PRODUCTIVITY OF FLORIDA SPRINGS
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with a selection by
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INTRODUCTION

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Contractor: Department of Biology, University of Florida, Gainesville (with Biology Branch, Office of Naval Research)

Principal Investigator: James L. Yount

Associates: Howard T. Odum (Duke University)
Delle N. Swindale (University of Wisconsin)

Title of Project: Productivity of Florida Springs

Objectives: A study of basic factors that control productivity and of the effects of productivity on community structure and density by an analysis of the unique conditions supplied by selected constant temperature springs.

I N D E X

Technical Reports

Publications

Published:

Laessle, A. M. 1953. The use of root characteristics to separate various ribbon leaved species of Sagittaria from species of Vallisneria. Turtox News 31(12):2

Odum, H. T. 1953. Dissolved phosphorus in Florida Waters. Rep. Invest. Fla. Geol. Surv. 9:1-40.

Odum, H. T. 1953. Factors controlling marine invasion in Florida Fresh-waters. Bull. Mar. Sci. Gulf Carib. 3:134-156.

Odum, H. T. and B. Parrish. 1954. Boron in Florida Waters. Quart. J. Fla. Acad. Sci. 17:106-109.

Berner, L. + W.C. Sloan. Occurrence of Mayfly nymph in brackish water. Ecology 35(1):1p.

Odum, H. T. and D. K. Caldwell. 1955. Fish respiration in the natural oxygen gradient of an anaerobic spring in Florida. Copeia: 104-106.

Odum, H. T. and J. Johnson. 1955. Silver Springs and the balanced aquarium controversy. Science Counselor, December: 128-130.

Odum, H. T. and R. C. Pinkerton. 1955. Times speed regulator, the optimum efficiency for maximum power output in physical and biological systems. American Scientist. 43: 331-343.

Sloan, W. C. 1956. A comparative ecological study of the insects of two Florida Springs. Ecology. 37:81-97.

In Press:

Odum, H. T. 1956. Primary production in flowing waters. Limnology and oceanography J. (42 pp. manuscript, 2 tables, 8 figures).

Odum, H. T. 1956. Efficiencies, size of organisms, and community structure (16 pp. manuscript, 4 figures). Ecology.

Whitford, L. A. 1956. The communities of algae in the springs and spring streams of Florida. Ecology.

Completed Manuscripts submitted for publication:

Caldwell, D. K., H. T. Odum, T. Hellier, F. Berry. Some characteristics of centrarchid fish populations in a constant temperature spring (28 pp. manuscript, 4 figures).

Odum, H. T. Productivity of Silver Springs Florida. (120 pp. manuscript 37 figures, 15 tables).

Odum, H. T. Primary production measurements in eleven Florida Springs and a marine turtle grass community (25 pp. manuscript, 14 fig.)

Manuscripts in Preparation:

Yount, J. L. Factors that influence species variety in Silver Springs Florida.

FACTORS THAT CONTROL SPECIES NUMBERS IN SILVER SPRINGS (2)

James L. Yount

The present report represents a continuation of studies reported in the Third Annual Report of the present series (Yount, 1956). In this earlier report, it was found that a number of factors affect species variety in Silver Springs, notably productivity and time. These factors were studied by examining diatoms on slides left in a highly productive place and a place of low production in Silver Springs. In addition, an intermediate station was studied, but unfortunately, this station was destroyed twice, so that no attempt is made here to report those inconclusive results.

It is interesting to note (Figs. 5-7 of Yount, 1956 and 1-3 of the present report) that the rich station remained more or less static from about 60 days of age until the most recent examination at 238 days; this is reverse the situation at the same station from an age of 4 to about 50 days of age (Figs. 1-4 of Yount, 1956). On the other hand, at the poor station the species variety and numbers of individuals were more or less static from age 7 to about 80 days, whereas from about age 115 to 205 days, these were dynamic. These differences were apparently dependent on the differences in productivity at the two stations and time, so that an apparent climax formed at both stations after different lengths of time in the spring. In this connection, it should be mentioned that the poor station was covered by a mass of floating Sagittaria everytime it was visited until December of 1955 (age 115 days) when it was noted that no floating mass was covering the slide box (there was still considerable shade from an overhanging tree, however), and a mass did not cover the slide box at any time it was visited since then.

There is apparently some discrepancy in the trend at the rich station, in that the species variety increased slightly at age 148 and 188 days (Figs. 2-3 of present paper) over that of age 61 and 93 days (Fig. 5-6 of Yount, 1956). The difference, however, is slight enough, I think, to be accounted for as individual variation.

In summary, then, as revealed by Figs. 1-3, the rich station (5) species variety remained rather low throughout the newer slides examined, but the poor station's (12) species variety gradually diminished. At the same time, numbers of individuals remained high at the rich station at about 2000 individuals counted in 10 oil immersion fields. At the poor station, however, during this same period, the numbers per 10 fields increased to almost 2000 individuals, while the species variety decreased. These facts emphasize conclusions drawn earlier, that where production is high, species variety is low, and vice versa, provided other environmental factors are similar in the compared habitats.

Reference:

Yount, J. L. 1956. Factors That Control Species Numbers in Silver Springs. (In) Yount and Odum, Productivity of Florida Springs; Third Annual Report to Biology Branch of Office of Naval Research.

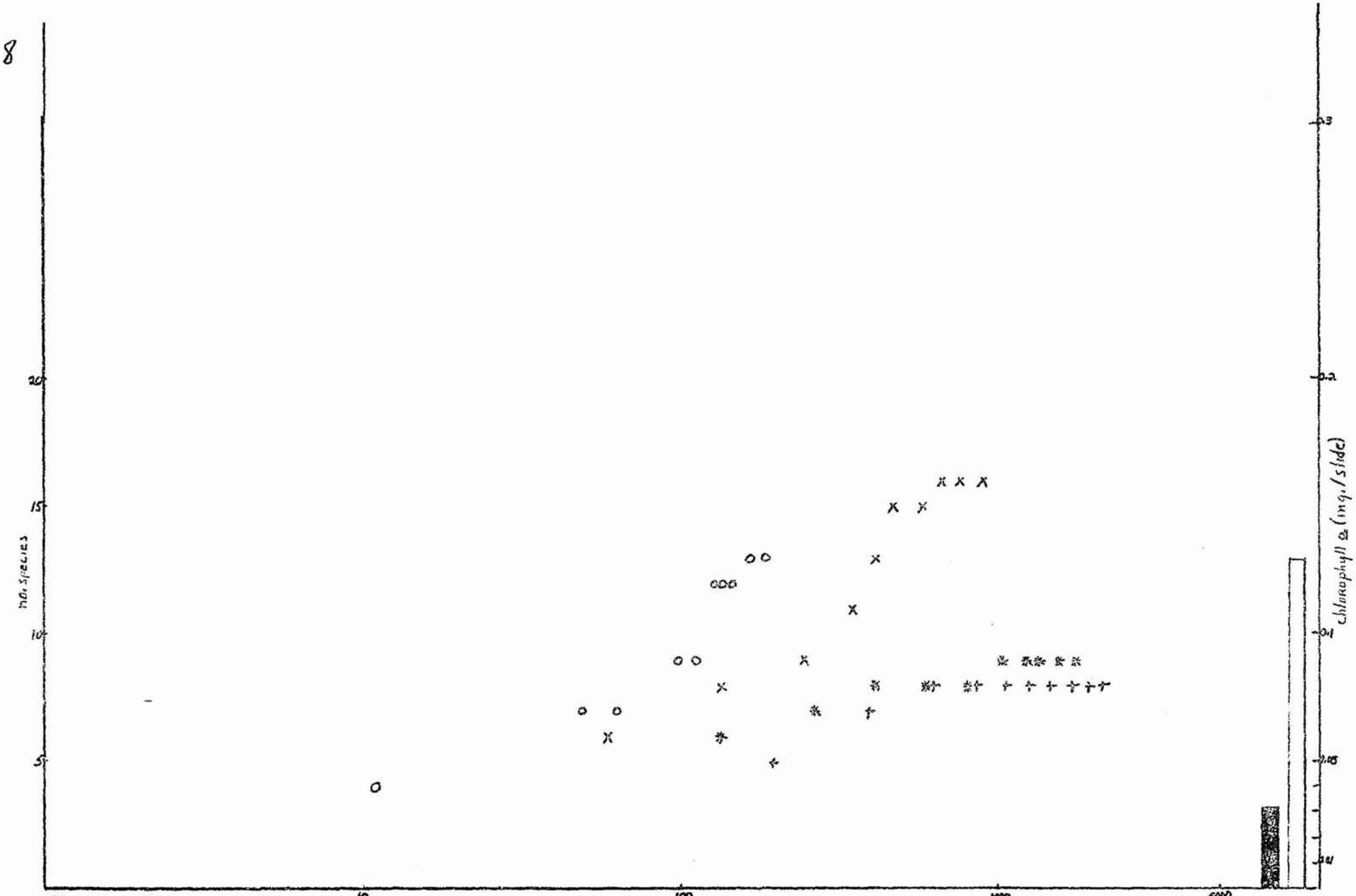

Fig. 1. Diatom species-individual curves from slides left in Silver Springs, Florida for 93 days, near boil, and 115 days, side pool, Chlorophyll quantity (average of 2 slides from each station) is indicated by the histograms (solid = side pool; clear = near boil). + = slide 1, near boil; * = slide 2, near boil; X = slide 1, side pool; O = slide 2; side pool.

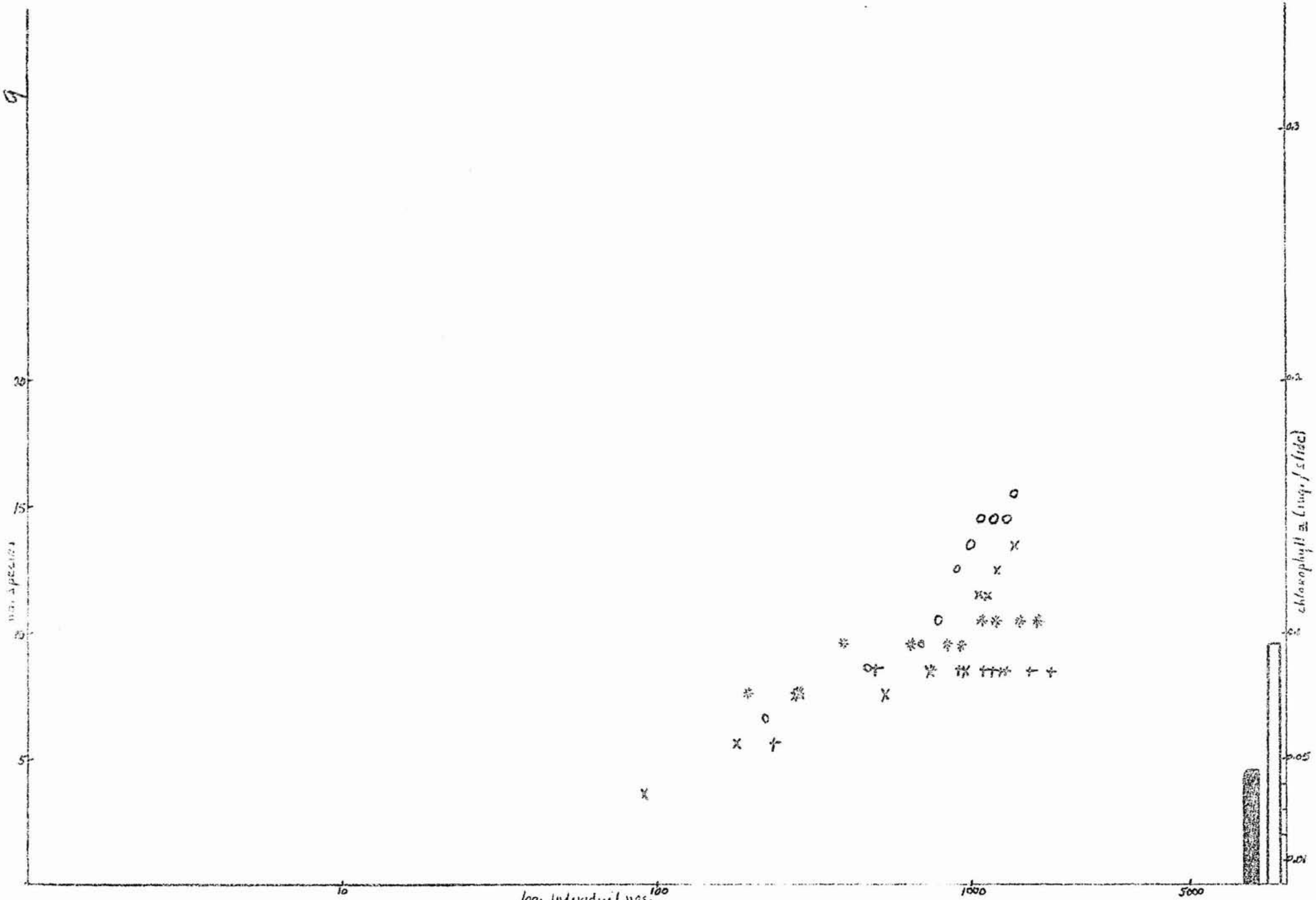

Fig. 2 Diatom species-individual curves from slides left in Silver Springs, Florida for 148 days, near boil, and 155 days, side pool. Chlorophyll quantity (average of 2 slides from each station) is indicated by the histograms (solid = side pool; clear = near boil). ✝ = slide 1, near boil; * = slide 2, near boil; X = slide 1, side pool; O = slide 2, side pool.

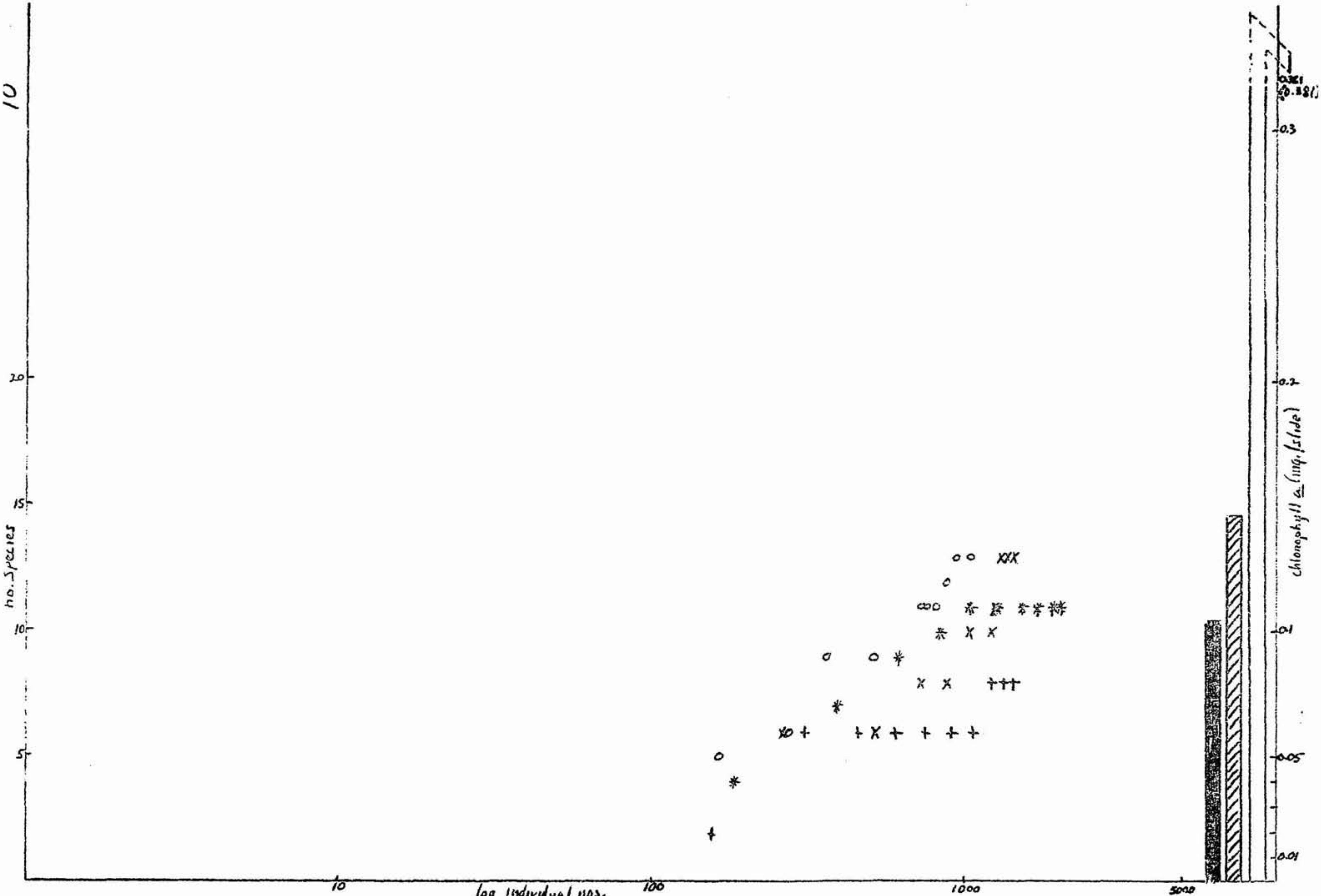

Fig. 3. Diatom species-individual curves from slides left in Silver Spring, Florida for 188 and 238 days near boil and 205 days side pool. Chlorophyll quantity (average of 2 slides from each station) is indicated by the histograms (solid = side pool; clear = near boil). + = 188 days, near boil; * = 238 days, near boil; X = slide 1, side pool; 0 = slide 2, side pool.

Study of the Biomass of Parasites in the Stumpknockers

At the request of H. T. Odum, Dr. Wanda Hunter assisted by Dr. Winona Vernberg determined the numbers and approximate dry biomass of all parasites in ten stumpknockers taken in winter and ten taken in summer. The idea of a pyramid of biomass for the parasitic food chain is much discussed in ecological circles but rarely demonstrated. The total weight was about 2.27 mg/fish in winter and 3.62 mg/fish in summer. Using some rough estimates of parasite metabolism from representative measurements made by Hunter and Vernberg, it is possible to state that the very numerous but slight weighted parasites are not taking a large part of the total metabolism of these dominant fish. Apparently the energy flow to the carnivores is greater than to the parasites of these fish under the conditions of steady state in Silver Springs.

Summary: Factors That Influence Species Variety in Silver Springs, Florida

James L. Yount

Factors that influence species variety in Silver Springs were discussed in detail in the Third Annual Report, and some additional data are presented above in the present report. These factors were classified and some were studied in detail.

Classification of factors affecting species variety resulted in a division into two principal factors, the history of the area and proximity of the area to the general optimum. The history of the area includes isolation, new species formation and the time factor or age of the substrate or medium.

Proximity of the area to the general optimum includes two chief headings, abiotic and biotic factors. Abiotic factors that affect species variety include physical and chemical factors, as well as geologic factors, etc., e.g., temperature, pH, currents and the like. Biotic factors include competition, predation, cooperation and the like. Productivity, which combines both abiotic and biotic factors, was found to be of major importance in influencing the species variety.

It was concluded that there are always a combination of various factors affecting the species variety of an area, and that productivity and time were each very important factors, perhaps more than the others. These two latter were examined and reported on in detail in the Third Annual Report.

Summary: Macrophytic Communities in Florida Inland Waters*

By Delle N. Swindale

During the period from September 1954 to June 1955 an investigation was made of the communities of large submerged plants in many of Florida's inland waters. Methods, which were quantitative and qualitative, were described in previous reports.

Differences in habitat and associated communities in various parts of the same body of water necessitated the study of communities by stands rather than by entire lakes, ponds, springs, or rivers. Thus different depths in a particular area of a lake often had different communities, as did different parts of rivers, especially some of those with salinity gradients.

Three coastal springs and their runs (Weekiwachee, Homosassa and Chassahowitzka) were sampled at various locations quantitatively and qualitatively. The individual stands were weighted by the percentage area of the spring-river system which they represented and estimates of average standing crop were obtained for each system. The average figures for the three spring systems were 3941, 4000, and 4620 lbs./acre dry weight, compared to 4686, 3774, and 3667 lbs./acre dry weight for the same three systems, as calculated by Dr. Davis from his data of 1953. The relatively small discrepancy between the two sets of results support the reliability of the estimate and suggest a relative stability in total plant standing crop in these springs from year to year.

Data on percentage dry weight contributed by each species in six spring-systems, and importance of each in each stand of four springs were presented in tabular form. Diagrammatic maps of the vegetation in six spring pools were also presented.

The percentage of joint occurrence of each species and the frequency of each in the quadrats sampled in each stand were used to formulate a classification system for the communities in Florida's lakes, ponds, and spring-systems. The classification was based on the vegetation itself but was subsequently correlated with the environment.

The communities studied fall into two main groups, mostly independent of each other in regard to dominant species. There were few intermediate stands and hence the two groups were discussed separately.

The first group included the springs, their runs, and some of the large lakes studied. The relative frequency distributions of the species among the stands arranged in order of the classification system used showed that these stands constituted a vegetative continuum with species attaining dominance in the following order: *Hydrocotyle umbellata*, *Fontinalis* sp., *Nasturtium officinale*, *Chara* sp., *Ludwigia natans*, *Najas guadalupensis*, *Ceratophyllum demersum*, *Sagittaria lorata*, *Vallisneria* sp., and *Potamogeton pectinatus*.

The species vary in the amplitude of their distribution and the species at one extreme of the above list rarely occur together with species at the other extreme.

This order of stands is correlated with water quality, the species at

* This work was supported by the University of Florida through a post-doctoral fellowship, with additional support from this project.

the Hydrocotyle end occurring in more oligotrophic waters than those at the Potamogeton pectinatus end, which are more eutrophic and which include the most saline waters sampled. Often substrate correlations were also obvious. The relationships of the various species to environmental factors and to each other were discussed in detail in the January 1956 report.

The other main group of stands included the ponds, small lakes and some of the larger lakes. The chemical analyses showed a lower mineral content in their water than in those of the previous group. The stands formed a vegetative continuum with a trend from oligotrophy toward eutrophy, manifested by increase in the richness of the substrate and increase in plankton content of the water. Some bodies of water deviated from the general gradient of oligotrophy to eutrophy because of an excess of organic matter. These brown-stained, peaty-substrate waters were dominated by species seldom dominant in harmonic waters.

Graphs of the two continua and the dystrophic species' distribution, and tables of environmental correlations were presented.

Notes on taxonomy and identification of some of Florida's submerged plants were presented with emphasis on Vallisneria and some species frequently found in a sterile form in submerged communities.

COMMENT IN RETROSPECT

The "springs" project as originally conceived is now completed. The possibilities of the constant environments exceeded even the most optimistic proposals. New methods were developed for measuring the metabolism, community weights, and to some extent the species structure of the flowing water environment. A very detailed study was made on one spring, Silver Springs. Comparison was then made between Silver Springs and others. Efficiencies of photosynthesis were high and closely related to light intensity under these conditions of continually renewed medium. The data obtained stimulated thinking that led to two papers on ecological theory. Then methods and interpretations were extended in one paper to flowing waters in general. A study of coral reef structure and metabolism with similar methods was an outcome of the springs work. Seven papers dealt with special features in the springs environment that were related to production but somewhat aside from the general theme. These dealt with boron, marine invasion, phosphorus geochemistry, fish respiration, insect species scarcity, the immensely rich algal communities, and fish populations at constant temperature. The constancy of the environment permitted data to be additive and made the studies extremely economical. Many persons participated as acknowledged in the reports and final papers.

According to present hopes all of the manuscripts now in the publication mill will be printed before the close of 1957. The reprints will be assembled together and submitted as the final report.

The possibilities of the springs are still hardly touched. It would be very advantageous if a biological station for community research were established on one of the springs with a budget such as this present project has had.

H. T. Odum