

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

Ecological Dynamics of Tropical Inland Waters

Lakes and rivers of the tropics are rich with variety and human relevance, yet do not figure prominently in surveys of general freshwater biology and limnology. The fruits of their scientific exploration are largely embodied in regional and specialist descriptions and analyses. In this book the authors take a generalized view, on a world-wide scale, that is dynamic and quantitative in outlook. They set out to integrate events and processes under tropical conditions, not only geographically but also within a continuum of physics, chemistry and biology. The volume contains numerous illustrations and detailed documentation of literature. Together the two authors have gathered experience from several tropical countries over three to four decades. They provide a foundation that will be of value to all who work with tropical inland waters, with interests ranging from water quality to fisheries. The volume will also have an appeal to those researchers, teachers and students in limnology and freshwater biology everywhere who are curious about the tropical implication and application of their subject.

JACK TALLING is a Fellow of the Royal Society of London and an Honorary Research Fellow at the UK's Freshwater Biological Association.

JACQUES LEMOALLE is a Research Scientist at ORSTOM (Institut français de recherche scientifique pour le développement en coopération) in France.

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

ECOLOGICAL DYNAMICS OF TROPICAL INLAND WATERS

JACK F TALLING

JACQUES LEMOALLE



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press
 978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters
 Jack F Talling and Jacques Lemoalle
 Frontmatter
[More information](#)

CAMBRIDGE
 UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9780521621151

© Jack Talling, Jacques Lemoalle and ORSTOM 1998

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 1998

First paperback edition 2010

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Talling, J. F. (John Francis)

Ecological dynamics of tropical inland waters / Jack F. Talling,
 Jacques Lemoalle.

p. cm.

Includes bibliographical references and index.

ISBN 0 521 62115 1 (hb)

1. Lake ecology—Tropics. 2. Stream ecology—Tropics.
3. Freshwater biology—Tropics. 4. Limnology—Tropics.
5. Biogeochemistry—Tropics. I. Lemoalle, J. (Jacques) II. Title.

QH84.5.T35 1998

577.63'0913—dc21 97-51548 CIP

ISBN 978-0-521-62115-1 Hardback

ISBN 978-0-521-16940-0 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

Contents

<i>Preface</i>	<i>page</i> viii
<i>Acknowledgements (text-figures)</i>	ix
1 Introduction	1
1.1 Scope	1
1.2 Historical background	4
1.3 Environmental conditions influenced by tropical latitude	7
2 Environmental transfers in space and time	8
2.1 Energy balance	8
2.2 Water balance	17
2.3 Water movements	27
2.4 Chemical balance	46
(a) Input–output: pathways and fluxes	46
(b) Chemical budgets (mass balances)	65
3 Resource utilization and biological production	82
3.1 Primary utilization: energy	82
(a) Underwater light penetration and interception	83
(b) Depth-profiles of photosynthesis	89
(c) Photosynthetic characteristics	94
(d) Losses: surface inhibition and respiration	97
(e) Rates per unit area	100
(f) Mathematical models	108
(g) Efficiencies	109
(h) Non-planktonic systems: microphytobenthos and macrophytes	112
3.2 Primary utilization: nutrients	117
(a) Nutrient uptake and environmental availability	118
(b) Element composition of biomass	121
(c) Fluxes of uptake and regeneration	124
(d) Limiting nutrients	132
3.3 Secondary utilization	140
(a) Food acquisition	140
(b) Food assimilation and use	146
(c) Production–biomass relationships	153
(d) Rates of production per unit area	160
3.4 Decomposition and recycling	163
3.5 Food webs	170
(a) Food chains and food webs	170
(b) ‘Pyramids’ of biomass	175
(c) Fluxes in simpler food chains	177
(d) Quantitative models of food webs	180
(e) Fish yield related to primary production	183
(f) Chemical tracers	185

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

vi

4	Patterns of environmental change with time	188
4.1	Quantitative characterizations of time-variability	189
4.2	The diel (24 hour) cycle: radiation control and environmental consequences	191
4.3	The annual cycle: control by radiation, water and wind regimes	193
	(a) Radiation regime dominance	194
	(b) Water regime dominance	204
	(c) Interaction between the radiation, water and wind regimes	212
	(d) Approach to the aseasonal aquatic environment	217
4.4	Cycles with other periodicities	218
4.5	Long-term and aperiodic change	222
	(a) Climate and hydrological balance	224
	(b) Climate and stratification regime	229
	(c) Other trends and singular changes	231
5	Reactive components of time-variability	232
5.1	Chemical components	232
	(a) Major ionic constituents	233
	(b) Major plant nutrients	235
	(c) The gases O ₂ and CO ₂	241
	(d) Reduced chemical species	244
	(e) Organic matter	245
5.2	Biological components	246
	(a) General	246
	(b) Heterotrophic bacteria	252
	(c) Aquatic macrophytes	254
	(d) Phytomicrobenthos	259
	(e) Phytoplankton	261
	(f) Zooplankton	274
	(g) Zoobenthos	284
	(h) Fishes	294
	(i) Air-breathing vertebrates	307
5.3	Rates of biological production	312
5.4	Biological diversity	321
5.5	Systems	325
	(a) Interactions of cyclic systems in time	325
	(b) Systems of associated time-courses	330
6	Concluding: tropical distinctiveness	343
	Appendix A Sources of regional information	348
	Appendix B Name changes and synonymy	350
	Appendix C Quantities, units and conversion factors	352
	Appendix D Symbols used in the text	355
	<i>References</i>	359
	<i>Index to water-bodies</i>	427
	<i>General index</i>	432

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

Preface

This book has its origin in several ventures involving Franco-British collaboration over the past 30 years. One main focus was African shallow lakes, with intensive fieldwork during the late 1960s and early 1970s within the International Biological Programme and – later – a pan-African overview. Our fascination with tropical freshwater science developed from this and other experience in Africa.

We have felt, however, that regional experience and regional description have most reward when integrated into a generalized science. The stage then becomes the entire tropics and the specific a special case of the general. Such integration we have tried to provide here. The subject is developed using comparative examples. It is founded upon a resolution into fluxes and flux-interactions, using quantities of energy, water and chemical elements as ‘common currencies’. Biological activities fit within, and participate in, these circulations. We then take up the consequences of time-variability at different frequencies and at various levels of organization. In the background is the question of tropical distinctiveness.

The book, is, therefore, organized around dynamic themes. We hope that it will be of value to those in tropical countries with scientific and practical interests in inland waters; also to those working at higher latitudes who would like to obtain a fuller perspective of their subject. For reference by both groups we have provided a detailed biography of the rather scattered literature.

Our venture has received help from numerous sources. Much early inspiration came from co-workers in the field, including our late colleagues Julian Rzóška and Leonard Beadle. We are grateful to others who have offered valuable comments and advice. They include Eddie Allison, Mary Burgis, Rob Hart, Xavier Lazzaro, Stephen Maberly, Jean Pagès, and Ed Tipping. Most of all, we have benefited from constructive criticism of the entire text by Geoffrey Fryer, Rosemary Lowe-McConnell and Roger Pourriot. Our two parent organizations, the Freshwater Biological Association (FBA) at Windermere and ORSTOM at Montpellier, have provided crucial support throughout. We are indebted to the FBA for use of its fine library facilities; from these much of the literature cited here can be obtained at moderate cost, under some conditions (excluding entire books), by photocopies supplied by post (the Document Delivery Service). Jack Talling is grateful to ORSTOM for financial support that enabled him to work at Montpellier. Also impor-

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

viii

tant was assistance with typing; here we are especially indebted to Kirsty Ross at Windermere and Marie-Christine Pascal at Montpellier. Funding from the Royal Society, and the professional skill of Kilian McDaid, enabled the redrawing of many text-figures. Finally the friendly help and advice of Alan Crowden and Maria Murphy of Cambridge University Press did much to smooth the path to final publication.

Jack F. Talling

Freshwater Biological Association

Windermere

Cumbria

UK

Jacques Lemoalle

ORSTOM

Montpellier

France

Acknowledgements (text-figures)

We are indebted to the following publishers and others for their kind permission to reproduce from published text-figures. The figures listed, in conjunction with the references, give the attribution to authors, journals or books, and bibliographic details.

Academic Press, London – Figs. 5.34, 5.39a

Akademie Verlag (now Wiley – VCH Verlag), Berlin – Figs. 5.7, 5.18, 5.20

American Fisheries Society, Bethesda – Fig. 3.47

American Geophysical Union, Washington DC – Fig. 2.27

American Society for Limnology & Oceanography – Figs. 2.5, 2.11, 2.12, 2.14, 2.32, 3.24, 3.26, 3.30, 4.17, 4.19

Asociacion Venezolana para el Avance de la Ciencia, Caracas – Fig. 5.41

Blackwell Science, Oxford – Figs. 2.15, 3.2, 3.12b, 3.13, 3.18, 3.19a, 3.28a, 3.32, 3.42, 4.2, 4.15, 4.16, 5.11, 5.27, 5.29, 5.50

Cambridge University Press – Figs. 5.32, 5.37, 5.38

Ecological Society of America, Washington DC – Figs. 4.20, 5.36

Editions ORSTOM, Paris – Figs. 2.1, 2.9, 2.34, 3.13b, 3.14, 3.16, 3.23, 3.35, 3.36a, 3.40, 3.43, 4.6b, 5.2, 5.3, 5.21a, 5.28, 5.53

Editor, *Aquatic Living Resources*, Nancy – Figs. 5.40, 5.56

Elsevier Science, Amsterdam – Figs. 2.3, 3.29

Prof. G. Fryer, Windermere – Fig. 3.33

Japanese Society of Limnology, Tokyo – Fig. 3.20

Kluwer Academic Publishers, Dordrecht – Figs. 2.24, 2.25, 2.28, 2.29, 2.33, 3.5, 3.8, 4.1, 5.4, 5.9, 5.12, 5.14, 5.15, 5.30

Météo-France, Paris – Figs. 4.11a, 4.12

Natural Resources Institute, University of Greenwich, UK – Figs. 2.19, 2.37, 3.45, 4.18, 5.33

Cambridge University Press

978-0-521-62115-1 - Ecological Dynamics of Tropical Inland Waters

Jack F Talling and Jacques Lemoalle

Frontmatter

[More information](#)

x

Contents

Oxford University Press – Figs. 2.22, 2.36, 3.25

Publisher and author, *Physiology & Ecology (Japan)*, Kyoto – Fig. 3.17

Royal Society, London – Figs. 2.18, 3.3, 3.12, 3.34

E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart – Figs. 2.6, 2.10, 2.13, 2.16, 2.35, 3.3, 3.13*a*, 3.22, 4.4, 4.7, 4.8, 4.9, 5.1, 5.39*b*, 5.42, 5.55

SCOPE Publications, Paris – Fig. 2.26

SPB Academic Publishing, Amsterdam (now Backhuys Publishers, Leiden) – Figs. 1.2, 2.20, 4.10

Springer-Verlag, Heidelberg – Figs. 3.19*b*, 3.27, 3.31, 3.37, 3.44, 3.48, 5.8, 5.21*b*, *c*, 5.46

Dr J. van der Heide, Amsterdam – Fig. 5.6

Zoological Society of London – Figs. 5.43, 5.44, 5.45