with several other amphisbaenians, including *Z. quadrifrons.*

Zygaspis quadrifrons (Peters 1873) Kalahari Round-snouted Worm-Lizard
This small species ranges from Namibia eastwards through Botswana, S DRC, Zambia and Zimbabwe to C Mozambique (Fig. 6.11) [KAL]. It feeds largely on termites and may be found in shallow burrows under rocks, logs or leaf litter.

Chirindia swynnertoni Boulenger 1907 Swynnerton's Round-snouted Worm-Lizard
This very small and slender species occurs in C Mozambique and SE Zimbabwe, also S Tanzania, mainly in miombo woodland, but also on floodplains in the Urema trough [EAS].

Monopeltis zambezensis Gans & Broadley 1974 Zambezi Wedge-snouted Worm-Lizard
This slender species is endemic to the Middle Zambezi Valley from Chete Gorge east to the Kanyemba area (Fig. 6.12) [MZ]. In the Dande Safari Area it is sympatric with *Zygaspis quadrifrons* and *Dalophia pistillum.*

Monopeltis mauricei Parker 1935 Western Slender Wedge-snouted Worm-Lizard
This very slender species is endemic to the Kalahari, extending north to the Kafue National Park and east into the Hwange District of Zimbabwe (Fig. 6.12) [KAL]. It has a vicariant species, *M. sphenorhynchus* Peters, in the Limpopo Basin. The diet includes termites (*Odontotermes*), ants and beetles.

Dalophia ellenbergeri (Angel 1920) Barotse Pestle-tailed Worm-Lizard
This genus is distinguished by its relatively long tail terminating in a callus pad, which seems to be used to block the end of its burrow to entry by carnivorous ants. This very slender species ranges from Barotseland (where it is sympatric with *D. pistillum*) into SE Angola (Fig. 6.13) [BAR]. When the Zambezi floodwaters inundate the Barotse floodplain, the amphisbaenians retreat to emergent termitaria or the fringing woodland (Owen, pers. comm.).

Dalophia angolensis Gans 1976 Angolan Pestle-tailed Worm-Lizard
This species is endemic to E Angola, with a single specimen recovered from the stomach of a snake (*Xenocalamus mechowii*) collected on the Zambezi River just inside Zambia (Fig. 6.13) [ANG].

Dalophia pistillum (Boettger 1895) Zambezi Pestle-tailed Worm-Lizard
This large species (maximum length 63 cm) has a wide, but patchy distribution extending from the extreme south of Angola and NE Namibia east through Botswana, Zambia and Zimbabwe to C and N Mozambique, with isolated records from northern regions of South Africa (Fig. 6.13) [KAL]. Although it inhabits Kalahari sand regions, it also tolerates harder substrates, as in the northern districts of Zimbabwe. The diet includes adult and larval beetles, termites (*Allodontermes* and *Hodotermes*), ant larvae and pupae (*Camponotus* sp.).

Dalophia longicauda (Werner 1915) Okavango Pestle-tailed Worm-Lizard
This elongate species has a very restricted distribution in the Caprivi Strip and the Hwange District of Zimbabwe, with isolated records from the Okavango River (type locality) and Okavango Delta (Fig. 6.13) [CAP]. It seems to be at least parapatric with the very similar *D. pistillum* throughout its range, and the two species can only be distinguished on counts of caudal annuli, i.e. tail length. The diet includes beetle larvae and ant larvae and cocoons (*Camponotus* sp.).

SERPENTES

TYPHLOPIDAE

Rhinotyphlops schlegelii (Bianconi 1850) Schlegel's Blind-Snake
This large, robust, species has a sharp horizontal cutting edge to the snout (in adults) and a visible eye. Above it is uniform black or mottled, immaculate below. Its range extends from S Angola and NE Namibia through Botswana and northeastern parts of South Africa to Swaziland and S Mozambique (to just north of the Save River) [WS].

Rhinotyphlops mucruso (Peters 1854) Zambezi Blind-Snake
This is the largest blind snake in the world, attaining a maximum length of 95 cm. It has a sharp horizontal cutting edge to the snout (in adults) and a visible eye. It occurs in lineolate and blotched

colour phases, immaculate below. Its range extends from coastal Kenya south to C Mozambique, west to SE DRC, Zambia, Zimbabwe and E Botswana [EAS]. The diet of blind snakes consists largely of ant brood and they feed infrequently, but build up large fat reserves. Large females lay up to 60 eggs.

LEPTOTYPHLOPIDAE

Leptotyphlops pungwensis Broadley & Wallach 1997 Pungwe Worm-Snake

This small pallid species is known only from the subadult holotype collected from the oil pipe-line trench crossing the Pungwe Flats between Muda and Lamego, where it was sympatric with both *L. longicaudus* and *L. scutifrons* [PUN].

Leptotyphlops scutifrons (Peters 1854) Peters' Black Worm-Snake

This all-black species has a wide range from Kenya south to South Africa and west to eastern Angola and Namibia [EAS]. It is the commonest species on the floodplains of Mozambique, but has not been recorded in western Zambia. The worm snakes feed on ant brood and small termites.

PYTHONIDAE

Python natalensis A. Smith 1840 Southern African Python

This is Africa's second largest snake, attaining a length of 5 m and exceeded only by the Northern African Python (*P. sebae*), which may exceed 6 m. This species ranges from C Kenya south to the Eastern Cape Province and west to DRC and Namibia [EAS], but in some areas has been locally exterminated by man. It is particularly common in waterside habitats, where it can ambush waterfowl and mammals coming to drink. Small Nile Monitors and crocodiles may be taken, while juveniles will take fish caught in nets or fish traps. This large snake is frequently eaten by man.

VIPERIDAE

Causus rhombeatus (Lichtenstein 1823) Rhombic Night-Adder

This large species (up to 93 cm)has a huge range in East Africa from the Sudan south to the southern coastal strip of South Africa [EAS]. It inhabits moist savanna and feeds mainly on toads. The long venom glands extend back into the neck, but the venom is very weak and bites on humans cause little more than local pain and swelling.

Causus bilineatus Boulenger 1905 Lined Night-Adder

This smaller species occurs in Angola, SE DRC and NE Zambia [ANG]. It inhabits moist miombo woodland.

Causus defilippii (Jan 1862) Snouted Night-Adder

This small species (maximum length 42 cm) occurs in East African savannas from Tanzania south to KwaZulu-Natal, extending west to Zimbabwe and E Zambia [EAS]. It has short venom glands and the bite causes local pain and swelling in man.

VIPERINAE

Proatheris superciliaris (Peters 1854) Eyebrow Viper

This recently erected monotypic genus seems to be basal to a clade terminating in the arboreal vipers of the genus *Atheris* (Broadley 1996b). The Eyebrow Viper is an inhabitant of floodplains from the northern end of Lake Malawi south to Beira (Fig. 6.14) [LZ]. This terrestrial snake shelters in rodent burrows, emerging at night to feed on frogs and small rodents. Gravid females may be found basking during the day.

Bitis arietans (Merrem 1820) Puffadder
This heavily built viper has a pan-African distribution, being absent only from deserts, rainforests and high mountains [PAN]. A very common species in savannas, it relies on its cryptic colouration to escape observation as it lies in wait for rodents, consequently it is responsible for many snake bites on humans. The cytotoxic venom causes massive local tissue destruction, but very few bites are fatal.

ATRACTASPIDIDAE

Amblyodipsas polylepis (Bocage 1873) Purple-glossed Snake
This large uniform black back-fanged snake (males up to 55 cm, females up to 112 cm) ranges from coastal Kenya south to KwaZulu-Natal and west to Angola [EAS]. It spends most of its time underground in burrows, feeding mainly on blind snakes and other fossorial reptiles. It moves around on the surface at night during wet weather.

Amblyodipsas ventrimaculatus *(Roux 1907)* Kalahari Purple-glossed Snake
This small fossorial species has a purple-brown to black vertebral band, the flanks and subcaudals are bright yellow, the rest of the ventrum white. The distribution is limited to Kalahari sand regions of N Namibia, N Botswana, W Zambia and NW Zimbabwe [KAL]. The diet includes small amphisbaenians (*Zygaspis quadrifrons*) and limbless skinks (*Typhlacontias* spp.).

Xenocalamus bicolor *Günther 1868* Bicoloured Quill-snouted Snake
This slender species is very variable in colouration. The 'typical' phase is black above and white below. In the Kalahari occurs a phase which is yellow above with a double row of purple-brown blotches, which may be confluent, white below. The only two specimens from Mozambique (Cheringoma Plateau) are uniform black above and below. The distribution covers Namibia, Botswana, northwestern parts of South Africa, N Zimbabwe and C Mozambique (Fig. 6.15) [KAL]. There is a sister species, *X. lineatus* Roux, in the Limpopo Basin. These burrowing snakes feed on amphisbaenians (*Zygaspis* and *Monopeltis*).

Xenocalamus mechowii Nieden 1913 Elongate Quill-snouted Snake
This large, but slender, species (maximum length 68 cm) is yellow to purple-brown above, with two rows of darker blotches, yellowish white below; a few melanistic specimens occur. It ranges from the Congo Basin south to N Namibia, W Zambia and NW Zimbabwe, being confined to Kalahari sand regions (Fig. 6.15) [COB]. The diet is restricted to amphisbaenians (*Zygaspis, Monopeltis* and *Dalophia*).

Aparallactus lunulatus (Peters 1854) Reticulated Centipede-eater
This fossorial species is olive grey above with dark-edged scales, juveniles have a black collar followed by a series of black spots, but these gradually fade out in adults. It has an enormous range from Ghana west to Ethiopia and south to S Mozambique [EAS]. Snakes of this genus are specialist feeders on centipedes.

Aparallactus capensis A. Smith 1849 Cape Centipede-eater
This small species has a wide range from Kenya to South Africa and west to Angola and Namibia [EAS]. It is usually found under logs and stones in savanna, but also extends onto floodplains and into montane grassland.

ELAPIDAE

Elapsoidea semiannulata Bocage1882 Angolan Garter-Snake

This fossorial species has a wide range from Senegal east to the Central African Republic and W DRC, then south to N Namibia and W Zambia [ANG]. It is sympatric with *E. boulengeri* on the Barotse floodplain and in the E Caprivi, but can be distinguished by its white ventrum.

Elapsoidea boulengeri Boettger 1895 Boulenger's Garter-Snake

This nocturnal species has a wide range in SE Africa, from E DRC, western and SE Tanzania south to Swaziland and the northern parts of South Africa, west to Zambia, Botswana and N Namibia (Broadley 1998) [EAS]. It occurs in savanna from sea level to 1500 m and is often associated with floodplains or mopane woodland. Juveniles are black with white or yellow crossbands, but these disappear in adults. The diet includes small snakes, lizards and amphibians.

Naja annulifera Peters 1854 Snouted Cobra

This large cobra (up to 245 cm) ranges from S Malawi to Swaziland and Kwazulu-Natal, west to Zimbabwe and E Botswana [EAS]. It usually lives in derelict termitaria and may be found basking nearby during the day. It does most of its hunting by night, feeding largely on toads, but also taking rodents, other snakes and eggs of domestic poultry, often becoming a persistent raider of chicken runs and killing any hen that interferes with it. This species secretes a potent neurotoxic venom and an untreated bite on man is likely to cause death through respiratory failure.

Naja anchietae Bocage 1879 Anchieta's Cobra

This species is closely related to the previous one, but it can be distinguished by usually having 17 scale rows at midbody, often reducing to 15 rows on the neck, whereas *N. annulifera* usually has 19 rows both at midbody and on the neck. This results in the scales on the neck of *N. anchietae* being distinctly larger. In large adults the snout becomes more pointed than in *N. annulifera*. This cobra inhabits moist savanna in Angola, NE Namibia, N Botswana, SW Zambia and NW Zimbabwe, with an apparently relict population in the Bangweulu swamps (Witte 1953, Pike 1964) [KAL]. In the eastern part of its range it seems to be restricted to a Kalahari sand substrate. Its ecology is similar to that of the previous species.

Naja melanoleuca Hallowell 1857 Forest Cobra

This large cobra inhabits forested or formerly forested areas of sub-Saharan Africa from Senegal east to Ethiopia, Kenya and S Somalia, south to Angola in the west and KwaZulu-Natal in the east [PAN]. It has a catholic diet, including small mammals, toads and frogs, lizards and snakes. It climbs and swims well and is expert at catching fish. It occurs along trout streams in the Nyanga National Park.

Naja nigricollis Reinhardt 1843 Black-necked Spitting Cobra

This big cobra (up to 270 cm) has a wide range in moist savannas from Senegal east to Ethiopia and S Somalia, south to Angola, Zambia, N Malawi and W and N Tanzania [NS]. Subadults are dark grey-brown above, adults usually become black, there is a single broad black band on the throat, the rest of the ventrum being mottled. The ecology is similar to that of the Snouted Cobra, but this species has fangs modified for 'spitting', the venom being projected as a diffuse spray aimed at the eyes of a person interfering with the snake. Unless washed out quickly, the cornea may be permanently damaged, resulting in blindness. The venom is cytotoxic and bites can cause extensive local necrosis.

Naja mossambica Peters 1854 Mozambique Spitting Cobra
This is a relatively small cobra, reaching a maximum length of 154 cm. It has a wide range from SE Tanzania south to KwaZulu-Natal (with relict populations in S Somalia and on Pemba Island), west through S Malawi, S Zambia [Laurent (1956) indicates a relict population on the floodplain south of the Bangweulu swamps], Zimbabwe and Botswana to N Namibia and S Angola [EAS]. Its ecology resembles that of *N. nigricollis*, but being a smaller snake, the effects of its bite and 'spitting' are usually less serious.

COLUBRIDAE
Lycodonomorphus mlanjensis Loveridge 1953 Mulanje Water-Snake
This robust snake inhabits montane grasslands in southern Malawi and eastern Zimbabwe (Fig. 6.16) [EEX]. It is a diurnal constrictor which preys upon frogs (including *Xenopus*) and small fish (including *Clarias*) in highland streams (Broadley 1967).

Lycodonomorphus rufulus (Lichtenstein 1823) Brown Water-Snake
This nocturnal water snake has a wide range in well-watered regions of South Africa and Zimbabwe, with a relict population on Gorongosa Mountain in Mozambique (Fig. 6.16) [EES]. In the northern part of its range it is common in mountain streams, where it feeds on frogs, tadpoles and small fish. It is often sympatric with *L. mlanjensis* (Broadley 1967).

Lycodonomorphus whytii (Boulenger 1897) Whyte's Water-Snake
This species is only known from three specimens from the extreme north of Malawi and SW Tanzania (Fig. 6.16) [EEN]. The habitat appears to be montane streams; a specimen from Rungwe mountain contained the remains of a frog.

Lycodonomorphus obscuriventris FitzSimons 1964 Floodplain Water-Snake
This small species inhabits floodplains from S Malawi through Mozambique to N KwaZulu-Natal, extending west into southeastern Zimbabwe, the Kruger National Park and N Swaziland (Fig. 6.16) [LZ]. These snakes have been found in the late afternoon, hunting small frogs at the edges of muddy pans frequented by elephant (Broadley 1967).

Lycophidion multimaculatum Boettger 1888 Blotched Wolf-Snake
This species ranges from S Gabon south through Angola to the Caprivi Strip, east through S DRC and N Zambia to the extreme west of Tanzania (Broadley 1996a) [ANG]. It is sympatric with *L. capense* in the E Caprivi.

Lycophidion capense capense (A. Smith 1831) Cape Wolf Snake
This small snake has a wide range in savannas from the SW Cape north to Namibia, S Zambia, Malawi and S Tanzania [EAS]. It is a nocturnal constrictor that feeds mainly on sleeping skinks.

Lycophidion nanum (Broadley 1968) Dwarf Wolf Snake
This very small species inhabits C Mozambique, just entering Zimbabwe at the southern end of the Chimanimani National Park [PUN]. This is a specialist predator on the small amphisbaenian *Chirindia swynnertoni.*

Grayia ornata (Bocage 1866) Ornate Water-Snake
This aquatic species was described from the Angolan highlands and has a wide range in the Congo Basin [COB]. The only Zambian specimen was taken from a fish trap in the Kasombo stream, a

forested tributary of the Zambezi near its source. It had a frog in its stomach (Broadley 1983), but these snakes usually eat fish.

Grayia tholloni Mocquard 1897 Thollon's Water-Snake
This small species has a wide range from the Sudan south to W Tanzania west to Angola [COB]. The only two Zambian records are from the Mweru Wantipa (Broadley 1983) and the Kasombo stream (Broadley 1991), where it is sympatric with *G. ornata*. This is the southernmost locality for both species.

BOIGINAE
Crotaphopeltis hotamboeia (Laurenti 1768) Herald Snake
This small back-fanged snake has an enormous range through the savannas of sub-Saharan Africa [PAN]. It is nocturnal and feeds largely on toads.

Crotaphopeltis barotseensis Broadley 1968 Barotse Water-Snake
This species has so far been recorded only from Kalabo (the type locality) on the Barotse floodplain and in the Okavango Delta (Fig. 6.17) [OKO]. It seems to replace the previous species in papyrus beds. The diet includes a variety of frogs (Broadley 1968).

Dipsadoboa aulica (Günther 1864) Marbled Tree-Snake
This back-fanged arboreal snake ranges from S Malawi south to KwaZulu-Natal and westwards into SE Zimbabwe, the Kruger National Park and Swaziland (Fig. 6.17) [EAS]. It inhabits riparian woodland along large rivers, taking refuge in hollow trees or beneath leaf litter and it feeds mainly on geckos and arboreal frogs, especially *Hyperolius*. Several have been found in thatched roofs.

Dipsadoboa flavida flavida (Broadley & Stevens 1971) Mulanje Cross-barred Tree-Snake
This snake is only known from a restricted area at the foot of Mount Mulanje in S Malawi (Fig. 6.17) [EEM]. Its favourite daytime retreat is inside old bamboo stems, from which it emerges at night to hunt frogs (*Hyperolius* spp., *Afrixalus* spp.) in nearby reedbeds.

Dipsadoboa flavida broadleyi Rasmussen 1989 Eastern Cross-barred Tree-Snake
This subspecies has a wide range from S Somalia south to Maputo in S Mozambique. There are only five records from Mozambique (Fig. 6.17) [EAS], where *D. aulica* is the commoner species.

NATRICINAE
Natriciteres bipostocularis Broadley 1962 Southwestern Forest Marsh-Snake
This small non-venomous snake inhabits forest-savanna mosaic from the Angolan highlands eastwards along the southern rim of the Congo Basin to NE Zambia (Fig. 6.18) [ANG]. It feeds on small frogs and tadpoles.

Natriciteres sylvatica Broadley 1966 Southeastern Forest Marsh-Snake
This species occurs on the margins of coastal forest patches from S Tanzania south to N KwaZulu-Natal (Fig. 6.18) [ECF]. Its diet includes fish-eating spiders.

Natriciteres olivacea (Peters 1854) Olive Marsh-Snake
This small snake has a huge range from Guinea east to the Sudan and then south to S Mozambique and west to Angola (Fig. 6.18) [NS]. The diet includes frogs, tadpoles and small fish; they have also been seen eating alate termites. The marsh snakes have fragile tails, which snap off if seized.

Limnophis bicolor Günther 1865 Angolan Striped Swamp-Snake
This robust aquatic snake occurs on the Angolan highlands, extending eastwards to the Zambezi headwaters (Fig. 6.19) [ANG].

Limnophis bangweolicus (Mertens 1936) Bangweulu Striped Swamp-Snake
This snake ranges from the swamps of Mweru Wantipa and Lake Bangweulu along the southern rim of the Congo Basin into Angola, and south along the Upper Zambezi to the Okavango swamps (Fig. 6.19) [PUZ]. This species has a more pointed snout than the previous one, suggesting that it pokes around in crevices for its prey. A spiny eel was found in one stomach, but it takes a variety of small fishes.

PSAMMOPHIINAE
Psammophylax tritaeniatus (Günther 1868) Three-lined Grass-Snake
This handsomely striped diurnal back-fanged snake has a distribution extending from S Tanzania south to the central plateau areas of South Africa (Free State) and west to Angola and Namibia [EAS]. It inhabits open grasslands and feeds on lizards, frogs and mice.

Psammophylax variabilis Günther 1893 Grey-bellied Grass-Snake
This species inhabits montane grasslands from S Rwanda, Burundi, SE DRC and SW Tanzania south to S Malawi (Zambia and Mulanje plateau), but occurs on floodplains in W Zambia and the E Caprivi, entering Botswana at Kasane [CPS]. It is ovo-viviparous, at least the southern part of its range, and its diet includes small fish.

Rhamphiophis acutus acutus (Günther 1888) Eastern Striped Beaked-Snake
This diurnal back-fanged snake ranges from Angola, through N Zambia to W Tanzania and Burundi [ANG]. It inhabits savanna woodland, especially miombo, and includes lizards and frogs in its diet.

Rhamphiophis acutus jappi Broadley 1971 Barotse Striped Beak-Snake
This subspecies was described from Kalabo and has been recorded upstream at Zambezi (Balovale) [BAR]. It may be adapted for life on floodplains, as the Zambezi specimen had a large amphisbaenian (*Dalophia ellenbergeri*) in its stomach.

Rhamphiophis rostratus Peters 1854 Rufous Beaked-Snake
This large species has a wide range at low altitudes in East Africa, extending from the S Sudan south to Mozambique and the Mpumalanga Province of South Africa and west to N Botswana and the Caprivi [EAS]. It spends most of its time underground in rodent burrows and its diet includes a wide range of small vertebrates, including snakes.

Dromophis lineatus (Dumèril & Bibron 1854) Lined Olympic-Snake
This snake ranges through West Africa from Guinea to the Sudan, south through C Africa to Zambia and the E Caprivi, just entering Botswana at Kasane, while the only Zimbabwean specimen (probably a waif) was collected on the south bank of the Zambezi at Nampini (Fig. 6.20) [NS]. This species inhabits swamps and dambos and its diet includes rodents and frogs.

Psammophis mossambicus Peters 1882 Olive Grass-Snake
This large species ranges from the Sudan south to KwaZulu-Natal and west to Namibia [EAS]. It is usually uniform olive above and yellow below. Its preferred habitat is thick grass and reed beds and it preys upon rodents, lizards and frogs.

COLUBRINAE

Meizodon semiornatus semiornatus (Peters 1854) Semiornate Snake
This small species ranges from Kenya and Uganda south to KwaZulu-Natal, reaching its western limit on the Zimbabwe/Botswana border in the vicinity of the Kazuma depression (Fig. 6.19) [EAS]. It usually occurs along drainage lines and lives in hollow trees or under the loose bark on dead trees. It feeds on small frogs and lizards.

Prosymna stuhlmannii (Pfeffer 1893) East African Shovel-snout
This savanna species ranges from S Somalia south to KwaZulu-Natal, extending west to E Zambia, Zimbabwe and the Northern Province of South Africa [EAS]. The diet of these snakes consists of reptile eggs and they are often found inside hollow logs, where geckos lay their eggs.

Philothamnus angolensis Bocage 1882 Angolan Green-Snake
This large arboreal green-snake (up to c.120 cm) has a range extending from Angola and N Namibia through S DRC, Zambia and N Botswana to S Tanzania, Malawi, Zimbabwe and Mozambique to N KwaZulu-Natal (Fig. 6.21) [WS]. It is abundant in extensive beds of reeds and papyrus but also occurs in overhanging trees along river courses. It feeds mainly on frogs and toads, but also takes small lizards and nestling birds.

Philothamnus hoplogaster (Günther 1863) Southeastern Green-Snake
This small green-snake has a wide range in the East African savannas from Kenya south to the coast of the Eastern Cape Province in South Africa and west to Zambia and the E Caprivi [EAS]. Its preferred habitat is open grassy vleis and dambos. It feeds mainly on frogs, but also takes small fish and lizards.

Philothamnus ornatus Bocage 1872 Ornate Green-Snake
This handsome species has a yellow-bordered red-brown vertebral stripe. It has a patchy distribution from Angola east through Zambia to Lake Malawi at Nkhata Bay, south into N Botswana and Zimbabwe along the Harare-Nyanga watershed (Fig. 6.22) [ANG]. It is usually found along small streams or vleis in open grassland with patches of bullrushes and sedges. It feeds on small frogs.

Philothamnus heterolepidotus (Günther 1863) Slender Green-Snake
This very slender, small-headed, species ranges from S Sudan west to Ghana and south to Tanzania, N Zambia and Angola (Fig. 6.22) [CPS]. Its preferred habitat seems to be extensive beds of reeds and papyrus.

Philothamnus natalensis (A. Smith 1848) Natal Green-Snake
This species inhabits the south Mozambique plain from the Pungwe Flats south to Lake St Lucia in Maputaland, it extends inland to the eastern slopes of Mount Nyangani and the Save-Runde confluence in E Zimbabwe and the eastern border of the Kruger National Park (Fig. 6.22) [ECF]. It is usually associated with coastal forest.

Philothamnus semivariegatus (A. Smith 1840) Variegated Bush-Snake
This long slender species occurs throughout the tropical savannas of sub-Saharan Africa [PAN]. It is strongly arboreal and feeds largely on geckos and other lizards, although frogs are also taken.

Philothamnus punctatus (Peters 1866) Spotted Bush-Snake
This species inhabits the East African lowlands from Somalia south to N Mozambique [EAS]. It has been collected at Nkhata Bay on the western shore of Lake Malawi.

Dispholidus typus (A. Smith 1829) Boomslang
This large back-fanged tree-snake has an extensive distribution throughout the savannas of sub-Saharan Africa [PAN]. Its preys largely on chameleons, but also takes nestling birds and frogs. Its bite can be fatal to humans, the venom causing extensive internal haemorrhage.

Thelotornis oatesii (Günther 1881) Oates' Savanna Vine-Snake
This slender arboreal back-fanged snake has a wide range from S Angola and northern Namibia, east to S DRC, Zambia, Malawi, N Botswana, Zimbabwe and W Mozambique [WS]. It often sits immobile in a bush beside a stream waiting for suitable prey to come within range. The vine snakes have the best eyesight of any African snake, and having spotted a suitable frog, lizard or small snake, they descend to the ground and slowly stalk their prey before seizing it after a short rush.

Thelotornis mossambicanus (Bocage 1895) East African Savanna Vine-Snake
This snake has a wide range from S Somalia south to C Mozambique, extending west into Malawi and E Zimbabwe [EAS], where it hybridises with the previous species (Broadley 1979). This species inhabits coastal forests and savannas and is usually smaller and more slender than *T. oatesii*.

Dasypeltis scabra (Linnaeus 1758) Rhombic Egg-eater
This species has a pan-African distribution in savannas [PAN]. It is particularly common and reaches a large size (approx. 1 m) in swamps, where the nests of bishop and weaver-birds provide an abundant supply of eggs.

CROCODYLIA
CROCODYLIDAE
Crocodylus niloticus Laurenti 1768 Nile Crocodile
This species is ubiquitous in suitable water bodies throughout tropical sub-Saharan Africa [PAN]. Hutton (1984) carried out a field study on the crocodile population at Ngezi Dam. Blake (1974) and Blake & Loveridge (1975) reported on the role of crocodile rearing in Zimbabwe for commercial farming and conservation purposes.

AMPHIBIA
PIPIDAE
Xenopus laevis (Daudin 1802) Common Clawed-Frog
This totally aquatic species of "platanna" occurs throughout well-watered parts of South Africa and north to Zimbabwe and S Malawi [SS], except where replaced by the following two species.

Xenopus petersii Bocage 1895 Angolan Clawed-Frog
This frog has a wide range on plateau areas of SC Africa from Angola and N Namibia through S DRC, Zambia and N Botswana to SW Tanzania [ANG]. It seems to prefer clear water.

Xenopus muelleri (Peters 1844) Tropical Clawed-Frog
This species has an enormous range at low altitudes from the Sudan south to KwaZulu-Natal and west to Ghana. It is common along the Middle and Lower Zambezi and also occurs in the Okavango Delta, the Caprivi and on the Barotse floodplain [EAS]. This frog is found in muddy backwaters which dry out, when the *Xenopus* take refuge at the bottom of cracks in the dried mud where there is still some moisture.

BUFONIDAE

Bufo gutturalis Power 1927 Guttural Toad

This common large toad has a wide range in moist savannas from Kenya and Uganda south to the northern parts of South Africa [EAS].

Bufo garmani Meek 1867 Olive Toad

This large toad has a patchy distribution in dry savannas from Somalia south to the northern parts of South Africa [EAS].

Bufo poweri Hewitt 1935 Kalahari Toad

This very large toad occurs in the Kalahari, extending into NW Zimbabwe and north to the Barotse floodplains [KAL].

Bufo maculatus Hallowell 1854 Flat-back Toad

This moderate-sized toad occurs throughout tropical savannas of sub-Saharan Africa [NS].

Bufo lemairii Boulenger 1901 Yellow Swamp Toad

This toad is unusual in having a pointed snout like a frog, the males are brilliant yellow during the breeding season. The species has a limited range from the Okavango Swamps (Haacke 1982) along the floodplains of the Upper Zambezi to Lake Bangweulu, the Chambeshi River (Mertens 1937), and S DRC (Fig. 6.23) [OKO]. Pitman (1934) noted, "In mid-May found in hundreds of thousands in an extensive swamp on the edge of the flats east of the Bangweulu swamps, between the Rivers Lulimala and Lukulu, near the village of Marbo. Has a very pleasing mellow cry, which is quite musical when uttered simultaneously by several dozens".

Bufo kavangensis Poynton & Broadley 1988 Kavango Dwarf Toad

This very small toad ranges from NE Namibia through N Botswana to NW Zimbabwe [OKO]. Males call while clinging to grass stems in shallow pans.

Bufo beiranus Loveridge 1932 Beira Dwarf Toad

This tiny toad has a patchy distribution from the Pungwe Flats via the Middle Zambezi and SW Zambia to the Barotse floodplain [MZ].

MICROHYLIDAE

Phrynomantis bifasciatus (A. Smith 1847) Red-banded Rubber-Frog

This fossorial species has a wide range in savannas from Kenya south to KwaZulu-Natal and west to N Namibia [EAS]. It lives underground and feeds mainly on termites, emerging during the rains to breed in temporary pans, the high-pitched trilling call of the male being very distinctive.

Phrynomantis affinis Boulenger 1901 Red-spotted Rubber-Frog

This nominal species is only known from a few specimens from N Namibia, W Zambia and S DRC [WS]. Its status is uncertain.

HEMISIIDAE

Hemisus marmoratus (Peters 1854) Marmorate Shovel-snouted Frog

This small fossorial species has a wide range in East Africa from Somalia south to N KwaZulu-Natal and west to the E Caprivi [EAS]. It spends most of its time underground, feeding on termites.

***Hemisus* "barotseensis"** sp. nov. Barotse Shovel-snouted Frog
Specimens of a small *Hemisus* recently collected on the Barotse floodplains differ in advertisement call, morphology and colour pattern, and represent an undescribed species [BAR].

Hemisus guineensis microps Laurent 1972 Congo Shovel-snouted Frog
This large form ranges from the lower DRC through Angola and W Zambia to the Okavango Swamps [ANG].

Hemisus guineensis broadleyi Laurent 1972 Broadley's Shovel-snouted Frog
This large form ranges from the Hwange District of Zimbabwe east to the Pungwe Flats [LZ] and may be sympatric with *H. marmoratus.*

RANIDAE
Pyxicephalus adspersus Tschudi 1838 Highveld Bullfrog
This very large frog ranges across plateau areas of South Africa, Botswana, C Namibia, Zimbabwe and C Mozambique [SS]. It breeds in temporary pans, gorges itself on a wide range of invertebrates and small vertebrates (frogs, snakes, rodents), then spends the dry months underground in a cocoon derived from the epidermis.

Pyxicephalus edulis Peters 1854 Tropical Bullfrog
This smaller species occurs throughout savanna lowlands of East Africa as far south as Maputaland and west to Nigeria [EAS]. Its breeding behaviour is quite different from that of *P. adspersus* (Channing *et al*. 1994).

Tomopterna cryptotis (Boulenger 1907) Kalahari Sand-Frog
This is a very common frog in Namibia, the Kalahari and dry savannas of Zimbabwe and W Mozambique [WS], breeding in ephemeral pans.

Tomopterna marmorata (Peters 1854) Marmorate Sand-Frog
This russet-coloured species has a more eastern distribution [EAS] and is usually associated with sand rivers, burying itself in the damp sand of the river bed during the dry season.

Rana angolensis Bocage 1866 Common River-Frog
This frog has a wide distribution throughout the central plateau areas of Africa from Ethiopia south to South Africa [CPS]. It lives along well vegetated banks of streams and rivers, jumping into the water when disturbed.

Rana johnstoni Günther 1893 Mulanje River-Frog
This aquatic species is endemic to cold mountain streams on Mulanje Mountain in S Malawi [EEM].

Rana inyangae Poynton 1966 Nyanga River-Frog
This diurnal species is known only from the Nyanga and Chimanimani National Parks on the eastern escarpment of Zimbabwe [EEZ]. It lives in turbulent water in cold mountain streams and frequently sits on rock ledges behind small waterfalls.

Strongylopus fasciatus (A. Smith 1849) Striped Long-toed Frog
This species has a disjunct distribution extending from the southern coast and plateau regions of South Africa to the Eastern Highlands of Zimbabwe, with relict populations scattered across the

Zimbabwean plateau (Fig. 6.24) [EES]. These frogs live in grassy dambos and only resort to water to breed. Their long toes are not webbed.

Strongylopus fuelleborni (Nieden 1910) Poroto Long-toed Frog
This is a vicariant species of *S. fasciata* with relict populations on the highlands of Malawi and SW Tanzania [EEN]. Its habitat is montane meadows (Loveridge 1953d).

Hylarana darlingi (Boulenger 1902) Golden-backed Frog
This attractive frog inhabits plateau areas from Angola through Zambia and Zimbabwe to S Malawi and W Mozambique [ANG]. It occurs in both savanna and coastal forest.

Hylarana lemairei (Witte 1921) White-lipped Frog
This forest species has the tips of the toes expanded into discs. It inhabits the S DRC, NE Angola and N Zambia, where it is common at the Zambezi headwaters [ANG].

Hylarana galamensis (Dumèril & Bibron 1841) Galam Swamp Frog
This strongly aquatic frog ranges from Senegal east to S Somalia, south to the Save River in Mozambique, and west to Malawi and N Zambia, including the Bangweulu Swamps (Fig. 6.25) [NS].

Hildebrandtia ornata (Peters 1878) Ornate Burrowing Frog
This beautiful frog ranges from Kenya south to Mozambique and west to S Angola and N Namibia [EAS]. It inhabits open savanna and breeds in ephemeral pans.

Ptychadena subpunctata (Bocage 1866) Spot-bellied Ridged-Frog
This large species has a wide range centred on the swamps and river backwaters of the Upper Zambezi and the Okavango Delta, extending into Angola and S DRC (Fig. 6.25) [ANG].

Ptychadena oxyrhynchus (A. Smith 1849) Sharp-snouted Ridged-Frog
This frog ranges through moist savanna woodlands from Senegal to the Eastern Cape Province of South Africa [NS]. It breeds in shallow pools along streams or on rock outcrops.

Ptychadena anchietae (Bocage 1867) Plain Ridged-Frog
This species has a wide range through dry savannas from Ethiopia south to KwaZulu-Natal and west to Angola [EAS]. Its usual habitat is the bare margins of 'sand rivers' where it takes to the water when disturbed. It takes refuge under debris deposited by floodwaters.

Ptychadena obscura (Schmidt & Inger 1959) Obscure Ridged Frog
Similar to the previous species, but restricted to the SE DRC and N Zambia [COB].

Ptychadena mascareniensis (Dumèril & Bibron 1841) Mascarene Ridged-Frog
This savanna species has a patchy distribution from Sierra Leone east to Egypt and south to Kwazulu-Natal (Fig. 6.26) [NS], it also occurs on Madagascar, Mascarene and Seychelles Islands. This frog is restricted to swamps and marshes.

Ptychadena porosissima (Steindachner 1867) Striped Ridged-Frog
This small species inhabits uplands from Ethiopia and Uganda south to the Eastern Cape Province of South Africa and west to Angola [EAS]. It lives in open grasslands and dambos.

Ptychadena grandisonae Laurent 1954 Grandison's Ridged-Frog
This species ranges from NE Angola through Zambia to E DRC and Rwanda [ANG].

Ptychadena upembae (Schmidt & Inger 1959) Upemba Ridged-Frog
This species has been recorded from Angola, S DRC, Zambia and Malawi [ANG].

Ptychadena uzungwensis (Loveridge 1932) Udzungwe Ridged Frog
This frog inhabits upland grasslands from Rwanda south to the Soutpansberg, extending west to E Angola (Fig. 6.27) [EAS].

Ptychadena pumilio (Boulenger 1920) Dwarf Ridged-Frog
This small species has a patchy distribution in moist savanna from Senegal east to DRC and south to Maputaland [NS]. It is unusual in being very active in the day time.

Ptychadena guibei Laurent 1954 Guibe's Ridged-Frog
This small species has a patchy distribution from Angola east to C Mozambique and north to S DRC [ANG]. It inhabits moist grassland and savanna, especially in dambos.

Ptychadena mossambica (Peters 1854) Mozambique Ridged-Frog
This short-legged species occurs from Kenya and Uganda south to Maputaland, west to Zambia the E Caprivi and Botswana [EAS]. It is common along sand rivers (with *P. anchietae*) and on some floodplains.

Ptychadena schillukorum (Werner 1907) Nile Ridged-Frog
This short-legged species ranges from the White Nile south to the Pungwe Flats in C Mozambique and west to Ghana (Fig. 6.26) [NS]. It inhabits floodplains and Loveridge (1953b) found specimens "sunken in damp sand under debris deposited on sand bars by the shrinking Zambezi River (near Tete)". Males call while floating in the water.

Ptychadena mapacha Channing 1993 Mapacha Ridged-Frog
This short-legged species is presently known only from the E Caprivi near Katima Mulilo (Channing 1993) [CAP].

Phrynobatrachus acridoides (Cope 1867) Zanzibar Puddle-Frog
This small frog inhabits lowland savannas from West Africa to Somalia and south to Maputaland, extending westwards into Malawi and E Zimbabwe [NS]. It is abundant on the Pungwe Flats and other floodplains.

Phrynobatrachus natalensis (A. Smith 1849) Natal Puddle-Frog
This species occurs throughout savanna areas south of the Sahara [NS], except where replaced by *P. acridoides*. It is usually associated with permanent shallow water.

Phrynobatrachus mababiensis FitzSimons 1932 Mababe Dwarf Puddle-Frog
This very small species has a wide range in E and S Africa [EAS] and is usually sympatric with one of the previous two species.

Phrynobatrachus parvulus (Boulenger 1905) Angola Dwarf Puddle-Frog
This little frog occurs in highland areas from Angola and DRC east to Tanzania, Malawi and E Zimbabwe [ANG]. It inhabits moist savanna and margins of montane forest, being common at the margins of weed-choked pools.

Cacosternum boettgeri (Boulenger 1882) Boeettger's Dainty Frog
This pretty little frog ranges from Ethiopia to South Africa, but avoids the tropical lowlands and mountain ranges [CPS].

RHACOPHORIDAE
Chiromantis xerampelina Peters 1854 Southern Foam-nest Frog
This large tree frog occurs throughout the East African lowlands from coastal Kenya south to Maputaland and west to E Botswana and the E Caprivi [EAS]. It is particularly common in mopane woodland. The foam nest is whipped up from mucus produced with the eggs by the female, assisted by one or more males.

HYPEROLIIDAE
Leptopelis flavomaculatus (Günther 1864) Yellow-spotted Forest Tree-Frog
This large tree frog ranges from coastal Kenya south to C Mozambique, inland to Malawi and the eastern escarpment in Zimbabwe [EAS]. It is usually found in lowland forests near streams and it has a distinctive cat-like drawn-out "meeeow" call, with males usually calling from leaves or branches three or four metres above ground level.

Leptopelis broadleyi Poynton 1985 Triad Tree-Frog
This small species inhabits N and C Mozambique, just entering S Malawi and E Zimbabwe. Males call from trees and bushes at a height of one to two metres and have a distinctive triad "meow-meow-meow" call.

Leptopelis mossambicus Poynton 1985 Mozambique Tree-Frog
This moderate sized tree frog ranges from S Malawi south through Mozambique, SE Zimbabwe, NE South Africa and Swaziland to Maputaland (Fig. 6.28) [EAS]. Males call from reedbeds or low shrubs, the call being an abrupt "cluck".

Leptopelis parbocagii Poynton & Broadley 1987 Upemba Burrowing-Frog
This species inhabits upland regions from Angola east through S DRC and N Zambia to Malawi and N Mozambique (Fig. 6.28) [ANG]. Males call from the ground or low vegetation.

Leptopelis bocagii (Günther 1864) Bocage's Burrowing-Frog
This 'burrowing tree frog' inhabits upland savannas from Ethiopia south to Zimbabwe (Fig. 6.28) [CPS]. It spends the dry season underground, and when the rains break the males initially begin calling from underground and then from ground level. The call is a brief "cluck".

Kassina maculata (Duméril 1853) Red-legged Pan Frog
This large frog inhabits the East African lowlands from Kenya south to KwaZulu-Natal (Fig. 6.29) [EAS]. It breeds in shallow pans and lagoons, the males calling while floating in the water. During the dry season, these frogs may often be found aestivating in banana axils.

Kassina kuvangensis (Monard 1937) Kuvangu Running-Frog
This moderate-sized frog has a restricted range from S Angola to NW Zambia (Fig. 6.29) [OKO]. They call from shallowly-flooded grasslands. The large tadpoles are spectacularly mottled in black and yellow.

Kassina senegalensis (Duméril & Bibron 1841) Senegal Running-Frog
This small species occurs throughout tropical savannas south of the Sahara [NS]. It breeds in shallow ephemeral pans and pools, the males calling from under the shelter of grass tufts. These frogs aestivate under rocks and logs and within termitaria.

Afrixalus brachycnemis (Boulenger 1896) Malawi Spiny Reed-Frog
This small savanna reed frog ranges from coastal Kenya to S Malawi [EAS]. The males call from grass or reeds standing in shallow water.

Afrixalus delicatus Pickersgill 1984 Kwazulu Spiny Reed-Frog
This tiny reed frog inhabits a narrow coastal strip from the Zambezi Delta south to Durban [LZ]. Its habitats includes coastal bush and grassland marshes and swamp forests (Pickersgill 1984).

Afrixalus crotalus Pickersgill 1984 Rattling Spiny Reed-Frog
This species ranges from SE Tanzania through S Malawi, N and C Mozambique into E Zimbabwe [EAS]. Abundant on floodplains and pans in savanna.

Afrixalus wittei (Laurent 1941) Witte's Spiny Reed-Frog
This species ranges from N Angola, S DRC and W and N Zambia to SW Tanzania [COB]. It inhabits moist savannas.

Afrixalus fornasinii (Bianconi 1849) Fornasini's Spiny Reed-Frog
This larger species ranges from Kenya south to KwaZulu-Natal, extending into Malawi and E Zimbabwe [EAS]. Common in reedbeds.

Hyperolius tuberilinguis A. Smith 1849 Tinker Reed-Frog
This reed frog inhabits the eastern lowlands from Kenya to KwaZulu-Natal, extending into Malawi and E Zimbabwe [EAS]. Common in reedbeds surrounding swamps and bordering rivers.

Hyperolius pictus Ahl 1931 Variable Montane Reed-Frog
This reed frog is restricted to the highlands of SW Tanzania and N Malawi [EEN]. It is common around small pools and streams on the Nyika Plateau and during the day can be found sitting on heaths and sedges about a metre above water level (Stewart & Wilson 1966).

Hyperolius quinquevittatus quinquevittatus Bocage 1866 Five-lined Reed-Frog
This species ranges from the Angola highlands through SE DRC, N Zambia and Malawi to S Tanzania [ANG]. It occurs in swampy grassland.

Hyperolius quinquevittatus mertensi Poynton 1964 Mertens' Reed-Frog
This small subspecies replaces the typical form on the Nyika Plateau [EEM], living on short grasses and sedges and breeding in small pools between tussocks (Stewart & Wilson 1966).

Hyperolius kivuensis Ahl 1931 Kivu Reed-Frog
This species inhabits moist savanna woodlands from Uganda south to S Zambia [CPS].

Hyperolius argus Peters 1854 Argus Reed-Frog
This attractive species inhabits the eastern lowlands from S Somalia south to Durban, entering S Malawi and E Zimbabwe [EAS]. The preferred habitat is large bodies of still water such as lagoons and backwaters of big rivers. Males prefer calling from horizontal surfaces such as lily pads and emergent rocks.

Hyperolius puncticulatus (Pfeffer 1893) Golden Sedge-Frog
This species inhabits forested areas from coastal Kenya and Tanzania, through the southern highlands to S Malawi [EAS]. In Mugesse Forest on the Misuku Hills they were found sitting on leaves 1-2 m above the ground. Loveridge (1953d) gives the habitat as "montane meadows", but reports that a series was taken in wild bananas in the Matipa Forest on the Misuku Mountains, while two males were caught at the foot of Mulanje Mountain while calling from grass and sedges in a swamp (Loveridge 1953b).

Hyperolius mitchelli Loveridge 1953 Mitchell's Sedge-Frog
This attractive species ranges from the Usambara Mountains in NE Tanzania south through Malawi to C Mozambique [EAS]. The types were collected in a banana grove near the shore of Lake Malawi just north of Mtimbuka (Loveridge 1953b). At Maforga, the southernmost locality, they were calling from shrubs beside a small marshy stream in an area of forest/savanna mosaic (Poynton & Broadley 1987).

Hyperolius spinigularis Stevens 1971 Spiny-throated Sedge-Frog
This small sedge frog was described from the Chisambo Tea Estate at the foot of Mulanje Mountain. It is otherwise only known from the East Usambara Mountains in NE Tanzania [MEA]. The species prefers rather overgrown dambo areas in protected areas.

Hyperolius pusillus (Cope 1862) Water-lily Frog
This small species ranges from S Somalia to the Transkei [EAS]. It inhabits open pans in savanna and males call from lily pads.

Hyperolius nasutus Günther 1864 Günther's Sharp-snouted Reed-Frog
This small species occurs throughout sub-Saharan tropical savannas [EAS]. Males call from reeds, sedges and grass stems well above water level.

Hyperolius benguellensis (Bocage 1893) Benguela Sharp-snouted Reed-Frog
This closely related species has a patchy distribution from Angola and N Namibia east to Malawi and Zimbabwe [WS].

Hyperolius viridiflavus complex
This group of reed frogs has long been considered a taxonomic nightmare (Poynton & Broadley 1987), but their relationships are now being investigated using DNA sequencing (Wieczorec, Drewes & Channing, in prep.). The following taxonomic arrangement is still provisional, as tissue samples have not yet been collected for many of these taxa.

Hyperolius marmoratus taeniatus Peters 1854 Striped Reed-Frog
This frog inhabits the Mozambique plain south to Lake St. Lucia, extending into S Malawi and NE and S Zimbabwe [EAS]. Abundant in reedbeds surrounding swamps or along rivers.

Hyperolius alborufus Laurent 1964 Cazombo Reed-Frog
This form is restricted to the Upper Zambezi headwaters in NW Zambia and adjacent Angola [ZHW].

Hyperolius angolensis Steindachner 1867 Angolan Reed-Frog
This species ranges from E Angola and N Namibia into W Zambia and N Botswana [ANG]. Channing & Griffin (1993) treated *H. angolensis* as a full species because its advertisement call differs from that of *H. marmoratus*.

Hyperolius swynnertoni broadleyi Poynton 1963 Broadley's Reed-Frog
This handsomely striped reed frog inhabits the Eastern Highlands and central plateau regions of Zimbabwe, with a relict population on Gorongosa Mountain in Mozambique [ZIM].

Hyperolius marginatus marginatus Peters 1854 Margined Reed-Frog
This form has a curious range from N Malawi and E Zambia through the W Mozambique pedicle and along the Middle Zambezi Valley and escarpment to the Botswana border in the Hwange National Park [MZ].

Hyperolius marginatus albofasciatus Hoffman 1944 White-striped Reed-Frog
This subspecies is restricted to the uplands of S Malawi and N Mozambique [EEM].

Hyperolius pyrrhodictyon Laurent 1965 Kafue Flats Reed-Frog
This reed-frog is restricted to the Kafue Flats and environs [KAF] and is distinguished by a bold red ventral network (Laurent 1965).

Hyperolius melanoleucus Laurent 1941 Black and White Reed-Frog
This form extends from the highlands of extreme SE DRC south through the upper Kafue tributaries to the Lusaka area [COB].

Hyperolius nyassae Ahl 1931 Nyasa Reed-Frog
This form is restricted to the reed beds and swamps along the northern shores of Lake Malawi [MAL].

6.5 CONSERVATION

6.5.1 **Wetlands of special interest**

Barotse Floodplain

The central Barotse floodplain covers an area of up to 7500 km^2. Although largely covered with grass, there are isolated clumps of trees (especially on termitaria) which provide suitable habitat for arboreal reptiles, particularly those snakes that prey upon birds eggs and fledglings. The Barotse floodplain has been a relatively stable area since the early Tertiary (c. 50 million years BP) and consequently may have the richest herpetofauna, as it includes elements of the Kalahari fauna and two vicariant endemic species, all the elements of the palaeo-Upper Zambezi wetland fauna, and elements from the Angola highlands and Congo Basin, in addition to widespread savanna species entering from the east. The many fossorial and terrestrial reptiles inhabiting the Barotse floodplains make a mass migration to the woodlands when the Zambezi is in flood (R.G. Japp, pers. comm.) or else retreat to the emergent termitaria (C.R. Owen, pers. comm.).

Chobe - Linyanti System
During the Quaternary this section of the mid-Zambezi trough contained a palaeo-Lake Caprivi, linked by the Chobe River to Lake Liambezi and the Kwando/Linyanti swamps (Shaw & Thomas 1988). This swamp area has been a major barrier to some fossorial reptiles, especially amphisbaenians. This floodplain system is linked to the southern Barotse floodplain, so it has a similar herpetofauna. The area is vulnerable to dessication, being largely dependent on high Zambezi floods backing up into it.

Lower Shire River
The floodplains and marshes in this area are densely populated and heavily cultivated on the Malawi side of the river and only the permanently flooded core of the Elephant Marsh is likely to remain intact. With the development of irrigation schemes, the expansion of sugar plantations and rice paddies are major threats to wetland habitats. The herpetofauna is similar to that of the Zambezi Delta and the Pungwe Flats.

Zambezi Delta
The present Zambezi Delta is very young, dating back only to the Pleistocene. The previous course turned south through the Urema trough and Pungwe Flats to reach the sea near Beira. Despite the delta being the 'core area' of the Lower Zambezi ecosystem, its herpetofauna remains poorly known. It has a wide range of habitats and should support a diverse herpetofauna, including many of the species presently known from the Lower Shire River and the Pungwe Flats.

Lake Bangweulu & Chambeshi River
The herpetofauna of this huge area of open lake, rivers, swamps and floodplains remains poorly known, but undoubtedly rivals that of the Barotse floodplain in richness. It apparently has most of the palaeo-Upper Zambezi herpetofauna in addition to many elements from the Angola highlands and the Congo Basin. It is presently linked to Lake Mweru by the Luapula River, but the presence of *Limnophis bangweolicus* in the Mweru Wantipa indicates that this marshy area was formerly linked to Lake Bangweulu, perhaps via the Chambeshi River. The Lake Bangweulu complex is clearly a key to our understanding of the zoogeography of the Zambezi Basin wetlands and extensive fieldwork is required to improve our knowledge of the herpetofauna. The lake could prove to be a southern stronghold of the Slender-snouted Crocodile (*Crocodylus cataphractus*), which is under threat throughout most of its range.

6.5.2 **Species of conservation interest**

Eumecia johnstoni Nyika Serpentiform Skink
This elongate skink is only known from the type specimen, collected over 100 years ago on the Nyika Plateau. It may now be extinct due to grass fires, but may still survive in permanently wet swampy areas, where it would be difficult to find.

Proatheris superciliaris Eyebrow Viper
This near-endemic monotypic genus appears to be restricted to a floodplain habitat and appears to be close to the primitive stock that gave rise to the arboreal bush vipers of the genus *Atheris*. It could come under pressure through increasing cultivation of flood plains for rice, which is apparent near Beira.

Crotaphopeltis barotseensis Barotse Water Snake
This small back-fanged snake seems to more or less restricted to papyrus swamps of the Palaeo-Upper Zambezi system. Its position is secure unless any way of removing papyrus on a large scale is developed.

Hemisus barotseensis Barotse Snout-burrowing Frog
This small frog is a Barotse floodplain near-endemic, but does not seem to threatened in any way.

Ptychadena mapacha Mapacha Ridged-Frog
This species is at present known only from the East Caprivi wetlands, so its status is uncertain.

Hyperolius marmoratus pyrrhodictyon Kafue Reed-Frog
This frog is endemic to the Kafue Flats and is likely to prove to be a good species. It could be at risk during the tadpole stage due to agricultural pollution from fertilisers and insecticides.

6.5.3 **Sites of conservation interest**

Most sites consist of large and complex areas of open water, swamps and floodplains, making it impossible to accurately map distributions of reptiles and amphibians or to determine sites particularly worthy of conservation. In such cases the selection of such sites will have to be based on habitat, i.e. vegetation types. An exception is in northern Mwinilunga District, where wetland areas are on a much smaller scale. Here a case could perhaps be made for a conservation area extending from the forested Zambezi source close to the DRC border, westwards across the Nyambala Plain and the watershed between the Upper Zambezi tributaries and the Luakela River (an affluent of the Lunga River, which in turn is a tributary of the Kabompo River) to the forested Kasombu (Isombo) stream where it flows into Angola.

6.6 INTRODUCTION OF REPTILES INTO DAMS IN THE MIDDLE ZAMBEZI

Few reptiles can be considered important natural resources. The Nile Crocodile is already being farmed for the production of skins, meat and curios. All the chelonians are used for food, but the most important is the Zambezi Flap-shelled Turtle (*Cycloderma frenatum*) which provides quite a lot of meat (females attain a carapace length of 56 cm). Females lay around 15-25 hard shelled eggs about 35 mm in diameter, which are eaten by the Yao along the southern shores of Lake Malawi (Loveridge 1953a). These turtles feed largely on aquatic snails and bivalves. The latter are now superabundant in Lake Kariba, where the 'fossilised' trunks of submerged trees provide a good substrate for them (Kenmuir 1978). The situation is presumably similar in Lake Cabora Bassa. It is recommended that these artificial impoundments could be enriched by the introduction of *Cycloderma* from southern Lake Malawi (or the Lower Zambezi). The eggs could be collected and flown to a Zimbabwean crocodile farm for incubation, the hatchlings being released in the estuaries in the Matusadona National Park.

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Table 6.1. Checklist of the reptiles and amphibians of wetlands in the Zambezi Basin and outside.

Habitat aquatic status: aq - fully aquatic; sa - semi-aquatic; fp - typically inhabiting floodplains; (blank) - migrant onto dry floodplains.

Cluster Range clusters: ANG - Angola Highlands eastwards; BAR - Barotse near-endemic; CAP - Caprivi near-endemic; COB - Congo Basin; CPS - Central Plateau savanna; EAS - East African savanna; ECF - East African coastal forest; EE - Eastern Escarpment [suffix letters: M Malawi; N North; S South; X trans-Zambezi; Z Zimbabwe]; KAF - Kafue Flats endemic; KAL - Kalahari; LZ - Lower Zambezi; MAL - Lake Malawi north shoreline; MZ - mid-Zambezi valley; NS - northern savanna; PAN - pan-African south of Sahara; PUN - Pungwe Flats; PUZ - palaeo-Upper Zambezi; SS - southern savanna; WS - western savanna.

Wetland areas: Zhw - Zambezi headwaters; Bar - Barotse floodplains; Cho - Chobe/E Caprivi; Oka - Okavango Delta; Ban - Bangweulu swamps; Kaf - Kafue Flats; Kar - Lake Kariba; Chv - Lake Chivero; Nya - Nyanga National Park; MRP - Misuku/Rungwe/Poroto mountains; Nyk = Nyika Plateau; Mal - Lake Malawi shoreline; Mul - Mulanje Mountain; Chi - Lake Chilwa; LSh - Lower Shire valley; Del - Zambezi Delta; Pun - Pungwe Flats; Upe - Upemba swamps & environs; Mwe - Lake Mweru & Mweru Wantipa; Map - Maputaland.

Species	**Habitat**	**Cluster**	**Area**																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
REPTILIA																						
TESTUDINES																						
Pelomedusidae																						
Pelomedusa subrufa	sa	PAN		X	X	X								X			X	X		X	X	X
Pelusios nanus	aq	ANG	X				X															
Pelusius subniger	sa	EAS							X	X							X		X		X	
Pelusios bechuanicus	aq	PUZ		X	X	X		X														
Pelusios castanoides	aq	EAS												X		X	X	X	X			X

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Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Pelusios rhodesianus	aq	PUZ		X	X	X	X	X		X				X						X		X
Pelusios sinuatus	aq	EAS						X	X	X	X			X			X	X	X			X
Trionychidae																						
Cycloderma frenatum	aq	LZ												X		X	X	X	X			
Testudinidae																						
Kinixys spekii		CPS			X			X	X	X				X						X	X	X
Kinixys belliana		EAS															X	X				X
SQUAMATA																						
Agamidae																						
Agama mossambica		EAS									P				X	X	X	X	X			
Chamaeleonidae																						
Chamaeleo dilepis		EAS	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X
Gekkonidae																						
Lygodactylus angolensis		ANG							X											X	X	
Lygodactylus capensis		EAS	X	X	X	X		X		X	X			X	X		X	X	X			X
Lygodactylus chobiensis		PUZ		X	X	X		X	X													
Hemidactylus mabouia		EAS	X	X	X	X		X	X					X	X	X	X	X	X			X
Scincidae																						
Typhlacontias gracilis	fp	BAR		X																		

Species	Habitat	Cluster	Area																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Typhlacontias rohani		KAL		X	X	X																
Mabuya boulengeri	fp	EAS										X		X	X		X	X	X			
Mabuya ivensi	sa	ANG	X																			
Mabuya megalura		CPS										X						P	X	X	P	
Mabuya punctulata		KAL		X	X																	
Mabuya varia		EAS	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mabuya wahlbergii		WS	X	X	X	X		X	X	X	X										?	
Mabuya striata		EAS					X					X		X	X	X	X	X	X	X	?	X
Eumecia anchietae	fp	ANG	X	X				P												X		
Eumecia johnstoni	?	EEM											X									
Lygosoma afrum		EAS					X							X		X	X	X	X		X	
Lygosoma sundevallii		CPS		X	X	X		X	X	X	X			X						X		X
Panaspis wahlbergii		EAS	X				X	X		X				X				X	X	X	X	X
Panaspis "maculicoliis"		CPS		X	X	X																
Typhlosaurus jappi		BAR		X																		
Cordylidae																						
Chamaesaura miopropus		ANG	X					P				X	X									
Gerrhosauridae																						
Gerrhosaurus major		EAS							X						X	X	X		X			X
Gerrhosaurus nigrolineatus		WS						X	X	X	X			X			X			X	P	
Gerrhosaurus auritus		KAL		X																		
Gerrhosaurus bulsi		ANG	X																	X		

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Gerrhosaurus flavigularis		EAS								X	X			X	X		X	X	X			X
Tetradactylus ellenbergeri	fp	COB	X	X								X								X		
Lacertidae																						
Latastia johnstoni		EAS												X		X					X	
Varanidae																						
Varanus niloticus	sa	PAN	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X
AMPHISBAENIA																						
Amphisbaenidae																						
Zygaspis kafuensis		KAF						X														
Zygaspis nigra		ANG		X																		
Zygaspis quadrifrons		KAL	X	X	X	X	X		X	X							X			X	X	
Chirindia swynnertoni		EAS																	X			
Monopeltis zambezensis		MZ							X													
Monopeltis mauricei		KAL			X			P														
Dalophia ellenbergeri	fp	ANG		X																		
Dalophia angolensis		ANG	P																			
Dalophia longicauda		CAP			X																	
Dalophia pistillum		KAL		X	X	X			X								X		X			

Species	Habitat	Cluster	Area																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
SERPENTES																						
Typhlopidae																						
Rhinotyphlops schlegelii		WS			X	X																X
Rhinotyphlops mucruso		EAS		X			X	X	X	X	X			X	X		X	X	X	X	X	
Leptotyphlopidae																						
Leptotyphlops pungwensis	fp	PUN																	X			
Leptotyphlops scutifrons		EAS				X				X	X						X		X			X
Pythonidae																						
Python natalensis		EAS	P	X	X	X	X	X	X	X	X			X	X	X	P	X	P	X	P	X
Viperidae																						
Causus rhombeatus		EAS	X	X		X	X	X	X	X	X	X		X	X					X	X	X
Causus bilineatus		ANG	X	X			X															
Causus defilippii		EAS					X		X	X	X	X		X	X		X	X	X			X
Proatheris superciliaris	fp	LZ												X		X	X	X	X			
Bitis arietans arietans		PAN	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X
Atractaspididae																						
Amblyodipsas polylepis		EAS		X	X	X	X		X	X				X		X					X	X
Amblyodipsas ventrimaculatus		KAL		X	X																	
Xenocalamus bicolor		KAL							X													
Xenocalamus mechowii		COB		X	X	X																

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Aparallactus lunulatus		EAS							X	P							X		X		X	
Aparallactus capensis		EAS		X					X	X	X				X				X	X	X	X
Elapidae																						
Elapsoidea semiannulata		ANG		X	X																	
Elapsoidea boulengeri		EAS		X	X	X		X		P					X		X		X			X
Naja annulifera		EAS							X	X	X						X	X	X			X
Naja anchietae		KAL		X	X	X	X	X														
Naja melanoleuca	sa	PAN	X				X				X	X	P	X	X			X			X	X
Naja nigricollis		NS	X	X	X		X							X						X	X	
Naja mossambica		EAS			X	X		X	X	X	P			X	X	X	X	X				X
Colubridae																						
Lycodonomorphus mlanjensis	sa	EEX									X				X							
Lycodonomorphus rufulus	sa	EES								P	X											X
Lycodonomorphus whytii	sa	MRP										X										
Lycodonomorphus obscuriventris	fp	LZ															X	X	X			X
Lycophidion multimaculatum		ANG	X	X	X															X	X	
Lycophidion capense capense		EAS			X			X		X	X				X		X	X	X			X
Lycophidion nanum		PUN																	X			
Crotaphopeltis hotamboeia		PAN	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Crotaphopeltis barotseensis	sa	OKO		X	P	X																
Dipsadoboa aulica		EAS															X					X
Dipsadoboa flavida flavida		EEM													X							
Dipsadoboa flavida broadleyi		EAS																X	X			
Natriciteres bipostocularis	sa	ANG	X																			
Natriciteres sylvatica	sa	ECF									X	X		X	X	X	X					X
Natriciteres olivacea	sa	NS		X	X	X	X	X		X			X	X		X	X	X	X	X	X	
Limnophis bicolor	aq	ANG	X																			
Limnophis bangweolicus	aq	OKO		X	X	X	X														X	
Grayia ornata	aq	COB	X																		X	
Grayia tholloni	aq	COB	X																			
Psammophylax variabilis		CPS		X	X							X	X		X							
Rhamphiophis acutus acutus		ANG	X				X							X								
Rhamphiophis acutus jappi	fp	BAR		X																		
Rhamphiophis rostratus		EAS				X			X					X			X					
Dromophis lineatus	fp	NS		X			X	P						X							X	
Psammophis mossambicus		EAS	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X
Meizodon s. semiornata	fp	EAS						X	X							X	X	X	X			P

Species	Habitat	Cluster	Area																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Prosymna stuhlmannii		EAS							X	X				X	X		X	X	X			X
Philothamnus angolensis	sa	WS	X	X	X	X					X			X	X	X	X	X	X	X	X	X
Philothamnus hoplogaster	sa	EAS	X	X				X	X	X	P			X	X	X	X	X	X	X	X	X
Philothamnus ornatus	sa	ANG	X	X	X	X	X			X	P			X							X	
Philothamnus heterolepidotus	sa	CPS	X	X																X	X	
Philothamnus natalensis	sa	ECF									X								X			X
Philothamnus punctatus	sa	EAS												X								
Philothamnus semivariegatus		PAN	X	X	X	X	X	X	X	P	X			X	X		X	X	X	X	X	X
Dispholidus typus		PAN	X	X	X	X	X	X	X	X	X	X		X	X	X	P	X	P	X	X	X
Thelotornis oatesii		WS	X	X	X	X		X	X	P	P			X			X			X		
Thelotornis mossambicana		EAS									X	X		X	X				X			
Dasypeltis scabra	fp	PAN	X	X	X	X	X	X	X	X	P		X	X	X	X	X	X	X	X	X	X
CROCODYLIA																						
Crocodylidae																						
Crocodylus niloticus	aq	PAN		X	X	X	X	X	X	X	P			X		X	X	X	X	X	X	X
Crocodylus cataphractus	aq	PAN					?														X	

Species	Habitat	Cluster	Area																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
AMPHIBIA - ANURA																						
Pipidae																						
Xenopus laevis	aq	SS								X	X		X		X							X
Xenopus muelleri	aq	EAS		X	X	X			X					X		X	X	X	X		X	X
Xenopus petersii	aq	ANG	X	X	X	X		X				X								X		
Bufonidae																						
Bufo gutturalis		EAS	X	X	X	X		X	X	X	X		X	X	X		X	X	X	X		X
Bufo garmani		EAS			X			X	X													
Bufo poweri		KAL		X	X	X																X
Bufo maculatus		NS		X	X	X				X	P			X			X	X				X
Bufo lemairii	fp	OKO		X	X	X														X		
Bufo kavangensis	fp	OKO				X																
Bufo beiranus	fp	PUN		X															X			
Microhylidae																						
Phrynomantis bifasciatus		EAS		X	X	X		X	X	X	X			X		X	X					X
Phrynomantis affinis		WS		X																		
Hemisidae																						
Hemisus marmoratum		EAS			X			X	X	X	X			X	X		X	X				X
Hemisus "barotseensis"	fp	BAR		X																		
Hemisus guineensis microps		ANG		X	X	X																
Hemisus guineensis broadleyi		LZ								X									X			

Species	Habitat	Cluster	Area																			
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Ranidae																						
Pyxicephalus adspersus		SS			X	X				X									X			X
Pyxicephalus edulis		EAS		X				X								X	X	X	X			X
Tomopterna cryptotis		WS		X	X	X		X								X	X		X			
Tomopterna marmorata		EAS							X													X
Rana angolensis	sa	CPS	X		X					X	X	X	X	X	X	X	X		X	X		X
Rana johnstoni	aq	EEM													X							
Rana inyangae	aq	EEZ									X											
Strongylopus fasciatus		EES								X	X											
Strongylopus fuelleborni		EEN										X	X		X							
Hylarana darlingi		ANG		X	X			X		X					X							
Hylarana lemairei		ANG	X																	X		
Hylarana galamensis	sa	NS					X							X		X		X	X		X	
Hildebrandtia ornata		EAS		X				X		X									X			
Ptychadena subpunctata	sa	ANG	X	X	X	X																
Ptychadena oxyrhynchus	sa	NS			X	X		X	X	X	X		X	X	X			X	X	X	X	X
Ptychadena anchietae	fp	EAS			X			X	X		X			X	X		X		X	X		X
Ptychadena obscura		COB	X																	X		
Ptychadena mascareniensis	sa	NS		X	X	X		X					X	X		X	X			X	X	X
Ptychadena porosissima		EAS	X	X						X	X		X							X		X

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Ptychadena grandisonae		ANG	X	X	X									X						X		
Ptychadena upembae		ANG		X										X	X					X		
Ptychadena uzungwensis		EAS	X	X							X	X	X	X	X					X		
Ptychadena pumilio		NS	X	X		X								X	X	X				X		X
Ptychadena guibei		ANG	X	X	X									X	X	X			X	X		
Ptychadena mossambica	fp	EAS			X	X		X	X	P						X	X	X	X			X
Ptychadena schillukorum	sa	NS												X		X	X		X	X	X	
Ptychadena mapacha		CAP			X																	
Phrynobatrachus acridoides	sa	NS												X		X	X	X	X		X	X
Phrynobatrachus natalensis	sa	NS	X	X	X	X		X	X	X	X	X	X	X	X	X	X			X	X	X
Phrynobatrachus mababiensis	sa	EAS	X	X	X	X		X	X	X	X		X	X		X	X	X	X		X	X
Phrynobatrachus parvulus	sa	EAS								X	X		X	X								
Cacosternum boettgeri		CPS						X		X												X
Rhacophoridae																						
Chiromantis xerampelina		EAS			X			X	X					X			X	X				X
Hyperoliidae																						
Leptopelis flavomaculatus		ECF									X			X	X							
Leptopelis broadleyi		LZ													X				X			

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Leptopelis mossambicus		EAS															X	X	X			X
Leptopelis parbocagii		ANG												X	X		X			X		
Leptopelis bocagii		CPS	X	X				X		X	X			X								
Kassina maculata	sa	EAS													X		X	X	X			X
Kassina kuvangensis	sa	OKO	X	X																		
Kassina senegalensis		NS	X	X	X	X		X	X	X						X		X	X	X	X	X
Afrixalus brachycnemis		EAS												X	X							
Afrixalus delicatus		LZ																X	X			X
Afrixalus crotalus		EAS															X					
Afrixalus wittei		COB	X	X				X												X	X	
Afrixalus fornasinii		EAS											X	X	X		X	X	X			X
Hyperolius tuberilinguis		EAS									X			X	X		X	X	X			X
Hyperolius pictus		EEN										X	X									
Hyperolius q. quinquevittatus		ANG	X									X			X	X						
Hyperolius q. mertensi		EEM											X									
Hyperolius kivuensis		CPS						X														
Hyperolius argus		EAS															X	X	X			X
Hyperolius puncticulatus		ECF										X	X		X							
Hyperolius mitchelli		EAS												X					P			
Hyperolius spinigularis		MEA													X							
Hyperolius pusillus		EAS												X		X	X	X	X			X

Species	Habitat	Cluster	Area																		
			Head	Bar	Cho	Oka	Ban	Kaf	Kar	Chv	Nya	MRP	Nyk	Mal	Mul	Chi	LSh	Del	Pun	Upe	Mwe	Map
Hyperolius nasutus		EAS	X	X	X			X		X	X		X	X	X			X	X			X
Hyperolius benguellensis		WS		X				X		X											X	
Hyperolius marmoratus taeniatus		EAS															X	X	X			X
Hyperolius alborufus		ZHW	X																			
Hyperolius angolensis		ANG		X	X	X																
Hyperolius s. broadleyi		ZIM								X	X											
Hyperolius m. marginatus		MZ							X					X								
Hyperolius m. albofasciatus		EEM												X	X		X					
Hyperolius pyrrhodictyon		KAF						X														
Hyperolius melanoleucus		COB																				
Hyperolius nyassae		NLM												X								

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Fig. 6.1. The Zambezi wetlands

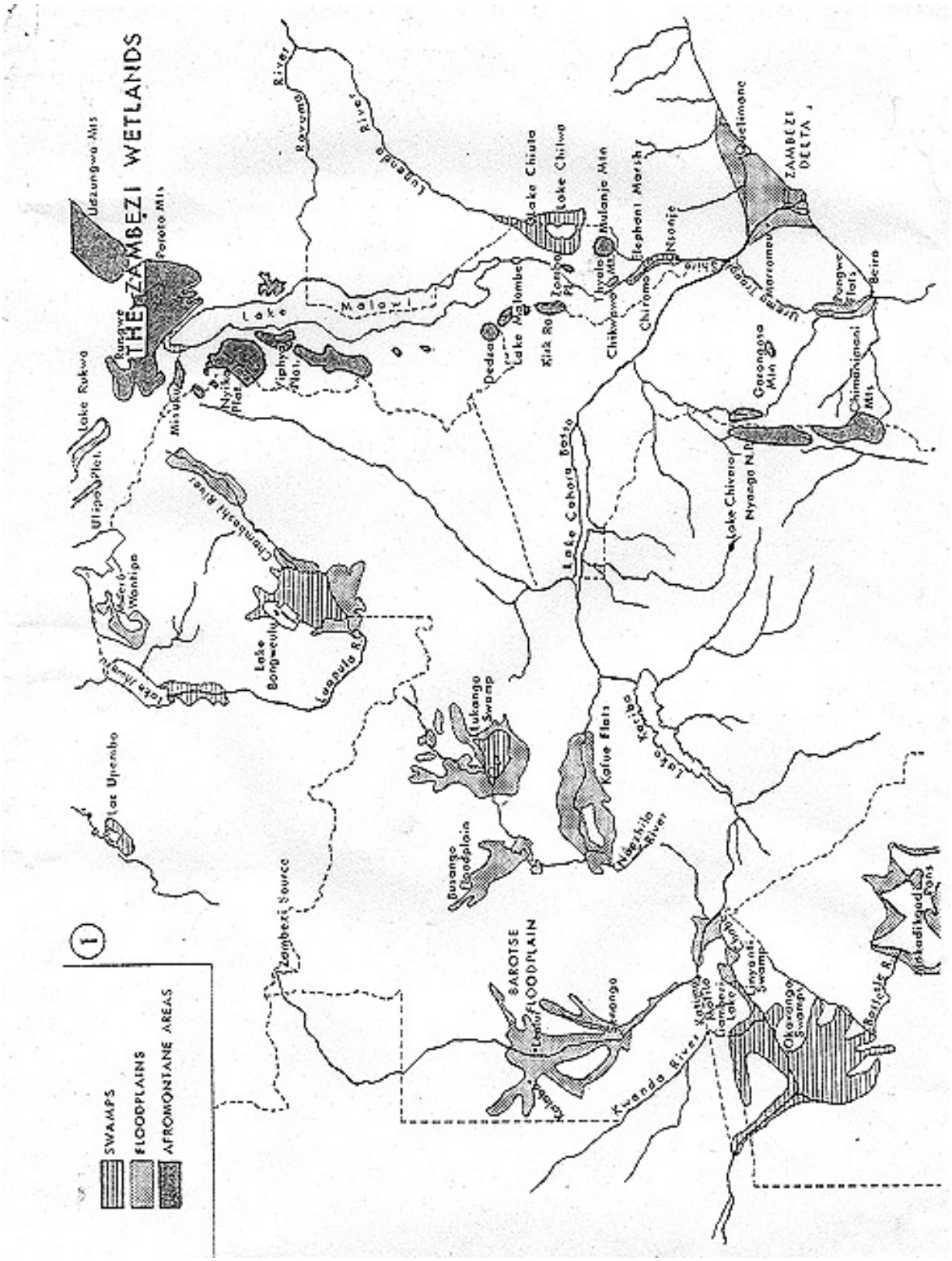


Fig. 6.2. Africa showing the present distribution of Kalahari sand and derived east coast alluvium [fine stipple], palaeo-lakes [coarse stipple, names in upper case] and recent lakes and swamps [coarse stipple, names in lower case].

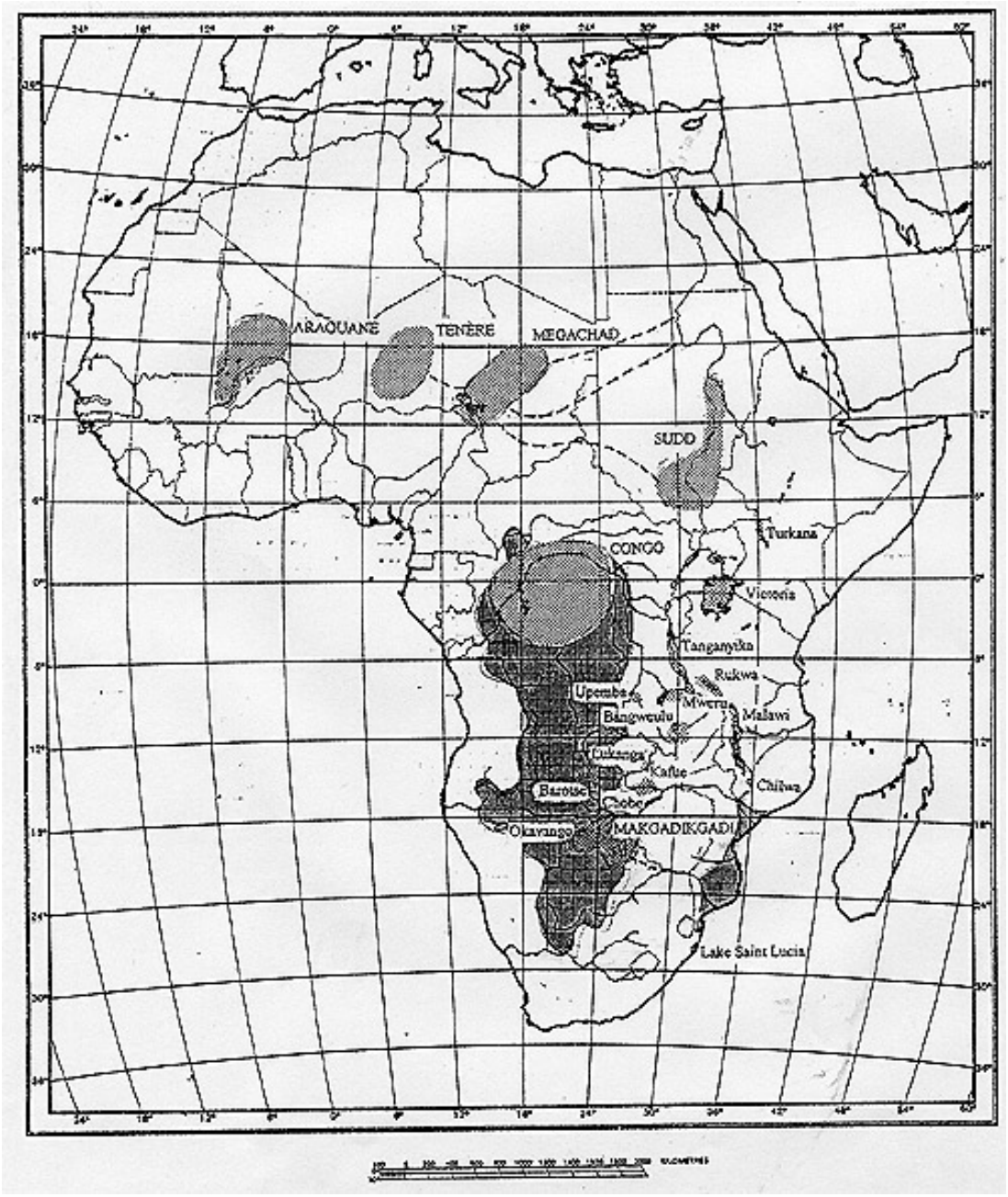


Fig. 6.3. Distribution Map: *Pelusios nanus, P. subniger, P. bechuanicus.*

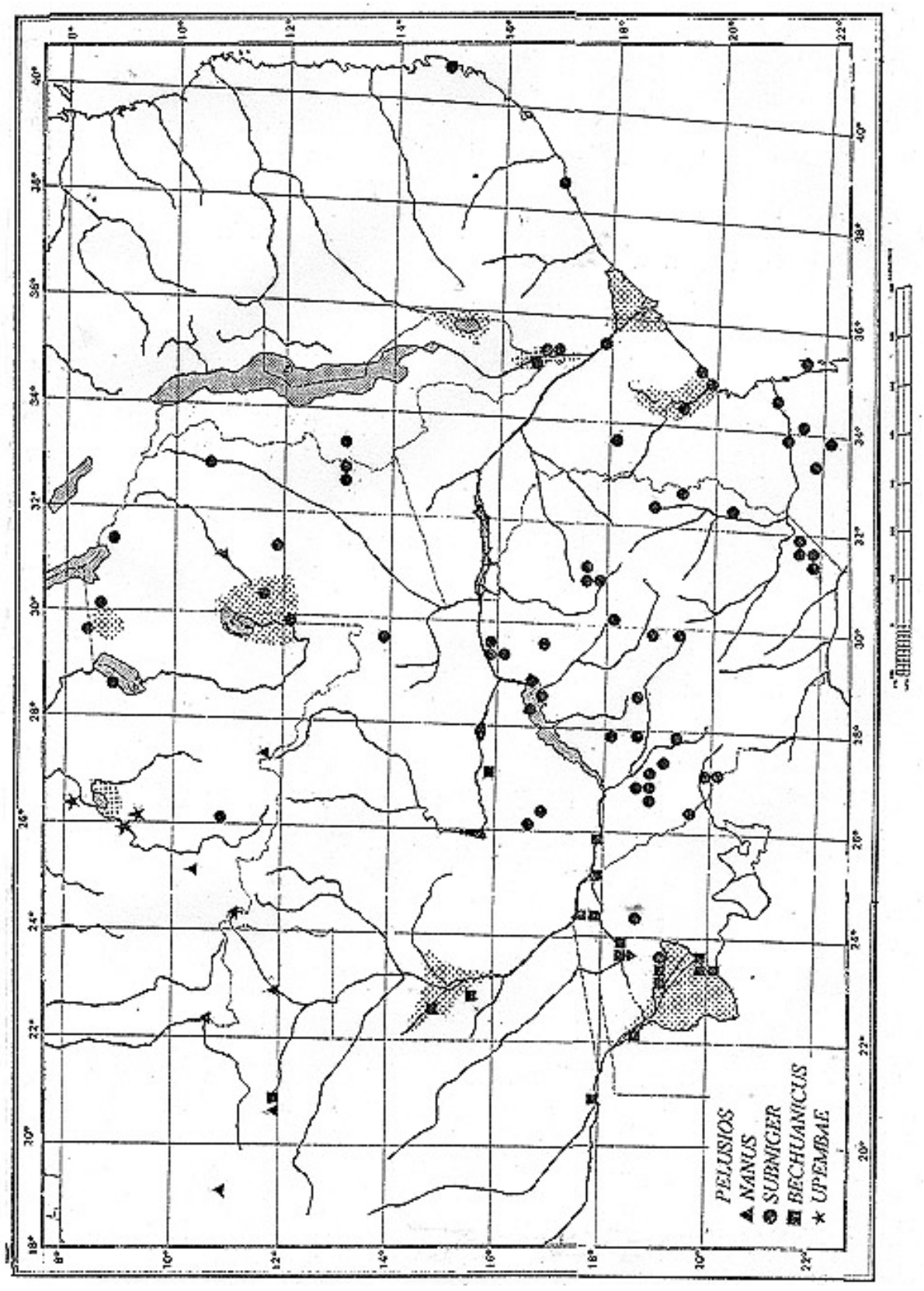


Fig. 6.4. Distribution Map: *Pelusios castanoides, P. rhodesianus*

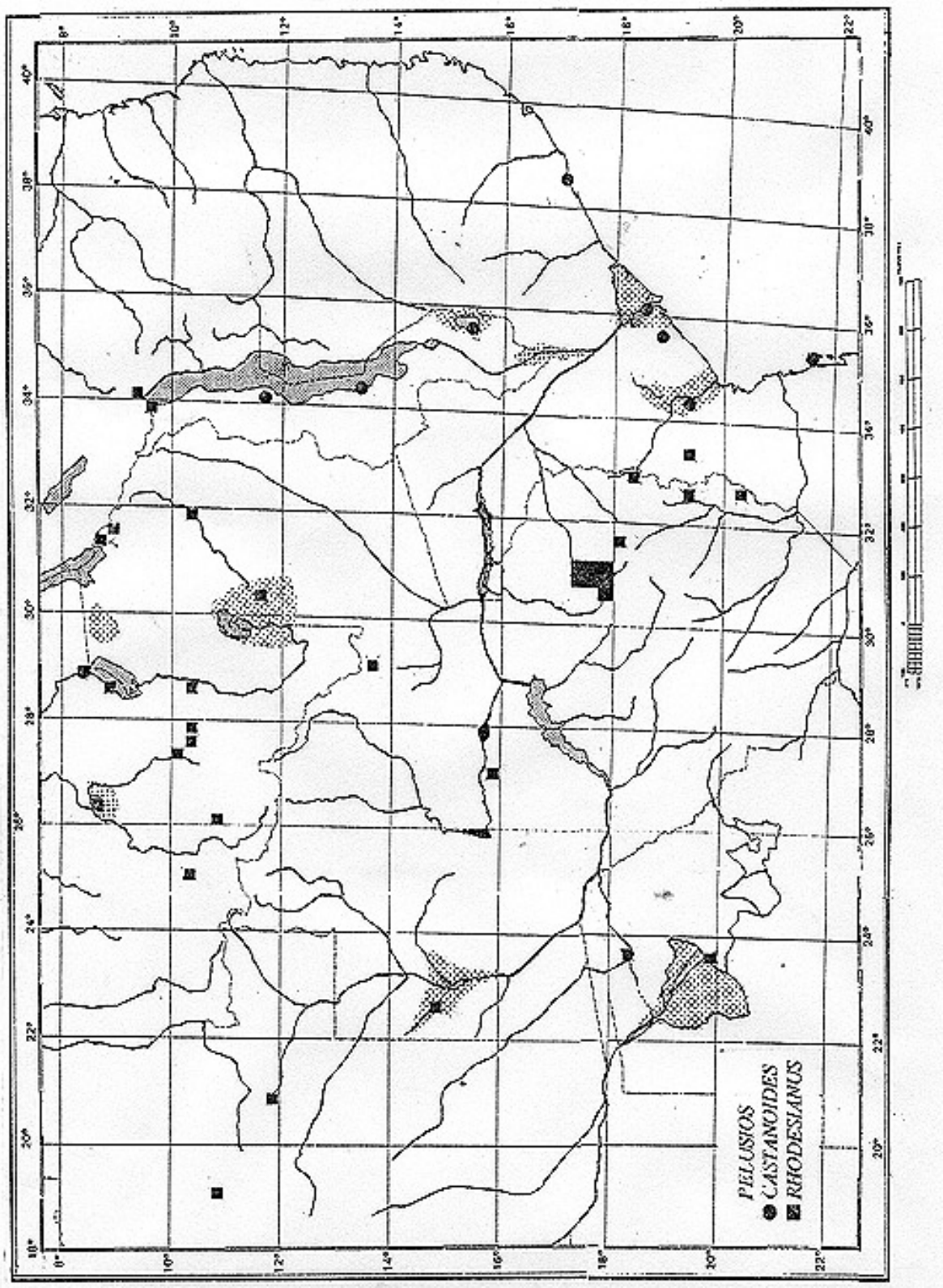


Fig. 6.5. Distribution Map: *Cycloderma frenatum*

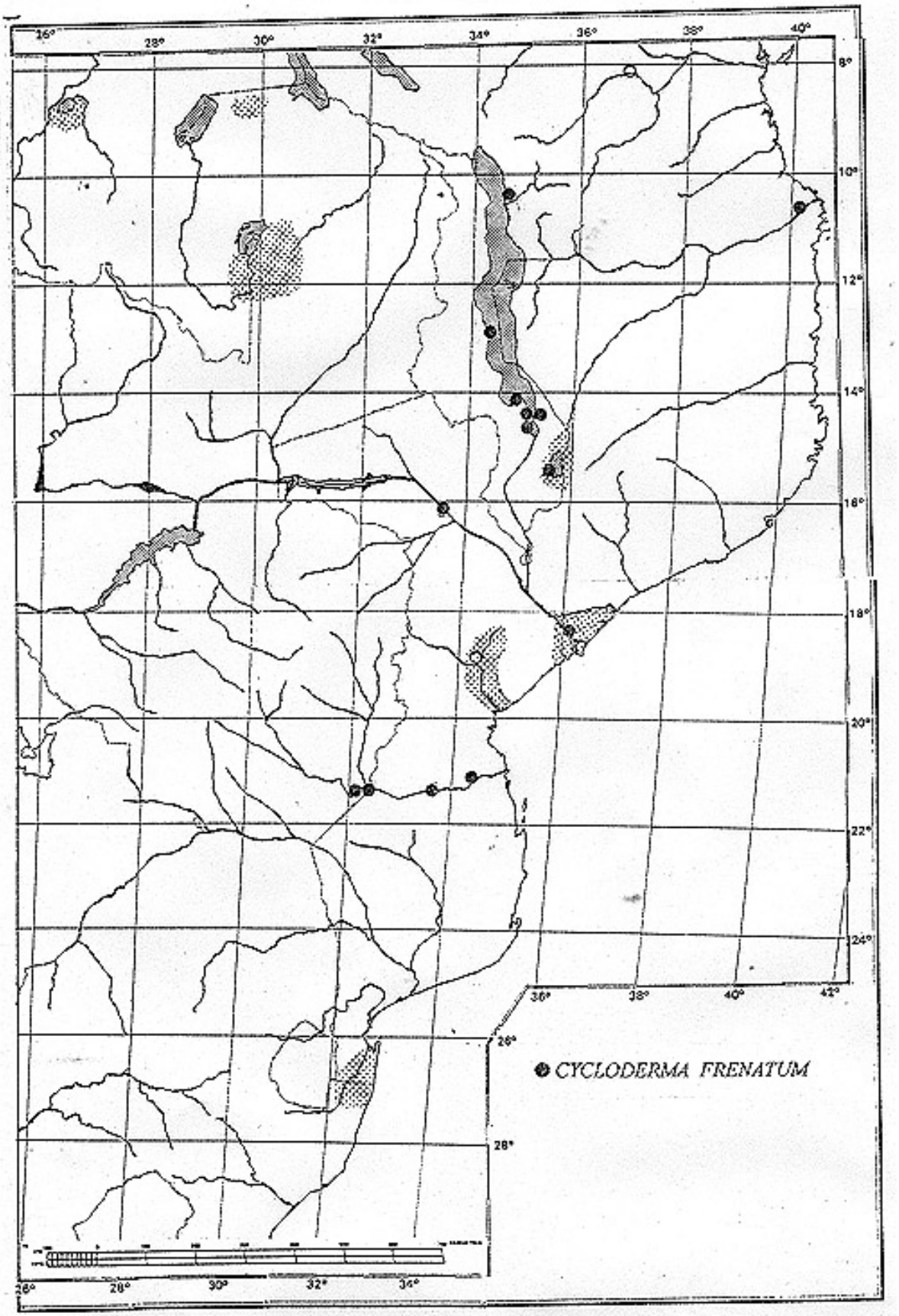


Fig. 6.6. Distribution Map: *Lygodactylus chobiensis, L. gutturalis*

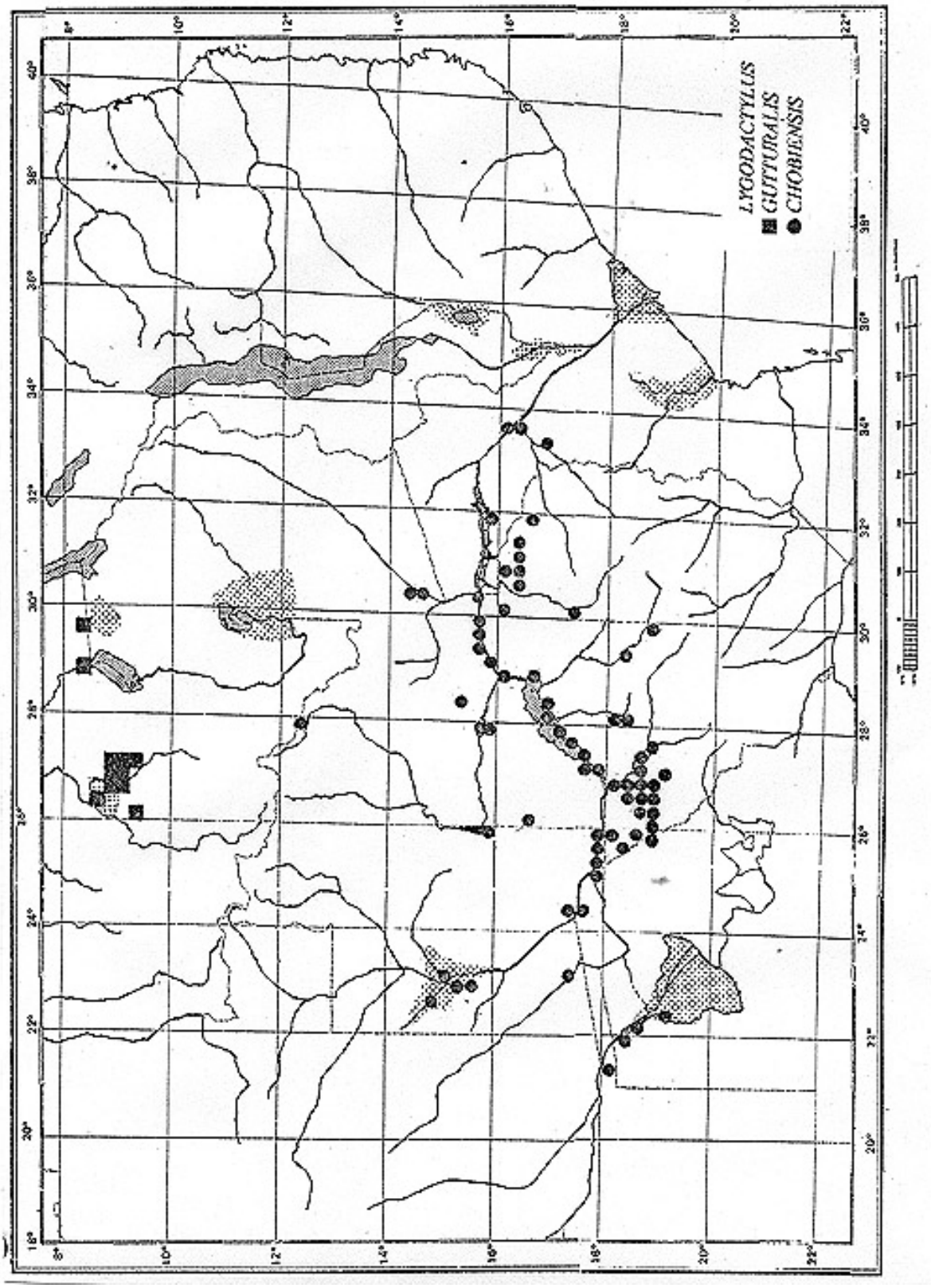


Fig. 6.7. Distribution Map: *Typhlacontias gracilis, T. rohani, Mabuya boulengeri, M. megalura*

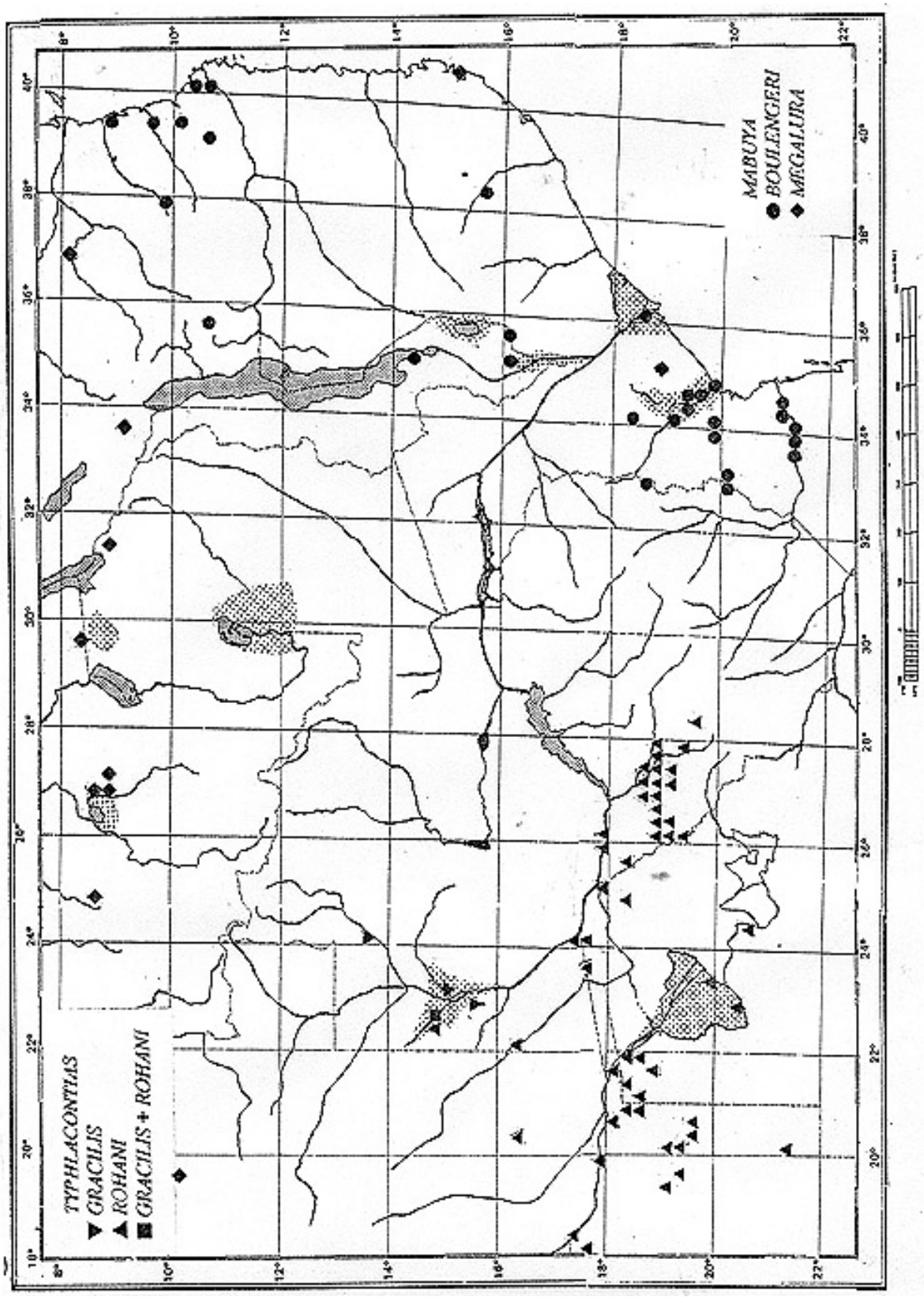


Fig. 6.8. Distribution Map: *Eumecia anchietae, E. johnstoni*

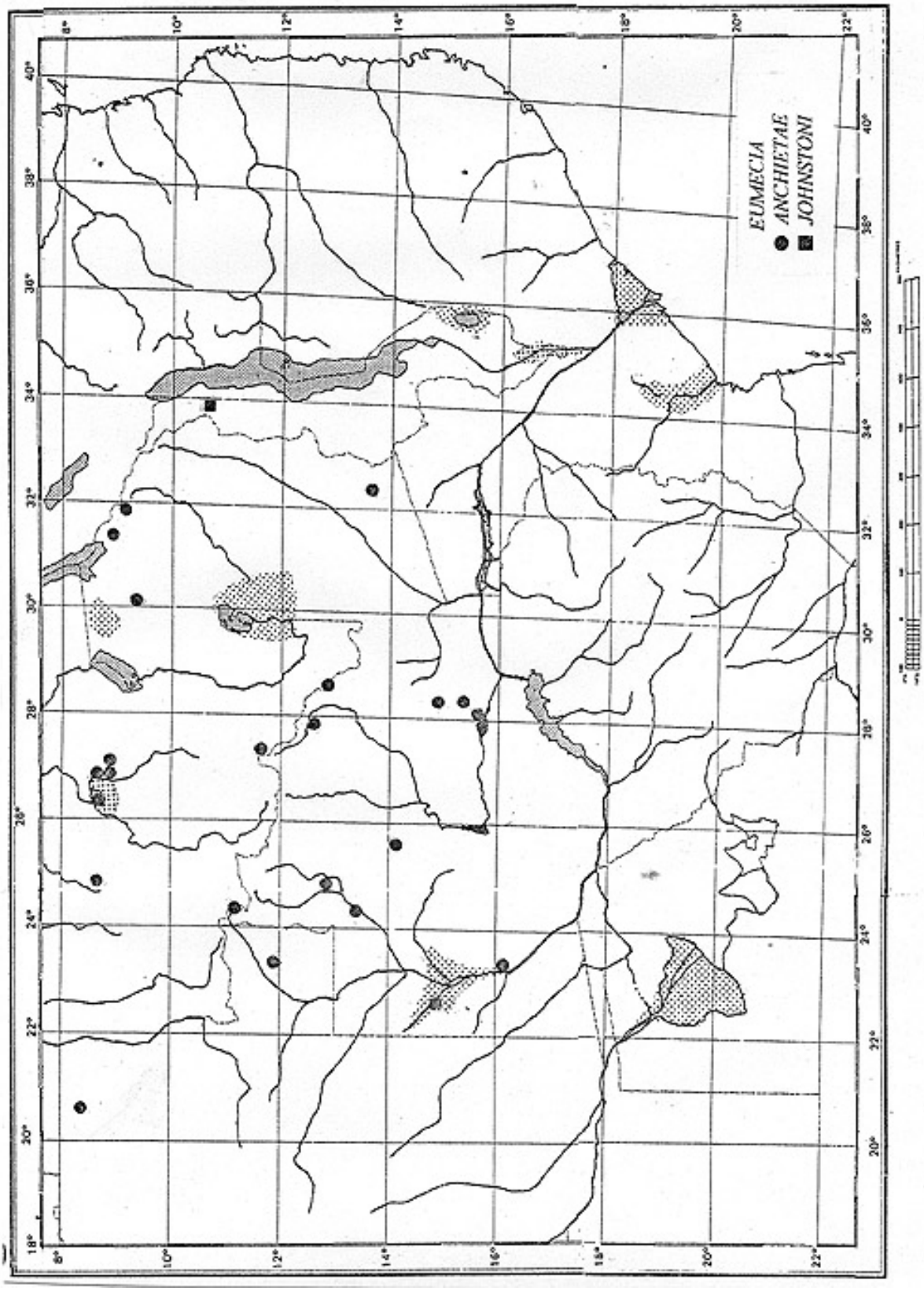


Fig. 6.9. Distribution Map: *Gerrhosaurus nigrolinestus, G. auritus, G. bulsi*

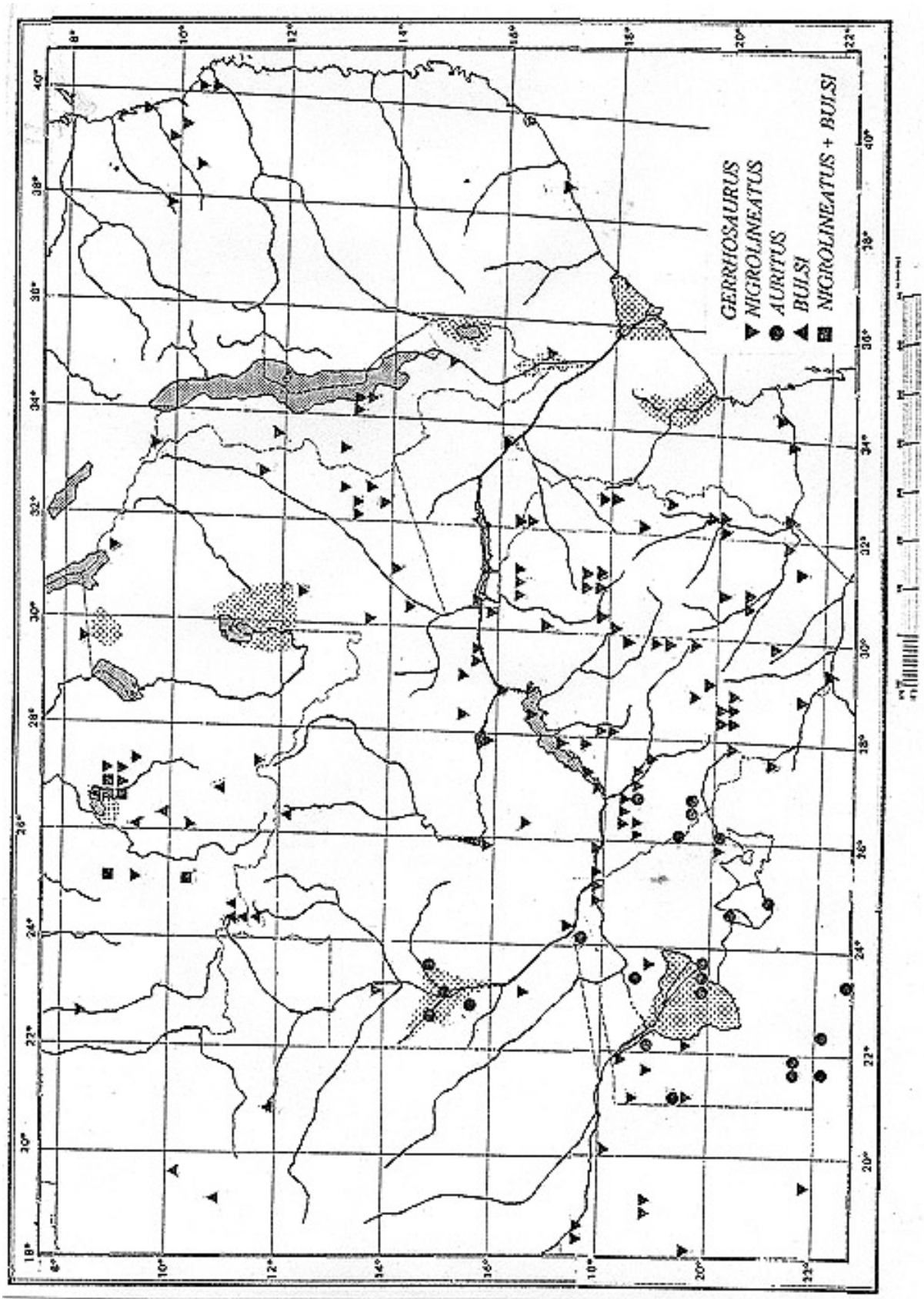


Fig. 6.10. Distribution Map: *Tetradactylus ellenbergeri, Chamaesaura miopropus, C. macrolepis*

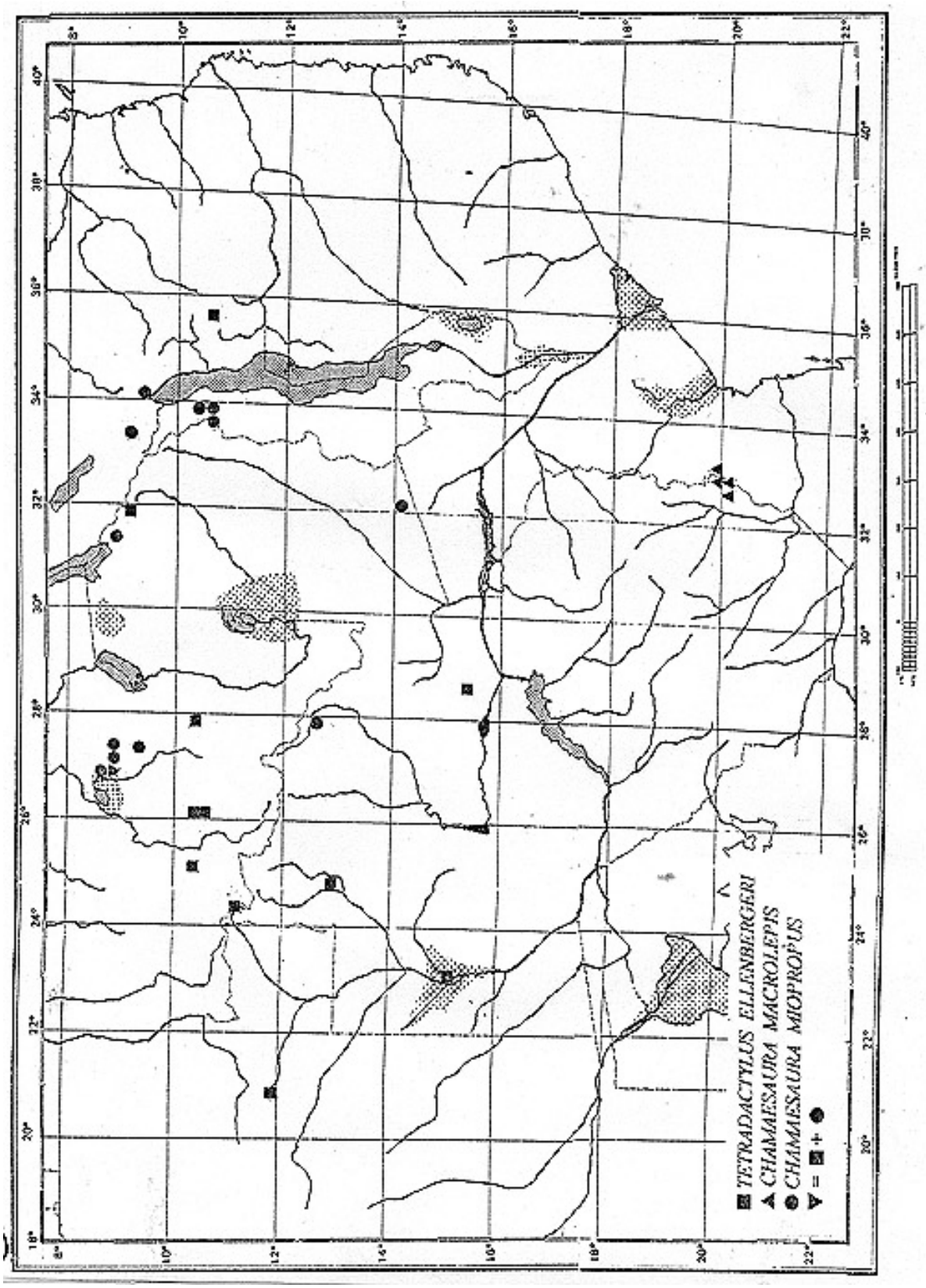


Fig. 6.11. Distribution Map: *Zygaspis kafuensis, Z. nigra, Z. quadrifrons, Chirindia swynnertoni*

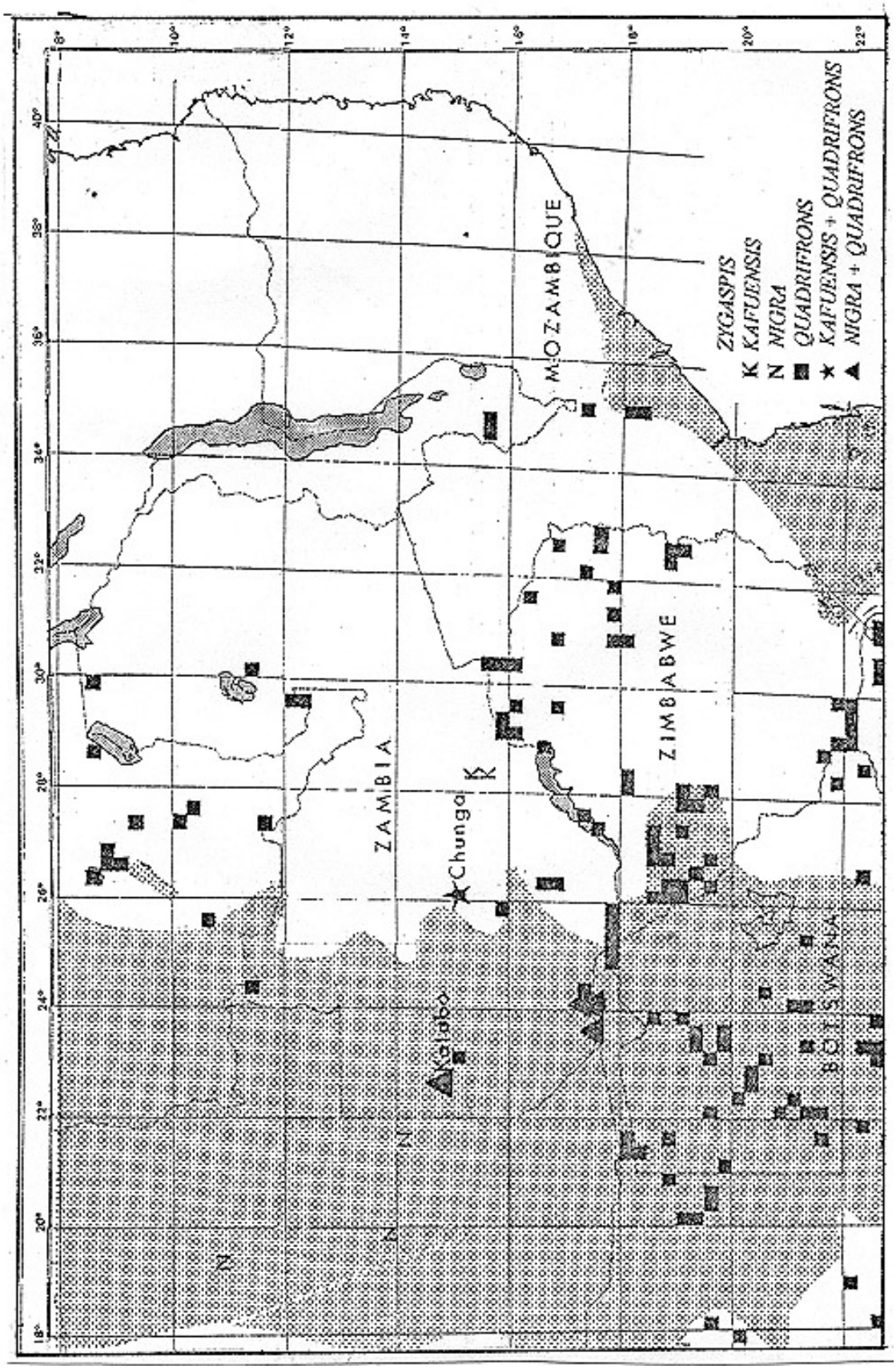


Fig. 6.12. Distribution Map: *Monopeltis zambezensis, M. sphenorhynchus, M. mauricei, Mabuya ivensii*

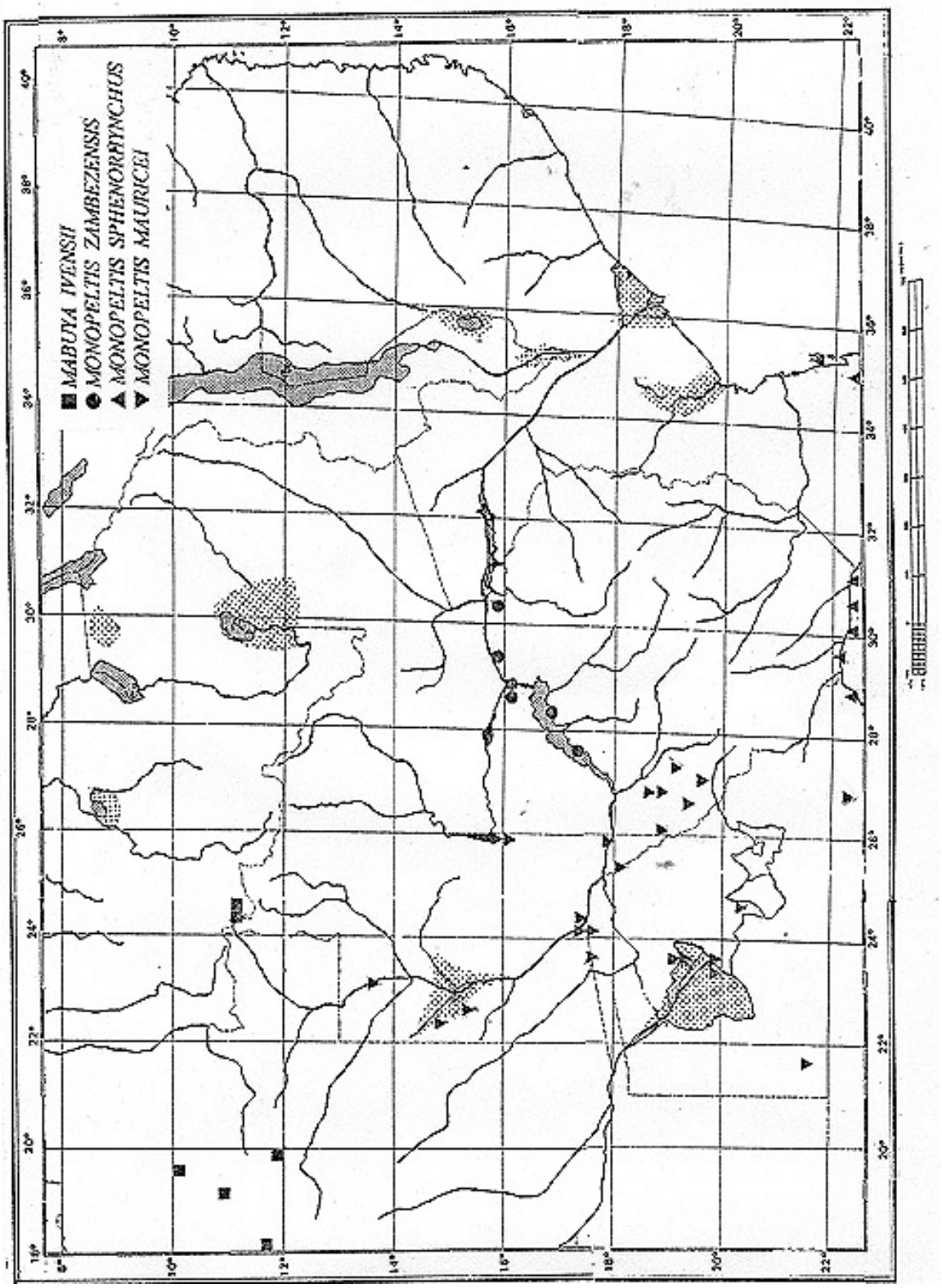


Fig. 6.13. Distribution Map: *Dalophia pistillum, D. longicauda, D. angolensis, D. ellenbergeri*

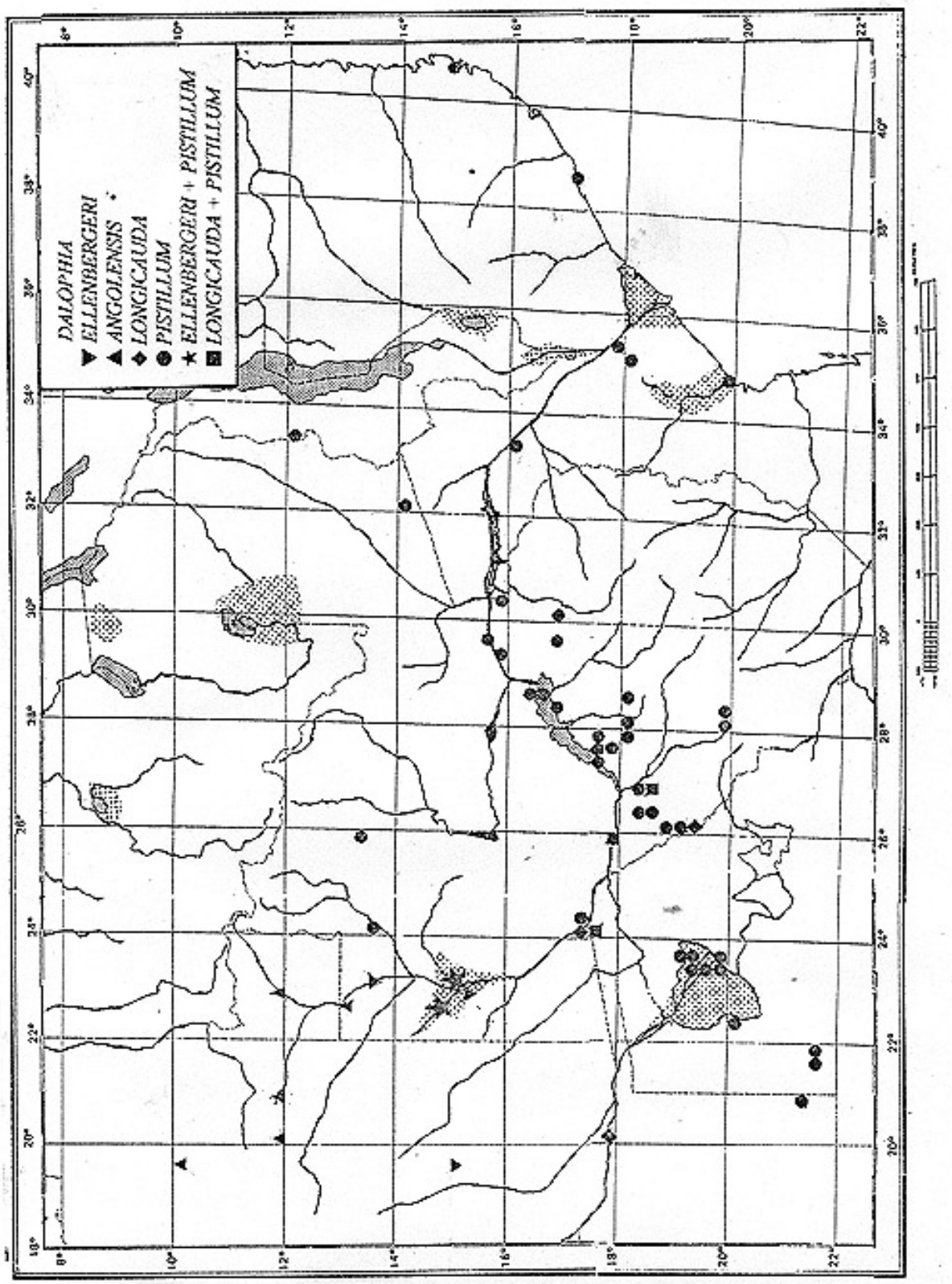


Fig. 6.14. Distribution Map: *Proatheris superciliaris*

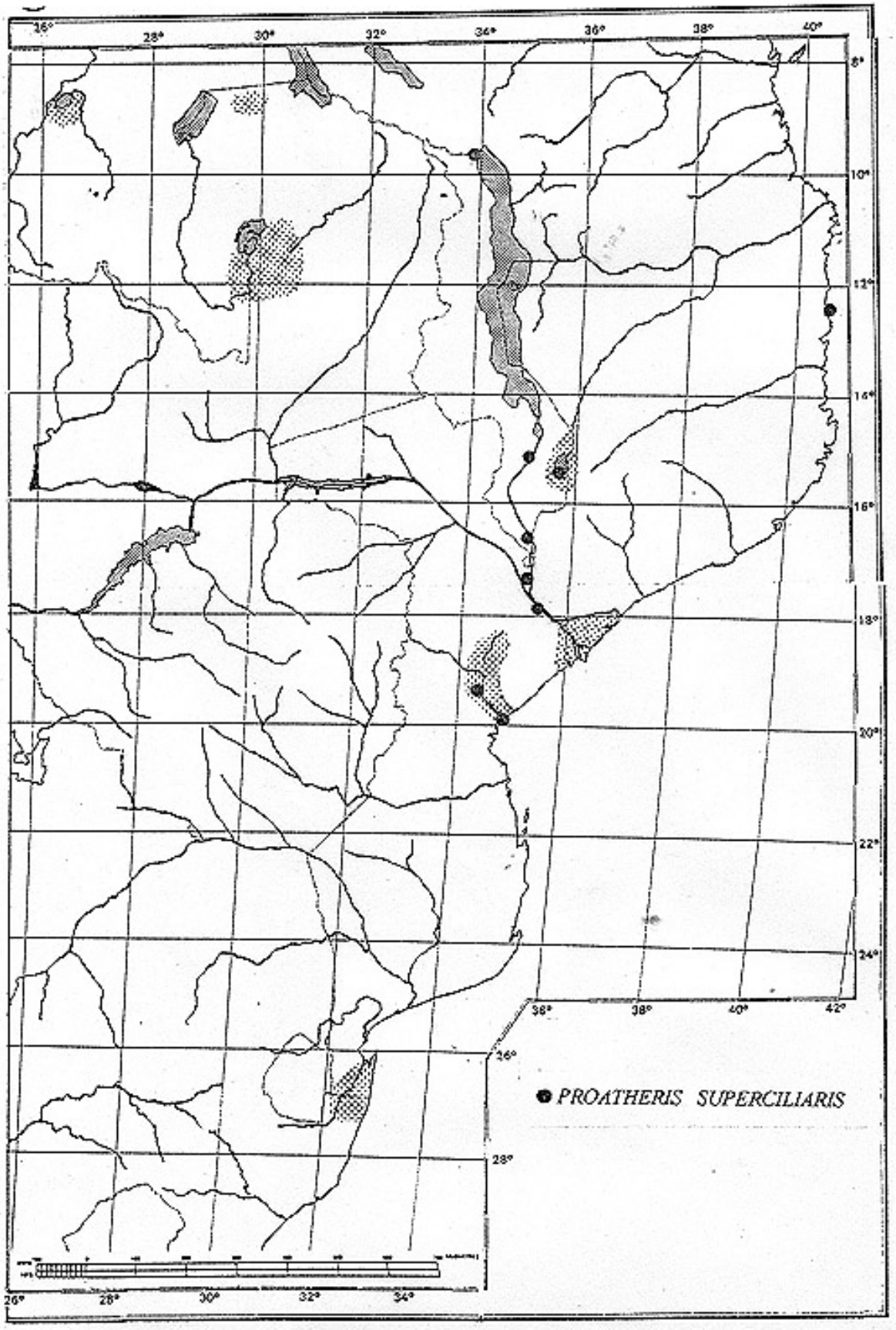


Fig. 6.15. Distribution Map: *Xenocalamus bicolor, X. lineatus, X. mechowii*

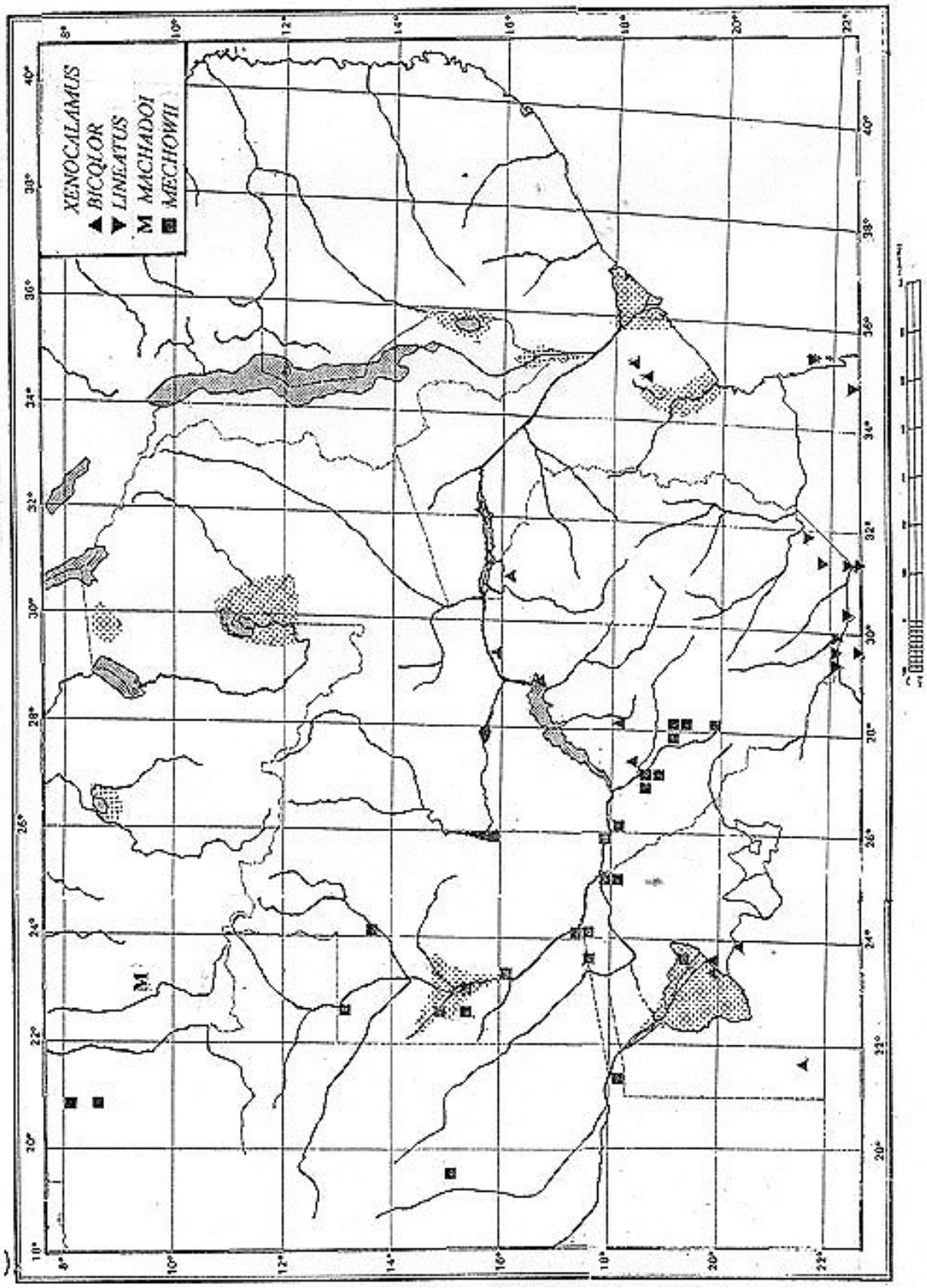


Fig. 6.16. Distribution Map: *Lycodonomorphus bicolor, L. rufulus, L. whytii, L. mlanjensis, L. obscuriventris*

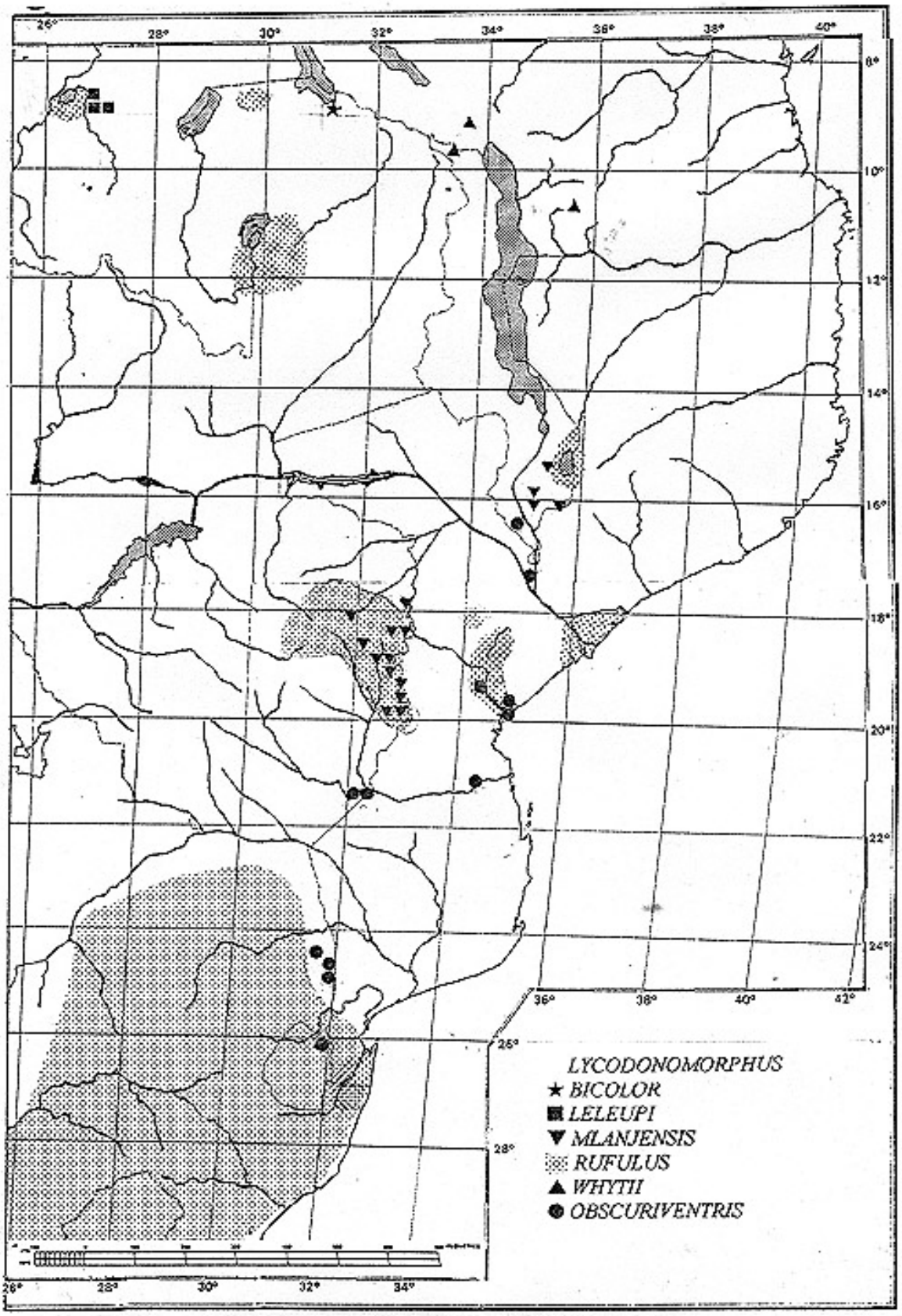


Fig. 6.17. Distribution Map: *Crotaphopeltis barotseensis, C. degeni, Dipsadoboa shrevei, D. aulica, D. flavida flavida, D. flavida broadleyi*

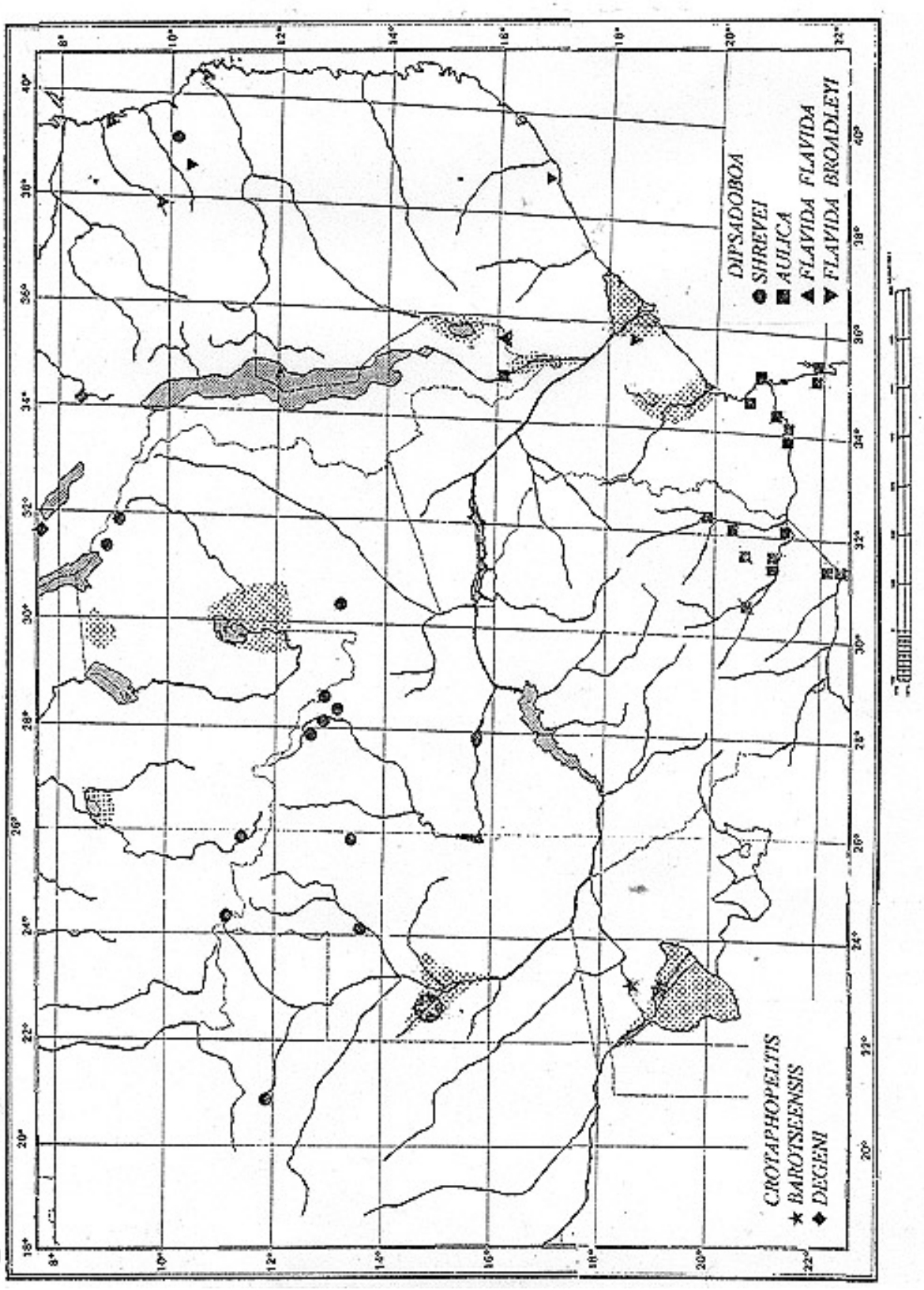


Fig. 6.18. Distribution Map: *Natriciteres bipostocularis, N. sylvatica, N. olivacea*

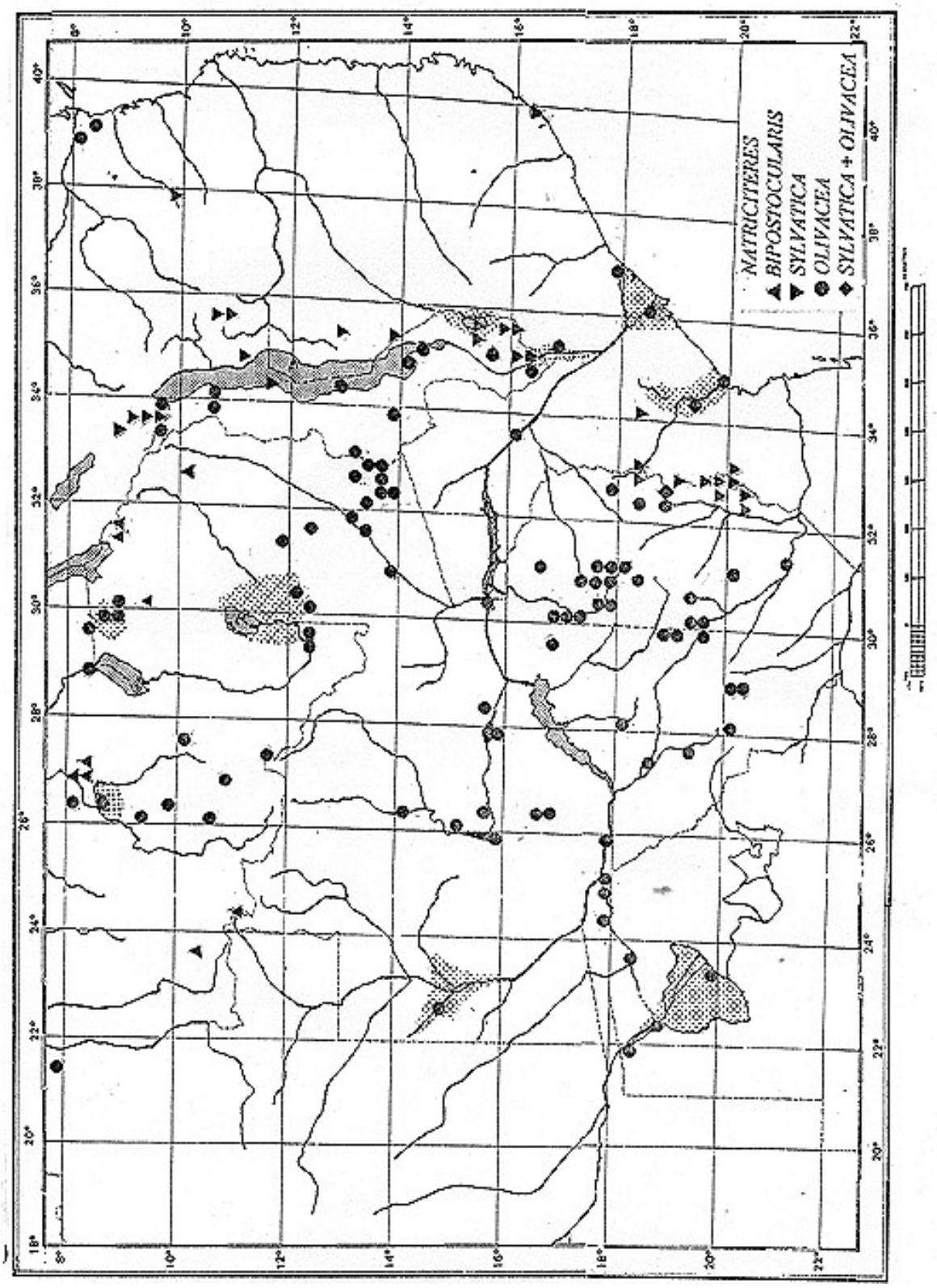


Fig. 6.19. Distribution Map: *Limnophis bicolor, L. bangweolicus*, *Meizodon semiornata semiornata*

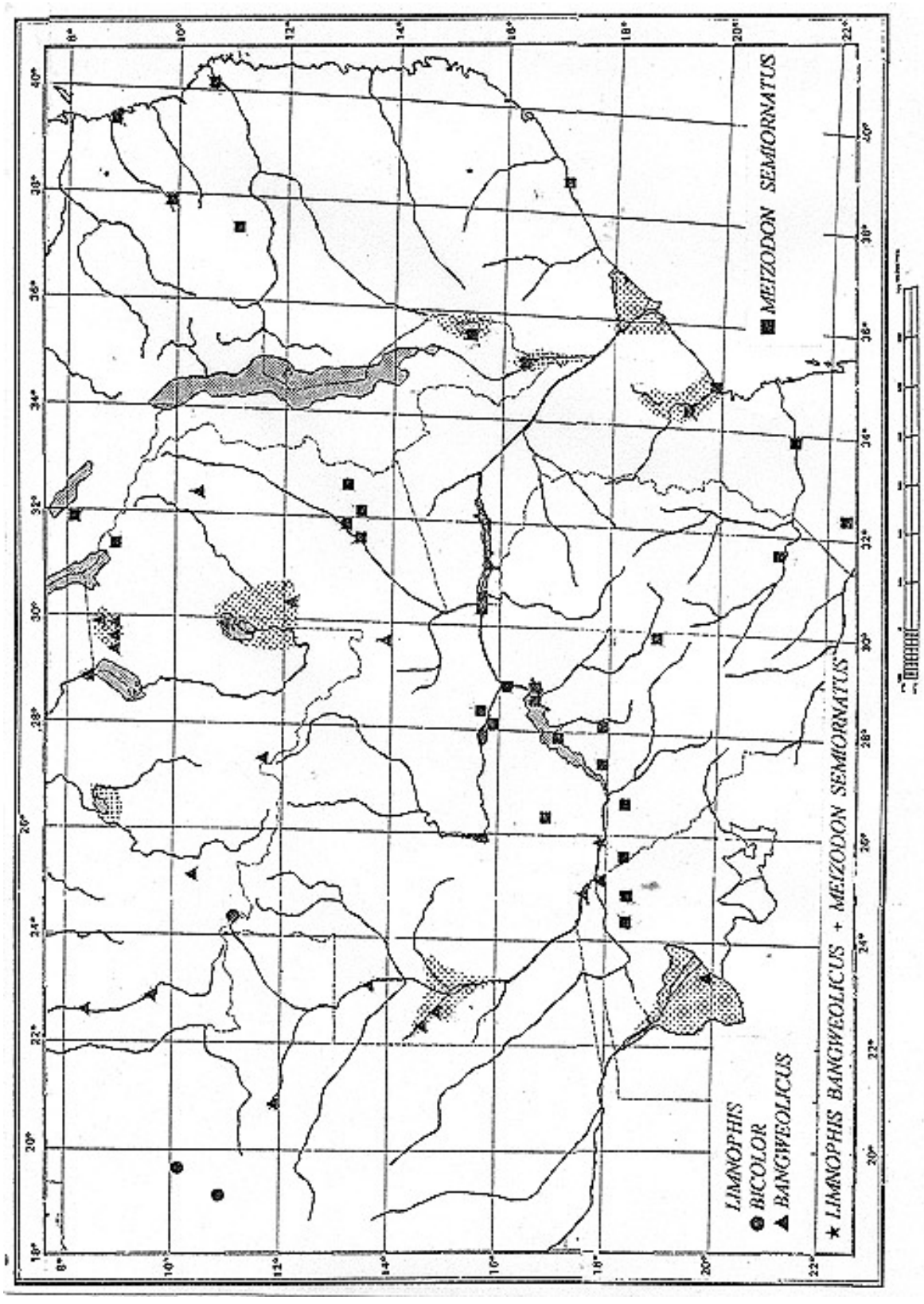


Fig. 6.20. Distribution Map: *Dromophis lineatus, Dromophis* sp. nov.

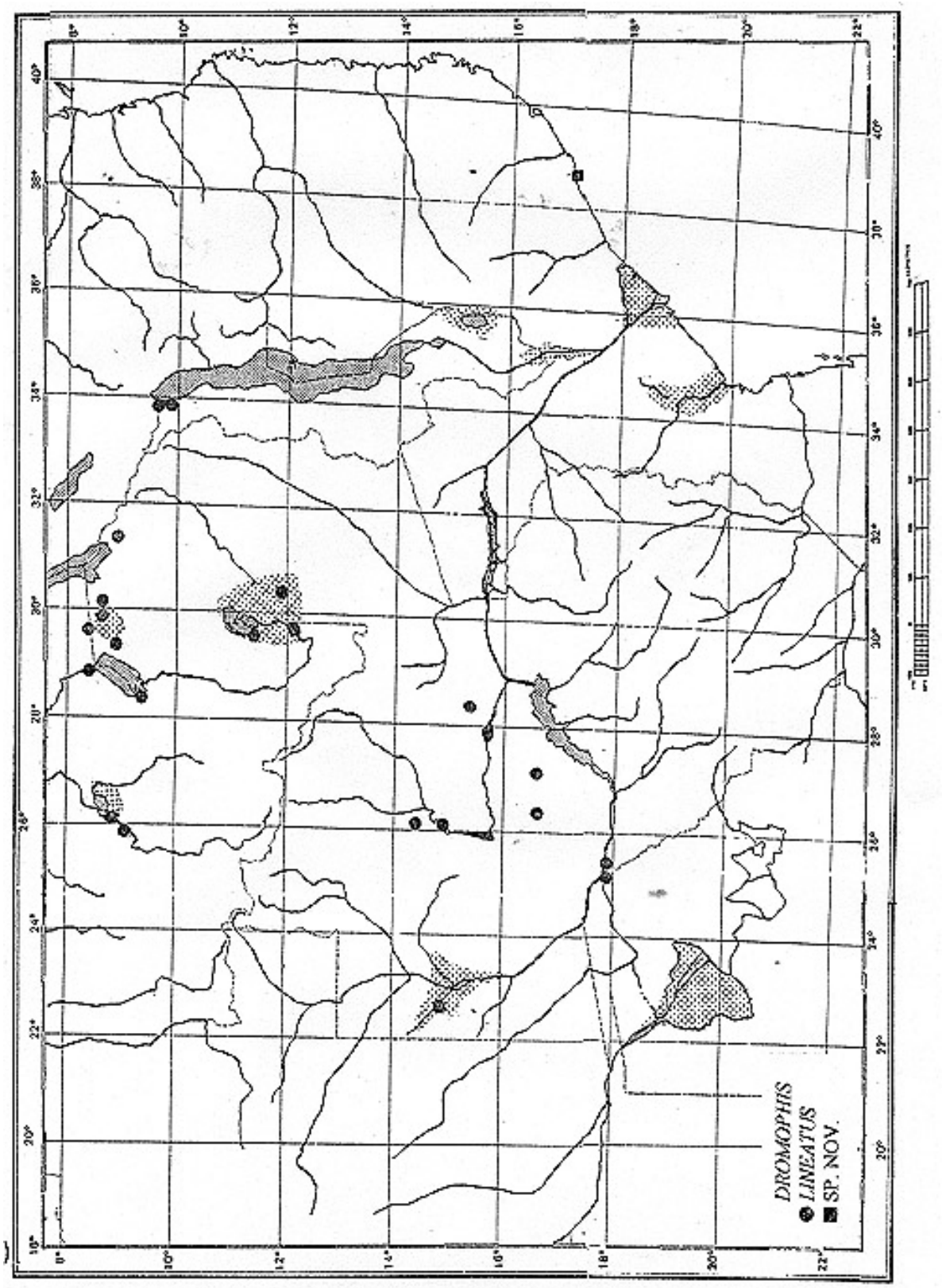


Fig. 6.21. Distribution Map: *Philothamnus angolensis, P. punctatus*

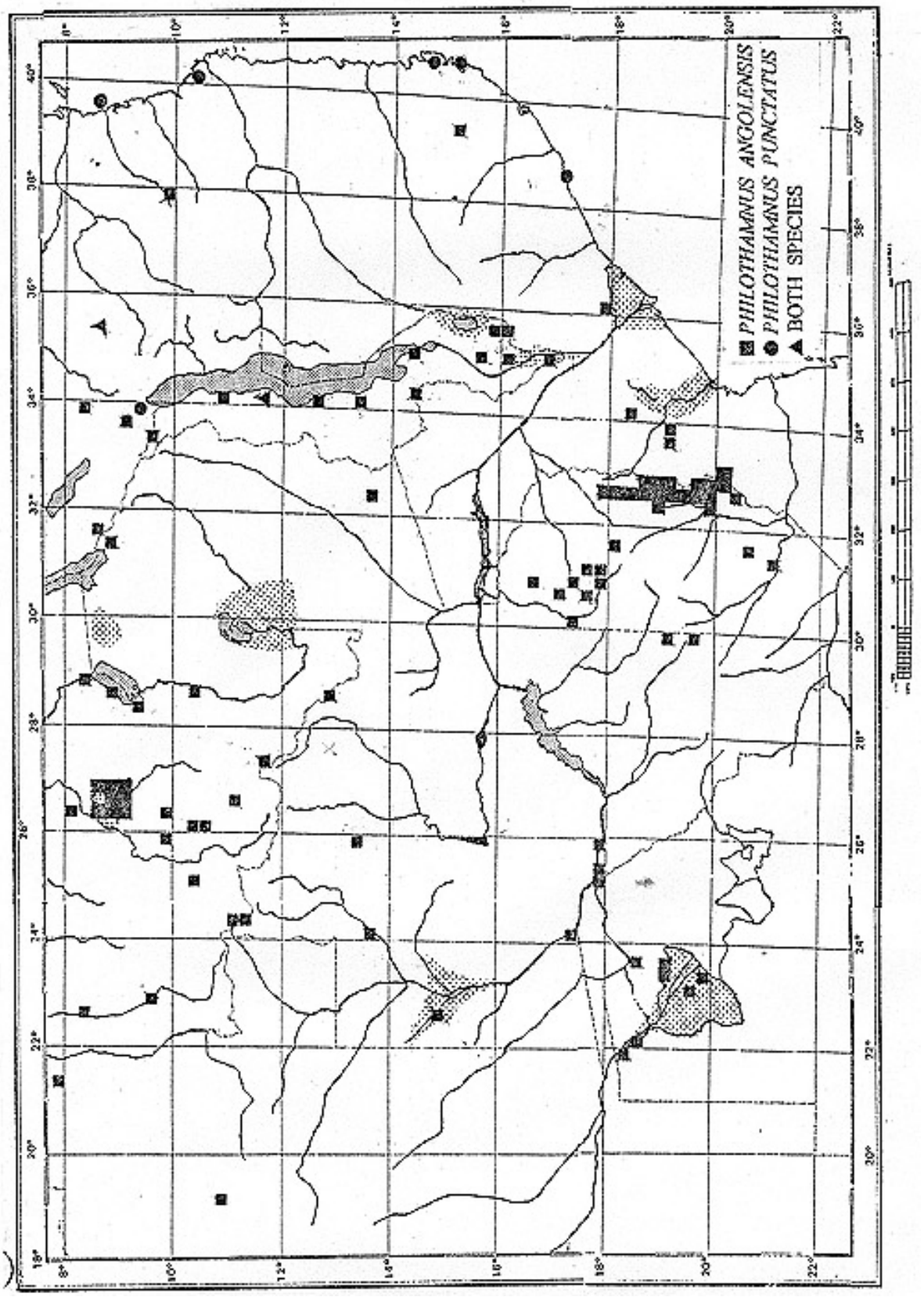


Fig. 6.22. Distribution Map: *Philothamnus natalensis, P. ornatus, P. heterolepidotus*

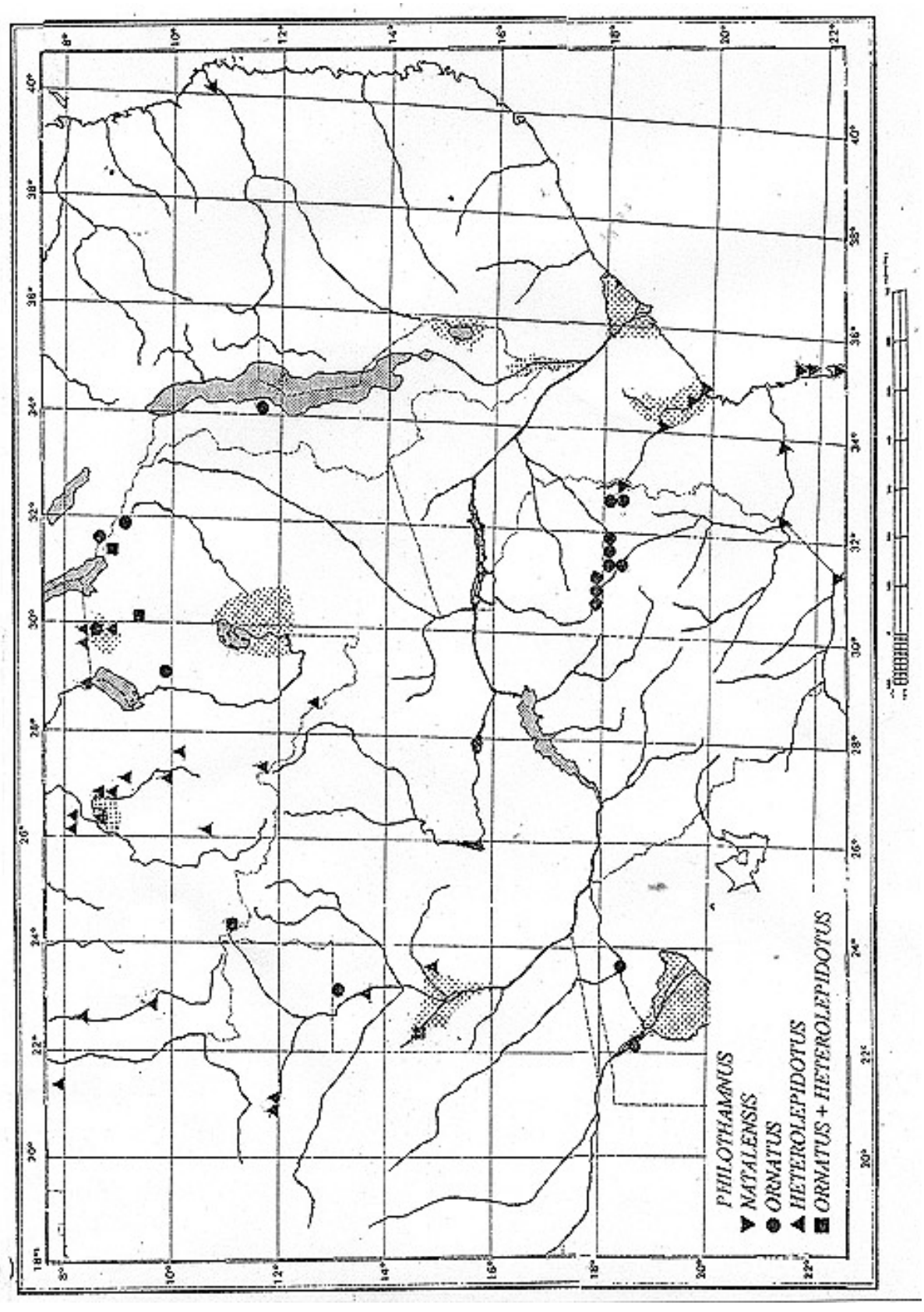


Fig. 6.23. Distribution Map: *Bufo lemairii*

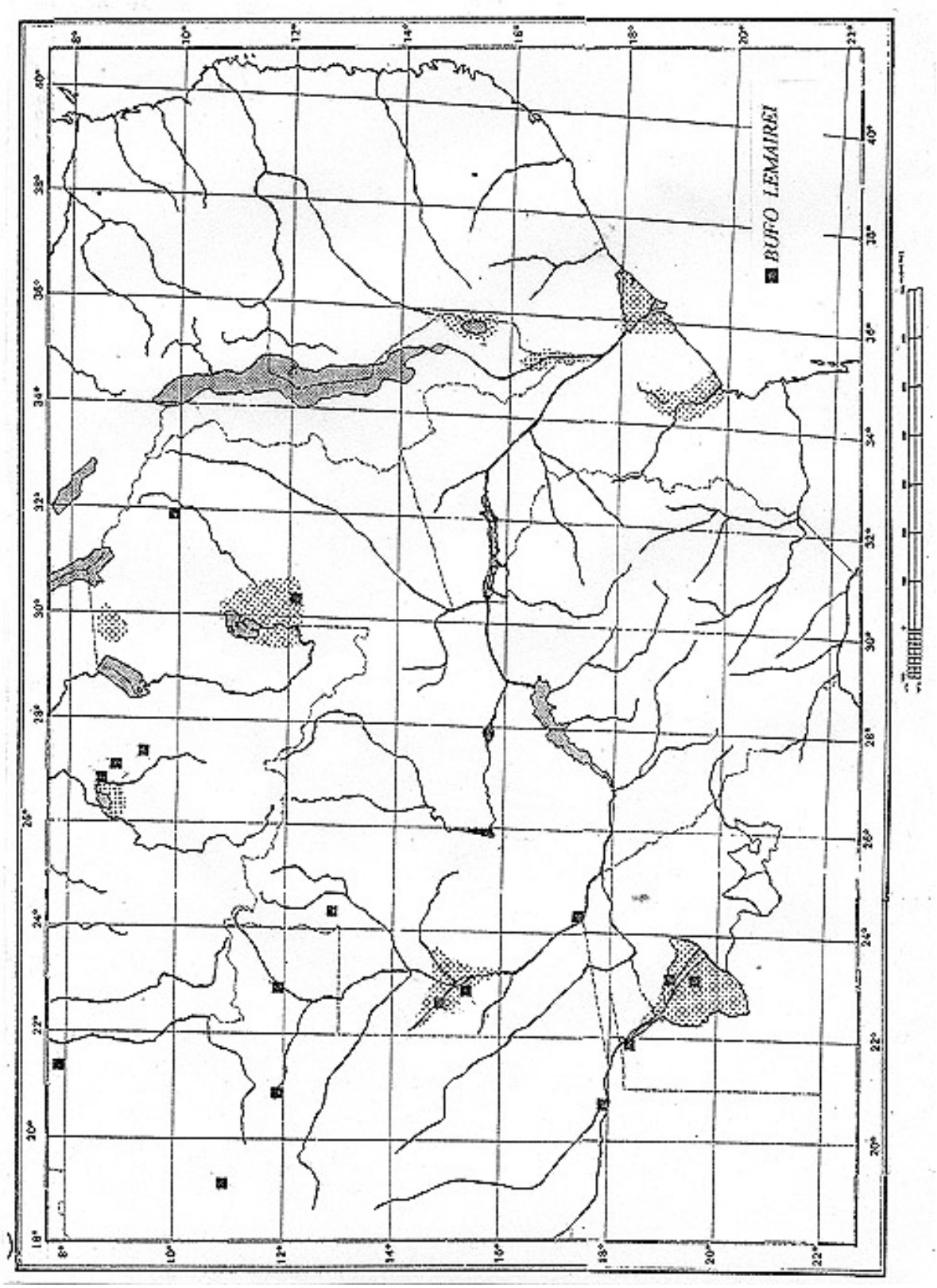


Fig. 6.24. Distribution Map: *Strongylopus fasciatus, S. fuelleborni*

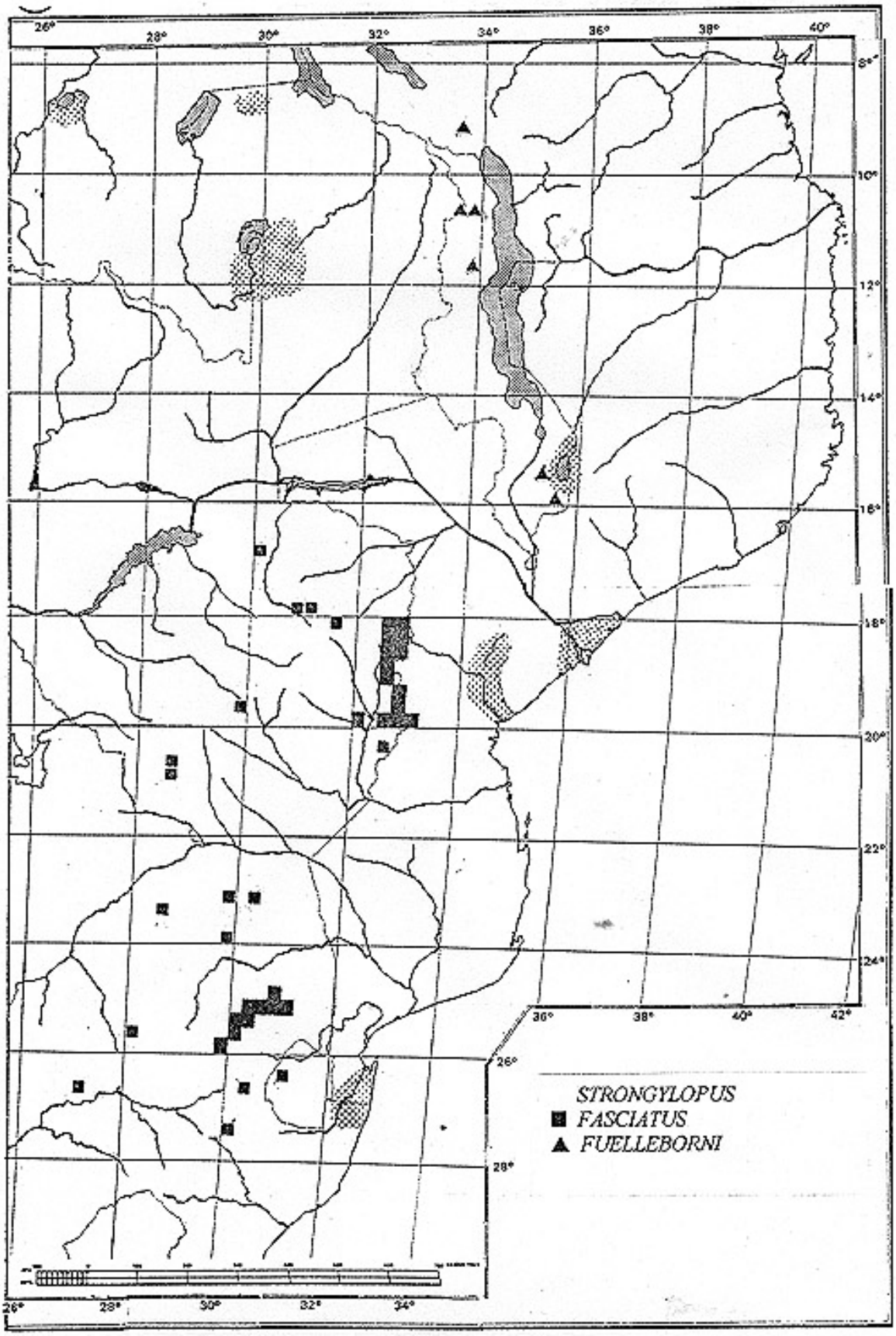


Fig. 6.25. Distribution Map: *Hylarana galmensis, Ptychadena subpunctata*

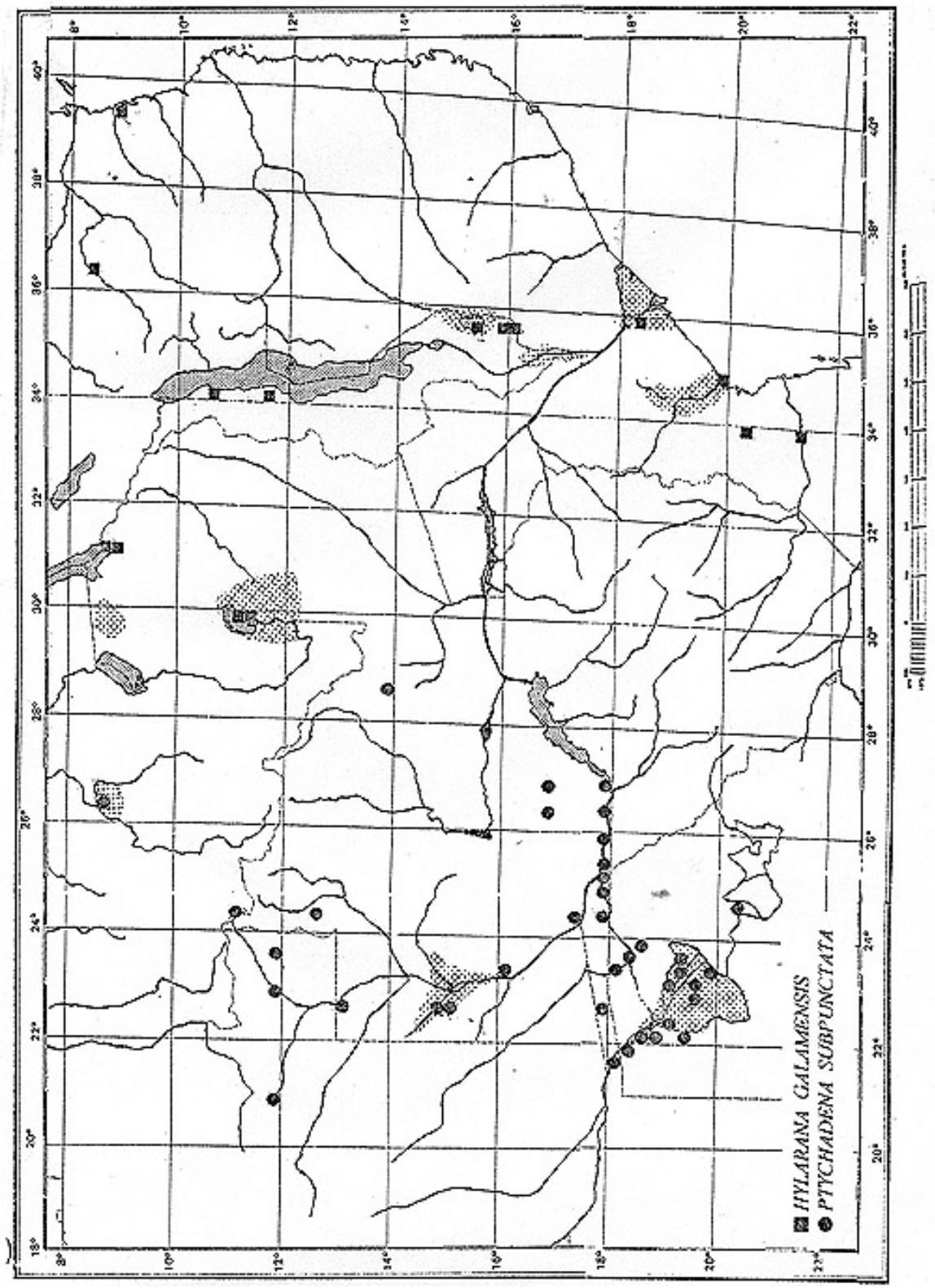


Fig. 6.26. Distribution Map: *Ptychadena mascareniensis, P. schillukorum*

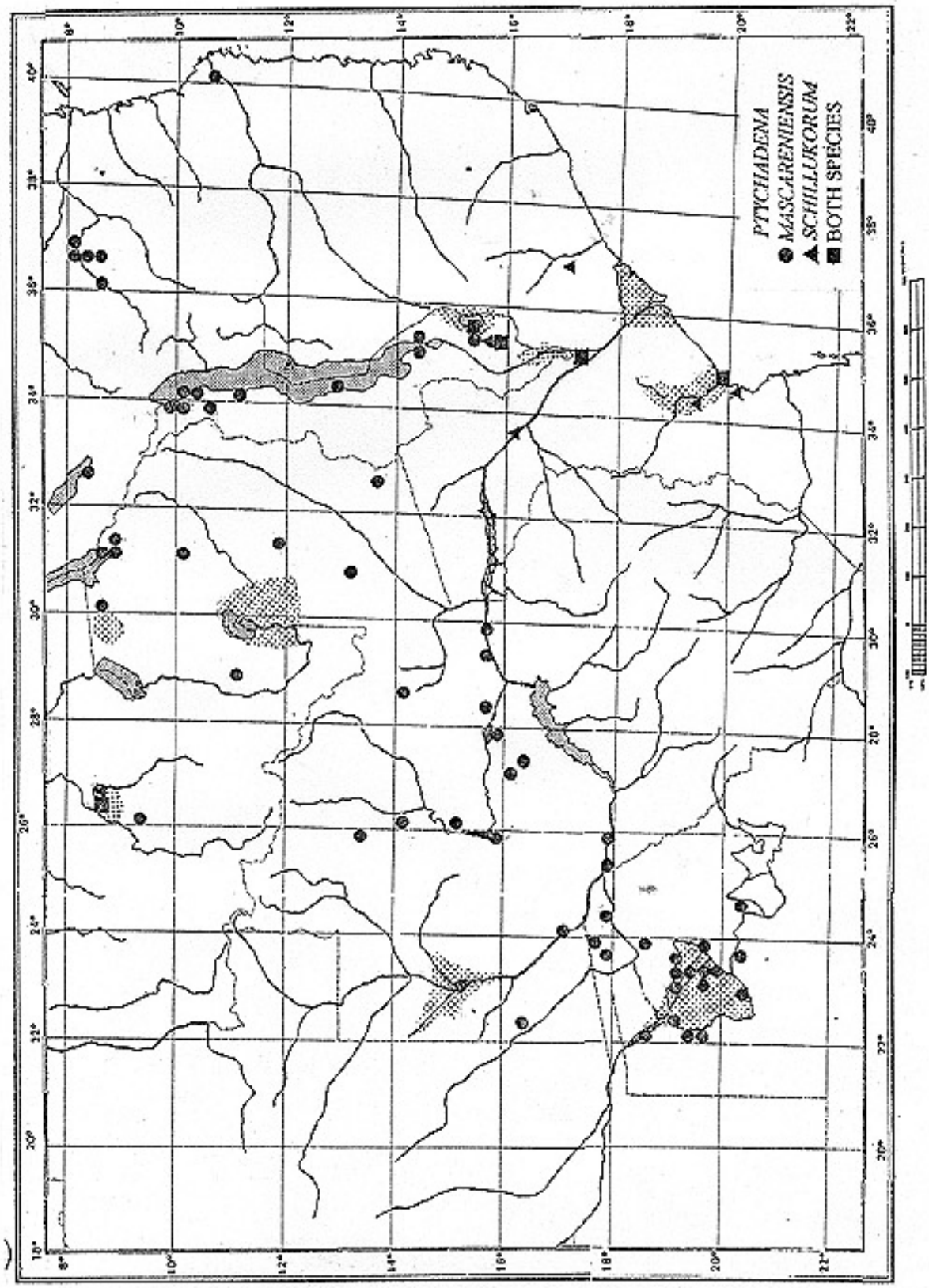


Fig. 6.27. Distribution Map: *Ptychadena uzungwensis*

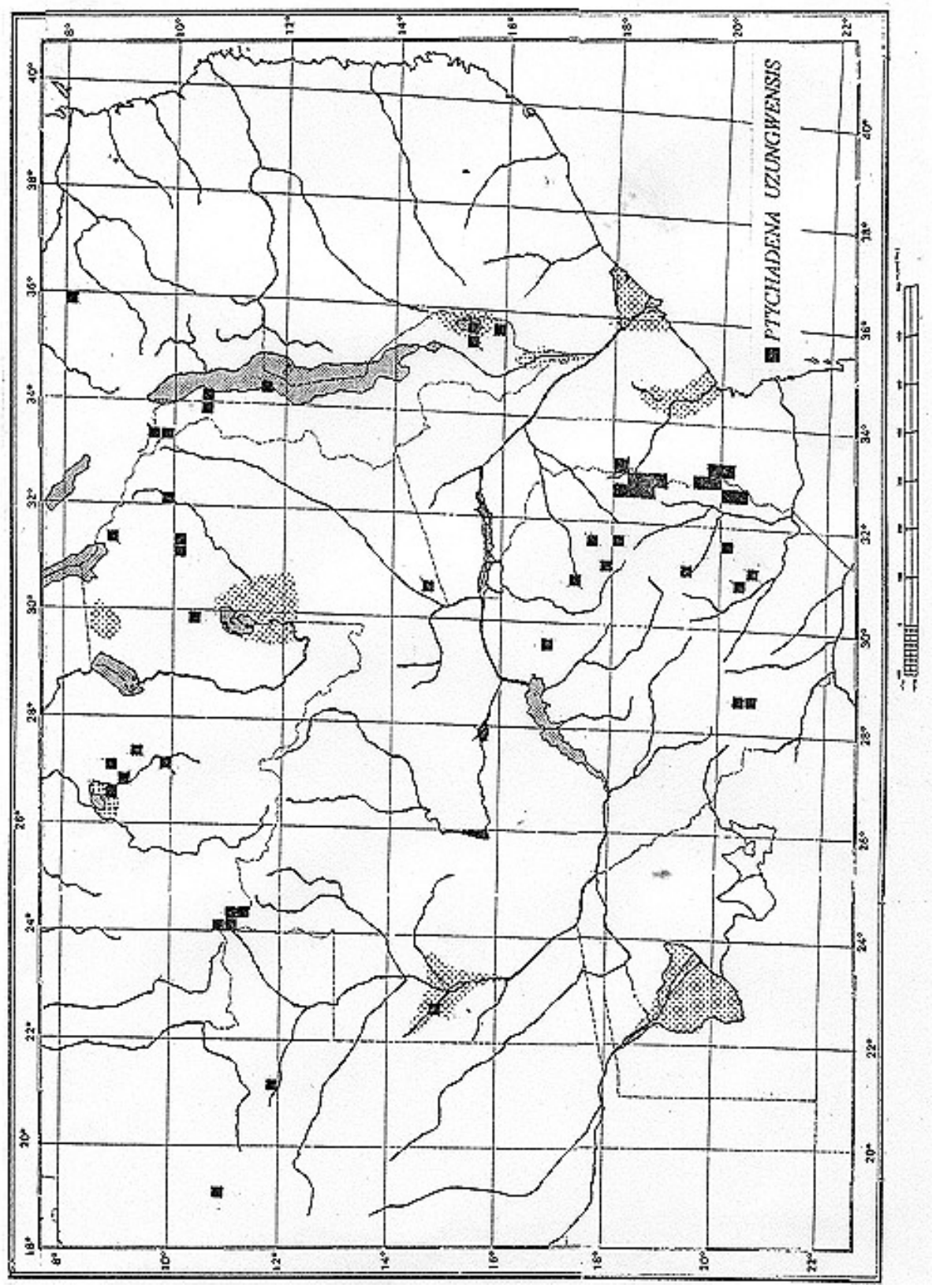


Fig. 6.28. Distribution Map: *Leptopelis mossambicus, L. parbocagii, L. bocagii*

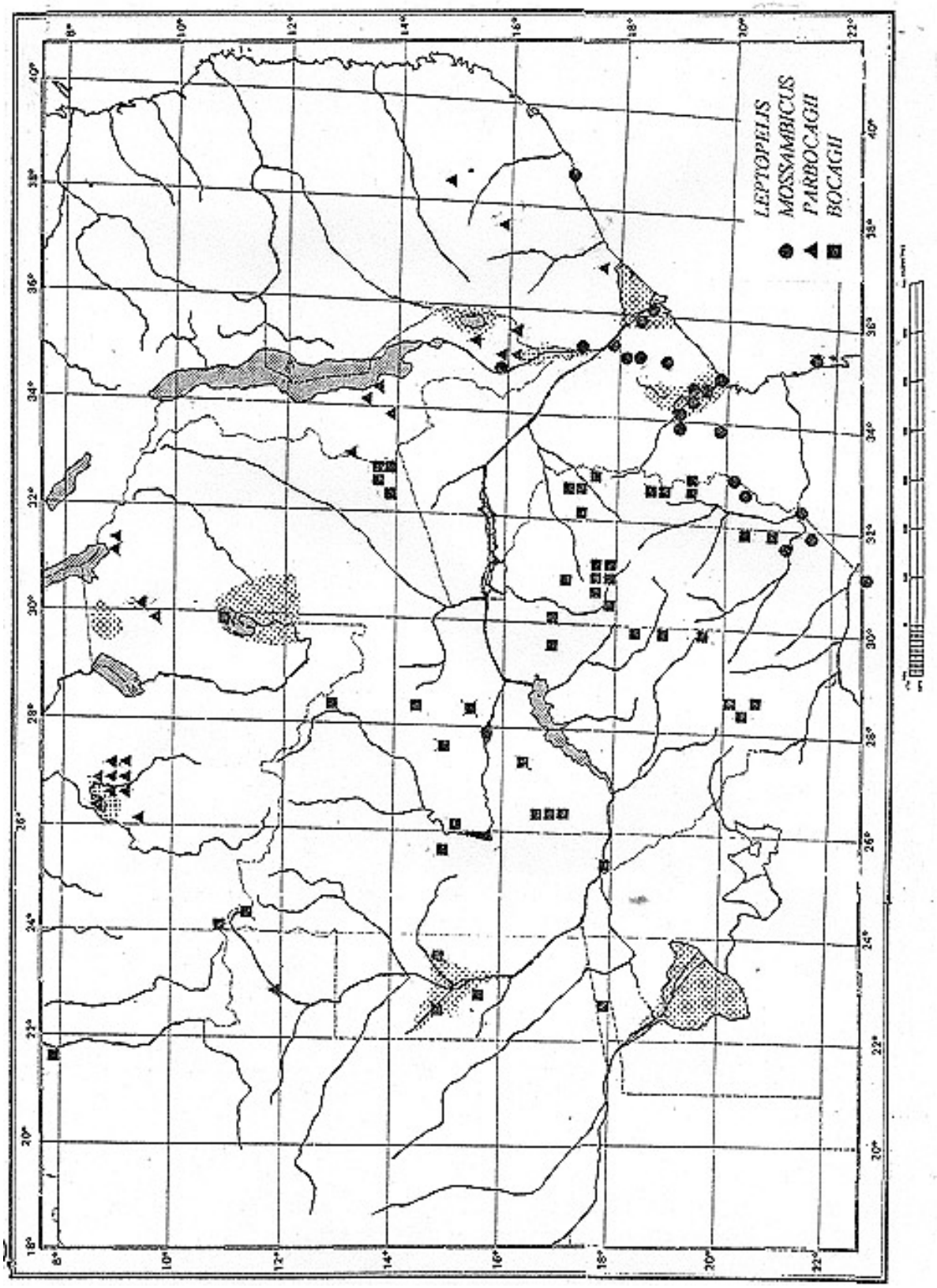
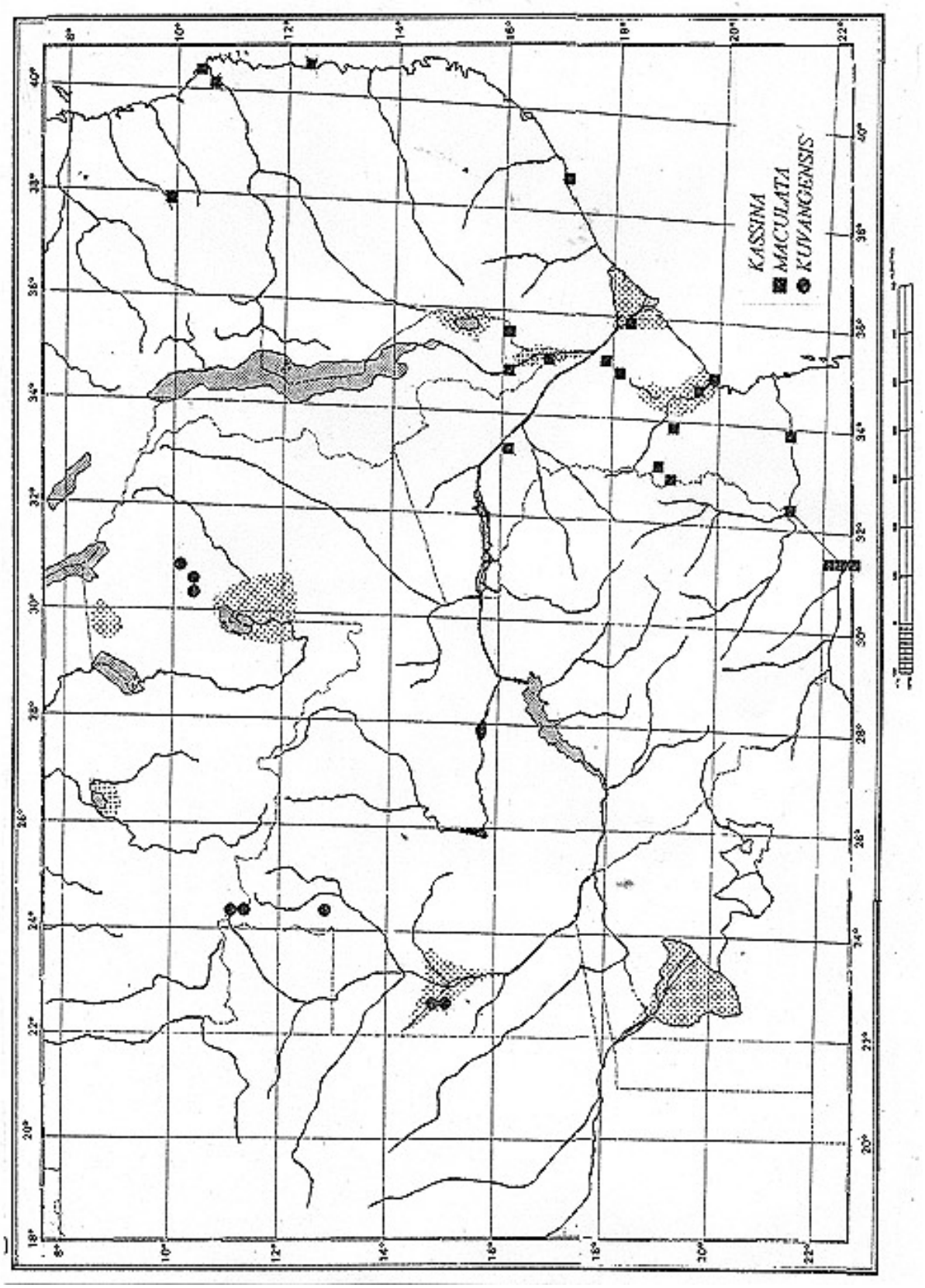


Fig. 6.29. Distribution Map: *Kassina maculata, K. kuvangensis*



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CHAPTER 6 : APPENDIX 1
SURVEY OF THE WETLAND AMPHIBIANS OF THE BAROTSE FLOODPLAINS

Alan Channing

1. INTRODUCTION

As part of the Zambezi Basin Wetlands Biodiversity project, being implemented by the Biodiversity Foundation for Africa and the Zambezi Society on behalf of IUCN-ROSA, a survey of the amphibians of the Barotse floodplain area was carried out from 26 October to 4 November 1998. This was at the onset of the rainy season, the period when amphibians are most active. Although it rained at every site during this period, there was insufficient precipitation to bring out all the species. This report should thus be regarded as one of a series that should be carried out at different times of the year.

Four sites were visited: the Bulozi Floodplain near Mongu, part of the Luena Flats some 50 km north of Mongu, Ndau School about 60 km south of Mongu, and the Luanginga River northwest of Kalabo. Each site was only visited very briefly.

2. SURVEY TECHNIQUES AT NDAU SCHOOL

The surveys of amphibians (by A. Channing and J. Measey) and reptiles (by G. Rasmussen and S. Broadley) were carried out separately, but the techniques employed in both surveys are given here. Only the results of the amphibian survey are presented in this appendix; Appendix 6.2 incorporates reptile findings.

2.1 Amphibians

The intention here was to structure a survey in such a way that it could be repeated easily. As the area is heavily disturbed it was considered more productive to conduct a standard 24 hour survey based on sounds, adults and tadpoles.

(a) *Sounds*: This involves listening after dark and also after rain, to determine:
i) where species are calling, and
ii) which species are present based on calls.
Sites where species are calling are visited to check for the presence of other non-calling species.

(b) *Adults*: Damp places and other likely habitats are carefully examined after dark using good torches, looking for feeding adults.

(c) *Tadpoles*: Pools, lake edges, and vegetated stream edges are netted during the day and night looking for the presence of tadpoles. If caught, samples are preserved for later identification.

2.2 Reptiles

The survey comprised the following four techniques:

(a) *Pitfall traps*: The start of the survey was at the mango grove north of Ndau School (15º25.14S / 22º58.00 E). From the mango trees three pitfall sites each with three buckets (32 cm diam. x 32 cm depth) were constructed. Pitfalls were left out for a full 24 hour period commencing 1900 hrs. (a) Site 1: bearing 150º x 300 m from mango grove, set adjacent to papyrus 1 m above water level (two amphibians collected). (b) Site 2: bearing 130º x 180 m, set adjacent to moist grass habitat 2 m above water level (nil return). (c) Site 3: bearing 0º x 50 m, set in short dry grassland habitat 4 m above water level (one lizard).

Pitfalls were set running parallel with the water body. The drift fence was made of corrugated plastic, 9 m long, 30 cm high and set 3-5 cm into the substrate. Buckets were set so that the lip of the bucket

was 100 mm below ground. Buckets were set at 6 hour intervals, with the first and last bucket 1.5 m from the end of the drift fence.

(b) *Transects:* The collecting transect was walked from the camp at 15º25.14S / 22º58.00E, bearing 150º until the woodland ecotone was reached, a distance of 1000 m (three lizards seen).

A further transect was done for 1000 m on a bearing of 150º from the mango trees north of Ndau School using three people walking 3 m apart. Along this transect active reptile holes on grass plain were counted (27 active holes sighted). The objective of this exercise was to evaluate reptile activity.

(c) *Leaf litter search*: At the forest ecotone, five trees were selected and 5 m^2 of leaf litter was removed going right up to the base of the tree. The top 7 cm of substrate was raked over (two lizards seen). More leaf litter was checked 15 m away (nil return).

(d) *Visual search:* Scanning of school buildings was carried out at 1100 hrs (three lizards seen) and 1700 hrs (two lizards seen).

3. SPECIES LISTS

3.1 Bulozi Floodplain near Mongu

26 October to 4 November 1998; centred on 15º15'36.7" S / 23º07'46.0 E

Grassy floodplain used extensively for cassava cultivation and cattle grazing. Consists of a number of shallow depressions that fill seasonally, as well as permanent flowing water.

Family Bufonidae

Bufo gutturalis Power, 1927 — Guttural Toad
Locally abundant, found on grassy floodplain and near water.

Bufo maculatus Hallowell, 1854. — Flat-backed Toad
Very common along the edges of waterways.

Family Hemisotidae

Hemisus marmoratus (Peters), 1854 — Marbled Snout-burrower
Found in damp soil near water in localised patches of thick vegetation.

Family Hyperoliidae

Hyperolius m. angolensis Steindachner, 1867 — Angolan Reed Frog
Found above ground level in tall papyrus adjacent to water

Leptopelis bocagii (Gunther), 1864 — Bocage's Tree Frog
Widespread in grassy flood plain in rangelands.

Family Microhylidae

Breviceps poweri Parker, 1934 — Power's Rain Frog
Found on grassy floodplain. Abundant but difficult to find.

Family Pipidae

Xenopus petersi Bocage, 1895 — Peter's Platanna
Common in water bodies with muddy substrates.

Family Ranidae

Phrynobatrachus natalensis (Smith), 1849 — Natal Puddle Frog
Abundant near water.

Ptychadena mascareniensis (Dumeril & Bibron), 1841 Mascarene Ridged Frog
Locally abundant in flooded grassland.

Ptychadena subpunctata (Bocage), 1866 Spotted Ridged Frog
Locally very common around waterbodies with thick vegetation.

Ptychadena taenioscelis Laurent, 1954 Small Ridged Frog
Present in localized patches in thick vegetation near water.

Pyxicephalus adspersus Tschudi, 1838 African Bullfrog
Uncommon. Found on grassy flood plain.

Tomopterna tandyi Channing & Bogart, 1996 Tandy's Sand Frog
Occur in patches on the grassy floodplain. (Previously called *T. cryptotis*)

3.2 **Luena Flats, 50 km north of Mongu** 26 October to 4 November 1998; centred near Sikongo, 14º49'26.7"S / 23º11'28.1"E
Grassy floodplain with patches of palms and woodland.

Family Hemisotidae
Hemisus g. microps Cope, 1865 Guinea Snout-burrower.
Common on raised "islands" where palms are present.

Family Hyperoliidae
Leptopelis bocagii (Gunther), 1864. Bocage's Tree Frog.
Very common in low numbers on the grassy flood plain.

Family Pipidae
Xenopus petersi Bocage, 1895 Peter's Platanna
Common in cattle drinking ponds and other water bodies. Found with small catfish.

3.3 **Luanginga River, northwest of Kalabo** 26 October to 4 November 1998; centred on 14º58.4'S / 22º41.1'E
Grassy floodplain fringed with woodland. Used for cattle grazing and some cassava fields.

Family Bufonidae
Bufo gutturalis Power, 1927 Guttural Toad
Locally abundant, found on grassy floodplain and near water.

Family Microhylidae
Phrynomantis bifasciatus (Smith), 1847 Banded Rubber Frog
Scarce, recorded from the vegetation along the Lueta River.

Family Ranidae
Ptychadena subpunctata (Bocage), 1866 Spotted Ridged Frog
Locally very common around waterbodies with thick vegetation.

3.4 **Ndau School** 26 October to 4 November 1998; centred on 15º25'05.3"S / 22º58.02.6"E
Very disturbed vegetation used for grazing cattle and cassava fields. Deep lake and much flowing water. The woodland west of the area was too dry to survey.

Family Bufonidae
Buto gutturalis Power, 1927 Guttural Toad
Locally abundant, found on grassy floodplain and near water.

Bufo maculatus Hallowell, 1854. Flat-backed Toad
Very common along the edges of waterways.

Family Hyperoliidae
Leptopelis bocagii (Gunther), 1864 Bocage's Tree Frog
Very common in low numbers on the plain.

Family Pipidae
Xenopus petersi Bocage, 1895 Peter's Platanna
Abundant in the lake.

Family Ranidae
Phrynobatrachus natalensis (Smith), 1849 Natal Puddle Frog
Common in thick vegetation along the lake edge.

Tomopterna tandyi Channing & Bogart, 1996 Tandy's Sand Frog
Present near the lake edge.

4. DISCUSSION

4.1 Amphibian success on the Floodplain

At the present time no mechanized agriculture is used, no insecticides are used, and very little drainage manipulation has taken place. This makes the flood plain as a whole an interesting frog habitat that should yield many ore new (unrecorded) species.

We recorded the African bullfrog for the first time. This is surprising given the huge size of the adults and their day-time breeding activity. However, our local sources informed us that they are not eaten by the local Lozi speakers.

4.2 The Floodplain as a unit

We travelled extensively across the floodplain. There is no reason to suggest that there are different frog habitats present on a macro-scale. The sites we surveyed (Mongu, Kalabo, Ndau and Sikongo) can all be regarded as the same habitat in terms of frogs.

I suggest that future surveys work in easily accessible areas, probably the floodplain adjacent to Mongu, in order to maximize the return per unit effort.

4.3 Changes of usage patterns on the Floodplain

I recommend that increased usage of the flood plain for grazing or large-scale agriculture, be discouraged. The teachers at Ndau School are aware of the increasing human pressure on their environment, from more people around the area, to fishermen coming from as far as Lusaka in order to catch fish in their lake. Frogs are presently able to survive due only to the relatively low-level use of the flood plain.

4.4 Special frog species

We recorded 16 species, of which two have not previously been found in the area. Given better rains, I believe that there are probably 10 or more additional species to be added to the checklist. It is not possible to single out any frog species of special biological or conservation concern.

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CHAPTER 6 : APPENDIX 2
THE HERPETOFAUNA OF BAROTSELAND, ZAMBIA

Donald G. Broadley

1. INTRODUCTION

The herpetofauna of Barotseland is poorly known but obviously very rich. A few reptiles collected by the Swiss missionary Boiteaux were reported on by Roux (1907). The earliest comprehensive collection from Lealui District was made by the French missionary Ellenberger and deposited in the Natural History Museum in Paris, where they were reported on by Angel (1920, 1921, 1922) who described four new species of reptiles. During the period 1962-64, R.G. Japp, a representative of WENELA based at Kalabo, made large collections which were deposited in the Field Museum of Natural History, Chicago, and the Natural History Museum of Zimbabwe. From this material I described three new species and one subspecies of reptile.

Unfortunately the BFA herpetofaunal survey carried out at the end of October 1998 was hampered by lack of sufficient rain to bring the reptiles and amphibians out in force, but the mammal and bird team, which went in a week later, did get some rain and added more species to the list. My wife and I visited the area for ten days in March 1999, at the end of the rains, concentrating on the western edge of the floodplain around Ndau School and added more snakes and amphisbaenians. Altogether these surveys recorded one new species of frog and four new amphibians for Barotseland. Three lizards new for Barotseland were also northwestern range extensions, while one lizard and one snake were recorded east of the Zambezi for the first time.

2. ANNOTATED CHECKLIST

REPTILIA

CHELONIA (tortoises/turtles)

Pelomedusidae

Pelomedusa subrufa (Bonnaterre) Helmeted Terrapin

This widespread species inhabits ephemeral pans. It has been recorded from Kalabo (Broadley 1971).

Pelusios bechuanicus FitzSimons Okavango Hinged Terrapin

New material: Mongu (shell), Ndau School (hatchling); previously recorded from Kalabo. This is the common terrapin in the clear waters of the Okavango and the Upper Zambezi. It also occurs on the Kafue Flats and an ancestral form crossed the watershed into the Congo Basin and gave rise to a sister species *P. upembae* in the Upemba National Park (Broadley 1971).

Pelusios rhodesianus Hewitt Zambian Hinged Terrapin

New material: several broken shells from Ndau School; previously recorded from Kalabo (Broadley 1971). This terrapin prefers weed-choked backwaters and its distribution seems to be centred on the Bangweulu Swamps.

SAURIA (lizards)

Agamidae

Acanthocercus atricollis A. Smith Southern Tree Agama

New material: Ndanda, also seen at Ndau School. This widespread large tree agama has previously been recorded from Lealui (Angel 1920).

Agama armata Peters Tropical Spiny Agama

New material: Ndanda. This eastern tropical species has previously been recorded from Lealui (Angel 1920).

Chamaeleonidae

Chamaeleo dilepis Leach — Common Flap-neck Chameleon

New material: Ndau School. This widespread species has previously been recorded from Lealui (Angel 1920) and Kalabo.

Gekkonidae

Lygodactylus capensis (A. Smith) — Cape Dwarf Gecko

New material: Mongu. This widespread species was previously recorded from Lealui (Angel 1920).

Lygodactylus chobiensis FitzSimons — Chobe Dwarf Gecko

New material: Lealui, Ndau School. This species, previously recorded from Kalabo, is endemic to the Zambezi Basin, extending downstream to Tete.

Hemidactylus mabouia (Jonnés) — Tropical House Gecko

New material: Mongu. New for Barotseland, but the wide distribution of this species is due to the accidental transportation of the eggs by man.

Scincidae

Sepsina angolensis Bocage — Angola Burrowing Skink

The only Zambian specimens of this western species are from Kalabo (Broadley 1971).

Typhlacontias gracilis Roux — Barotse Burrowing Skink

New material: Mongu, Ndau School; previously recorded from Lealui (Angel 1920). This small limbless skink is endemic to western Zambia.

Typhlacontias rohani Angel — Kalahari Burrowing Skink

This species is closely related to *T. gracilis* and the two species are sympatric at Kalabo (Haacke 1997). *T. rohani* has a wide range from northeastern Namibia across to the Hwange District of Zimbabwe.

Mabuya maculilabris (Peters) — Speckle-lipped Skink

This tropical forest species reaches its southern limit in Zambia at Kalabo (Broadley 1971).

Mabuya capensis (Gray) — Cape Skink

This widespread southern African skink extends into the Kalahari and there appears to be a relict population on the Liuwa Plain (Broadley 1971).

Mabuya punctulata Bocage — Speckled Skink

New material: Ndanda, Ndau School. This is the first record of this small arenicolous species east of the Zambezi, it was previously recorded from Kalabo. It ranges from southwest Angola through the Kalahari to southern Mozambique.

Mabuya varia (Peters) — Variable Skink

New material: Ndau School, Ndanda. This widespread savanna species was previously recorded from Kalabo.

Mabuya wahlbergii (Peters) — Wahlberg's Skink

New material: Mongu, Ndau School, Sikongo. This western arboreal species is a common commensal of man, living on buildings.

Eumecia anchietae Bocage — Bocage's Dambo Skink

This large skink, with vestigial limbs and a long tail, inhabits swampy areas from Angola to western Kenya. It has been recorded from Lealui (Angel 1920) and Kalabo.

Lygosoma sundevallii (A. Smith) Sundevall's Writhing Skink
New material: Ndau School. This widespread central African fossorial skink has been recorded from Lealui (Angel 1920) and Kalabo.

Panaspis "*maculicollis*" Jacobsen & Broadley, in prep. Spotted-neck Snake-eyed Skink
New material: Ndanda. New for Barotseland, these specimens also represent a northwestern range extension for this small species.

Typhlosaurus jappi Broadley Barotse Legless Skink
This species is endemic to Barotseland and was described from Kalabo.

Lacertidae
Ichnotropis capensis (A. Smith) Cape Rough-scaled Lizard
New material: 4 & 20 km SE of Kalabo, Ndau School, Ndanda. This is the commonest sand lizard in the Kalahari sand regions, previously recorded from Lealui (Angel 1920) and Kalabo. An "annual" species.

Ichnotropis squamulosa Peters Common Rough-scaled Lizard
New material: Ndanda. New for Barotseland and a northwestern range extension for this widespread "annual" species, which has its life cycle staggered in relation to that of *T. capensis.*

Gerrhosauridae
Gerrhosaurus auritus Boettger Kalahari Plated Lizard
New material: Ndau School, Ndanda. This Kalahari endemic was previously recorded from Lealui (Angel 1920) and Kalabo. It seems to be very common in Barotseland, but is replaced in northwestern Zambia by *G. bulsi* Laurent.

Tetradactylus ellenbergeri (Angel) Ellenburger's Plated Snake-lizard
The type specimen is from Barotseland (Angel 1922), but all other records are from further north (Angola to SE Tanzania).

Varanidae
Varanus niloticus (Linnaeus) Nile Monitor/Water Leguaan
This widespread species has been recorded from Kalabo and was seen at Ndau School.

AMPHISBAENIA (worm lizards)
Amphisbaenidae
Zygaspis nigra Broadley & Gans Black Round-snouted Amphisbaenian
New material: Ndau School. This large species was described from Kalabo. It extends south to the eastern Caprivi and west into Angola, but has not been found east of the Zambezi.

Zygaspis quadrifrons Peters Kalahari Round-snouted Amphisbaenian
New material: Ndau School. This widespread small species has previously been recorded from Lealui (Angel 1920) and Kalabo.

Dalophia ellenbergeri Angel Barotse Pestle-tailed Amphisbaen
New material: Ndau School. This slender species was described from Lealui; there is a long series from Kalabo and a single record from SE Angola.

Dalophia pistillum (Boettger) Zambezi Pestle-tailed Amphisbaenian
This large species has been recorded from Lealui (Angel 1920) and Kalabo. It has a wide range in the Zambezi basin, extending south through the Kalahari into northern regions of South Africa.

SERPENTES (snakes)

Pythonidae

Python natalensis A. Smith — Southern African Python

New material: Ndau School. This is the first record from Barotseland, but there is a specimen from Kabompo to the north.

Typhlopidae

Typhlops schmidti Laurent — Schmidt's Blind Snake

This species occurs in the southeast of the DRC and NW Zambia. It has been recorded from Kalabo.

Rhinotyphlops mucruso (Peters) — Zambezi Blind Snake

This widespread East African species has been recorded from Lealui (Roux-Estève 1974).

Viperidae

Causus rhombeatus (Lichtenstein) — Rhombic Night Adder

This widespread savanna species has been recorded from Kalabo.

Causus bilineatus Boulenger — Lined Night Adder

This small species has been recorded from Kalabo, which seems to be close to the southern limit of its range.

Bitis arietans (Merrem) — Puff Adder

This widespread savanna species has been recorded from Kalabo.

Atractaspididae

Atractaspis congica Peters — Congo Stiletto Snake

This western fossorial species reaches the southern limit of its range at Katima Mulilo in the eastern Caprivi. It has been recorded from Kalabo.

Amblyodipsas polylepis (Bocage) — Common Purple-glossed Snake

New material: Ndau School, Lealui. This widespread fossorial species had previously been recorded from Lealui (Angel 1921) and Kalabo.

Amblyodipsas ventrimaculatus (Roux) — Kalahari Purple-glossed Snake

This Kalahari endemic was described from Barotseland and has been recorded from Lealui (Angel 1921) and Kalabo (Broadley 1971).

Xenocalamus mechowii Peters — Angolan Quill-snouted Snake

New material: Ndau School. This large fossorial species is a specialist predator on amphisbaenians. It is restricted to Kalahari sand regions and has previously been recorded from Senanga (Pitman 1934) and Kalabo District (Broadley 1971).

Hypoptophis wilsoni Boulenger — Wilson's Burrowing Snake

This very rare species is known only from the southeastern DRC and western Zambia. One specimen has been recorded from Kalabo (Broadley 1971).

Aparallactus capensis A. Smith — Cape Centipede-eater

This widespread species has been recorded from Kalabo.

Elapidae

Elapsoidea semiannulata Bocage — Angolan Garter Snake

New material: Mongu (first record east of the Zambezi). This Angolan species has previously been recorded from Kalabo (Broadley 1971) and Liumba Hill Mission.

Elapsoidea boulengeri Boettger Zambezi Garter Snake
This species is widespread in the Zambezi Basin but in Barotseland it has only been recorded from Lealui (Angel 1921).

Naja anchietae Bocage Anchieta's Cobra
This species replaces the Snouted Cobra (*Naja annulifera*) in the Kalahari sand regions. It has been recorded from Lealui (Angel 1921, as var. *barotseensis*) and Kalabo.

*Naja nigricolli*s Reinhardt Black-necked Spitting Cobra
This large species, widespread in west and central Africa, reaches the southern limit of its range at Katima Mulilo. It has been recorded from Lealui (Angel 1921), Sikongo and Kalabo.

Colubridae
Lamprophis ? fuliginosus (Boie) Sooty House Snake
Barotseland and eastern Caprivi specimens seem to represent this west and central African species, but fresh material is needed to confirm this range extension. Specimens have been recorded from Lealui (Angel 1921) and Kalabo. To the south and east, the Brown House Snake (*L. capensis* Duméril & Bibron) occurs.

Mehelya capensis (A. Smith) Cape File Snake
This widespread large savanna species has been recorded from Kalabo.

Mehelya nyassae (Günther) Black File Snake
This small species has been recorded from Kalabo.

Lycophidion multimaculatum Boettger Blotched Wolf Snake
This western species has been recorded from Kalabo District and Mongu (Broadley 1971) and extends south to the Caprivi.

Natriciteres olivacea (Peters) Olive Marsh Snake
This widespread aquatic species has been recorded from Lealui (Angel 1921) and Kalabo.

Limnophis bangweolicus (Mertens) Bangweulu Striped Swamp Snake
This water snake is endemic to the greater Okavango system and has been recorded from Kalabo (Broadley 1971).

Psammophylax variabilis Günther Grey-bellied Grass Snake
In the eastern part of its range this species inhabits montane grassland, but there is a western population on the Barotse floodplain extending south to Kasane. It has been recorded from Kalabo (Broadley 1971).

Rhamphiophis acutus jappi Broadley Barotse Striped Beaked Snake
New material: Ndau School. This subspecies was described from Kalabo and extends up the Zambezi River to Zambezi (Balovale). It is replaced by the typical form in Mwinilunga District.

Dromophis lineatus (Duméril & Bibron) Lined Olympic Snake
This swamp-dwelling species reaches its southern limit in the Kazungula area. It has been recorded from Kalabo.

Psammophis jallae Peracca Jalla's Sand Snake
This widespread species has been recorded from Lealui (Angel 1921) and Kalabo (Broadley 1971).

Psammophis mossambicus Peters Olive Grass Snake
New material: Ndau School. Previously recorded from Lealui (Angel 1921) and Kalabo.

Psammophis angolensis (Bocage) Dwarf Sand Snake
This dwarfed species has been recorded from Lealui (Angel 1921) and Kalabo District.

Prosymna angolensis Boulenger Angola Shovel-snout
This western species has been recorded from Kalabo (Broadley 1971). Its diet consists of reptile eggs.

Philothamnus angolensis Bocage Angola Green Snake
New material: Ndau School. This species inhabits reedbeds and trees along streams. It has previously been recorded from Lealui (Angel 1921) and Kalabo.

Philothamnus hoplogaster Bocage Southeastern Green Snake
This species inhabits open dambos. It has been recorded from Kalabo.

Philothamnus ornatus Bocage Ornate Green Snake
This striped green snake has been recorded from Lealui (Angel 1921) and Kalabo.

Philothamnus heterolepidotus (Günther) Slender Green Snake
New material: Ndanda. This very attenuated species reaches the southern limit of its range in Barotseland. It has been recorded from the Liuwa Plain.

Philothamnus semivariegatus (A. Smith) Variegated Bush Snake
This widespread species is less dependant on water than most members of the genus. It has been recorded from Kalabo.

Crotaphopeltis hotamboeia (Laurenti) Herald Snake
This widespread species has been recorded from Kalabo District.

Crotaphopeltis barotseensis Broadley Barotse Water Snake
This species is endemic to the greater Okavango system, where it is associated with papyrus swamps. Kalabo is the type locality.

Telescopus semiannulatus (A. Smith) African Tiger Snake
This widespread savanna species has been recorded from Lealui (Angel 1921) and Kalabo.

Dispholidus typus (A. Smith) Boomslang
This widespread savanna species has been recorded from Lealui (Angel 1921) and Kalabo.

Thelotornis oatesii (Günther) Oates' Vine Snake
New material: Matabele Plain. This western savanna tree snake has been recorded from Lealui (Angel 1921) and Kalabo.

Dasypeltis scabra (Linnaeus) Common Egg-eater
This widespread species has been recorded from Lealui (Angel 1921) and Kalabo.

CROCODYLIA
Crocodylidae
Crocodylus niloticus Laurenti Nile Crocodile
Sight records: Ndau School. In an ecological survey, Cott (1961) analysed the stomach contents of 179 crocodiles collected between Lukulu and Senanga in 1957. Adults were feeding mainly on fish (especially *Claris* sp.) and terrapins. Only one contained human remains.

AMPHIBIA

Pipidae

Xenopus petersii Bocage — Peters' Clawed Frog/Platanna
New material: Kalabo, Mongu, Sikongo, Ndau School. Previously recorded from Lealui (Angel 1921) and Kalabo District.

Xenopus muelleri (Peters) — Tropical Clawed Frog/Platanna
Previously recorded from Kalabo (Broadley 1971).

Bufonidae

Bufo gutturalis Power — Guttural Toad
New material: Ndau School, Ndanda. Previously recorded from Kalabo District.

Bufo poweri Hewitt — Power's Toad
New material: Ndanda, Ndau School. New record for Barotseland.

Bufo maculatus Hallowell — Flatback Toad
New material: Mongu, Ndau School. Previously recorded from Kalabo.

Bufo lemairii Boulenger — Lemaire's Toad
New material: Ndau School. This swamp-dwelling species has previously been recorded from Kalabo (Broadley 1971), Lukona Mission and Sesheke.

Bufo beiranus Loveridge — Beira Dwarf Toad
This small species has been recorded from Kalabo and Sandaula Plain.

Microhylidae

Phrynomantis bifasciatus (A. Smith) — Red-banded Rubber Frog
Heard at Kalabo.

Phrynomantis affinis (Boulenger) — Spotted Rubber-Frog
A specimen in poor condition from Kalabo was assigned to this species with some doubt (Poynton & Broadley 1985).

Breviceps poweri Parker — Power's Rain Frog
New material: Mongu. Previously recorded from Kalabo.

Breviceps adspersus Peters — Bushveld Rain Frog
Recorded from Kalabo (Broadley 1971).

Hemisotidae

Hemisus barotseensis Channing & Broadley (in press) — Barotse Snout-burrowing Frog
New material: Mongu, Sikongo, Ndanda, Ndau School. Alan Channing recorded the diagnostic call of the holotype male at Mongu. Previously recorded from Lealui (as *Hemisus marmoratum* (Angel 1921) or *H. guineensis microps* (Laurent 1972)).

Ranidae

Pyxicephalus adspersus Tschudi — Common Bullfrog
New material: Mongu. Recorded from Lealui by Angel (1921).

Pyxicephalus edulis Peters — Tropical Bullfrog
Recorded from Kalabo (Parry 1982).

Tomopterna ? cryptotis (Boulenger) Kalahari Sand Frog
New material: Mongu, Ndau School, Ndanda. Previously recorded from Kalabo and Sandaula Plain. A recording made by R. Sternstedt at Ndau School should establish the identity of this population.

Hylarana darlingi (Boulenger) Golden-backed Frog
Recorded from Kalabo (Broadley 1971). This species occurs in both open savanna woodland and evergreen forest.

Ptychadena subpunctata (Bocage) Spot-bellied Grass Frog
New material: Mongu, Kalabo, Ndanda. Previously recorded from Kalabo.

Ptychadena mascareniensis (Duméril & Bibron) Mascarene Grass Frog
New material: Mongu. New record for Barotseland.

Ptychadena porosissima (Steindachner) Striped Grass Frog
Recorded from Nyambala and Sandaula Plains (Broadley 1971).

Ptychadena grandisonae Laurent Grandison's Grass Frog
Recorded from Kalabo (Broadley 1971).

Ptychadena upembae (Schmidt & Inger) Upemba Grass Frog
Recorded from Sandaula Plain.

Ptychadena perplicata Laurent Plicate Grass Frog
New material: Ndanda. New record for Barotseland, previously recorded from Angola and N Zambia.

Ptychadena uzungwensis (Loveridge) Udzungwe Grass Frog
New material: Ndanda. Previously recorded from Kalabo.

Ptychadena pumilio (Boulenger) Dwarf Grass Frog
New material: Mongu. Previously recorded from Kalabo and Liuwa Plain.

Ptychadena guibei Laurent Guibé's Grass Frog
Recorded from Sandaula Plain.

Phrynobatrachus natalensis (A. Smith) Natal Puddle Frog
New material: Mongu, Ndau School, Ndanda, Litoya Dambo. Previously recorded from Kalabo and Sandaula Plain.

Phrynobatrachus mababiensis FitzSimons Mababe Dwarf Puddle Frog
New material: Ndanda. Previously recorded from Kalabo and Sandaula Plain.

Hyperoliidae
Leptopelis bocagii (Günther) Bocage's Burrowing Frog
New material: Mongu, Sikongo, Ndau School, Ndanda. Previously recorded from Kalabo.

Kassina kuvangensis (Monard) Cubango Running Frog
Recorded from Kalabo and Kalengo (Broadley 1971).

Kassina senegalensis (Duméril & Bibron) Senegal Running Frog
Recorded from Kalabo, Nyambela and Sandaula Plains.

Afrixalus wittei (Laurent) Witte's Leaf-folding Frog
Recorded from Kalabo (Broadley 1971).

Hyperolius nasutus Günther Günther's Sharp-snouted Reed Frog
New material: Ndanda, Ndau School. Previously recorded from Kalabo and Sandaula Plain.

Hyperolius benguellensis (Bocage) Bocage's Long Reed Frog
New material: Ndanda. New record for Barotseland.

Hyperolius angolensis Steindachner Angolan Reed Frog
New material: Kalabo, Lealui (with juvenile pattern, but this is the type locality of *aposematicus* Laurent, which may be a valid taxon). Previously recorded from Kalabo and Sandaula Plain (Broadley 1971).

3. DISCUSSION

At present the herpetofauna of the Barotse floodplain and environs is known to include 70 species of reptiles (Testudines 3; Sauria 23; Amphisbaenia 4; Serpentes 39; Crocodylia 1) and 34 species of amphibian. This makes it the most species-rich wetland in the Zambezi Basin. However, there seem to be several species missing. No tortoises have been recorded, but both the Leopard Tortoise (*Geochelone pardalis*) and Speke's Hinged Tortoise (*Kinixys spekii*) are likely to occur, with a possibility of Bell's Hinged tortoise (*Kinixys belliana*) coming from Angola. No species of Thick-toed Gecko (*Pachydactylus*) has been recorded in Barotseland and the Savanna Monitor (*Varanus albigularis*) should occur. There should be a worm snake, either *Leptotyphlops kafubi*, which occurs in the region of the Zambezi headwaters, or *L. scutifrons*, which occurs to the south in the eastern Caprivi. Pitman (1934) reported that Mr J. Soane Cambell had found one specimen of a small horned adder during his over 20 years of residence in Barotseland, so *Bitis caudalis* may occur. Two piscivorous water snakes of the genus *Grayia* occur in the Upper Zambezi tributaries and could extend downstream to Barotseland. Several more back-fanged snake species are likely be added to the Barotseland checklist, including Bark Snake (*Hemirhagerrhis nototaenia*), the Three-lined Grass Snake (*Psammophylax tritaeniatus*), the Rufous Beaked Snake (*Rhamphiophis rostratus*), the Stripe-bellied Sand Snake (*Psammophis subtaeniatus*) and Gerard's Black and Yellow Burrowing Snake (*Chilorhinophis gerardi*). The Semiornate Snake (*Meizodon semiornata*) favours drainage lines and is likely to occur on the Barotse floodplain, so the total number of snake species in Barotseland could be close to 50. It is also likely that more species of amphibians will be added to the list.

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CHAPTER 6 : APPENDIX 3
SURVEY OF THE REPTILES AND AMPHIBIANS OF THE ZAMBEZI DELTA

W.R. Branch

1. HISTORICAL STUDIES

The terrestrial vertebrates of Mozambique remain very poorly-known. Scientifically, Mozambique (including the Zambezi Delta area) remains unstudied and there exist few recent reviews for any vertebrate Class. Reptiles were first reviewed by Peters (1882), following his original explorations in the early part of the 19th century. With the exception of an unpublished review (Broadley 1966), no recent synopsis of the herpetofauna of Mozambique has appeared, although numerous generic reviews have improved our knowledge for the area (see sections 3.2 and 4.2). During recent (1997) surveys for a proposed mining development in the coastal region around Moebase (Zambézia Province), important herpetological collections have been made, including the discovery of new species, important range extensions and additions to the Mozambique herpetofauna (Branch, in prep.).

2. MATERIALS AND METHODS

2.1 Field survey

A field survey, organized by the Biodiversity Foundation of Africa, was undertaken from 24 July to 10 August 1999 to the Zambezi Delta and its surroundings. The herpetological team comprised William Branch and Bernardo Muantinte, with opportunistic assistance supplied by other members of the survey. During this visit all accessible habitats present in the delta area were inspected, and the presence of reptiles and amphibians confirmed by the collection of voucher specimens and/or the presence of characteristic tracks and signs. Due to problems of access and time constraints certain habitats were not adequately surveyed, e.g. mangrove and permanent wetland. Localities in the palm savanna-wetland ecotone were well-surveyed, but displayed varying degrees of human impact. However, these were not considered serious limitations of the survey. The unsurveyed habitats, although among the most pristine in the region, contain a small range of microhabitats and also have relatively depauperate herpetofaunas. In contrast, Malingapansi and Marromeu and the surrounding old sugar cane fields still retained high herpetofaunal diversity. Paid local assistants were also used to collect specimens.

2.2 Collections

Representative collections of reptiles and amphibians were collected opportunistically and systematically from the study area and its surroundings. Some specimens were purchased from local villagers, who were questioned as to where they were collected, but these specimens usually lacked detailed habitat data. Specimens were euthanased, fixed in buffered formalin and stored in spirit. Identification of specimens was based on comparison with specimens held in the Port Elizabeth Museum, and by reference to keys in the relevant scientific literature. Voucher specimens were preserved, labelled, photographed and deposited in the Port Elizabeth Museum herpetological collection. A representative collection has been forwarded for deposition in the National Museum, Maputo.

2.3 Conservation categories

No Red Data Books have been prepared for Mozambique. It has therefore been necessary to make a conservative assessment of potentially threatened species in Mozambique by considering their conservation status in Red Data Books from adjacent countries (South Africa) and in international lists, e.g. CITES legislation or the IUCN Red List of threatened animals (Ballie & Groombridge 1996; henceforth termed Red List).

The following categories are included in the South African Red Data Book (SA RDB) for Reptiles and Amphibians (Branch 1988):

Endangered (End) — Species in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are species whose numbers have been reduced to a critical level or whose habitat has been so drastically diminished and/or degraded that they may be deemed to be immediate danger of extinction.
Vulnerable (Vul) — Species believed likely to move into the Endangered category in the near future if the causal factors continue operating. Included are species of which all or most of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbances, species with populations which have been seriously depleted and whose ultimate security is not assured, and species with populations which are still sizable but which are under threat from serious adverse factors throughout their range.
Rare — Species with small populations which are not at present endangered or vulnerable but which are at risk. These species are localized within a restricted geographical areas or habitats, or are thinly scattered over a somewhat more extensive range.
Indeterminate (Indet.) — Species that are suspected of belonging in the categories Endangered, Vulnerable or Rare, but for which insufficient information is currently available.

The following additional categories have also been applied:
Restricted — Taxa endemic and localized within limited geographical areas. They could easily be threatened and their status should be monitored. The host country is their sole guardian, and their loss would result in the extinction of the taxa.
Peripheral — Taxa with a restricted distribution, but whose main distribution falls outside the political boundaries of the area. The local population could easily be threatened and their status should be monitored. The host country is not their sole guardian and their loss would not result in the extinction of the taxa, but would reflect deterioration of the local environment.

Specific attention was paid to species known to be endemic or mainly restricted to Central Mozambique.

3. AMPHIBIANS

3.1 Introduction

Amphibians are an important and often neglected component of terrestrial vertebrate faunas. They are well represented in sub-Saharan Africa, from which approximately 600 species have been recorded. Currently amphibians are of increasing scientific concern as global reports of declining amphibian populations continue to increase (Phillips 1994, and references therein). Although there is no consensus on a single cause for this phenomenon, there is general agreement that the declines in many areas, even in pristine protected parks, are significant and do not represent simple cyclic events. Frogs have been aptly called bioindicator species, whose abundance and diversity is a poignant reflection of the general health and well-being of aquatic ecosystems.

Amphibians are important components of wetland systems, particularly ephemeral systems from which fish are either excluded or of minor importance. In these habitats, they are dominant predators of invertebrates, many of which may impact significantly on humans (e.g. as vectors of disease, such as mosquitos and bilharzia snails) or their livestock and/or crops.

3.2 Amphibians in a regional context

The diverse amphibian fauna of Mozambique was recently reviewed by Poynton and Broadley (1985-1991), who recognized 53 species occurring in the country. Despite this relatively high diversity, they noted no endemic Mozambique amphibians. Although this review forms a useful baseline, it should be noted that their map of collecting effort in Mozambique (Poynton & Broadley 1991: 246) reveals dramatically how poorly known much of Northern Mozambique remains. North of the Zambezi River they noted that "large tracts are poorly or uncollected". The Central Mozambique region, excluding the Zambezi Delta, is only slightly better surveyed. For the Zambezi Delta region, Poynton and Broadley (1985-1991) record only 12 species – *Xenopus muelleri, Hemisus marmoratum, Amnirana galamensis, Phrynobatrachus acridoides, Leptopelis mossambicus, Kassina senegalensis, Afrixalus delicatus, A. fornasini, Hyperolius tuberilingus, H. argus, H.*

pusillus and *H. marmoratus taeniatus*. All are based on collections by Cott (Parker 1930) from the Fambani River near Marromeu (1835Bc).

3.3 **Sampling**

Amphibian specimens were collected opportunistically by turning logs, water weed, etc, and by searches of water margins at night. Tadpoles were also collected and identified by reference to existing keys, or sent for identification. A number of specimens obtained during fish surveys were also included.

3.4 **Limitations and cautions**

It should be stressed that the survey occurred out of the main amphibian breeding season. As a consequence few frogs were breeding during the visits. Surveys of such limited scope cannot be considered adequate to confidently assess the total amphibian diversity present. Breeding for most amphibian species in the region is at its most intense following the onset of summer rain (December-January). Of 19 amphibian species recorded from the area during the visit, only four species were calling in July-August, and no amplexus and/or spawning was noted. A considerable number of species had thus finished breeding and returned to dormancy at the time of the survey. Their presence in the area could not therefore be confirmed.

Recent taxonomic studies in southern Africa (Boycott 1988, Channing *et al*. 1994) have identified cryptic, sibling amphibian species only after careful analysis of their breeding calls. Amphibians are often morphologically conservative, with cryptic species being indistinguishable on external morphology. In such circumstances, identification of species relies on analysis of advertisement calls. Some identifications are therefore provisional.

These factors limit the extent to which the amphibian fauna can be adequately referenced, and the confidence with which the conservation status of the amphibians and their sensitivity to developmental impacts be assessed. Despite these caveats, however, the amphibian survey was still considered successful and it represents one of the most important scientific collections obtained from the region.

3.5 **Amphibians present in the Zambezi Delta area**

Over 150 specimens were collected, and numerous other observations made. The presence of a total of 19 amphibian species were confirmed in the Delta area (Table 1 - see end of this Appendix). Breeding in the area was confirmed by vocalization for a number of species, including *Hyperolius argus, Phrynobatrachus acridoides* and *Bufo maculatus*. The presence of tadpoles and metamorphosing juveniles of *Xenopus muelleri, Phrynobatrachus mababiensis, P. acridoides, Kassina maculata, Hyperolius marmoratus, Afrixalus fornasini* and *Arthroleptis stenodactylus* indicate that these species also breed in the area.

A number of other amphibian species recorded from the Zambezi Delta area (Fambani River; Parker 1930) but which were not collected during the survey, include *Hemisus marmoratus*, *Afrixalus delicatus, Hyperolius tuberilingus* and *H. pusillus*.

Other species that are likely to occur in the region (Poynton & Broadley 1985-1991) include:
Highly probable – *Phrynomantis bifasciatus, Ptychadena anchietae*, *Ptychadena mascareniensis*, *Ptychadena schillokorum* and *Amnirana galamensis*;
Possible – *Arthroleptis xenodactyloides, Leptopelis flavomaculatus, Hildebrandtia ornata* and *Ptychadena guibei.*

3.6 **New discoveries and range extensions**

No obviously new amphibian species were discovered in the Zambezi Delta region. This is not unexpected in view of the lack of amphibian endemics in Mozambique, and the uniform coastal habitat. However, two small hyperoliid specimens could not be easily assigned to known species. One specimen, collected in a banana plantation in Malingapansi, may represent *Hyperolius parkeri* from coastal Tanzania and Kenya, which has been recorded once from Central Mozambique (Dondo, Poynton & Broadley 1987). Another small hyperoliid collected at the base camp on the western edge of the wetlands of the Marromeu Buffalo Reserve

is referred to *Hyperolius*, but is not obviously referable to known species. It has a horizontal pupil and creamy, reticulate colouration.

Specimens of the running frog *(Kassina senegalensis*) appear more gracile and more conspicuously marked than specimens from the southern parts of the species' extensive range. They appear referable to the *argyreivittis* form (Poynton & Broadley 1987, Schiøtz 1999), and may merit further taxonomic investigation.

It is possible that taxonomic novelties still exist among the Zambezi Delta amphibians. Resolution of the taxonomic status of these forms will require further surveys during the main frog breeding season so that detailed recordings of vocalizations can be obtained.

Species confirmed in the region, but which were previously unrecorded from the Zambezi Delta (based on distribution maps in Poynton & Broadley 1991) included *Pyxicephalus edulis, Ptychadena mossambica, Phrynobatrachus mababiensis, Kassina maculata, Hyperolius nasutus, Chiromantis xerampelina, Bufo gutturalis* and *B. maculatus.*

3.7 **Comments on the amphibian fauna**

The confirmed amphibian fauna of the Zambezi Delta includes 19 species, with a further five species probably occurring and four others possible. This is lower than that of coastal Maputaland (41 species, Passmore & Carruthers 1995), although comparable to the tropical component (34 species, Poynton 1990) of the latter.

Due to the poor comparative data for amphibian distributions in Central and Northern Mozambique, many of the specimens collected represent important range extensions, or gap fillers, relative to the distributions in Poynton & Broadley (1991). These include:

Arthroleptis stenodactylus – With the exception of material collected at Moebase (Branch, unpub. obs.), these specimens are the only records from the coastal plain north of Beira.

Pyxicephalus edulis – There are few records of this large, fossorial species in Central and Northern Mozambique. With the exception of recent material from Moebase (Branch, unpub. obs.), these are the only records east of Caia.

Ptychadena pumilio – There are few Mozambique records of this wide-ranging species. This is the only record for the lower Zambezi River. Although only once recorded from northern Mozambique, this species was common at Moebase (Branch, unpub. obs.).

Phrynobatrachus mababiensis – These are the first records from the coastal plain north of Beira.

Chiromantis xerampelina – There are few Mozambique records of this wide-ranging species from the lower Zambezi and northern Mozambique. These are the first records from the coastal plain north of Beira.

Kassina maculata – South of 13°S, these are the only records from the coastal plain north of Beira. Also known from Caia and Dondo.

Kassina senegalensis – Although previously collected at Fambani, there are only three records for northern Mozambique E of 36°E. The species has recently been collected at Moebase (Branch, unpub. obs).

Bufo maculatus – The first records for the coastal plain north of Beira for this wide-ranging species.

3.8 **Amphibian species of special concern**

No Mozambique amphibian species are listed in the international Red List (Baillie & Groombridge 1996) and no Southern African threatened amphibians (Branch 1988) occur in the region. However, caution should taken in assuming that the conservation status of all the amphibians in the region is safe. Mozambique has not prepared a national inventory of endangered species, and this report cannot presume to predetermine its

national priorities, or the extent of national threats to the herpetofauna. The absence of threatened amphibian species is more a reflection of conservation effort than scientific knowledge. Ballie and Groombridge (1996) note that globally the numbers of known threatened amphibians "... are certainly under-estimates as relatively few have been evaluated.", and that "... the percentage of amphibians that are estimated to be threatened (25%) is similar to that of mammals, reptiles and fishes." The status of 'isolated' populations of *Hyperolius parkeri* and *H. mitchelli* recorded from the Zambezi Delta region (Poynton & Broadley 1987) require fuller investigation.

3.9 **Biology notes**

All amphibians are intolerant of marine ecosystems and are absent from the shore, estuarine and brackish mangrove environments. Arboreal species may, however, traverse and forage in mangrove foliage. Amphibians are found in all other habitats within the region. One species, the shovel-footed squeaker (*Arthroleptis stenodactylus*), undergoes direct development and is therefore not dependent upon standing or flowing water. It lays its large eggs underground in damp soil, where they undergo direct development, the tadpole stage being spent within the egg, fully developed froglets emerging. It was only found in forested habitats on the edge of the wetlands. The Mozambique rain frog (*Breviceps mossambicus*) is another burrowing species that undergoes direct development. It probably also occurs in the Delta region, but in sandy, well-drained soils around the edge of the wetlands. It will occur only in transit through low-lying areas that become seasonally inundated. All other frogs in the region require water bodies for their free-living tadpoles to complete development.

The East African puddle frog (*Phrynobatrachus acridoides*) was collected in seepage areas at most sites (5 of the 11 in the study region). These included woodland, palm savannah and disturbed habitats. Other common wetland species, that adapted well to disturbed habitats, included *Afrixalus fornasini* and *Hyperolius marmoratus taeniatus*. Fossorial amphibians (*Pyxicephalus edulis* and *Kassina senegalensis*) were only collected in the vicinity of human settlements. However, the apparent restriction of these species to these habitats is an artifact of collecting effort. These cryptic, burrowing species were uncovered during land clearing activities during both subsistence farming and sugarcane field preparation. These species may have been present in other habitats but overlooked.

3.10 **Existing impacts on amphibians**

Exploitation

No evidence of exploitation of frogs in the region was noted. Although dried fish were commonly offered in the market stalls of Marromeu and other villages, no large amphibians were offered. This is somewhat surprising, for although the large majority of amphibians in the region are either distasteful (e.g. *Bufo* and *Phrynomantis* spp), the African bullfrog (*Pyxicephalus edulis*) is edible (hence its scientific name) and was known to be eaten by local people (Peters 1882).

Habitat destruction

The loss of forest habitats for cultivation will affect only a few of the forest adapted amphibians. Rice plantations within the wetlands were restricted to a relatively small area and did not significantly affect breeding sites for the amphibians present. Similarly, although the preparation of sugar cane fields causes considerable habitat destruction, it is high-intensity agriculture in a well-circumscribed area. Moreover, due to the relatively long standing crop period, many fossorial reptiles and amphibians have been shown to be relatively tolerant of sugarcane production (Johnson & Raw 1989).

The maintenance of a system of drainage channels in the sugar plantations also provides corridors for movement by aquatic species and also breeding habitats for many small amphibians. The presence of permanent water bodies may also stimulate populations of species that have extended larval development (e.g. *Amnirana galamensis*) or require permanent water (e.g. the tropical platanna *Xenopus muelleri*).

There was no evidence of visible pollution within the vicinity of the permanent or temporary local villages. However, the use of herbicides and insecticides during sugar cane production can be expected to increase and should be monitored.

4. REPTILES

4.1 Introduction

Reptiles form a significant, but neglected component of terrestrial vertebrate faunas in Africa. With the exception of land tortoises all terrestrial reptiles are carnivorous, although some larger lizards do supplement their diet with vegetable matter in certain seasons. In ecosystems reptiles therefore play an important role in nutrient cycling and in population control of their prey items. Most snakes are specialist feeders, taking specific and limited food classes, and this is often reflected in their common names, i.e. egg-eaters, slug-eaters, centipede eaters, etc. They are usually habitat generalists, occupying a wide range of specific habitats and vegetation types, provided their primary prey is present. In contrast, most lizards take a wide-range of insect prey, and niche separation between sympatric species usually occurs via habitat selection and/or diel activity (e.g. most geckos are nocturnal). Congeneric species especially occupy different habitats that are determined more by the habitat physical and substrate characteristics rather than the presence of specific plants and/or soil.

4.2 Reptiles in a regional context

The reptile fauna of Mozambique was last reviewed by Peters (1882). At that time studies in the area were in their infancy, and large tracts of the country were unexplored. This remains the situation for much of northern Mozambique. However, the reptile fauna of southern Mozambique (i.e. south of the Zambezi River), was reviewed in Branch (1998) and the snakes in Broadley (1990b). Together these cover a significant proportion of the total Mozambique reptile fauna. Since 1988 there have been a number of reviews of reptile groups in the region, (eg. Broadley 1990a, 1992, 1994, 1995, 1996, 1997, Broadley & Broadley 1997, Broadley & Wallach 1997), particularly the fossorial forms inhabiting the alluvial coastal sands. These were prompted by studies on the fauna inhabiting the Bazaruto Archipelago. Broadley & Howell (1991) have also recently reviewed the reptile fauna of Tanzania, and this gives an indication of the species likely to extend along the coastal plain into northern and central Mozambique.

Integration of the above publications indicates that approximately 153 reptile species occur in southern and central Mozambique. Endemicity in Mozambique reptiles is surprisingly low with only approximately 12 taxa endemic to the country, most being associated with disjunct populations on the various off-shore islands.

4.3 Sampling

Most reptiles were collected opportunistically during surveys on foot in the various habitats present in the study area. Sticky glue traps were used in an attempt to collect inaccessible arboreal species. Fossorial species were uncovered by raking within leaf litter, and in sandy soil beneath rotting logs, collapsed huts, etc. Many specimens were collected by local villagers. Most specimens were preserved and accessioned into the Port Elizabeth herpetological collection. Identification was confirmed by comparison with voucher specimens and from published keys.

Local villagers were also shown a series of colour pictures (Branch 1998) and asked whether they were familiar with the species. Evidence of local utilization of reptile species was obtained by direct questioning of villagers and also by observations on village middens for reptile remains.

4.4 Limitations and cautions

Due to late rains the seasonally inundated wetlands were still drying out. This may have delayed the onset of snake activity during the survey. The large number and variety of snakes collected around Marromeu during the last three days of the survey indicates that snake activity had just started. The reptile fauna of the Zambezi Delta region appears to be relatively well-known. The lack of rupicolous habitats and the large areas of seasonally-inundated grassland limit habitat diversity, which in turn probably reduces reptile diversity. Few taxonomic novelties can be expected.

4.5 Reptiles present in the Zambezi Delta

A diverse reptile fauna was discovered in the Zambezi Delta region, listed in Table 1. It comprises 33 species, including 11 lizards, 19 snakes, 2 chelonians and a crocodile.

Other species that are likely to occur in the region (Branch 1998, Broadley 1990b) are listed in Table 2 (see end of this Appendix). It includes at least four chelonians, 18 snakes, one amphisbaenid and six lizards. Together with the confirmed species, this gives a projected reptile fauna of over 50 species.

4.6 **New discoveries and range extensions**

No new reptile taxa were discovered during the survey. In addition, most reptiles were previously known from the region and only three represent significant records or range extensions.

Blue-tailed tree lizard (*Holaspis guentheri laevis*) – On two occasions these small, attractive, arboreal lizards were observed in riverine forest near Site 2. Despite the use of sticky traps they eluded capture. They are few Mozambique records for the species (Amatongas (Cott 1934), Cavalo, near Gorongosa Mountain, Dondo, Inhamitanga Forests (Broadley, pers. comm.), and Moebase, northern Mozambique (Branch, unpub. obs). The Camp 1 records represents a slight eastern range extension in the delta region.

Black file snake (*Mehelya nyassae*) – There are very few records of this small, semi-fossorial species, from Mozambique (Inhambane, Maputo, Lumbo - Broadley 1966, 1990b). The Marromeu record represents a range extension of approximately 400 km east from the nearest records in Eastern Zimbabwe.

Cross-barred tree snake (*Dipsadoboa flavida broadleyi*) – This very rare and secretive arboreal species was previously known from only two Mozambique records (Beira and Maputo), that represented a considerable disjunction from the East African population (southern Somalia to Tanzania). The species has also recently been collected at Moebase (Branch, unpub. obs). The Camp 1 record is the fifth for Mozambique, and a slight northern extension from Beira that closes the coastal gap between the southern and northern populations (Rasmussen 1989).

4.7 **Reptiles of special concern**

The lack of a National Red Data List for Mozambique means that an assessment of the conservation status of the reptile fauna must be made by comparison with international lists and/or those from adjacent countries.

Only five Mozambique reptile species are listed as threatened in the 1996 Red List; all are sea turtles. None enter significantly into the Zambezi Delta system.

An additional Mozambique chelonian listed in the Near Threatened category of the 1996 Red List is the Zambezi soft-shelled terrapin (*Cycloderma frenatum*). This large trionychid has a patchy distribution in the Zambezi drainage area. No specimens were obtained. Discussion with local fishermen was contradictory. Some knew the species, but considered it rare and not found in the main river. The majority of fishermen questioned did not know the species.

An additional five reptiles are listed on CITES legislation (all in Appendix II). All have been listed in general categories (Pythonidae, Testudinidae, Varanidae and *Chamaeleo*) because elsewhere in Africa they have been subject to over-exploitation, either for the skin trade (pythons and monitors) or pet trade (chameleons and tortoises).

4.8 **Biology notes**

Many reptiles were rare (or inactive during the survey period) and encountered three or less times (19 species). It was thus not possible to assess their habitat requirements on the specimens collected. The habitat associations of the majority of species were thus determined from general knowledge of their biology and behaviour.

The apparent lack of habitat specificity among reptiles is characteristic of snakes, which may simplistically be considered food-limited, i.e. they specialize on specific food types and will hunt them in a variety of habitats. Lizards and chelonians are usually more habitat specific, but select physical characteristics of their environment rather than specific plant species. Thus miombo and riverine forests may support similar reptile species that simply require thick vegetation, hollow tree stumps, or leaf litter. Reptiles linked to well-wooded

habitats include: the Mozambique agama (*Agama mossambica*), Eastern tree lizard (*Holaspis guentheri laevis*), tiger snake (*Telescopus semiannulatus*), boomslang (*Dispholidus typus*), cross-barred tree snake (*Dipsadoboa flavida broadleyi*), and the green mamba (*Dendroaspis angusticeps*). Boulenger's skink (*Mabuya boulengeri*) was twice encountered in ecotonal situations, on fallen logs alongside clearings.

Some generalist species (6) were encountered in three or more habitats, and included the house gecko (*Hemidactylus platycephalus)*, flapnecked chameleon (*Chamaeleo dilepis*), spotted bush snake (*Philothamnus semivariegatus*), white-lipped cat snake (*Crotaphopeltis hotamboeia*) and puffadder (*Bitis arietans*).

Aquatic species, utilizing the wetlands include the hinged terrapin (*Pelusios castanoides*), Nile monitor (*Varanus niloticus*), Nile crocodile (*Crocodylus niloticus*), and various frog-eating snakes, e.g. white-lipped cat snake (*Crotaphopeltis hotamboeia*), southern green snake (*Philothamnus hoplogaster*) and olive marsh snake (*Natriciteres olivacea*).

Reptile habitat specialists, particularly fossorial species, may continue to survive in cultivated lands (Johnson & Raw 1989), and locally included the Zambezi blind snake (*Rhinotyphlops mucruso*) and southern burrowing asp (*Atractaspis bibronii*).

4.9 **Existing impacts on terrestrial reptiles**

Exploitation

On two occasions salted Southern African python (*Python natalensis*) skins (each approximately 2.5 m TL) were noted in villages (Marromeu and Malingapansi). Neither were offered for sale. Both were killed by local farmers who complained that the pythons had killed chickens around their homes. That both farmers had bothered to keep the skins indicates that they had a commercial value. No further evidence was found indicating that this exploitation was directed, and not simply incidental. Elsewhere in Africa, trade in python and monitor skins reaches very large scales.

The hunting concession at Safari Delta Lodge (Coutada 11) stated that it occasionally had clients who shot crocodiles in the Delta. An extended river trip from Marromeu to Malingapansi (5-6 August) revealed only 16 crocodiles basking on the river banks, all downstream from Luabo. They ranged in size from 2.5 m to juveniles, and all were visible, basking on sand and mud banks during the day. They allowed relatively close approach indicating that current hunting pressures cannot be high.

Habitat Destruction

The large-scale clearance of forest and well-wooded savanna can be expected to impact significantly on many reptiles. For arboreal, forest specialists this will obviously result in habitat loss and fragmentation. In some cases, however, more generalist species foraging in open veld may be expected to increase in numbers. This is particularly likely for terrestrial species. Commensal species such as the striped skink (*Mabuya striata*) and Cape dwarf day gecko (*Lygodactylus capensis*) can be expected to increase in numbers around villages. Large numbers of snakes, including large venomous species, were still present in the cleared sugarcane fields around Marromeu, indicating that many are tolerant of some disturbance.

4.10 **Reptiles of medical significance**

Venomous Snakes

Mozambique has a rich snake fauna including 16 venomous species (Spawls & Branch 1995). Snakes with medically significant venom were common in the Zambezi Delta. Eight venomous species were present (Southern burrowing asp, *Atractaspis bibronii*; green mamba, *Dendroaspis angusticeps*; forest cobra, *Naja melanoleuca*; spitting cobra, *N. mossambica*; snouted cobra, *N. annulifera*; puff adder, *Bitis arietans*; boomslang, *Dispholidus typus*; Mozambique twig snake, *Thelotornis mossambicanus*), of which seven have bites that have caused human fatalities (Spawls & Branch 1995). Of the 56 snakes seen or collected, 15 were venomous with the puff adder (6 specimens, 10.7%) and spitting cobra (5 specimens, 8.9%) being among the commonest species encountered. Another three venomous species (Swamp adder, *Proatheris superciliaris*; black mamba, *Dendroaspis polylepis*; and Boulenger's garter snake, *Elapsoidea boulengeri*) may also occur in the region.

Discussion with fishermen indicated that snakebite was not uncommon in the region and that some fatalities occurred each year. No estimate of the incidence of snakebite and subsequent mortality was possible, however. The species responsible for the majority of bites were given as the puffadder, Mozambique spitting cobra and southern burrowing asp.

Crocodiles

Large Nile crocodiles (>2 m) are still found in the Zambezi Delta, and two large specimens capable of attacking people were observed downstream from Malingapansi. Interviews with local fishermen and farmers indicated that all were aware of crocodile attacks in the region and thus took due care near water. They accepted the presence of crocodiles, however, and made no attempt to kill large specimens unless they were known to be a danger to people or livestock. The main concern for many fishermen was damage to set gill nets.

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Appendix 6.3, Table 1 Herpetofauna of the Zambezi Delta, Central Mozambique.

Y = Voucher specimen(s); O = Observed

Taxon	Common name	Sites											Total
		1	2	3	4	5	6	7	8	9	10	11	
CLASS REPTILIA													
LACERTILIA (lizards)													
FAMILY: GEKKONIDAE													
Hemidactylus mabouia	Tropical house gecko	O											1
Hemidactylus platycephalus	Flat-headed house gecko		Y						O	Y			3
Lygodactylus capensis capensis	Cape dwarf gecko	O							O	Y	Y		4
FAMILY: VARANIDAE													
Varanus niloticus	Nile monitor	Y								Y			2
FAMILY: CHAMAELEONIDAE													
Chamaeleo dilepis dilepis	Flap-necked chameleon									Y			1
FAMILY: AGAMIDAE													
Agama mossambica	Mozambique agama		Y										1
FAMILY: LACERTIDAE													
Holaspis guntheri laevis	Eastern tree lizard		O										1
FAMILY: SCINCIDAE													
Mabuya varia	Variable skink		Y										1
Mabuya boulengeri	Boulenger's skink									Y	Y		2
Mabuya striata	Striped skink	O	Y						O				3
FAMILY: GERRHOSAURIDAE													
Gerrhosaurus flavigularis	Yellow-throated plated lizard		Y		Y								2
SERPENTES (snakes)													

Taxon	Common name	Sites											Total
		1	2	3	4	5	6	7	8	9	10	11	
FAMILY: TYPHLOPIDAE													
Rhinotyphlops mucruso	Zambezi blind snake										Y	Y	2
FAMILY: BOIDAE													
Python natalensis	Southern African python				O								1
FAMILY: COLUBRIDAE													
Lamprophis capensis	Brown house snake		Y							Y	Y		3
Mehelya nyassae	Black file snake										Y		1
FAMILY: ATRACTASPIDIDAE													
Atractaspis bibronii	Southern burrowing asp										Y		1
FAMILY: COLUBRIDAE													
Natriciteres olivaceae	Olive marsh snake									Y			1
Prosymna stuhlmanni	Stuhlmann's shovel-snouted snake									Y			1
SUBFAMILY: COLUBRINAE													
Dipsadoboa flavida broadleyi	Cross-barred tree snake		Y										1
Crotaphopeltis hotamboeia	White-lipped cat snake	Y	Y							Y	Y		4
Philothamnus hoplogaster	Southern green snake		Y							Y	Y		3
Philothamnus s. semivariegatus	Variegated bush snake	Y	Y							Y	O		4
Dispholidus typus	Boomslang									Y			1
Thelotornis mossambicanus	Mozambique twig snake									Y			1
SUBFAMILY: PSAMMOPHIINAE													
Psammophis mossambicus	Olive grass snake									Y	Y		2
FAMILY: ELAPIDAE													
Naja annulifera	Snouted cobra										Y		1

Taxon	Common name	Sites											Total
		1	2	3	4	5	6	7	8	9	10	11	
Naja mossambica	Mozambique spitting cobra										Y	Y	2
Naja melanoleuca	Forest cobra										Y		1
Dendroaspis angusticeps	Green mamba									Y			1
FAMILY: VIPERIDAE													
Bitis arietans arietans	Puff adder	Y	Y					O		Y	Y		5
CHELONIA (tortoises/terrapins)													
FAMILY: TESTUDINIDAE													
Kinixys belliana belliana	Bell's hingeback tortoise									Y			1
FAMILY: PELOMEDUSIDAE													
Pelusios castanoides castanoides	Yellow-bellied hinged terrapin									Y			1
CROCODYLIA (crocodiles)													
FAMILY: CROCODYLIDAE													
Crocodylus niloticus	Nile crocodile									Y			1
CLASS AMPHIBIA													
ANURA (frogs/toads)													
FAMILY: ARTHROLEPTIDAE													
Arthroleptis stenodactylus	Shovel-footed squeaker				Y								1
FAMILY: BUFONIDAE													
Bufo gutturalis	Guttural toad		Y							Y			2
Bufo maculatus	Flat-backed toad		Y								Y		2
FAMILY: HYPEROLIIDAE													
Afrixalus fornasinii	Greater leaf-folding frog	Y	Y							Y	Y		4
Hyperolius argus	Argus reed frog		Y				Y			Y			3

Taxon	Common name	Sites											Total
		1	2	3	4	5	6	7	8	9	10	11	
Hyperolius marmoratus taeniatus	Painted reed frog		Y	Y						Y	Y		4
Hyperolius cf parkeri	Parker's reed frog									Y			1
Hyperolius sp.			Y										1
Hyperolius nasutus	Long reed frog		O										1
Kassina maculata	Red-legged kassina						Y			Y			2
Kassina senegalensis	Bubbling kassina										Y		1
Leptopelis mossambicus	Mozambique tree frog									Y	Y	Y	3
FAMILY: PIPIDAE													
Xenopus muelleri	Tropical platanna										Y		1
FAMILY: RANIDAE													
Phrynobatrachus acridoides	East African puddle frog		Y			Y	Y			Y	Y		5
Phrynobatrachus mababiensis	Dwarf puddle frog		Y	Y									2
Ptychadena mossambica	Mozambique grass frog		Y								Y		2
Ptychadena pumilio	Dwarf grass frog		Y										1
Pyxicephalus edulis	African bullfrog									Y	Y	Y	3
FAMILY: RHACOPHORIDAE													
Chiromantis xerampelina	Grey tree frog		Y										1
Total species		**52**	**8**	**24**	**2**	**3**	**1**	**3**	**1**	**3**	**28**	**23**	**4**

Appendix 6.3 Table 1 (continued) List of localities:

1	26-28 July 1999	18°17'28"S / 35°56'21"E	Marromeu, Zambezi River
2	28 July-3 Aug 1999	18°33'13"S / 35°40'37"E	Camp 1, patch of riverine forest on edge of Zambezi wetlands
3	28-31 July 1999	18°33'45"S / 35°40'59"E	Wet grassland, edge of wetlands near Camp 1 (Woody's trap line)
4	28-31 July 1999	18°33'22"S / 35°39'37"E	Dry forest on edge of wetlands, pit-trap array for Woody
5	29-31 July 1999	18°33'15"S / 35°39'48'E	Clear river in semi-cleared *Brachystegia* woodland, near Camp 1
6	31 July 1999	10 km E of Site 7	Palm & wooded 'island' on floodplain
7	36376	18°25'03"S / 36°06'02"E	On Zambezi River, 2 km downstream from Luabo
8	5 Aug 1999	18°48'57"S / 36°14'46"E	Fishing village in mangroves near mouth of Zambezi
9	5-8 Aug 1999	18°40'36"S / 36°06'17"E	Malingapansi village, 65 km S Marromeu; mixed grassland, palm savanna & riverine forest
10	3-10 Aug 1999	18°23'04"S / 35°52'55"E	Old sugar canes fields, 4 km W Marromeu
11	9 Aug 1999		Nhane Village, 9.5 km upstream from Marromeu

Appendix 6.3, Table 2 : Reptiles that have or may yet be discovered in the Zambezi Delta region, but which were not confirmed during the field survey.

Species	Scientific Name	Locality
Terrapins (4 species)		
Marsh terrapin	*Pelomedusa subrufa*	Quelimane
Pan hinged terrapin	*Pelusios subniger*	
Serrated hinged terrapin	*Pelusios sinuatus*	
Zambezi soft-shelled terrapin	*Cycloderma frenatum*	
Snakes (19 species)		
Pungwe thread snake	*Leptotyphlops pungweensis*	Pungwe Flats
Eyebrow viper	*Proatheris superciliaris*	Beira
Snouted night adder	*Causus defilippii*	
Black mamba	*Dendroaspis polylepis*	Mossuril
Boulenger's garter snake	*Elapsoidea boulengeri*	
Cape centipede eater	*Aparallactus capensis*	Angoche
Floodplain water snake	*Lycodonomorphus obscuriventris*	Charre
Dwarf wolf snake	*Lycophidion nanum*	Chitengo, Gorongoza Nat. Park
Snouted wolf snake	*Lycophidion acutirostris*	Lumbo
Cape file snake	*Mehelya capensis*	
Semiornate snake	*Meizodon semiornatus*	
Angola green snake	*Philothamnus angolensis*	Moebase, Shire Valley
Natal green snake	*Philothamnus natalensis*	Beira
Dwarf sand snake	*Psammophis angolensis*	
Eastern stripe-bellied sand snake	*Psammophis orientalis*	
Marbled tree snake	*Dipsadoboa aulica*	Chinde
Eastern tiger snake	*Telecopus semmiannulatus*	
Common eggeater	*Dasypeltis scabra*	
Eastern eggeater	*Dasypeltis medici*	Ribaue
Olive marsh snake	*Natriciteres olivacea*	Angoche
Amphisbaenids (2 species)		
Swynnerton's worm lizard	*Chirindia swynnertoni*	Pungwe Flats
Pestle-tailed worm lizard	*Dalophia pistillum*	Beira
Lizards (7 species)		
Wahlberg's Snake-eyed skink	*Panaspis wahlbergi*	
Mozambique writhing skink	*Lygosoma afrum*	
Eastern Coastal skink	*Mabuya depressa*	Beira
Grass-top skink	*Mabuya megalura*	Chiniziua Dist.
Common rough-scaled lizard	*Ichnotropis squamulosa*	Charre
Tropical girdled lizard	*Cordylus tropidosternum*	
Rough-scaled plated lizard	*Gerrhosaurus major*	Pungwe Flats