<u>Filename:</u> Does the Evolution and Divergence of Utah Lake Sucker Genetic, Morphological, and Ecological Characteristics Point to High Abundance of Phytoplankton Primary Production in Utah Lake Throughout its History?
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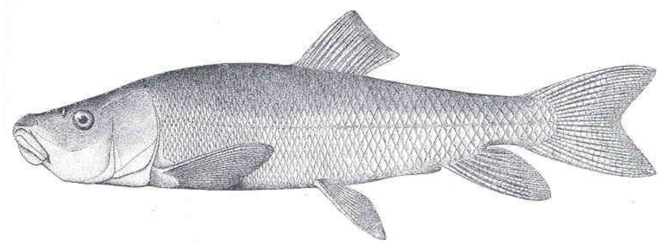
Does the Evolution and Divergence of Utah Lake Sucker Genetic, Morphological, and Ecological Characteristics Point to High Abundance of Phytoplankton Primary Production in Utah Lake Throughout its History?



Technical Memo

To

Wasatch Front Water Quality

By

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Cover images: First image of June Sucker, https://en.wikipedia.org/wiki/June_sucker. Second image of Utah Sucker: https://www.chegg.com/flashcards/lab-practical-2-6c292a6f-5b9e-4b6e-8a84-82f1faa6b2ec/deck

Introduction

There is quite a bit of interest by water quality managers in finding out whether Utah Lake historically had high water column primary production (i.e., phytoplankton) or if water column primary production has increased dramatically (e.g., algal blooms) post European settlement. Several paleo sediment core sample studies are currently underway on Utah Lake trying to help answer this management question.

Justification

While paleo core sampling can help us understand changes in primary production related ecology of Utah Lake, another supplementary approach is to examine the evolution and ecology of two of the lake's native fish species that are phylogenetically very similar but ecologically dissimilar, June Sucker, *Chasmistes liorus* and Utah Sucker, *Catostomus ardens.* June Sucker, a federally listed Threatened species, are zooplanktivores, that is, they filter feed on zooplankton within the water column, whereas Utah Sucker are benthivores that feed on benthic (sediment) algae and invertebrates[1].

June Sucker and Utah Sucker evolved during the Pleistocene in ancient Lake Bonneville, survived the great floods that drained Lake Bonneville, and persisted through the many major droughts that caused catastrophic ecosystem shifts throughout the lake's history, including those that occurred throughout Utah Lake's evolutionary history[2] (Bagely et al. 2018, Mock et al. 2006, Sperstad 2018).

Literature Review

The following is a brief literature review.

Utah Sucker and June Sucker life history, evolution, and phylogeny (e.g., taxonomy) differ, even though the two species that evolved from the same ancestors but are now from separate genera can hybridize. It is assumed that the present variety of June Sucker, *Chasmistes liorus mictus* found in Utah Lake is likely a hybrid (Bagely et al. 2018, Mock et al. 2006, Sperstad 2018).

The taxonomy of June Sucker is presented in Table 1.

Table 1. Taxonomy of June Sucker, Chasmistes liorus including subspecies. This table also includes Utah Sucker as a related genus.

Family: Catostomidae
Subfamily: Catostominae
Tribe: Catostomini:
Related genera within tribe: *Catostomus, Deltistes, Xyrauchen, Chasmistes*
Species:

[1] We consider the invasive carp, *Cyprinus carpio* to be an analog of both June Sucker and Utah Sucker. See Richards 2021.

[2] Utah Lake is but a small remnant of Lake Bonneville.

Chasmistes brevirostris Cope, 1879 — shortnose sucker
Chasmistes cujus Cope, 1883 — cui-ui
Chasmistes fecundus (Cope & Yarrow, 1875) — Webug sucker
Chasmistes liorus *D. S. Jordan, 1878 — June sucker*
Chasmistes liorus liorus *D. S. Jordan, 1878*
Chasmistes liorus mictus R. R. Miller & G. R. Smith, 1981
†*Chasmistes muriei* R. R. Miller & G. R. Smith, 1981 — Snake River sucker
†*Chasmistes spatulifer* R. R. Miller & G. R. Smith, 1967
†Presumed extinct
Bagely et al. (2018) places *Chasmistes liorus* into their phylogenic tree *Clade 8*, which includes: *Catostomus ardens, C. macrocheilus, C. tsiltcoosensis, C. columbianus, C. tahoensis*

Miller and Smith (1981) wrote that:

> "Formerly abundant in Utah Lake, to which this species was confined except tor a yearly spawning migration up tributaries, especially the Provo River, *Chasmistes liorus* is thought to have been depleted by the combined effects of the pollution arid severe drought of the mid-1930's on Utah Lake, and the effects of agricultural and domestic use of the Provo River on reproduction (Miller, 1979). When numbers became low, extensive hybridization with *Catostomus ardens* apparently led to introgression of new traits into the population. The *Chasmistes* that returned to abundance in the 1940's and 50's is distinctly different than the original species."

Belk, Rader, and Mills (2011) stated that:

> "Apparent hybridization in every known population of this genus and introgression in almost every population is unusual even in fish biology. In each case the hybridization seems to have been associated with reduction of favorable habitat or numbers of *Chasmistes* presumably leading to mixed-species spawning associations, as observed by Hubbs (1955: 18). The result has been a rapid shift to morphological characters intermediate between *Chasmistes* and the local *Catostomus* in Utah Lake."

Mock et al. (2006) stated that:

> "The Utah sucker (*Catostomus ardens)* is endemic to the Bonneville Basin and the upper Snake River drainage in western North America and is thought to hybridize with the federally endangered June Sucker (*Chasmistes liorus mictus*) in Utah Lake (Bonneville Basin). Here we describe the discovery of a major subdivision in Utah suckers (4.5% mitochondrial sequence divergence) between the ancient Snake River drainage and the Bonneville Basin. This boundary has not previously been recognized in Utah suckers based on morphologic variation but has been recently described in two endemic cyprinids in the region. Populations in valleys east of the Wasatch Mountains in Utah clustered with the Snake River populations, suggesting that these valleys may have had an ancient hydrologic connection to the Snake River. We also found evidence of population isolation within the Bonneville Basin, corresponding to two Pleistocene sub-basins of the ancient Lake Bonneville. In contrast, we found no molecular evidence for deep divergence between Utah suckers and June suckers in Utah Lake or for a history of hybridization between divergent lineages in that population, although we recognize that demographic events may have obscured this signal. These findings suggest that the morphological differences between Utah and June suckers in Utah Lake may be the result of strong, and relatively recent, ecological selection"

Mock et al. (2006) also stated that, "Extant *Chasmistes* spp. appear to be phylogenetically closer to sympatric *Catostomus* spp. than to allopatric *Chasmistes* spp. (Li 1999; Mock et al. 2006; Tranah & May 2006)." And that the sucker species in Utah Lake,

> "may have a long, reticulated history of genetically shallow but morphologically pronounced divergence and convergence, following fluctuating environmental conditions. Under this scenario, gene flow between morphologically dissimilar subpopulations may be an asset to the long-term persistence of the complex (Arnold 1997; Dowling & Secor 1997), ironically including both ends of the morphological spectrum."
>
> "It is possible that this reduction in Utah Lake's depth has enhanced the persistence of intermediates by decreasing the distance between the limnetic and benthic habitats, enabling them to more efficiently exploit both niches and thus reduce selection against them."
>
> "The nature of the morphological variation in Utah Lake suckers is consistent with the concept of benthic (benthivorous) vs. limnetic (planktivorous) fitness peaks. The limnetic niche would be expected to favour the June sucker morph's terminal mouth position and reduction in lower lip size, whereas the benthic niche would be expected to favour the large, heavily papillated lips and ventral mouth orientation of the Utah sucker morph. In a pilot study, lip size and lower lip gap size were shown to be heritable (M. Belk, unpublished data). Recently, Utah Lake suckers of intermediate morphology (as defined in the present study) have been shown to have stable isotopic signatures for 13C and 15N that are intermediate to those of June and Utah morphs (Cole 2008), further indicating that these morphologies have an ecological basis."

Miller and Smith (1981) stated that, "Chasmistes are midwater planktivores with numerous, dendritic gill rakers and large, terminal mouths. The terminal position of the mouth is so exceptional among the usually ventral-mouthed sucker family that it has been regarded as an extreme specialization"

Miller and Smith (1981) also stated that:

> "The June sucker, so-named because peak spawning time occurs that month, abounded in Utah Lake before 1900, but no individual representing the original form has, to our knowledge, been preserved in this century. The great drought of the mid-1930's, coupled with domestic use of its major spawning stream, the Provo River, decimated the suckers and other fishes in this rather shallow lake when its surface area was reduced from 93,000 to 50,000 acres."
>
> "During the winter of 1934-35 the water was so shallow that hundreds of tons of suckers and carp were killed due to freezing and crowding in the few deep holes. . . . In the spring of 1935, there were no suckers to run up Provo River, something that has never happened before in the history of Utah Lake" (Tanner, 1936: 167)."

Discussion

From this brief literature review and our ecological experience studying Utah Lake ecosystem it appears that June Sucker morphology and ecology dramatically evolved to exploit ample abundances of zooplankton that were not being utilized by other fish species[3]. This dramatic evolution did not happen by accident but was selected for by the environment. We surmise that such abundances of zooplankton could only have existed if very high abundances of their food resource, phytoplankton also co occurred. If this is the case, as we surmise, then very high abundances of phytoplankton could have only occurred if high concentrations of nutrients were available within the water column. These dynamics likely varied substantially throughout the

[3] All of Utah Lake's native fish species feed on zooplankton as juveniles, which is further evidence of the large abundance of zooplankton, phytoplankton, and nutrients throughout Utah Lake's history.

evolution of Lake Bonneville and later in Utah Lake. Given the high content of nutrients in the limestone parent geologic material in the watershed on which Lake Bonneville and then Utah Lake evolved over 30K years, we also suggest that in its early evolution, Lake Bonneville may have been oligotrophic for a brief geologic period, but relatively quickly (in geologic time) turned mesotrophic about the time June Sucker diverged from ancestral Catostomini. The shallow nature of often terminal Utah Lake relatively quickly underwent eutrophication and ample evidence shows that eutrophication quickly accelerated once the European human race became established in the watershed. Given this scenario, it does not seem that Utah Lake can ever return to an oligotrophic state, if at all it ever was. Certainly, more research into this line of evidence is warranted.

Literature Cited

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