

ECOLOGY

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ABSTRACTS

Changes in Yellow Bass Growth Rates and Density During the First Ten Years of Its Establishment in Monroe Reservoir. ROBERT L. BALL, Indiana Department of Natural Resources, Avoca, Indiana 47420.—Growth rates of yellow bass, *Morone mississippiensis*, in Monroe Reservoir have declined rapidly since the first native year class developed in 1969. At the third annulus, back-calculated growth of the 1969 year class averaged 26.2 cm, compared to 19.6 cm for the 1976 year class. Most of the loss of growth has occurred by the end of the second year of life. Growth during the first year of life prior to 1974 averaged 12.0 cm, while it dropped to an average of 9.7 cm in the following five years. Average growth increments during the second year of life decreased 2.1 cm during the same period.

Growth in terms of annual length increments indicates that growth has not decreased steadily and is not inversely related to density of yellow bass, although density in terms of kg/ha. of yellow bass has increased over the 10 year study period.

Although the size of yellow bass in the Monroe sportfishing catch was good initially (fish averaged 0.13 kg each in 1973 and 1974), the mean weight dropped to 0.10 kg in 1979. Reduced weight and presence of a bacterial infection in the adult population of this species was followed by a reduction in sportfishing harvest of yellow bass in 1979. Limited food supply seems to be the immediate cause of poor growth. Reduction of growth of larger bluegill, and both reduced growth and reduced abundance of yellow perch in Monroe, indicate a dearth of small crustaceans and larval insects for which these three species appear to be competing in the open areas of the lake. Also, a lack of open water predators, such as white bass and walleye, may have contributed to the decline in yellow bass growth rates.

Habitat, Food, and Life History Overlap in Temporary Pond Snails: Evidence for Competition. KENNETH M. BROWN, Department of Biological Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.—Ponds ranging from heavily wooded and temporary to open and permanent in nature were quantitatively sampled for a period of three years to study niche relationships among the guild of pulmonate snails inhabiting them. *Aplexa hypnorum* and *Helisoma trivolvis* were specialists in, respectively, wooded temporary ponds, and open permanent ponds. *Lymnaea elodes* and *Physa gyrina* were more common in partially wooded, temporary ponds. Food selection experiments indicate that *A. hypnorum* specializes on detritus, and *L. elodes* on periphyton, but that *P. gyrina* and *H. trivolvis* are generalists. Overlap in life history patterns indicates that congeners should rarely co-exist, and field data supports this hypothesis. Finally, field manipulation experiments indicate that faster growing species, that are food specialists, are better competitors.

Detrital Dynamics Regulate Mosquito Production in Treehole Ecosystems.

STEPHEN R. CARPENTER and DURLAND FISH, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.—Production of the treehole mosquito *Aedes triseriatus* is intimately linked to the rate of decay of leaf litter. Scanning electron micrographs reveal that mosquito larvae consume fungal hyphae and bacteria from surfaces of decaying leaves. Abundance of microbes is strikingly reduced by mosquito feeding, suggesting intense competition among larvae for food. Although mosquitoes reduce the abundance of the microflora, they increase its rate of respiration and thereby increase the rate of production of microbial biomass.

A laboratory comparison of mosquito production at five larval densities (5, 10, 20, 40, and 80 larvae) in microcosms composed of 300 ml of water and 1 g of either sugar maple, black oak, or beech leaf litter demonstrated that maple leaves are superior, and oak leaves are inferior, producers of mosquitoes. Maple leaves decompose faster than oak and beech leaves. Decay rates of detritus increase with increasing larval density, presumably because thinning of the microflora by mosquito feeding enhances the metabolism of the detritus. However, this effect is confounded by heavy mortality of larvae at high densities. Density dependent mortality was more severe on oak and beech than on maple. As larval density increases, elapsed time until pupation increases while substantial decreases in survivorship, pupal weights, and production occur. Our results suggest that strong density dependent regulation of larval mosquitoes occurs in nature, and that competition for food is the means of this regulation.

Limiting Nutrients and Primary Productivity.

WILLIAM Y. B. CHANG, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan 48109.—Lake Monroe is the largest reservoir in Indiana with a daily mean productivity of 200 mgC/m²/day in an observed range from 26 mgC/m²/day to 714 mgC/m²/day. It is a medium soft reservoir; the acid combining capacity varies from 0.28 - 0.71 meq./l with a mean slightly above 0.5 meq./l. The results of diurnal changes in major nutrients, the C, N, and P ratios, and bioassay experiments indicated that phosphorus is the major limiting nutrient on algal photosynthesis in this lake. Surface photo-inhibition may be used to indicate the sufficiency of light for the species of algae in the water. The low productivity in December, January, February, and early March can be attributed to light limitation due to low water transparency.

Attrition of White Ash in Red Pine Plantations in Eastern New York.

WILLIAM BLISS CRANKSHAW, Department of Biology, Ball State University, Muncie, Indiana 47306.—White ash (*Fraxinus americana*) has a high mortality in Red pine (*Pinus resinosa*) plantations in glaciated areas of eastern New York. Ash reproduction, from seed disseminated by wind, is one of the most common woody plants occurring in the red pine plantations. A high mortality of this ash occurs at the pole stage (4-6 inch d.b.h.). A positive correlation was determined between the percent slope and ash mortality in plantations with equivalent spacing of pines.

Success of Bald Cypress Seedlings in the Drawdown Zone at Salamonie Reservoir.

WILLIAM BLISS CRANKSHAW, Department of Biology, Ball State University, Muncie, Indiana 47306.—In the spring of 1974 over 1000 two year old bald cypress seedlings were planted in the drawdown zone at Salamonie Reservoir on the Upper Wabash watershed. Plantings were made on sites which varied in vegetation covers, percent slope, exposure, and soil texture. An evaluation of bald cypress

establishment was made in 1980. Approximately one third of the planted seedlings survived. The highest establishment rate occurred behind groves of black willows which minimized damage from driftwood and ice floes at high pool level.

Effect of Habitat Productivity, Permanence, and Predation on the Life History of A Temporary Pond Snail. DENNIS DEVRIES, Department of Biological Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.

—Two temporary ponds and one permanent pond in northeastern Indiana support populations of the pulmonate snail *Lymnaea elodes*. Physico-chemical parameters vary among ponds with overall mean temperature and dissolved oxygen levels the highest in the permanent pond. Periphyton growth rates are also higher in the permanent pond. Field rearing experiments with predators excluded show that survival, growth, and reproductive rates are highest in the permanent pond as expected if the populations are food limited. However, populations reach the highest density in one of the temporary ponds where minnows are absent. Hence, vertebrate predators may control populations in more permanent ponds, and productivity may be important in vernal ponds.

Periphyton Productivity of Three Sample Sites along Juday Creek, St. Joseph County, Indiana. JOHN S. FEZY, and RICHARD W. GREENE, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.

—Periphyton productivity is being measured at three different types of stream settings along Juday Creek, a first order stream which empties into the St. Joseph River in northwestern Indiana. The sample sites include areas where the stream passes through agricultural land, residential and natural habitats. Glass slides are being used as artificial substrates in both horizontal and vertical position to monitor periphyton production. It is measured at 3 week intervals and is based upon ash weight. Physical stream parameters and water chemical analysis are being conducted to determine whether there are nutrient fluctuations through the seasonal changes and what part, if any, they may play in productivity in this particular aquatic ecosystem. Periphyton production has been greatest in the agricultural setting, while the natural habitat has exhibited the least. Correlation between biomass fluctuation, discharge and water temperature has been observed. The amount of water flowing over the cells is an important aspect of the productivity within a stream ecosystem, continuously supplying and removing nutrients and various waste products from the zone of diffusion about each cell. The same general trends have been noted for both horizontal and vertical substrates, however, more definite relationships have been observed on vertical substrates than on horizontal ones.

An Updated Evaluation of Sampling Efficiencies of Overstory Sampling Methods.

STEPHEN W. FLETCHER, Environmental Science and Engineering, Inc., Gainesville, Florida 32604.—In 1958, Lindsey, Barton, and Miles published a comparison of sampling efficiencies of various forest sampling methods, tested in an Indiana forest. A recent assessment of methods in southern Louisiana allowed an opportunity to use similar evaluation methods for comparing sampling methods along wetland-upland gradients and to comment upon the applicability of their conclusions for other regions.

Study sites involved wetland, upland, and intermediate areas in cypress-tupelogram, southern mixed hardwood, and oak-pine communities of various ages. Each of two study sites were divided into the three zones, and a tally was made of all trees within 10m by 10m grid units. Six quadrat variations and two plotless

methods for overstory density and basal area, as well as two cover estimation methods, were evaluated. This evaluation was based upon sampling efficiency and accuracy as compared to the relative importance values from the tally results.

Using the concepts of %SEM and "constant adequacy level", it was determined that circular quadrats, plotless methods, and cover estimates all were more efficient than square or rectangular quadrats. Plotless methods, although efficient, were not as accurate in depicting true species composition, as measured by Sorenson's similarity index comparisons to the tally results.

It is concluded that for most quantitative sampling programs, range-finder-measured 100m² circular quadrats (in conjunction with the Bitterlich variable radius method for basal area) are best suited in this region as well as in Indiana communities. However, when there is less need for statistically defensible data, simple cover estimates can produce virtually identical results with greater efficiency. In certain conditions of low species diversity or sufficient stand size, the plotless methods may be the best methods. Such conditions must be properly validated on a site specific basis if dependable results are to be obtained with the plotless methods.

Macrophyte Induced Fluctuations of Water Chemistry in an East-Central Indiana Borrow Pit Lake. PAUL A. GLANDER and THOMAS S. MCCOMISH, Department of Biology, Ball State University, Muncie, Indiana 47306.—Selected water chemistry parameters were measured in a 3.2 ha borrow pit lake from June to October in 1978 after preliminary evaluation in 1977. Data were collected at a macrophyte station in shallow water and at a control station void of macrophytes in deep water.

Dense beds of *Potamogeton pectinatus* L. and *P. pusillus* L. dominated at the macrophyte station. Dry weight macrophyte biomass, including associated *Aufwuchs*, peaked in July but was gone by August.

Photosynthesis at the macrophyte site accounted for elevated dissolved oxygen, and biomass was positively correlated with total dissolved oxygen. Respiration over night was positively correlated with biomass and accounted for lower morning dissolved oxygen. Photosynthesis increased pH and respiration lowered pH over night on most sample dates but the relationship was not significant.

Macrophyte biomass had little influence on daily total alkalinity, however, there was a positive correlation with seasonal levels. Photosynthesis increased evening CO₃²⁻ alkalinity and decreased HCO₃⁻ alkalinity. Morning levels of CO₃²⁻ alkalinity were lowered due to respiration while HCO₃⁻ alkalinity increased. Macrophyte biomass was positively correlated with CO₃²⁻ alkalinity and negatively correlated with HCO₃⁻ alkalinity.

The summer water chemistry dynamics of the lake were clearly regulated by littoral submerged aquatic macrophytes and associated *Aufwuchs*. These results demonstrate the impact of dense aquatic macrophytes on general water chemistry of shallow lentic systems in central Indiana.

A Comparison of the Effect of Aluminum on a Single Species Algal Assay and Indigenous Community Algal Toxicity Bioassay. JOANNE M. PAYTON and RICHARD W. GREENE, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.—Since the enactment of the Toxic Substances Control Act (TSCA, PL 94-469) there has arisen a definite need for developing methods to evaluate the effects of toxic substances on aquatic organisms relative to the prediction of the effects on natural populations. This study simultaneously examines the

effects of varying concentrations of aluminum at pH 5.0 on *Scenedesmus bijgua*, and on the indigenous phytoplankton community from Fishtrap Lake, LaPorte, Indiana. Experiments with algal assays have shown that there is a marked decrease in cell growth as aluminum concentrations increase from 500 ug/l to 1000 ug/l Al. In the case of the indigenous phytoplankton community assay, plots of diversity versus time exposed to aluminum show an initially higher diversity index with a higher aluminum concentration. The plots also indicate a more dramatic decline in diversity as time progresses in the assays containing 1000 ug/l Al.

Growth and Phosphorus Uptake as a Function of Temperature in the Colonial Green Alga *Volvox globator* L. KEN ROBERTS and W. HERBERT SENFT II, Ball State University, Muncie, Indiana 47306.—The growth of *Volvox globator* L. was measured at five different temperatures and nine different phosphorus concentrations. Growth rate was hyperbolically related to phosphorus concentration for all temperatures using a Monod growth model. Optimal growth rates were dependent upon temperature and varied from 0.20 div/day ($T = 10^{\circ}\text{C}$) to 1.17 div/day ($T = 20^{\circ}\text{C}$). No growth occurred at 30°C . Phosphorus uptake by *V. globator* was found also to be dependent upon external phosphorus concentrations and temperatures. Maximal uptake occurred at 30°C . The lack of growth of this algae at 30°C , therefore, is not caused by physiological restrictions on phosphorus uptake.

The Small Mammals of Spencer County, Indiana. ROBERT K. ROSE, Old Dominion University, Norfolk, Virginia 23508.—The small mammals of Spencer County, Indiana were examined during 4 studies conducted on a 1498 ha site near Rockport from 1973 through 1977, and briefly at nearby locations in late 1977. In all, 7 forest and 8 oldfield plots were studied on the Rockport site. Oldfields had both more species and more individuals. Prairie voles predominated in oldfields and white-footed mice in forests. Two concurrent snap- and pitfall-trapping studies revealed the presence of relatively large numbers of southeastern shrews, and in 1 study these shrews were the second most numerous species on the Rockport site. Pitfall traps yielded more species but fewer individuals than snap traps. The mammals collected in the county included 4 insectivores, 3 microtine rodents, 2 Old World murid rodents, white-footed mice, and meadow jumping mice. Analysis of barn owl pellets collected from a roost near the site provided an independent estimate of the composition of small mammal populations and also revealed the existence of the eastern cottontail and eastern woodrat. This study, which confirms the absence of the meadow vole in Spencer County, also provides new information about local abundance of southeastern shrews and southern bog lemmings and new distributional records for meadow jumping mice and both masked and southeastern shrews.

Trends in the Climatic Adaptations of Lichens. ROBERT SCHWARZWALDER, JR., Department of Biology, Indiana University, Bloomington, Indiana 47405.—Lichen ecology has traditionally shown a distinct bias toward temperate and boreal ecosystems. The dearth of research on subtropical and tropical ecosystems has resulted in unwarranted generalizations and an underestimation of the complexity of the lichen symbiosis. In an investigation of corticolous epiphytes in southern Louisiana I discovered variations in horizontal zonation patterns on isolated tree boles, microhabitat utilization and niche specialization which differed from patterns noted in temperate and boreal lichen studies. Personal observations on the microhabitat preferences of *Candelaria concolor* (Dicks.) Stein., a minutely foliose lichen common throughout the continental United States, and a French study of climatic influences on corticolous epiphyte distributions in Java indicate decreas-

ing horizontal zonation and increasing microhabitat specialization with decreasing latitude. Latitudinal distribution also correlates with the growth form of lichens: fruticose forms being more abundant in cooler climates; crustose lichens, in warmer climates. Like other organisms, lichens display an increased diversity in form and niche specialization in tropical and subtropical climates. Variations in lichen growth appear to be due to differences in illumination, temperature, humidity and precipitation. Further study of these variations will expand and may reshape our understanding of the lichen symbiosis.

Seasonal, Spatial and Developmental Variability of Benthic Macroinvertebrates in a Northern Indiana Stream. BRUCE W. SCHWENNEKER and RONALD A. HELLENTHAL, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.—Variability in the seasonal and spatial distribution of 29 benthic macroinvertebrate taxa from a riffle area of Juday Creek, a first order tributary of the St. Joseph River, was evaluated from November 1979 to May 1980. Five samples along each of three transects in an apparently uniform riffle area with an average velocity of 2.3 m/sec. were collected during November, January, April and May using a Hess Sampler. Organisms were separated from the substrate using sugar flotation, and were identified, sorted by instar, size or stage, and counted. Samples from each transect and sampling date were compared using analysis of variance, and components of variation attributable to location and date were estimated for each taxon. Season, stage, and location were found to affect both the densities of organisms and sample variability. Late instars of *Chimarra obscura* (Walker) (Trichoptera: Philopotamidae) had sample standard deviations which ranged from 6.8 to 0.53 on different dates. Sample variances for this species also varied along transects where samples taken near the center of the riffle had standard deviations as much as 4 to 8 times greater than those collected closer to the riffle margins. Sample variability also differed among life cycle stages and instars of the same species. Pupae of *Symphitopsyche sparna* (Ross) had a coefficient of variation more than 3 times larger than last instar larvae. Since sample variability directly affects the assumptions and power of statistical tests, excessive and inconsistent sample variation complicates sampling strategies, experimental designs, and analyses. In studies of benthic communities employing secondary production or diversity measurements these complications may be profound. A preliminary sampling program can be used to identify and to estimate important components of sample variance. These estimates may be used in the development of efficient and effective sampling schemes.

Spatial Patterning of a *Volvox Globator* L. Population in a Northern Minnesota Pond. W. HERBERT SENFT II and ARTHUR J. WHITE, Department of Biology, Ball State University, Muncie, Indiana, 47306.—The spatial distribution of the colonial green alga *Volvox globator* L. is remarkably non-uniform in nature. Detailed sampling of a small, northern Minnesota pond in Lake Itasca State Park revealed a distinct clumping and aggregating pattern that is not related to wind mixing. The abundance of *V. globator* colonies in the water column varied tremendously ranging from 0 colonies/ml to a high of 17.5 colonies/ml. Dense aggregations of *V. globator* colonies were always associated with shallow water (<0.50 m) and areas of macrophyte abundance. In particular, the densest concentration of colonies was found in shallow water (<0.40 m) directly above a large mat of aquatic moss. It is not known whether macrophytes produce chemical changes in the water column necessary for *Volvox* growth or simply provide a structural retreat for the algal colonies. It is certain, however, that any quantitative samplings of *Volvox* popula-

tions in small ponds must take into account the complex distributional patterns of these algae.

Relationships of Algal Trophic State Indices in Indiana Lakes and Reservoirs.

PATRICK F. SULLIVAN and STEPHEN R. CARPENTER, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.—A comparison of 14 trophic state indices was based on 42 phytoplankton samples from 22 Indiana lakes and reservoirs. Trophic state indices included: Nygard's Myxophycean, Chlorophycean, Euglenophycean, diatom, and compound indices; Palmer's genus and species indices; average diversity (H'); number of taxa; maximum diversity; cell concentration; evenness; mean number of taxa/ml; and concentration of the most abundant taxon. We used principal components analysis to determine the patterns of indices in sample space and samples in index space. Distortion due to curvature ("the horseshoe effect") was corrected by projecting points onto tangents of the arc of a quadratic fit to the ordination results, evidently a new method of linearizing curved ordination spaces.

Average diversity explained about 80% of the total inter-lake variation. Peak average diversity occurred in mesotrophic samples, and average diversity decreased toward both oligotrophic and eutrophic ends of the gradient. Because average diversity varies non-monotonically with degree of eutrophication, comparisons based on average diversity alone can yield misleading conclusions about relative trophic state. On the other hand, classical indices of trophic state (Nygard's, Palmer's, number of taxa, and cell concentration) appear to be monotonically related and yield more or less convergent results. We suggest that a species list (from which Nygard's and Palmer's indices are calculated) and a simple measurement of cell concentration provide a relatively reliable assessment of the trophic state of the phytoplankton. Little additional information about trophic state is obtained from the considerable labor involved in the species-specific cell counts needed to calculate average diversity.