# Chapter 1
# Angolan Biodiversity: Towards a Modern Synthesis


**Brian J. Huntley and Nuno Ferrand**

**Abstract** Angola possesses an unusually rich diversity of ecosystems and species, but this natural wealth is poorly documented when compared with other countries in the region. Both colonial history and extended wars challenged progress in biodiversity research and conservation, but since peace was achieved in 2002 a rapidly increasing level of collaboration between Angolan and visiting scientists and institutions has seen a blossoming of biodiversity research. The absence of comprehensive reviews and syntheses of existing knowledge, often published in extinct journals and inaccessible official reports, necessitates a modern synthesis. This volume brings together the existing body of scientific results from studies on Angola's landscapes, ecosystems, flora and fauna, and presents an outline of opportunities for biodiversity discovery, understanding and conservation as well as collaborative research.

**Keywords** Africa · Biomes · Collaborative research · Conservation · Ecoregions

## Background and Context

Angola is a country of unusually rich physiographic, climatic and biological diversity. It occupies only 4% of the terrestrial area of Africa, yet it possesses the highest diversity of biomes and is second only to mega-diverse South Africa in terms of the number of ecoregions found within its borders. However, scientific literature on its

B. J. Huntley (✉)
CIBIO-InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Vairão, Portugal
e-mail: brianjhuntley@gmail.com

N. Ferrand
CIBIO-InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Laboratório Associado, Campus de Vairão, Universidade do Porto, Vairão, Portugal

Departamento de Biologia, Faculdade de Ciências, Universidade do Porto, Porto, Portugal

Department of Zoology, Auckland Park, University of Johannesburg, Johannesburg, South Africa
e-mail: nferrand@cibio.up.pt



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biodiversity is extremely limited when compared with most African countries. Much of that which has been published is difficult to access or out of print. This volume seeks to redress this situation.

Here we present a review of what is known about Angola's biodiversity. Much of the existing literature dates from the nineteenth and early to mid-twentieth centuries. Following independence in 1975, field studies were curtailed by the instabilities of an extended civil war. It was not until after the peace settlement of 2002 that a new wave of research has been possible. Initial attempts to establish collaborative field expeditions were frustrated by visa and permit restrictions, but these challenges were gradually overcome and by the 2010s a vibrant programme of joint projects has evolved. Today many foreign specialists work in partnership with Angolan researchers and institutions, producing a new flow of scientific results of which many are presented in this volume.

For any comprehensive synthesis, both temporal depth and spatial breadth is necessary. An historical perspective is presented in each chapter. Angolan indigenous knowledge has contributed to the insights and materials that have informed visiting researchers from the eighteenth century to the present day. The pioneering studies and exhaustive botanical collections of the Austrian botanist, Friedrich Welwitsch (1806–1872), the zoological collections of the indefatigable Portuguese naturalist José Anchieta (1832–1897) and the Swiss botanist John Gossweiler (1873–1952) set benchmarks for later work (Swinscow 1972; de Andrade 1985). Each succeeding student of Angola has added to the description of its biological diversity. While botanists such as Romero Monteiro (1970) and zoologists such as Crawford-Cabral (1983) have summarised available biogeographic information within a national context, no comprehensive synthesis of studies on Angola's fauna, flora and ecosystems has yet been undertaken. The need for an integrated account has become evident in the past decade, as increasing numbers of expeditions and collaborative projects have evolved as part of the country's 'peace dividend'.

## Approach and Purpose of This Synthesis

A modern synthesis is not easily achieved. Much of the early literature on Angola's biodiversity resides in publications and reports that are difficult to source. This review attempts to reference these important but sometimes elusive accounts, in order to provide students with access to what information is available. While focusing on papers in peer-reviewed journals, some topics need to draw on unpublished reports filed in government departments. It also seeks to bring together the findings of recent, post-independence studies, many of which are still in progress or in press. It is intended to serve the new generation of Angolan students by providing a comprehensive but focused synopsis of what is known on the biomes, landscapes, flora and fauna of Angola. It should also bring Angola to the attention of researchers across Africa and beyond, revealing the great diversity of life, and the multiple questions on the structure and functioning of Angola's biodiversity that await exploration, examination and explanation.

In structuring this book, this introduction leads through synopses on the country's terrestrial and marine biogeography, paleontological record, recent landscape evolution and land transformation, to chapters on its flora and vegetation. The main body of this volume is devoted to accounts of its fauna – selected invertebrate groups that have promise as indicators of environmental stress, and all vertebrate groups. In each treatment, the need for increased conservation measures for threatened taxa and habitats is a recurrent theme, while research opportunities are highlighted. While general inventories and checklists are progressing well, the state of ecological knowledge remains rudimentary. Topics as fundamental as ecological processes such as the flows of energy, water and nutrients; the ecological impacts of phenomena such as fire, invasive species, herbivory, droughts and frosts; community structure, plant-animal interactions and the impacts of land-transformation and of climate change are yet to be researched in Angola. This volume's content is limited by the availability of information. It is therefore opportunistic, covering those taxonomic groups and those features and processes for which a critical mass of information is available. The focus is primarily on the terrestrial ecosystems and biota of Angola, but the importance of the marine environment is described in accounts on marine biodiversity and ocean dynamics, and on the richness of the whale, dolphin and marine turtle faunas of Angolan waters.

In comparison with similar reviews for other African countries with long and strong traditions of research into their biodiversity and ecology, and for which comprehensive syntheses of the state of knowledge are available (e.g. Namibia: Barnard 1998; Southern Africa: Davis 1964; Werger and van Bruggen 1978; Huntley 1989; Tanzania: Sinclair 2012), this account reveals both the strengths and weaknesses of the research agenda of the colonial era, and the challenges of the recent past. While institutions such as the *Instituto de Investigação Científica de Angola* and the *Instituto de Investigação Agronómica de Angola* undertook very important studies on many taxa, and on vegetation, soils and agronomy, and the *Museu do Dundo* amassed and distributed a vast series of collections of the animal species of the Lundas, the coverage of disciplines and of the remote regions of Angola was weak.

## Biodiversity Surveys: Historical Synopsis

The history of scientific exploration and biological collection in Angola is relatively modest. Whereas South Africa, by 1975, had over three million herbarium specimens collected by some 2500 botanists since the late eighteenth century (Gunn and Codd 1981), Angola had less than 300,000 specimens collected by just 300 botanists during the same period (Figueiredo and Smith 2008). Despite the relatively limited coverage of Angolan collections, the great botanist Francisco Mendonça was occasioned to state in his preface to Gossweiler and Mendonça (1939):

> We are happily able to confirm that the flora of Angola is the best known in tropical Africa, due to the attention given by the state towards the botanical exploration of the colony, and the great interest and zeal of scientists in its study.

The Swiss zoologist, Monard (1935), had been less sanguine:

> A regrettable fact about the Natural History of Angola is the scarcity of concrete information about the nature, distribution, and habits of the large game. The Boers … never communicated their observations. The Portuguese hunters … did not write reports on their hunts, or if they did, did so in newspapers or magazines that never enter the scientific literature. The observations remain, in this way, lost to the naturalist who is not able to locate such work.

In truth, during the colonial era, investment in research on the country's biodiversity was limited. The achievements of early pioneers such as Friedrich Welwitsch, José Anchieta and John Gossweiler were quite remarkable, and those of more recent agronomists, botanists and zoologists such as Castanheira Diniz, Romero Monteiro, Grandvaux Barbosa, Brito Teixeira, Crawford-Cabral, Rosa Pinto, Barros Machado, etc., were equally laudable, indeed amazing.

The war years from 1975 to 2002 saw very few researchers venturing into the field. Most activities were limited to brief searches for remnant populations of giant sable (Estes 1982), marine turtles (Carr and Carr 1991), birds (Günther and Feiler 1986a, b; Hawkins 1993), and a countrywide assessment of the state of wildlife populations (Huntley and Matos 1992). The Southern African Botanical Diversity Network (SABONET) project attempted to stimulate botanical studies in Angola from the mid-1990s (Huntley et al. 2006), while the Kissama Foundation funded a vegetation survey of the northern extreme of Quiçama (Jeffrey 1996) and introduced a mixed assemblage of antelope and ostriches into the park in 2000 (Walker 2004). The last decades of the twentieth century were aptly described as a period of *confusão* – confusion (Maier 2007). In brief, from Angola's independence in 1975, until the twenty-first century, cooperative field research over most of the country was challenged by the impacts of war. But dramatic and positive change came with the dawn of the new millennium.

## Research Collaboration in the Twenty-First Century

From 2000, especially after the peace agreement of April 2002, field activities expanded rapidly. Most notably, Vaz Pinto has focused on a long-term study on giant sable in Cangandala (Walker 2004; Vaz Pinto 2018), Morais (2017) has led surveys of marine turtles along the Angolan coast, and Mills (2010, 2018) has undertaken field studies on birds across the country.

International support for environmental conservation and research strengthened from 2001, when the Global Environment Facility, through the United Nations Development Programme, initiated a multidisciplinary project to develop a transboundary diagnostic analysis of hydro-environment threats within the Okavango River Basin, known as the Environmental Protection and Sustainable Management of the Okavango River Basin Project (EPSMO). The project's aim was to facilitate the protection of the Basin's aquatic ecosystems and biological diversity (OKACOM 2009, 2011). The project included participation from Angola, Botswana and

Namibia and provided a strong impetus to future multi-national projects in the Basin. A further initiative, the Integrated River Management Project, was funded by USAID/Southern Africa between 2004 and 2009 and provided both institutional and management planning support to the national partners (OKACOM 2009). The EPSMO project was succeeded by the SAREP project described below.

The OKACOM projects were focused on major water management needs and did not embrace detailed biodiversity surveys. Indeed, until 2009, biodiversity research activities in Angola had been essentially individual efforts, with limited funding. Difficulties experienced in obtaining visas to visit, and permits to collect specimens in Angola were a continuing challenge faced by foreign scientists. With the signing of an agreement between the South African National Biodiversity Institute (SANBI), the Angolan Ministry of Environment and the *Instituto Superior de Ciências da Educação* (ISCED), Lubango, in 2009, more ambitious cooperative biodiversity projects became possible. Initially designed as training exercises, the series of Rapid Biodiversity Assessments, in Huíla/Namibe (Huntley 2009), Lunda-Norte (Huntley 2011; Huntley and Francisco 2015) and across western Angola (Rejmánek et al. 2017), brought over 40 scientists from 14 countries to Angola to work with local students and researchers.

By the early 2010s, a wide diversity of major cooperative programmes had developed, including those of the Southern African Regional Environmental Programme (SAREP), the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) (Revermann et al. 2018), the National Geographic Okavango Wilderness Project (NGOWP 2018), and conservation initiatives of NGOs such as *Elephants without Borders*, *Panthera*, Peace Parks Foundation, the Kavango-Zambezi Transfrontier Conservation Area (KAZA) project and several others. Collaboration between foreign museums and universities and Angolan counterparts stimulated additional specialist interests, collectively gaining momentum until the present. In October 2012, CIBIO (Research Centre in Biodiversity and Genetic Resources) at the University of Porto, Portugal, and ISCED-Huíla (Lubango) established a collaborative research, capacity building and advanced training project – the ISCED/CIBIO TwinLab initiative. The initiative was soon replicated in South Africa, Mozambique, Namibia and Zimbabwe, and the whole network of TwinLabs now forms a UNESCO Chair *Life on Land*, awarded at the end of 2017.

For much of the post-independence period, biodiversity research efforts had been un-coordinated and opportunistic. With the establishment of the *Instituto Nacional de Biodiversidade e Áreas de Conservação* (INBAC) in 2011, the opportunity arose for a greater level of coordination and priority setting. The *Plano Estratégico da Rede Nacional da Áreas de Conservação de Angola* (GoA 2011), provided a stimulus to studies in key biodiversity hotspots such as Mount Moco, Mount Namba, Serra da Neve, Serra Pingano, Cumbira, Lagoa Carumbo, and to the vast and very poorly researched catchments of the Cuando Cubango. While a greater level of inter-institutional collaboration is still possible, the momentum developed over the past decade has been unprecedented since 1975. The successes of the recent past are

presented in this volume, often drawing on work that is still in progress, is unpublished, or is in press.

## Chapter Outlines

Angola is a large country, and as emphasised throughout this volume, it has a rich diversity of landscapes, seascapes and associated biomes and ecoregions. The history of biodiversity research in Angola stretches over 200 years. The spatial, temporal and taxonomic scales embraced in this book results in it being structured in five parts. Part I, Chap. 1 (Huntley and Ferrand this chapter) provides an introduction to the book and its content. Chap. 2 (Huntley 2019) outlines the country's biogeography, drawing on the long history of geomorphological and landscape analysis in Angola, and describes the diversity of seven terrestrial biomes, 15 ecoregions and 32 vegetation types. In Chap. 3 Kirkman and Nsingi (2019) synthesise the findings of recent multi-national research activities on the Benguela Current Large Marine Ecosystem project and other studies on Angola's coastal and marine systems. The long history of the evolution of Angola's biota is introduced by Mateus et al. (2019) in Chap. 4, where the exciting recent discoveries in Angola's fossil record, most especially that of the Cretaceous, is described. A highlight was the discovery of the sauropod dinosaur *Angolatitan adamastor*, the first dinosaur to be found in Angola (Mateus et al. 2011). These authors emphasise the fact that for very long periods – hundreds of millions of years – the absence of fossiliferous rocks in Angola excludes the possibility of tracking animal and plant evolution in Angola over such long periods.

Part II presents an historical and contemporary analysis of our understanding of the country's flora and vegetation and on curious patterns and evolutionary processes in some typical Angolan plant communities. In Chap. 5 Goyder and Gonçalves (2019) note that the vascular flora now totals 6850 species, with 14.8% of these being endemic. The two early vegetation maps of Angola, prepared by the pioneers Gossweiler and Mendonça (1939) and Barbosa (1970), having served the country for many decades, now deserve renewed mapping efforts at a finer scale, using modern remote sensing and numerical analysis approaches, as recommended by Revermann and Finckh (2019) in Chap. 6. Of the many intriguing features of Angolan vegetation, the patterns of plant community/soil/animal associations, such as the 'fairy circles' of the Namib (Juergens 2013; Cramer and Barger 2013), 'fairy forests' of the miombo, and the influence of coastal fog on desert vegetation and fauna; are of special interest to ecologists. Few of these phenomena have been adequately interpreted, but Zigelski et al. (2019) in Chap. 7 presents recent studies on the 'underground forests' of the *chanas de ongote* of the Angolan plateau. The landscapes of Angola are not static, being subject to multiple processes of transformation. In Chap. 8, Mendelsohn (2019) uses results from satellite technologies and ground surveys to describe the dramatic impacts of deforestation, fires, mining and agricultural activities on vegetation, soils and water quality at landscape scales.

Part III details the results of surveys that have advanced rapidly over the past two decades on two invertebrate groups – dragonflies and butterflies. These colourful and taxonomically distinctive insects are known to be sensitive to subtle changes in environmental conditions, such as forest cover and water quality, and serve as effective indicators of change in environmental health. The chapters (9 and 10) on butterflies (Mendes et al. 2019) and on dragonflies (Kipping et al. 2019) have enriched Angola's knowledge of these important ecological groups. Prior to 2009, for example, only 158 species of dragonflies and damselflies were known from Angola. By 2018 this number had increased to 260. The butterfly checklist now stands at 792 species and subspecies, up by over 220 species and subspecies since the turn of the millennium. In contrast to the encouraging progress in these taxa, key environmental engineers – ants and termites – remain poorly documented and await study.

A major component of this volume has been devoted to the vertebrate taxa that have enjoyed the attention of scientists active in Angola since the mid-nineteenth century. Part IV presents detailed accounts of the pioneering work of such luminaries as Anchieta, Bocage, Boulenger, Machado, Rosa Pinto and Crawford-Cabral, but also of the very many other contributors to the inventory of Angola's vertebrate fauna. Skelton (2019), Chap. 11, provides a concise summary of what is known of Angola's ca. 358 species of freshwater fishes (of which 22% are endemic), and also presents a model of post-Cretaceous biogeography of Angola and the roles of regional tectonics and river capture on the speciation and distribution of the fish fauna. Baptista et al. (2019), Chap. 12, cover the amphibian fauna, noting that the group clearly deserves further survey given that thus far only 111 species have been recorded (compared to 128 species for similar-sized but much drier and cooler South Africa). In Chap. 13, Branch et al. (2019) offer a comprehensive account on the 278 species of Angolan reptiles and their patterns of diversity and endemism, documenting key reptile hotspots deserving further exploration. They predict that as many as 75 new species of lizards await discovery in Angola. Both Branch and Baptista demonstrate the value of molecular phylogenetics in clarifying taxonomic complexes in reptiles and frogs.

Angola, with ca. 940 bird species recorded, has in recent years become a favoured destination of ecotourists searching for the country's 29 endemic bird species, and Dean et al. (2019) provide in Chap. 14, a chronology of ornithological surveys, a listing of endemics and near-endemics, and sites of special interest to bird enthusiasts, both professional and amateur. They emphasise, as highlighted by Hall (Hall 1960), the faunistic importance of the Angolan Escarpment, and also of the relict Afromontane forests of the highlands (Vaz Silva 2015), as areas of critical importance to understanding the evolution of Africa's avifauna. These isolated, fragmented and rapidly declining forests merit the highest level of protection to secure their futures as evolutionary fingerprints of the past.

A team of ten mammal specialists, coordinated by Beja et al. (2019), present a major synthesis (Chap. 15) on Angola's 291 mammal species. This chapter fills a need felt since Hill and Carter's (1941) benchmark study, and the more recent coverage of ungulates by Crawford-Cabral and Veríssimo (2005). With 73 species

of bats (one third of the bat species known for Africa) Angola has the highest number of species for southern Africa, despite the comparatively limited intensity of surveys undertaken to date. The most diverse mammal group, rodents, has 85 species listed for Angola, of which 13 are endemic or near-endemic. While the number of endemic mammal species is modest, the vulnerability of many species to extinction within Angola is high and deserves urgent conservation measures. Less well known to Angolans than the terrestrial mammals is the country's unusually rich marine mammal fauna. The 28 species of cetaceans (whales and dolphins) found off Angola's coast have been the subject of surveys and research undertaken by Weir (2019) since 2003. As noted in Chap. 16, the possible presence of a further seven species of cetaceans in Angolan waters makes the country globally important for marine mammal conservation.

The Angolan mammal that has enjoyed national and international attention is the Giant Sable Antelope, which has been the subject of an intense research and conservation project since 2002 (Chap. 17), led by Vaz Pinto (2019). The successful rescue and rehabilitation of this national icon, from the brink of extinction, is a conservation model for which Angola can justifiably be proud. The success of the Giant Sable Project needs replication for the many mammal species that are known to have been reduced to very low numbers, or have been hunted to extinction in Angola. These include most large carnivores – Cheetah, Lion, Wild Dog, plus many herbivores – Black-faced Impala, Red Hartebeest, Lichtenstein's Hartebeest, Tsessebe, Southern Lechwe, Puku, Forest Buffalo, Giraffe, Black Rhino, Western Gorilla, Chimpanzee, Forest Elephant and Manatee.

The final section of this volume (Part V) presents an overview of the country's conservation history and current opportunities for action, Chap. 18 (Huntley et al. 2019); and an introduction to the importance of natural history museums and herbaria in the country's biodiversity science and conservation agenda, Chap. 19 (Figueira and Lages 2019). What is abundantly clear, as expressed in the concluding chapter, (Russo et al. 2019), is that Angola is alive with research and conservation opportunities, stimulated by recent initiatives led by the Angolan government and supported by the international community.

This volume provides a first synthesis of what is known and published about Angola's diverse landscapes, biomes and ecosystems and the species that inhabit them. It is a humble attempt by its 46 contributors to place this knowledge before researchers and conservationists in Angola and beyond, especially those who might be stimulated to strengthen the imperfect understanding and vulnerable state of Angola's biodiversity. It is the fervent hope of this book's editors that this volume will provide an entry point for many young Angolan students to study the literature, be inspired by the dedication, tenacity and wisdom of the early pioneers and contemporary explorers, and enter careers in field-based biodiversity research and conservation in Angola.

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