Comprendre l'épidémiologie de la chytridiomycose amphibienne dans les Pyrénées: une approche transdisciplinaire

38ème rencontre GEEFSM, 2021

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GloMEc GLOBAL CHANGE IN MOUTAIN ECOSYSTEMS

Laboratoire écologie fonctionnelle et environnement

Introduction

Scheele, B. C. *et al.* **Amphibian fungal panzootic causes catastrophic and ongoing loss of biodiversity**. *Science* **363**, 1459–1463 (2019).

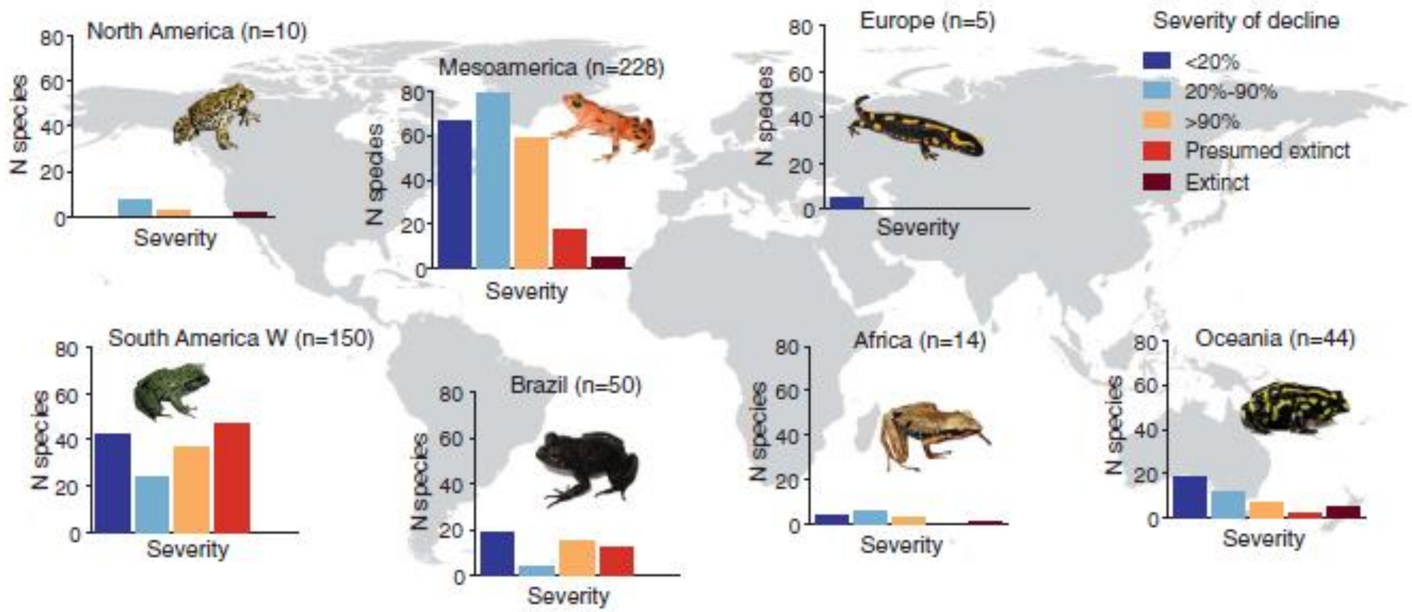

Fig. 1 Global distribution of chytridiomycosis-associated amphibian species declines. Bar plots indicate the number (N) of declined species, grouped by continental area and classified by decline severity. Brazilian species are plotted separately from all other South American species (South America W); Mesoamerica includes Central America, Mexico, and the Caribbean Islands; and Oceania includes Australia and New Zealand. No declines have been reported in Asia. *n*, total number of declines by region. [Photo credits (clockwise from top left): *Anaxyrus boreas*, C. Brown, U.S. Geological Survey; *Atelopus varius*, B.G.; *Salamandra salamandra*, D. Descouens, Wikimedia Commons; *Telmatobius sanborni*, I.D.I.R; *Cycloramphus boraceiensis*, L.F.T.; *Cardioglossa melanogaster*, M.H.; and *Pseudophryne corroboree*, C. Doughty]

Ecosystems (2013) 16: 146–157
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ECOSYSTEMS
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Disease-Driven Amphibian Declines Alter Ecosystem Processes in a Tropical Stream

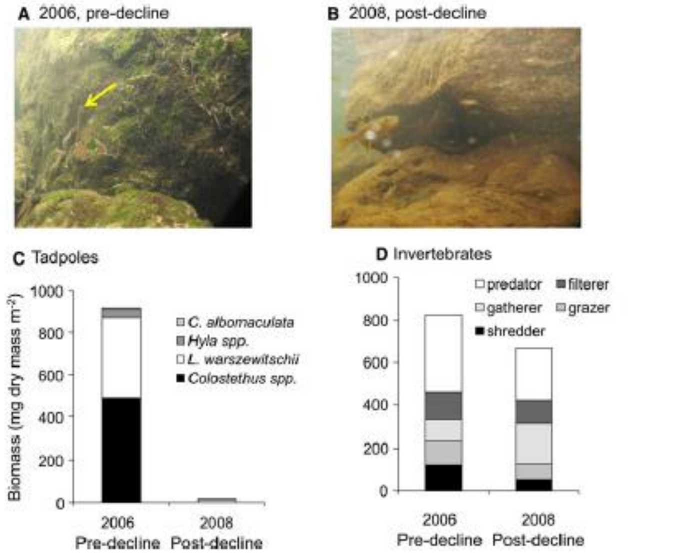
M. R. Whiles,[1]* R. O. Hall Jr.,[2] W. K. Dodds,[3] P. Verburg,[4] A. D. Huryn,[5] C. M. Pringle,[6] K. R. Lips,[7] S. S. Kilham,[8] C. Colón-Gaud,[9] A. T. Rugenski,[1] S. Peterson,[1] and S. Connelly[6]

BIODIVERSITY LOSS

Tropical snake diversity collapses after widespread amphibian loss

Science 367, 814–816 (2020) 14 February 2020

Elise F. Zipkin[1]*, Graziella V. DiRenzo[1,2], Julie M. Ray[3], Sam Rossman[1,4], Karen R. Lips[5]



- -impact sur le fonctionnement des écosystèmes…
- -Notamment de **montagnes** !
- -Amphibiens = sentinelles + lien entre mondes aquatiques et terrestres
- -Menacés (>40%) en partie par **maladies infectieuses émergentes**

Batrachochytrium dendrobatidis (Bd)

- Décrit en 1999, Longcore et al.
- Champignon aquatique avec **zoospore**, sans hyphe
- Parasite intracellulaire tissus kératinisés des amphibiens
- Hyperplasie, hyperkératose
- Perturbation osmorégulation → mort souvent sans signe clinique
- spectre >1000 espèces, susceptibilités différentes

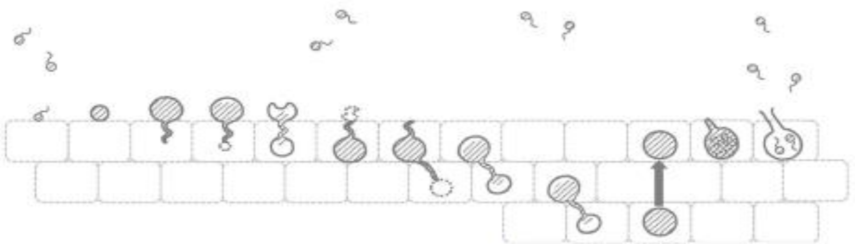
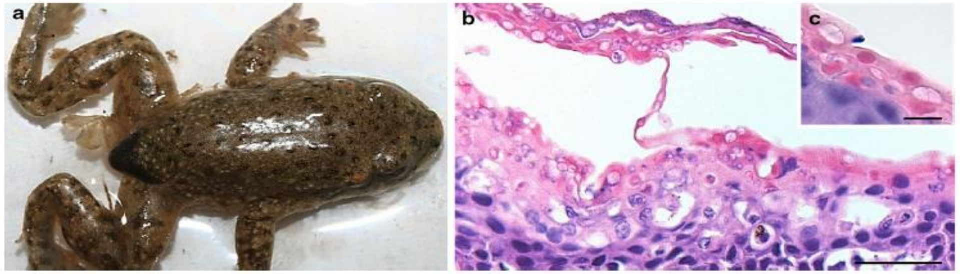
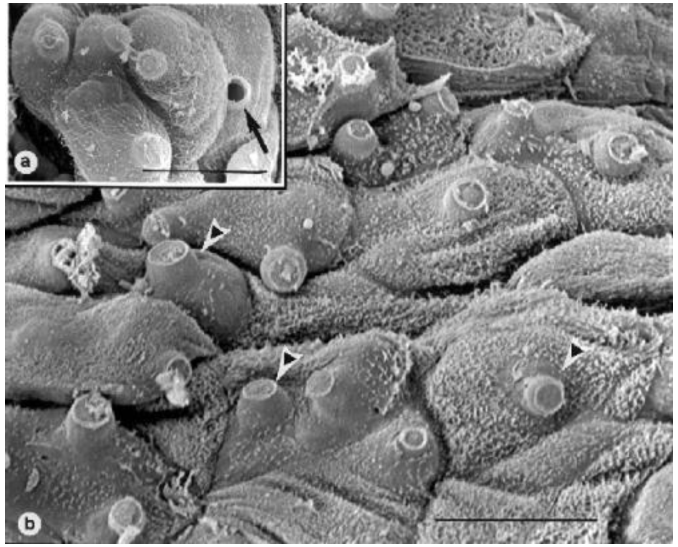


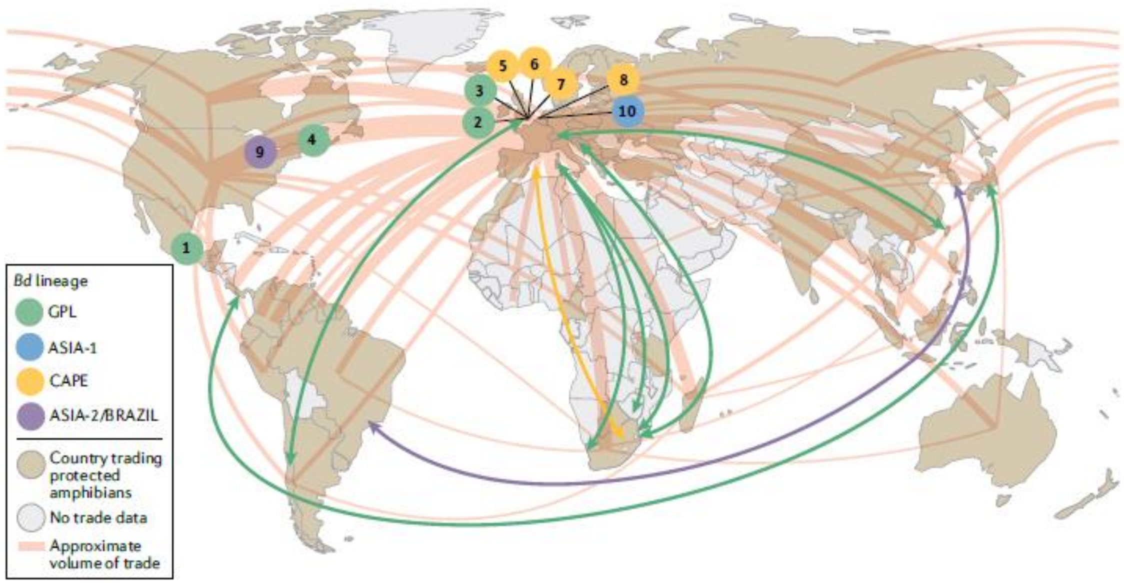
Fig. 9 Infection cycle of *Batrachochytrium dendrobatidis* in a susceptible host. The endobiotic lifecycle includes successively germ tube mediated invasion, establishment of intracellular thalli, spread to the deeper skin layers, upward migration by the differentiating epidermal cell to finally release zoospores at the skin surface

Van Rooij, et al. Amphibian chytridiomycosis: a review with focus on fungus-host interactions. *Veterinary Research* **46**, 137 (2015).





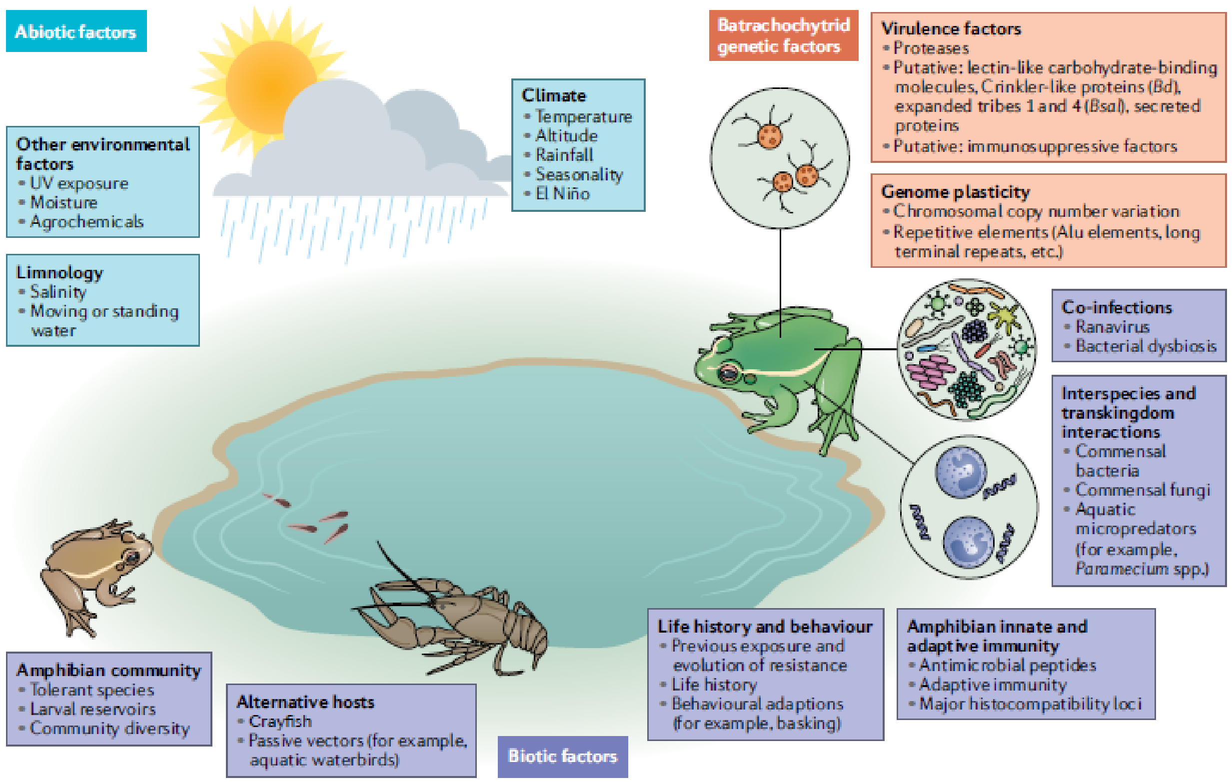
Epidémiologie



O'Hanlon, S. J. *et al.* **Recent Asian origin of chytrid fungi causing global amphibian declines.** *Science* **360**, 621–627 (2018).

- Propagation anthropique
- Origine péninsule coréenne
- Bd GPL
- Bd maintenant présent partout où amphibiens vivent
- Transmission directe et indirecte

Epidémiologie complexe



Fisher, M. C. & Garner, T. W. J. **Chytrid fungi and global amphibian declines**. *Nature Reviews Microbiology* 1–12 (2020)

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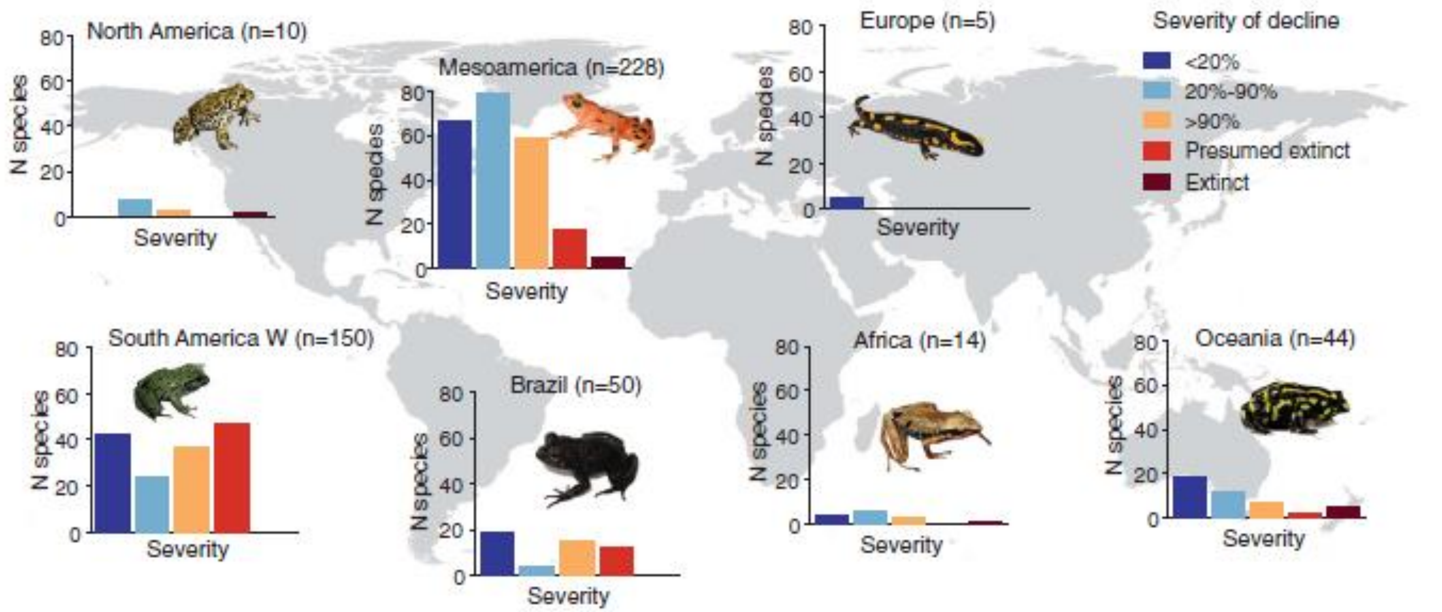

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ECOSYSTEMS

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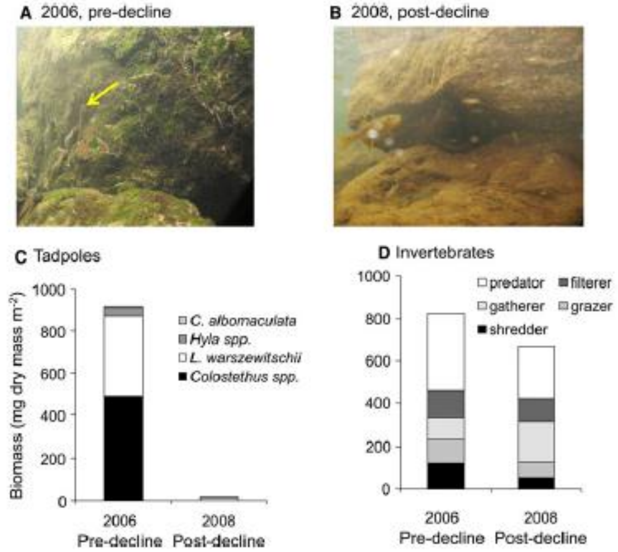
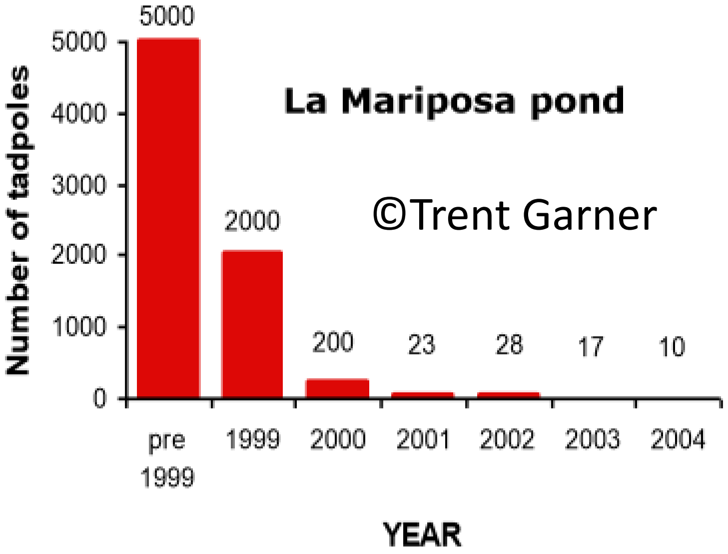


-Impliquée dans le **déclin** d'au moins **501 espèces** (dont 1 par Bsal)
-Cause proximale présumée de **l'extinction** d'au moins **90 espèces**
-impact sur le fonctionnement des écosystèmes

Et en Europe continentale ?

- Peñalara Natural Park, Sierra de Guadarrama, Espagne (768 ha, 1800–2430 m)

Alytes obstetricans



Bosch, J. et al. . **Evidence of a chytrid fungus infection involved in the decline of the common midwife toad (Alytes obstetricans) in protected areas of central Spain**. *Biological conservation* **97**, 331–337 (2001).

Epidémiologie péninsule ibérique

Fonds pour la Recherche

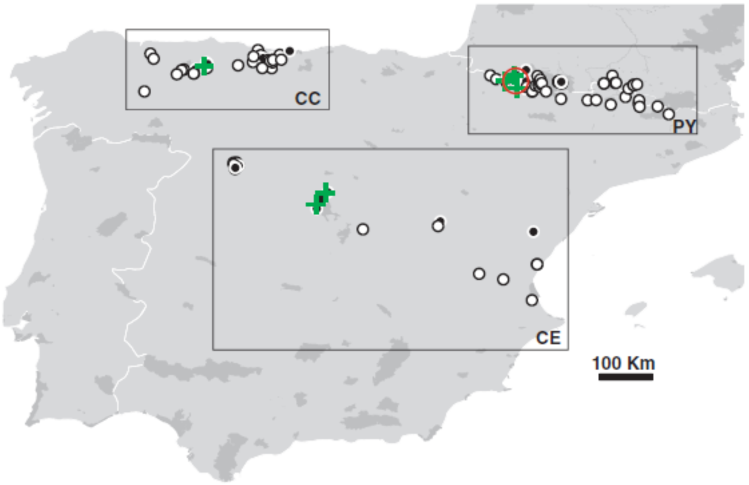
ECOLOGY LETTERS

Ecology Letters, (2010) 13: 372–382 doi: 10.1111/j.1461-0248.2009.01434.x

LETTER

Factors driving pathogenicity vs. prevalence of amphibian panzootic chytridiomycosis in Iberia

Susan F. Walker,[1,4] Jaime Bosch,[2] Virgilio Gomez,[3] Trenton W. J. Garner,[4] Andrew A. Cunningham,[4] Dirk S. Schmeller,[5] Miguel Ninyerola,[6] Daniel A. Henk,[1] Cedric Ginestet,[7] Christian-Philippe Arthur[8] and Matthew C. Fisher[1]*



74 populations *d'Alytes obstetricans* suivies

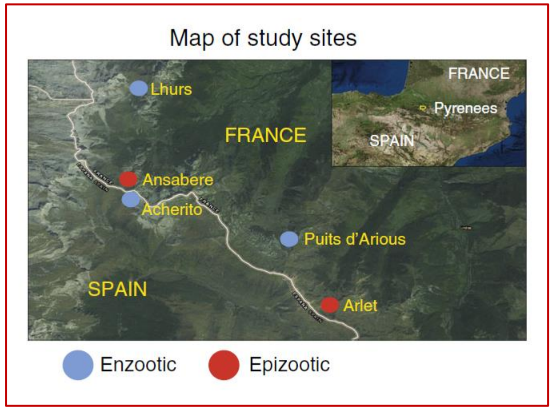
- Bd = **généraliste**, persiste partout où introduit et où il y a des amphibiens
- Infection ≠ maladie
- **Solide association entre altitude et mortalités massives** due à la chytridiomycose amphibienne chez *Alytes obstetricans* **(>1600m)**
- **Récente introduction** d'un seul genotype de Bd dans les **Pyrenées** (cluster)

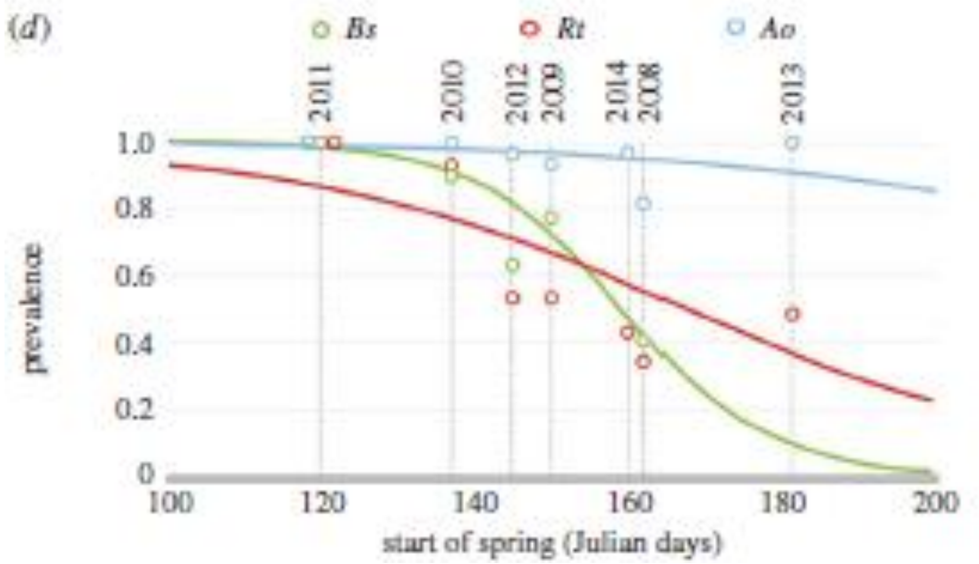
Epidémiologie lac d'Arlet (vallée d'Aspe)

(1986m), 3 hôtes, 7 ans de suivi

Climate forcing of an emerging pathogenic fungus across a montane multi-host community

Frances C. Clare[1,2], Julia B. Halder[2], Olivia Daniel[3], Jon Bielby[1], Mikhail A. Semenov[4], Thibaut Jombart[2], Adeline Loyau[5,6,7], Dirk S. Schmeller[5,6], Andrew A. Cunningham[1], Marcus Rowcliffe[1], Trenton W. J. Garner[1], Jaime Bosch[8] and Matthew C. Fisher[2]





-Importance traits d'histoire de vie

-Importance de la structure de la communauté

-Importance des facteurs climatiques

Par quels mécanismes le climat impacte-t'il?

- ***Alytes obstetricans*** maintained a **high prevalence** of infection independent of time of spring thaw.
- perennially **overwintering midwife toad larvae** act as a year-round **reservoir**
- robust temporal association between the **timing of the spring thaw and Bd infection in two host species (*Rana temporaria, Bufo spinosus*)**

Table 2. Visual estimates of live amphibian abundance+less than 100; ++100–1000; +++ more than 1000.

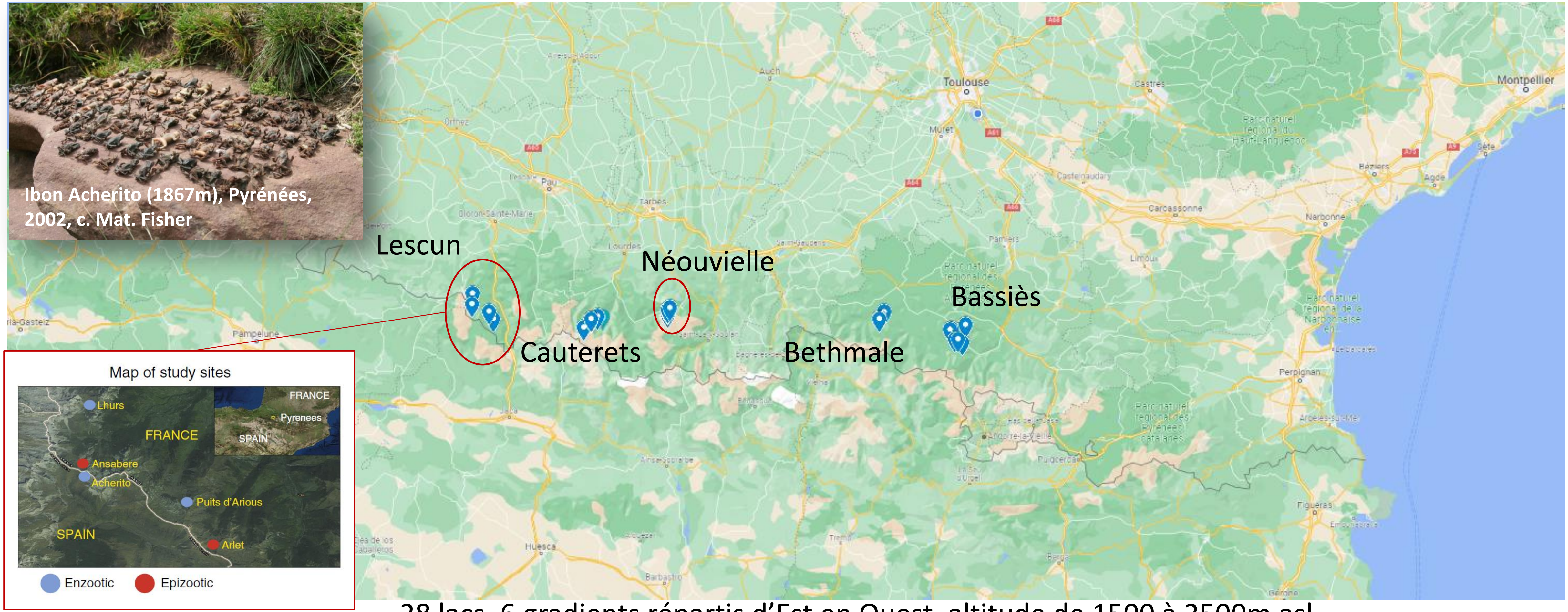
year	*Ao* OW tadpoles	*Ao* Mets	*Rt* Mets	*Bs* Mets
2008	+++	++	+++	+++
2009	+++	++	+++	+++
2010	+++	++	+++	++
2011	+++	++	+++	++
2012	++	++	+++	+
2013	+	++	+++	0
2014	+	++	+++	0

Pyrénées: projet P3 et GloMEc

- Clusters Vallée d’Aspe (Lescun, toujours infecté) + Néouvielle (résolu?)
- Pas de difference de virulence
- Populations d’*Alytes obstetricans* semblent assez proches génétiquement
- Alors pourquoi différence de dynamique entre lacs?

Lacs infectés avec persistence, faible prevalence d’infection (bleu)

Lacs infectés avec déclin, forte prévalence (rouge)

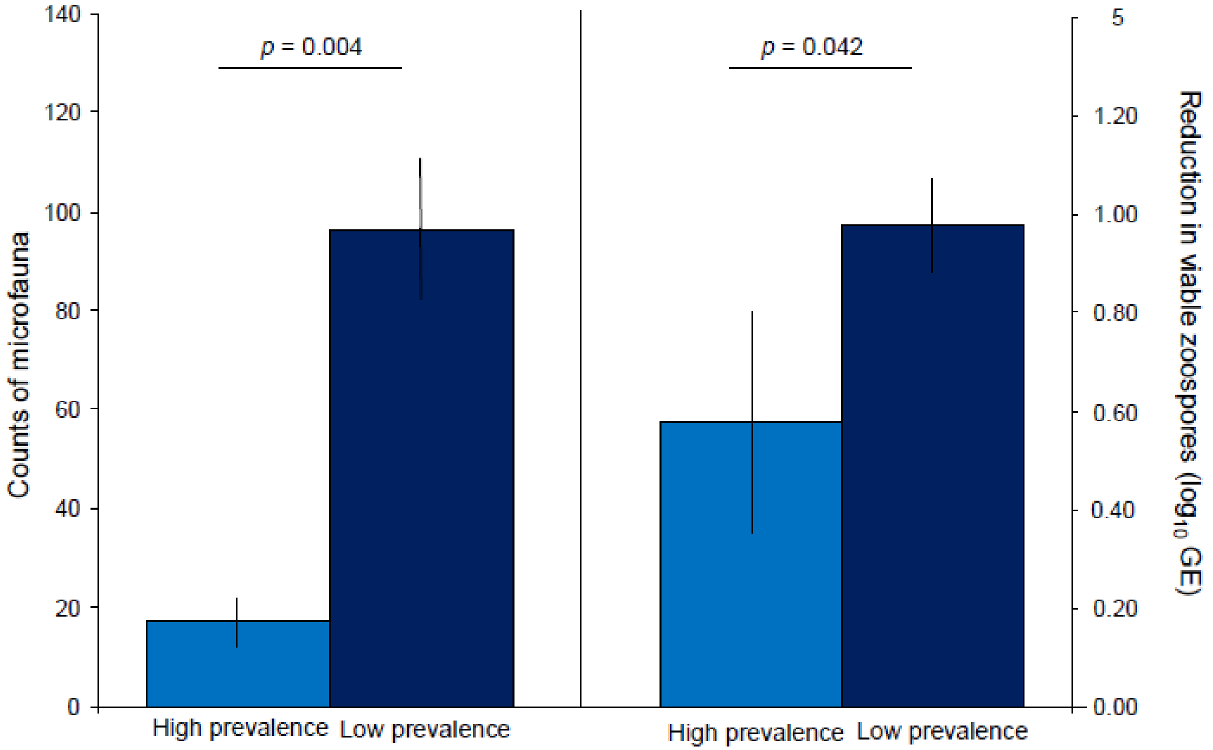


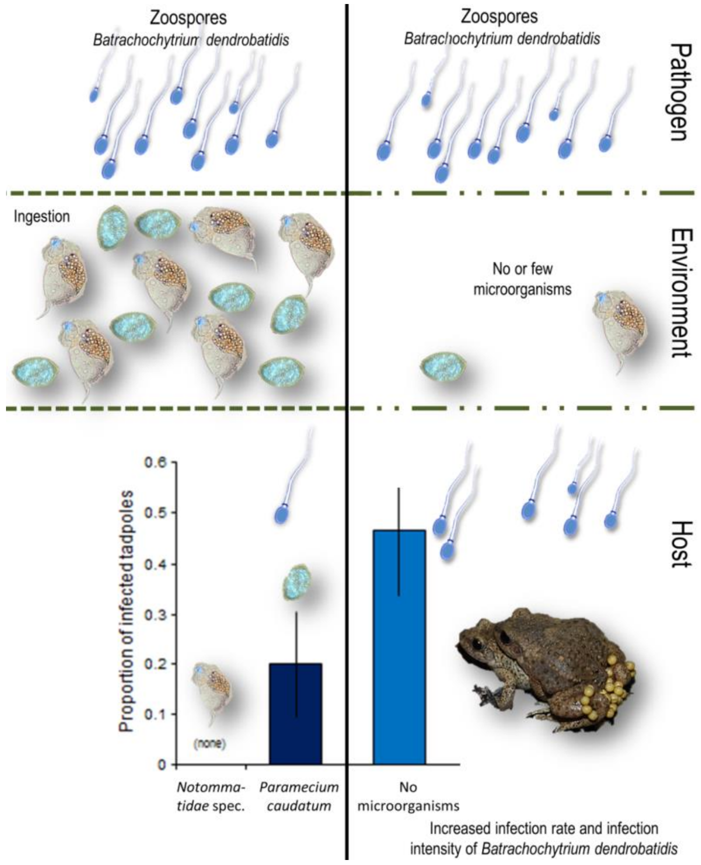
28 lacs, 6 gradients répartis d’Est en Ouest, altitude de 1500 à 2500m asl

Current Biology *24*, 176–180, January 20, 2014 http://dx.doi.org/10.1016/j.cub.2013.11.032

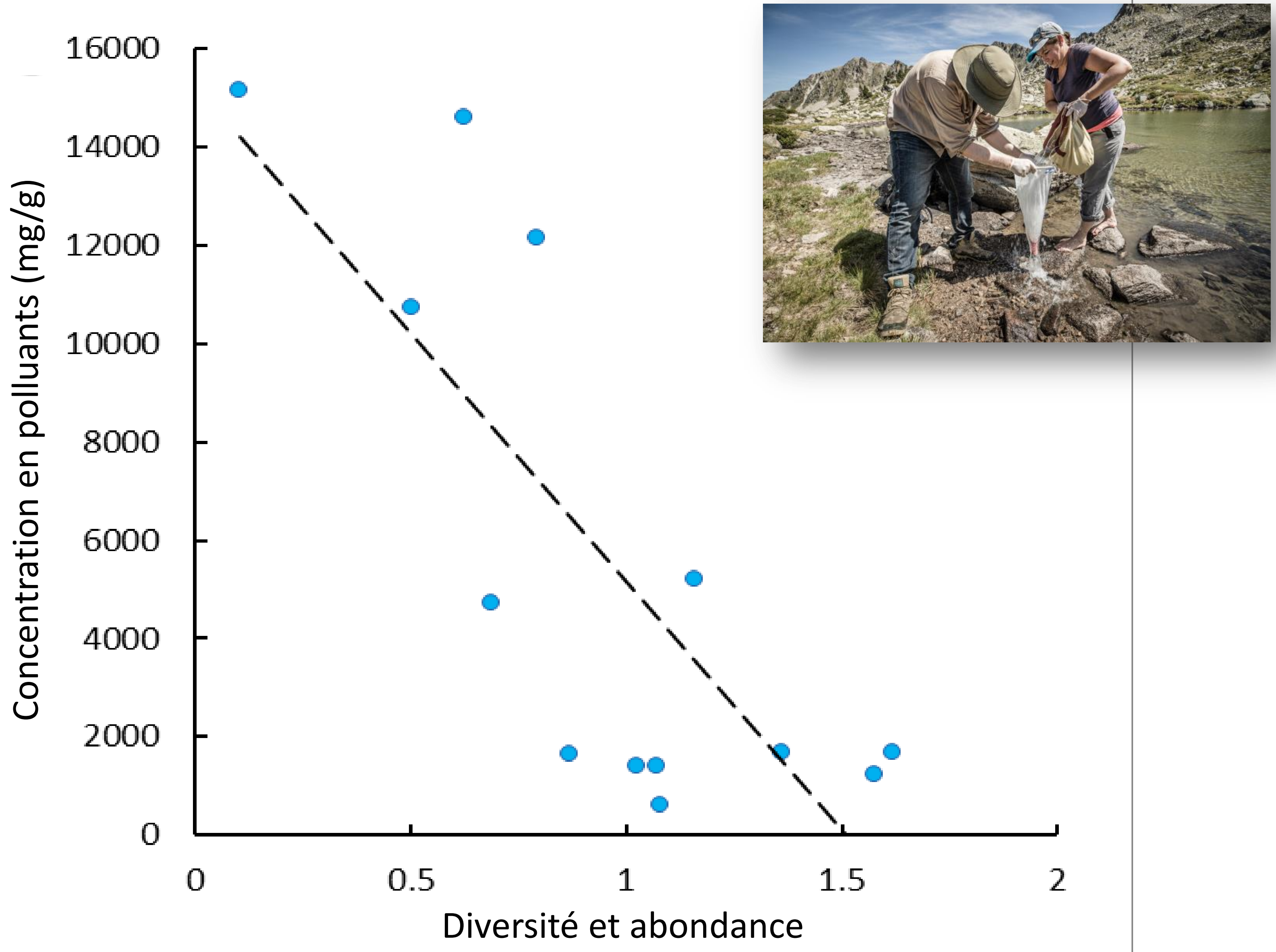
Microscopic Aquatic Predators Strongly Affect Infection Dynamics of a Globally Emerged Pathogen

Dirk S. Schmeller,[1,2,3,7,*] Mark Blooi,[4,7] An Martel,[4] Trenton W.J. Garner,[5] Matthew C. Fisher,[6] Frédéric Azemar,[2,3] Frances C. Clare,[5,6] Camille Leclerc,[3] Lea Jäger,[3] Michelle Guevara-Nieto,[3] Adeline Loyau,[1,2,3,7] and Frank Pasmans[4,7]

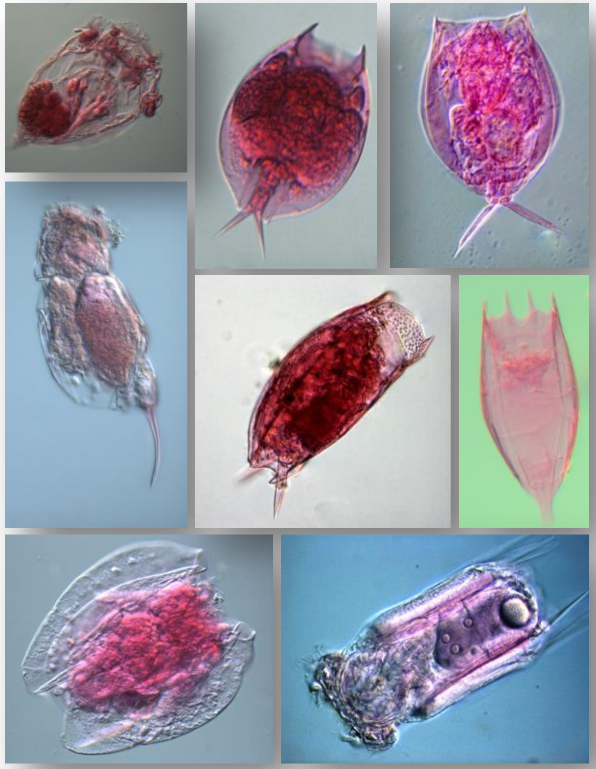




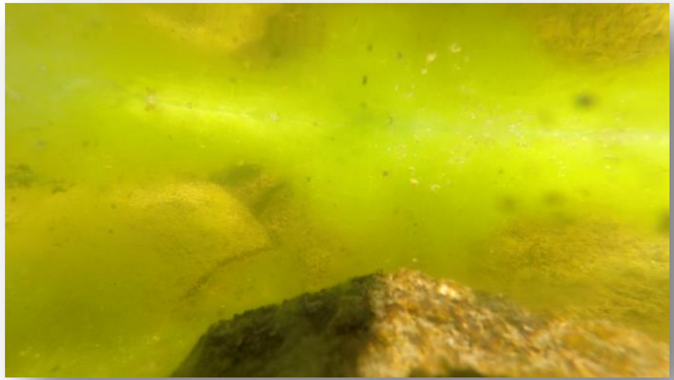
Pollution



Concentration en polluants (mg/g)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
Diversité et abondance

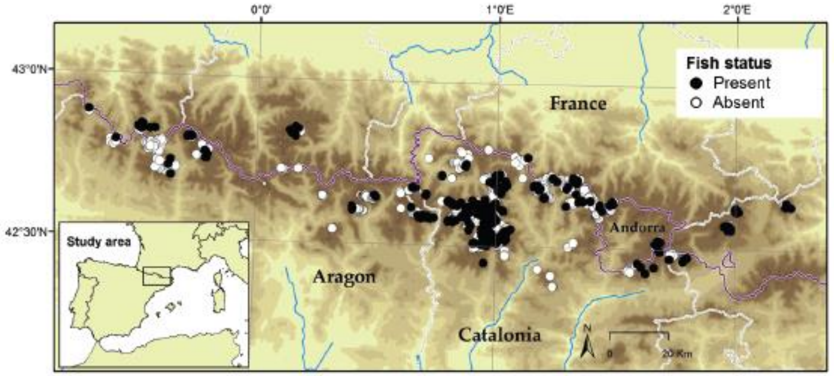


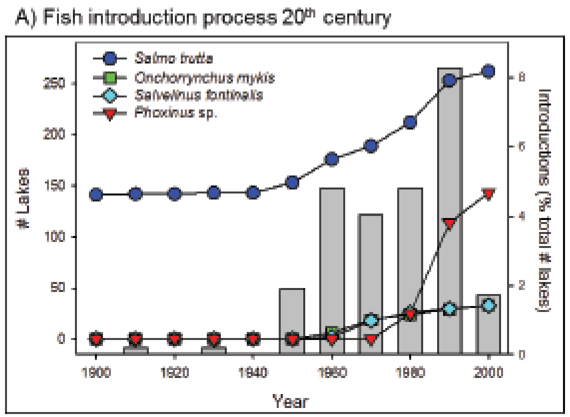
Pastoralisme, dégradation, eutrophisation

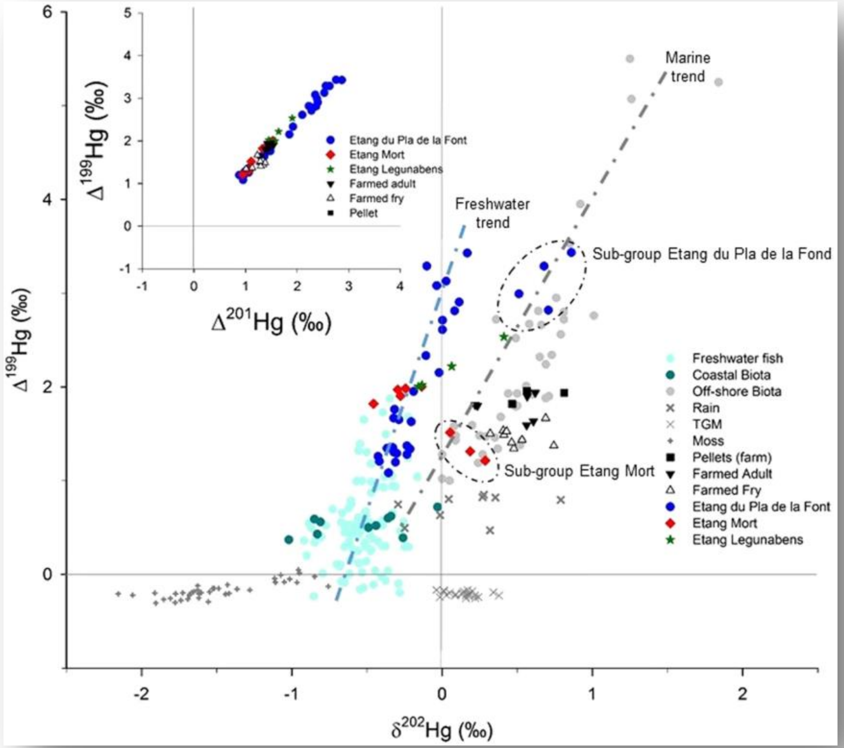


Empoissonnement

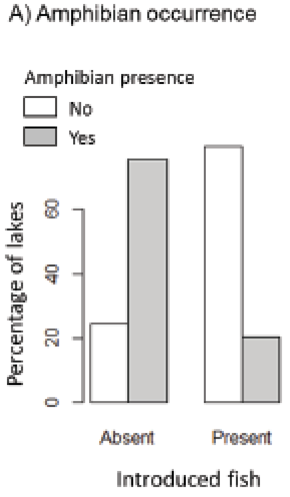
- Miró, A. et al. **Large negative effect of non-native trout and minnows on Pyrenean lake amphibians**. *Biological Conservation* **218**, 144–153 (2018).
- Miró, A. & Ventura, M. **Introduced fish in Pyrenean high mountain lakes: impact on amphibians and other organisms, and conservation implications.** 15 (2020).

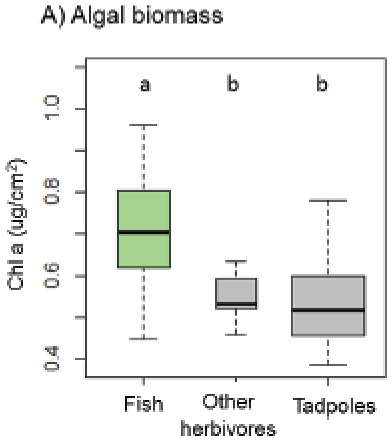


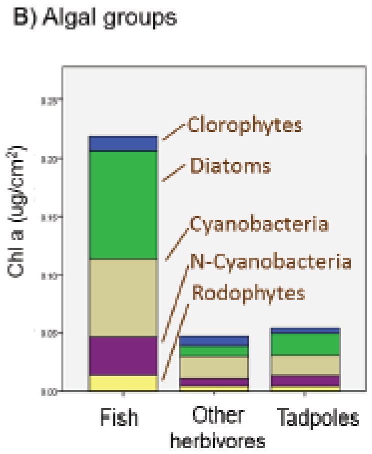




Hansson, S. V. *et al.* **Transfer of marine mercury to mountain lakes.** *Scientific Reports* **7**, 12719 (2017).





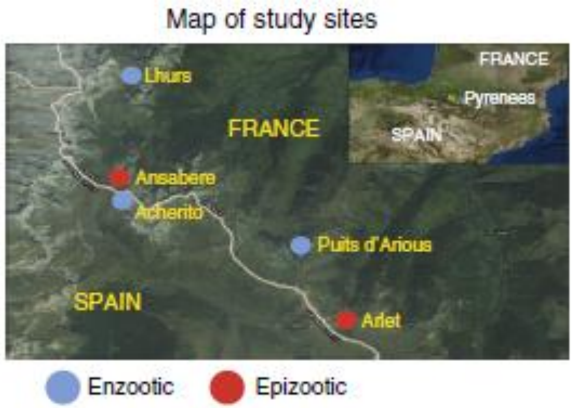


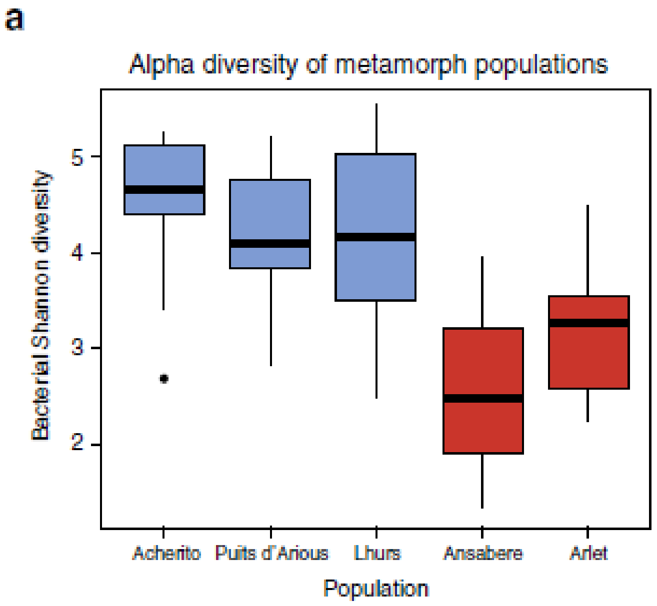
Microbiote cutané des amphibiens (1)

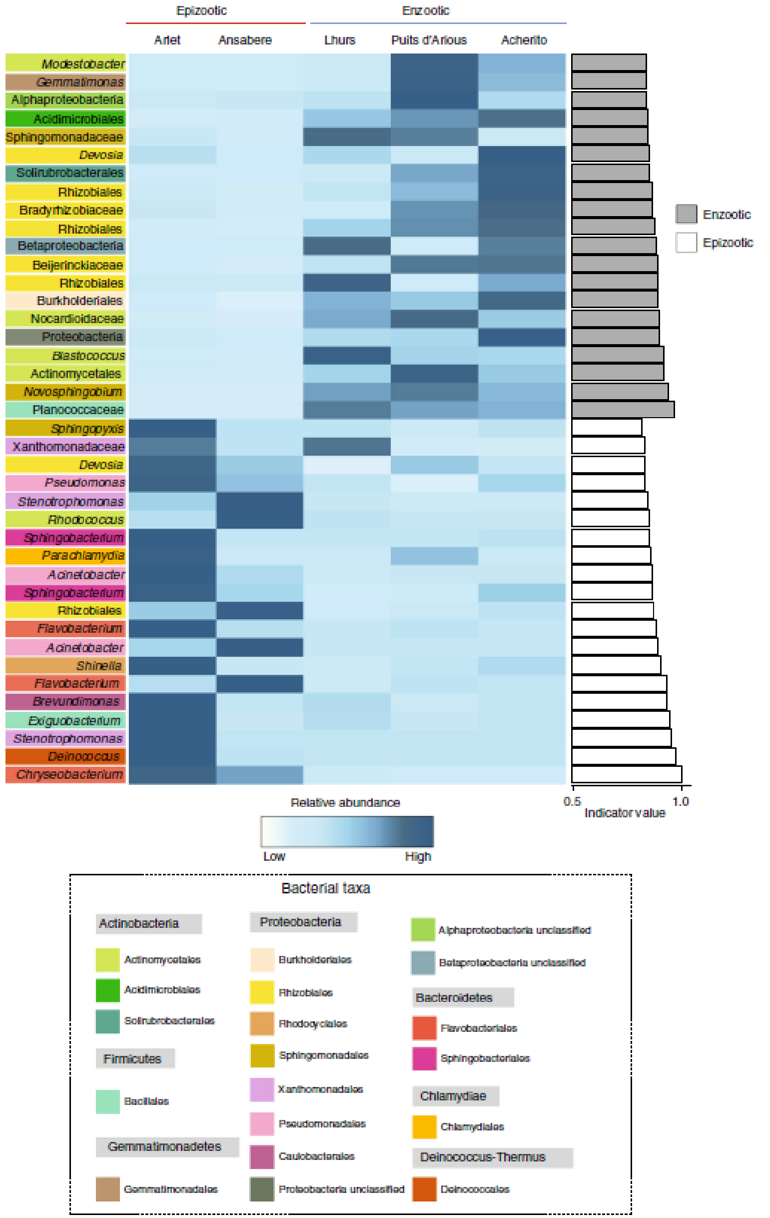
ARTICLE
DOI: 10.1038/s41467-018-02967-w OPEN

Amphibian chytridiomycosis outbreak dynamics are linked with host skin bacterial community structure

Kieran A. Bates[1,2], Frances C. Clare[2], Simon O'Hanlon[1], Jaime Bosch[3], Lola Brookes[2], Kevin Hopkins[2], Emilia J. McLaughlin[2], Olivia Daniel[1], Trenton W. J. Garner[2], Matthew C. Fisher[1] & Xavier A. Harrison[2]



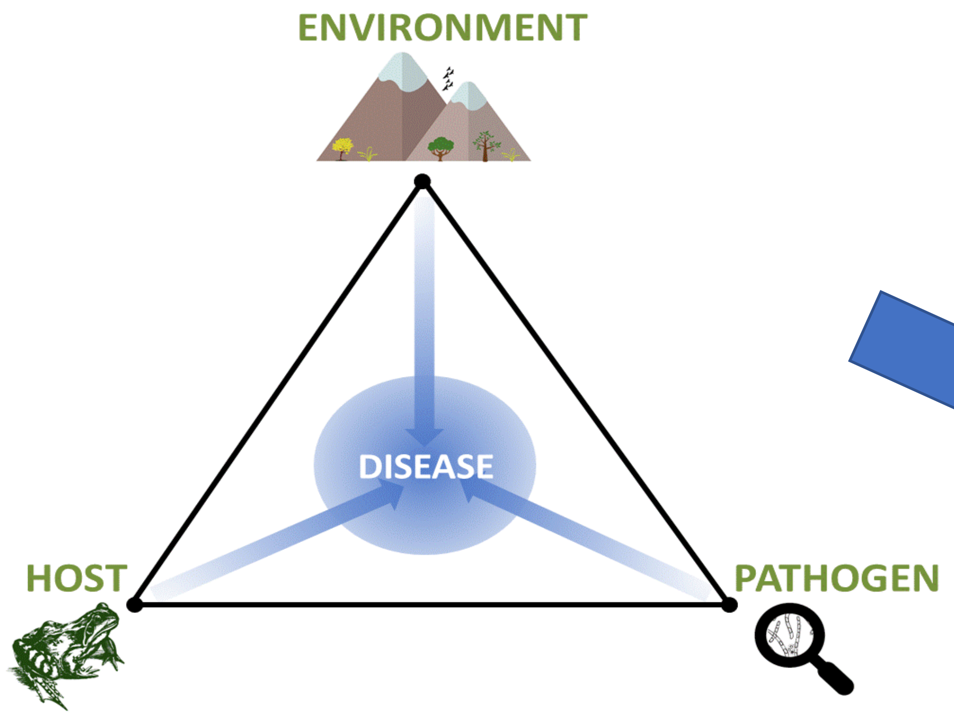




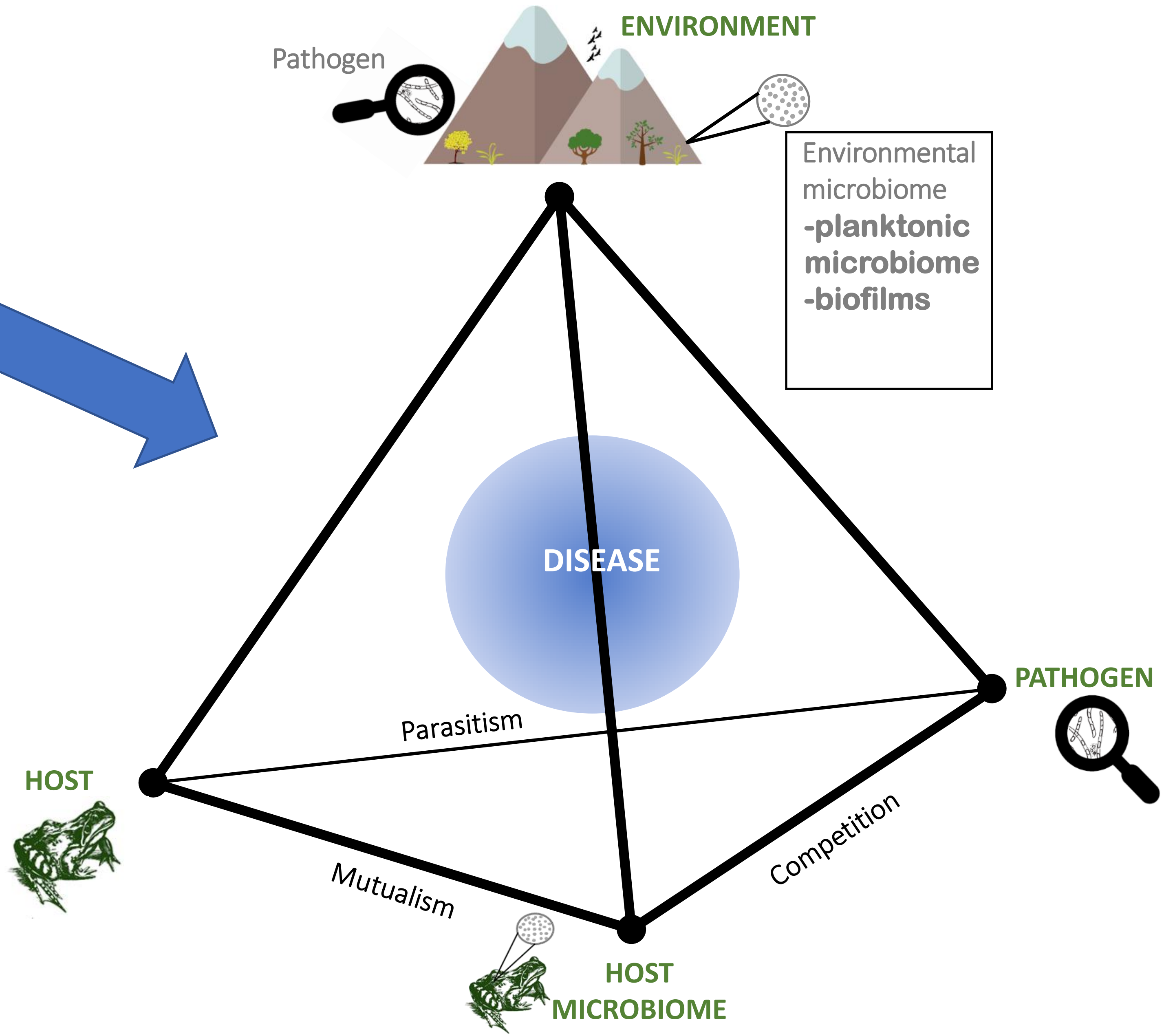
Cause ou conséquence?

Bernardo-Cravo et al., **Climate and fish impact tadpole skin microbiome in mountain lakes,** *in prep***.**

The Disease Pyramid



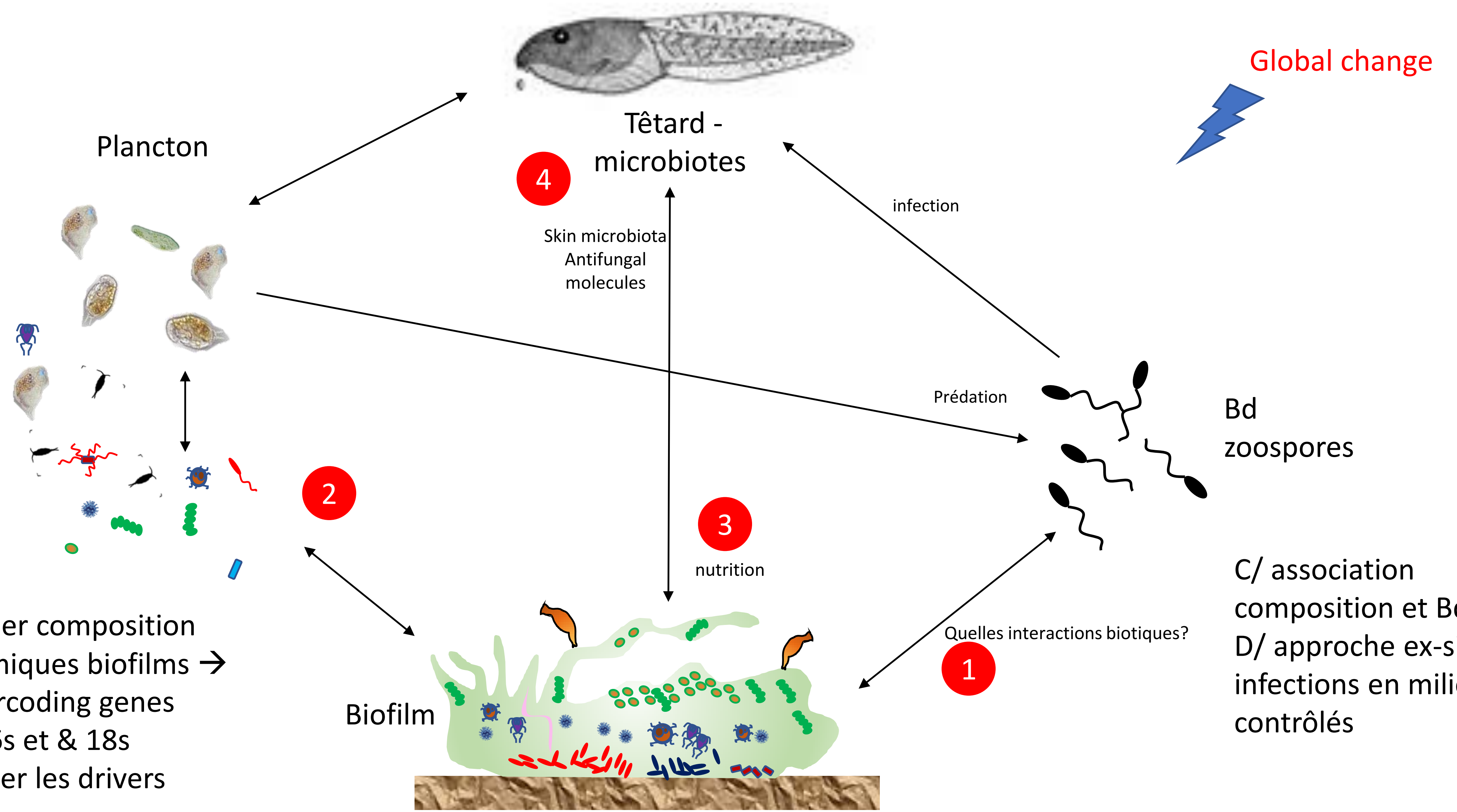
Bernardo-Cravo et al. Trends in Parasitology, 2020



Biofilms: un autre facteur biotique ?

- Sentenac et al. (2021), **The significance of biofilms to human, animal, plant and ecosystem health**, Functional Ecology, *in press*
- Biofilms: most dominant & productive mode of microbial life on earth, essential in mountain freshwater ecosystems

Biofilms: un autre facteur biotique ?

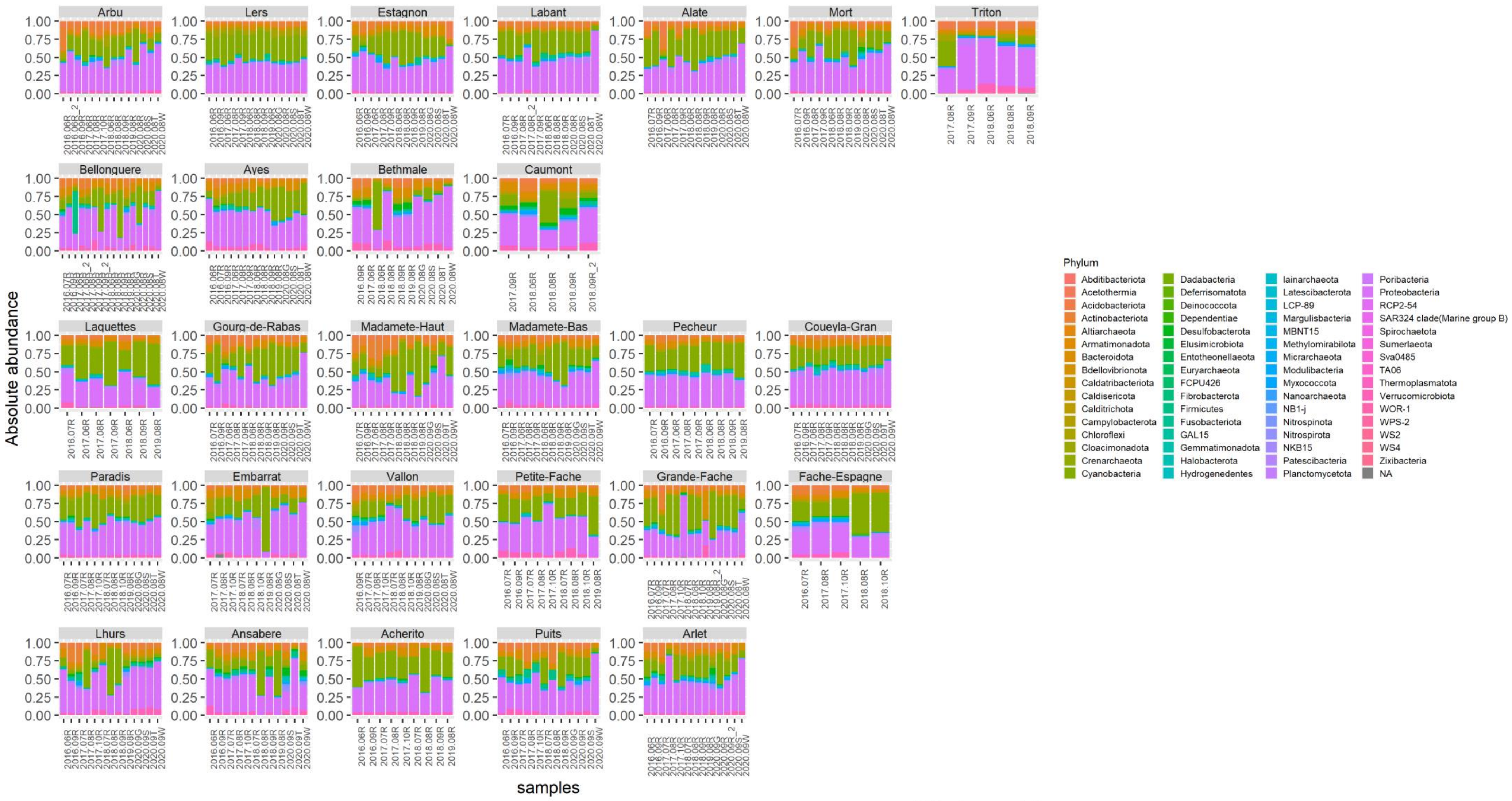


A/ étudier composition taxonomiques biofilms → metabarcoding genes ARNr 16s et & 18s
B/ étudier les drivers

C/ association composition et Bd ?
D/ approche ex-situ, infections en milieu contrôlés

Composition barplots of all samples

all ASV stacked, colored by Phylum



ASV not represented

Conclusions

- Liens entre biodiversité, environnement et santé animale (et écosystème)
- Collaboration vétérinaire, écologues (animale, communauté, microbienne), démographe, généticien etc.
- Importance des amphibiens dans les écosystèmes de montagne
- Pollution, degradation habitat, changement climatique, + maladies émergentes
- **Ranavirus + Batrachochytrium salamandrivorans → ? + co-infection**
- Risque pour espèces endémiques de montagne: Calotriton des Pyrénées, de Montseni, Salamandre de Lanza, Salamandre noire

- Merci à Dirk Schmeller, Adeline Loyau, Oliver Machate, Judith Laufer, Adriana Bernardo-Cravo
- Projet GloMEc, AXA fond pour le recherche, MESRI, INPT

Merci pour votre attention

Lescun





Cauterets





Néouvielle




Bethmale



@Hsentenac , hugo.sentenac@toulouse-inp.fr

Hugo Sentenac,
www.p3mountains .org

Bassiès






Presentation

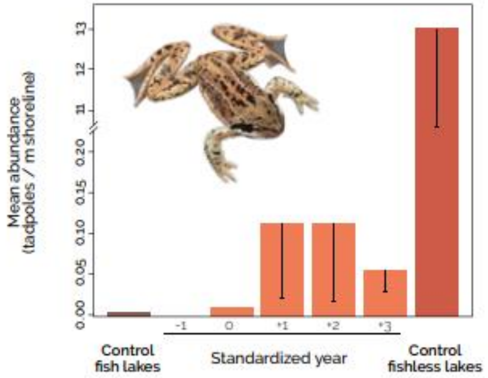
- Classes préparatoires(Dijon, 2008-10)
- Ecole vétérinaire(Lyon,2010-15)
  - Thèse: Causes de non-éclosion chez *Circus cyaneus*
- Pratique vétérinaire mixte(2015-18)
- MSc Wild Animal Health (London, Santiago, 2018-19)
  - Projet de recherche: Probabilité de détection de *Batrachochytrium dendrobatidis (Bd)* chez *Rhinoderma darwinii*
- PhD (Laboratoire Ecologie fonctionnelle et Environnment, Toulouse (UMR 5245), en cours 2019-2022)
  - Biofilms benthiques des lacs pyrénéens et relations avec la dynamique d'infection par *Bd*

Fonds pour la Recherche

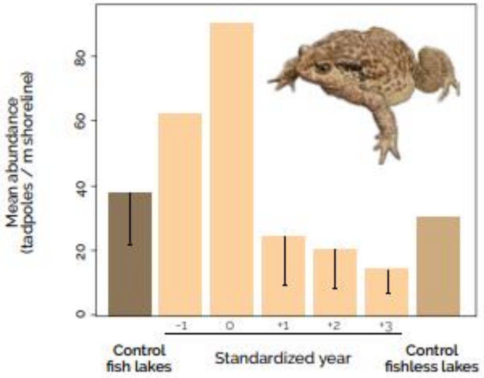
Life Limnopirineus

The group of organisms with the clearest response to fish eradication were the macroinvertebrates from the littoral zone, with an **increase in taxa richness over time and a convergence of macroinvertebrate composition to that of natural lakes.**

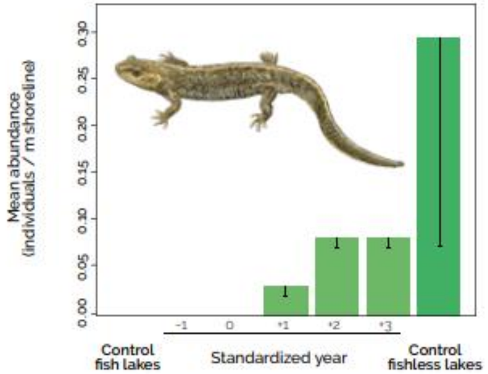
COMMON FROG



SPINY TOAD



PYRENEAN BROOK NEWT



PALMATE NEWT