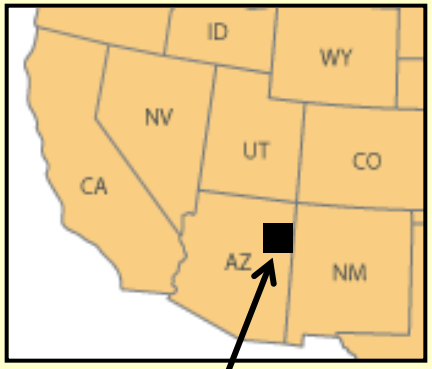
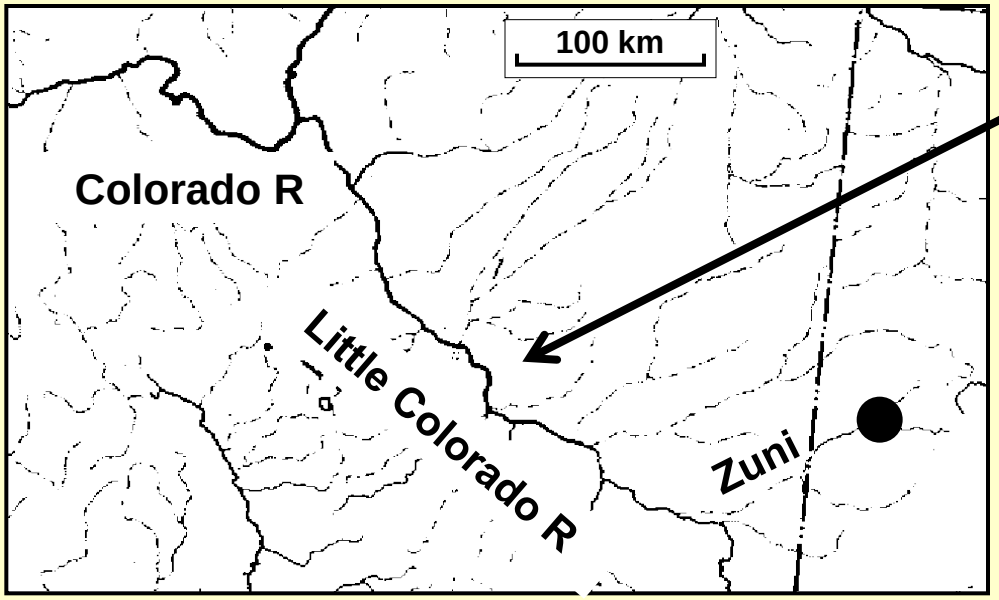
# Zuni bluehead sucker

- ***Catostomus discobolus yarrowi***
- **Little Colorado River (LCR), NM and AZ**
- **1834, Cope**
  - **type locality: Zuni River NM, headwaters of the LCR**




**Little Colorado R**

# Morphological diversity

- **Hybrid origin - Smith et al. 1983**
  - ***C. d. yarrowi* = *C. discobolus* X *C. plebeius***

***discobolus*** ⟷ ***yarrowi*** ⟷ ***plebeius***

- **Little Colorado River (LCR) basin**
  - **stream capture late Pleistocene**
    - **LCR and upper Rio Grande (NM)**

# Subject of debate

**Smith et al. 1983**

- **allozyme data**
  - **16 polymorphic loci**

+

- **morphology**

↓

**Introgression:**

- **LCR headwaters *and* further downstream**
- **Introgression and hybrid origin *does* explain variation in *yarrowi***

**Crabtree and Buth 1987**

- **allozyme data**
  - **16 polymorphic loci**

↓

**Introgression:**

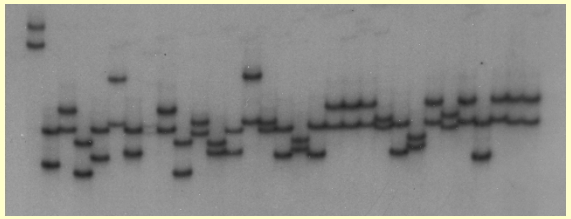
- **LCR headwaters *only***
- **Introgression hypothesis explaining variation in *yarrowi* *not* well supported**
- **Hypothesized another distinct form in the LCR**

# Goals

- **Examine extent of introgressive hybridization of *C. plebeius* in the LCR**
- **Evaluate population structure of mountain suckers in LCR relative to adjacent drainages**
  - **Information used to identify units for management**

# Methods

- **Survey of genetic variation**
  - **Sequences**
    - **mtDNA:**
      - **cytochrome B gene, (260 bp)**
    - **nDNA:**
      - **2H2 (251 bp)**
      - **RAG, recombination activation gene (277 bp)**
  - **Analysis of single stranded conformational polymorphisms (SSCPs); direct sequencing**
    - **451 individuals**
    - **18 populations**



# Sampling sites

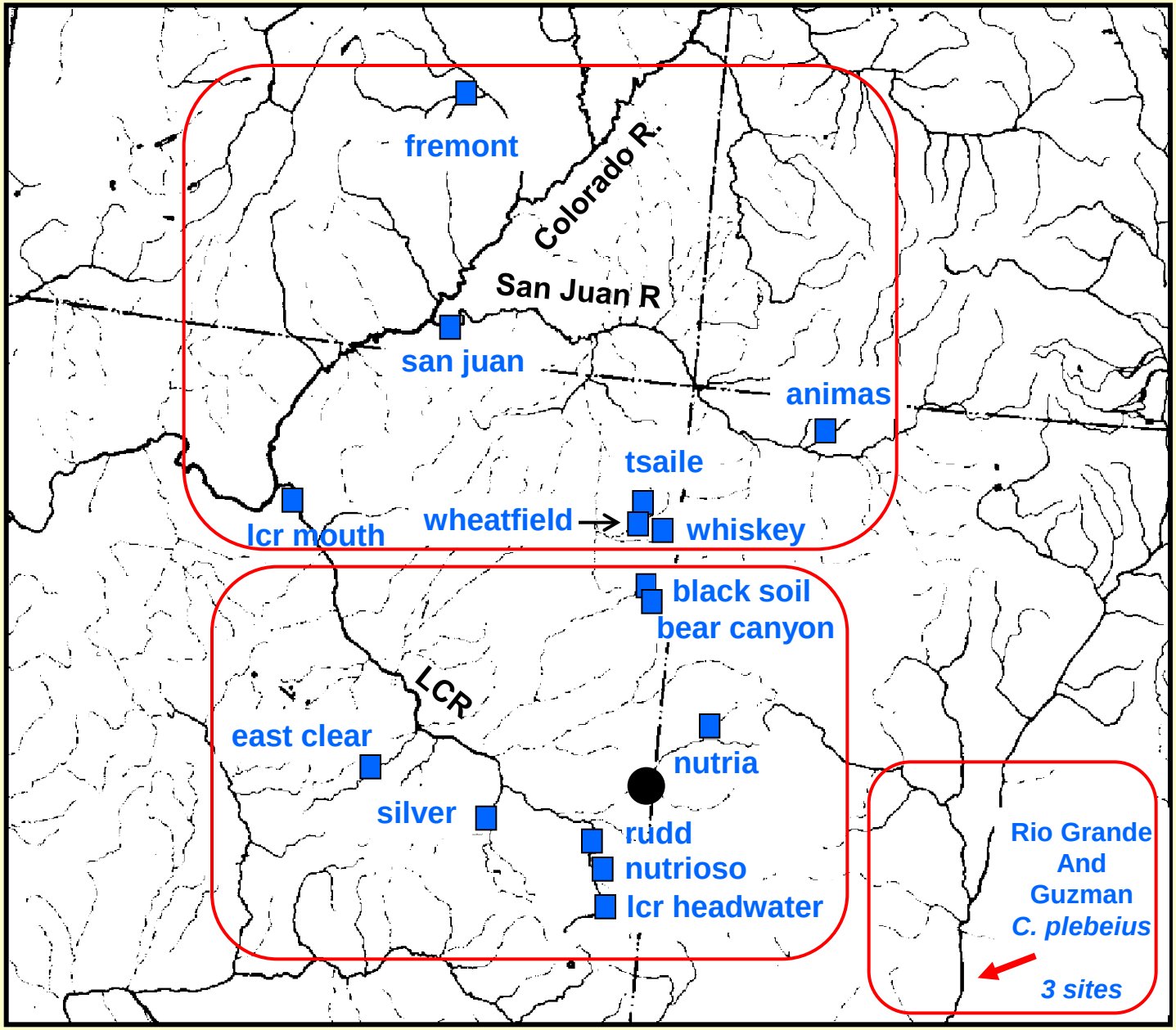
**18 populations**

**7 mainstem Colo. and San Juan**

**8 Little Colorado**

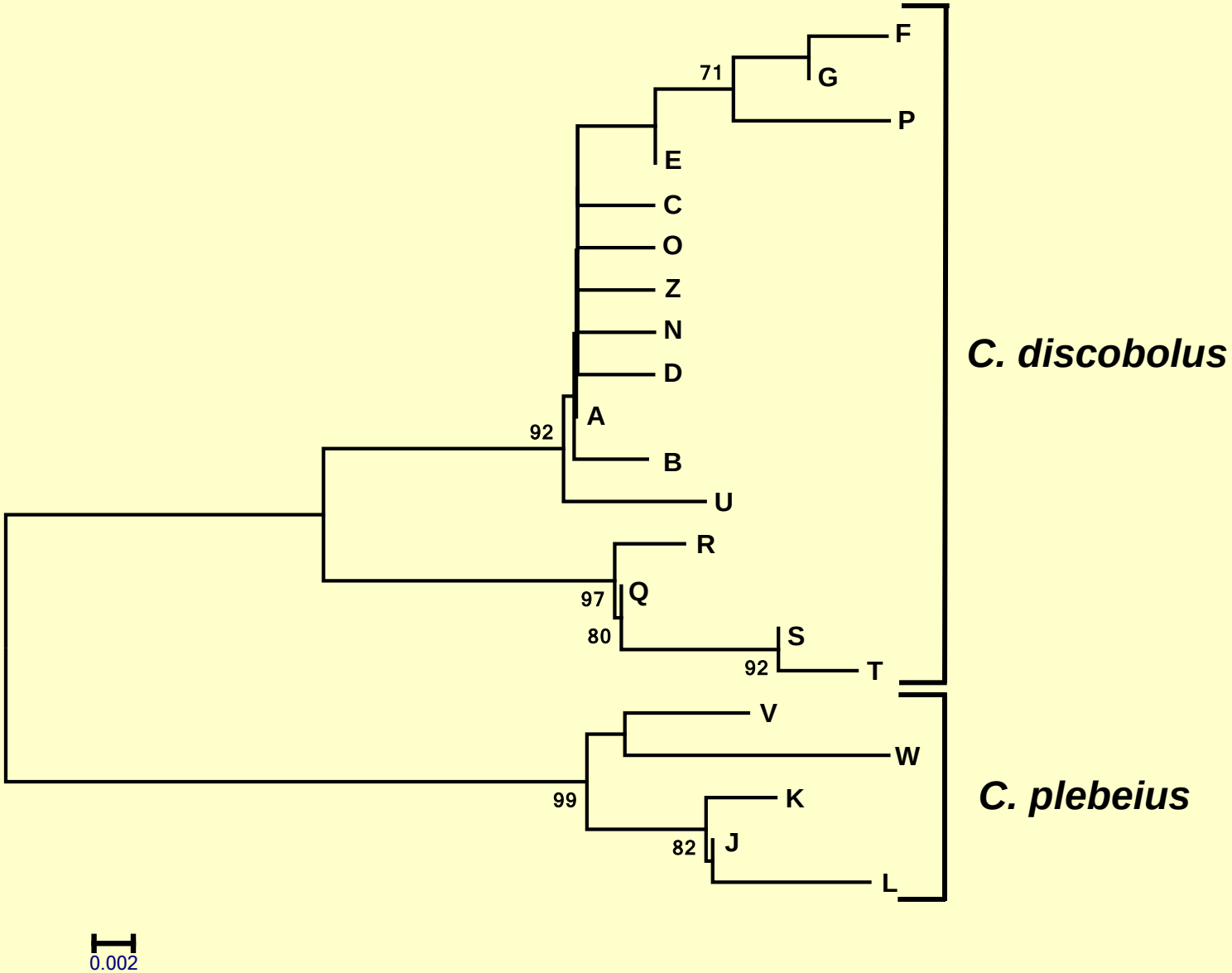
**3 NM and MEX *C. plebeius***

**Type locality: Zuni R**



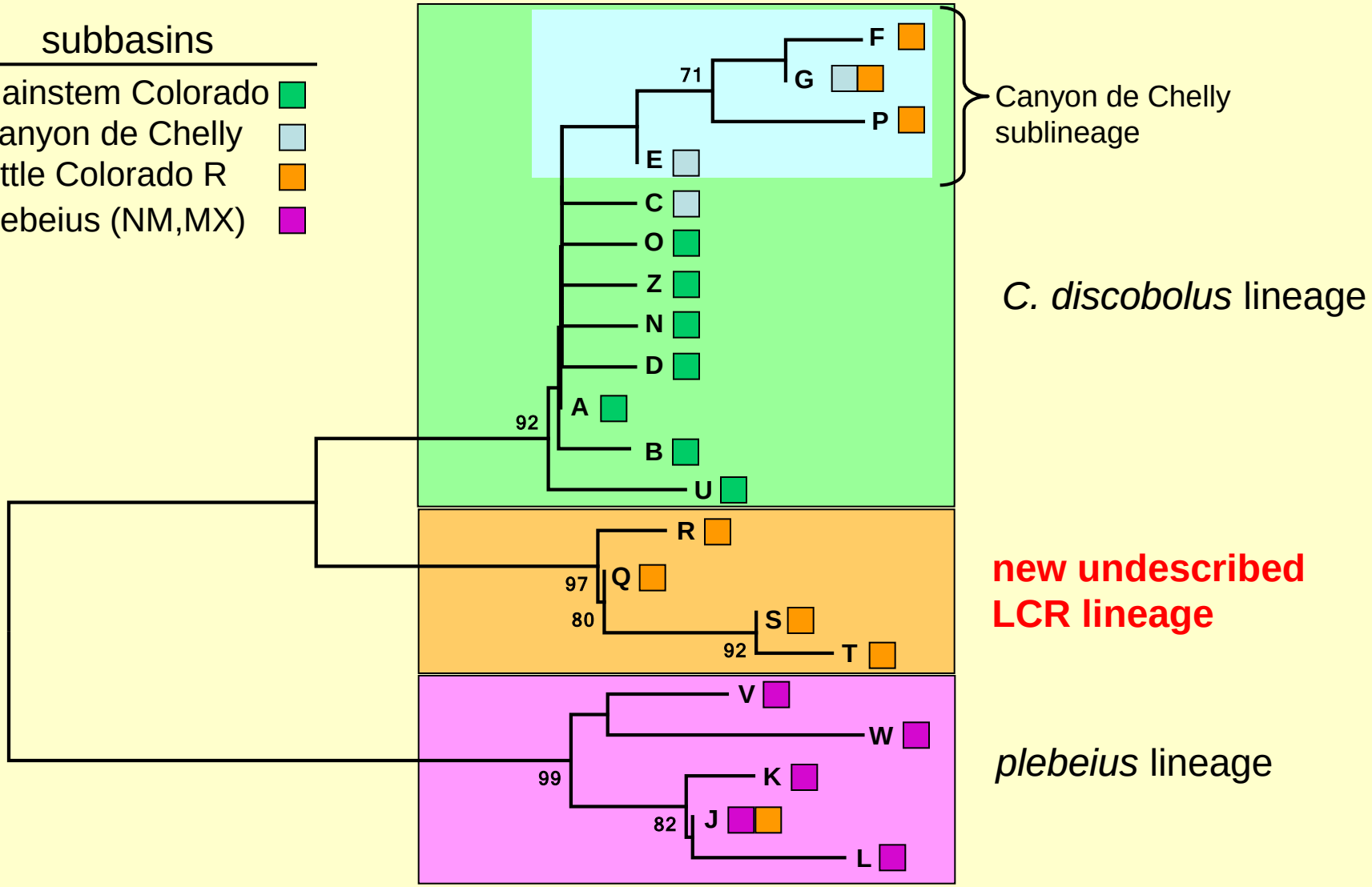
# mtDNA phylogeny for cytochrome *b* gene

**Neighbor-joining tree (1000 bootstrap replicates)**

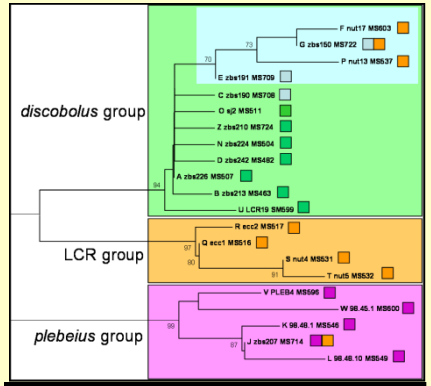


# mtDNA phylogeny for cytochrome b gene

Neighbor-joining tree (1000 bootstrap replicates)



# mtDNA haplotypes by lineage



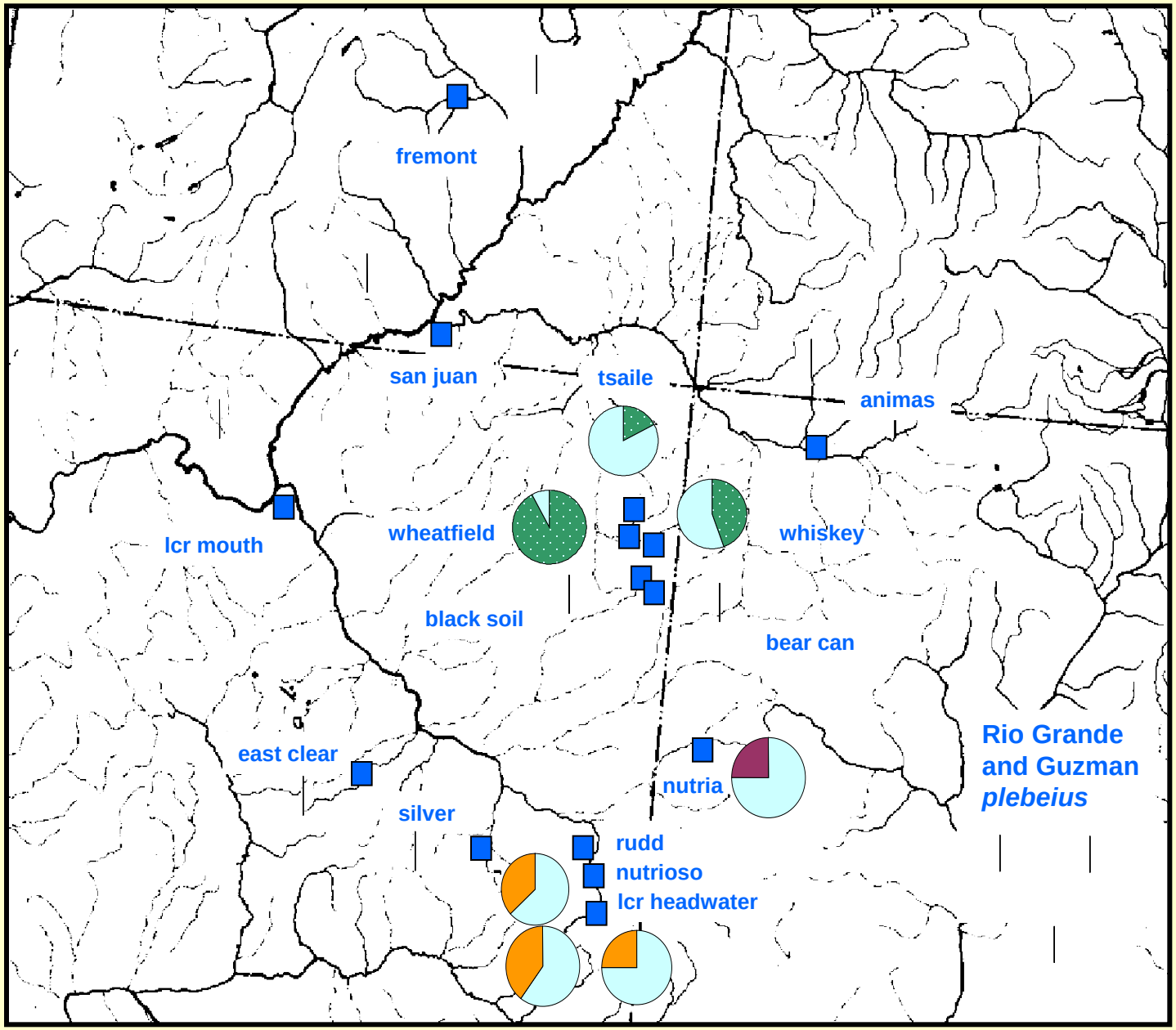

**Legend** (by phylogenetic group)

***C. discobolus***
**Allele C (stipled)**

**Canyon de Chelly**

**Little Colorado**

***C. plebeius***



# Summary mtDNA

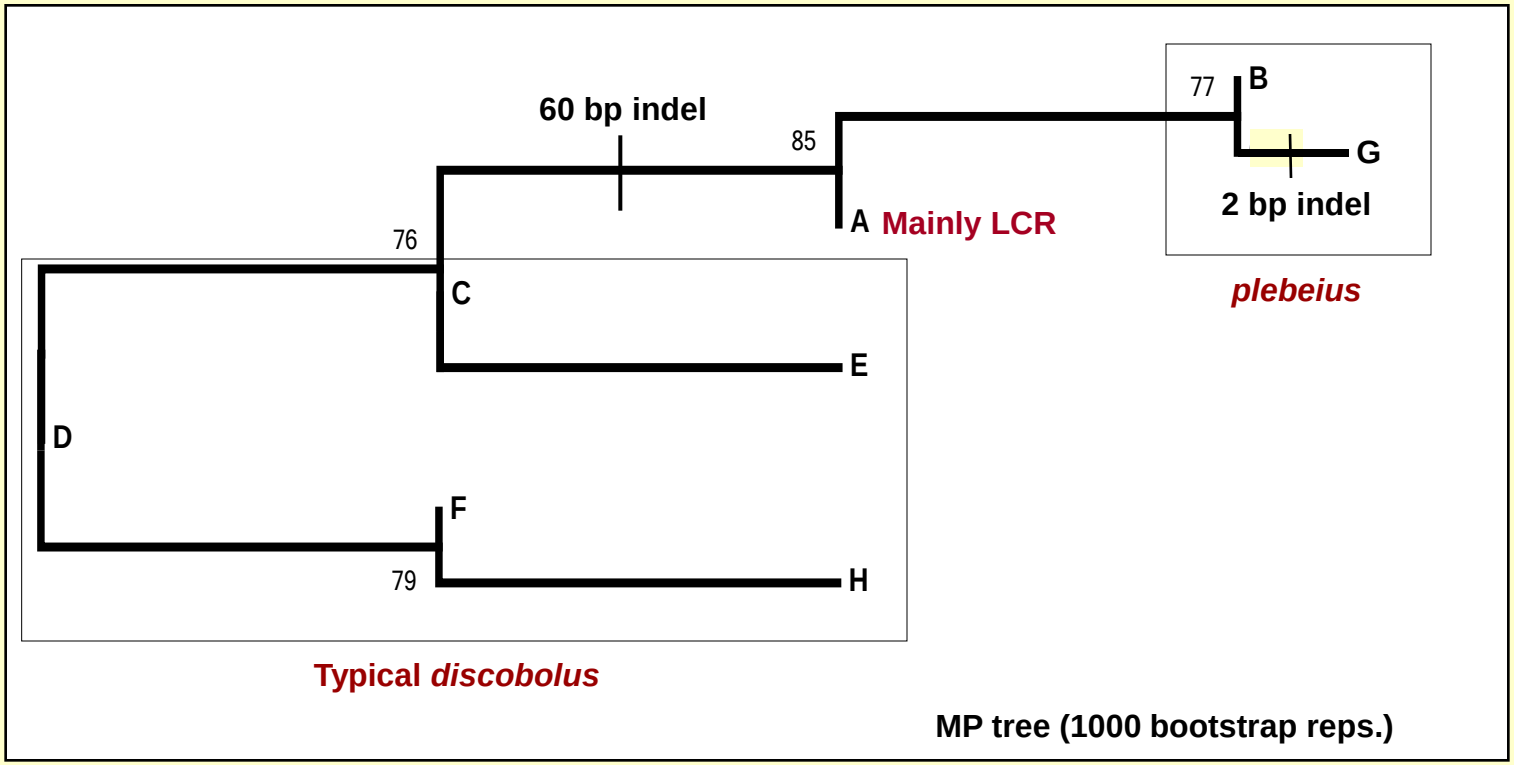
- **Three distinct lineages**
  - **mainstem Colorado /San Juan lineage**
    - **Canyon de Chelly**
  - **LCR lineage**
  - ***C. plebeius* lineage**

- **concordant with geography**

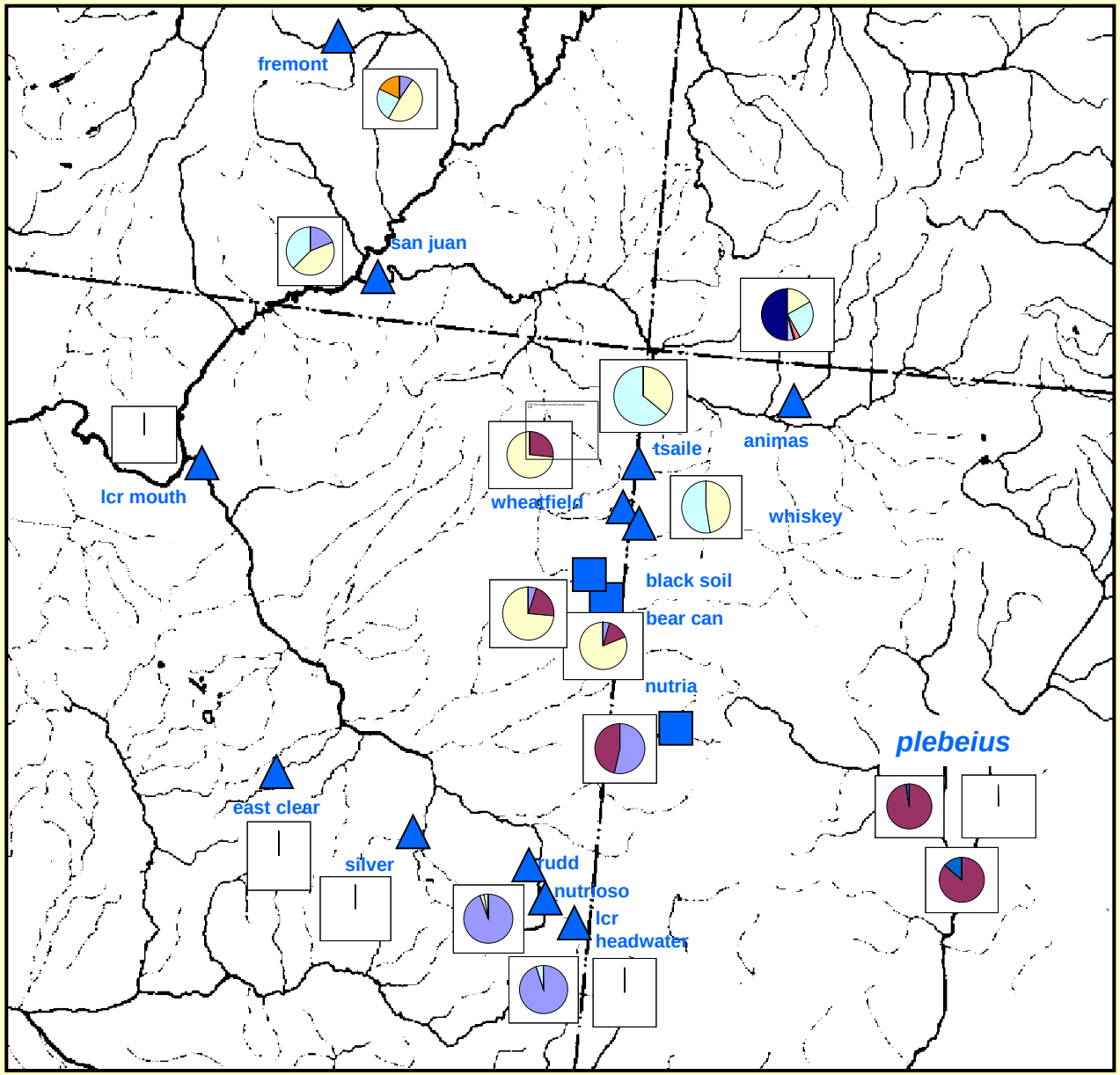
- ***C. plebeius* is in one upper LCR population (Nutria)**

# What about the nDNA?

# 2H2 allele phylogeny



# 2H2 allele distribution

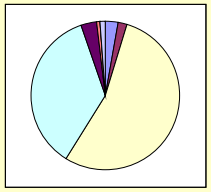



## Major alleles

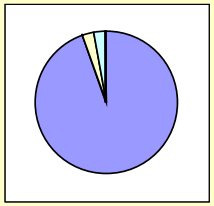
A-LCR
B-*plebeius*
C-Colorado
D-Colorado

- ***plebeius*** **alleles in Canyon de Chelly**
- **Colorado alleles in LCR**

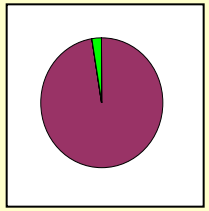
# Cross-basin gene flow for 2H2 gene



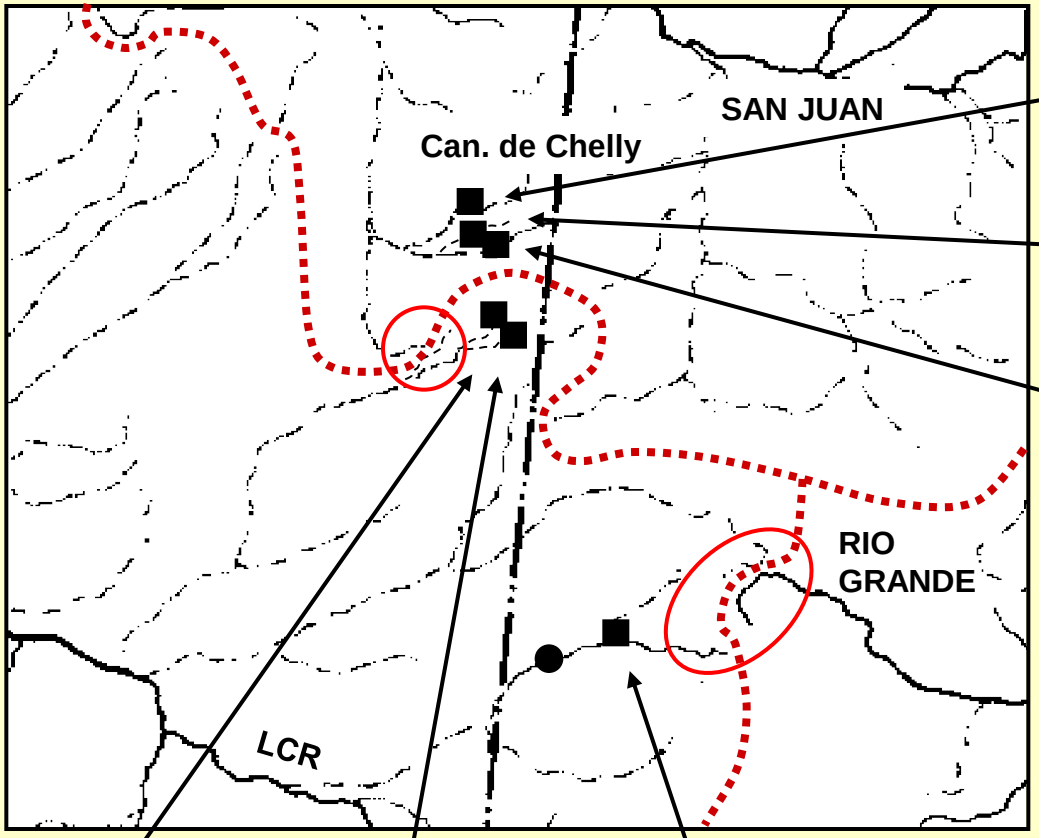
average
Colo. /San Juan

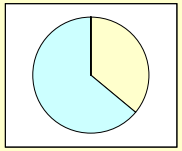


average
LCR

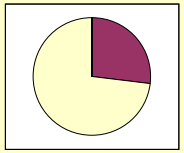


average
*plebeius*

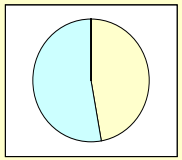


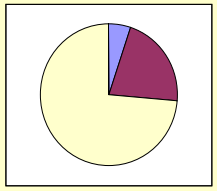
tsaile



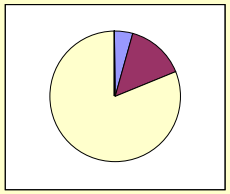
wheatfield



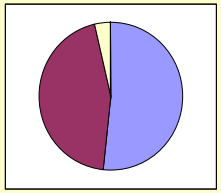
whiskey



black soil



bear canyon

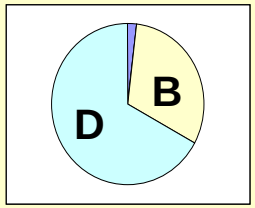


nutria

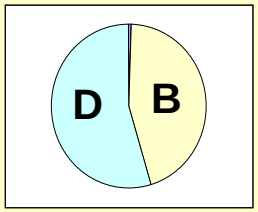
Type locality:
Zuni R

# nDNA alleles for RAG

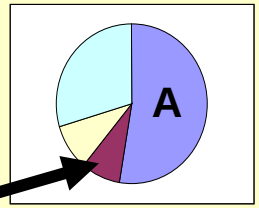
| subbasin | site | A | B | C | D |
|---|---|---|---|---|---|
| mainstem Colo. | ANIMAS | 3 | 19 | | 25 |
| mainstem Colo. | FREMONT R | | 10 | | 52 |
| mainstem Colo. | SAN JUAN R | | 18 | | 4 |
| mainstem Colo. | LCR @ Colo.(mouth) | | 4 | | 28 |
| Can. de Chey | TSAILE | | 35 | | 23 |
| Can. de Chey | WHEATFIELD | | 4 | | 22 |
| Can. de Chey | WHISKEY | 1 | 29 | | 38 |
| Little Colo. | BLACK SOIL | 19 | | | 35 |
| Little Colo. | BEAR CANYON | 66 | 1 | | 47 |
| Little Colo. | E. CLEAR | 74 | 3 | | 2 |
| Little Colo. | SILVER | 34 | | | |
| Little Colo. | RUDD | 18 | 2 | | 18 |
| Little Colo. | NUTRIOSO | 19 | 3 | | 13 |
| Little Colo. | LCR (headwaters) | 13 | | | 27 |
| Little Colo. | NUTRIA | 24 | 39 | 42 | 9 |
| Rio Grande | JEMEZ R | | | 8 | 4 |
| Guzman | SAN MIGUEL R | | | | 20 |
| Guzman | SANTA MARIA R | | | | 40 |



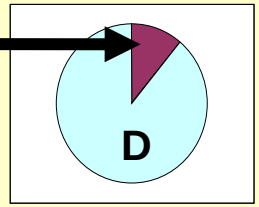

**Colorado mainstem**



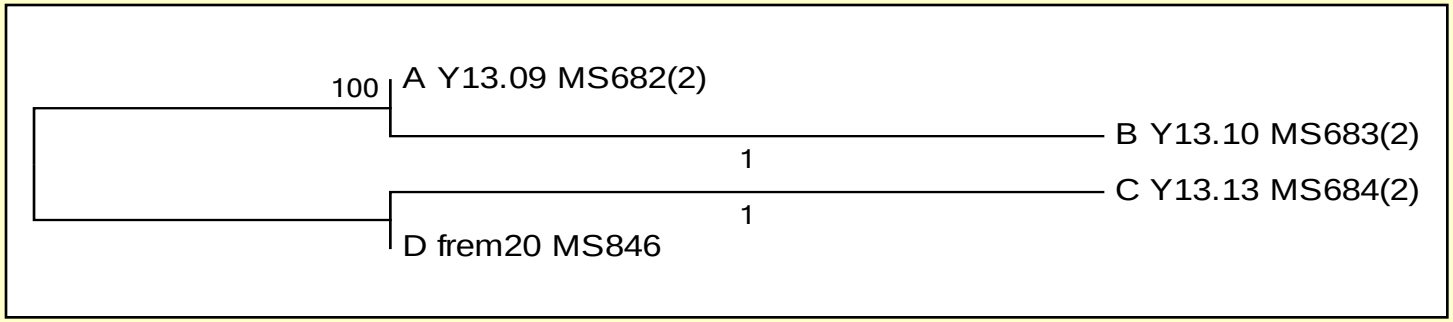

**Canyon de Chelly**




**LCR**




**NM/MEX *plebeius***



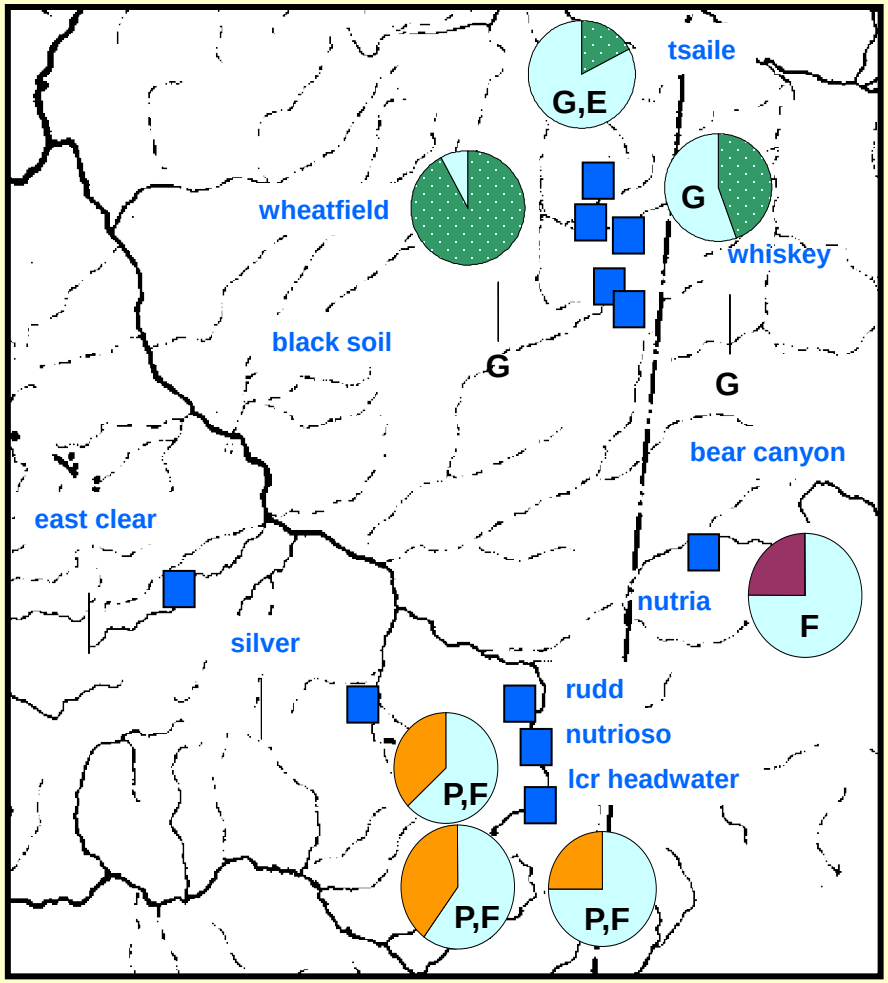
# Summary

- **Considerable variation:**
  - **mtDNA**
    - **21 haplotypes**
    - **Diagnostic for at least three forms (and Canyon de Chelly?)**
    - **Evidence for exchange among drainages and hybridization**
  - **2H2**
    - **8 alleles**
    - **Diagnostic for three forms**
    - **Evidence for exchange among drainages and hybridization**
  - **RAG**
    - **4 alleles**
    - **Not diagnostic (widespread allele D)**
    - **Other alleles consistent with above patterns**
      - **Evidence for exchange among drainages and hybridization**
- **Patterns of variation identify geographic units**

# Variation and hybridization

- **Novel LCR variant distinct from *discobolus* and *plebeius***
  - **Undescribed form in north draining LCR tributaries**
  - **Genetically distinct but not evident with morphology**
- **Introgression of *C. plebeius* into LCR (all 3 loci)**
  - **Nutria and Black Soil/Bear Canyon sites**
  - **Limited *C. plebeius* influence in San Juan (Wheatfield)**
- ***C. discobolus* alleles from San Juan via Canyon de Chelly into LCR**
  - **How long ago and how far?**

# mtDNA haplotypes by lineage




- **Different haplotypes in Canyon de Chelly and Kin Li Chee vs. headwaters LCR**
- **Variation in ages of contact**
- **Sequence of more variable genes necessary to address isolation of each of these regions**

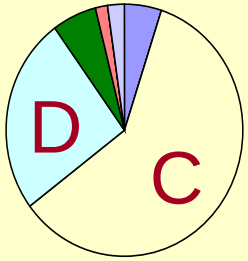
# Disposition of *C. d. yarrowi*

- ***C. d. yarrowi*** **in LCR is of hybrid origin**
  - **Includes contributions from three genetic lineages**
    - ***C. discobolus***
      - **includes Canyon de Chelly subgroup**
    - ***C. plebeius***
    - **Undescribed LCR form**
- **Results consistent with both previous studies**
  - **Admixture with *plebeius* could explain widespread morphological intermediacy (Smith et al. 1983)**
  - **Distinct form in LCR could account for additional variation (Crabtree and Buth 1987)**

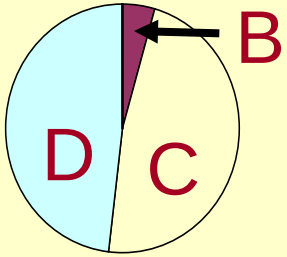
# nDNA 2H2 alleles

| subbasin | site | A | B | C | D | E | F | G | H | total |
|---|---|---|---|---|---|---|---|---|---|---|
| mainstem Colo. | ANIMAS | | | 17 | 25 | | 3 | | 4 | 49 |
| mainstem Colo. | FREMONT R | 6 | | 30 | 15 | 11 | | | | 62 |
| mainstem Colo. | SAN JUAN R | 3 | | 7 | 6 | | | | | 16 |
| mainstem Colo. | LCR @ Colo.(mouth) | | | 54 | | | | | | 54 |
| Can. de Chelly | TSAILE TOTAL | | | 21 | 37 | | | | | 58 |
| Can. de Chelly | WHEATS TOTAL | | 7 | 19 | | | | | | 26 |
| Can. de Chelly | WHISKEY TOTAL | | | 34 | 38 | | | | | 72 |
| Little Colo. | BLACK SOIL | 4 | 16 | 56 | | | | | | 76 |
| Little Colo. | BEAR CANYON | 1 | 1 | 92 | | | | | | 94 |
| Little Colo. | E. CLEAR CR | 80 | | | | | | | | 80 |
| Little Colo. | SILVER CR | 34 | | | | | | | | 34 |
| Little Colo. | RUDD CR | 36 | | 1 | 1 | | | | | 38 |
| Little Colo. | NUTRIOSO CR | 38 | | | 2 | | | | | 40 |
| Little Colo. | LCR (headwaters) | 38 | | | | | | | | 38 |
| Little Colo. | NUTRIA TOTAL | 58 | 50 | 4 | | | | | | 112 |
| Rio Guzman | SAN MIGUEL R | | 19 | | | | | 3 | | 22 |
| Rio Guzman | SANTA MARIA R | | 39 | | | | | 1 | | 40 |
| Rio Grande | JEMEZ R | | 12 | | | | | 0 | | 12 |

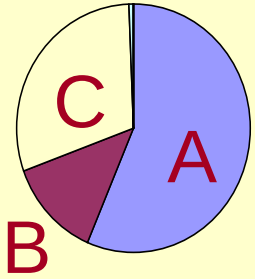
mainstem Colorado



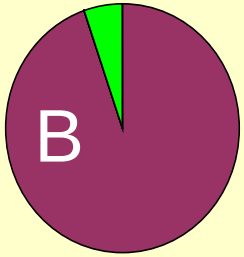

Canyon de Chelly




LCR




NM/MEX *plebeius*



# mtDNA haplotypes

| subbasin | site | A | B | N | Z | D | O | U | C | G | E | R | Q | S | T | P | F | J | K | L | V | W | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mainstem Colo. | ANIMAS | 16 | 5 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | 25 |
| mainstem Colo. | FREMONT R | 16 | 15 | | | | | | | | | | | | | | | | | | | | 31 |
| mainstem Colo. | SAN JUAN R | 3 | 2 | 2 | | | 1 | | | | | | | | | | | | | | | | 8 |
| mainstem Colo. | LCR @ Colo.(mouth) | 15 | | | | | | 1 | | | | | | | | | | | | | | | 16 |
| Can. de Chey | TSAILE TOTAL | | | | | | | | 5 | 17 | 7 | | | | | | | | | | | | 29 |
| Can. de Chey | WHEATS TOTAL | | | | | | | | 12 | 1 | | | | | | | | | | | | | 13 |
| Can. de Chey | WHISKEY TOTAL | | | | | | | | 16 | 20 | | | | | | | | | | | | | 36 |
| Little Colo. | BLACK SOIL | | | | | | | | | 38 | | | | | | | | | | | | | 38 |
| Little Colo. | BEAR CANYON | | | | | | | | | 47 | | | | | | | | | | | | | 47 |
| Little Colo. | E. CLEAR CR | | | | | | | | | | | 34 | 6 | | | | | | | | | | 40 |
| Little Colo. | SILVER CR | | | | | | | | | | | | | 3 | 14 | | | | | | | | 17 |
| Little Colo. | RUDD CR | | | | | | | | | | | | | 2 | 10 | 5 | 2 | | | | | | 19 |
| Little Colo. | NUTRIOSO CR | | | | | | | | | | | | | 1 | 7 | 7 | 5 | | | | | | 20 |
| Little Colo. | LCR (headwaters) | | | | | | | | | | | | | 1 | 4 | 4 | 11 | | | | | | 20 |
| Little Colo. | NUTRIA TOTAL | | | | | | | | | | | | | | | | 42 | 14 | | | | | 56 |
| Rio Guzman | SAN MIGUEL R | | | | | | | | | | | | | | | | | 7 | 2 | 1 | | | 10 |
| Rio Guzman | SANTA MARIA R | | | | | | | | | | | | | | | | | 1 | | | | 19 | 20 |
| Rio Grande | JEMEZ R | | | | | | | | | | | | | | | | | | | | 6 | | 6 |