Are African bats going to compensate the future loss of bat fauna in Europe due to climate change?

S. Smeraldo[1], C. Vale[2], H. Rebelo[2,3], A. Martinoli[4], M. Piccioli Cappelli[4] & D. Russo [1,3]

1 Wildlife Research Unit, Dipartimento di Agraria, Università degli Studi di Napoli Federico II, Portici, Napoli, Italy

2 CIBIO/InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos da Universidade do Porto, Instituto de Ciências Agrárias de Vairão, Vairão, Portugal

3 School of Biological Sciences, University of Bristol, Bristol, UK

4 Unità di Analisi e Gestione delle Risorse Naturali – Guido Tosi Research Group, Dipartimento di Scienze Teoriche e Applicate, Università degli Studi dell'Insubria, Varese, Italy

INTRODUCTION

Bats are an excellent model to study range shifts due to climate change because they are widely distributed, their physiology responds to local climatic conditions and several species have high mobility and potential to colonise new suitable areas.

In this study we predict:

(1) how climate change might affect the distribution of bat species occurring in Europe, Africa and Middle East
(2) if African bats have the potential to colonize Europe in the future
(3) which interspecific ecological relationships might be established when some species co-occur in new colonised areas

METHODS

SDMs

We developed Species Distribution Models (SDMs) for 16 bat species using climatic predictors (R package "biomod2"). Predictions were projected over the future climate for 2050 and 2070 and two RCP (4.5 and 8.5) using three Global Circulation models (CCSM4, HadGEM2-ES and MIROC-ESM models). Binary maps were produced for each species both in the current and future climatic conditions, by the max TSS threshold. These maps were summed to obtain a prediction of community richness

Cluster Analyses

We used a Cluster analyses (R package "cluster") to assign the bat species to functional groups on the basis of eco-morphological features

Niche Overlap Analyses

We applied the "Ecospat" package in R to analyses the overlap between the climatic niche of species belonging to the same functional group resulting from the cluster analyses

RESULTS

EVALUATION
Excellent predictive performances for all species (AUC > 0.9)

Species' range expansion

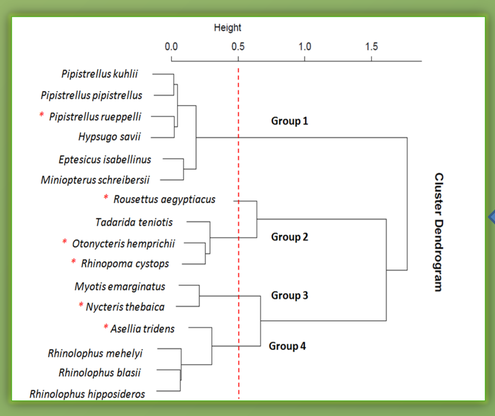
- **60% of the species shows a huge range expansion in the future scenarios compared with the present (blue rows)**
- **Four species, of which three currently occur only in Africa and Middle East, might likely have a significant contraction of their geographical range (red rows)**

Species	Potential suitable habitat (%)			
	2050		2070	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Asellia tridens	105	101	105	94
Rhinolophus blasii	67	62	61	39
Rhinolophus hipposideros	207	243	230	295
Rhinolophus mehelyi	240	265	263	314
Hypsugo savii	335	396	376	493
Pipistrellus kuhlii	332	373	357	312
Pipistrellus pipistrellus	267	308	290	344
Pipistrellus rueppelli	100	96	95	72
Nycteris thebaica	68	58	60	34
Myotis emarginatus	207	239	223	276
Otonycteris hemprichii	109	107	107	106
Rhinopoma cystops	185	195	192	220
Rousettus aegyptiacus	89	84	86	67
Tadarida teniotis	323	382	358	386
Eptesicus isabellinus	493	668	634	1077
Miniopterus schreibersii	232	276	265	349

Species	Future area not overlapping with current area (%)			
	2050		2070	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Asellia tridens	36.8	41.8	41.4	51.7
Nycteris thebaica	1.1	1.4	1.4	2
Otonycteris hemprichii	20.7	21.1	20.8	28.6
Pipistrellus rueppelli	27.6	31	29.4	31.2
Rhinopoma cystops	47.8	51.1	50.1	56.1
Rousettus aegyptiacus	4.1	4.5	4.6	5.1

Range shift of African species

- **70% of African species might occupy new colonisation areas in the future (red rows)**

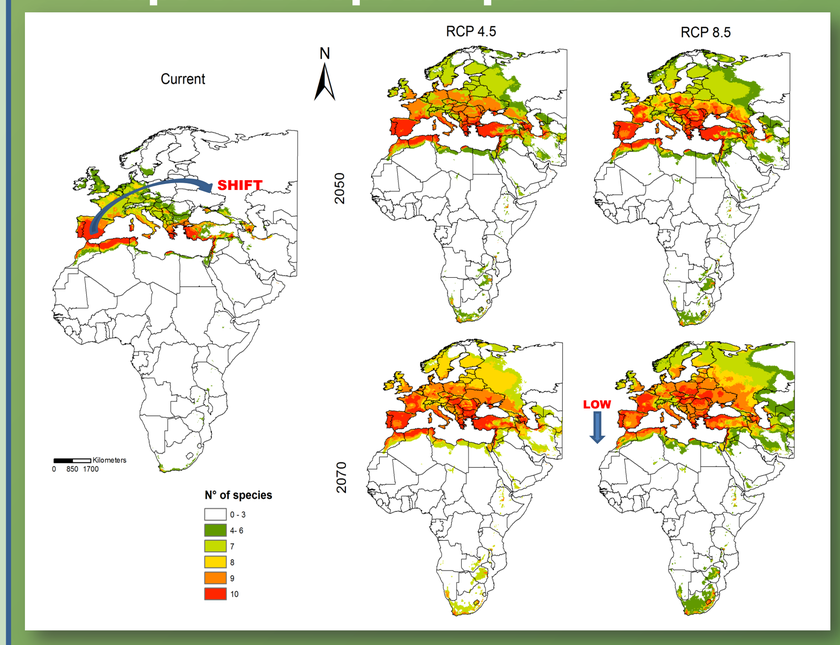


Functional groups and potential competitors

- **The cluster dendrogram shows four functional groups**
- **African species (*) are grouped together with European species**
- **Species belonging to the same functional group might share ecological requirements in sympatric areas and interspecific interactions, like competition, might be established among them**

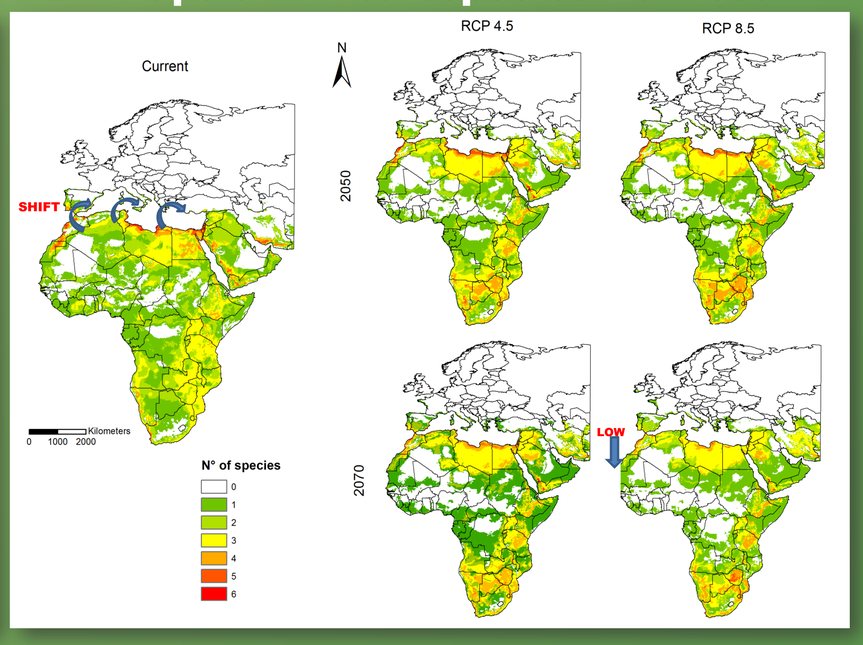
Predictions under climate change

Maps of European species richness



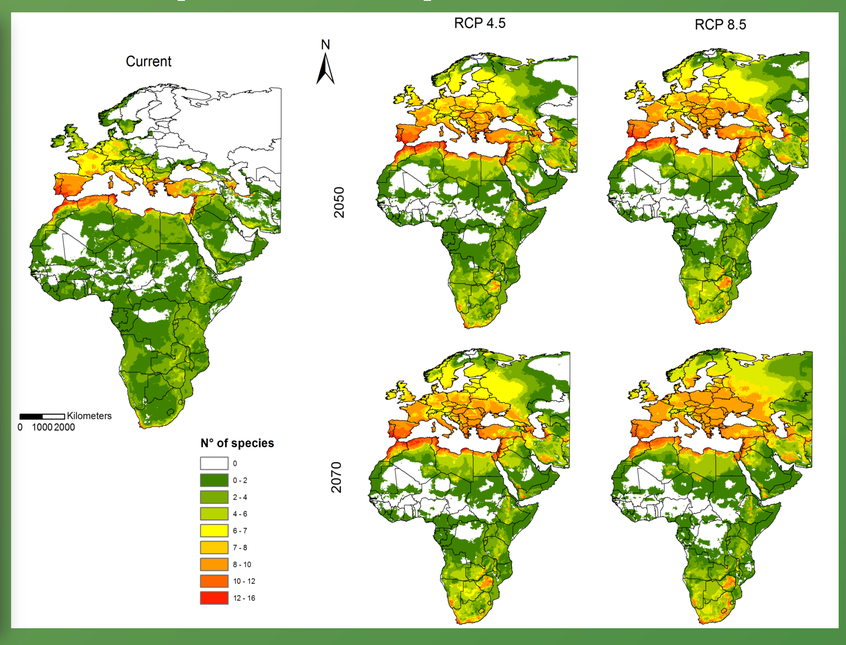
- **Species suitable habitat might shift towards northern latitudes**
- **Species richness decreases in some areas of Iberian peninsula and Northern Africa**

Maps of African species richness



- **50% of African species might likely colonise Southern Europe and part of Turkey**
- **Species richness decreases in some areas of North and Central Africa**

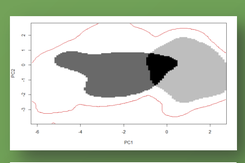
Maps of Total species richness



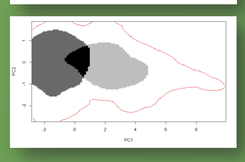
- **Species richness increases towards Central-Northern Europe, Middle East and Southern Africa and it decreases in Northern Marocco, Algeria and in some regions of Central Africa towards the Equator**

Niche overlap analyses

Asellia tridens-Rhinolophus mehelyi



Tadarida teniotis-Rhinopoma cystops



In the present

Little climatic niche overlap

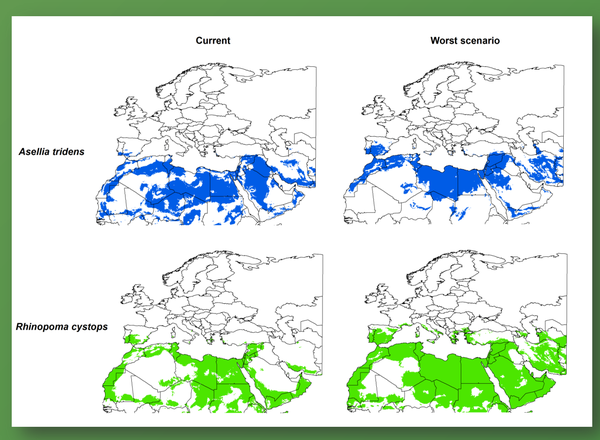
NO COMPETITION

In the future

Species	Potential overlap (%)				
	Current	2050 RCP 4.5		2070 RCP 8.5	
A. tridens-R. mehelyi	6.2	21.3	23.2	22.9	25.7
R. cystops-T.tenotis	6.9	19.5	22.2	21.3	29.2

Potential exclusion by competition between African and European species belonging to the same functional group

Binary maps of two African bat species



- **Current scenario: suitable habitat in Europe but African species don't occur**
- **Future scenario: suitable habitat increases in Europe**

MAIN CONCLUSIONS

We conclude that:

- **The presence of African bat species will likely compensate a future loss of the European bat species that would shift their range northwards.**
- ***A. tridens* and *R. cystops* have the potential to colonize suitable habitat in Europe in the future because they are both abundant and very much spread species which might migrate.**
- **Species belonging to the same functional group occurring in sympatry in the future in the European territory might show interspecific interactions.**

Potential competition, besides habitat suitability, should be used as a filter to calibrate models of expansion to Europe of African species.