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PRIMARY PRODUCTION OF PHYTOPLANKTON IN THE THREE TYPES OF AMAZONIAN WATERS

by

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I. Introduction

The limnology of the waters in the Amazon region, a landscape which is characterized to a very great extent by the interrelationship between the land and the water, has for a number of years been in a state of intensive investigation (see SIOLI 1965a, SCHMIDT 1972e). This activity corresponds to the growing scientific interest in these tropical ecosystems and also to the growing practical economic significance which these systems have for the entire region. Until now, however, there has been very little concrete data having to do with the important question of the productivity of these waters (see SCHMIDT 1972d). The earliest exact information of this nature was furnished solely by BRAUN (1952), who wrote on the biomasses of plankton and benthic organisms in lakes that lie in the Tertiary of the lower Amazonian region, by MARLIER (1967), who wrote on the biomasses and production of plankton, benthic fauna and shore vegetation of waters in the vicinity of Manaus, and by FITTKAU (1964), who wrote on the biomasses of lower fauna from smaller deep forest streams. One single series of investigations on primary production of phytoplankton in the Rio Negro was published by HAMMER (1962).

As the findings of the above mentioned authors and as the ample practical experience and the numerous observations of those who have become well acquainted with this region indicate, the fundamental differences which distinguish the three Amazonian water types (white-, black-, and clear-water; see SIOLI 1950, 1951, 1965b) in their physical and chemical characteristics also have an effect on their biological productivity. In order to acquire a deeper insight into these problems, detailed investigations were begun in 1967 at the suggestions of SIOLI by JUNK, who concentrated on the ecology and production of the floating meadows, which are strongly developed on numerous rivers and lakes of this region, and by the author, who concentrated on the primary production of the phyto-

plankton in the three water types of the region. As SIOLI already pointed out in 1969, these two biological areas together represent the most important sites of aquatic primary production in Amazonia. Both projects were carried out as a collaborative activity between the Instituto Nacional de Pesquisas (INPA) in Manaus and the Max-Planck-Institute of Limnology, Department of Tropical Ecology, Plön, West Germany, and are at the same time Brazilian contributions to the International Biological Program (IBP). The results of the first subject sphere have already been published in part (JUNK 1970) and are in print. In a second published series, of which this paper is the beginning and for which a total of about 5–7 single papers are planned, the results of the investigations on primary productivity of phytoplankton and additionally the results of the most important of those necessary secondary investigations shall be presented. Some partial results have previously appeared as single studies (SCHMIDT 1968, 1969a, 1969b, 1970, 1972a, 1972b, 1972c).

Such comprehensive and detailed study would not have been possible if so many people had not been so helpful. For this reason I would like at this point to thank all our Brazilian colleagues very much, above all Sr. Antônio José dos Santos, Sr. Umbelino Jorge de Oliveira, Sr. Amaury Vieira dos Santos, and Sr. Jôrge Kraus for their tireless assistance in the numerous and often fatiguing excursions. Sr. José Carlos Oliveira placed his house at our disposal to use as a field laboratory and sleeping quarter during the work on Lago do Castanho, for which we are very grateful. I would further like to express our gratitude to Miss Ingrid Mau, who counted the ¹⁴C preparations, and to Professor Dr. Jürgen Overbeck, who gave us the use of his special laboratory for this. We gratefully acknowledge the valuable help of Dr. Hans-Jürgen Krambeck in the mathematical processing of the large quantity of experimental data through E.D.V. To all those who contributed to the realization of this project and whom I have not named specifically, I would also like to express my thanks at this time. Most of all I would like to thank my wife, Heike, whose always enthusiastic and interested technical assistance in the lab and on the excursions has contributed considerably to the accomplishment of the set goals.

For the planned study, the Rio Negro, the classic and most significant member of its category, was chosen as an example of a blackwater. The sampling station was located approximately 12 km above Manaus in the Ponta Negra bay. The Rio Tapajós, which empties into the lower Amazon at the city of Santarém in the State of Pará served as an example of clearwater; it is a typical representative of this type of Amazonian waters. The sampling stations were located in its lower course, about 30 km above Santarém. Both rivers had only a slight water current and even exhibited a distinct vertical stratification of the water mass during calm weather in the area of the sampling station, at least to a certain depth. The Rio Tapajós in its enormously wide lower course is in many of its features more like a lake than a river. Additional particulars on the characteristics of these waters will be discussed later in the treatment of their productivity.

From the outset, however, it didn't seem sensible to choose a river, say the Amazon, respectively the Rio Solimões, for the investigation of primary productivity in white-water. Because of the strong current and the extremely low depths of visibility in this water in proportion to its great depth, a significant autochthonous development of phytoplankton is hardly possible in this water except in the protected inlets in which the suspended material is partially sedimented out, nor can a measurable primary production of allochthonous phytoplankton which is washed from other locations into the river (see SCHMIDT 1970) be expected. For the above mentioned reason, the photosynthesis of an algal cell in such waters – if it occurs at all – is way below the compensation point of assimilation and dissimulation, and the organism must, therefore, sooner or later die. Any existing primary production will at least remain far below the range that would be possible on the basis of the nutrient content of the water due to these conditions. On the other hand, for the study of

the primary production of phytoplankton in white-water, many sites were available in which the current diminishes and the light climate, due to the associated sedimentation of suspended materials, becomes considerably more favorable for the phytoplankton. The more suitable sites are lakes of the flood plain region of the Amazon, its várzea. In protected inlets and other regions of the river with little current and partial sedimentation of the suspended materials, i. e. away from the open water, the conditions for phytoplankton naturally also become more favorable. However, due to the expected strong influence of the very widespread floating meadows and other environmental conditions the inlets appeared less favorable for the planned investigations. The use of a lake as an example of a white-water naturally resulted in the fundamental problem that the supply of nutrients to this area is not so continuous, as is the case with running water. In those várzea lakes, which are directly connected to the river throughout the year, however, the entire water mass will for all practical purposes normally be replaced each year, so that at least in this way the nutrient supply is renewed. Finally, the várzea lakes should in general not be neglected entirely anyway in a comprehensive investigation of phytoplankton primary productivity in Amazonia because of their great number and significance.

SIOLI (1951 and 1957) has already reported on the origin of the várzea and its lakes and on other features of this region, so that more on this need not be dealt with further here. For this study, naturally, only those lakes were considered which contained as much as possible only "decanted" white-water, that is, water from the Rio Solimões after more or less complete sedimentation of suspended material specific to that river, and having no other tributaries. These theoretical prerequisites encountered various difficulties, however. All of these lakes contain rain water, which not only falls directly on the lake's surface, but also drains directly from a more or less large catchment area into the lake. In addition numerous smaller lakes of the várzea are connected to the river only at high water level. Because of the possibly incomplete annual water exchange in these lakes, the conditions were too specialized to be included within the scope of this study. On the other hand, other lakes are fed by tributaries from the terra firme, land not part of the flood plain. These streams may be more or less strongly pronounced black-waters, a situation which can likewise present very special water conditions that are very difficult to generalize. Finally, the choice of a lake had to also include the practical consideration that we had to be able to get to it on a somewhat regular basis with the means at our disposal.

In the end, Lago do Castanho, which lies in the region of Janauacá in the vicinity of Manaus, was chosen as the best compromise to all these various considerations. As will be confirmed by the results of the investigations, which almost expanded into an entire course of study in the total limnology of this lake, Lago do Castanho may be designated as a quite typical representative of the várzea lakes of central Amazonia. Further details on the limnology of this water will also be reported in separate papers in this series. As should be emphasized right away, however, even Lago do Castanho may not be simply regarded as the typical várzea lake. This is generally not possible because still too little is known about these lakes in regard to their morphological characteristics, the various aspects of their aquatic conditions and the particularities of their limnology.

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