

GeoGuide

Jan Nyssen · Miro Jacob ·
Amaury Frankl *Editors*

Geo-trekking in Ethiopia's Tropical Mountains

The Dogu'a Tembien District



Springer

GeoGuide

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The Dogu'a Tembien District

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Foreword I

As the first of its kind, *Geo-trekking in Ethiopia's Tropical Mountains, the Dogu'a Tembien District* represents the state of the art of the scientific knowledge concerning a district in Ethiopia where the natural and social environment and the agricultural system have been intensively investigated. Several studies on a Ph.D. and M.Sc. level were conducted by Ethiopian and Belgian students. For their field studies, the students stayed with the community to understand, comprehend and internalise the manifested social and biophysical dynamics. Furthermore, the insights into the indigenous knowledge of the communities have been explored and incorporated in the knowledge systems used to close the gap between the farmers' knowledge, scientific interpretation and the perception of the policymakers. Several workshops, conferences and seminars were organised (involving the communities) so as to own and sustain the generated knowledge. In the villages, young students were engaged as data collectors, translators and guides. Their contributions made a substantial improvement in understanding the whole landscape, including the cultural and physiographic heritages.

The book aims to reach a broader public and includes a very accurate and self-explanatory map, I believe the first such detailed map in the region, as well as a description of the trekking routes. This makes it an interesting source of information and a guide for international as well as local visitors. As much as possible, the technical jargon was minimised to enable readers to immerse themselves in the scenic landscape with evidently revealing observation points. Previously unexplored cultural and heritage sites are described and incorporated into the chapters. It is appropriate to mention the tremendous trust and confidence we got from so many local people to reveal all the pertinent information to our researchers during visits to viewpoints, churches, caves, households and community engagements.

The Dogu'a Tembien GeoGuide builds upon the outcomes from the Mekelle University's cooperation with its Belgian partners. The editor, Prof. Jan Nyssen, has been instrumental in this endeavour as he partnered through smaller and larger projects. Together with the co-editors Dr. Amaury Frankl and Dr. Miro Jacob and many senior colleagues, they coached the M.Sc. and Ph.D. students from Mekelle University and from various Belgian universities for their fieldwork in Ethiopia. They also initiated different development projects, particularly in the Dogu'a Tembien District, such as May Zegzeg, EthioTrees, Ma'ar and School WatSani. The results from all these activities formed the basis for this book and allowed to attract other high-level scholars so that a large range of natural and social sciences could be addressed.

In September 1994, when Jan came for the first time to undertake his M.Sc. field study, I accompanied him to Dogu'a Tembien as his local promoter. That is when he fell in love with the people and the landscape of the area. He vowed to understand the socio-economics and biophysical attributes of the area and wanted to share it with researchers, academics and policymakers. In "sickness and health", he is still in solidarity with the society who openheartedly accepted him and several students to undertake their research. Since then, he has been coming regularly to Ethiopia for research linked with several universities. When in Ethiopia he mostly lives in Dogu'a Tembien—he knows the district like his hand palm, likewise the people also know him as their kin. "Mister Jon" is a household name in the area.

Jan and the other authors of this book have published many articles in peer-reviewed journals, as a first author and as a co-author together with Ph.D. students. All this accumulated scientific knowledge is now accessible to a broader public.

We hope that the publication of this book will contribute to tourism development in Tigray and to diversification in tourism branding. Ethiopia has a lot to offer to geo-tourists, in the concept of geo-parks, and Dogu'a Tembien could become a major geo-touristic destination, given its unique ABC combination: "A" for Abiotic, with the presence of numerous different geological formations, clearly visible as the landscape is deeply nicked, and a wide variety of soil types, each used for a specific purpose; "B" for Biotic with more than a hundred church forests and several remnant forests—the Chege forest measures almost one square kilometre; and "C" for Cultural with ten ancient rock churches, military headquarters in caves or birthplaces of historic persons: Ras Alula is from Mennawe, Emperor Yohannes from Melfa, and there are claims that the Queen of Sheba was born near Tselere. Special attention has been given to the traditional agricultural system and the recently improved

land management, which allow the *Tembienot* (inhabitants of Tembien) to live in an—sometimes challenging—environment but resilient enough to change it into opportunities.

Mekelle, Ethiopia
February 2019

Prof. Dr. Mitiku Haile
Ph.D. in Soil Science, Ghent
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Founding President of Mekelle
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of Ethiopia to UNESCO

Foreword II

It is a great pleasure for me to introduce the present publication on geo-trekking in Tigray, for several reasons. The book, the online map and the trekking guide provide the first-time ever description of an area in Ethiopia that deserves to be better known for its invigorating landscape, inspiring people and rich heritage locations. The Dogu'a Tembien area is a fascinating example of a rural landscape with a history as old as the Aksumite kingdom. The area is a stronghold of Christianity, with numerous churches that can be visited along the geo-trekking routes described in the present publication.

The materials provide an excellent basis for fostering sustainable tourism in a local setting where tourism infrastructure has so far been largely absent. Here, visitors will trek along local trails and stay overnight in traditional housing, bringing with them most of the items they need for their well-being, such as sleeping bags, maybe tents and cooking materials, as well as water purification devices or tablets. They will be more than rewarded for their choice of modest conveniences by encountering traditional lifestyles and visiting beautiful sites.

Many of the geo-sites described along the trekking routes are of national and international significance. The authors have taken great care to describe these sites for visitors who want to improve their on-the-spot understanding of geomorphological, geological and hydrological features in a tropical mountain setting, and who wish to deepen their insights into the historical, sociological and cultural dimensions of the land and its agriculture.

Three distinguishing features characterise the authors' work. The first volume of *Geo-trekking in Ethiopia's Tropical Mountains: The Dogu'a Tembien District* provides an excellent example of science-based information on the Dogu'a Tembien environment. Although it can be used as a stand-alone scientific publication, it will be even more valuable when used in combination with a field tour along one or several of the many trekking routes provided.

Second, the geo-trekking map has been prepared as an online supplement to the book, originally prepared at a scale of 1:50,000 on which all locations and trails are found, and where some features for geo-trekking have been added. Besides topography, which is represented with contour lines at 25 metres' vertical interval, a hill shade and the river network, the map shows general land cover, location names, boundaries, trails and roads, Christian churches, and most importantly, names of locations with specific geo-features described in the book, such as caves, waterfalls, quarries, landslides, terraces, gullies and many more.

Third, the separate guide for trekkers starts with useful general information, followed by a detailed description and illustration of close to 40 trekking routes, each lasting from a few hours to several days. Most routes start in a given location at, or nearby, the town of Hagere Selam, the capital of Dogu'a Tembien District, and end in a location of particular interest, such as a rock-hewn church, a waterfall or a spectacular view of the landscape. Some routes follow, in part, motorable tracks that can be used for shortening the walk or making a quick motorised return to the centre possible, where more modern facilities for lodging and eating are available. In addition to the time calculated for the routes, travellers will have to add the time to the starting point as well as the time to return from the end point. For routes up to about 5 hours' walking, a good physical condition will suffice, whereas for routes from 5 to 15 h, prior training will definitely be needed. Finally, a few of the routes are long-distance treks; i.e., they last several days and end as far as the Simien Mountains situated in Gonder, way beyond Tekezze River. Distance, duration, difference in up-and-down elevation and degree of difficulty are given in a graphic format at the beginning of each description, while the text is supplemented with a detailed account of features along the trail, often illustrated by photographs, graphs, drawings and cross-sectional profiles. Finally, very useful in the trekking guide is a Tigrinya—English glossary, with nearly 200 most useful words for the non-Tigrinya speaker. It is, however, assumed that all groups travelling on foot in such an area will employ a local guide to accompany them. The English of these guides will usually be limited, so that knowledge of some words in Tigrinya will not only be useful, but will also guarantee immediate attention from local people who will always react positively to such efforts.

In sum, I wholeheartedly recommend this publication, particularly for its innovative combination of scientific material and an online overview map with a broad number of geo-trekking options. Let us hope that this will motivate many local to international visitors to travel to Hagere Selam Town and use the

geo-trekking material to visit the Dogu'a Tembien area and learn more about its rich geo-heritage, current landscape and hard-working people.

Erlenbach im Simmental, Switzerland
February 2019

Prof. em. Dr. Hans Hurni
Geography and Sustainable
Development, University of Bern

Preface for Volume I

In order to reach a broader public of people who are interested in geo-sites and human–environment interactions, we took the initiative to prepare a geo-guide concerning the District Dogu’a Tembien in Ethiopia. This mountainous area with a rich culture and a scenic landscape is probably the most studied in the country. We attempt to make our research findings accessible to a wider public, pointing at the observations on geomorphology, geology, hydrology, vegetation, human–environment interactions, rural sociology, land management and soil and water conservation and particularly the large effort that is done on environmental management. At the same time, Volume II provides concise and site-specific contents for scientific and student excursions, and it enhances and promotes geo-heritage and geo-tourism.

Since our large team has been carrying out research in that district for 25 years and has published in journals and organised conferences, the time has come to convey the wide array of new scientific knowledge to the broader public. This has already partly been done through field trips with farmer groups and excursions of conference participants (Dryland Forests 2004; High Land 2006; Water 2011; Livelihood 2013), stays and treks by three international scientific trips (two by the International Association of Geomorphologists and one by the Belgian Flemish Association of Geography Teachers), one excursion with our own master’s students and the publication of a 100-page vulgarisation work in the Tigrinya language. Here, the scientific writings and the earlier partial field guides have been fully rewritten, edited, reviewed and published as a comprehensive geo-touristic work.

Many of the geo-sites in Dogu’a Tembien are only accessible on foot, and data collections for the different chapters were mostly done that way. As this involved many semi-permanent stays in Dogu’a Tembien, we could prepare Volume II as a trekking guide, which will enhance the sustainable trekking tourism at the same time. Volume II indicates the exact field locations of the

geo-sites: whoever is working, living in or visiting Ethiopia can observe our findings in the field.

Volume I reads as a regional geographical monograph, reporting dense research findings for one district of about 1000 km² in Ethiopia; it is also the first geo-trekking guide for the country. After a Part I (five chapters) that sets the natural and social scene (of the district), the seven chapters of the Part II cover the details of geology and geomorphology and include the best sites for geological observations, as well as the setting of Dogu'a Tembien's rock churches. Part III addresses the surface water, groundwater and rivers. In Part IV, the biodiversity, forests, flora and wildlife are handled, whereas Part V presents the different geomorphic processes that can be observed (and that have been studied in detail) in Dogu'a Tembien. Part VI discusses the interaction between humans and the environment, particularly the agricultural system, soils, land use, livestock and land management, while Part VII holds five chapters about the historical, sociological and cultural dimensions, all in relation to the land and environment. As stated, Volume II provides information so as to allow a geo-trekking visit to the district: detailed logistics, a description of more than 350 km of geo-trekking routes and a specially elaborated geo-trekking map on a scale of 1:50,000.

The authors of each chapter tried to avoid the most specific jargon of their research field or explained the terminology otherwise. Yet, when necessary, Andrew Goudie's glossary (<http://www.geomorph.org/2014/07/iag-glossary-of-geomorphology-by-prof-andrew-goudie-2/>) will set the reader back on track (jointly with Wikipedia).

The editors, after consulting Tigrinya linguists, have not applied a scientific transcription of the Ge'ez into the Latin script for location names and historical persons, which would require the use of diacritics. We tried to render the terms as close as possible to the Tigrinya originals, both in spelling and pronunciation. Stressed consonants are doubled in the transliteration: "Addi". We however allowed simplifications, for example if diphthongs would sound like one vowel. Single speech marks (´) are used after letters that are pronounced with an ejective or guttural sound. Regarding place names, we have also adopted the form that was utilised in the local discourse, particularly the shorter colloquial form of longer place names; an example is "Dabba Selama", which is the short form of "Inda Abba Selama". In a few exceptional cases, we departed from this line of thought when names had become standardised in the international usage: Mekelle, Adigrat, Haile Selassie, Kolla. For location names within the designation of the geological formations, we continued to apply the terminology that had been transmitted since the early geological

works in the nineteenth century, though they sometimes depart strongly from the actual names of the place that was referred to: “Antalo Limestone” refers to the town of Hintalo (the formation does not even outcrop in that place!). Obviously, for the names of the Ethiopian authors of our chapters or of cited publications, we have accepted the transliteration used by the authors themselves. In the reference lists, Ethiopian authors are conventionally referred to by their name followed by their father’s name.

Almost every chapter holds one or several maps that indicate the (relative) location of the geological or geographical features. For the exact positioning, we refer to the online supplementary map of Volume II (Chap. 36). Furthermore, Chap. 31 discusses all maps and aerial photographs available for Dogu’a Tembien in detail.

Finally, the two volumes of this book have been written for a broad audience inside and outside Ethiopia, including tourists interested in natural resources, occasional visitors, regional geographers, inhabitants of the surrounding cities (who look for a weekend activity), tourism professionals, government decision-makers, hikers who want to go “off the beaten track” and scholars from various disciplines looking for background information on Dogu’a Tembien and Tigray. We hope that it will please you...

Ghent, Belgium
February 2019

Jan Nyssen
Miro Jacob
Amaury Frankl

Preface for Volume II

In order to reach a broader public of people who are interested in geo-sites and human–environment interactions, we took the initiative to prepare a geo-guide concerning the District Dogu’a Tembien in Ethiopia. This mountainous area with a rich culture and a scenic landscape is probably the most studied in the country. In Volume I, we attempted to make our research findings accessible to a wider public, pointing at the observations on geomorphology, geology, hydrology, vegetation, human–environment interactions, rural sociology, land management and soil and water conservation and particularly the large effort that is done on environmental management. Volume II provides concise and site-specific contents for scientific and student excursions, and it enhances and promotes geo-heritage and geo-tourism.

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Volume II holds numerous cross references to themes developed in Volume I. Yet, when necessary, Andrew Goudie’s glossary (<http://www.geomorph.org/2014/07/iag-glossary-of-geomorphology-by-prof-andrew-goudie-2/>) will set the reader back on track (jointly with Wikipedia).

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Ghent, Belgium
February 2019

Jan Nyssen
Miro Jacob
Amaury Frankl

Acknowledgements for Volume I

The editors wish to thank the large number of people who have contributed to this book, including the inhabitants of Dogu'a Tembien, the authors, the reviewers and publishing staff.

In Dogu'a Tembien, literally thousands of people (mostly farmers) have given information, granted access to their land, invited researchers to their home for coffee or *siwa*, provided accommodation and shown directions. Priests have opened their churches, and office-holders made data available. On the occasion of group excursions, the villagers from Hech'i, Harena and other settlements have organised welcome parties for the visitors. The society as a whole hosted researchers and students, who could also benefit from the skills of their housekeepers and cooks. We have learned to walk in these mountains from local people, who guided us through the tangle of paths and field accesses. Guides and translators were our direct link to the cultural environment. They taught us to see, hear and understand the landscape and told us if it was possible to walk across a farmers' field, where a dog could be expected, or when it was time to speed up (in order to reach home before sunset).

The authors are to be congratulated for their contributions and their numerous revisions and for moulding the text into the format of this book. The authors are from Ethiopia and many other countries and have strong expertise in their fields. Most of them are academics, but a few also come from governmental and non-governmental organisations. The authorship reflects likewise close international collaborations and friendships overseas.

We particularly wish to thank Johanna Schwarz and Claudia Mannsperger at Springer Nature in Heidelberg, Germany; through lots of correspondence on the manner in which the book should be conceived and complemented, they have always encouraged and assisted us in a very professional way. Frances Williams, author of "Understanding Ethiopia" in the same Springer GeoGuide series, gave useful conceptual advice regarding this book and reviewed several

chapters. A large group of scientists reviewed one or more chapters and followed up the rewriting: Alemayehu Wassie, Andrea Sembroni, Araya Alemie, Bart Muys, Bedru Babulo, Ben Derudder, Biadgilgn Demissie, Daan Dekeukeleire, Denyse Snelder, Derege Meshesha, Elise Monsieurs, Etefa Guyassa, Federico Sani, Francesco Dramis, Geert Baert, Geoffrey Houbrechts, Hanne Hendrickx, Hans Hurni, Harapriya Rangan, Jan Kropáček, Jan Moeyersons, Jan Vanderborg, Joost Dessen, Jozef Deckers, Jozef Naudts, Karen De Coene, Karen Vancampenhout, Katrien Descheemaeker, Kristien Ooms, Liesbet Nyssen, Lieve Dillen, Lorenzo Borselli, Luc Lens, Lukas Mauerhofer, Mark Breusers, Meheretu Yonas, Mekete Dessie, Nils Broothaerts, Paolo Billi, Pierre-Gil Salvador, Raf Aerts, Rossano Ciampalini, Seifu Admassu, Sofie Annys, Stéphane Follain, Tesfaalem Ghebreyohannes, Tesfay Araya, Tony Prave, Valery Terwilliger, Veronique Dermauw, Vincent Hallet, Willy Verheye and Zbelo Tesfamariam. Bart Dewit from the Geography Department of Ghent University customised an in-house editorial management Web interface. Sabine Cnudde and Karine Van Acker from the same department contributed to proofreading and technical support. Ronald Ykema assisted in mapping, and Mieke Nyssen has artistically drawn the 16 large mammals of Dogu'a Tembien.

Over the years, many institutions have funded the research that lies on the basis of the various chapters. All these financial contributions are recognised, but listing all would inevitably lead to embarrassing omissions. Yet, there should be a special mention for the core contribution by the Flemish University Cooperation VLIR-UOS from Belgium.

On a more personal note, Jan Nyssen, the lead editor of this book, wishes to acknowledge the support by his spouse Annemie Goossens, throughout 25 years of research undertakings in Ethiopia.

Acknowledgements for Volume II

The editors wish to thank the large number of people who have contributed to this book, including the inhabitants of Dogu'a Tembien, the authors, the reviewers and publishing staff.

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We acknowledge the assistance of Seifu Gebresslassie, Abraha Teklu and Romha Assefa in locating the geo-sites and establishing the trek routes. Raf Aerts contributed substantially to the section on mountain safety, and Wolbert Smidt coached the consistent transliteration of place names from Ge'ez to Latin alphabet. Sofie Anny's, Miro Jacob, Hanne Hendrickx, Liesbet

Nyssen and Hailemariam Meaza read parts of the chapters of Volume II and contributed significantly to restructuring it. All co-authors of chapters (Volume I) are acknowledged for indicating potential geo-sites, as well as Frances Williams and Amaury Frankl for thoroughly reviewing Chaps. 37 and 38.

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Raptor Perch Sites for Biological Control of Agricultural Pest Rodents

18

Meheretu Yonas and Herwig Leirs

Implementation of physical land management activities in agroecosystems, such as stone bunds to curb soil erosion, may have unintended consequences, including providing habitat for small mammal pests, but could also provide perching spots for raptor predators. In this chapter we discuss the major rodent species responsible for crop damage in crop fields in Dogu'a Tembien and their major raptor predators. We demonstrate the role of the physical land management structures in this interaction.

18.1 Raptors as Biological Control Agents

Predator impacts on rodent populations can be direct or indirect. In the former case, predators influence population dynamics of rodents by physically removing individuals, whereas in the latter case the presence of predators induces behavioural (e.g. reduced spatial activity) or physiological responses on the prey due to perceived predation risk.

In agriculture, rodents are both a pre-harvest and post-harvest pest problem, causing major threats to food security and safety. In Dogu'a Tembien, farmers are

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mostly relying on chemical control (zinc phosphide rodenticide), domestic cats and field clearance to manage rodents in crop fields and storage areas. These control measures, however, are taken only when rodent population densities are high and heavy damages are already inflicted. Rodenticides generally provide effective control in the short term. However, use of chemicals raises many concerns such as affordability, the risk to non-target species (including raptors), development of resistance by the rodents, and low efficacy of action. Hence, there is an increasing need to develop ecologically sound and easy to adopt rodent management strategies to reduce the costs and risks associated with rodenticides. Some sustainable rodent management methods such as the use of natural predators for biological control can be more appropriate for the rural agricultural situations. Biological control strategies, such as creating suitable conditions into attract raptors into crop fields, in general, are not labour intensive and, in fact, can easily be integrated with the usual farming practices.

18.2 Rodents in Agroecosystems in Dogu'a Tembien

The livelihood of farmers in Dogu'a Tembien heavily depends on agriculture, and cereals dominate the farming. The main crops grown are barley (*Hodeum vulgare*), wheat (*Triticum* sp.), tef (*Eragrostis tef*) and pulses, such as grass pea (*Lathyrus sativus*), horse bean (*Vicia faba*) and lentil (*Lens culinaris*) (Chap. 27). As in most countries in Africa south of the Sahara, insects, birds and rodents are the major agricultural pests. In a survey study in Dogu'a Tembien, farmers estimated 9 to 44% pre-harvest yield loss in annual production of wheat and barley crops due to rodent attacks. A pre-harvest crop loss that would have supported a family of 5 heads for about 3 months has been estimated per hectare in smallholder experimental plots.

In Ethiopia, roughly 84 species of rodents have been recorded; a dozen of which are considered agricultural pests. The most common pest rodents with widespread distribution in agricultural fields and storage areas in Dogu'a Tembien (and in the Tigray region) are three Ethiopian endemic species: the Dembea grass rat (*Arvicanthis dembeensis*), Ethiopian white-footed rat (*Stenocephalemys albipes*), and Awash multimammate mouse (*Mastomys awashensis*) (Photo 18.1).



Photo 18.1 The predominant rodent species in crop field in Dogu’a Tembien: the Dembea grass rat (*Arvicanthis dembeensis*, Adult average head-body length (HB) ~ 15 cm) (left), Ethiopian white-footed rat (*Stenocephalemys albipes*, HB ~ 13.25 cm) (top right), and Awash multimammate mouse (*Mastomys awashensis*, HB ~ 12.2 cm) (bottom right). Photos Meheretu Yonas

18.2.1 Dembea Grass Rat (*Arvicanthis dembeensis*)

The Dembea grass rat is the most widespread rodent species in Dogu’a Tembien in various open habitats, scrublands, agricultural fields, peri-domestic and domestic habitats. It is a diurnal species possibly contributing to a significant portion of the rodent diet of day-active raptors. In crop fields, significantly more captures of the species were reported in fields with higher density of stone bunds (low walls to curb soil erosion by runoff) than in fields with lower densities, suggesting that a higher density of stone bunds (i.e., shorter inter-stone-bund distance) provide increased cover against predators. After harvest and before the commencement of the next cropping season (December to June), physical structures such as stone bunds, stone heaps and boulders remain the sole providers of the required cover for the species as the contribution of vegetation cover dwindles gradually due to harvest, livestock grazing and dry spell until virtually no vegetation cover remains in the fields. Therefore, day-active raptors such as Augur buzzard (*Buteo augur*; Photo 18.2) and Steppe eagle (*Aquila nipalensis*; Photo 18.3) are frequently observed in crop fields perching in areas with dense stone bunds, stone heaps and boulders around which the rodents occur in relatively higher abundances.

Photo 18.2 Augur buzzard (*Buteo augur*; body length ~ 55–60 cm long). Note the rufous tail. Photos by Claude Barrau and Adriaan Dijkssen (inset)



Photo 18.3 Steppe eagle (*Aquila nipalensis*; body length ~ 60–80 cm). Photos by Claude Barrau and Adriaan Dijkssen (inset)



18.2.2 The Ethiopian White-Footed Rat (*Stenocephalemys albipes*)

The Ethiopian white-footed rat is the most widespread of six valid species of the genus *Stenocephalemys* in Ethiopia. In Dogu'a Tembien, it is widespread in a variety of habitats, including crop fields and exclosures (degraded lands that have been excluded from human and livestock interference for rehabilitation; Chap. 16), and even in human settlements. It co-occurs with the grass rat and the Awash multimammate mouse *M. awashensis* in these habitats. Being nocturnal and burrowing, the species prefers crop fields with Vertisols, clay-rich soils that shrink and swell with changes in moisture content. It probably contributes to a significant portion to the rodent diet of night-active raptors such as Barn owl (*Tyto alba*; Photo 18.6).

18.2.3 The Awash Multimammate Mouse (*Mastomys awashensis*)

The Awash multimammate mouse is a species of rodent only reported to date from few regions in Ethiopia with sparse distribution. In Dogu'a Tembien, it commonly occurs in crop fields, domestic and peri-domestic habitats in wider altitudinal range (1500 m up to 2700 m). Being nocturnal and burrowing, the species too prefers crop fields with Vertisols. Likewise, the multimammate mouse possibly contributes to a significant portion to the rodent diet of night-active raptors such as Barn owl. Phylogenetically, the Awash multimammate mouse is the sister taxon of the Natal multimammate mouse (*M. natalensis*), a species found almost everywhere in Africa south of the Sahara and considered a serious agricultural pest throughout its range.

18.3 Common Raptors

Raptors in agroecosystems are not only ecologically important as top predators, but also provide farmers with a natural source of pest control by consuming many vertebrate pest species that cause damage to crops and reduce yields. The most regularly observed raptor birds in crop fields in Dogu'a Tembien are Augur buzzard (*Buteo augur*) (Photo 18.2), Common Buzzard (*Buteo buteo*), Steppe Eagle (*Aquila nipalensis*) (Photo 18.3), Lanner falcon (*Falco biarmicus*) (Photo 18.4), Black kite (*Milvus migrans*) (Photo 18.5), Yellow-billed kite (*Milvus aegyptius*)

Photo 18.4 Lanner falcon
(*Falco biarmicus*; body
length ~40–50 cm). Photos
by Claude Barrau and
Adriaan Dijkse (inset)



Photo 18.5 Black kite
(*Milvus migrans*; body
length ~50–60 cm). Photos
by Claude Barrau and
Adriaan Dijkse (inset)





Photo 18.6 Barn owl (*Tyto alba*; body length ~30–40 cm). Note that the *Jacaranda mimosifolia* in which the bird is perched, is not indigenous to Dogu’a Tembien. Photo by Jan Jackers

and Barn owl (*Tyto alba*) (Photo 18.6). Below we provide information on the distribution and feeding habits of each of the species. Unfortunately, information about the raptors population sizes in the study area (e.g., number of breeding pairs) is yet unknown.

18.3.1 Augur Buzzard (*Buteo augur*)

The Augur buzzard (Photo 18.2) is a regularly observed raptor bird in Dogu’a Tembien, inhabiting a mixture of open habitats, rocky areas and cliff ledges for hunting and nesting in hilly and mountainous areas. It is also frequent in crop fields, particularly perching on roadside trees and electric poles, stone bunds, stone heaps, boulders and on top of crop piles at harvest. It has also been observed in church forests and exclosures (see Chap. 17). With its distinctive rufous tail and white

underparts and underwings, the species is predominantly observed soaring over cliffs in rocky areas (Photo 18.9) and moving to crop fields for hunting prey. It feeds mainly on small mammals, followed by reptiles, birds, insects and road kill.

18.3.2 Common Buzzard (*Buteo buteo*)

In Dogu'a Tembien, the Common buzzard occurs less frequently than the Augur buzzard. The diet of the species is versatile depending on the prey animals available, with small mammals being usually predominating. In some areas it might perhaps qualify as rodent specialist, since some pairs refrain from breeding when rodents are scarce. In other areas small mammals comprised 67% of the diet of the species.

18.3.3 Steppe Eagle (*Aquila nipalensis*)

As the name indicates, the Steppe eagle (Photo 18.3) is a raptor bird of open habitats like steppes, deserts, semi-deserts, grasslands and even agricultural areas. It feeds mainly on small mammals on its breeding grounds, and when wintering it appears to feed mainly on mole rats in East Africa, but also on termites and red-billed quelea in southern Africa. It mostly hunts from perches, but also in flight. In Dogu'a Tembien, the species is regularly seen perching on roadside trees and electric poles, stone bunds, stone heaps, boulders, cliff edges and on top of crop piles at harvest. It has been observed to build its nest in tall trees in church forests in the area.

18.3.4 Lanner Falcon (*Falco biarmicus*)

The Lanner falcon (Photo 18.4) is a large falcon that breeds in Africa, southeast Europe and Asia. It lives in a wide variety of habitats: deserts, forests, woods, plains, and savannahs, but needs rocky escarpments and cliffs nearby for nesting. The species has also been observed in the middle of several Ethiopian cities. In Dogu'a Tembien, the species perches on electric poles, stone bunds and on top of crop piles at harvest. The best place and time to observe the species is along crop fields and rocky cliffs early in the morning and late in the afternoon, flying often low over the ground. The Lanner falcon feeds mostly on birds such as pigeons, doves, larks and poultry, but also on small mammals.

18.3.5 Black Kite (*Milvus migrans*)

Black kite (Photo 18.5) and Yellow-billed kite are probably the most widely distributed raptor bird species in Ethiopia occurring in almost all habitat types. Black kite is only present as a visitor during the winter of the northern hemisphere. Yellow-billed kite (*M. aegyptius*) is the Afrotropical allopatric kite species, which is almost indistinguishable from Black kite, except that it has an entirely yellow bill. In Dogu'a Tembien, Black kite would likely be the first raptor to appear along the road, villages and town. Its diet also includes a variety of fish, reptiles, amphibians, small mammals and birds. Black kites catch and eat their prey by using their sharp talons to dig into and pull apart the prey both in aerial and ground attacks.

18.3.6 Barn Owl (*Tyto alba*)

The Barn owl (Photo 18.6) is a nearly cosmopolitan, nocturnal raptor occurring in a great variety of habitats, including cultivated fields, grasslands, woodlands, roadside verges around towns and villages. It predominantly feeds on small mammals, and has been demonstrated to be a very effective biological control of rodent pest, resulting in lower crop damage. In Dogu'a Tembien, owls are the chief nocturnal raptors in crop fields and the two common nocturnal species, the Ethiopian white-footed rat and the Awash multimammate mouse constitute the largest portion to its diet. Another owl species, Greyish eagle-owl (*Bubo cinerascens*), has been recorded at the margins of crop fields with many stone bunds, in densely wooded gullies through exclosures and in church forests (Photo 17.6).

Other birds of prey in Dogu'a Tembien include Pallid harrier (*Circus macrourus*), Peregrine (*Falco peregrinus*), Dark chanting goshawk (*Melierax metabates*), Montagu's harrier (*Circus pygargus*), Pearl-spotted owl (*Glaucidium perlatum*), African hawk-eagle (*Hieraaetus spilogaster*), Lammergeier (*Gypaetus barbatus*) and Long-crested eagle (*Lophaetus occipitalis*) (see Chap. 17).

18.4 Raptor Perching Sites (Physical Land Management)

In Dogu'a Tembien, the land use is typically dominated by crop fields (~65%) in flat and gently sloping areas, complemented by rangeland and exclosures (Chap. 25). Largely, crop fields are equipped with stone bunds (Photo 18.7; Chaps. 21 and 26),

and occasionally with elongated stone heaps (locally called *zala*), built following the contours to control runoff and soil erosion. Especially in the upper parts of Dogu'a Tembien, crop fields lack trees and other natural vegetation, hence except for cliff edges, they are largely devoid of natural raptor perching spots. Therefore, the physical land management structures, particularly the stone bunds and stone heaps are the predominant perching spots, supporting raptor populations to persist in these highly modified landscapes. Noteworthy, the use of raptors as biological control agents in crop fields requires the availability of a good number of perches for hunting.



Photo 18.7 Stone bunds as physical land management method. Note how the stone bunds are built following the contour of the landscape and how they extend from crop fields to rural villages. Photo Meheretu Yonas

18.4.1 Stone Bunds

As discussed in Chaps. 13 and 21, like many places of the Ethiopian highlands, Dogu'a Tembien suffers from strong runoff and soil loss. Stone bunds and bench terraces have been constructed in the crop fields since the beginning of the 1980s to curb the problem of soil erosion and to increase soil moisture (Photo 18.7). Stone bunds are built from large basalt or limestone fragments reinforced by gravel and soil. Herbs and grasses can grow on them. They are built following the contours of the topography of the crop fields with an average height of about 1 m and the average inter-stone-bund distance depending on the slope gradient. The stone bunds are also used to demarcate individual crop fields, and at times extend to adjacent rangelands and even rural villages. These physical land management structures however have resulted in an unintended consequence, providing refuge for rodent pests. In a forest restoration experiment in an enclosure near Miheni in Dogu'a Tembien, researchers found that 52% of the experimentally deposited African wild olive seeds were removed from depots within 1 m distance from stone bunds, while this was only 3% of the seeds deposited in depots further away from these structures. On the other hand, the physical land management structures are used by a variety of raptors as a perching point. The hunting activities of the raptors perching on the structures is especially visible from mid-October onwards, after the start of the first harvesting activities, with peak activity between mid-November and December when harvesting of the staple crops (wheat and barley) takes place.

18.4.2 Stone Heaps

In some crop fields, stone heaps are made when there are too much stones still left in the fields after construction of the stone bunds. Ideally the farmers would have thrown the excess stones out of their farmlands instead of piling them up in the fields. However, this is not possible for farmers surrounded by crop fields and located far from roads, paths and uncultivated land. Like the stone bunds, stone heaps also provide shelter for rodents as well as perching conditions for raptors.



Photo 18.8 Experimental set up for giving-up density (GUD) study. Photos Meheretu Yonas

18.5 Perceived Predation Risk Experiment

To investigate whether stone bunds make a difference for predation of rodents, we used a so-called “Giving-Up-Density” (GUD) experiment during the 2008 and 2009 cropping seasons in crop fields in the May Zegzeg watershed near Hagere Selam (~ 200 ha, $13^{\circ} 40'N$, $39^{\circ} 10'E$) (Photo 18.8). This experiment measured how high the predation risk was as perceived by the rodents themselves. Basically, we provided a given amount of seeds mixed in a tray with sand and one day later, we sieved and measured how much seed was left in the tray. The underlying idea is that rodents will continue looking for the seeds in the sand until they find that the chances for finding more seeds no longer outweigh the risk for predation in that place. Therefore, if they perceive a high predation risk, they will leave more seeds in the tray than when predation risk is low. By placing trays nearby (~ 1 m) and far

(~ 10 m) from the stone bunds, the perceived predation risk at these places could be compared. In the fields with high density of stone bunds, 16–38% of the seeds were eaten from the trays placed near the stone-bunds and 16–24% from the trays placed far from the stone bunds. On the other hand, in the fields with low densities of bunds, only 10–13% of the seeds were eaten near the stone bunds and about 9% from the trays placed far from the stone bunds. Doing this, we found that rodents indeed feel less threatened close to the stone bunds.

In summary, physical land management activities such as stone bunds are playing a vital role in shaping the biological control of rodent pests by raptors in Dogu'a Tembien, by providing perching sites. The most common pest rodents with widespread distribution belong to three species, all of which are endemic to Ethiopia: the Dembea grass rat, Ethiopian white-footed rat and Awash multi-mammate mouse. From our preliminary results, we conclude that higher density



Photo 18.9 Cliffs such as this outcrop of basaltic rocks in the May Zegzeg catchment above the village of Hechi are frequently used as nesting and perching sites for raptors. They are also an excellent site to collect raptor pellets for feeding analysis and to determine the contributions of rodents to the raptors diet. Photo Meheretu Yonas

stone bunds not only provide better nesting sites, but also feeding areas with low-risk of predation. Hence, based on the experiment, we suggest attracting rodent predators by installing raptor perches near stone bunds.

Field observation sites: as there are rodents, raptors, stone bunds and cliffs (Photo 18.9) all over Dogu'a Tembien, the studied phenomena may be observed along all trekking routes. Detailed studies were done along treks #12 and #13.

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