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ECOLOGICAL STUDIES OF SOME DOLINE PONDS IN EAST TENNESSEE[1]

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The doline ponds in this study are located in the Tennessee section of the Ridge and Valley Physiographic Province which extends from the St. Lawrence Valley to the Coastal Plain of Alabama, a distance of about twelve hundred miles. It is the folded and faulted eastern part of the Paleozoic Interior Sea. The section of the province running through East Tennessee is bounded on the east by the Unakas and Great Smoky Mountains of the Blue Ridge Province and on the west by the Cumberland Mountains and Cumberland Plateau of the Appalachian Plateau Province. Its greatest width in this section is about forty miles.

The particular region under consideration surrounds Jefferson City which is in this section of East Tennessee. Jefferson City is about two and one-half miles from the Holston River, which flows in the direction of the longitudinal axis of the Ridge and Valley Province and is about equidistant from its eastern and western boundaries.

The underlying rock is predominantly dolomite (sedimentary), apparently of Cambrian or Ordovician age. Solution erosion has given the entire countryside the aspects of mature karst topography where the drainage is mainly underground. The underlying rock is literally honeycombed with subterranean passages. In many cases the roofs of these passages have collapsed and left the surface dotted with sinkholes of varying sizes and shapes. In the Jefferson City area they tend to be circular and usually have gentle sloping sides. They might well be described as funnel-shaped. Sinkholes of this type are known as dolines.

Drainage in dolines is toward the center, thence to underground channels. Whenever the drainage passages become clogged, water accumulates in small lakes or ponds. Most of the water comes from surface drainage, rarely from streams flowing into them. There are exactly one hundred ponds, which are nearly all of the doline type, within a four mile radius of Jefferson City's City Hall (Topographic maps, 1939 edition).

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In this region where most of the streams are underground, doline ponds are very important economically as watering holes for cattle. Almost all of them are included in pastures. Farmers say that some of them are twelve to fourteen feet deep, but most are less than half that depth. Some fill quickly by silting, but since they have economic value, farmers keep them scooped out as it becomes necessary. Some of the ponds, especially small shallow ones, dry up frequently in the summer; others have not been dry as long as some of the older farmers can remember. Occasionally, a pond will come into existence when the underground drainage passages are blocked, or one may disappear just as suddenly when the drainage channels become unstopped. Water levels fluctuate considerably with variations in rainfall and evaporation.

Aside from some general observations over a three year period, most of the detailed information comes from an intensive study beginning the first of June and extending through mid-July (1956), thus portraying their late spring and early summer aspects. In all, fifteen ponds were studied. Two ponds, Hodge and Swann, were given special, daily attention for one month.

Hodge Pond

Hodge Pond is located on the Collins Road about three miles from Cherokee Dam near Jefferson City. Comprising one acre at the time of the study, it occupied about another half acre at high level. The watershed area around the pond occupies fourteen acres, mostly of gentle grassy slope, providing pasture for dairy cows. Lying in a bowl-shaped depression, it was cleared of silt about fifty years ago and has been an all-year pond since 1945.

Almost daily a green heron (*Butorides virescens virescens* L.) and five killdeers (*Charadrius vociferus vociferus* L.) were at the pond's edge. Rough-winged swallows (*Stelgidopteryx ruficollis serripennis* Audubon) and kingbirds (*Tyrannus tyrannus* L.) skimmed the surface intermittently. Goldfish abound in the pond, attaining a length of seven inches. The most notable aspect of the pond in summer is the "water bloom" of the blue-green alga, *Polycystis,* which forms a floating layer and penetrates the water as well. The dairymen informed us that cows will not drink from the pond when it is like this, going rather to the barn for their water. After July 3, a small portion of the pond was covered with *Euglena sanguinea* Ehr. About that time, the fish appeared to be dying at an accelerated rate, forty-six dead ones being counted on July 5.

Surface water was slightly alkaline seventeen days, slightly acid nine days, and neutral four days. On the other hand, the bottom water was slightly alkaline only three days, acid twenty-five days, and neutral two days. Temperature variations near

the bottom were much less than at the surface, ranging from two to eleven degrees F. in a twenty-four hour period, with six degrees being the most frequent variation. Surface temperatures varied as much as twenty-four degrees in the same period, with maximum temperatures running to 101 degrees. Temperatures were taken from anchored maximum-minimum thermometers.

Swann Pond

Swann Pond, located on the north side of the dual-lane highway two miles east of Jefferson City, originally occupied an area of about one and a half acres. When the new highway was constructed, about half of it was filled. During the thirty day study, the water level fell about six inches, contracting the area still more. Its watershed is about eight acres, partly of woods and partly of grassy pasture. The water is relatively clear with no "water bloom", so cows come to the pond for water. Willows (14 years old), spike-rush, sedges, and roses (*Rosa setigera* Michx.) are along the edge; pondweed is in water.

A green heron, rough-winged swallows, and kingbirds were usually seen at this pond. No fish were found after extensive seining. Insects were much more abundant than in the Hodge Pond. There were damselflies, dragonflies, water bugs, culex mosquitoes, water boatmen, whirligig beetles, and mayflies.

The water was usually slightly alkaline, with a range in pH from 6.4 to 9.2 at the surface and 7.2 to 9.6 at the bottom. Bottom temperatures varied as much as ten degrees F. in a twenty-four hour period; top temperatures varied a maximum of 17 degrees. The maximum surface temperature was ninety-seven degrees F.

The total rainfall of 2.70 inches during the period of study was not enough to keep the water level from falling in either pond. Atmospheric temperatures for the same period were minimum 57 degrees F. and maximum 94 degrees F.

Ponds In General

Bottoms

About ninety percent of doline ponds in this region have soft muddy bottoms ranging in depth from three inches to two feet (Miller Pond). The average seems to be close to six inches. Mr. Crawford scooped out a section of Swann Pond when it was dry two years ago. He said there were about fourteen inches of clay over about sixteen inches of blue mud. Below the blue mud were about eight inches of "lime". Godwin Pond had a sandy, gravelly bottom.

Marginal Vegetation

The amount of marginal vegetation is closely related to the degree of water level fluctuations as well as to the amount of

disturbance around the banks. The water levels of small, shallow ponds fluctuate so much that they may not have any strictly hydrophytic plants around them. Instead, common grasses and weeds grow close to the water's edge. Since most ponds are in pastures, browsing animals seldom give plants much of a chance to get started. The marginal plants most frequently found around cleared pasture ponds are spike-rush (*Eleocharis obtusa* [Willd.] Schultes). rushes (*Juncus spp.*), sedges (*Carex* spp.), cattail (*Typha latifolia* L.), and willow (*Salix nigra* Marsh.). These are usually present in small quantities. One exception is a pond near Unaka Motor Court where cattails grow in a marginal bed at least twenty feet wide. Pondweed (*Potamogeton diversifolius* Raf.) is present in shallow water.

One pond near the City Water Works is located in the woods. Here, sycamore (*Platanus*), elm (*Ulmus*), hackberry (*Celtis*), ash (*Fraxinus*), and willow (*Salix*) fringe the banks. Buttonbush (*Cephalanthus occidentalis* L.) grows on the banks and in the shallow water along the edge. More than fifty per cent of the pond is filled with a rhizomatous grass which seems to be *Glyceria* sp. Pondweed (*P. diversifolius* Raf.) grows among the grass.

Protozoa

The ciliates abound in kind and number. *Loxodes, Oxytricha,* and *Paramecium* are three of the free swimming forms. *Vorticella* and *Epistylis* are two attached forms. *Epistylis* can be collected from the shells of nearly all painted turtles, which seem to be in all the ponds. Shells of ameboid protozoa in the order Testacea can be seen occasionally.

Among the flagellated protozoa, Euglenas occur in such abundance that they may cover the entire water surface with a scum. There are several species among which are the easily recognized ones, such as *E. sanguinea* Ehr., *E. viridis* Ehr., and *E. spirogyra* Ehr. *Chlamydomonas* and *Sphaerella* were taken from a small pond on Black Oak Road; *Phacus* and *Trachelomonas* were taken from Simpson Pond.

Worms

The flatworm *Planaria* is in the Reservoir Pond, and *Dalellia,* also a flatworm, is in the Thomas Pond. Nematodes are in almost all water samples. They and the rotifers (trochal worms) are by far the most abundant of worms. One rotifer was identified as *Anuraea.* Another trochal worm of the Gastrotricha group was collected several times. The annelid worms most frequently seen were leeches. Some were attached to turtles while others were attached to all types of debris. There were earthworm-like annelids under leaves in the Reservoir Pond.

Mollusks

Only two kinds of snails were collected. *Physa,* a sinistral type, predominated. *Planorbis,* a discoidal type, was collected twice.

Crustaceans

Minute crustaceans could be found almost every time we looked for them. The three types were water fleas (*Daphnia*), copepods (*Cyclops*), and ostracods. We saw crayfish burrows around the Reservoir Pond.

Insects

Representatives of eight orders of insects were identified. Collembola was represented by a few specimens of water springtails in family Smynthuridae. There were some mayfly nymphs of the order Ephemeroptera. Both adults and nymphs of Odonata were at all ponds. Dragonfly nymphs included *Anax, Celithemis, Gynacantha, and Libellula;* damselfly nymphs included *Chromagrion, Enallagma, Hesperagrion,* and *Nehallennia.* Genera and species from Coleoptera were *Coptotomus, Cybister, Dineutes assimilis* Kby. (whirligig beetle), *Hydroporus undulatus* Say (predaceous diving beetle), *Matus bicarinatus* Say (predaceous diving beetle), *Tropisternis striolatus* Lec. (water scavenger beetle), and *Psephenus lecontei,* Lec. From Hemiptera, there were *Belostoma* (giant waterbug), *Buenoa, Corixa, Gerris* (water strider), *Lethocerus, Notonecta* (back swimmer), *Ranatra* (water scorpion), and *Rheumatobates.* The hellgramite or dobsonfly larva, genus *Chauliodes,* was the only insect seen from Neuroptera. Trichoptera were evident in the form of numerous larval cases attached to rocks and submerged logs. Diptera had three genera, *Chironomus* (true midge), *Dixa* (midge), and *Culex* (mosquito). Midge larvae seemed to be most abundant; mosquitoes were scarce.

Arachnids

Some strictly aquatic arachnids, the water mites, were in the Godwin and McMurray Ponds. The Godwin Pond was literally teeming with both immature and adult hydrachnid mites, apparently *Neumania spinipes* Muller.

Chordates

Mr. James Henry, who has seined local ponds extensively, says he has caught only warm water species. He has caught Baltimore minnows (*Carassius auratus* L.), bream (probably *Lepomis*), bull-head catfish (*Ictalurus* sp.), carp (*Cyprinus carpio* L.), mud minnows (*Umbra pygmaea* Dekay), and white suckers (*Catostomus commersonnii commersonnii* Lacepede). He and others report catches of bass where ponds have been stocked. It is a common practice to stock larger ponds with bass, bluegill, crappie, drum, and saugers; but from all indications they do not survive well. We collected Baltimore minnows, catfish, goldfish (*Carassius auratus* L.), and sunfish (probably *Lepomis*).

Frogs are the most abundant amphibians. Adult bullfrogs (*Rana catesbeiana* Shaw) and grassfrogs (*Rana pipiens* Schreber) are in almost all of the ponds, as are also tadpoles of all

sizes. Toad eggs were seen in Rankin Pond (Lebanon Community). Some small salamanders were in the Reservoir Pond.

The painted turtle (*Chrysemys picta picta* Schneider and intergraded forms) appears to be present in all ponds. The snapping turtle (*Chelydra serpentina serpentina* L.) was caught in one-fifth of the ponds studied. A twenty-nine pound specimen was caught in Miller Pond (Lebanon Community) last year. Even the box turtle (*Terrapene carolina carolina* L.) was observed playing in one of the ponds.

The only mammal known to be closely associated with the ponds is the muskrat.

Algae

The algal flora was consistently rich in variety. The plankton and shallow water types were most common. Some genera (or species) were found in almost every pond; others were found only once. Some were abundant enough to give a distinct aspect or to definitely influence other life present. Such was the case of *Polycystis* in Hodge Pond. The water was so thick with *Polycystis* that when samples were allowed to set for a while, fully one-third of its volume settled in a gelatinous mass to the bottom of the jar. It is reported that this alga is responsible for killing fish by suffocation. It may be true, for dead fish were frequently seen, not only this year but in previous years. Other ponds had a bloody appearance due to *Euglena sanguinea* Ehr. This bloody bloom usually begins to appear toward the last of May and continues into fall. The best concentrations of this species seemed to be in ponds near barns where the water-shed was rich with manure.

Oscillatoria spp. were the most frequent blue-green algae. Others were *Anabaena, Anabaenopsis, Chroococcus, Holopedium, Merismopedia, Polycystis, Spirulina,* and *Synechococcus.*

The diatoms were always present. Those occurring most frequently were *Brebissonia, Gomphonema, Navicula, Stauroneis,* and *Synedra.*

From order Tetrasporales of the green algae, there were *Gloeocystis, Palmella,* and *Sphaerocystis.* From order Ulotrichales, there were *Stichococcus bacillaris* Nag. and *Ulothrix.* From the Oedogoniales, there were *Bulbochaete* and *Oedogonium.* The former was found only in Thomas Pond while the latter was in several places. From the Chlorococcales, there were *Ankistrodesmus falcatus* (Corda) Ralfs., *Characium, Closteridium lunata* Reinsch, *Closteriopsis, Coelastrum, Crucigenia tetrapedia* (Kirchner) W. and G. S. West, *Dictyosphaerium, Kirchneriella, Oocystis, Palmellococcus, Pediastrum boryanium* (Turp.) Menegh., *Pediastrum simplex* Meyen, *Polyedriopsis spinulosa* Schmidle, *Scenedesmus, Selenastrum,* and *Tetraedron.* From the Zygnematales, there were numerous desmids and *Spirogyra.* Some of the desmids were *Arthrodesmus, Closterium,*

Cosmarium bioculatum Breb., *Cosmarium* spp., *Micrasterias, Netrium, Pleurotaenium,* and *Staurastrum natator* var. *crassum* W. and G. S. West. A few small tufts of *Chara,* which occupies an uncertain taxonomic position, were in one-fifth of the ponds.

Summary

1. Doline ponds which are products of solution erosion, are numerous around Jefferson City, Tennessee.
2. They are economically important primarily as water-holes for cattle, but are also used as farm fish ponds and swimming holes.
3. At certain times, some of them have conspicuous aspects due to an abundance of algae or protozoa.
4. In general, marginal vegetation is scarce, but a few species frequently occur in small quantities.
5. A detailed comparison of the ponds reveals considerable differences in water characteristics as well as in the fauna and flora.
6. Protozoa and algae abound in variety and quantity.
7. Groups of animals represented in the fauna are Flat Worms, Round Worms, Annelid Worms, Molluscans, Crustaceans, Insects, Arachnids, Fish, Amphibians, Turtles, and one representative of Mammalia.
8. College students of biology and high school pupils studying biology will find ponds, such as those studied and here reported, most interesting as natural aquaria. Studies over a period of one year or longer should yield interesting and meaningful results. We commend pond studies to our readers and to students of general biology everywhere.

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