

# Wildlife Ecology and Conservation

M. Balakrishnan

21st Century Biology and Agriculture : Textbook Series  
*Series Editor : Anantanarayanan Raman*





---

*21st Century Biology and Agriculture*

# Wildlife Ecology and Conservation

---

---



*21st Century Biology and Agriculture*

# Wildlife Ecology and Conservation

– **Mundanthra Balakrishnan**

Professor, Department of Zoological Sciences, College of Natural  
Sciences, Addis Ababa University, Addis Ababa, Ethiopia



SCIENTIFIC  
PUBLISHERS

*Published by:*

**SCIENTIFIC PUBLISHERS (INDIA)**

Jodhpur

Delhi

—

—

*5 A, New Pali Road*

*4806/24, Ansari Road*

*P.O. Box 91*

*Daryaganj*

*Jodhpur - 342 001*

*New Delhi - 110 002*

*INDIA*

*INDIA*

E-mail: [info@scientificpub.com](mailto:info@scientificpub.com)

Website: [www.scientificpub.com](http://www.scientificpub.com)

© 2016, M. Balakrishnan

All rights reserved. No part of this publication or the information contained herein may be reproduced, adapted, abridged, translated, stored in a retrieval system, computer system, photographic or other systems or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the author and the publishers.

*Disclaimer:* Since every effort has been made to avoid errors and omissions, this publication is being sold on the understanding that neither the author nor the publishers nor the printers would be liable in any manner to any person either for an error or for an omission in this publication, or for any action to be taken on the basis of this work. Any inadvertent discrepancy noted may be brought to the attention of the publishers, for rectifying it in future editions, if published.

*Cover illustration:* This textbook series *21st Century Biology and Agriculture* launched by Scientific Publications, Jodhpur (India), celebrates the native, but critically-threatened bird of the western semi-arid grasslands and scrubs of India, the great Indian bustard *Ardeotis nigriceps* (Gruiformes: Otidae). The great Indian bustard has been a part of Indian culture and tradition, known as *gonādh* (*Sanskrit*), because the male call closely resembles the mooing of cows. Artist: Urvashi Sharma.

ISBN: 978-81-7233-974-6

eISBN: 978-93-87307-70-4

Printed in India

# Foreword

The year 2015 is a landmark year in international development. It marks the transition from Millennium Development Goals to a new post-2015 agenda for sustainable development, with new Sustainable Development Goals as pillars of this new development agenda, and for advancing international efforts to cope with global climate change.

Sustainable development and wildlife as defined by Mundanthra Balakrishnan in *Wildlife Ecology and Conservation* are closely interlinked. At the same time, as we address our development challenges, we are at the mid-way mark in the process of trying to achieve the goals and targets of the Strategic Plan for Biodiversity 2011–2020. All these efforts are aimed at meeting the challenges of alleviating poverty, improving human health and providing clean water, food and energy for all. It has become ever clearer that conserving our biological diversity is *sine qua non* not only for making sustainable development become reality but for the well-being of humankind itself.

How does all this relate to Prof. Balakrishnan's book *Wildlife Ecology and Conservation*?

Education for all and capacity building are key elements in the processes discussed above. This is where the book by Prof. Balakrishnan comes into play. It serves as an element in these contexts and, more specifically, at its target clientele, the college and university students and teachers in the Indian subcontinent. The book uses the right approach, viz. a connotation of wildlife as encompassing all organisms not directly under human control and which build the fabric of our "natural ecosystems". The latter term is however discussed controversially: there are virtually no ecosystems, which have not been influenced by humans to various extents. Again, wildlife traditionally refers to non-domesticated animal species, but has come to include all animals, plants, fungi and other organisms, which grow or live wild in an area and have not been introduced by humans. As a matter of fact, the distinction between wildlife and biodiversity, not even in contexts such as agro-ecosystems or urban ecosystems ("urban wildlife"), may not be as straight forward as commonly thought.

Loss of wildlife and biodiversity has been a serious issue and challenge at all levels, from local to international. Bringing biodiversity loss to a complete halt, as repeatedly requested and currently aimed at in the international "Vision 2050" for biodiversity, may be too lofty a goal to

be achievable in the coming decades, or it may be even impossible to be achieved in its entirety, lastly a result of continued growth of the human population and concomitant rising pressure on natural resources.

Wildlife has experienced enormous losses. According to a recent report of the World Wide Fund for Nature (WWF), between 1970 and 2014 wildlife has been globally reduced by over 50%. Severely affected have been the tropical realms, in particular the Neotropical and Indo-Pacific Realms. Global species extinction rates are generally estimated 1,000 times or even more than the normal or background extinction rate.

India, a mega diverse country, contains two of the 34 global hotspots of biodiversity. Neighbouring countries in South Asia have two more biological hotspots, which are partially contiguous to India. Special efforts have been taken to conserve biodiversity and wildlife in India. For instance, in line with the Aichi Targets, India has defined its specific targets to address the different facets of biodiversity. In international debates, India has been a forerunner in stressing the need for a global change in our production and consumption patterns. In view of the continued human population growth and increasing pressure on natural resources and ecosystems, this change may be needed ever more for the conservation of biodiversity for our future generations.

I have known Mundanthra Balakrishnan for a long time. We first met when he still worked in southern India, at the Department of Zoology, University of Kerala, and I carried out research on the biogeography of India and Sri Lanka. Since then we have been in regular contact.

*Wildlife Ecology and Conservation* is not just another book on wildlife ecology and conservation. Its primary focus is on education. Accordingly, its design reflects the series focus on “self-directed learning”, as pointed out in the series preface at the beginning of the book. *Wildlife Ecology and Conservation* is targeted at college and university students and teachers in the Indian subcontinent. A major add-on is the 13 text boxes in which specific aspects are highlighted. These include species-specific situations, examples of ecosystems, major institutions working on wildlife issues in India, butterfly farming, and specific methodology used in wildlife research.

Depth and breadth of discussing wildlife and conservation issues is a major feature and strength of Prof. Balakrishnan’s book. This holistic approach is reflected *inter alia* in the introduction which sets the scene, an overview of the biogeography of India and major ecological aspects of wildlife, followed by chapters on habitats, predator–prey interactions, ecological principles, conservation with emphasis on India and the South



Asian subregion, human–wildlife conflicts, economic aspects related to wildlife, protected areas and wildlife conservation, conservation biology, and international instruments. The book concludes with two chapters on methods used in ecological studies of wildlife. Each chapter ends with content-related questions posed to the reader. Both theoretical and practical aspects of wildlife ecology and conservation are, therefore, presented.

With rapid population growth and development in India, conservation of biodiversity and wildlife and related education efforts have become ever more pressing an issue. Specifically with regard to this situation, I hope that this book will make a difference. Moreover, I do hope that *Wildlife Ecology and Conservation* will become a standard textbook for education about wildlife and its conservation, not only for current and future generations of students and teachers of India, but also at regional and international levels.



Mechernich,  
June 11, 2015

**Prof. Dr. Walter R. Erdelen**  
Former Assistant Director-General for Natural Sciences  
UNESCO



## Series Preface

With great pleasure, the Scientific Publishers (Jodhpur) and I launch the third volume of the postgraduate textbook series under the general title *21<sup>st</sup> Century Biology and Agriculture* for use in the Indian subcontinent.

This series aims at fulfilling the knowledge needs of postgraduate learners in agriculture and biology, focussing on self-directed learning. Keeping this point in full view, these volumes would dilate on contemporary information in chosen themes in a pertinent, but brief backdrop of historical knowledge, with appropriate textual information laced with relevant illustrations. Most importantly, these books aim to cater to the self-learning needs in passionate and committed learners. By self-learning, the teacher's role turns into mentoring rather than tutoring. Vital details have been 'box'ed so that learners can internalize them easily, swiftly, and forever. Care has been exercised to integrate examples from the Indian subcontinent, so that the learners can relate to concepts and principles quickly. The most critical aspect is the inclusion of specific case studies and interactive-mode of learning, so that learners can learn about the day-to-day issues and application of theory that surround the nominated theme effectively. Every effort has been meticulously made to see that the books launched under this series are easily readable and user friendly.

Tanay Sharma of Scientific Publishers (Jodhpur) readily agreed to my demand to identify and recruit an efficient copy editor, who has done a neat job.

This book entitled *Wildlife Ecology and Conservation* executed by M. Balakrishnan is the third book of this series. Balakrishnan is a well-known wildlife ecologist of India. Presently he is working as professor of Zoology, Addis Ababa University in Ethiopia. He has contributed to diverse aspects of wildlife biology, ethology and ecology. Scientific Publishers (Jodhpur) and I consider his acceptance to write this book a great honour.

Many more similar titles have been enlisted and will be appearing in the near and far future. Scientific Publishers (Jodhpur) and I thank Balakrishnan for readily and willingly accepting to our request by executing this task, and importantly doing it speedily.

India is a land of varied landscapes. One of the remarkable natural icons of India is the Great Indian Bustard, the populations of which are

restricted to Western India. Because this series is being published from Jodhpur, I thought it will be appropriate to remind ourselves of the uniqueness of this splendid bird and make every effort of conserve its diminishing population.

All books slated to appear in the series *21st Century Biology and Agriculture* will celebrate this Indian icon.

I am confident that learners will benefit from the information and knowledge shared by M. Balakrishnan; I am also confident that post-graduate teachers of biology and agriculture in the Indian subcontinent would find this material appropriate to prescribe this book as a learning resource.

**Anantanarayanan Raman**

Editor-in-Chief, Textbook Series  
*21st Century Biology and Agriculture*  
School of Agricultural & Wine Sciences  
Charles Sturt University  
Orange, NSW 2800, Australia

# Preface

This textbook on Wildlife Ecology and Conservation is prepared as requested by Scientific Publishers, Jodhpur, for the use of students of College and University students and teachers in India. My long-term experience of over 40 years at the University of Kerala, Agricultural University of Norway and Addis Ababa University, Ethiopia, where I have been dealing with this subject area in teaching and research have helped me to put in all essential information with suitable examples to introduce the subject matter in a simple way, and I hope our students can easily grasp and understand the basic concepts of wildlife ecology and conservation biology using this book. For a better understanding of the subject, I have drawn more examples from India with additional examples from Africa and elsewhere in the tropics.

As a deviation from routine textbooks, I have included 13 special boxes in this book. Some of these boxes are case studies, some are typical examples and others are details of techniques. These boxes are prepared by eminent scientists having long-term experience in the respective subject areas. I expect that these boxes will serve for details of the subject with first hand elaborations by well-known scientists, which will be of high use for the student community to know at least some of the scientists in their own fields of interest. Contributors of these boxes have also agreed that anyone who may read these boxes can contact them for further information and ideas, if required, and all of them have given their full postal address and e mail IDs for this purpose. I am extremely thankful to each of these contributors for devoting their time in response to my request and providing me their text and figures on time.

I thank Dr. S. Anilkumar (one of my former post-graduate and doctoral students at the University of Kerala, India), now at Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala for helping me in the preparation of the drawings used in this book. My son, Sharon M. Balakrishnan is thanked for his help in final editing of figures and photos included in this book. He has also supported me on computer technical problems during the final editing of the text, figures and photos. I am also thankful to a number of my post-graduate and doctoral students whom not only I taught, but from whom I also learned various issues of wildlife ecology, conservation and management I have presented in this book. I am also thankful to them for

their valuable feedback on my ecology, biodiversity and other wildlife related courses.

The text of this book was prepared using my spare time in Addis Ababa. In this context, I am indebted to Addis Ababa University, particularly to the Department of Zoological Sciences for giving me excellent working facilities and comfortable working atmosphere. Professor Afework Bekele, former Dean, Faculty of Science has been supporting me throughout my over 13 years of career with Addis Ababa University, which made me to continue here for such a long time even beyond my expectations. I sincerely thank my other Ethiopian colleagues, Dr. Kifle Dagne, Dr. Dawit Abate, Dr. Gurja Belay, Dr. Ababe Getahun and Dr. Tilaye Wube, under whom I have worked from time to time, for their support.

I take this opportunity to thank Professor Anantanarayanan Raman, Charles Sturt University, Australia, for inviting me to write this book. Mr. Tanay Sharma, Scientific Publishers (India) and his team of officials are thanked for their immediate and efficient responses on all my clarifications, particularly during the final stage of the preparation of this book.

I have reproduced parts of my publications appeared in few of the scientific journals as part of student review, exercise and case study for which I thank the Society of Photo-Optical Instrumentation Engineers (SPIE); National Institute of Ecology, New Delhi; International Scientific Publications, New Delhi; International Society for Tropical Ecology; Blackwell Publishing Ltd; Indian Academy of Sciences; Elsevier; Association for Tropical Biology and Conservation; Bombay Natural History Society; and the International Union for Conservation of Nature and Natural Resources.

I will fail in my attempt if I do not thank my parent institution, the Department of Zoology, University of Kerala, Thiruvananthapuram, where I started my academic career as a doctoral student and retired as a full Professor. This institution was responsible for my academic advancements and success, with its limited facilities and funding just like any of the other Indian State Universities. The earlier experience I had with the Kerala Forest Research Institute, Peechi as a staff of its Division of Wildlife made me to advance as a wildlife ecologist, for which I thank my then senior colleague, Dr VS Vijayan, who introduced me to the field of wildlife ecology. It was with him that I first made wildlife field observations in the famous Silent Valley forests of Kerala.

I have made my wife, Mrs. P.C. Roopa to suffer for a long time during the preparation of this text, as I have been spending much of my time at home to complete this task. I take this opportunity to thank her for her patience.

**M. Balakrishnan**

Addis Ababa,  
March 30, 2015.





# List of Boxes

Box 1.1.	Caecilians – The Elusive Limbless Amphibians by <i>K Ramachandran and OV Oommen</i> .....	2
Box 1.2	Glimpses of the Indian Barbets by <i>HSA Yahya</i> .....	6
Box 1.3.	Mountain Nyala by <i>B Afework</i> .....	12
Box 1.4.	Mutualism – A Case Study in the Western Ghats of Kerala, India by <i>S Anilkumar</i> .....	29
Box 2.1.	Wetland Ecosystems, Wildlife and Conservation by <i>B Gopal</i> .....	42
Box 2.2.	Mountain Lakes of Norway – Heavily Influenced by Human Activities by <i>Reidar Borgstrøm</i> .....	50
Box 2.3.	The Lion-tailed Macaque: A Case Study on the Impacts of Forest Fragmentation by <i>A Kumar and G Umapathy</i> .....	57
Box 4.1.	Biology and Behaviour of Bats by <i>G Marimuthu</i> .....	107
Box 5.1.	Wildlife Research in India in Two and Half Decades by the Wildlife Institute of India – Achievements at a Glance by <i>K Sankar</i> .....	158
Box 5.2	Bombay Natural History Society – Conservation Activities and Recent Achievements by <i>AR Rahmani</i> .....	167
Box 7.1.	Butterfly Farming for Conservation and Awareness Creation by <i>G Mathew and E George</i> .....	211
Box 13.1.	Camera-Trapping by <i>HV Goldman</i> .....	363
Box 13.2.	Remote Sensing and Geographic Information System in Wildlife Habitat Analysis by <i>PS Roy and S Nandy</i> .....	374



# Contents

<b>1. Introduction .....</b>	<b>1-40</b>
1.1. Wildlife – Definition and Scope.....	1
1.2. Wildlife Ecology and Management .....	14
1.3. Biomes of the World.....	15
1.4. Biogeographic Zones of India.....	16
1.5. Ecology of Natural Communities .....	21
1.6. Niche in Wildlife Ecology .....	25
1.7. Ecological Succession .....	26
1.8. Association between Species.....	28
1.9. Diversity, Stability and Resilience.....	37
<b>2. Wildlife Populations and Habitats .....</b>	<b>41-81</b>
2.1. Types of Habitats.....	41
2.2. Habitat and Food Resources for Wildlife .....	49
2.3. Habitat Association of Wildlife .....	56
2.4. Disturbances in Natural Habitats .....	65
2.5. Climate Change and its Effects on Wildlife.....	70
2.6. Ozone Depletion .....	75
<b>3. Predator–Prey Interactions .....</b>	<b>82-99</b>
3.1. Behavioural Ecology .....	82
3.2. Food and Feeding .....	85
3.3. Foraging as a Major Activity of Animals .....	85
3.4. Predation and Predator–Prey Interactions .....	86
3.5. Lotka-Volterra Model of Predator–Prey Interactions .....	89
3.6. Optimal Foraging Theory (OFT).....	90
3.7. Aggregation in Response to the Availability of Food.....	91
3.8. Food as a Factor Responsible for Distribution of Animals.....	93
3.9. Mammalian Foraging and Seed Dispersal .....	93
3.10. Feeding Behaviour of Animals as a Factor Responsible for Maintaining Healthy Habitats .....	94

<b>4. Ecological Principles in Wildlife Management and Conservation.....</b>	<b>100-133</b>
4.1. Introduction .....	100
4.2. Goal of Wildlife Management .....	101
4.3. Human Interactions in Natural Habitats.....	102
4.4. Habitat Loss and Fragmentation .....	102
4.5. Habitat Restoration .....	103
4.6. Population Structure and Regulation .....	103
4.7. Wildlife Stocking.....	104
4.8. Competition between Wildlife and Livestock.....	104
4.9. Wildlife Harvest .....	104
4.10. Reintroduction .....	105
4.11. Wildlife Conservation and Management .....	106
4.12. Behavioural Biology and Wildlife Management .....	106
4.13. Communication .....	114
4.14. Scent-Marking .....	115
4.15. Problems and Prospects in Wildlife Management .....	118
4.16. Urban Wildlife.....	120
<b>5 Conservation of Threatened Wildlife in India and Neighbouring Countries.....</b>	<b>134-179</b>
5.1. Introduction .....	134
5.2. India.....	135
5.3. Nepal .....	172
5.4. Sri Lanka .....	175
5.5. Pakistan .....	176
5.6. Future Prospects .....	177
<b>6. Human–Wildlife Conflict .....</b>	<b>180-208</b>
6.1. Human–Wildlife Conflicts (HWCs).....	180
6.2. Cattle Lifting and Crop Raiding by Wildlife .....	187
6.3. Case studies .....	188
6.4. Wildlife-related Conflicts in African Wildlife Foundation (AWF) Heartlands.....	193
6.5. Measures to Mitigate HWCs .....	194
6.6. Physical Barriers.....	197
6.7. Visual, Auditory and Olfactory Stimuli to Scare Wild Animals.....	198
6.8. Compensation and Benefit Sharing .....	202

6.9. Highway Traffic through Forests.....	203
<b>7. Wildlife Farming and Hunting.....</b>	<b>209-228</b>
7.1. Farming Wild Animals.....	209
7.2. Crocodile Farming.....	218
7.3. Ostrich Farming.....	220
7.4. Deer Farming.....	220
7.5. Rangelands.....	222
7.6. Behaviour of Farm Animals and Farm Management.....	223
7.7. Game Hunting.....	225
<b>8. Economic Benefits of Wildlife.....</b>	<b>229-244</b>
8.1. Introduction.....	229
8.2. Assessing Economic Benefits of Wildlife.....	230
8.3. Non-consumptive Value of Wildlife.....	231
8.4. Consumptive Value of Wildlife.....	232
8.5. Wildlife as Pests.....	232
8.6. Civet as Economically-important Wildlife.....	234
8.7. Economics of Wildlife Conservation.....	236
8.8. Hidden and Unknown Features of Wildlife and Wildlife Habitats.....	236
8.9. Carbon Sequestration.....	238
<b>9. Protected Areas and Wildlife Conservation.....</b>	<b>245-277</b>
9.1. Wildlife Conservation and Protected Areas.....	245
9.2. History of Protected Area System.....	246
9.3. World Coverage of PAs.....	248
9.4. Megadiversity Countries and Hotspots.....	250
9.5. Protected Areas and Conservation Initiatives.....	250
9.6. Features of Areas to be Conserved.....	253
9.7. Categories of Protected Areas.....	256
9.8. IUCN revised categories of PAs – 1994.....	259
9.9. <i>In-situ</i> Gene banks: A New Category of PA.....	261
9.10. Types of Utilization.....	262
9.11. Criteria for the Selection of PAs.....	262
9.12. Protected Area Management/Park Management.....	268
9.13. Local People and Protected Area Management.....	273

<b>10</b>	<b>Conservation Biology .....</b>	<b>278-307</b>
10.1.	Conservation Biology as a New Discipline in Biology .....	279
10.2.	Aims of Conservation Biology .....	281
10.3.	An Overview of Extinction.....	283
10.4.	A Major Extinction Spasm .....	288
10.5.	IUCN Threatened Species Categories.....	291
10.6.	Concept of Keystone Species, Umbrella Species and Flagship Species .....	294
10.7.	Conservation Perspectives for the Future .....	297
10.8.	Conservation Strategies .....	299
10.9.	Conservation Agenda .....	300
10.10.	Application of Conservation Activities.....	301
10.11.	The World Conservation Strategy 1980 and Since Then .....	303
<b>11.</b>	<b>International Conventions on Wildlife and Nature Conservation .....</b>	<b>308-319</b>
11.1.	Reasons for International Collaboration .....	309
11.2.	Organizations and Institutions .....	310
11.3.	Conventions (Treaties and Agreements).....	311
<b>12.</b>	<b>Traditional Methods in Wildlife Ecology.....</b>	<b>320-360</b>
12.1.	Ecological Monitoring .....	321
12.2.	Species–Area Curve .....	325
12.3.	Population Studies .....	326
12.4.	Population Estimation.....	342
12.5.	Population Indices .....	344
12.6.	Estimating Biodiversity .....	348
12.7.	Trapping Wild Animals .....	355
<b>13</b>	<b>Modern Techniques in Wildlife Ecology and Habitat Analysis .....</b>	<b>361-394</b>
13.1.	Camera-Trapping.....	362
13.2.	Biotelemetry and Radio-tracking.....	368
13.3.	Remote Sensing and Geographic Information System.....	373
13.4.	Ecological and Conservation Genetics .....	384
13.5.	DNA Fingerprinting .....	386
	<b>References .....</b>	<b>395-411</b>
	<b>Subject Index .....</b>	<b>412-441</b>
	<b>Author Index.....</b>	<b>442-446</b>