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Aetokthonos hydrillicola gen. et sp. nov.: Epiphytic cyanobacteria on invasive aquatic plants implicated in Avian Vacuolar Myelinopathy

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Abstract

Research into the taxonomy of a novel cyanobacterial epiphyte in locations where birds, most notably Bald eagle and American coots, are dying from a neurologic disease (Avian Vacuolar Myelinopathy—AVM) has been ongoing since 2001. Field investigations revealed that all sites where birds were dying had extensive invasive aquatic vegetation with dense colonies of an unknown cyanobacterial species growing on the underside of leaves. Morphological evaluation indicated that this was a true-branching, heterocystous taxon falling within the former order Stigonematales. However, 16S rRNA gene sequence demonstrated that it did not match closely with any described genus or species. More recent sequence analysis of the 16S rRNA gene and associated ITS region from additional true branching species resulted in a unique phylogenetic placement distant from the other clades of true-branching cyanobacteria. Light, epifluorescent, and transmission and scanning electron micrographs confirm the novel characteristics of this species, which is true-branching form with uniseriate basal filaments. It is encased within a firm sheath and has heterocytes both within the filaments and at the tips of the branches. The species is in a new genus of uncertain family assignment, and is herein named *Aetokthonos hydrillicola gen. et sp. nov.*

Introduction

A fatal disease, Avian Vacuolar Myelinopathy (AVM) killing bald eagles (*Haliaeetus leucocephalus* Linneaus (1766: 123)) and waterfowl in the southeastern U.S. was first documented in DeGray Lake, Arkansas in 1994. During the first three years of monitoring this emerging disease, 70 bald eagles and numerous American coots (*Fulica americana* Gmelin (1789: 704)) were found neurologically impaired or dead at DeGray Lake and nearby Arkansas lakes. Investigations of the mortality events included thorough necropsies and screening tissues for toxins and infectious disease agents. The only consistent finding was the presence of a unique lesion, an intramyelinic edema, most pronounced in the optic tectum and cerebellar tracts within the brains of affected birds in the myelin sheath of the brain (Thomas *et al.* 1998). In the absence of infectious disease agents and anthropogenic toxins that can cause particular type of lesion, researchers began to suspect that the eagles and waterbirds were exposed to a novel biologically produced neurotoxin (Fischer *et al.* 2006).

State and federal biologists from North Carolina, South Carolina, and Georgia tasked with bald eagle recovery were involved in the investigation in Arkansas. The following winter (1998), these biologists noted waterbirds displaying the same clinical signs of neurologic impairment within their home states. Impaired coots were collected during late fall from Woodlake (NC), Thurmond Lake (SC/GA), and Lake Juliette (GA) and histological examinations documented the characteristic AVM brain lesions. Wing clipped sentinel birds (wild American coots and game farm mallards *Anas platyrhynchos* Linnaeus 1758: 125) released at a North Carolina reservoir during a late fall mortality event became neurologically impaired within as few as five days (Rocke *et al.* 2002, Augspurger *et al.* 2003). Mallards housed in an off-site research facility with AVM-afflicted coots did not become neurologically impaired or develop

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propose that this species becomes the dominant late-season epiphyte due to its ability to survive in dense beds of senescing invasive plants when other epiphytes disappear due to low light, nutrients or temperature. Additionally, the neurotoxin it produces may deter the growth of other species. New hydrilla locations with AVM bird disease and dense colonies of *Aetokthonos hydrillicola* during 2011–2012 add additional confirmation of this species' role in AVM and expanding concern for wildlife.

While numerous toxin-producing planktonic species have long been recognized as a risk for fish, wildlife, and even human health (Chorus 2001, Landsberg 2002, Stewart *et al.* 2011), toxic cyanobacteria associated with invasive aquatic vegetation present a novel threat. Additional research on epiphytic cyanobacterial species should be conducted in order to determine toxin-producing capabilities. There may be environmental cues, including declining water temperature, lake turnover, nutrient release from the hypolimnion, declining day length, light levels, and aquatic plant senescence that enhance neurotoxin production. *Aetokthonos hydrillicola* has currently been detected throughout the southeastern United States. Spread of invasive aquatic vegetation may facilitate the invasion of this cyanobacterium. If these two invasions continue to expand their distribution, it could undermine the recovery of the bald eagle and threaten populations of waterbirds and other birds of prey. Recent feeding studies verified that both grass carp and herbivorous turtles were susceptible to AVM toxin present in a hydrilla/*A. hydrillicola* complex (Haynie *et al.* 2013, Mercurio *et al.* 2014). The spread of invasive aquatic vegetation and the toxicity of *A. hydrillicola* must be evaluated to determine food chain implications. Future research is needed to characterize the toxin to better evaluate and manage vegetation to mitigate the potential ecological impact of invasive aquatic vegetation and *A. hydrillicola* on waterbirds, birds of prey, and other aquatic wildlife.

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