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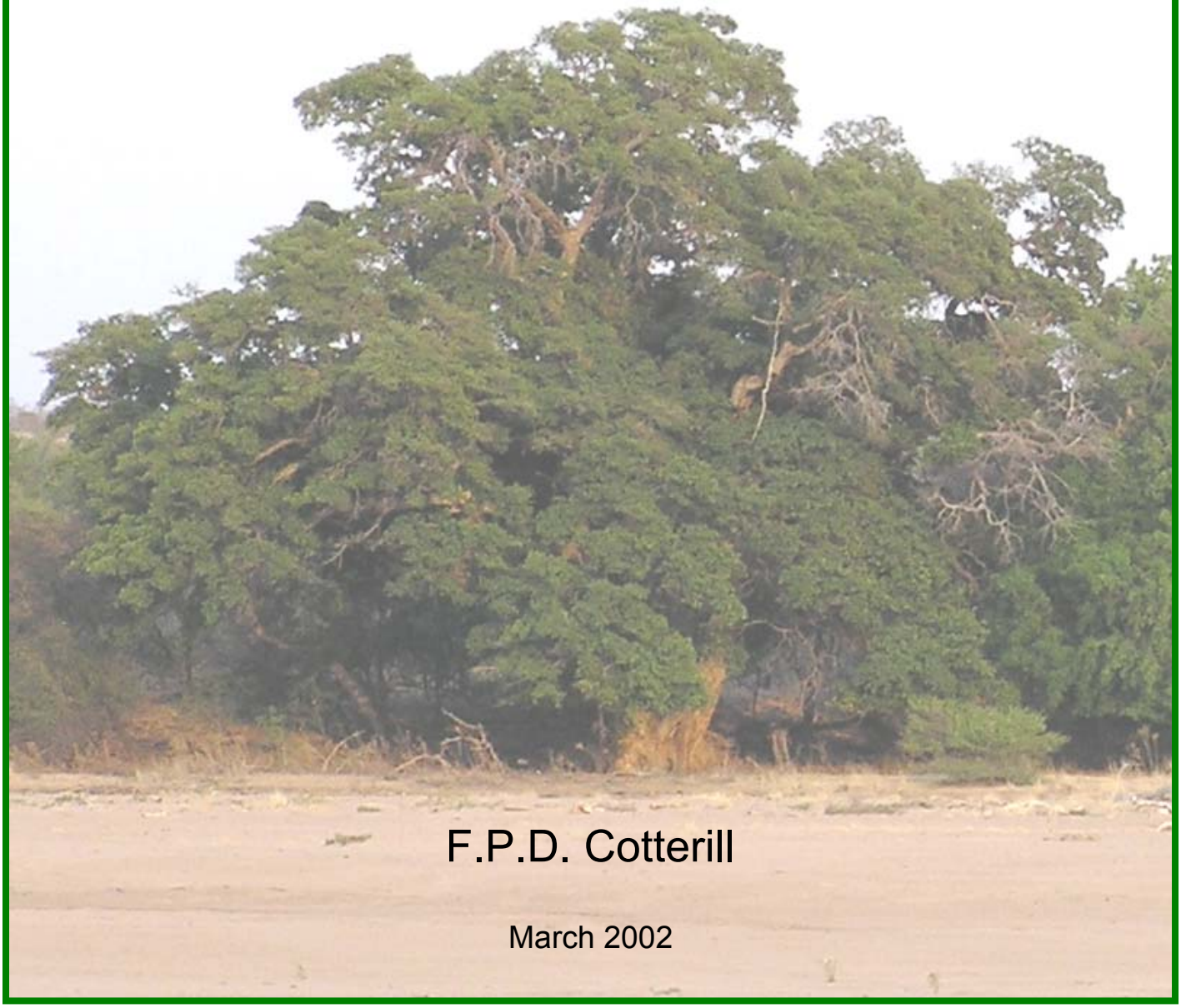

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F.P.D. Cotterill

SUMMARY

The first part of this paper describes a collection of mammals from the Ikelenge pedicle of the Mwinilunga District, northwest Zambia. This comprises 140 specimens of 20 species collected between 22 September and 12 October 1990, including the third specimen of tree pangolin *Manis tricuspis* known from Zambia, and the fourth known specimen of the musk shrew, *Crocidura ansellorum*, endemic to northwest Zambia.

The second part of the paper highlights the biodiversity of this region and discusses its conservation. The biogeography of the Ikelenge pedicle is discussed with respect to its exceptional biodiversity. A review of indicator species of vertebrates, Lepidoptera and Odonata emphasizes the global and national significance of the area's biodiversity resulting from the dominant influence of forest species of Guineo-Congolian affinity and also from those species endemic to the area. The presence of these endemics provides evidence for a region of endemism.

1. INTRODUCTION

Numerous scientific expeditions have explored the biota of the Mwinilunga District of northwest Zambia, a biologically rich region of the country adjacent to both Angola and the Democratic Republic of Congo (DRC) (Figure 1). This biologically interesting region of northwest Zambia is bounded on three sides by Angola and the DRC, and to the south by Barotseland. Collectors have paid special attention to the Ikelenge pedicle, which forms the northwest corner of Mwinilunga District. The pedicle abuts the equatorial divide between the headwaters of the Congo and Zambezi drainage systems. Its location and climate have been described in detail by Broadley (1991a), Bingham (1994) and Cotterill (2002). The annual minimum temperature averages 20^{o}C in July - the warmest in Zambia. Other important climatic determinants include a relatively high and prolonged rainfall period (October to May) with an average rainfall of 1400 mm per annum.

C.M.N. White collected various mammals from the Ikelenge pedicle in the 1940s, including specimens preserved in the Natural History Museum, London (BM). W.F.H. Ansell and C.W. Benson also collected mammals in the 1950s and 1960s; their significant finds included primates, Rodentia and Chiroptera typical of evergreen forest habitats in the Congo Basin. Ansell (1958) described four new taxa of rodents based on specimens collected in 1957 along the Sakeji and Isombu streams. In 1973, R. W. Dowsett led a multi-disciplinary expedition to the region under the auspices of the Livingstone Museum, Zambia; their mammal collection included two specimens of a new musk shrew (Ansell 1974, Hutterer & Dippenaar 1987a,b).

These collections of mammals have been exceeded in sampling effort by repeated surveys of birds, Lepidoptera, Odonata and plants (Leonard 1998, Pinhey 1984, Bingham 1994) respectively. One such expedition to Mwinilunga District was in 1963 under the auspices of the Department of Zoology, University College of Rhodesia and Nyasaland (now the University of Zimbabwe in Harare). Its main objective was to study the plants, birds and Lepidoptera of the *Cryptosepalum* forests to the south of the pedicle (Cottrell & Loveridge 1966). The expedition also visited Isombu stream in the Ikelenge pedicle to obtain comparative data. Their collections comprise a small but significant collection of small mammals, including the fourth known specimen of the dormouse, *Graphiurus monardi* (Ansell 1978).

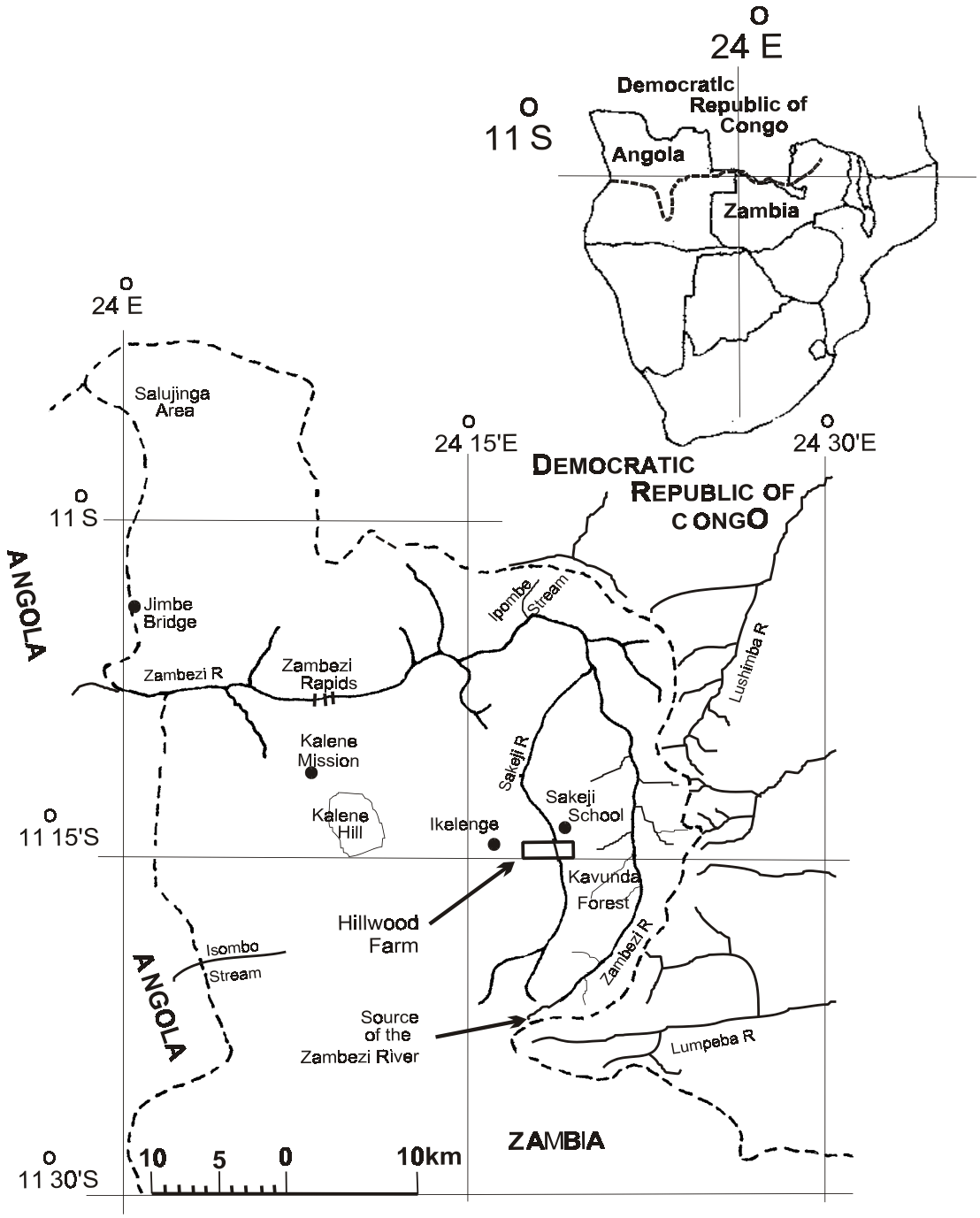

Figure 1. Map of the Ikelenge pedicle, northern Mwinilunga district, NW Zambia showing collecting localities mentioned in the text. Watercourses are depicted as solid lines, the dashed line depicts international boundaries. The equatorial divide formed by the Congo and Zambezi drainage systems is depicted by the dotted line on the smaller map of south-central Africa. Modified from Cotterill (2002).

Between 22 September and 12 October 1990 I collected small mammals in the Ikelenge pedicle, while D.G. Broadley made the first noteworthy collection of reptiles from the region (Broadley 1991a,b).

Nearly all zoological material from the Ikelenge pedicle is preserved in the BM, Livingstone Museum and the Natural History Museum of Zimbabwe (NMZB) while some plant specimens collected by Cottrell and Loveridge (1966) are in the National Herbarium, Harare.

The first part of this paper comprises an annotated systematic list of the mammal specimens obtained in 1990 that are now preserved in the NMZB. It is not currently possible to exhaustively review all mammalian material collected in the Ikelenge pedicle; many specimens are preserved in overseas museums. Nonetheless, these new data can be compared with published information (Ansell 1958, 1960, 1964, 1969, 1974, 1978).

The second part of this paper reviews the biodiversity of this region and discusses its conservation. The conservation significance of the region is highlighted with respect to the national and global significance of its biodiversity. Emphasis is placed on the endemics and forest species with Guinean-Congolian affinities. As with the mammal review, the considerable effort needed to complete exhaustive lists for vertebrate and invertebrate groups renders this a preliminary effort. Nevertheless, the data available provide ample evidence that the biodiversity in the Ikelenge pedicle is exceptional and of significant relevance to conservation.

This paper is dedicated to the many naturalists, especially the late W.F.H. Ansell (mammalogist), the late C.W. Benson (ornithologist), and the late E.C.H. Pinhey (entomologist), in recognition of their scientific contributions generated over many decades. The collective legacy of their collections constitutes the foundations of a knowledge of the biodiversity of the Ikelenge pedicle, and indeed much of south-central Africa.

2. METHODOLOGY AND TAXONOMY

Methods and measurements follow Cotterill (1996). Taxonomy of Mammalia follows Wilson & Reeder (1993) unless otherwise stated. Taxonomies of other groups follows Pinhey (1984) for Odonata; Ackery, Smith & Vane-Wright (1994) for Lepidoptera; Poynton & Broadley (1985, 1987, 1988) for Amphibia (updated partially by Schiøtz 1999); and Dowsett & Forbes-Watson (1993) for birds.

3. MAMMAL SPECIMENS COLLECTED FROM THE IKELENGE PEDICLE

Order INSECTIVORA

Family Soricidae

Crocidura ansellorum Hutterer & Dippenaar, 1987 Ansell's musk shrew

Hutterer & Dippenaar (1987a) described this rare shrew on the basis of three specimens from northwest Zambia. These comprise the holotype and one paratype collected in 1973 (Isombu Stream 11º16'S, 24º06'E in the Ikelenge pedicle), and the other paratype from Nyansowe Stream (12º13' S, 25º32' E in Solwezi District). A new specimen of *C. ansellorum* (NMZB 29814 &) was collected on Hillwood Farm on 25 September 1990 by D.G. Broadley in leaf litter under gallery forest along Kazombi Stream. It is preserved in ethanol with skull extracted. External measurements in millimetres are: Overall length (O) = 105; Tail (T) = 40.1; Ear (E) = 8; Hindfoot (HF) = 11.6. The dorsal and ventral colour of the pelage of the new specimen is a chocolate brown; cranially, this

specimen agrees with the description and measurements of the type series. It has been compared with the large series of *C. fuscomurina* in Bulawayo, from which it is clearly distinct. The discovery of this new musk shrew in northwest Zambia has provided novel insights into the biogeography of Afrotropical *Crocidura*. *C. ansellorum* is similar in size to *C. fuscomurina*, a species distributed widely across Africa's southern savannas, but Hutterer & Dippenaar (1987a) emphasized that these resemblances between the two taxa are superficial. The sister species of *C. ansellorum* appear to be the poorly known *C. bottegi* Thomas 1898 and *C. ludia* Hollister, 1916. Restricted within the west African forest block, the latter are all poorly known. *Crocidura ansellorum* from northwest Zambia appears to be the sole, and enigmatic, representative of these forest crocidurids south of the central Congo forest block.

Crocidura luna Dollman, 1910 Greater grey-brown musk shrew
One specimen (NMZB 29815 &) collected during ploughing an old cassava field on Hillwood Farm.

Order CHIROPTERA

Family Pteropididae

Epomophorus wahlbergi (Sundevall, 1846) Wahlberg's epauletted fruit bat
Ikelenge (NMZB 29854, 29911), Sakeji School (NMZB 30286)

Family Vespertilionidae

Pipistrellus capensis (A. Smith, 1829) Cape pipistrelle
Hillwood Farm (NMZB 29886, 29888). This species is widely distributed across subSaharan Africa.

Pipistrellus anchietai (Seabra 1900) Anchieta's pipistrelle
Hillwood Farm (NMZB 29855, 29885, 29887, 29889)
The status of this species is not as straightforward as generally believed (Koopman 1993, Cotterill 1996). Older specimens in the NMZB from the Ikelenge pedicle and elsewhere in northern Zambia (collected by W.F.H. Ansell and C.W. Benson) have been provisionally identified as *P. anchietai*; they possess a similar projection of the lachrymals and the distinctive morphology of the upper premolar. They are distinctly smaller, approximating *P. nanus* in size, but the braincase lacks the pronounced cranial inflation of *P. nanus*, and the latter's conspicuous upper premolar. Similar specimens have also been collected in Zimbabwe and central Mozambique. These specimens may well be referable to an existing taxon, but their clarification awaits detailed comparisons with other Afrotropical *Pipistrellus*, incorporating cranial, molecular and bacula characters.

Pipistrellus nanus (Peters, 1852) Banana bat
(NMZB 29585, 29588, 29600-2,7-9, 29816-35, 29869-84, 30293-96)
Based on personal observation this is the most abundant insectivorous bat in the Ikelenge pedicle. Three specimens were captured in a harp trap, but the majority were collected from their daylight roosts in unfurled banana leaves. Based on nomenclatural priority, Ansell & Dowsett (1988) replaced *africanus* (Rüppell 1842) as the senior synonym for *nanus*, but suggested the southern African population might be subspecifically distinct. Topotypical *P. africanus* is restricted to Ethiopia, a region renowned for its high endemism of small mammals. Until this problem is resolved by exhaustive review of all available material to demonstrate that southern African banana bats are conspecific with topotypical *P. africanus*, I regard *P. nanus* to be distinct from *P. africanus*.

Scotophilus dinganii (A. Smith, 1833) Yellow house bat
Kalene Mission (NMZB 29804-5) Hillwood Farm, (NMZB 29838-9)
These specimens were all taken within the attics of houses at Hillwood Farm and Kalene Mission. The females were in late pregnancy.

Family Hipposideridae

Hipposideros caffer (Sundevall, 1846) Sundevall's leaf-nosed bat
Two series were collected from Sakeji School and Hillwood Farm, both roosting in buildings. One maternity colony was roosting in the attic of a farmhouse on Hillwood Farm (NMZB 29806-13, 29837, 29840; 30210, 30211). Lactating females were carrying new born young on 25 September 1990.

Hipposideros ruber (Noack, 1893) Noack's leaf-nosed bat
The majority of this species were collected from small caves within small tributaries of the Sakeji River, near Ikelenge (NMZB 29842-29853, 29857-67, 29909, 33399). One of these streams was approximately 6 km north of the colony of *H. caffer* on Hillwood Farm. A male (NMZB 29836) was harp-trapped near Sakeji School. These collections from the Ikelenge pedicle confirm sympatry between *H. caffer* and *H. ruber*, which further substantiates that divergence between these sibling species is advanced (Fenton 1986, Heller 1992, Guillen, Juste & Ibanez 2000). The occurrence of *H. ruber* in Zambia was originally established by Ansell (1969), although Koopman (1975) questioned the validity of the taxon.

Family Rhinolophidae

Rhinolophus clivosus Cretzschmar, 1828 Geoffroy's horseshoe bat
One specimen (NMZB 29624 %) was collected from a small flooded cave formed under granite boulders in Ipombe stream, near an adjacent cave housing a large colony of *H. ruber*. Comparatively few specimens of *R. clivosus* are known from Zambia (Ansell 1978). This record constitutes the most northwesterly record for this species, which is more common in eastern and southern Africa (Thomas 1997).

Rhinolophus sakejiensis Cotterill, 2002 Sakeji horseshoe bat
Kavunda (11º 17'S; 24º 21'E) SE of Ikelenge (NMZB 29153 %, 29154 %, HZM 1.32236 %). These three specimens are the first representatives of a new species of *Rhinolophus*, known only from the Ikelenge pedicle. The new species has been exhaustively compared with related Afrotropical rhinolophids on the criteria of morphology of the skull, noseleaf and baculum. It is being described separately (Cotterill 2002). Although a member of the *ferrumequinum* group (as defined by Bogdanowicz 1992), this taxon is distinct from *R. clivosus zuluensis*, with which it is sympatric. Its closest relative is the poorly known *R. hillorum* Koopman, 1989 - originally described as the west African subspecies of *R. clivosus*. A forest species, *R. hillorum* is represented by a total of seven specimens from southwest Cameroon, Liberia and southern Nigeria (Koopman, Kofron & Chapman 1995, Cotterill 2002).

Family Nycteridae

Nycteris thebaica E. Geoffroy, 1818 Egyptian slit-faced bat
Sakeji School (NMZB 29803, 29856, 30290-30292). A small colony roosting in a storeroom.

Nycteris macrotis Dobson, 1876 Greater slit-faced bat
One specimen (NMZB 29868) was collected from a colony roosting in a storage room in Sakeji School. The colony was in a different building from that sheltering the colony of *N. thebaica*.

Family Molossidae

Mops niveiventer (Cabrera & Ruxton, 1926) White-bellied free-tailed bat
Seven specimens (NMZB 30029, 30297-30302) were collected from Mavunda, east of Sakeji School; these were captured from their daylight roost in a large hollow tree.

Order RODENTIA
Family Anomaluridae

Anomalurus derbianus (Gray, 1842) Lord Derby's anomalure (scaly-tailed flying squirrel)
Sakeji-Zambezi confluence and Congo-Zambian border (NMZB 29460-29463, 29468-29470), preserved as study skins and complete skeletons. This species of scaly-tailed flying squirrel is widespread in suitable habitat (tall miombo woodland) across western and central Zambia (Ansell 1978).

Family Sciuridae

Heliosciurus gambianus (Ogilby, 1835) Gambian sun squirrel
A lactating female (NMZB 29472) collected near the Zambezi River, northeast of Ikelenge; preserved as a study skin and complete skeleton. This species is widespread in suitable habitat (tall miombo woodland) across western and central Zambia (Ansell 1978).

Family Bathyergidae

Cryptomys bocagei (de Winton, 1897) Bocage's molerat
One specimen (NMZB 30287) was trapped in the vegetable gardens at Sakeji School. Molerat colonies, presumably of this species, were also seen in miombo woodland at the source of the Zambezi. No evidence was seen of the larger *C. mechowi* (Peters, 1881), which the local people said did occur in the past, but has been extirpated. Until the taxonomy of this diverse group of cryptic species is resolved, these specimens are provisionally allocated to *C. bocagei*, following Honeycutt, *et al.* (1991). It is unclear how *C. bocagei* is related to the other smaller Zambian *Cryptomys*, including *C. amatus* (Wroughton 1907) and the recently described *C. anselli* and *C. kafuensis* (Burda *et al.* 1999).

Order CARNIVORA

Family Mustelidae

Poecilogale albinucha (Gray, 1864) Striped weasel
Ikelenge area (1124a2; NMZB 29466, 29471).

Family Herpestidae

Galerella sanguinea (Rüppell, 1836) Slender mongoose
Ikelenge area (1124a2; NMZB 29464).

Order PHOLIDOTA

Manis tricuspis Rafinesque, 1821 Tree pangolin

NMZB 29467 ♀ from near Sakeji School is the third known Zambian specimen; it is preserved as a complete skeleton. The other two are in the American Museum of Natural History and NMZB (Ansell 1964, 1978, W. F. H. Ansell 1990 *in litt*.). The latter specimen (NMZB 11382) consists of a portion of skin and the distal portion of the tail. Two other individuals were seen, on 11 and 12 October, near Sakeji School and the Ipombe-Zambezi confluence respectively.

4. BIOGEOGRAPHY AND BIODIVERSITY OF THE IKELENGE PEDICLE

The contribution of this mammal collection to improving our knowledge of the Ikelenge pedicle is now discussed with respect to the biodiversity of the forest-savanna mosaic of south-central Africa. The discussion first considers notable mammals occurring in the region that indicate an affinity with the Guineo-Congolian forest belt.

4.1 The Mammalian Fauna

Species associated with mesic miombo savanna woodlands dominate the mammal fauna. These include the squirrels *Heliosciurus gambianus* and *Anomalurus derbianus*, and the molerats *Cryptomys bocagei* and *C. mechowi* (Ansell 1978). The other important biogeographical influence is that of species affiliated with tropical moist forest. The peripheries of these species' distributions coincide with the Ikelenge pedicle, and barely extend further south. They include several fruit bats and rodents, and at least two primates, *Colobus angolensis* and *Cercopithecus ascanius* (Ansell 1978), in addition to *Manis tricuspus* and *Crocidura ansellorum*. At least two mammals appear to be endemic to a localized region centred on the Ikelenge pedicle. As Hutterer and Dippenaar (1987a) have proposed for *C. ansellorum*, the new Sakeji horseshoe bat *Rhinolophus sakejiensis* is likely to occur in suitable habitat in neighbouring Angola and the Congo Basin, but is unlikely to occur further south into Zambia. In addition, there are two species of dormouse - *Graphiurus monardi* and another species of uncertain identity. The range of *G. monardi* is centred on the pedicle, with specimens known from eastern Angola, southwest DRC and Mwinilunga District (Ansell 1978).

Two new rodents have been described from the Ikelenge pedicle by Ansell (1958). These are *Steatomys minutis bensoni*, now a synononym of *S. krebsi mariae* (Ansell 1964), and the subspecies *australis* of *Malacomys longipes*, described from a patch of forest at the headwaters of Sakeji stream. This subspecies is not only valid, but is clearly quite distinct from typical *M. longipes*. These rats are restricted to aquatic habitat along streams in gallery forest. A distinctive character of *M. l. australis* is the pure white markings on the venter. In some specimens these form a Y-shaped cross on the belly that extends to form bands around the elbows of the forelimbs (Ansell 1974). A paratype, NMZB 8123, particularly illustrates this character. The discovery of *Malacomys* so far south was unexpected as the nearest locality is northeast Angola (Ansell 1958). The exact status of these 'subspecies' of rodents remains to be established, particularly when re-evaluated in terms of the Evolutionary Species Concept (ESC) that characterizes biodiversity more objectively (Adams 1998, Cotterill 2000, 2001, 2002). The apparent dichopatry (*sensu* Cracraft 1984), and especially the distinct morphology of this population in the Ikelenge pedicle, suggests that *M. australis* is a distinct species.

Besides *M. australis*, there are four interesting aquatic species among the forest mammals found in the Mwinilunga District - the Otter-shrew *Potamogale velox*, and the rodents *Colomys goslingi* and *Pelomys minor*. All are associated with aquatic habitats in gallery forest (Ansell 1978). *Potamogale*

velox and the rare Forest brook rat *C. goslingi*, are specialized aquatic predators dependent on fast flowing, clear perennial streams (Dieterlen & Statzner 1981, Stephan & Dieterlen 1982).

4.2 Biodiversity

Similar patterns are found in both plants and mammals, indicating that exceptional biodiversity is found in the Ikelenge pedicle. Appendix 1 lists the animal species endemic to the area, and those principally found in Guineo-Congolian forest. The diversity and species richness of its avifauna is also increased by the occurrence of many Guineo-Congolian species (Benson *et al.* 1971). New records of Guineo-Congolian birds from the area continue to be established, such as the Shrike-Flycatcher *Megabyas flammulatus* seen on the Jimbe River (Leonard 1998, Leonard & Van Daele 1998a,b). A similar enrichment by Guineo-Congolian reptiles and amphibians increases the herpetofaunal diversity (Broadley 1991a,b, Haagner, Branch & Haagner 2000).

Apart from Lepidoptera and Odonata, the invertebrate fauna in the pedicle has barely been studied. The Guinean-Congolian influence on Lepidopteran diversity is well documented (Gardiner 2000), and some notable indicator species are listed in Appendix 1. Distributions of wetland and forest butterflies within the more extensive miombo woodland appear to be restricted by both foodplants and microhabitat to localized patches of forest and wetland. The overall effect is to elevate species diversity in the region. Since the 1950s, repeated inventories around the Isombu stream and its environs in the western portion of the Ikelenge pedicle have shown that a relict butterfly fauna extends from its restricted gallery forests westwards into Angola. For example, eight species of *Euphraeda* occur here. Although forest species contribute considerably to the high diversity of Lepidoptera, wetland butterflies are also important, notably species of *Acraea* and *Zeretis* that require aquatic foodplants in swamps and dambos (Gardiner 2000). A similar situation applies with Odonata. No less than 148 species of dragonfly occur in the Mwinilunga area (FitzPatrick 2000), of which at least 19 are endemic (Pinhey 1984). This diversity is markedly increased by West African species (Pinhey 1978, 1981a,b).

4.3 Overview and Geomorphological Controls on Biodiversity

Lying within the Zambezian phytochorion (as defined by White 1983; see Frost 1996), the Ikelenge pedicle comprises a heterogenous landscape of mesic miombo woodland containing small but significant patches of tropical forest and wetland. At least 1000 species of flowering plants occur and the area has been highlighted as a globally important site of plant diversity (Bingham 1994).

A mosaic of deciduous miombo woodland and gallery forest dominates the landscapes of the southern Congo Basin, covering much of northern Angola and Katanga Province. Narrow stands of forest persist across the southern parts of the basin over 250 km south of the main moist forest belt. The southern margin of the mosaic approximates the Congo-Zambezi watershed, but extends slightly into the Zambezi Basin along the headwater tributaries, particularly in Mwinilunga District in Zambia and along tributaries of the Luapula and Lualaba rivers further west (White & Werger 1978). Here, gallery or riparian forests, known locally as *mushitu*, have persisted deep within the surrounding mesic savanna woodland landscape, where they are principally confined to shallow drainage channels with perennially moist soils. Edaphic conditions along forested drainage channels differ markedly from those on the interfluves supporting miombo woodland.

Ultimately, geomorphology has determined the distribution of this mosaic. The gently undulating topography of this part of the south-central African plateau results in sluggish drainage and many perennially-moist grasslands or dambos. Together with the region's mesic climate, this determines where gallery forest occurs, and in turn why populations of Guineo-Congolian forest organisms persist far south of the main forest blocks of the Congo Basin. Plants have a keystone role in

structuring these patches of habitat, resulting in an enrichment of the region's biodiversity by forest organisms.

Populations of certain Guineo-Congolian forest species persist deep within savanna. In the case of mammals, nearly all the Guineo-Congolian species are small-bodied. This subtle connectivity of gallery forest with the main blocks of moist forest further north is the most plausible explanation for congruent distributions of Guineo-Congolian species deep within mesic miombo savanna (Cotterill 2002). It is interesting that a similar landscape pattern in the Amazon Basin parallels this forest-savanna mosaic in the Afrotropics. There, gallery forests occurring along drainage channels also allows forest species to persist deep into savanna (Meave *et al.* 1991). The biogeographical significance of such forest-savanna mosaics is heightened if one considers their persistence over long periods. Gallery forests are refugia for forest organisms, and these populations have not only persisted successfully in savannas, but there is evidence for divergence from sister species in the main forest block, exemplified by Ansell's long-footed rat, *Malacomys australis*.

The occurrence of endemic mammals in the Ikelenge pedicle and its environs points to the evolutionary significance of forest-savanna mosaics, where gallery forest holds a key role in vicariance of forest organisms. Examples of divergence could reflect speciation during the Pleistocene. It would be interesting to quantify how forest species in the forest-savanna mosaics of south-central Africa differ from their source populations in the main moist belt. Comparative studies of these geographically dispersed populations could usefully elucidate phylogeographic patterns among these lineages (Cotterill *in press*).

5. CONSERVATION CRITERIA AND ISSUES

The unique biodiversity in the Ikelenge pedicle reinforces arguments for its conservation (Bingham 1994, Leonard & Van Daele 1998a). The significance of this biodiversity hotspot rests on two interrelated scientific criteria, of regional and global significance:

a) In a national context, species richness and diversity in the pedicle is higher than elsewhere in Zambia, or southern Africa south of 10°S. There is an assemblage of forest species that occurs here and nowhere else in Zambia (see Appendix 1), and Guineo-Congolian species augment the moist miombo biota.

b) While certain endemic vertebrates - including a frog, *Hyperolius m. alborufus*, and three mammals (*Crocidura ansellorum*, *Malacomys australis* and *Rhinolophus sakejiensis*) - indicate that Ikelenge's biodiversity is unique. Furthermore, an increased knowledge of Lepidoptera and Odonata constitute the main body of evidence for a region of endemism (Appendix 1). The actual extent of this hotspot of biodiversity, lying across adjacent Angola and the DRC, cannot presently be ascertained as little scientific collecting has been carried out. The separation of the Isombu forests in the extreme west of the pedicle from gallery forests interfacing directly with the Congo headwaters, as indicated by distributions of Lepidoptera (Gardiner 2000 and *pers. comm*.), suggests that some invertebrate endemics persist successfully in comparatively small habitat patches, and that they are also isolated from other Guineo-Congolian species. This may mean that, compared to other taxa, vertebrate endemics possess non-congruent ranges compared to invertebrates.

The local economy in the Ikelenge pedicle is based on small-scale agriculture supplemented by harvesting of local wildlife. Bee-keeping is economically significant. Forest Reserves include some moist miombo savanna and limited stands of gallery forest, but these are poorly policed. Gallery

forests along the Kazombi stream and Sakeji River are protected within Hillwood Farm, as is a delimited area around the Zambezi source (Bingham 1994). Conversion of gallery forest and miombo for short term agricultural gain has increased through the 1990s, and is especially acute in the north of the region. Shortage of land for crops is the main reason (Leonard 1998, Leonard & Van Daele 1998a). Many vertebrates, including birds, primates, bats, rodents and pangolins, routinely feature in the diet of the Lunda people, along with other bushmeat. Consumption rates appear to be high, as shown by the extirpation of *C. mechowi*, but are nowhere quantified. Large mammals (for example waterbuck, *Kobus crawshayi* Sclater, 1894 and Sable antelope, *Hippotragus niger* (Harris, 1838)) that were formerly widespread and abundant early in the 20th century are now extinct (P. Fisher, *pers. comm*.).

Successful conservation hinges on the creation and maintenance of protected areas in a stable and supportive economic environment. Ideally, evaluation of conservation priorities and ensuing activities needs to consider the pedicle in the context of neighbouring Angola and DRC. Political stability permitting, there is great potential to develop a special-interest tourism industry centred on more charismatic biodiversity, especially birds, plants, Lepidoptera and Odonata.

6 CONCLUSIONS

The Ikelenge pedicle of northwest Zambia contains biodiversity of global and regional importance. Its global importance is underwritten by the occurrence of endemics, whilst the biodiversity of the forest-savanna mosaic is of regional significance. This biodiversity is still poorly understood, and many more species await discovery. The knowledge already available for several animal groups justifies considerable interest and further research.

Conservation of areas within the pedicle and surrounding country is an obvious priority. Urgent action is called for to address the future of both species and the ecological complexes of which they are part. Conservation priorities and activities must be based on a comprehensive mapping of the existing and historical landscape mosaic. This must include habitats in adjacent countries to establish the actual extent of the endemic species. Attention should focus on gallery forests, especially along the Isombu, Sakeji and Zambezi rivers, and on existing forest reserves.

One option within Zambia itself is to try and derive economic benefit from the remaining key habitats through mechanisms that minimize negative impacts on biodiversity. Carefully planned and responsibly managed, a tourist industry could supplement, if not exceed, benefits currently derived from plant products, bushmeat, and the honey industry. The success of such a land use system requires maintenance of intact habitats in protected areas in which biodiversity is protected against unsustainable depletion. As argued by Attwell & Cotterill (2000), this requires that conservation planning and management be based on scientific knowledge of both biodiversity and human impacts.

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APPENDIX 1. Some indicator species of the biodiversity in the Ikelenge pedicle, northwest Zambia. These are either endemic species (**E**) or occur marginally (**M**) in the pedicle; distributions of all the marginal species are centred in Guineo-Congolian forest. Data collated from Ackery *et al*. (1994), Ansell (1964, 1969, 1974, 1978), Benson *et al.* (1971), Branch & Haagner (1993), Broadley (1991a,b), Dowsett & Forbes-Watson (1993), FitzPatrick (2000), Gardiner (2000), Haagner *et al.* (2000) Pinhey (1962, 1978, 1981a,b, 1984), Poynton & Broadley (1985, 1987, 1988) and Schiøtz (1999).

Taxon	Status
Odonata	
Chlorocnemis wittei Fraser, 1955	**M**
Ceragrion bakeri Fraser, 1941	**M**
Ceriagrion platystigma Fraser, 1941	**M**
Ceragrion sakejii Pinhey, 1963	**E**
Ceragrion sanguinostigma Fraser, 1955	**M**
Pseudagrion greeni Pinhey, 1961	**M**
Pseudagrion kibalense Longfield, 1959	**M**
Pseudagrion williamsi Pinhey, 1964	**M**
Chlorocypha frigida Pinhey, 1961	**E**
Chlorocypha wittei Fraser, 1955	**M**
Umma distincta Longfield, 1933	**M**
Prodasineura flavifacies Pinhey, 1981	**E**
Aciagrion zambiense Pinhey, 1972	**E**
Aciagrion nodosum Pinhey, 1964	**E**
Agriocnemis angolensis spatulae Pinhey, 1974	**E**
Chlorocypha wittei Fraser, 1955	**M**
Enallagma vaginale vaginale Sjöstedt, 1917	**M**
Ischnuragrion nodosum Pinhey, 1964	**E**
Onychogomphus kitchingmani Pinhey, 1960	**E**
Onychogomphus quirkii Pinhey, 1964	**E**
Phyllogomphus brunneus Pinhey, 1976	**E**
Diastatomma selysi Schouteden, 1934	**M**
Aeshna moori Pinhey, 1981	**E**
Aeshna wittei Fraser 1955	**M**
Anax congoliath lisombae Pinhey, 1962	**E**

Heliaeschna cynthiae Fraser, 1939		**M**
Monardithemis flava Longfield, 1945		**E**
Allorhizucha longistipes Pinhey, 1964		**E**
Crocothemis brevistigma Pinhey, 1961		**E**
Orthetrum macrostigma Longfield, 1945		**M**
Nesciothemis fitzgeraldi Longfield, 1955		**E**
Macromia bispina Fraser, 1954		**M**
Porpacithemis leakeyi (Pinhey, 1956)		**E**
Trithemis anomala Pinhey, 1956		**E**
Trithemis dichroa Karsch, 1893		**M**
Zygonyx flavicosta mwinilungae Pinhey, 1961		**E**
Zygonyx eusibia (Ris, 1912)		**M**
Lepidoptera		
Bicyclus sebetus Hewitson, 1877		**M**
Bicyclus trilophus Rebel, 1914		**M**
Bicyclus sophrosyne overlaeti Cond, 1965		**M**
Kamilla ansorgei (Rothschild, 1899)		**M**
Papilio phorcas congoanus Rothschild, 1896		**M**
Papilio hesperus Westwood, 1843		**M**
Graphium ridleyanus (White, 1843)		**M**
Pseudopontia paradoxa australis Dixey, 1923		**E**
Acraea (Actinote) mirifica Lathy, 1906		**E**
Leptosia hybrida somereni Bernardi, 1959		**M**
Leptosia nupta (Butler, 1873)		**M**
Charaxes acuminatus cottrelli Van Someren, 1963		**E**
Artitropa cama Evans, 1937		**M**
Argema kuhnei Pinhey, 1969	Kuhne's Lunar Moth	**M**
Temnora scitula (Holland, 1889)	Temnora Hawk Moth	**M**
Amphibia		
Hylarana lemairei (Witte, 1921)	Lemaire's Frog	**M**
Ptychadena obscura (Schmidt & Inger, 1959)	Plain Ridged Frog	**M**
Ptychadena keilingi (Monard, 1937)	Keiling's Ridged Frog	**M**

Leptopelis cynnamomeus (Bocage, 1893)	Bocage's Tree-Frog	**M**
Kassina wittei Laurent, 1940	Witte's Kassina	**M**
Hyperolius major Laurent, 1957	Greater Reed-Frog	**M**
Hyperolius bocagei Steindachner, 1867	Bocage's Reed-Frog	**M**
Hyperolius quinquevittatus quinquevittatus Bocage, 1866	Five-lined Reed-Frog	**M**
Hyperolius marmoratus alborufus Laurent, 1964	Red and white Reed-Frog	**E**
Bufo fuliginatus Witte, 1932	Sooty Toad	**M**
Reptilia		
Pelusios nanus Laurent, 1956	Dwarf Hinged Terrapin	**M**
Lygodactylus heeneni Witte, 1933	Heenen's Dwarf Gecko	**M**
Adolfus africanus (Boulenger, 1906)	Congo Forest Lizard	**M**
Causus lichtensteinii (Jan, 1859)	Forest night Adder	**M**
Grayia ornata (Bocage, 1866)	Ornate Water-Snake	**M**
Grayia tholloni Mocquard, 1897	Thollon's Water-Snake	**M**
Psammophis leopardinus Bocage, 1887	Chain-marked Grass-Snake	**M**
Thrasops jacksonii Günther, 1895	Black Tree-Snake	**M**
Thrasops aethiopissa ituriensis (Schmidt, 1923)	Variegated Tree-Snake	**M**
Thelotornis kirtlandii (Hallowell, 1844)	Forest Vine Snake	**M**
Aves		
Sarothura pulchra (Gray, 1829)	White-spotted flufftail	**M**
Jynx ruficollis Wagler, 1830	Red-throated wryneck	**M**
Columba unicincta Cassin, 1860	Afep Pigeon	**M**
Cercococcyx olivinus Sassi, 1912	Olive long-tailed cuckoo	**M**
Alcedo leucogaster (Fraser, 1843)	White-bellied kingfisher	**M**
Ptyrticus turdinus Hartlaub, 1883	Spotted thrush babbler	**M**
Neolestes torquatus Cabanis, 1875	Black-collared bulbul	**M**
Bleda syndactyla (Swainson, 1837)	African bristlebul	**M**
Indicator exilis (Cassin, 1856)	Western least honeyguide	**M**
Campethera caroli (Malherbe, 1852)	Brown-eared woodpecker	**M**
Stizorhina fraseri (Strickland, 1844)	Rufous ant thrush	**M**
Apalis rufogularis (Fraser, 1843)	Buff-throated apalis	**M**
Dyathorophyia castanea (Fraser, 1843)	Chestnut wattle eye	**M**

Muscicapa cassini Heine, 1859	Cassin's grey flycatcher	**M**
Muscicapa infuscata (Cassin, 1855)	Sooty flycatcher	**M**
Terpsiphone rufiventer (Swainson, 1837)	Red-bellied paradise flycatcher	**M**
Megabyas flammulatus Verreaux, 1855	Shrike-flycatcher	**M**
Bradypterus alfredi Hartlaub, 1890	Bamboo warbler	**M**
Nectarinia batesi (Ogilvie-Grant, 1908)	Bates's sunbird	**M**
Nectarinia rubescens (Vieillot, 1819)	Green-throated sunbird	**M**
Nectarinia bannermani (Grant & Mackworth-Praed, 1943)	Bannerman's sunbird	**M**
Ploceus superciliosus (Shelley, 1873)	Compact weaver	**M**
Mammalia		
Potamogale velox Du Chaillu, 1860	Otter shrew	**M**
Crocidura ansellorum Hutterer & Dippenaar, 1987	Ansell's musk shrew	**E**
Micropteropus pusillus (Peters, 1868)	Dwarf epauletted fruit bat	**M**
Lissonycteris angolensis (Bocage, 1898)	Angola fruit bat	**M**
Myonycteris torquata (Dobson, 1878)	Collared fruit bat	**M**
Rhinolophus sakejiensis Cotterill, 2002	Sakeji horseshoe bat	**E**
Colobus angolensis Sclater, 1860	Angola pied colobus	**M**
Cercopithecus ascanius (Audebert, 1799)	Red-tailed monkey	**M**
Manis tricuspis Rafinesque, 1821	Tree pangolin	**M**
Anomalurus beecrofti Fraser, 1853	Beecroft's anomalure	**M**
Graphiurus monardi (St Leger, 1936)	Monard's dormouse	**E**
Graphiurus sp.	Dormouse	**?**
Hylomyscus denniae (Thomas, 1906)	Wood mouse	**M**
Pelomys minor Cabrera & Ruxton, 1962	Creek rat	**M**
Steatomys krebsi mariae Ansell, 1958	Mary's fat mouse	**E**
Hybomys univittatus (Peters, 1876)	Hump-nosed mouse	**M**
Malacomys australis Ansell, 1958	Ansell's long-footed rat	**E**
Colomys goslingi Thomas & Wroughton, 1907	Forest brook rat	**M**