Geographic Variation, Isolation, and Evolution of Cutthroat Trout.



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Robert Behnke

In the late 1950s Robert Behnke began to reexamine the cutthroat trout. At that time management treated all cutthroat trout as being identical.





Behnke's phylogeny





Some conflicting data:

Allozymes

Yellowstone & Bonneville cutthroat trout in the Bear River Colorado River & Bonneville cutthroat trout in the main Bonneville Basin

Fossil data Lake Idaho Western Nevada

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Behnke's phylogeny



Allozyme data – 72 loci Shiozawa and Williams 1992



Yellowstone 600,000 100,000

40,000 Bonneville

Rainbow 70,000 Westslop

2 mya –

Coasta

Greenback

Rio Grande

Yellowstone 600,000 100,000 ahontan

estslop

Rainbow 70,000 w

mya

Coasta

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lorado

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Fossil data Lake Idaho Western Nevada

Oncorhynchus lacustris, redband lineage, Lake Idaho Chalk Hills Formation (7-9 mya) and Glenns Ferry Formation (4-3 mya)

Oncorhynchus belli 10.2 mya cutthroat lineage Truckee Formantion, Western Nevada

1 cm





9 mya Oncorhynchus 1 1 mya Flucho-Saryelinus Meage o Poison Creek Formation *ciniclope* Truckee Formation 10.2 mya Oncorhynchus belli CONTRACTOR OF on, Redband trout 📐 e Pacific dband trout son Si Mopung Hills O. clarkii Owens Lake core 700,000 ybp Trout

These data suggest that cutthroat and rainbow trout split more than 2 mya.

But, how did trout get into both Lake Idaho and Western Nevada? A brief overview of the geological history of the west:

~ 175 mya Pangea began to breakup

North America moved west, subducting the Farallon Plate

This initiated a series of orogenic (mountain building) events (Nevadan, 155-145 mya; Sevier, 150-45 mya; Laramide, 80 mya-35 mya). Two important events occurred.

1. A 3,000-4,000 m uplifted region, analogous to the Tibetan Plateau and the Altiplano of the Andes, formed South of this hotspot (the Nevadaplano or Great Basin Altiplano).

2. An overridden oceanic hotspot erupted in
Western North America - the Yellowstone Hotspot.
The hotspot modified drainage patterns. Associated
with this was a large lake in Eastern Idaho – Lake
Idaho.

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Lake Idaho – a rift lake 11 – 3.1 mya



http://geology.isu.edu/Digital_Geology_Idaho/Module11/calderas.jpg









ciniclope

Truckee Formation 10.2 mya Oncorhynchus belli

Mopung Hills O. clarkii

9 mya Oncorhynchus 1 mya Hycho-Salvelinus Meage

e Pacific almon, Redband trout 🛸

Pacific salmon in Lake Idaho indicate an active connection to the Pacific Ocean

ns Ferry 4.3 – 3.0 mya almon, Redband trout

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son S

ciniclope

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Where did the cutthroat trout enter Nevada?

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https://www.khanacademy.org/partner-Dunhuang content/asian-art-museum/aam-H TAGH himalayas/himalayas-ddp/a/introduction MTS Khotan 1 KASHMIR KUNLUN MOUNTAIN LADAKH 7 Xi'ning ZANGSKAR Kekor anzhou TIBETAN PLATEAU Dharamsala GUGE Mt. Kailash E • Derge Т New Delhi KHAM • Chengdu Lhasa https://pubs.geoscienceworld.org/gsa/lithos Shigatse . Yangzi TSANG • Gyantse phere/article/7/2/117/145732/punctuated-Kathmandu Thimphu 4.6 Yangzi shortening-and-subsidence-in-the 6000-884 5000-5000 BHUTAN PIVE AMATON FORELAND BASIN 4000-1000 Darjeeling 3000-4000 2000-3000 Peru Brahmaputra River 1000-2990 INDIA BURMA 500-1000 200-600 BANGLADESH 0-200 meters Fig. 2 15°S-(a) 6 Tibetan plateau 10°S Elevation (km) Andean plateau Δ Nazca 20°5 Plate 20°S-30°S 40°S 5000 m 70 2 Elevation 50°S 0 m Chile 0 Argentina 200 400 km 200 300 500 400 600 0 100 P/U Distance (km) 75°W 70°W

65°W

3000 m-4000 m (9,800'-13,123')





Starting 18-20 MYA the westward extension and block faulting of the Great Basin Altiplano forms the linear mountains and valleys of the Great Basin **ciniclope**

Truckee Formation 10.2 mya Oncorhynchus belli

Mopung Hills O. clarkii

9 mya Oncorhynchus

on, Redband trout 📐

Humboldt River fully integrated by 9 mya

edband trout

N Owens Lake core 700,000 ybp Troi

son Si

Sample locations





Maximum Likelihood bootstrap / Bayesian posterior probabilities

Greenback (Bear Creek)

Colorado (San Juan/Gunnison)



6.0 million years



Bonneville Greenback (Bear Creek) Colorado (Green) **Rio Grande A** Rio Grande B Colorado (Blue) **Bear River** Yellowstone Coastal Lahontan Westslope A Westslope B







Catrostrophic draining Lake Idaho Lahontan















and Hold

Where next?

Genome -> Exome -> Transcriptome

RAD/RRL Sanger

WS244202 WS244201





Where next?

Genome -> Exome -> Transcriptome

RAD/RRL Sanger

Results

30,375 Total Orthologous Transcripts



Percent Identity

	L 5	0 10	0 150	200	250	300	350	400	450	500	550	600	650	718
Consensus														
Identity														
1. Oncorhynchus_clarkii_BearRiver.fasta_comp199575_c0_seq1/1-575							I II	1	11		1			
Oncorhynchus_clarkii_utah.fasta_comp215197_c0_seq1/1-576									11					
 Oncorhynchus_clarkii_henshawi.fastacomp225348_c0_seq1/1-717 									11					



Where next?

Genome -> Exome -> Transcriptome

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