Lake Life: **Mayflies**

Diane Lauritsen

Are they a blessing or a nuisance? That was the question I posed in my very first newspaper article, and the subject was mayflies.

I had been working at a shallow natural lake in the Coastal Plain of North Carolina called Lake Waccamaw and had gotten interested in sharing what I knew about lake life with school groups and interested grownups; I then found that a newspaper column could be an even more effective way of sharing stories about the lake and its inhabitants.

It seems that my story about mayflies – written decades ago, I must now confess – continues to resonate as these aquatic insects begin their annual synchronized escape from the lake to the lakeshore landscape. The blessing their presence offers is a very visual sign of the health of a lake that is beloved by the people who live there.

Safety in the sediments

Mayflies are best known for the shortness of their time out of water; the scientific name of the group, Ephemeroptera, recognizes this ephemeral stage of their life. But it is the aquatic stages of their life, lasting for one or two years, that is critical to the success of these fascinating aquatic insects.

Success starts with finding a suitable place for their eggs to hatch and finding enough to eat while at the same time avoiding being eaten. The kind of mayflies found in lakes are called burrowing mayflies, as they find both food and safety from predators in the lake sediments.

Burrowing mayfly nymphs have excavation equipment attached to their head, in the form of two curved tusks separated by a shovel-like plate. They construct u-shaped burrows in soft sediments and have the ability to move water through their burrow by beating the rows of feathery gills attached to either side of their abdomen. This flow can provide particles of food, such as algae and detritus, and exposes their gills to oxygenated water. Lake Waccamaw is a relatively shallow, well-mixed lake with about half its lake bottom consisting of softer sediments suitable for burrowing (Figure 1).

Insects have exoskeletons, which means that they must shed their skin to grow. Aquatic insect growth stages are referred to as instars, and each successive instar is noticeably larger than the last. Burrowing mayfly nymphs can grow to a size that makes them very easy to spot when they are outside their burrow, and they can be relatively good swimmers, undulating their torsos as naturally as Michael Phelps doing the butterfly stroke.

In spring, mayfly nymphs swim up to the lake surface for the transformation into their final and short-lived life stages; their emergence from the water is usually synchronized, with large numbers of mayflies appearing almost like magic. Feeding frenzies can result at these times, and those who fish recognize that insect hatches can be good times to go out to try their luck.

Luck can be dependent upon how closely a lure mimics the appearance of the hatch. Creating specialized lures, or fly-tying, combines keen observation of aquatic insects and their habitats with artistic talent, dexterity and patience. It is mesmerizing to watch videos of fly-tying, such as "Tying a Burrowing Mayfly Nymph with Barry Ord Clarke": https://www.youtube.com/watch?v=eYE0dvqvUG8&t=3s.

Scientific illustration has long provided a merger of science and art, and arguably the best book on aquatic insects is a beautifully illustrated title published in 1983: *Aquatic Entomology: The Fishermen's and Ecologists' Illustrated Guide to Insects and Their Relatives*, by W. Patrick McCafferty, with illustrations by Arwin V. Provonsha. The illustration of the burrowing mayfly nymph in Figure 1 comes from this work (Figure 2).

A focus on mating

Mayflies are unique among aquatic insects in that they have an additional skin-shedding, or emergence, after they leave the water. The almost-adult form

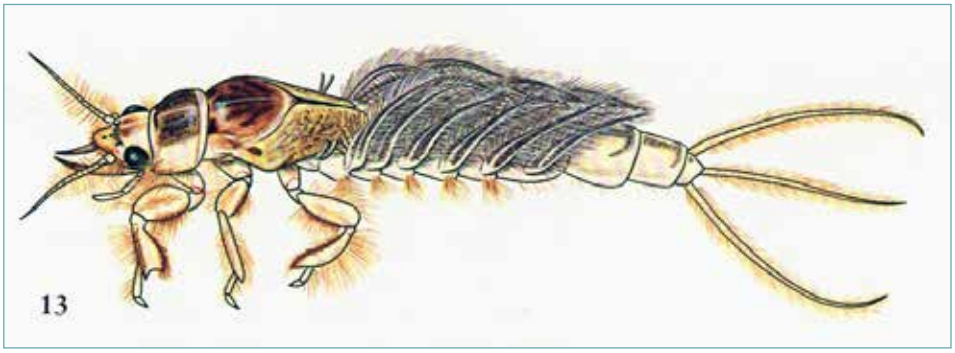

Figure 1. Hexagenia limbata *nymph (giant burrowing mayfly). Ghostly skins of nymphs split open along the top – can sometimes be seen floating on the lake surface during a hatch.* Image ©1981 by Arwin V. Provonsha.

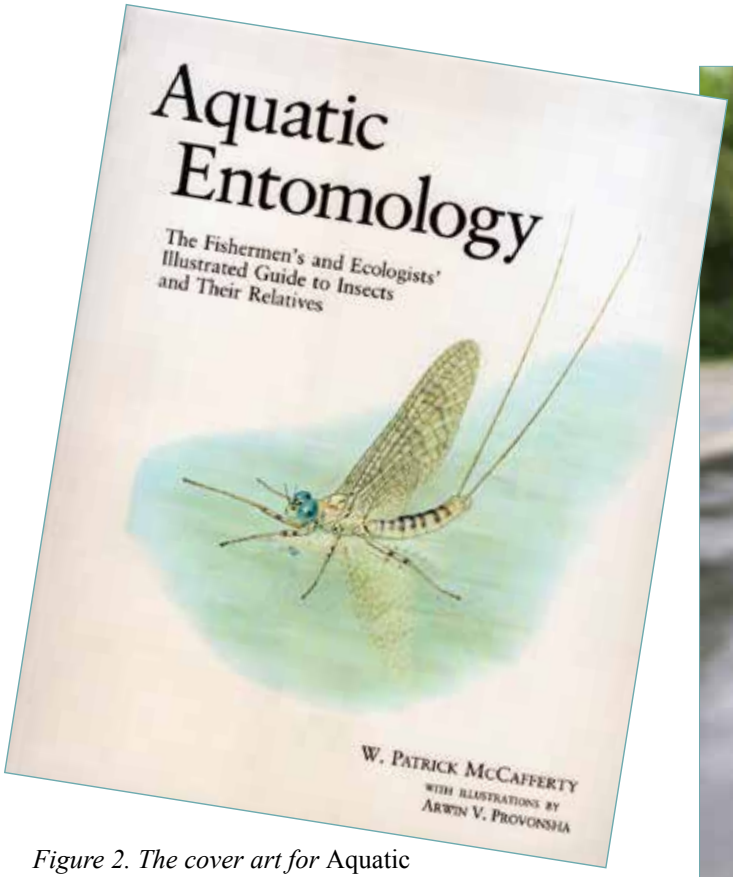

Figure 2. The cover art for Aquatic Entomology *features the graceful body shape of a mayfly dun (a fisherman's term) or subimago (a scientist's term).* Cover image ©1981 by Arwin V. Provonsha.

Figure 3. Subimagos (lighter in color) and imagos (grey in color) are generally found together at Lake Waccamaw, as they spend most of their time at rest. Mayflies do not feed during their brief time on land, but they can be an easy food source for bats, birds and dragonflies.

that leaves the water is called a subimago and it can be distinguished easily by its light coloration (by comparison to a true adult, or imago). Subimagos have tiny hairs covering their wings which serve to repel water, making it more likely that they can free themselves from the water surface and fly to the nearest perch on the lakeshore. These tiny hairs are not found on the wings of true adults, who need to be better at flight (Figure 3).

The grand event for mayflies is referred to as the "nuptial flight": Swarms of adult males can form in the air, moving up and down in a come-hither dance for females. After a brief coupling, females return to the lake from whence they came to lay their precious cargo of fertilized eggs. They dip up and down repeatedly, barely touching the water surface with the tip of their abdomen as small groups of eggs are released, to float down to the lake bottom where they quickly hatch into a new cohort of tiny nymphs, and the cycle begins again.

Mayflies as water quality indicators

Mayfly nymphs cannot survive in habitats with low or no dissolved oxygen; their disappearance from a lake can be a clear indication of changes at the sediment-water interface. Increased levels of organic enrichment – from algae blooms, submerged vegetation, or material washing into a lake – settles to the lake bottom, where it dies and decomposes. Microbes serve as decomposers, and it is their actions which rob the water of dissolved oxygen.

The mayfly hatch at Lake Waccamaw in the spring of 2013 was dramatically reduced, while another aquatic insect appeared in massive numbers: non-biting flies called midges. Midge larvae also inhabit lake sediments, and many species are specially adapted to living in dissolved oxygen-poor conditions: Their sausage-like gills are clustered at their rear end, and their bodies appear red due to the presence of hemoglobin (the same oxygen-bearing molecule found in humans).

What had happened? An explosion of submerged aquatic vegetation in the late summer of 2012 (including both native species and the invasive aquatic weed hydrilla), which provided a huge amount of biomass for decomposers to set upon over the winter (Figure 4).

Midges can produce multiple generations per year, so they can be a near-constant presence from spring to fall. Lakeshore residents felt that they were truly a nuisance (and would use stronger language), although the toads and dragonflies appreciated the bounty. The area of the lake that was infested with *hydrilla* was treated with an herbicide from 2013-2019, and native vegetation lakewide quickly returned to previously low levels (it is a blackwater lake). Midges blanketed the shoreline for several summers, eventually becoming a less-noticed presence, while the mayfly hatches gradually increased to their former numbers.

Mayflies have been referred to as "canaries in the coal mine" and the history of their abundance in Lake Erie has been

documented in a recent journal article by Lubya Burlakova and colleagues (Burlakova et al. 2014). Once extraordinarily abundant, mayflies disappeared as a result of organic and chemical pollution; Lake Erie was pronounced "dead" in the late 1960s, and there was a national outcry to implement pollution control measures. Burrowing mayflies gradually returned, although they were subsequently impacted greatly by the introduction of zebra and quagga mussels in the 1980s.

The spectacle of massive clouds of mayflies emerging from Lake Erie has been recorded remotely by weather radar (Stepanian et al. 2020); this methodology can be used to make calculations of mayfly abundance on a scale that has not been possible previously. Their numbers appear impressive, but the researchers concluded that mayfly emergence declined more than 80 percent over the period 2015-2019. They note that a number of stressors are likely impacting the burrowing nymphs, including agricultural pesticides, toxins produced by algae blooms, and reductions in dissolved oxygen levels. At this latitude, these mayflies have two-year life cycles, which underscores the importance of longer-term population monitoring (Figure 5) .

Mayflies have long been a fascination in their adult form, particularly as they are so easy to observe. If we can be good stewards of our lakes, we can ensure that their hidden-away juvenile stages thrive so that they can return to visit us landlubbers again in the spring, and the cycle of natural abundance continues.

References

Burlakova, L.E., A.Y. Karatayev, C. Pennuto and C. Mayer. 2014. Changes in Lake Erie benthos over the last 50 years: Historical perspectives, current status, and main drivers. *Journal of Great Lakes Research* 40: 560-573. https://doi.org/10.1016/j.jglr.2014.02.008.

McCafferty, W.P. 1983. *Aquatic Entomology: The Fishermen's and Ecologists' Illustrated Guide to Insects and Their Relatives*. Jones and Bartlett Publishers, Inc. 448 p.

Stepanian, P.M., S.A. Entrekin, C.E. Wainwright, D. Mirkovic, J.L. Tank and J.F. Kelly. 2020. Declines in an abundant aquatic insect, the burrowing mayfly, across major North American waterways. PNAS February 11, 2020, 117(6): 2987-2992. https://doi.org/10.1073/pnas.1913598117.

Diane Lauritsen got hooked on lakes as a student at the University of Michigan Biological Station in Northern Michigan, a region rich with a wide variety of lakes, including the nexus point for three of the Great Lakes. While there,she was encouraged to study the lake life that is found in and on lake bottoms. She continued her interest in benthic macroinvertebrates as a Ph.D. student at North Carolina State University, working on the invasive clam Corbicula and freshwater mussels, and developing a passion for the natural lakes of the NC Coastal Plain. At present Diane is studying nutrients and algae in one of these natural lakes as the limnologist and principal for LIMNOSCIENCES.

Figure 4. Lake Waccamaw lakeshore cottage, blanketed with insects: a mayfly with its recently vacated subimago skin, surrounded by an abundance of midges.

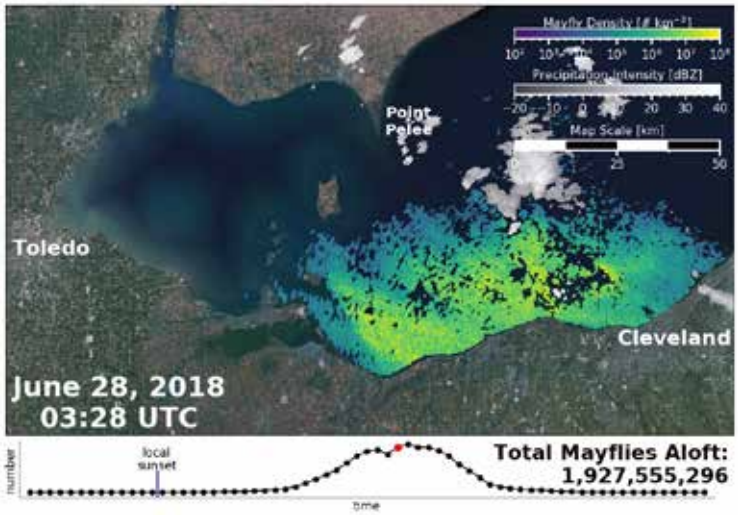

Figure 5. A weather radar image from a June 28, 2018 emergence event, with an estimated 1.9 billion mayflies moving across Lake Erie with the aid of high-elevation winds. This image taken from the video provided in supplementary materials from the online publication (Stepanian et al. 2020).