

Kanab amber snails and the management of the Grand Canyon

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What are Kanab amber snails (KAS)? *Oxyloma haydeni kanabense*

Oxyloma occurs in N-America (> 12 species and subspecies), Europe and S-Africa



Family SUCCINEIDAE Beck, 1837

The shell of succineids offer little indication of generic and specific identity, and identification is difficult. Genera are differentiated anatomically and many nominal species are poorly understood.



Various succineid shells. After Pilsbry (1948)

Oxyloma haydeni kanabensis

→ subspecies

What is a subspecies?

sometimes KAS is listed as species



the nominal subspecies

Oxyloma haydeni haydeni
Niobrara amber snail (NAS)



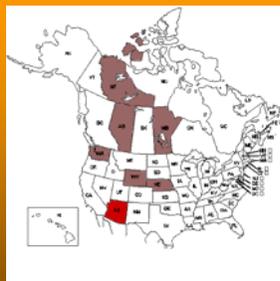
Oxyloma haydeni (W.G. Binney, 1858) Type locality: Loup Fork (E Nebraska)

Oxyloma haydeni kanabense Pilsbry, 1948 Type locality: Kanab Creek (SW Utah)

First specimens were collected in 1909 and placed in the species *Succinea hawkinsi*. Pilsbry transferred them to *Oxyloma* and erected the subspecies *kanabense* in the species *haydeni* for them based on shell morphology.



Niobrara amber snail



Kanab amber snail



- "strange" non-continuous pattern, large gaps
- sympatric populations in Arizona and Alberta?

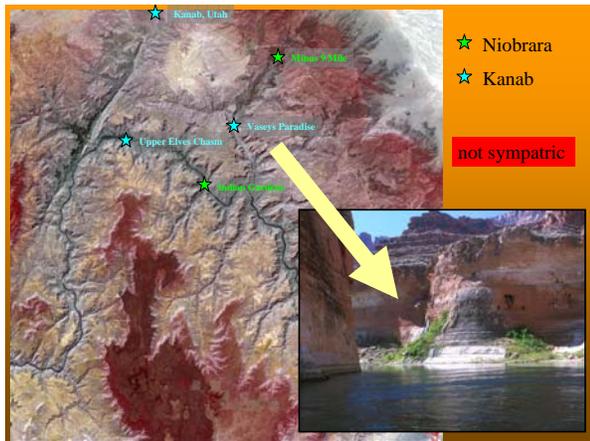
Oxyloma haydeni haydeni occurrences in Arizona



Oxyloma haydeni kanabensis occurrences in Arizona



- overall spotty distribution possibly related to habitat's permanently wet soil surface and/or shallow standing water (*Typha*)



Taxonomy (and distribution)

- taxonomy is not understood, taxa not well defined, limitations in morphology and anatomy (species, subspecies, populations?)
- distribution pattern not understood, known SW populations seem to be allopatric
- are the SW populations autochthonous?

➡ molecular methods

The conservation status...

- beginning of 90's KAS were only known from Three Lakes in the Kanab canyon, S Utah, in two small populations on private land (the Vasey's Paradise population was discovered in 94)
- 1992 emergency listing in Endangered Species Act (ESA) after populations were almost destroyed by earthmoving equipment
- KAS is the smallest species in ESA
- and why species? Isn't KAS a subspecies?

Kanab Amber Snail

Brandt Child bought 500 acres of property in Utah in 1990, planning to build a campground and golf course near his three lakes. The next year, the U.S. Fish and Wildlife Service told him he couldn't use his property because the lakes were inhabited by 200,000 federally protected thumb-nail-sized Kanab amber snails. The snails differ from other snails only because of their golden color.

A few months later, Mr. Child discovered 10 domestic geese near his ponds. After dutifully notifying federal officials, he was told that if the geese had eaten any snails, he faced a fine of \$50,000 per snail. A state wildlife agent and a Highway Patrolman arrived with a shotgun intending to shoot the geese and remove their stomachs to find out if any snails had been eaten.

The only thing that saved the geese was a reporter with the Southern Utah News who showed up and told them that she would photograph the massacre. The agents then decided to back off and finally settled on forcing the geese to vomit. No dead snails were found.

The geese are now safe, but Mr. Child is still out \$2.5 million because he can't use his property, and the government refuses to compensate him for his loss.

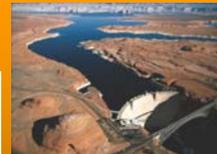
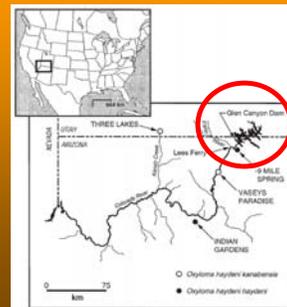
The Wall Street Journal -- December 27, 1993

VIS = very important snail

Major threats (for all SW *Oxyloma* species):

- loss of habitat (restricted distribution)
- de-watering
- trampling
- flooding

...and the Grand Canyon



Glen Canyon dam:

- built 1963
- power plant
- water release from power plant 20,000 to 25,000 cfs
- before 1963 seasonal high @ 100,000 cfs
- record of 300,000 cfs in 1884



Colorado river ecosystem:

- re-install natural river dynamics
- encourage sediment transport
- experimental floods of 45,000 cfs (approximately twice the normal power plant discharge)
- March/April 1996 (ca. 7 days) w/ estimated 10.7% of the total snail habitat and 7.7% of the population @ Vasey's Paradise lost (1275 KAS were translocated above the floodzone)



Would a full blown flood wipe out the KAS and NAS populations?

What have we got so far?

- a taxon of uncertain status (is KAS a species, subspecies, population?) shells
- weird distribution pattern (huge gaps, sympatry of KAS and NAS (?)) A&A
- very high profile conservation status with considerable legal consequences Mr. Child & Glen canyon dam
- a lot of information on the Vasey's paradise population (including a MSc thesis on the population's ecology and one on host plants)

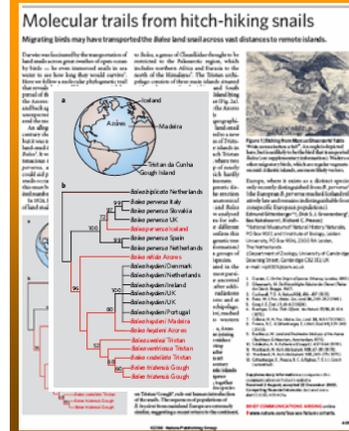
What scenarios could explain what we see?

1. the relict populations and cryptic species scenario
the SW KAS and NAS populations historically had a wider distribution and are solid taxa (subspecies or species), originated from the SW, hybridization
searching evidence:
 - fossils?
 - sympatry w/ morphological distinctiveness (species status)?
- fossils, yes. *Oxyloma* from SE Utah dated 9,200 years and in S Arizona and KAS N Utah (suspect) and Alberta (uncorroborated)
- not in SW US (?), in Canada unknown



What other scenarios could explain what we see?

2. the long distance dispersal (LDD) scenario
the SW KAS and NAS populations (and possibly others) originate from the core populations in the N (i.e. Alberta) and dispersed to SW locations through vectors
- searching evidence:
- vectors?
 - no sympatry and no morphological distinction (no taxon. status)?
 - waterfowl: *Oxyloma* on duck feet (ectozoochory and anecdotal), viable eggs in faeces (endozoochory)
 - yes, no sympatry and morphological distinction
 - additionally most pulmonates capable of selfing (self fertilization, hermaphrodites)



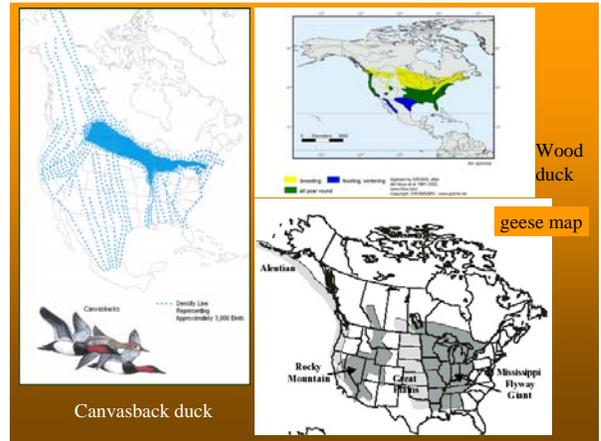
- Darwin already interested in LDD in "the most pedestrian of creatures"
- transequatorial dispersal over > 9,000 km
- *Balea* and *Tristania*
- *Tristania* = *Balea*

Need more support:

- are there migratory waterfowl which could transport snails and connect the N with the SW (and vice versa)?



webpage of Arizona Waterfowl Hunters



Wood duck

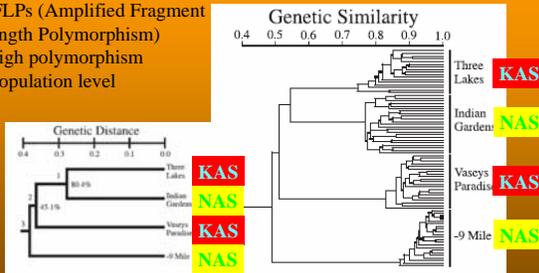
geese map

Canvasback duck

Molecular approaches

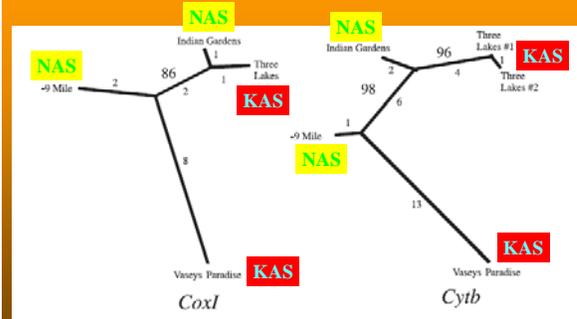
Mark Miller et al., NAU

AFLPs (Amplified Fragment Length Polymorphism)
- high polymorphism
- population level



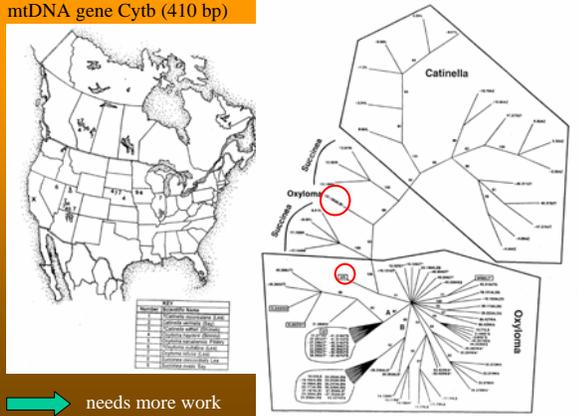
Three Lakes and Indian Gardens high level of genetic diversity, Vaseys Paradise and -9 Mile low levels (floods and/or selfing)

mtDNA genes *CoxI* (263 bp) and *Cytb* (410 bp) for phylogenetic analysis (species, subspecies)

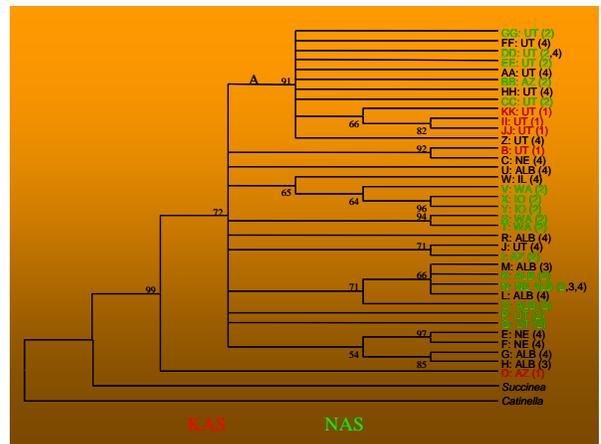


all different taxa (species, subspecies)?

mtDNA gene *Cytb* (410 bp)



needs more work



Ongoing:

double blind study with 14 batches of individuals/samples (locations) from Utah and Arizona

- Barry Roth: morphology and anatomy

- Mark Miller: microsatellite markers, two mtDNA genes

- Melanie Culver and Hans-Werner Herrmann: nuclear genes and SNPs (Single Nucleotide Polymorphism)

Can we flood the Grand Canyon?