Adaptation of rodents to arid environments: Jaculus, colour and remote sensing data

Zbyszek Boratynski

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Department of Biological and Environmental Science, University of Jyväskylä, Finland

BIODESERTS

BIODESERTS and rodents from Sahara-Sahel

Overview

1. **BIODESERTS** (Biodiversity of Deserts and Arid Regions Research Group):

   interests, aims, practices

2. Rodents in BIODESERTS:

   Jaculus, Felovia, Gerbillus

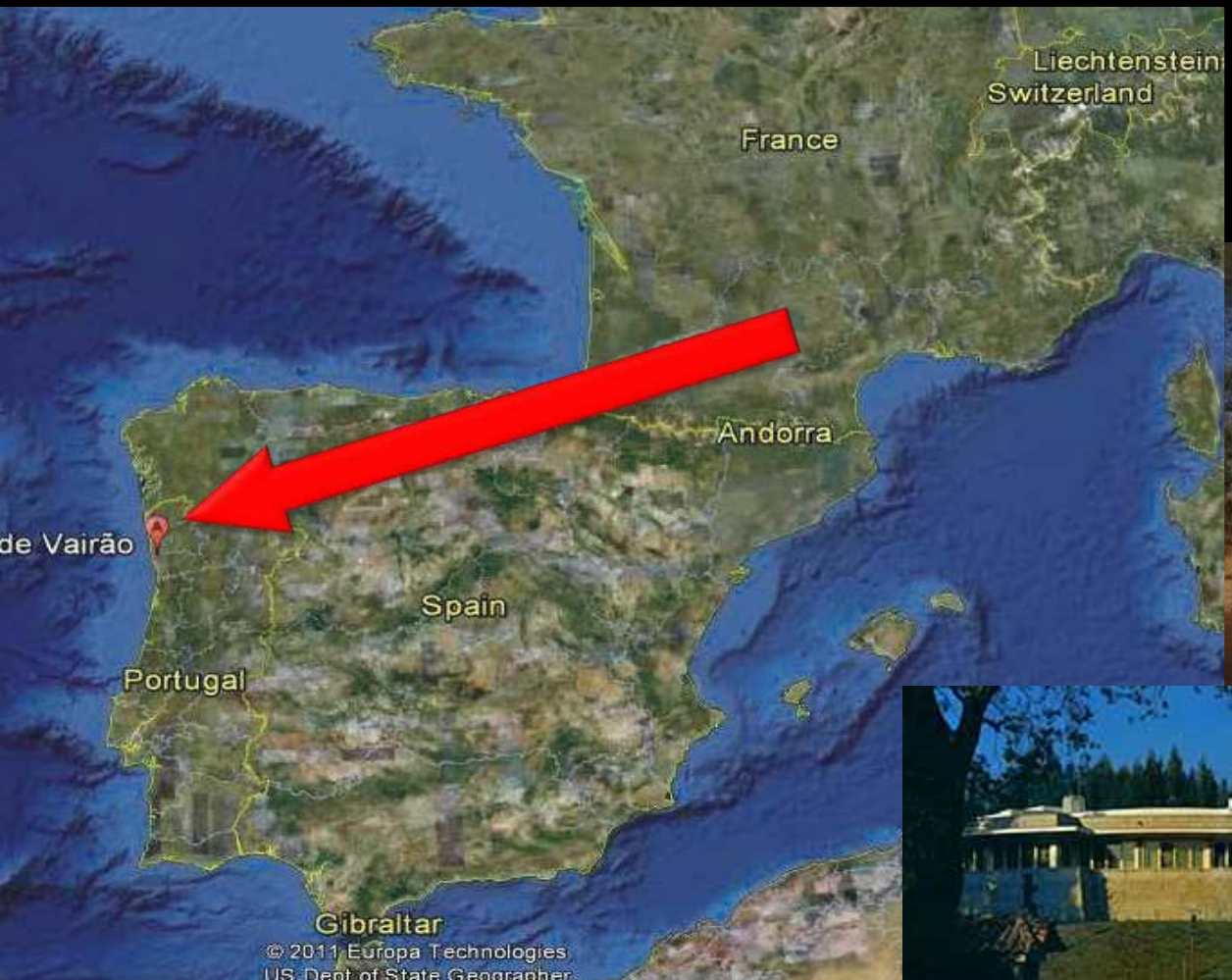
3. Prospects (plans, team, founds)

Research group - location:

Biodiversity of Deserts and Arid Regions

- assessing biodiversity patterns in deserts and arid regions

http://biodeserts.cibio.up.pt



CIBIO/InBio
Research Center in Biodiversity & Genetic Resources, University of Porto

Research group – main research lines:

Biodiversity of Deserts and Arid Regions

- assessing biodiversity patterns in deserts and arid regions

1. Biodiversity distribution:

distribution of species and identification of biodiversity hotspots, identification of environmental and physiological factors related to distribution, and multi-time scale modeling of biodiversity distribution

2. Evolutionary and Landscape processes:

determination of biogeographical relationships and spatial patterns in morphological and genetic variation, identification of barriers to gene flow, and investigation of the role of paleogeographical mechanisms in diversification events

3. Conservation planning:

identification of threatened taxa and of factors making populations prone to extinction, designing optimized reserve solutions for biodiversity conservation, simulation of climate change effects on biodiversity distribution.

Brito et al. 2014. Unravelling biodiversity, evolution and threats to conservation in the Sahara-Sahel. Biol Rev, 89:215-31

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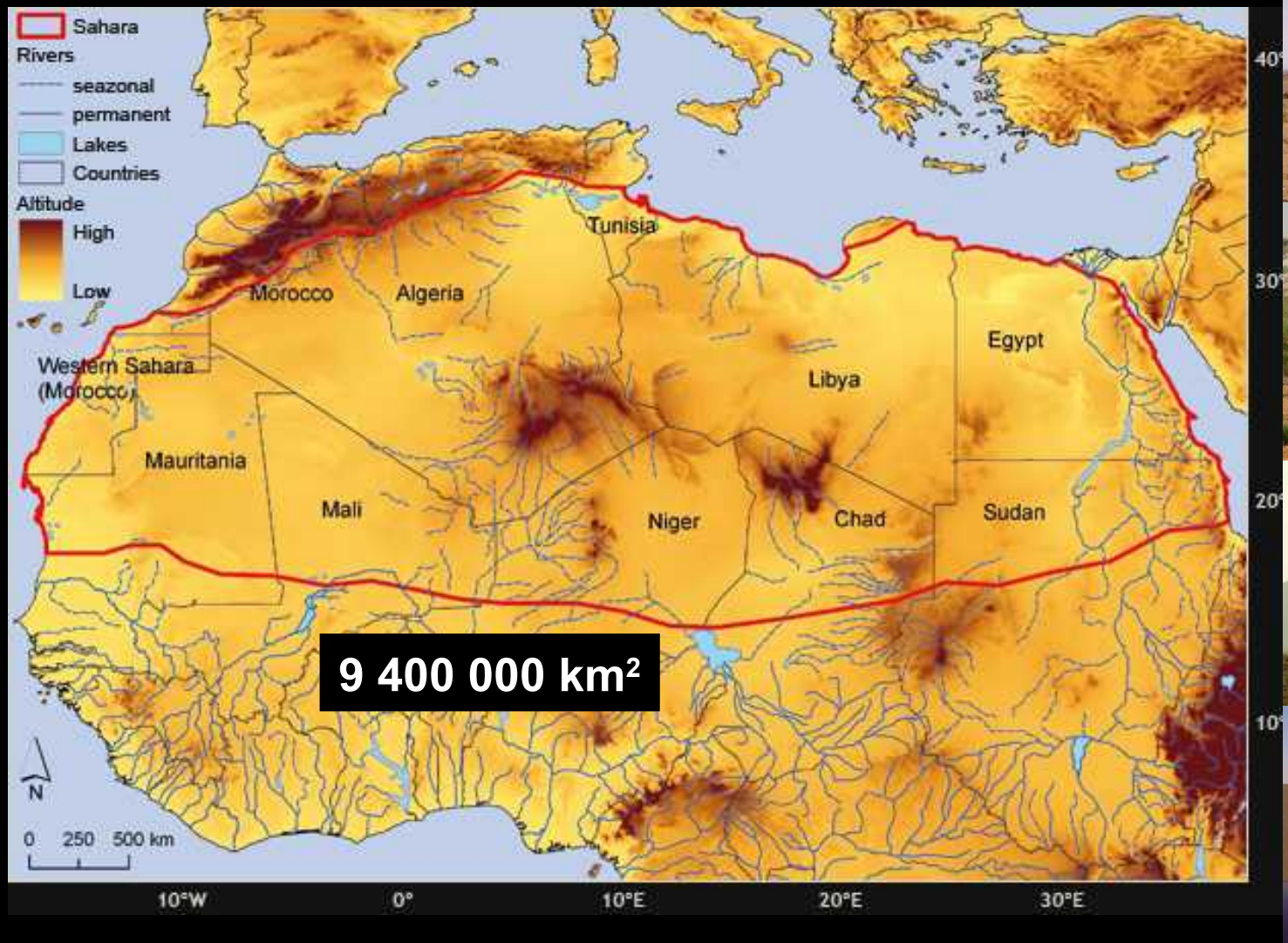

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http://biodeserts.cibio.up.pt

Challenges!

9 400 000 km² (Australia is only 7 600 000)

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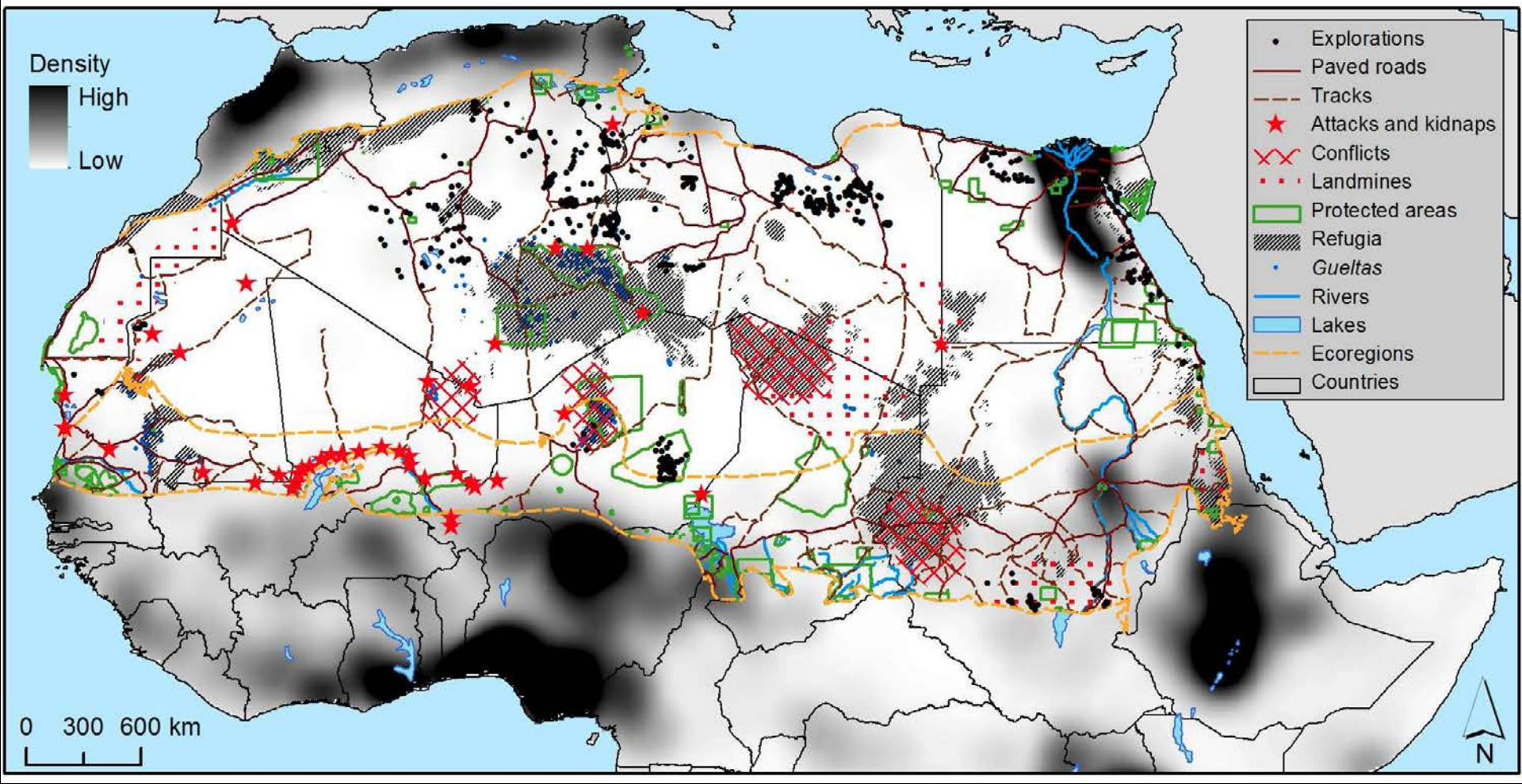

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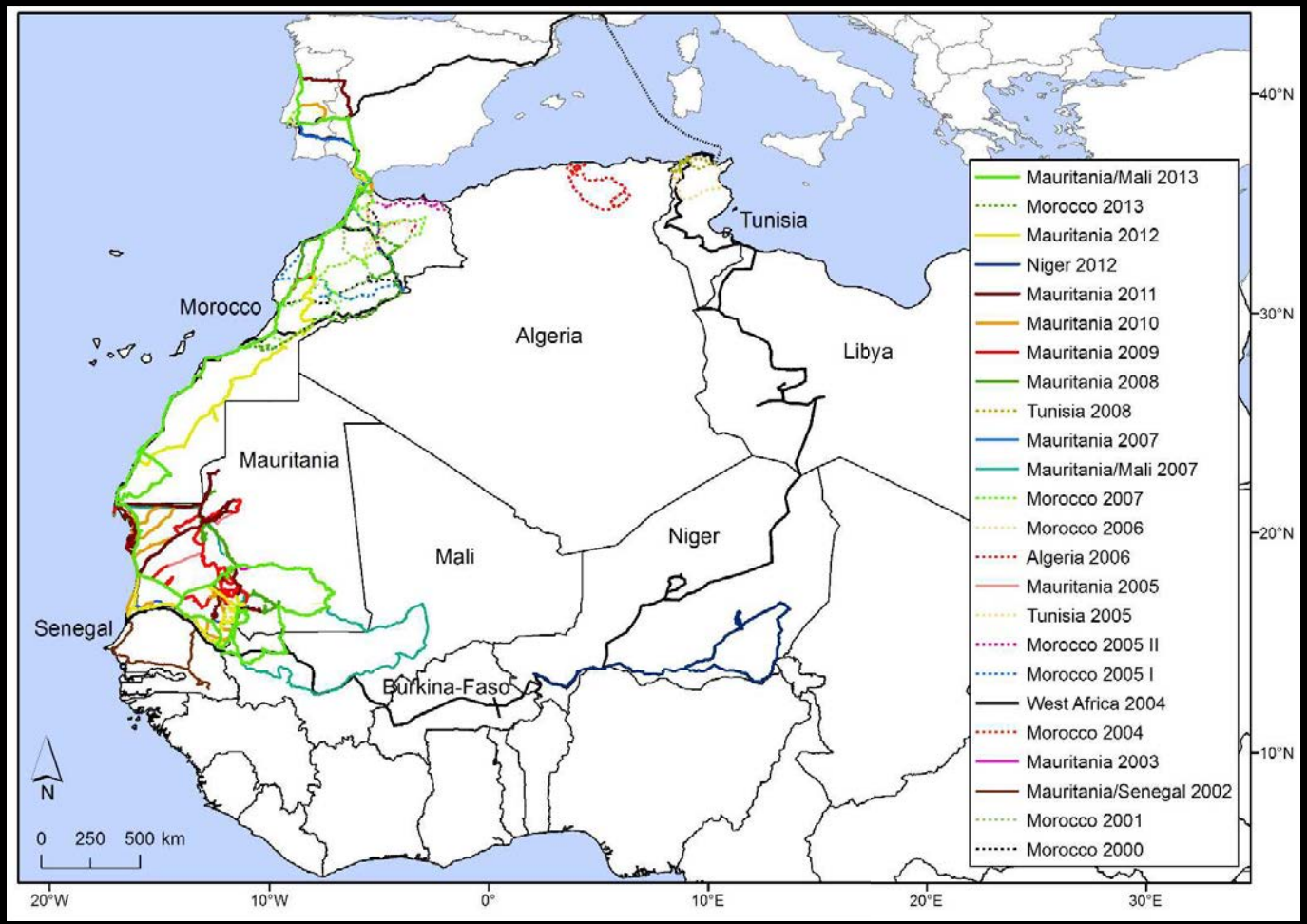


25 expeditions (2000 -2014):

10 countries
600 work days
100 000 km

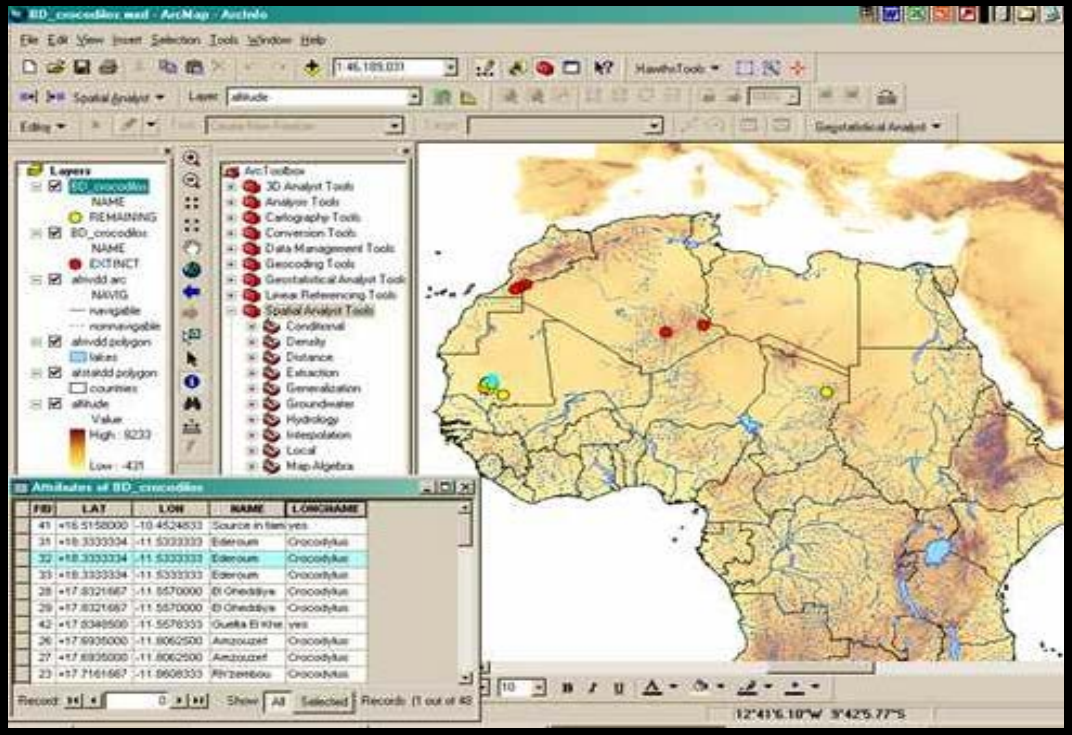
Research group - main aim:

Biodiversity of Deserts and Arid Regions

- assessing biodiversity patterns in deserts and arid regions

Geographical Information Systems, environmental data, inter- and intraspecific variation (e.g. genetic):

1. describe/predict biodiversity distribution
2. detect mechanisms affecting diversity distribution
3. find threats to diversity



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Biodiversity of Deserts and Arid Regions

- assessing biodiversity patterns in deserts and arid regions

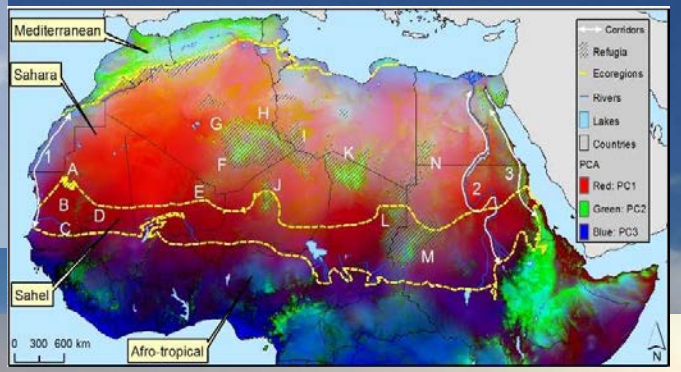


Mechanisms behind biodiversity patterns in Saharo-Sahelian rodents



Sahara – spatial variation

Altitude: -133 to 3415 m.n.p.m.
Topography: mountains, sand seas, rivers
Rainfall (aver. annual): ≈ 0 to 981 mm of rainfall
T. (aver. annual): 9.4 to 30.8 ºC



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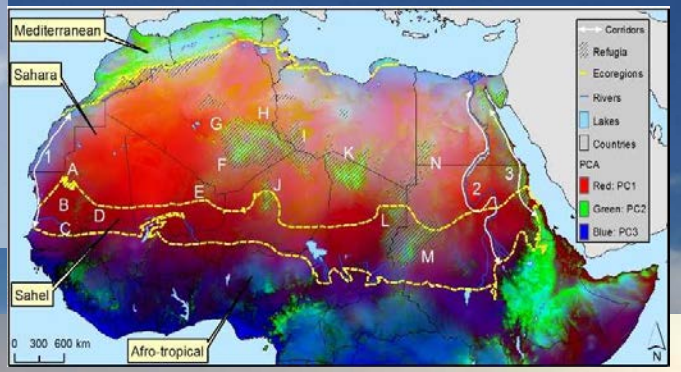
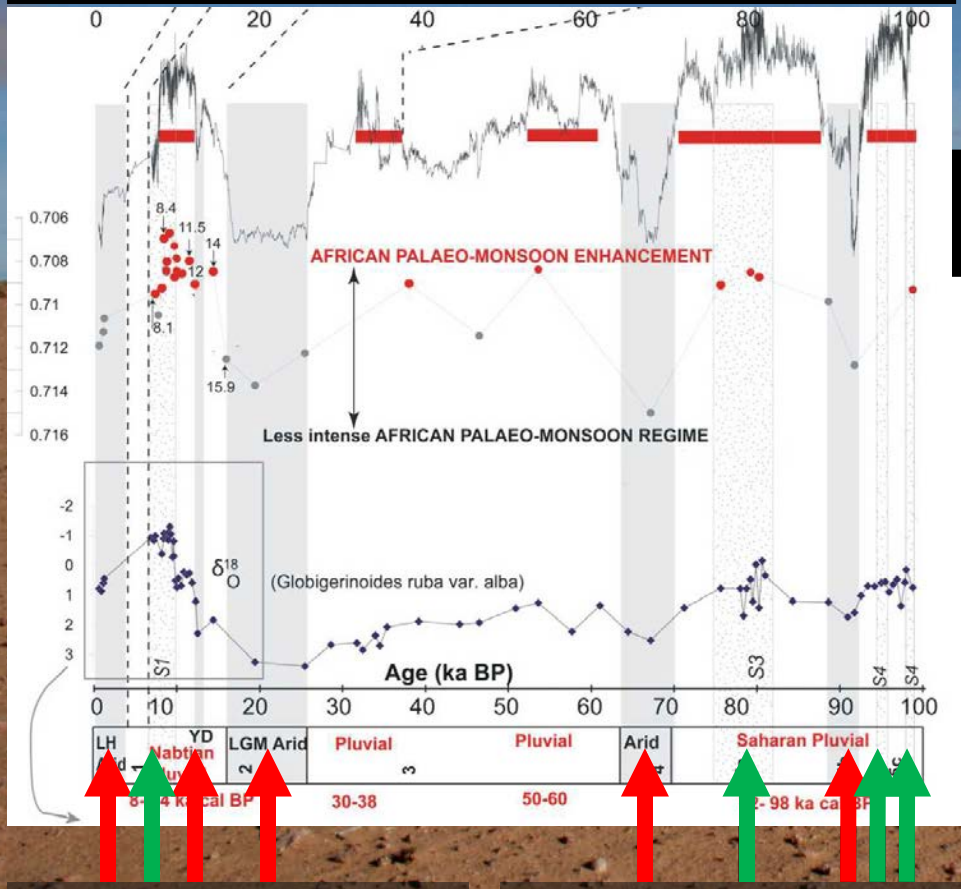


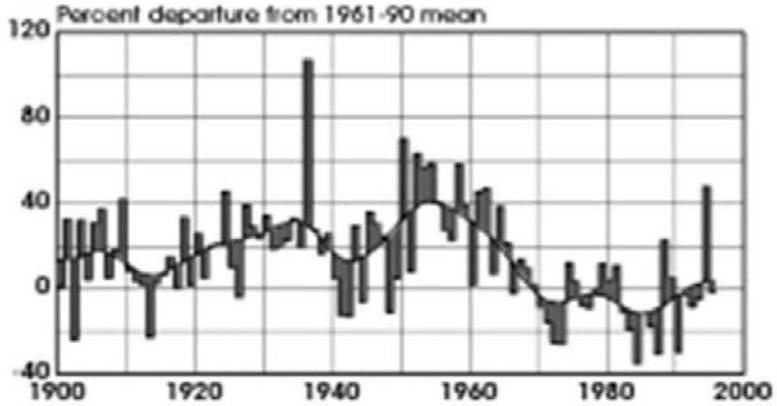
Sahara – temporal variation

Oscillating climate:
- since Pliocene eight to ten major dry-wet cycles
- least climate switch around 5000 year ago
- switches of habitat extend of about 1000 km

Ancient climate fluctuations: 0-100 000 B.P.



Ongoing fluctuation in precipitation: 1900-2000



Saharan arid periods

Green Sahara, wet periods

Sahara – temporal variation

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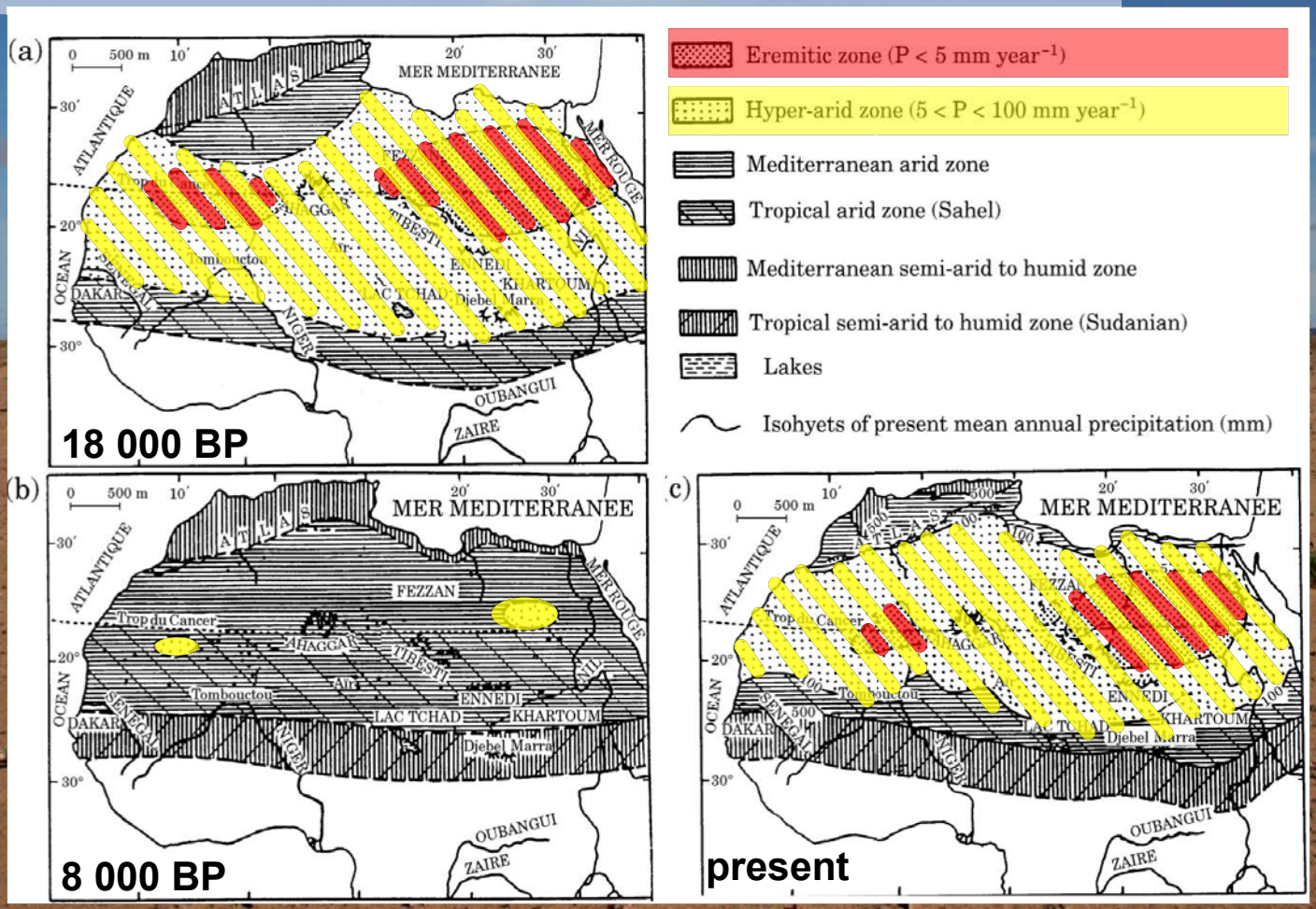

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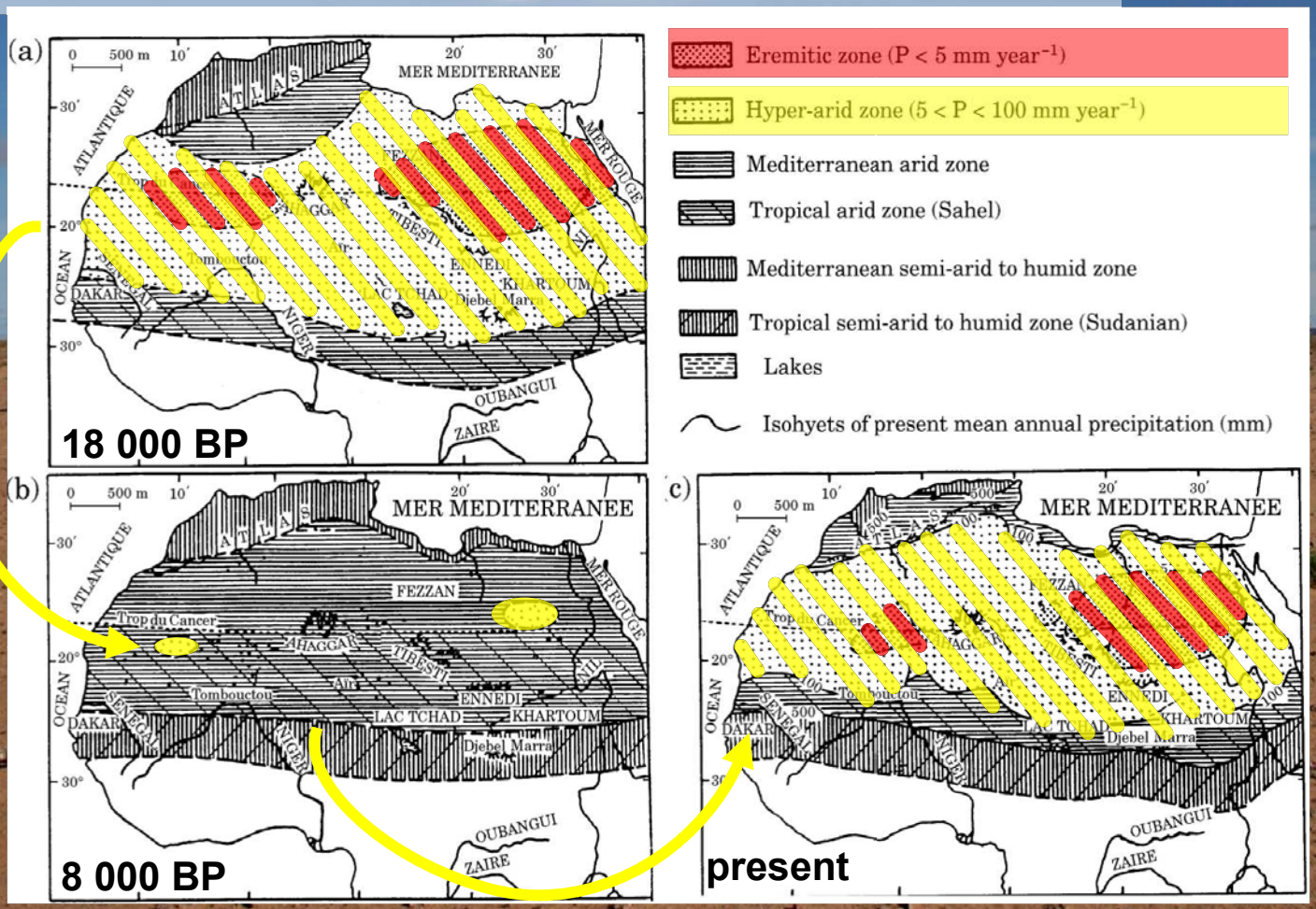
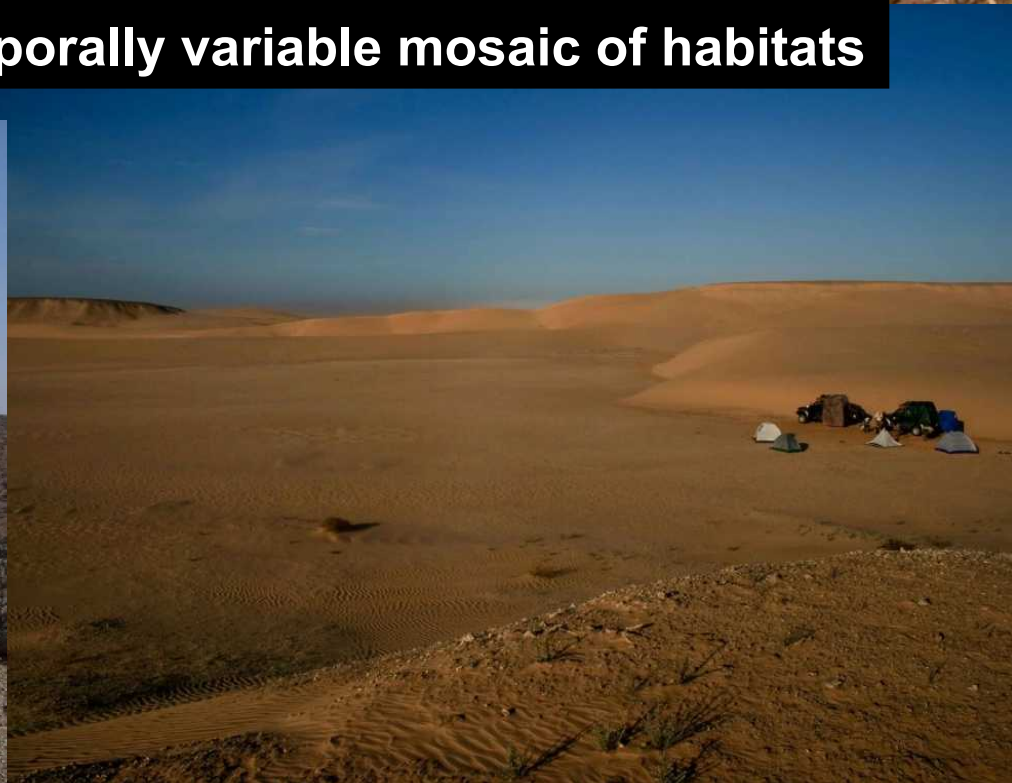


Sahara consist spatially and temporally variable mosaic of habitats



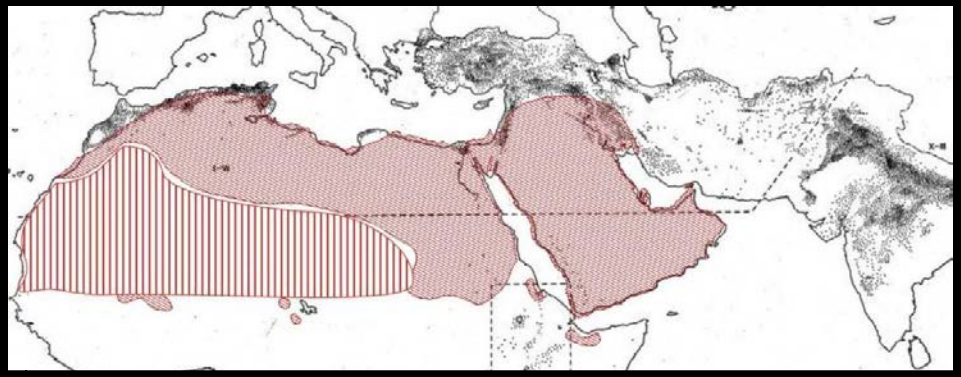
Sahara consist spatially and temporally variable mosaic of habitats

How organisms response to that variations?

Research group - main aim:

Biodiversity of Deserts and Arid Regions

- assessing biodiversity patterns in deserts and arid regions

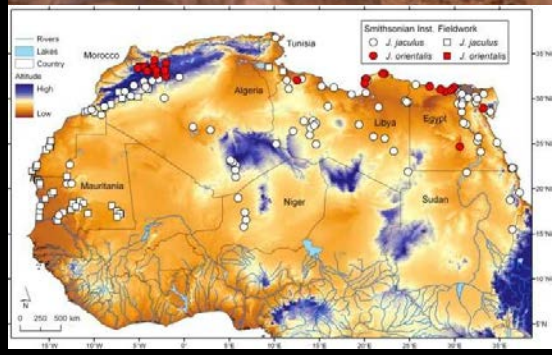


How spatial variation influence diversity within Saharan species?

How spatial variation influence diversity within Saharan species, lesser Egyptian jerboa (*Jaculus jaculus*)?

Available samples (298):

- 130 specimens, own samples (West Africa)
- 79 specimens, NMNH, Washington D.C. (Sahara)
- 11 specimens, HNHM, Hungary (East Africa)
- 8 specimens, Krakow, Poland (Algeria)
- 7 Natural History Museum, Vienna (East Africa)
- 16 Royal Belgian Institute of Natural Sciences (Sahara)
- 24 Royal Museum of Central Africa (Sahara)
- 23 La Specola, Florence, Italy (Somalia)



Field expeditions:

Algeria, Niger, Morocco, Tunisia, Mauritania, Mali

Boratyński Z, Brito JC, Mappes T (2012). The origin of two cryptic species of African desert jerboas (*Dipodidae: Jaculus*). Biological Journal of the Linnean Society, 10.1111/j.1095-8312.2011.01791.x

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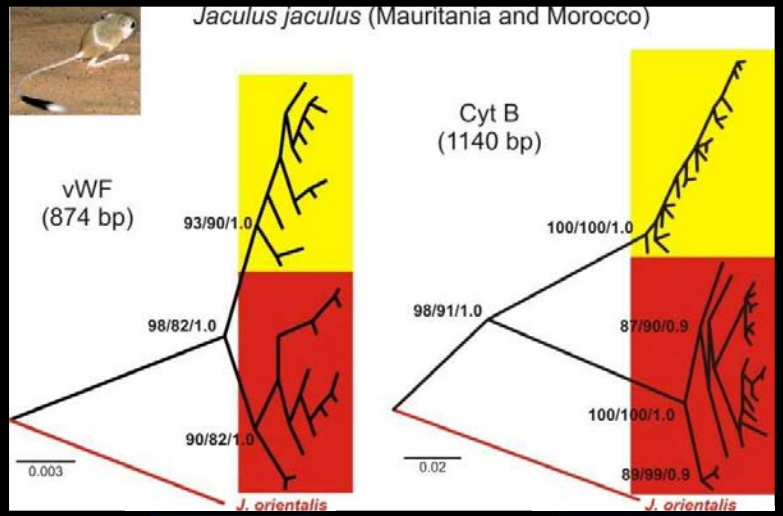
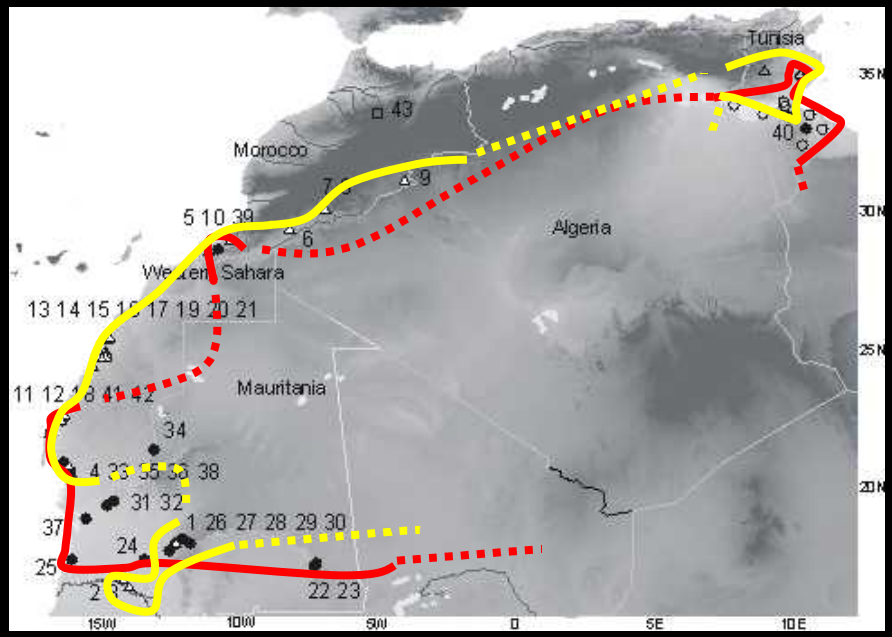
Genetic polymorphism

Jaculus jaculus **(Linnaeus 1758)**

- West Sahara (Mauritania, Morocco, Tunisia)
- 2 distinct and sympatric clades
- genetic variation on both mitochondrial and nuclear levels



1.3% **10.6%**



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Genetic polymorphism

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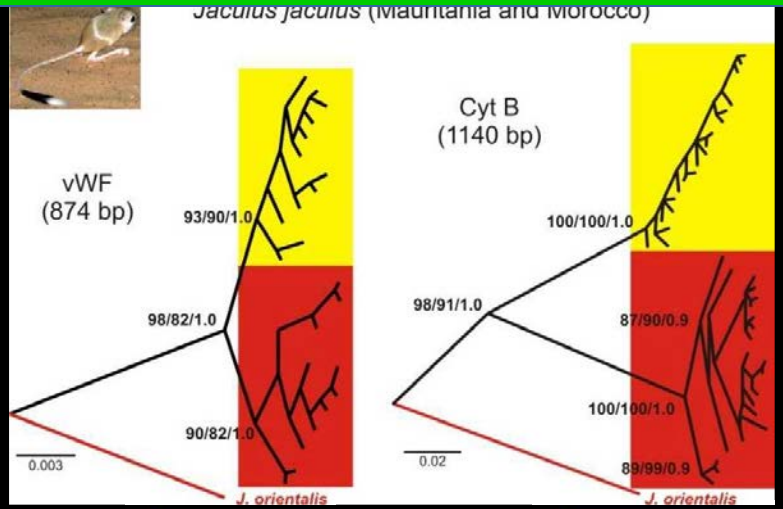
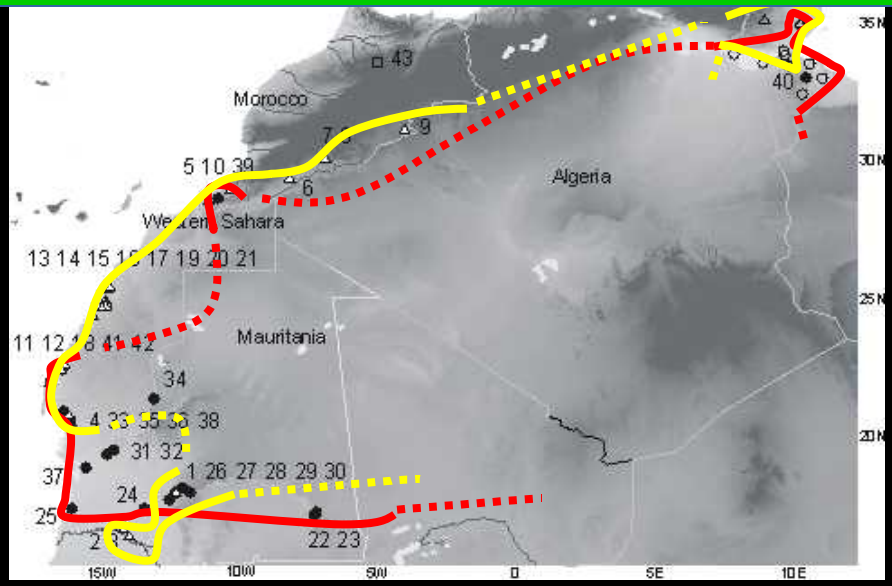
Geographical sympatry but ecological separation of distinct genetic lineages?



1.3% **10.6%**



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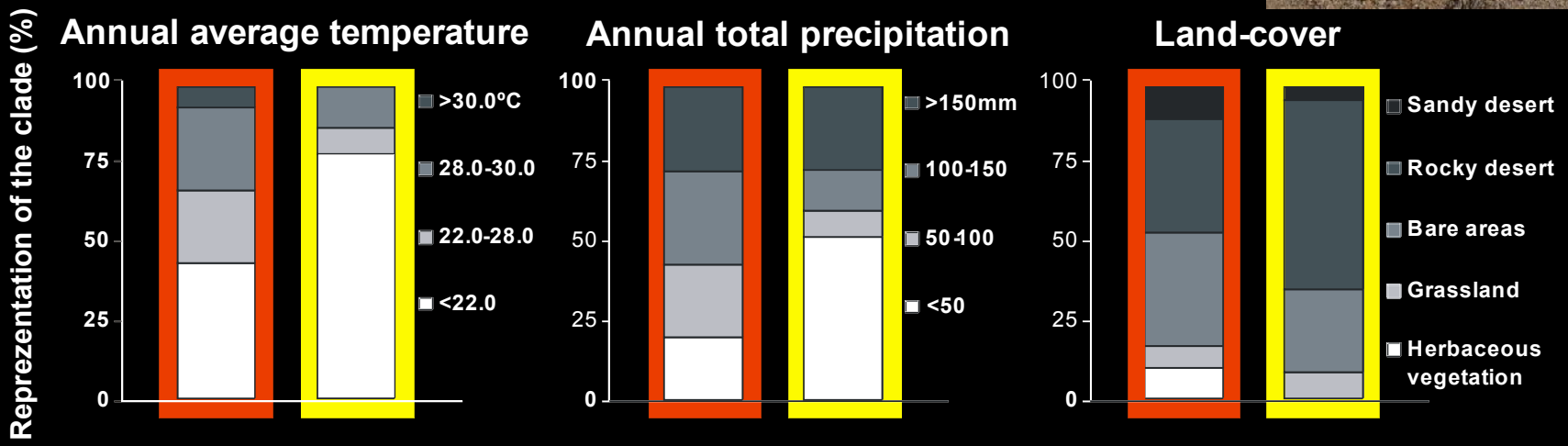
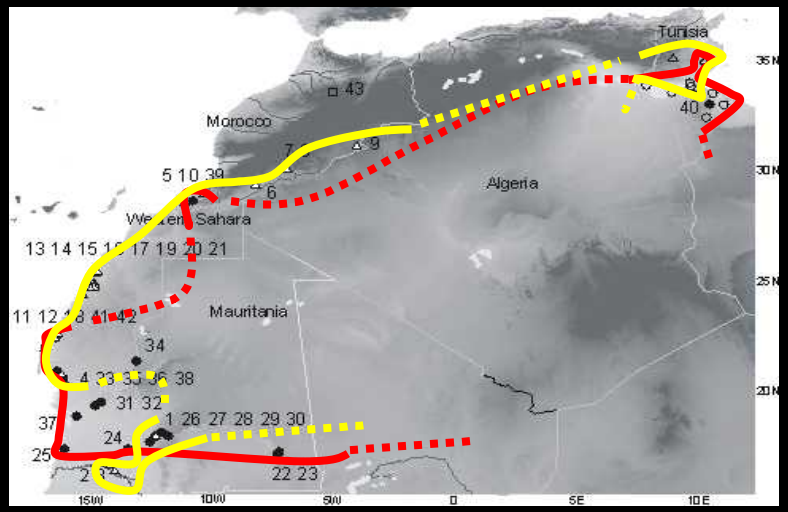
Habitat





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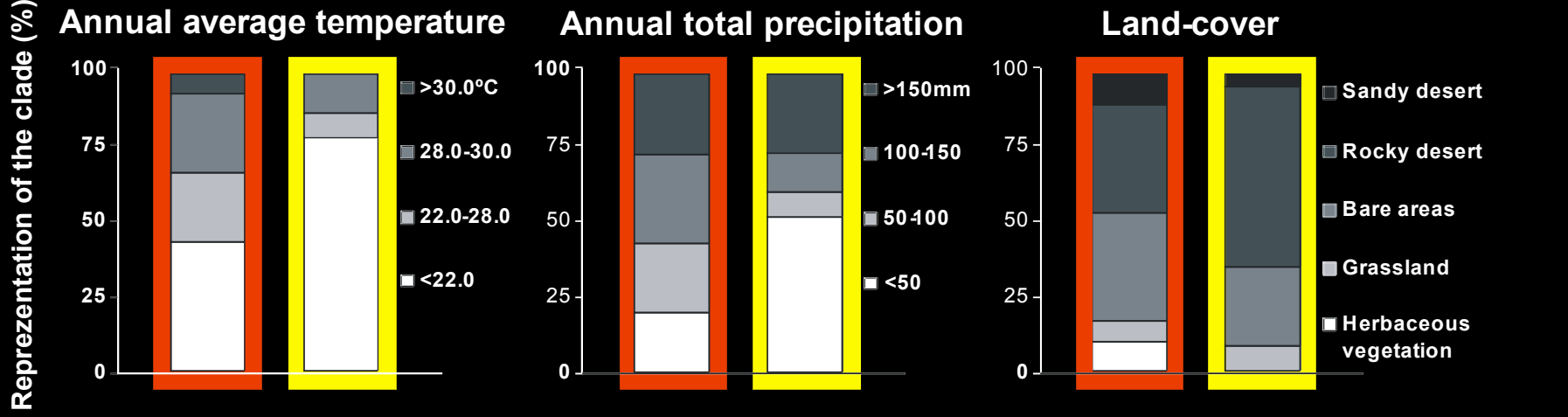
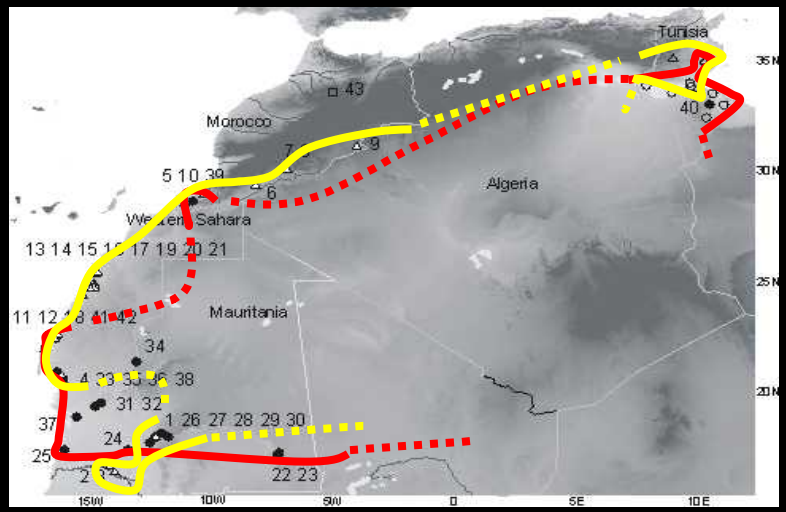
Habitat and phenotypic variation





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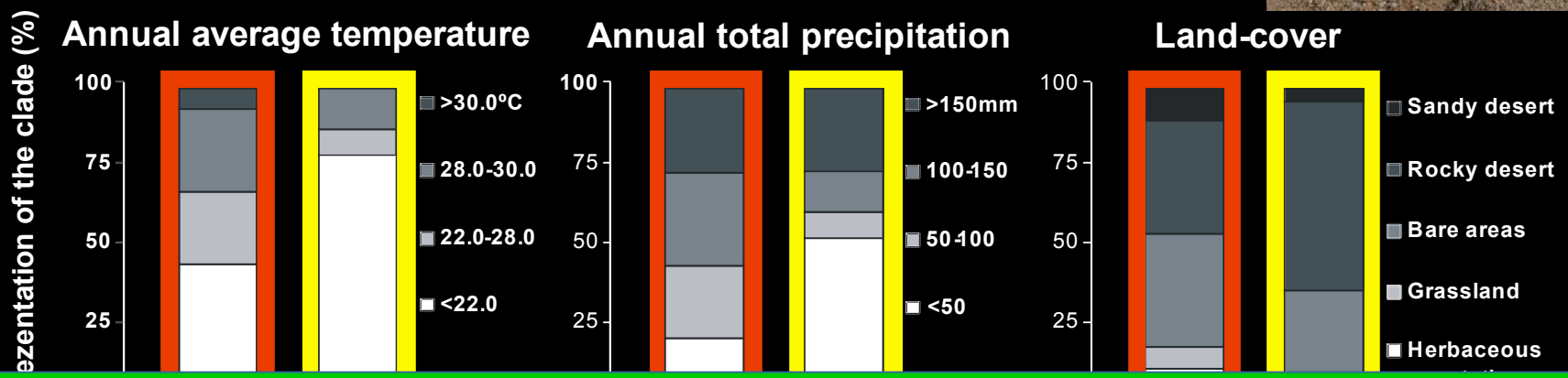
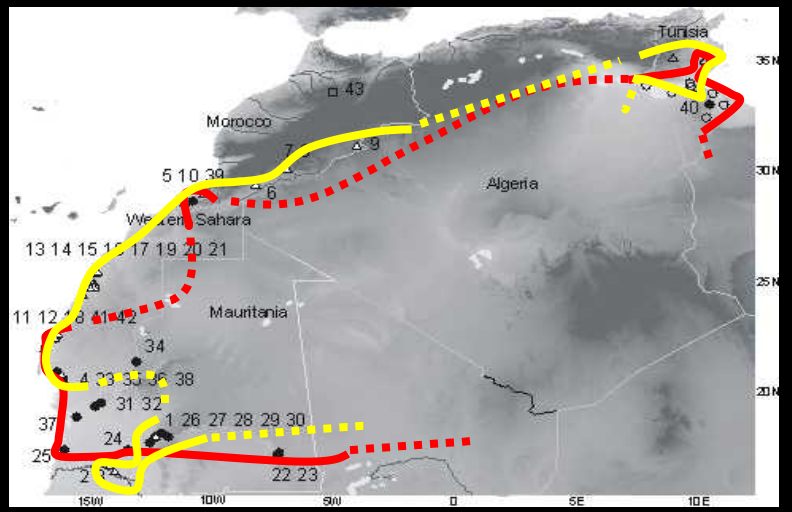


Variations in phenotype and habitat, but is there covariation?



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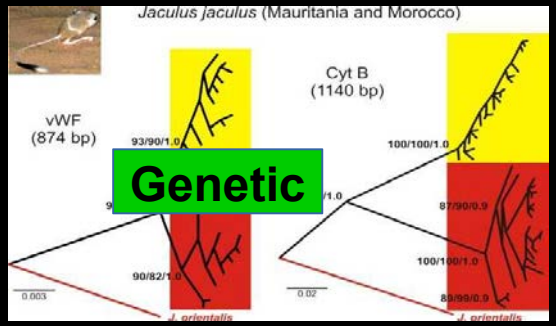
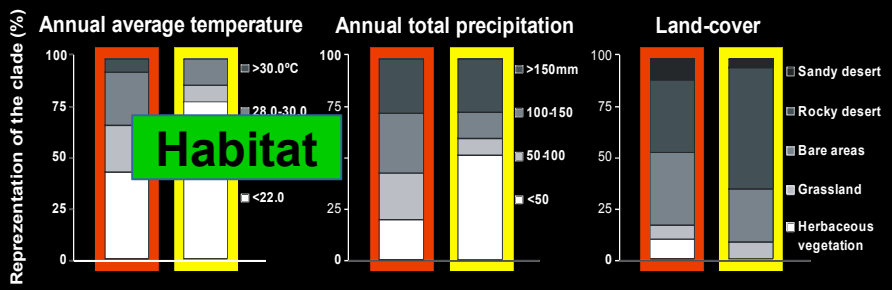
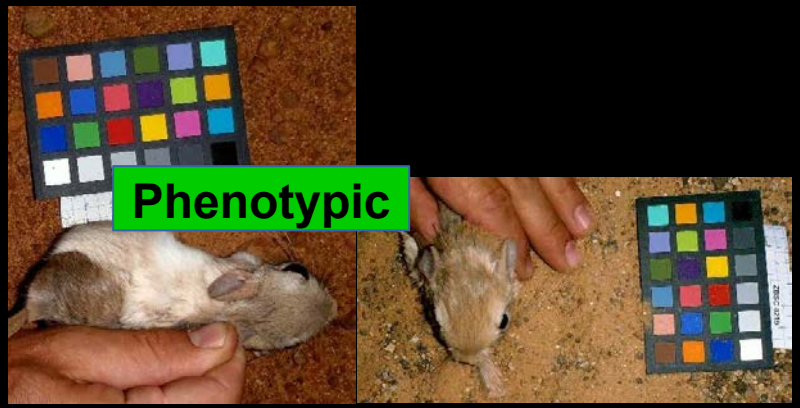
Covariation between genetic, habitat and phenotypic variation



QUESTIONS

Is evolution of camouflage involved?





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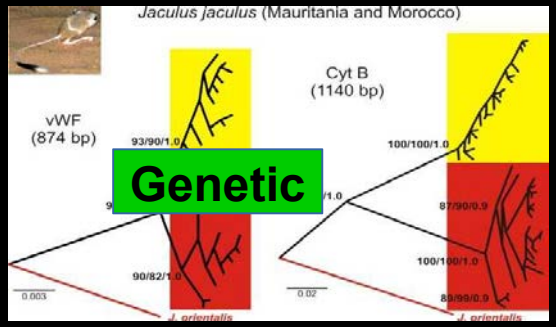

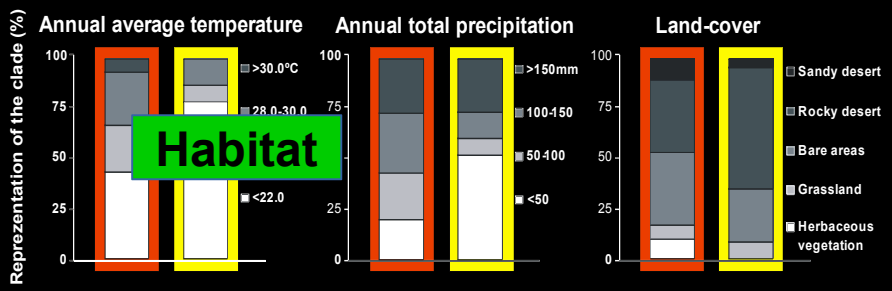

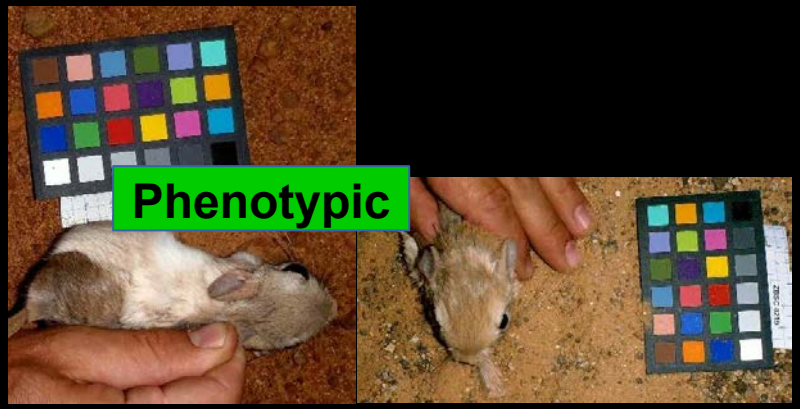

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Is evolution of camouflage involved?

Did it promote divergence?

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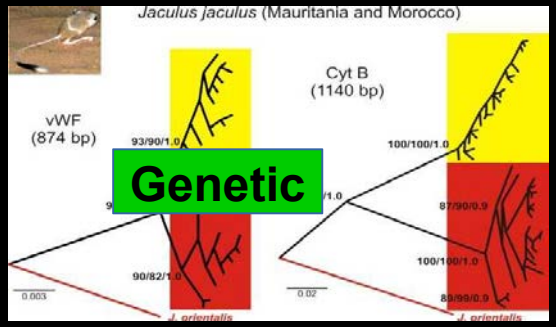

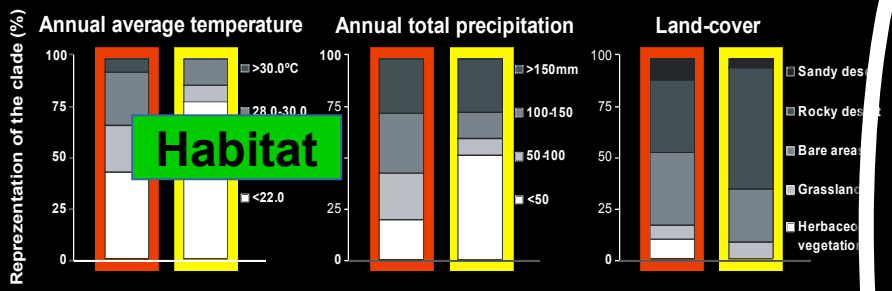

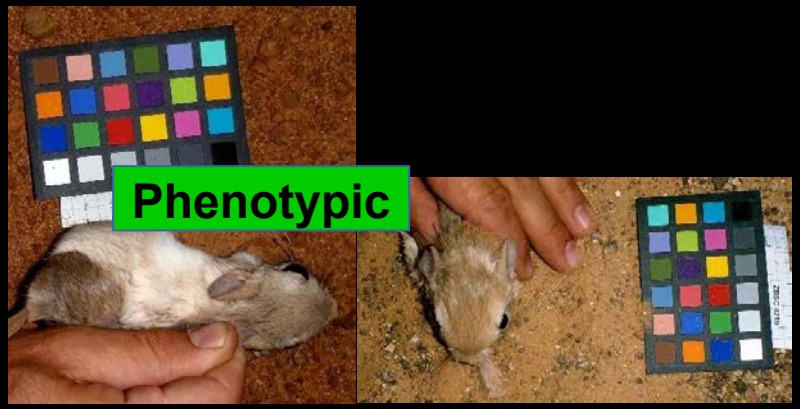

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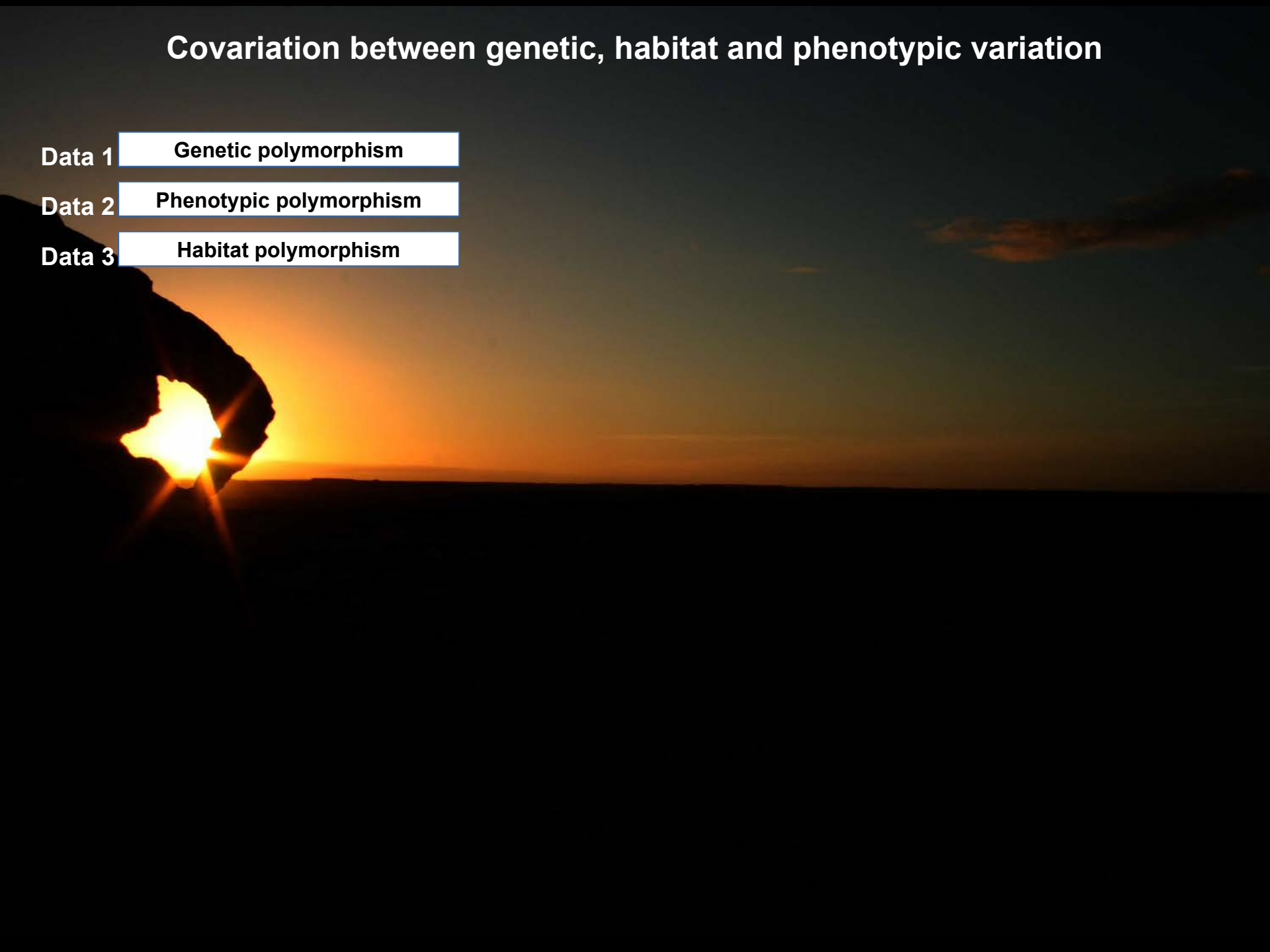
PREDICTIONS

Phenotypic and genetic divergence

Colors matching between soil and animal fur

Covariation between genetic, habitat and phenotypic variation



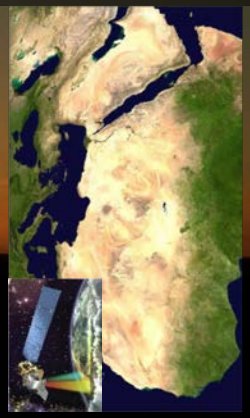
Covariation between genetic, habitat and phenotypic variation

Data 1 — Genetic polymorphism

Data 2 — Phenotypic polymorphism

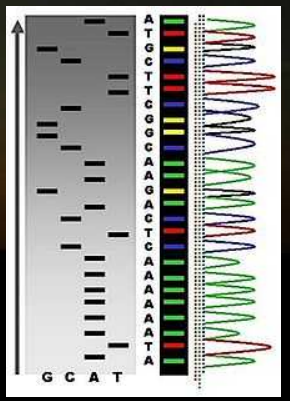
Data 3 — Habitat polymorphism

SATELLITE PHOTOGRAPHY



DIGITAL PHOTOGRAPHY

DNA SEQUENCING



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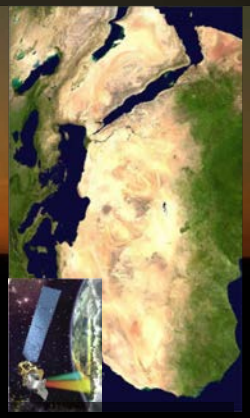

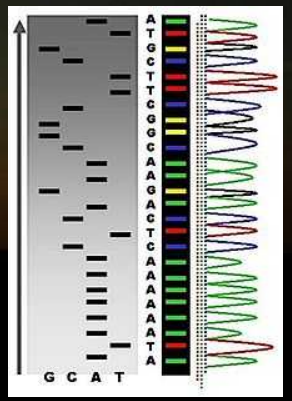

REMOTE SENSING

COLOR ANALYSES

PHYLOGENETIC RECONSTRUCTONS

Soil / rock color

Dorsal fur color

Relatedness between samples

Habitat luminosity and RGB colors

Phenotype luminosity and RGB

Genetic clade affiliations

Covariation between genetic, habitat and phenotypic variation

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SATELLITE PHOTOGRAPHY

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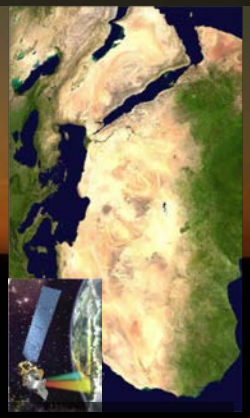
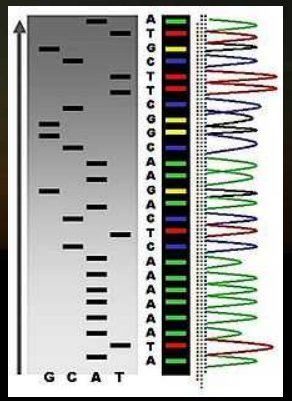
DNA SEQUENCING





REMOTE SENSING

COLOR ANALYSES

PHYLOGENETIC RECONSTRUCTONS

EFFECTS OF HABITAT AND GENETIC POLYMORPHISMS ON ANIMALS' PHENOTYPE

MIXED MODEL
and
AIC MODEL SELECTION

Habitat luminosity and RGB colors

Phenotype luminosity and RGB

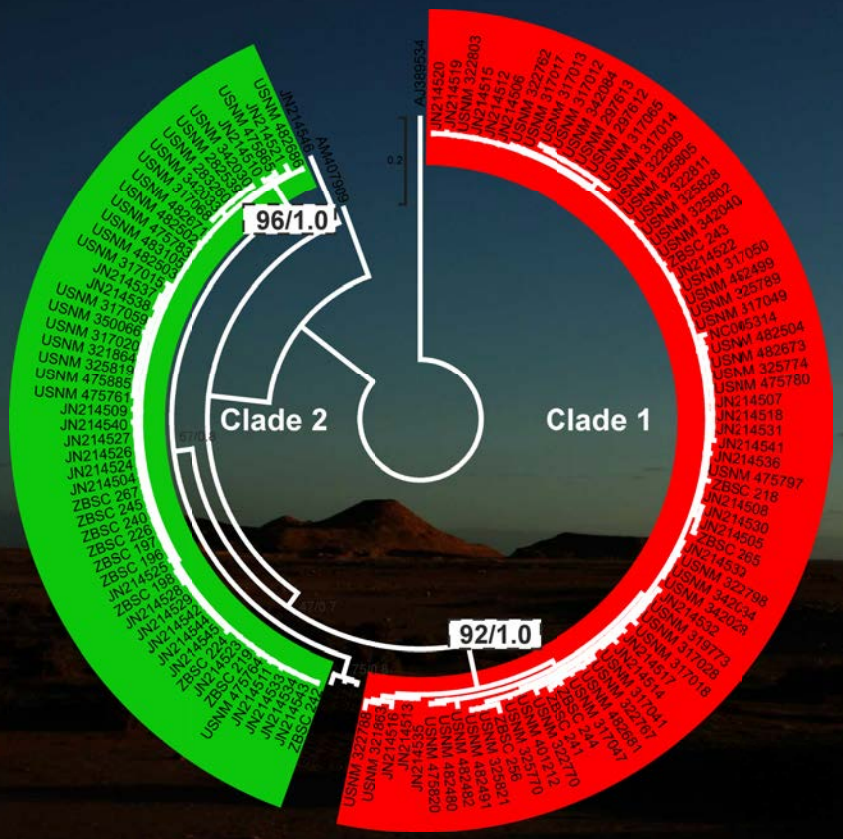
Genetic clade affiliations

Soil / rock color

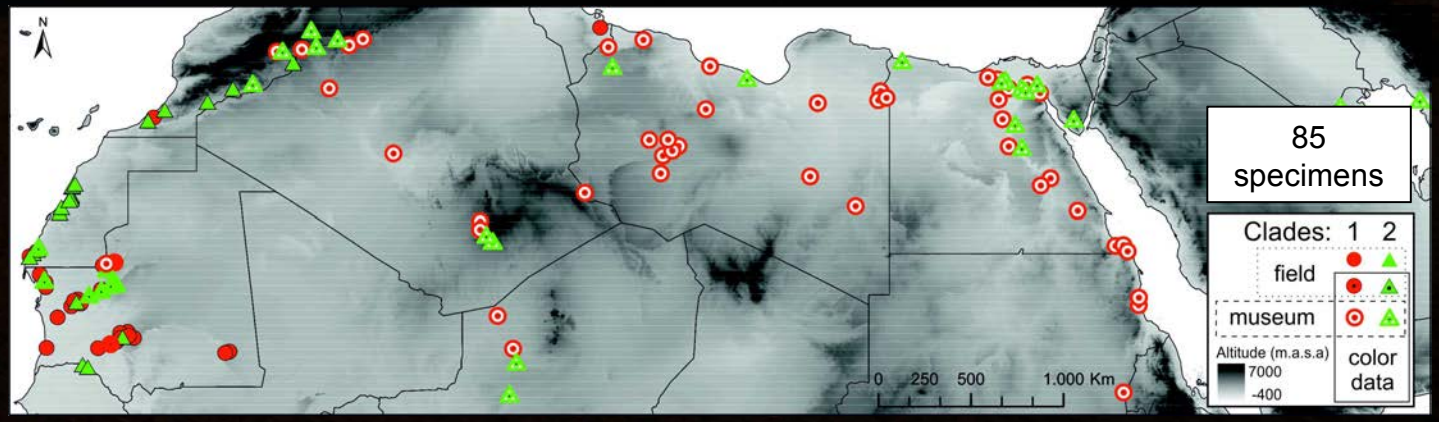
Dorsal fur color

Relatedness between samples

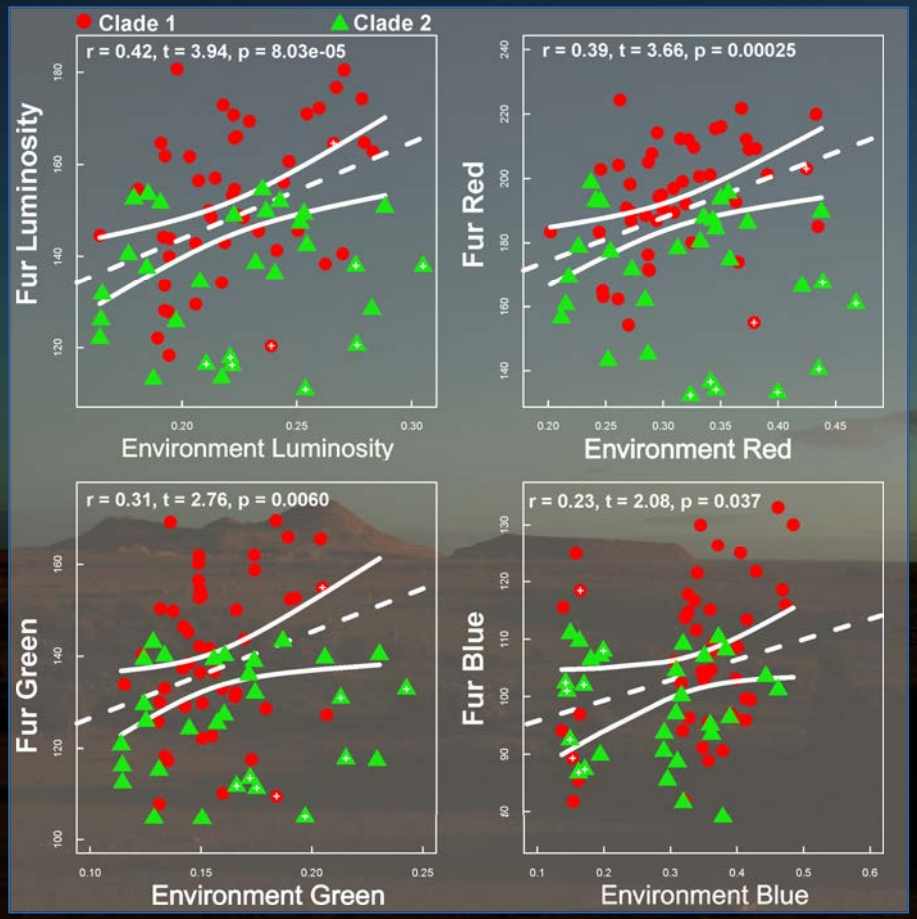
Geographic distribution of genetic polymorphism



Result 1: Sympatric distribution of two divergent genetic clades over North Africa



Phenotype-habitat correlation



Phenotype

Habitat

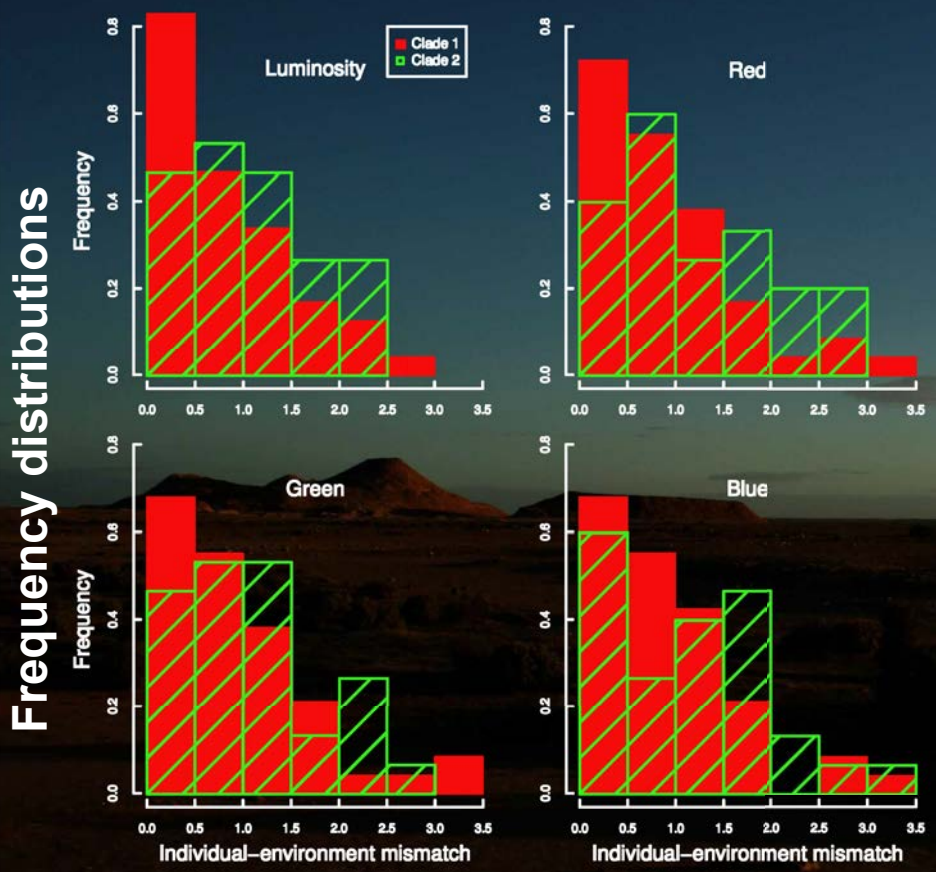
Correlations between habitat and animal colors

	Luminosity	Red	Green	Blue
All	0.42*	0.39*	0.31*	0.23*

* $p < 0.05$

Result 2: Correlation between animal and habitat coloration

Clade specific phenotype-habitat mismatch



Levels of mismatch between animal and habitat colors

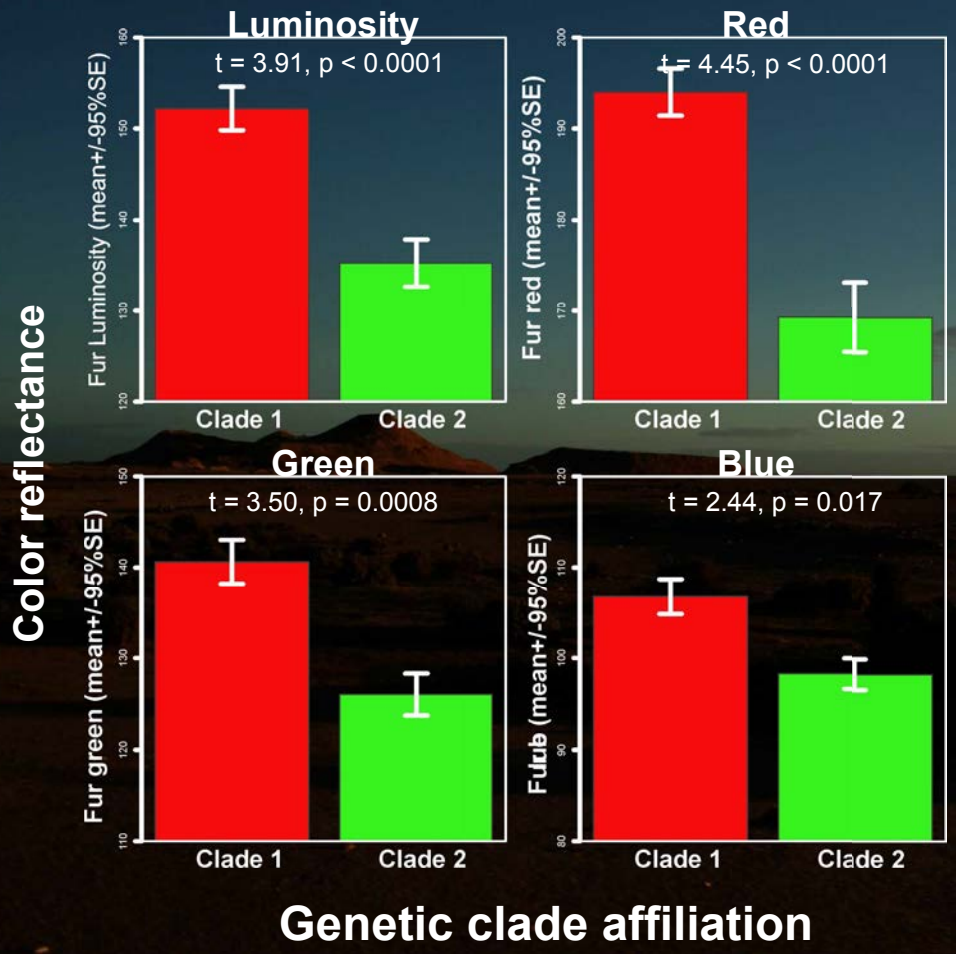
Correlations between habitat and animal colors

	Luminosity	Red	Green	Blue
Clade 1	0.45*	0.44*	0.31*	0.33*
Clade 2	0.40*	0.39*	0.41*	-0.16

* $p < 0.05$

Result 3: Animals from clade 1 match closer to their habitat colors

Phenotype divergence between lineages

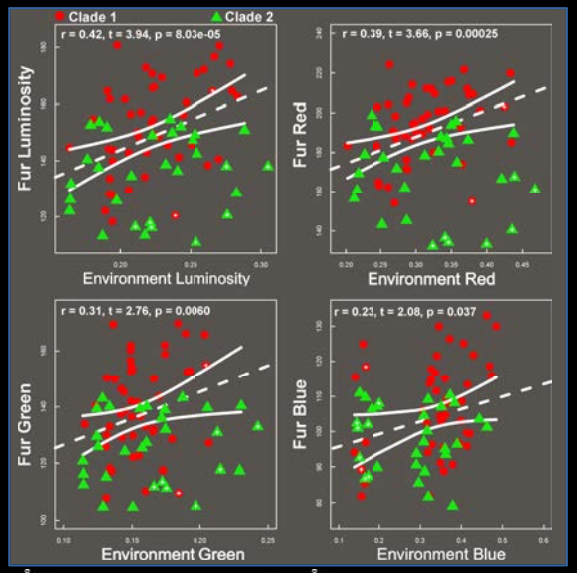


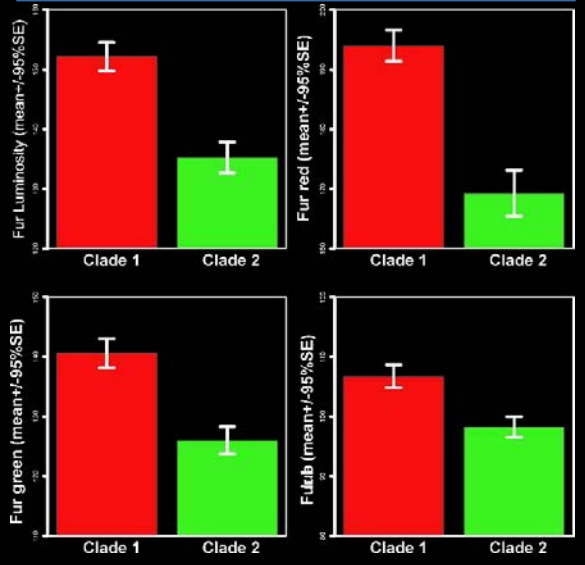
Differences between clades in coloration

	Luminosity	Red	Green	Blue
t	3.91	4.45	3.5	2.44
p	< 0.0001	< 0.0001	< 0.0001	0.017

Result 4: Clades differed in the level of expressed coloration

Covariation between genetic, habitat and phenotypic variation





QUESTIONS

Is evolution of camouflage involved?

Did it promote divergence?

Mixed model results

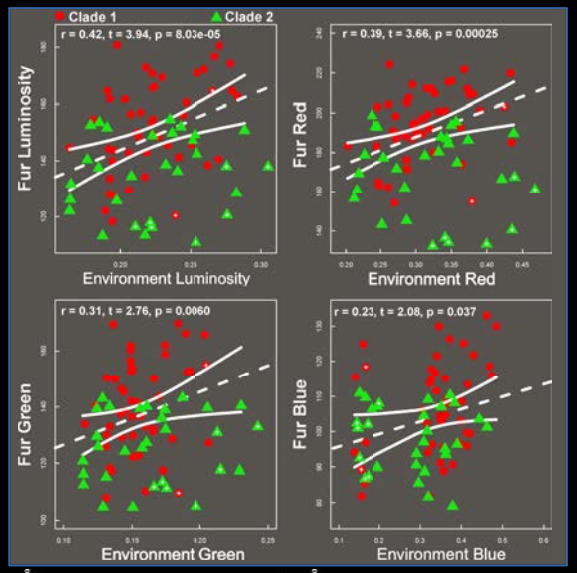
Clade afiliation	-13.1	3.35	73	-3.91	0.0002
Habitat coloration	113.0	28.6	73	3.95	0.0002

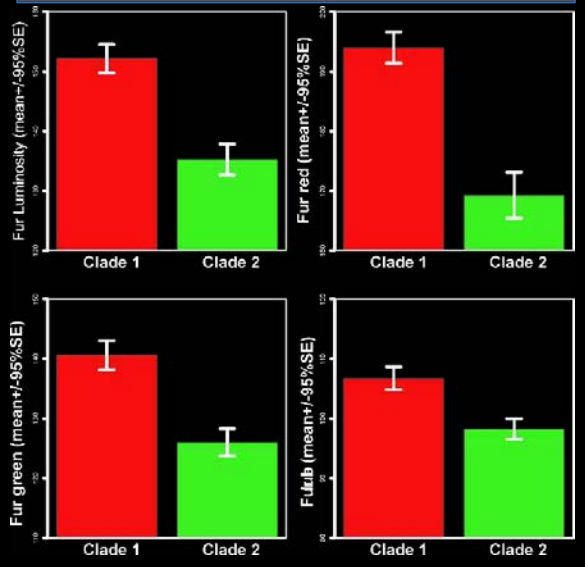
PREDICTIONS

Phenotypic and genetic divergence

Matching between soil and animal fur colors

Covariation between genetic, habitat and phenotypic variation





QUESTIONS

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Fur luminosity	Value	SE	df	t	p
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PREDICTIONS

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Matching between soil and animal fur colors

SUMMARY

Dorsal fur coloration matching coloration of the habitat

Phenotypic differences between genetic clades

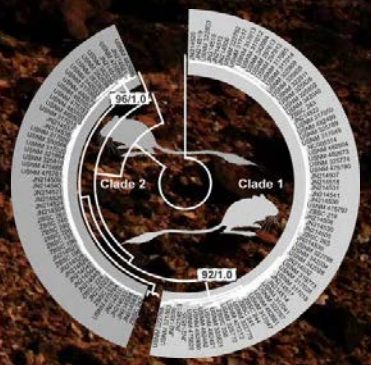
Clades, that occurs in sympatry over vast area of North Africa

Importance of an ecological mechanism

PERSPECTIVES

Ecological bases for reproductive isolation - ecological speciation?

Ecological factors in limiting distribution - habitat specialization?



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ONGOING PROJECTS

1. Genomic regions of divergences and phenotype variation
2. Level of reproductive isolation / hybridization
3. Ecological niche divergence / overlap

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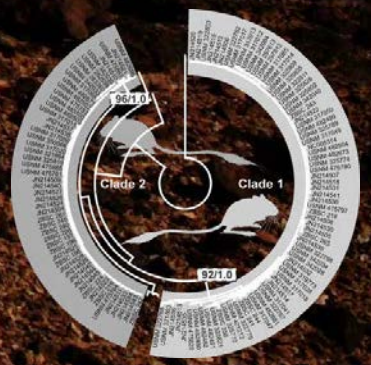


Phylogeography in a Sahara-Sahel mountain specialist, the Felou gundi

Endemic fimily (*Ctenodactylidae*) from North Africa

Genera:

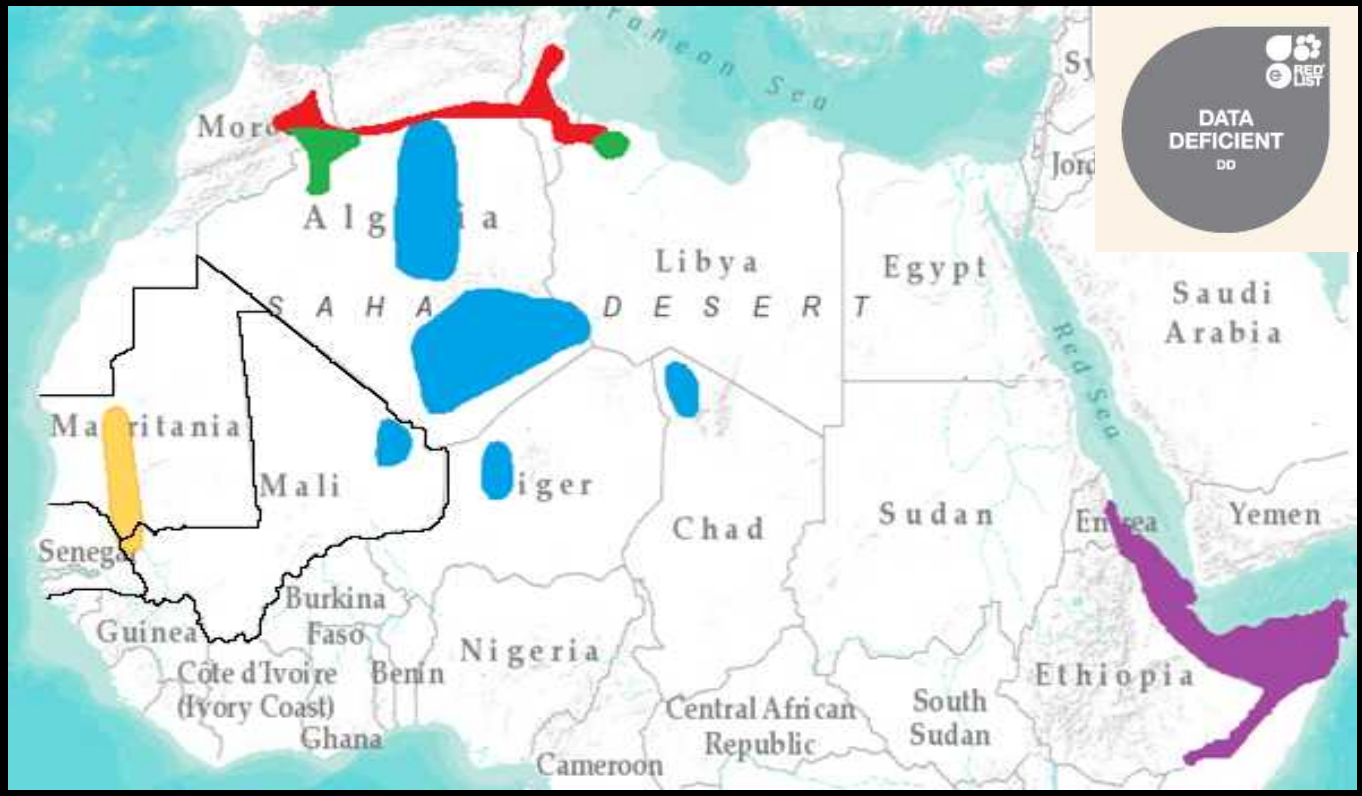
Ctenodactylus gu

and *C. vali*

Massoutiera mzab

Pectinator spekei

Felovia (*Felovia v*



Sousa, Silva, Brito and Boratyński. Phylogeographic structuring in a Sahara-Sahel mountain specialist, the *Felou gundi.* Submitted

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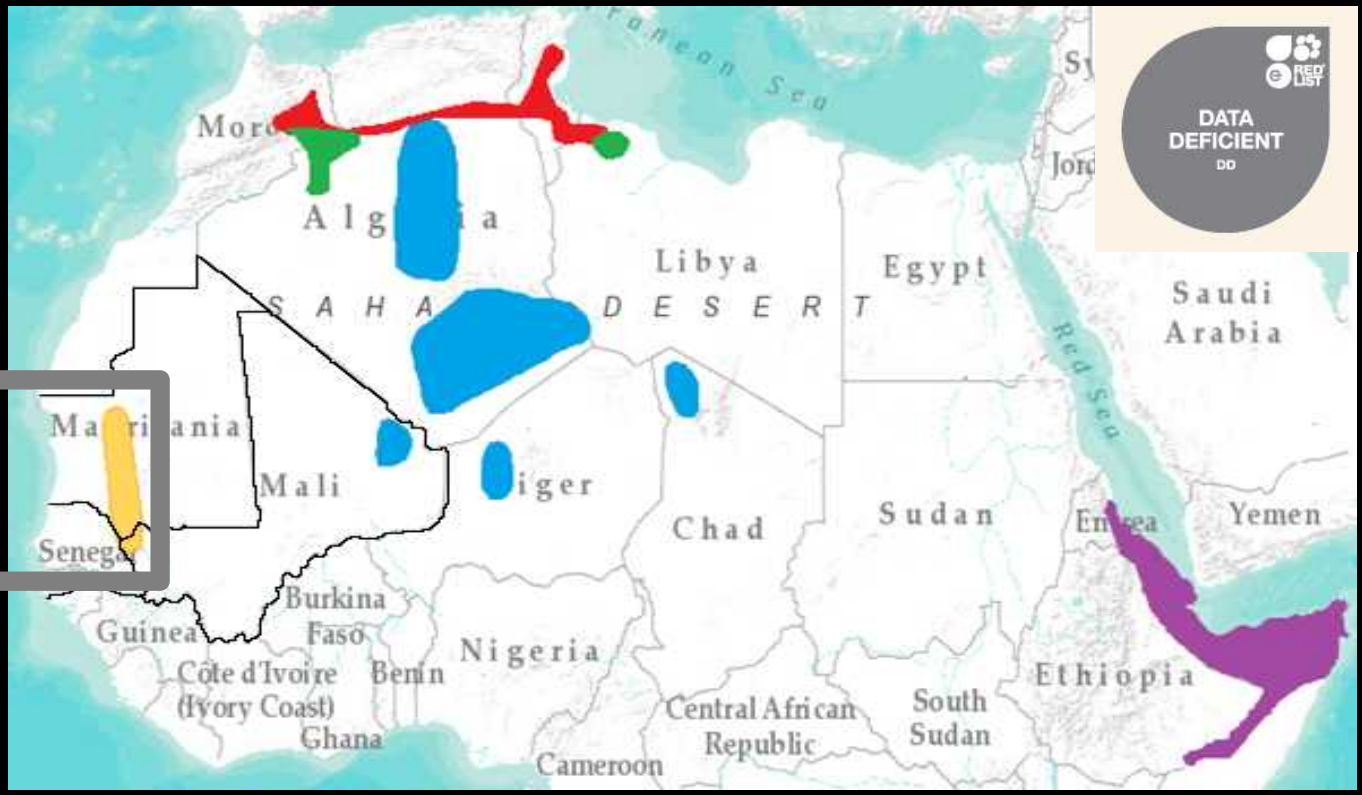
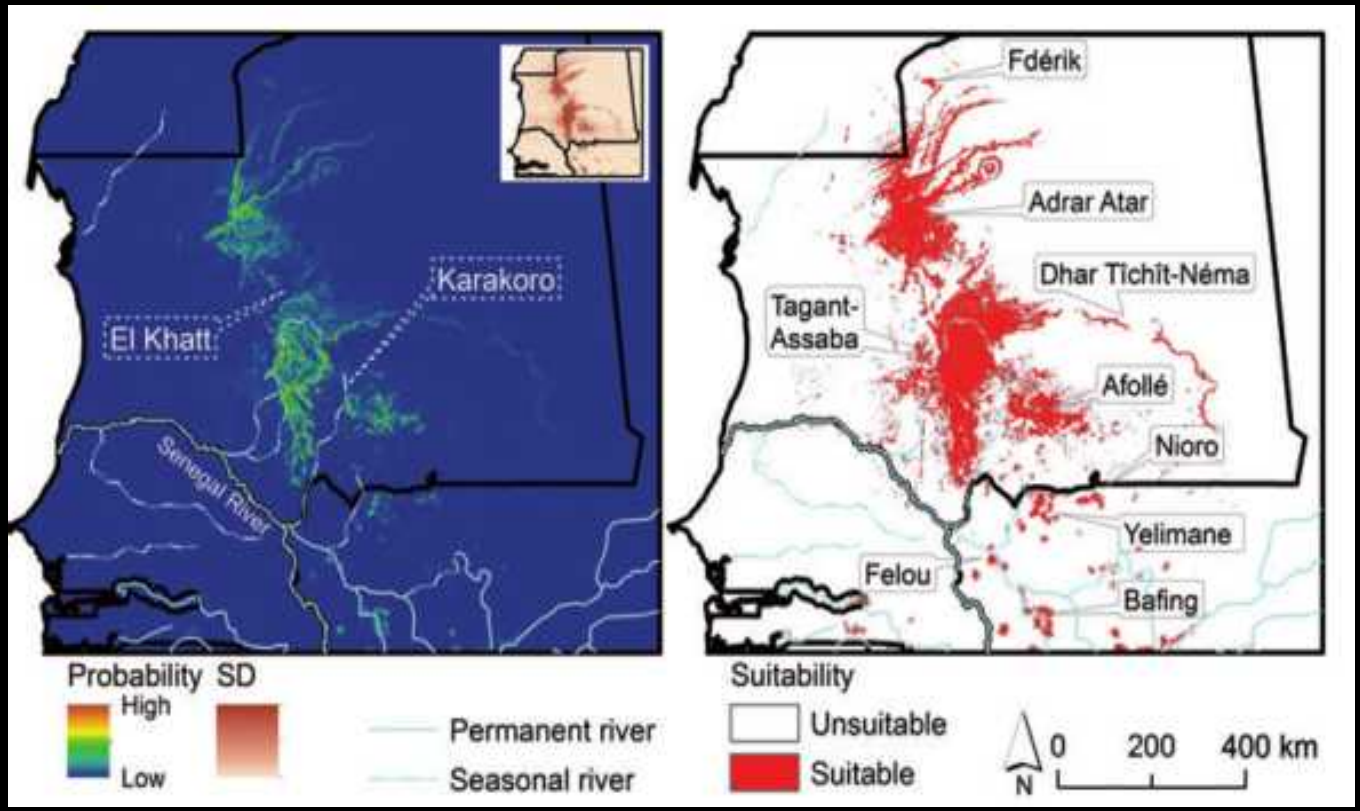


Phylogeography in a Sahara-Sahel mountain specialist, the Felou gundi

Ecological models predicted occurrence in 8 suitable habitat areas:
-with high slope
-around gueltas
-bare and rocky deserts areas.

Felovia (*Felovia vae*)



Vale et al. 2012. Distribution, suitable areas and conservation status of the Felou gundi (Felovia vae Lataste 1886). Mammalia, 76: 201

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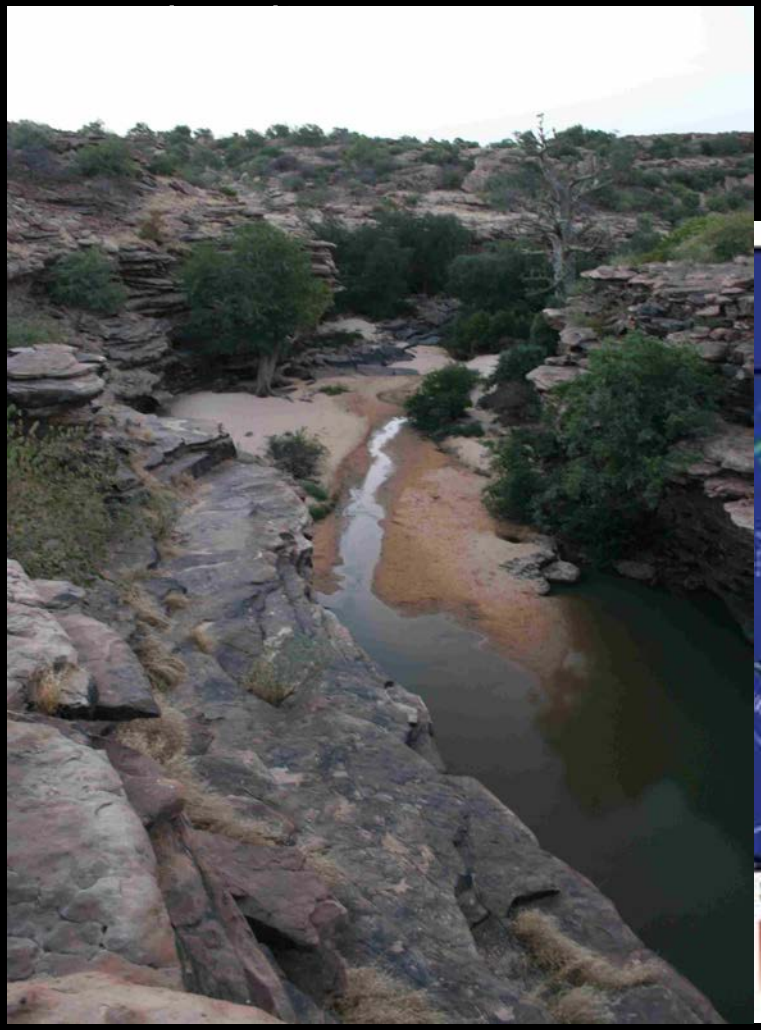

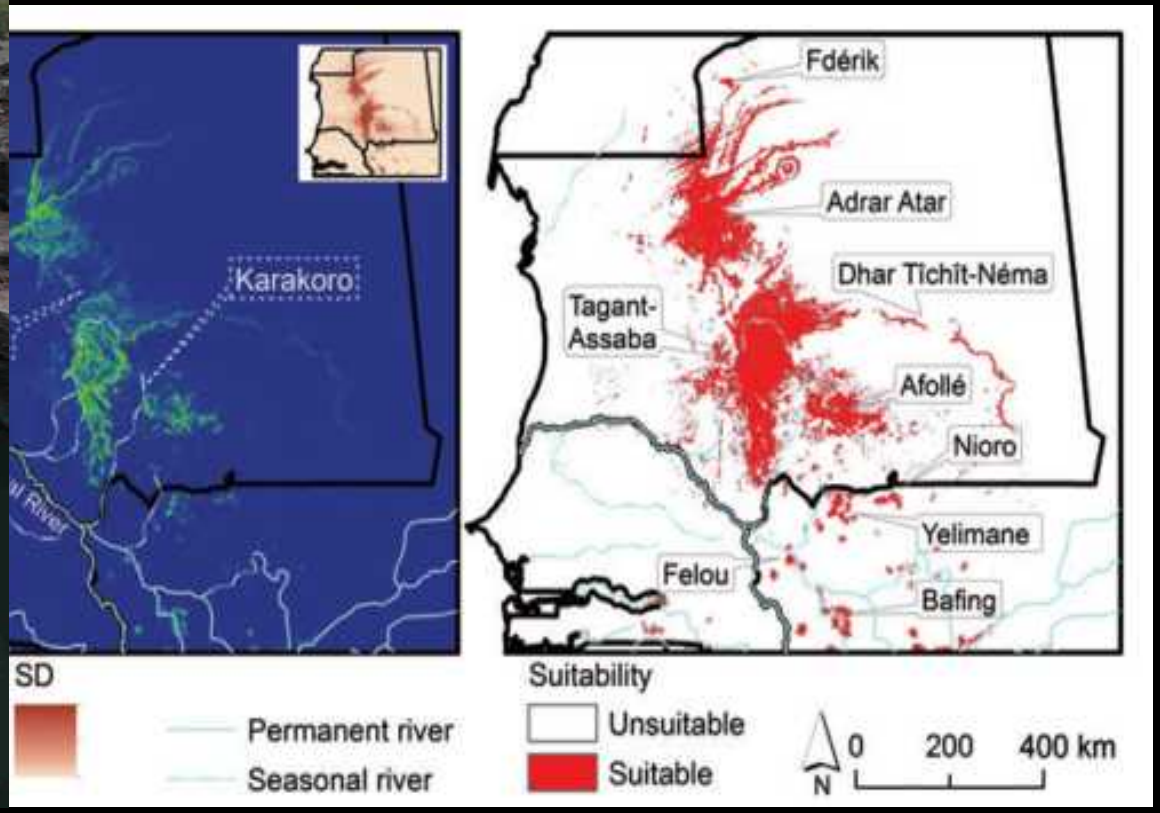

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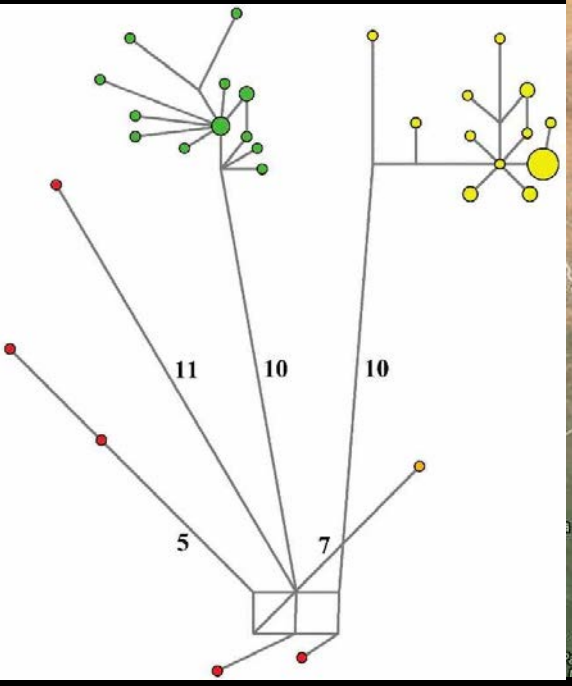

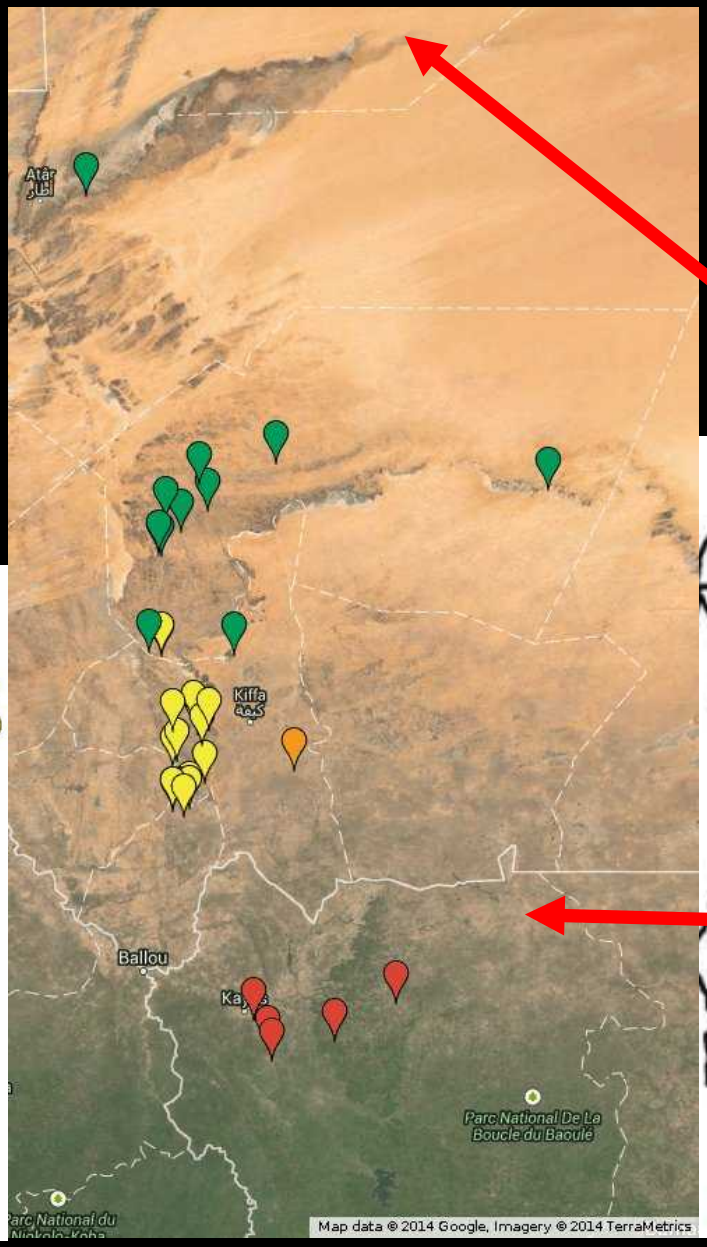

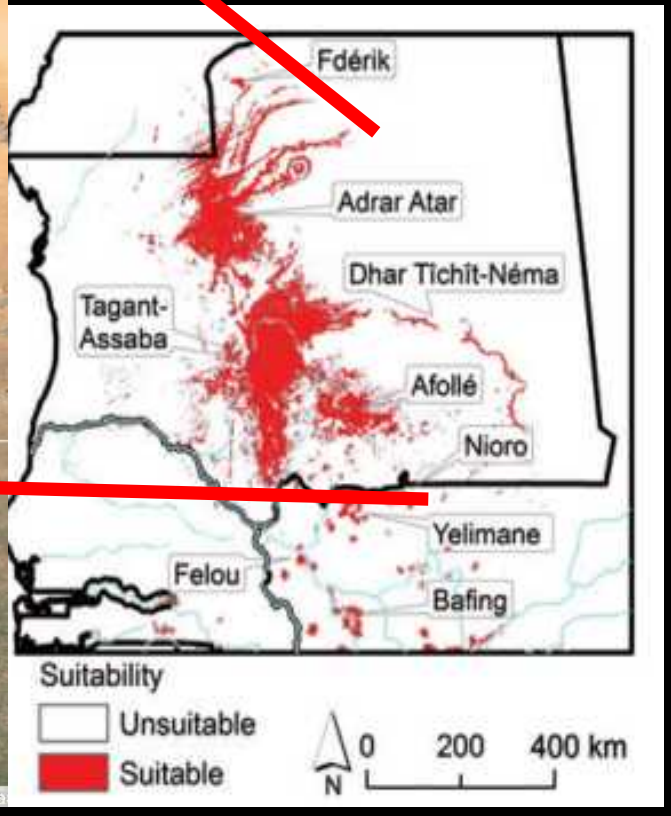

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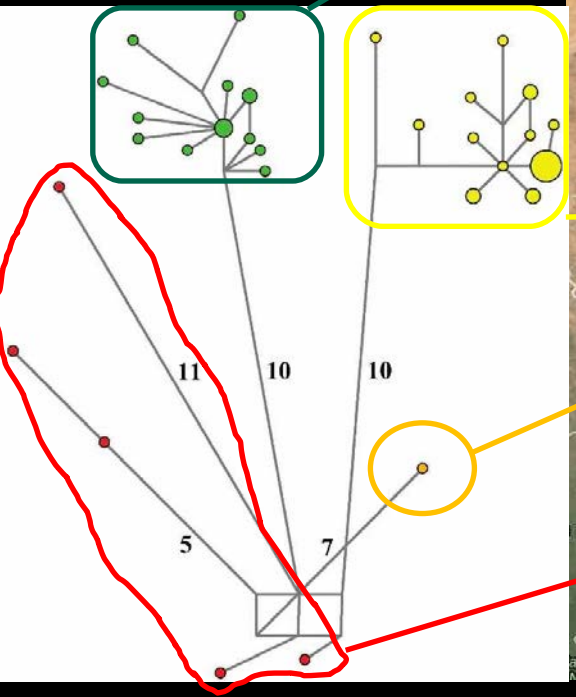
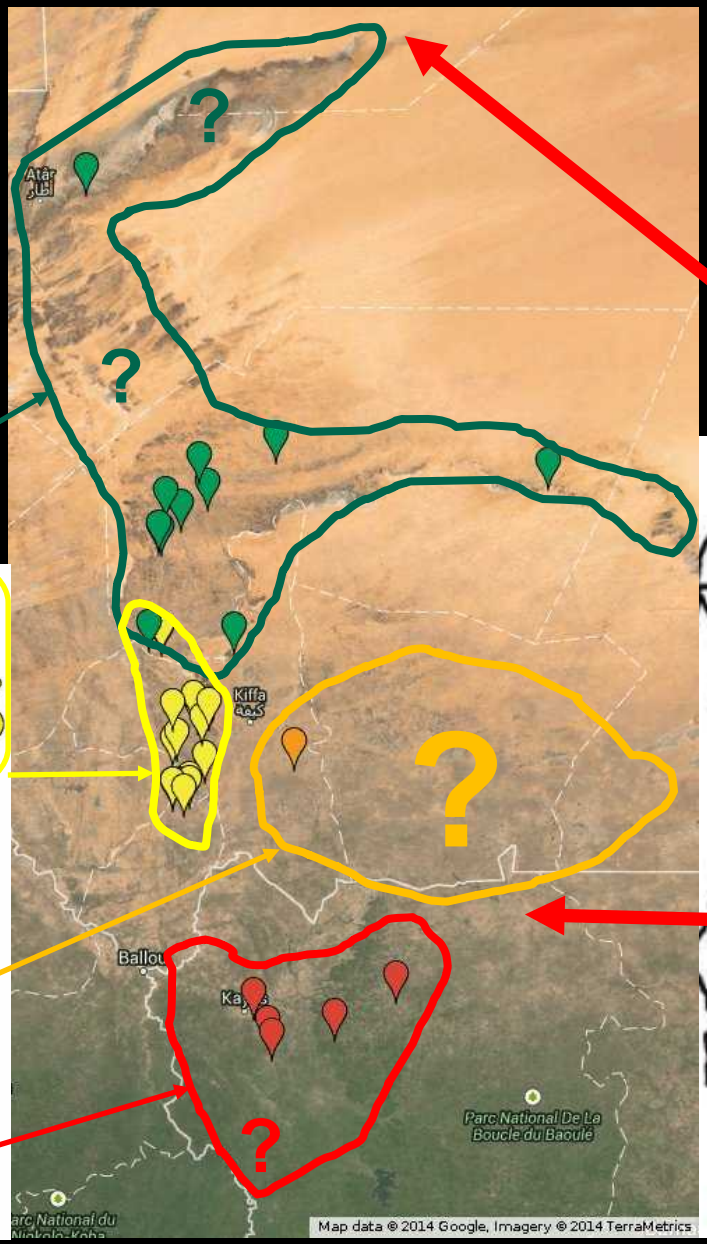
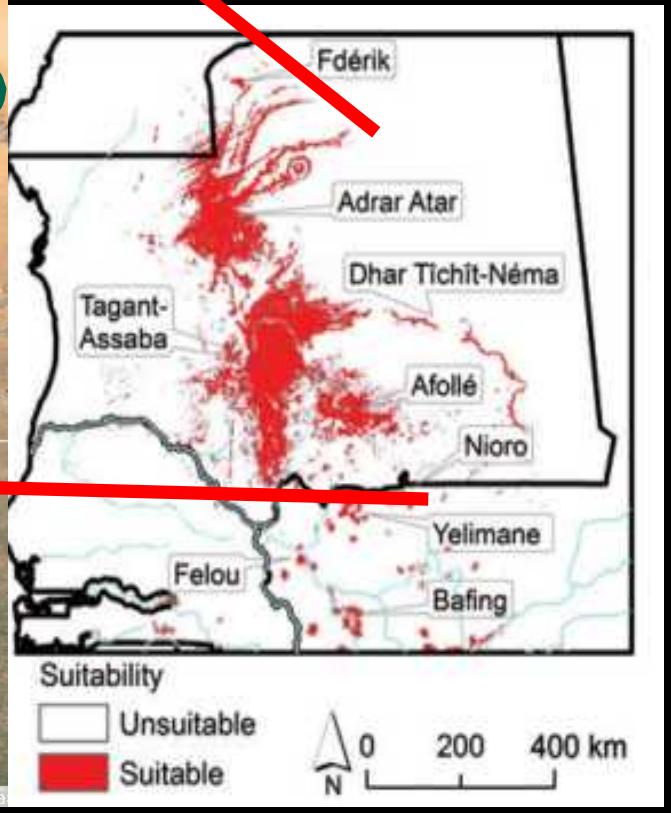


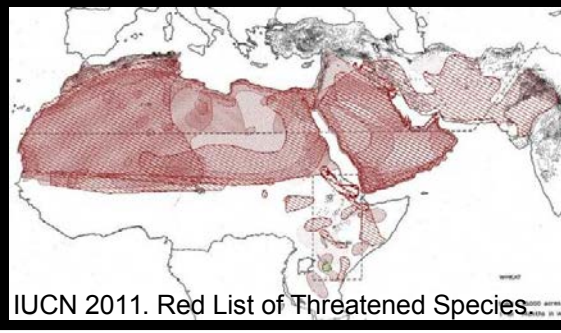




Diversity patterns in North Africa - the case of specious Gerbillus rodents

Available samples (632):
- 230 specimens, own samples (West Sahara)
- 10 specimens, HNHM, Hungary
- 104 specimens, Krakow, Poland
- 52 Natural History Museum, Vienna
- 65 Royal Belgian Institute of Natural Sciences
- 115 Royal Museum of Central Africa
- 56 La Specola, Florence, Italy

Field expeditions:
Algeria, Niger, Morocco, Tunisia, Mauritania/Mali/Senegal



IUCN 2011. Red List of Threatened Species.

Main interest:
- Mechanisms of speciation/diversification in *Gerbillus*
- Genomic regions of diversification and speciation

Ongoing work:
1. Phenotype - habitat linkage, colour variation between and within species
2. Phylogenetic reconstruction and sample barcoding
3. Ecological niche evolution

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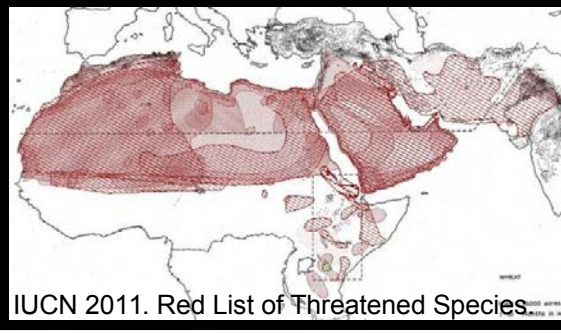

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Thank you for your attention!

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of Natural History

Pedro Santos

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Synthesis of Systematic Resources

ACADEMY OF FINLAND
RESEARCH FUNDING AND EXPERTISE

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Dedicamo-nos às viaturas Todo Terreno fazendo todo o tipo de transformações. Venha visitar-nos...

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