

THE FISHES AND THE FOREST

EXPLORATIONS IN AMAZONIAN NATURAL HISTORY



MICHAEL GOULDING

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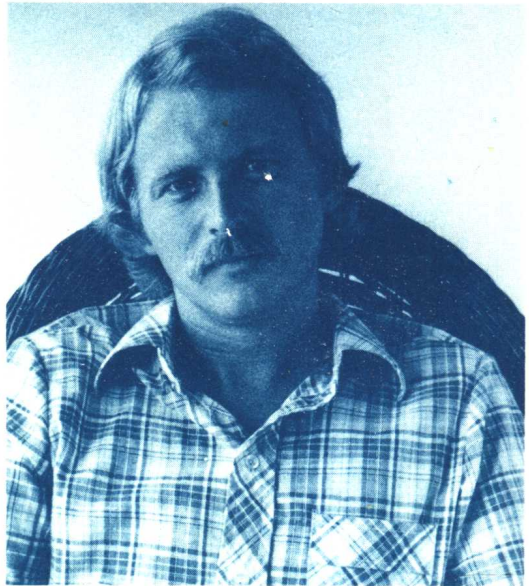
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"This book should be required reading for all who are interested in the conservation or development of this vast region. Moreover, though the author does not claim it, many of the lessons learned here may also apply to other areas of tropical forest, in Africa and the Asian tropics."

-- R. H. Lowe-McConnell



Michael Goulding is Research Scientist at the Instituto Nacional de Pesquisas da Amazonia (INPA), Manaus, Brazil, and is currently investigating fishes and flood-plain ecology under the auspices of INPA and World Wildlife Fund.

THE FISHES AND THE FOREST

FOREWORD

Throughout the tropics the rainforests are disappearing at an alarming and accelerating rate; recent forecasts suggest that unless urgent conservation measures are taken, little rainforest will remain into the next century. The Amazon basin contains the largest area of rainforest anywhere on earth, with the richest flora and fauna of any land ecosystem. If this forest goes, numerous plant and animal species specialized for forest life will vanish also. There is thus a pressing need for ecological studies that are of immediate importance for a sound conservation policy for the Amazon biota.

It is therefore a great pleasure to introduce this book with its wealth of facts about the lives of over fifty of the main commercial fishes of the Amazon basin and the role of the forest in maintaining them. Until this study very little was known about the life histories of many of these large species, as they are so much more difficult to study than aquarium-sized tropical fishes. This work has shown, rather surprisingly, that 75 percent of these fishes have food webs that originate in the flooded forests of the nutrient poor rivers of the Amazon basin.

Ecological studies undertaken from the Instituto Nacional de Pesquisas de Amazônia (INPA), based at Manaus, first demonstrated the efficiency of the tropical rainforest in taking up and recycling nutrients from very poor soils, with the corollary that when the forest is cleared the nutrients are removed, impoverishing the whole system. This present study has shown clearly that the fishes and inundation forest interact to a hitherto unexpected extent. Herein is the first substantive evidence that a large part of the fish fauna is nourished by the flooded forest. From this it seems clear that deforestation of the floodplain, as is at present happening in many

areas, will destroy much of the fish fauna and have very detrimental effects on the important commercial and subsistence fisheries of the region. Furthermore, the study has shown that about half the fish species that feed directly on fruits and seeds may aid seed dispersal. This fish dispersal of tree seeds is apparently a very old habit. If these fishes disappear, regeneration of these elements of the forest may be jeopardized.

In this work the author, Michael Goulding, has been aided both by scientists with a special knowledge of the Amazonian biota, and by local naturalists with long experience with Amazonian conditions. Not a little of the success in unravelling complex ecological relationships was owing to the helpful information given by the fishermen and others whose everyday lives take them deep into the flooded forest; this greatly speeded the process of gathering information about fish movements and the flowering and fruiting seasons. The ability to appreciate the contribution that those who know the forest well can make, has been one of the author's valuable assets. Their knowledge was also invaluable in combating the hazards encountered; not the largely imaginary dangers of the "green hell" of fiction—being eaten by piranha fish or caiman, chased by Indians—but the more real dangers of being lost in the seemingly endless maze of waters, drowned in rapids where the fishermen perch so perilously on the rocks, or succumbing to malaria.

Having survived, the studies continue, for so much information is still needed as a sound basis for conservation policies. This book should be required reading for all who are interested in the conservation or development of this vast region. Moreover, though the author does not claim it, many of the lessons learned here may also apply to other areas of tropical forest, in Africa and the Asian tropics; the important fisheries of the Grand Lac of the Mekong system, for example, declined after the forest was cleared, but the reasons for this decline were not well understood.

R. H. Lowe-McConnell

January 1980

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Most of the photographs were taken by INPA staff photographer, Mrs. Barbara Gibbs, under my direction; but their quality is due to her skills alone. Sr. Alberto Silva made the drawings. Mr. George Nakamura patiently typed the drafts and helped edit the final manuscript. Sr. Pedro

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INTRODUCTION

The main conclusion arrived at in this book, namely that Amazonian fishes and inundation forests have interacted to an extent unknown elsewhere on the planet will, it is hoped, be heeded by those South American governments who venture to deforest and develop their equatorial floodplains to other ends. The investigation attempts to offer the first substantive evidence that a large part of the Amazon's fish fauna is nourished in flooded forests and that floodplain deforestation might have detrimental effects on important commercial and subsistence fisheries.

The accelerated rate of deforestation in the tropics demands an equally accelerated means of communication between the results of scientific research and governments and the general public of the planet. Because my aim is to reach as many readers as possible, I have written this book in a manner designed to be comprehensible by scientists and all others—from economic developers to naturalists—interested in the Amazon or tropical ecology. The first three chapters following the introduction should serve to orient the reader on the nature of Amazonian aquatic ecosystems and the fish life found in them; following these, the next eight chapters will deal, *seriatim*, with aspects of the ecology of a large sample of the common groups of the larger fishes of the Amazon (little attention is given to small fishes in this work); chapter 12 explores the interactions of fishes with fruits and seeds, and chapter 13 examines the trophic structure of fishes in relation to flooded forests; finally, the main conclusions of the study are viewed in light of human modification of Amazonian floodplains. To facilitate the understanding of the plants and animals that I discuss, the book is heavily illustrated. Scientific and regional terms are brought together in a glossary found at the end of the book.

HOW THE FISHES AND FORESTS WERE STUDIED

Study Area

The main focus of this investigation centers on the upper Rio Madeira basin in the southern Amazon (fig. 0.1). The Rio Machado, the second largest affluent of the

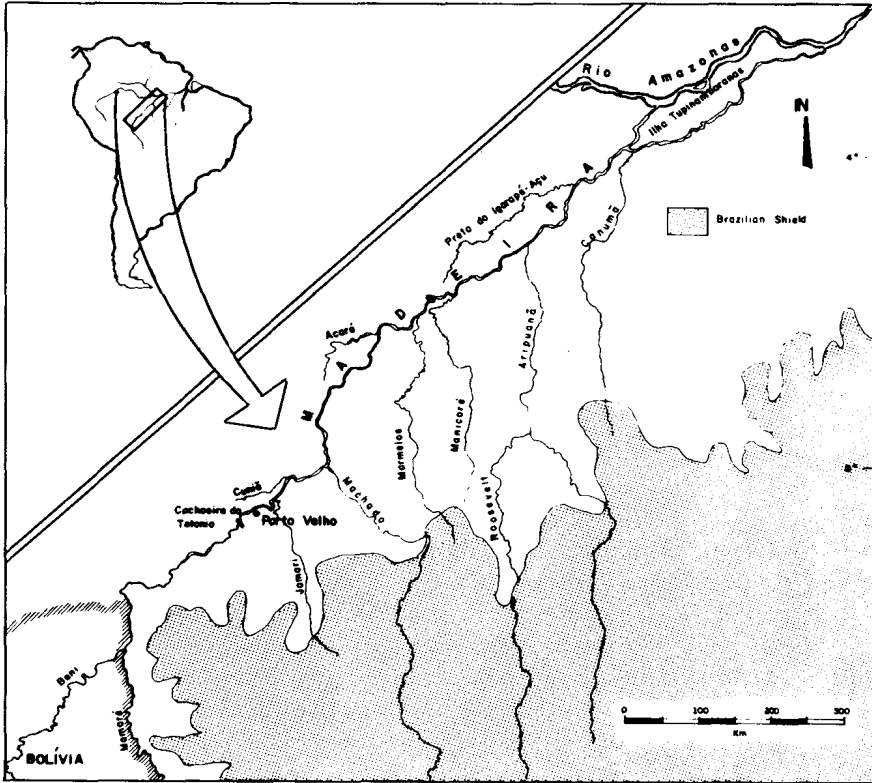


FIG. 0.1 The Rio Madeira basin.

Rio Madeira, was selected for an intensive study of the ecosystemic role of flooded forests in nourishing fishes and the effects of river-level fluctuations on the food supply and local migrations of fishes. The Rio Madeira was investigated during spawning and low water migrations (see chap. 2) when many fish species enter it in large numbers from its tributaries, including the Rio Machado.

The selection of the Rio Machado as the beginning point of this study offered the following advantages (though some only became apparent when the investigation was in full progress):

1. The food chains leading to the fishes studied appear to be representative, on a broad scale, of those found in other nutrient poor rivers of the Amazon, in which, as will be argued in this investigation, a large part of the fish biomass of many species, including most commercial ones, is nourished.
2. The transparency of the Rio Machado ranges from about 1–2 m, and thus fishes can be observed in the water.
3. Most of the fish species studied in the Rio Machado are widely distributed and abundant in the Amazon.
4. The Rio Machado is a fairly large river with extensive flooded forest that has been little modified by man.
5. There were fairly intensive commercial fishing operations at the mouth exploiting fishes that moved in and out of the river and this made it easier to verify the schooling, spawning, and migratory behavior of many of the fishes studied.
6. There is the small village, Calama, at its mouth, from which much could be learned from subsistence fishermen who represented a constant fishing effort that often reflected some of the ecological patterns of the fishes studied.
7. In the 150 km of the Rio Machado investigated there were about fifty families dispersed along its banks and these people were able to give us much ecological information about the local conditions.

Though this study focuses mainly on the upper Rio Madeira Basin, I have in some cases broadened its scope based on my own observations in other parts of the Amazon, published studies, and information kindly offered by my colleagues working on other aspects of fish ecology in the region.

Fishing Methods

Most of the fish specimens were captured with gill-nets (a wall of netting left in the water in which fish become entangled when entering it) employed during both

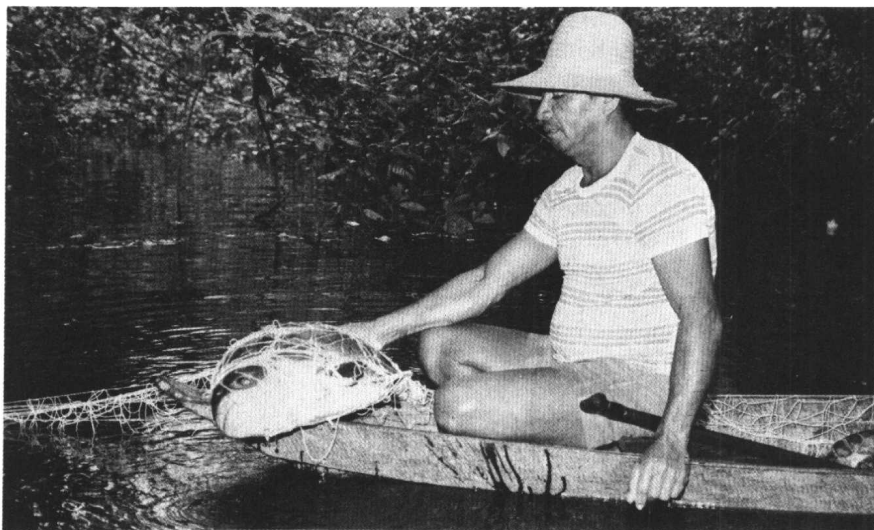


FIG. 0.2 Sr. Dorval (see text) removing a fish from a gillnet placed in the flooded forest.

day and night (fig. 0.2). Between 20 and 30 gillnets, ranging in length from 10 to 20 m and in mesh size from 6 to 24 cm (stretched), were usually employed at any one time to catch sufficient specimens in the flooded forests. The nets were placed at various intervals over a total distance ranging usually between 2 and 5 km, and each locale was fished from 2 to 5 days before moving on to another farther up or downstream. During the two years of investigation, about 150 km, as measured by way of the channel of Rio Machado, was fished in intervals of 5 to 15 km. During low water longer nets but with the same mesh sizes were used in the lakes of the Rio Machado. When the Machado runs shallow and clear in its channel, it is quite difficult to catch fish during the day and we had most success fishing at night with castnets thrown by hand and with 50 m long gillnets. Fishing poles were used to catch fishes in running water where gillnets could not be employed. Trotlines, measuring 100 to 200 m in length and constructed from heavy nylon line and with 3 or 4 baited hooks each, were employed to catch the large catfishes in the middle of the channel of the main rivers.

In addition to fishes captured by our own efforts, I also accompanied commercial fishing operations in the Rio Madeira during the low water period when many of the species studied make upstream migrations in it and had the opportunity to examine these fishes for stomach contents. Fish markets in the cities of Porto Velho and Humaitá were visited whenever possible and commercial catch data from the former was of great help in establishing schooling and migratory behavior of various species.

Based on our own fishing efforts, commercial operations and observation, I estimate that there are about fifty species of larger fishes—at least 10 cm in length when adults—that are common in the Rio Madeira and/or its tributaries below the first cataracts. A few of these species are confined to either the main trunk or to its tributaries, but most are found in both. Most of the common species were investigated, and I believe that those studied in the Rio Machado account for most of this river's fish biomass below the first cataracts.

Quantitative Basis

The quantitative basis of this study includes the analyses of the stomach contents of approximately three thousand fish specimens of fifty species captured mostly in 1977 and 1978 and a few during the high water season in 1979. Every month, in at least one of the two principal years investigated, was sampled for at least one week, though it was not possible to catch any particular species in every month of the year. Water level periods are more important than individual months, and the Rio Madeira and Rio Machado, for the purposes of this study, may be divided into high and low water seasons. The high water period, when the floodplain forests of the Rio Machado are inundated, lasts from about mid-December to mid-June, and the low water period, when the rivers are more restricted to their channels, accounts for the complementary six months. No significant differences, in terms of the basic types of food eaten by the fishes investigated, were found between the two principal years studied, and thus the results of both years are combined and minor differences elaborated on whenever necessary. Seasonal comparisons of fish diets are made according to the high and low