COMPARISON OF AQUATIC ECOSYSTEMS IN TWO NATIONAL WATERFOWL REFUGES[1]

by

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ABSTRACT

A study was made of the aquatic ecosystem of two national waterfowl refuges in Mississippi to determine if there are significant environmental differences between the two refuges which might be correlated with evident differences in wood duck (*Aix sponsa*) productivity. Standing crops of seeds and plants used by waterfowl were measured, soil and water quality analyses were made, and phytoplankton concentrations were determined. Various aquatic plant communities were sampled to determine the abundance and species of macroinvertebrates. The gullet contents of 50 young wood ducks collected indicated that the sampling technique used was effective in sampling the various species present with the exception of one family. Data collected showed the aquatic ecosystem of the Yazoo Refuge located in the Delta area of Mississippi was more fertile and supported larger standing crops of plants and animals than the Noxubee Refuge located largely in the Interior Flatwood Soils area of Mississippi.

INTRODUCTION

Detailed studies of aquatic ecosystems of shallow water impoundments of the Southeastern United States are few. Ecological factors affecting duck productivity are only very sketchily known (Hankla and Curtis 1966).

This study was initiated to determine factors responsible for observed differences in wood duck productivity in two aquatic ecosystems which are located in two different physiographic regions of Mississippi.

Information collected by personnel of the two refuge areas over a three year period revealed that the Yazoo Refuge had a much greater use of artificial nesting boxes with an average of 83 percent for the three years compared to 36 percent for the Noxubee Refuge. The nesting boxes in the Yazoo Refuge area averaged two eggs per clutch more than those in the Noxubee Refuge (Cunningham 1969, Baker 1971, and Dr. Jim Baker, personal communication 1971, Biologist, Merritt Island, N.W.R., PO Box 6504, Titusville, Florida, 32780).

A number of biologists have pointed out the need for animal protein for breeding waterfowl. Cook (1964) reported that wood ducks failed to reproduce when deprived of a diet high in protein. Cook (1964) also believes that breeding waterfowl and broods will probably reject wetland areas when animal foods are scarce.

A detailed ecological study of the two refuge areas would not only add to our limited ecological knowledge of shallow warm water impoundments but would also be of value in determining environmental differences that could be correlated with wood duck productivity.

STUDY AREAS

The Yazoo National Wildlife Refuge is located in Washington County in the Delta area of Mississippi. The refuge encompasses 11,000 acres (4,453 ha) of land and is characterized by flat to slightly undulating terrain. The soils are rich alluvium averaging 46 feet (13.98 m) in depth. The refuge area consists of 4,500 acres (1,821 ha) of agricultural land. A large portion of the open land is devoted to growing soybeans. A great deal of this land is interspersed with sloughs and cypress willow swamps which

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remain flooded most of the year. In the ecotone bordering the swampy lowland, hardwood stands of water oak (*Quercus nigra*), nuttall oak (Q. *nuttallii*), sugarberry (*Celtis laevigata*), sweetgum (*Liquidambar styraciflua*), water hickory (*Carya* aquatica), willow oak (Q. *phellos*), and overcup oak (Q. *lyrata*) cover about 2,000 acres (808 ha) within the refuge area.

The Noxubee National Wildlife Refuge is located in the northern part of Noxubee and the southern part of Oktibbeha Counties. The area encompasses over 46,000 acres (18,623 ha) of land with over 2,000 acres (809 ha) of water and over 12,000 acres (4,858 ha) of bottomland hardwoods and 1,700 acres (688 ha) of open land. The remaining acreage is in pine and upland hardwood. The major bottomland hardwood species are oak with water oak, willow, nuttal, cherrybark, overcup and Shumard making up the major species. The open land contains nearly 500 acres (202 ha) of soybeans and almost 200 acres (80 ha) in corn and sorghum. The remaining part is in pasture and hayland. Over 50 percent of the refuge area is in the interior flatwoods area with the remaining portion divided between upper coastal plains and the black belt soil area. The flooded area in which the study sites were located are in the flatwood soils which are level to poorly drained, medium to heavy textured, and low to inherent fertility. The upper coastal plain soils are gently rolling to rolling, moderate to well drained, and rate low in fertility. Soils of the blackbelt area are level to gently rolling clay, rated medium in fertility level.

METHODS AND PROCEDURE

Determination of Phytoplankton Concentrations

Plankton sampling was done by taking 400 ml. of water from the upper eight inches (20.32 cm) of the littoral zone and filtering it at the sampling site. Type RA Millipore R filters were tried in collecting phytoplankton, but due to the small pore size of the filter and the degree of suspended material in the water being sampled, clogging invariably occurred, and use of type RA Millipore R filters was discontinued. From 23 October 1969 to the end of the sampling period, type AP Millipore R prefilters were used for sampling.

Each filtrate was considered a sample. Seven samples were taken on each sampling date. After the prefilters had been placed in the filtering apparatus and sucked dry by the use of a Fisher hand operated air pump, each was placed in a 150 ml. wide mouthed glass container. The container was wrapped in aluminum foil and stored in a styrofoam cooler partially filled with ice, until the samples could be analyzed in the laboratory.

Five of the samples were analyzed for concentration of chlorophyll. Chlorophyll was extracted with 90 percent acetone, and concentrations were determined with the aid of a Bausch and Lomb Spectronic 20 spectrophotometer following the method of Strickland and Parsons (1960). With the remaining two samples, the abundance and identification of cells per sample were determined by examining the prefilters microscopically at maximum light intensity after clearing the prefilter with immersion oil using the technique described by McNabb (1960). Examination and extraction were done as quickly as possible and were always completed within 12 hours of the time the samples were taken.

Determination of Plant Coverage

Frequency of occurrence of aquatic vegetation was determined by using a modification of the line intercept method. All plants directly below a 100 foot tape at points one foot apart were recorded. Due to the growth habits of some of the plants recorded, it was possible in some instances for a floating species and a submerged species to be recorded at a single point.

Two permanent transects, each 100 feet (30.4 m) in length, were checked on each sampling date. An attempt was made to choose transect locations within the two refuges that were similar with respect to water amount and depth, and species composition. Permanent transects were established to determine changes in vegetation at

later dates. Two sloughs with relatively little water fluctuation and a relatively high degree of vegetative cover were chosen.

Some plants which were common within the two refuges did not occur on the line transect. A visual estimate was used to determine the percentage of water area covered by the various plant species in each plant community. Estimates of coverage were made as follows:

0-25 percent of water area occupied was recorded as sparse coverage
26-50 percent of water area occupied was recorded as medium coverage
51-75 percent of water area occupied was recorded as medium coverage
76-100 percent of water area occupied was recorded as full coverage.

Seed Availability Study

Seed samples were taken in those wetland plant communities which were common within each refuge. Plant communities sampled in the two refuges were as follows:

Yazoo National Wildlife Refuge - Mixed *Limnobium spongia* and *Ceratophyllum demersum, Polygonum lapathifolium,* and *Polygonum pensylvanicum.*

Noxubee National Wildlife Refuge - Mixed *Brasenia schreberi* and *Ceratophyllum demersum, Polygonum hydropiperoides, Polygonum densiflorum,* and *Echinochloa* crusgalli.

Twenty-five samples per sample date were taken in each plant community on four different occasions within each refuge. Samples were taken during that time of the year which was considered the peak of availability for seeds of the communities sampled. After the December samples were taken, it was found that high water levels present in the communities sampled at the Noxubee National Wildlife Refuge caused seeds in those locations to be covered with 4 to 6 feet (1.22 m to 1.83 m) of water. High water during late winter and early spring is a common occurrence at the Noxubee Refuge and makes seeds unavailable to waterfowl and nearly impossible to sample; therefore, sampling at Noxubee after 4 December 1969 was abandoned. Due to the extremely low production of seeds in the purely aquatic plant communities (*Limnobium spongia, Brasenia schreberi,* and *Ceratophyllum demersum*) at what should have been the optimum time for seed production, sampling in those locations was also discontinued. The only plant community with seed available to waterfowl and present in quantity enough to warrant further sampling was *Polygonum lapathifolium.* From January until the end of the sampling period in May, twenty-five samples per month were taken in the *Polygonum lapathifolium* community.

Samples were taken with a West Point turfgrass sampler having a 5.08 cm diameter and a 6.35 cm sampling depth. Sampling locations within the communities were selected by placing a compass staff with a rotating arrow in the approximate center of the plant community. The arrow was then spun and sampling begun on a line determined by the direction of the point of the arrow. Samples were taken approximately 15.24 cm from the compass staff and at 15.24 cm intervals. Each sample was then placed in a 270 ml cellophane bag and taken to the laboratory for analysis.

Seeds were separated from the rest of the sample with the aid of a series of Tyler sieves. Seeds were counted and allowed to dry and then weighed on a model P160 Mettler balance.

Invertebrate Collection

A rectangular metal box sampler modified after Gerking (1957) was used to sample the invertebrates found associated with different aquatic plant communities and drfit material. The sampling technique used was described by Arner, Wesley, and Anding (1968). The area sampled with the metal box was 1,596.77 sq. cms. Three samples were taken in each plant community at bimonthly intervals. The plants collected with the samples were washed in a tub and the washed material was transported to the laboratory for counting and identification of aquatic organisms. The macrofauna were removed with tweezers and eyedropper and placed in 10 percent formalin after which they were weighed on a Mettler single-pan balance to the nearest 1/1000 of a gram. The

quantitative work of this report for both invertebrates and plants is based on wet weights.

The dominant plant communities present in the Yazoo Refuge were sampled. The species composing the communities were *Hydrocotyle ranunculoides, Jussiaea diffusa, Spirodella polyrhiza, Myriophyllum brasiliense, Wolffiella floridana,* and a composite community containing *Spirodela polyrhiza, Limnobium spongia* and *Wolffia columbiana.*

At the Noxubee Refuge the following dominant plants were sampled for invertebrates: *Brasenia schreberi, Ceratophyllum demersum, Hydrolea quadrivalvis, Jussiaea diffusa, Nymphaea odorata, Polygonum hydropiperoids, Callitriche heterophylla, Eleocharis quadrangulata,* and *Saururus cernus.* In addition, drift materials made up largely of floating plant material such as decaying hardwood leaves, cones and cypress needles, seeds of *Saururus* sp., and small twigs were sampled by the same method in both refuge areas.

Collection of Young Wood Ducks

In order to determine the kinds of invertebrates that young wood ducks were utilizing and to determine if ducklings were finding food which we might have missed in our sampling procedure we planned to collect 50 ducklings from the Noxubee Wildlife Refuge area. Mr. Jim Baker of the Wildlife and Fisheries Department of Mississippi State University was assigned the responsibility of collecting the young wood ducks. The ducklings were killed at Noxubee with a 20 gauge shotgun mainly during the morning hours after they fed. Gullet contents were removed immediately after collection and placed in 10 percent formalin. The general procedure of food habit analysis as described by Korschgen (1969) was followed.

Water Chemistry

Water analyses were made from the study areas in the fall, winter, and spring. Hydrogen ion concentration was ascertained by a Sargent portable pH meter. Dissolved oxygen was obtained by using the Winkler Method. Dissolved carbon dioxide and the phenolphthalein and methyl orange alkalinity were determined with the Hach Fish and Stream Kit. These analyses were conducted in the field by following procedures outlined by Farber (1960) in Standard Methods for the Examination of Water and Wastewater.

Soil Chemistry

Fifty soil samples were taken at each sampling location by forcing a 1 1/4 inch (3.81 cm) plastic pipe into the muck to a depth of approximately one foot. The soil was separated into top soil and sub-soil and placed in separate soil boxes. The soil was analyzed for percent of organic matter, pH, available potash, and available phosphate by the Mississippi State University Soil Testing Laboratory.

RESULTS AND DISCUSSION

Plant Community Periodicity and Coverage

The importance of animal protein for egg production and hatchability has been documented for ducks by Cook (1964) and by Holm & Scott (1954). Moyle (1961) has recorded data from a number of investigations pointing up the relationship between submerged aquatics and the production of macroinvertebrates. Thus the persistance and occurrence of aquatic plants take on increased significance in evaluating the habitat for waterfowl.

The late persisting plants should influence production and hatchability of wood duck eggs by providing female ducks with sources of animal protein in the form of invertebrates inhabiting these plants.

Of the plants encountered in the study, *Hydrocotyle ranunculoides* was the only plant evident throughout the entire year, and was found only in the Yazoo Refuge. *Woffiella floridana* appeared in January at Yazoo and increased in abundance until

April when a rapid decrease was noted. *Spirodela polyrhiza* was first noted in February in the Yazoo Refuge. It increased greatly in number with the approach of warmer weather. In the Noxubee Refuge, only a slight increase of *Spirodela* was noted during the warmer months.

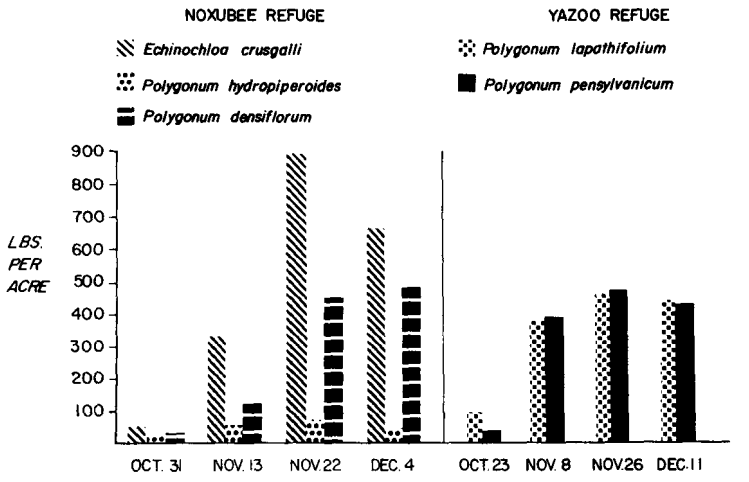
There were no aquatic plants evident in the Noxubee Refuge during January. Only sparse amounts of *Wolffia* were evident in Noxubee in December. *Spirodela* was the first plant to appear at Noxubee in February followed by *Callitriche, Brasenia,* and *Nymphaea* in late February.

Ceratophyllum demersum and *Jussiaea diffusa* were the last species to appear. *Ceratophyllum* was the most abundant submerged plant found in Noxubee in the summer and fall of the year. In the early spring of the year *Polygonum hydropiperoides* was the most common plant. This species, although an emergent summer plant, was usually found in a submerged or nearly submerged condition during the early spring. In the Yazoo Refuge, *Ceratophyllum* covered the greatest area during the summer and fall months while *Hydrocotyle* was the most common plant found in the early spring; *Spirodela* covered the largest area during the late spring period.

Seed Production of Wetland Plants

Several investigators of waterfowl food plants have suggested that the availability of a species, measured by occurrence and productivity, may largely determine its value (Low and Bellrose 1944). Of the eight native plant communities sampled, *Echinochoa crusgalli* and *Polygonum densiflorum* were found only on the Noxubee Refuge. *Echinochloa* had the highest yield with 884 pounds (991.21 kg/ha) per acre present in November. The maximum yield of *Polygonum densiflorum* was 481 pounds (538.74 kg/ha) per acre present in December (Figure 1). An analysis of variance showed that the plant communities of the Noxubee Refuge at the P .05 level had significantly higher seed yields than communities of the Yazoo Refuge during the fall. However, during the spring more seeds were available in the Yazoo Refuge.

FIGURE 1. A COMPARISON OF AVAILABLE SEED OF THE NOXUBEE AND YAZOO REFUGES DURING THE FALL AND EARLY WINTER.



In the Yazoo Refuge *Polygonum pensylvanicum* samples indicated a maximum standing crop of 470 pounds (527.31 kg/ha) per acre in November with *Polygonum lapat ifolium* having 462 pounds (517.45 kg/ha) per acre (Figure 1). Seeds of *Polygonum lapathifolium* were found throughout most of the spring sampling period in the Yazoo area in amounts ranging from 85.8 pounds (96.10 kg/ha) per acre in January to 23 pounds (25.87 kg/ha) per acre in April.

The *Polygonum* and *Echinochloa* seeds are a good source of carbohydrates which are a major source of fuel for growth and differentiation. According to Sturkie (1945) the respiratory quotient for early developing chick embryo was nearly 1.0, which indicates a high carbohydrate utilization Proximate analysis of seed by the Mississippi State Chemical Laboratory showed a N-free extract at 58.6 percent for *P. pensylvanicum* and 40.5 percent for *E. crusgalli.*

Invertebrate Collection

The number of invertebrates harbored by *Hydrocotyle* increased with plant coverage. During the winter months *Hydrocotyle* produced a mean standing crop of 39 pounds (44.12 kg/ha) per acre, and during the spring 163 pounds (182.72 kg³ha) per acre. *Jussiaea diffusa* was one of the last plant species to appear in the spring, but spread rapidly, especially in the summer months, and by early fall *Jussiaea* showed a mean standing crop with a weight of 109 pounds (122.18 kg³ha) per acre, the second highest producing plant community in the Yazoo Refuge (Table 1).

Table 1. Average wet weights of standing crops of invertebrates and wet weight ratios between standing crops of invertebrates and plants (average based on bimonthly collections as plants appeared during different seasons of the year).

Species of Plants	Noxubee Refuge		Yazoo Refuge	
	Inverte brates kg/ha	Ratio of animals to plants	Inverte brates kg/ha	Ratio of animals to plants
FALL				
Brasenia schreberi	153.65	1:98	--	--
Ceratophyllum demersum	213.10	1:49	68.61	1:182
Composite sample*	--	--	112.91	1:123
Hydrocotyle ranunculoides	--	--	182.72	1:93
Hydrolea quadrivalvia	54.82	1:151	--	--
Jussiaea diffusa	48.00	1:190	122.18	1:74
Nymphaea odorata	46.09	1:118	--	--
Polygonum hydropiperoides	48.00	1:2611	--	--
Spirodela polyrhiza	--	--	36.06	1:141
WINTER				
Drift material	38.11	1:863	20.87	1j;145
Hydrocotyle ranunculoides	--	--	44.12	1:166
SPRING				
Brasenia schreberi	86.11	1:91	--	--
Callitriche heterophylla	27.01	1:800	--	--
Drift material	215:41	1:77	58.15	1:363
Eleocharis quadranqulata	24.26	1:143	--	--
Hydrocotyle ranunculoides	--	--	182.65	1:157
Myriophyllum brasiliense	--	--	55.17	1:360
Polygonum hydropiperoides	41.54	1:297	--	--
Saurus cernus	34.07	1:506	--	--
Spirodella polyrhiza	--	--	145.92	1:137
Wolffiella floridana	--	--	69.05	1:379

*Consisted of *Spirodela polyrhiza, Limnobium,* and *Wolffia.*

In the Noxubee Refuge there were no aquatic pants available for sampling during the winter months. During the spring months (*Brasenia schreberi* and *Polygonum hydropiperoides* produced the largest standing crop of invertebrates. In the summer and fall *Ceratophyllum demersum* appeared and increased greatly. Fall sampling showed that the *Ceratophyllum* community had a mean standing crop of 190 pounds (213.10 kg/ha) per acre, the highest crop of any plant community on Noxubee Refuge (Table 1).

The highest ratio of animals to plant material was found in the *Ceratophyllum* community where a ratio of one gram of animals per 49 grams of plant material was recorded at the Noxubee Refuge. On the Yazoo Refuge the best ratio was found in *Jussiaea* where one gram of animals per 74 grams of plant material was measured (Table 1).

A study made during the spring months of 1968 in several wetland plant communities in the Noxubee Refuge showed a lower average standing crop weight of invertebrates in the *Brasenia schreberi* community in 1968 than in 1969 [21 pounds (23.64 kg/ha)] per acre compred to [76 pounds (86.11 kg/ha)] per acre; however sampling of the *Eleocharis quadrangulata* community in 1968 showed a higher average net weight of invertebrates in 1968 than in 1969 [36 pounds (40.76 kg/ha) compared to 21 pounds (24.26 kg/ha], while samples of the *Polygonum hydropiperoides* community showed a small difference in average net weight of organisms with 39 pounds (44.00 kg/ha) in 1968 and 37 pounds (41.54 kg/ha) in 1970. It seems apparent that standing crop weights will vary from year to year and season to season in the various plant communities (Figure 2).

Amphipoda were the most abundant aquatic organisms found in the Noxubee Refuge and they were found in greatest number in *Ceratophyllum*. *Anisoptera, Zygoptera,* and *Gastropoda* were encountered in the majority of the plant communities sampled in both refuges throughout most of the sampling periods.

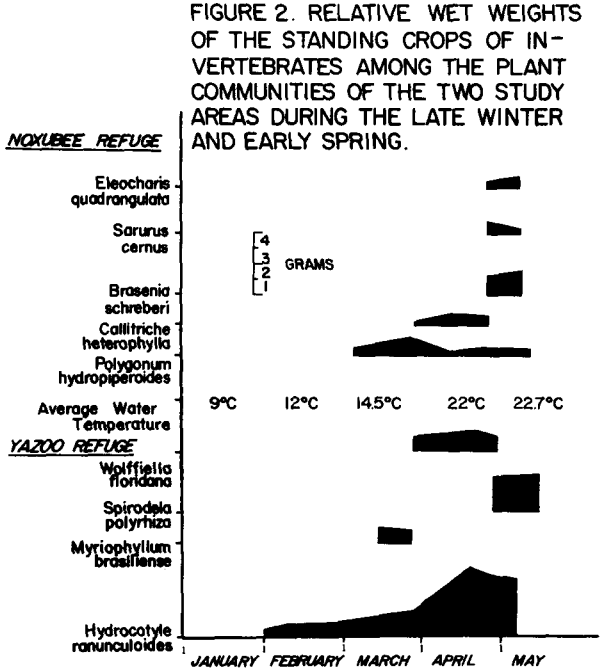
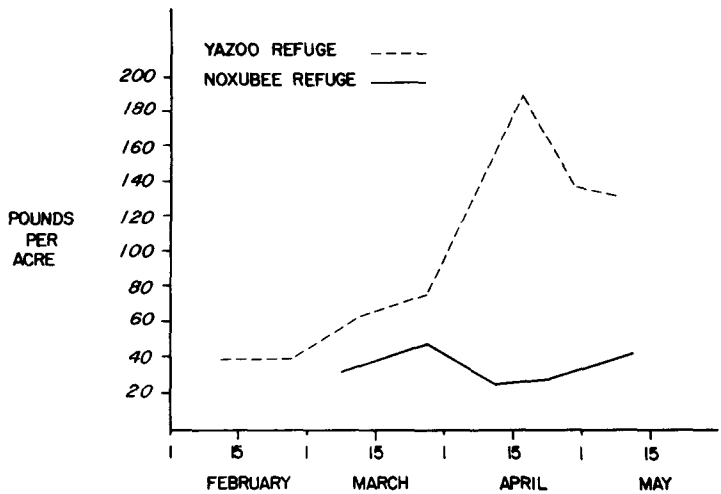


FIGURE 2. RELATIVE WET WEIGHTS OF THE STANDING CROPS OF INVERTEBRATES AMONG THE PLANT COMMUNITIES OF THE TWO STUDY AREAS DURING THE LATE WINTER AND EARLY SPRING.

FIGURE 3. THE AVERAGE TOTAL WET WEIGHTS OF INVERTEBRATES COLLECTED FROM THE TWO REFUGE AREAS DURING THE LATE WINTER AND SPRING PERIODS.



Analysis of variance showed that biomass of aquatic invertebrates was higher in the pant communities of the Yazoo Refuge throughout the fall, winter, and spring months, but statistically so at the $P<.05$ level only during April and May (Figure 2 and 3). The Mississippi Agricultural and Forestry Experiment Station statistician felt the data obtained between plant species and between seasons were too variable to utilize statistical analyses.

Drift material sampled in the Noxubee Refuge harbored more invertebrates than did any of the plant communities and considerably more invertebrates than drift collected in the Yazoo Refuge. Upon analysis it was found that three-fourths of the drift material in Yazoo consisted of woody stems, while the drift material in the Noxubee Refuge was more diversified and consisted of detritus, Brasenia leaves and stems, Cypress needles, Cypress buds and deciduous leaves, small woody stems and seeds of Bidens. This composition of drift material at the Noxubee Refuge produced the largest standing crop of invertebrates during the winter and spring m nths with a wet weight of 219 pounds (215.41 kg/ha) per acre in the spring and 34 pounds (38.11 kg/ha) per acre during the winter as compared to 51 pounds (58.15 kg/ha) per acre and 18 pounds (20.27 kg/ha) per acre for drift material sampled in the Yazoo Refuge. A difference was also noted in the areas where drift material was collected. Drift material collected in shaded areas produced less biomass than drift collected in open areas. Drift material was not nearly as abundant as were aquatic plants and thus did not contribute as much to the total invertebrate crops.

Food Items in Ducklings

Out of the 50 ducklings collected on the Noxubee Refuge only 37 contained food in their gullets. Thirty-one of these were from one week or under to four weeks of age while only six were from four to six weeks old. Animal food occurred in 97.2 percent of the ducklings' food items and composed 84.5 percent of the total volume. Mayfly and

dragonfly nymphs combined made up over half of the total volume. The only animal food item which was eaten in significant numbers which did not appear in our sampling procedure was the water treaders (Mesovelidae). Representatives of the family were found in 35 percent of the gullets but composed only five percent of the volume. Water treaders are extremely fast in their movements and evidently move out of the area sampled before the sample is collected.

Phytoplankton Abundance

Algae are the most important producers in the freshwater environment (Odum 1959). Their ability to photosynthesize food and anabolize proteins are factors contributing to their importance. Measurement of the production units may therefore give some indication of the productivity of certain bodies of water.

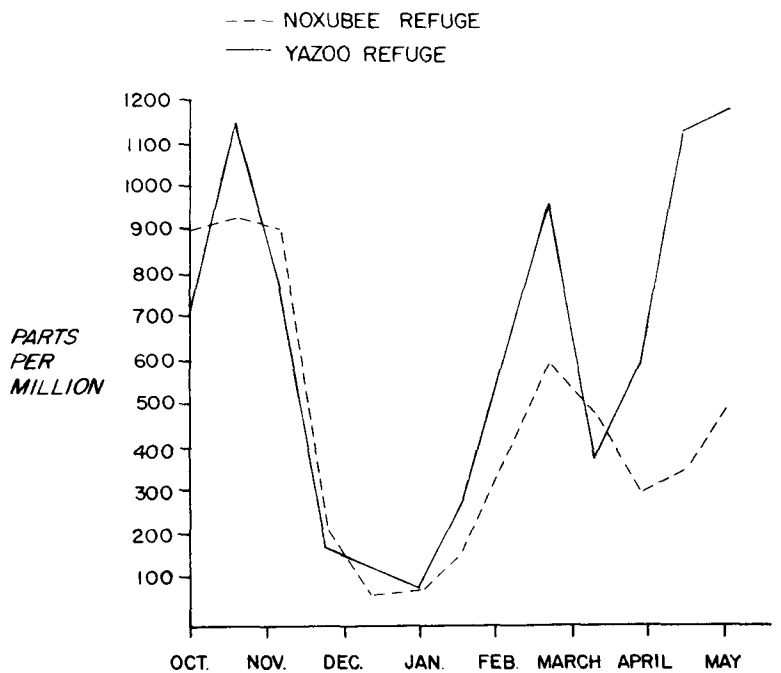
Measurements from filtered samples showed that the Yazoo Refuge produced significantly higher concentrations at the P .05 level of phytoplankton organisms than did the Noxubee Refuge. Fall peaks of abundance of phytoplankton were noted in October at Yazoo with a maximum of 1,175 organisms per liter, and in November at Noxubee when 840 organisms per liter were noted. Phytoplankton populations reached low peaks of abundance at Yazoo during December (282 organisms per liter), and January at Noxubee (107 organisms per liter). A spring peak of abundance at Yazoo occurred in May (1,610 organisms per liter), and in April at Noxubee (967 organisms per liter).

During the low period of abundance, diatoms were the only group of phytoplankton organisms observed. Diatoms were the dominant phytoplankton at both refuges throughout the sampling period. *Scenedesmus* sp. was the second most abundant organism during the fall at Yazoo with a maximum density of 102 organisms per liter in November. *Euglena* sp. was the second most common form during the spring at Yazoo reaching 407 organisms per liter in May. *Euglena* sp. was the second most abundant form at Noxubee during the sampling period with a fall maximum of 97 organisms per liter in November and a spring maximum of 197 organisms per liter in April.

Chlorophyll Concentration

The richness of an ecosystem is largely determined by its degree of productivity. While a rich or productive community may have a larger quantity of organisms than a less productive community, this is by no means always the case (Odum 1959). Due to this, mere abundance of phytoplankton organisms does not measure the primary productivity of a given area. Rhyther and Yentsch (1957) have described a method by which the organic production beneath a unit of water can be estimated from the chlorophyll content of the water.

FIGURE 4. SEASONAL COMPARISON OF AQUATIC CHLOROPHYLL CONTENT OF THE NOXUBEE AND YAZOO REFUGES.



Throughout most of the year significantly higher chlorophyll concentrations were observed at the Yazoo Refuge. Only during early October, November, and early March were chlorophyll concentrations higher on Noxubee (Figure 4).

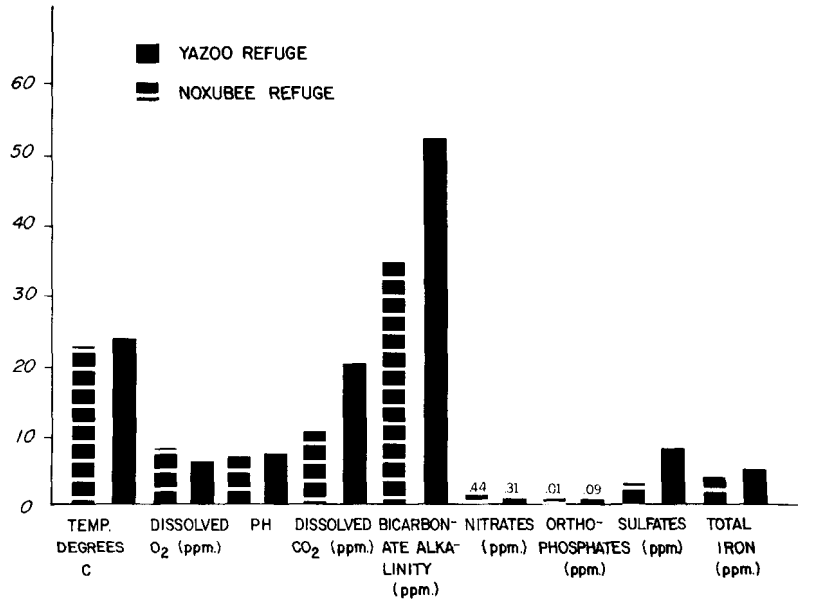
At the Yazoo Refuge a fall peak of chlorophyll concentration was observed in late October (118 ppm). A season low of 9 ppm occurred in December. Two spring peaks appeared at Yazoo, the first in late February (97 ppm) and the second in May (120 ppm). An extremely rapid decline of chlorophyll concentration was noted in early March when a low of 39 was observed. This low period of production was attributed to dilution caused by flooding.

A fall peak at Noxubee was recorded in late October (93 ppm). The lowest value occurred in December when 8 ppm was recorded. Two spring peaks also occurred at Noxubee although they were not as pronounced as the spring peaks at Yazoo. A maximum peak occurred in late February (59 ppm) and a lower peak (49 ppm) appeared in May (Figure 4).

Water and Soil Chemistry

Analysis of water samples showed that carbon dioxide, phosphates, sulfates, and bicarbonate alkalinity were significantly higher in the Yazoo Refuge than in the Noxubee Refuge (Figure 5). The total concentration of dissolved substances or minerals in natural waters is a useful parameter in describing the chemical density as a fitness factor, and as a general measure of edaphic relationships that contribute to productivity within the body of water (Reid 1965).

FIGURE 5. A COMPARISON OF WATER QUALITY DURING MAY, 1970, FOR THE TWO STUDY AREAS.



Soil analysis revealed that Noxubee soils were more acidic than the soils at Yazoo. The mean pH for the soils at Noxubee was 5.1, while the mean pH for Yazoo was 6.1. Available phosphate was rated high in both refuges, and available potash was rated very high in the Yazoo Refuge and low in the Noxubee Refuge.

The analyses of the Delta soils in the Yazoo Refuge and the Interior Flatwood soils of t e Noxubee Refuge agree with results reported by Vanderford (1962) which showed that only 11 percent of the Delta soils were low in available phosphorous and only eight percent of the soils tested were low in available potassium, while the Interior Flatwood soils were found low in phosphorous and potassium.

It was evident that more dissolved solids were available in the Yazoo ecosystem than in the Noxubee ecosystem.

SUMMARY AND CONCLUSIONS

Water chemistry revealed that the Yazoo Refuge had greater concentrations of several important dissolved solids and more carbon dioxide than the Noxubee Refuge.

Soil analysis showed that the Yazoo soils were higher in potash and less acid than the Noxubee soils. This difference in inherent fertility is reflected in higher phytoplankton concentrations in the Yazoo Refuge.

A larger biomass of invertebrates was found in the aquatic plant communities of the Yazoo Refuge during the critical winter and spring seasons than in the Noxubee Refuge.

Examination of animal items found in the gullets of young ducks showed that the major groups of invertebrates eaten by the ducklings were being collected in the sampling procedure used with the exception of one family, the Mesovelidae, which did not appear in our samples but was found in the gullets of a number of ducklings.

On the basis of the data collected in this study, the aquatic ecosystem of the Yazoo Refuge was more fertile and more productive of plant and invertebrate life than the Noxubee Refuge.

We feel that the differences in ecosystems very probably have influenced wood duck productivity.

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