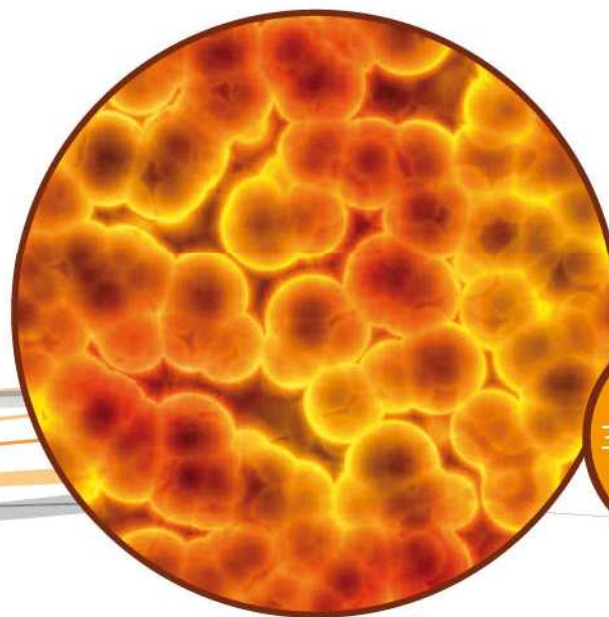


Les rencontres scientifiques de l'Anses

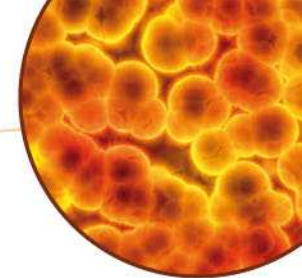
Restitution du programme national de
recherche environnement santé travail

De l'émergence à la résurgence des agents biologiques : caractérisation des facteurs de risque pour l'homme



Mercredi
30 novembre
2011

Maison internationale, Paris 14^e



Ecologie et évolution des maladies transmissibles. L'importance de l'approche intégrative

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UMR MIVEGEC IRD - CNRS - Universités de Montpellier 1 et 2, Montpellier

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Plan de la présentation

- ✓ Quelques éléments de définition
- ✓ Compréhension actuelle de la transmission de virus de grippe aviaire faiblement pathogènes
- ✓ Persistance dans l'environnement de micro-organismes et traits associés
- ✓ Transmission infectieuse et réseaux écologiques
- ✓ Quelques éléments de discussion

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Une définition de l'approche intégrative

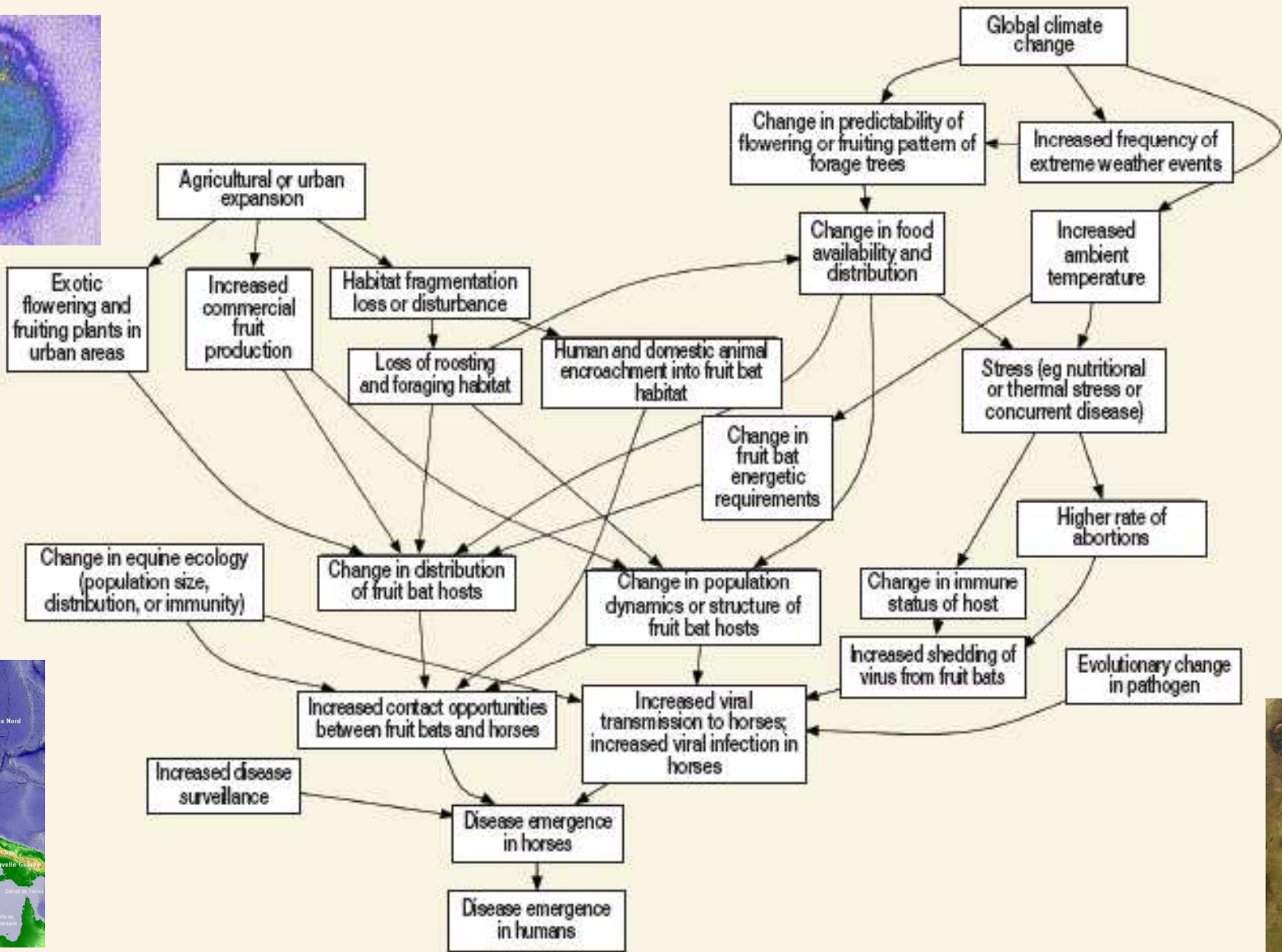
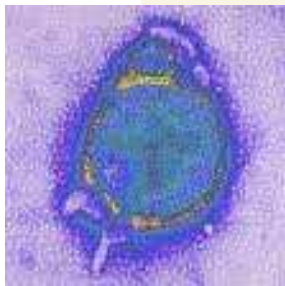
: qualifie un système qui influence (une infection) et qui consiste à étudier et mettre en regard les différents déterminants intervenant à différents niveaux d'échelles (d'une infection)

Les défis de la recherche intégrative

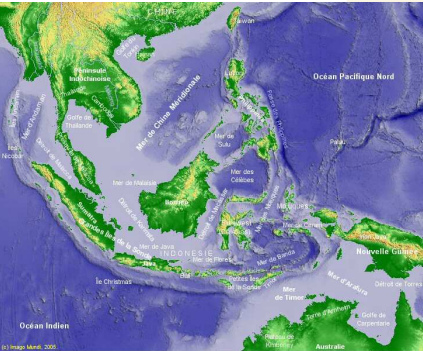
: les échelles d'organisation du gène à l'écosystème, voire même au-delà, sont ici importantes à prendre en compte

: les échelles spatiales et temporelles (temps longs et échelles spatiales supérieures) sont prépondérantes dans l'explication des phénomènes observés

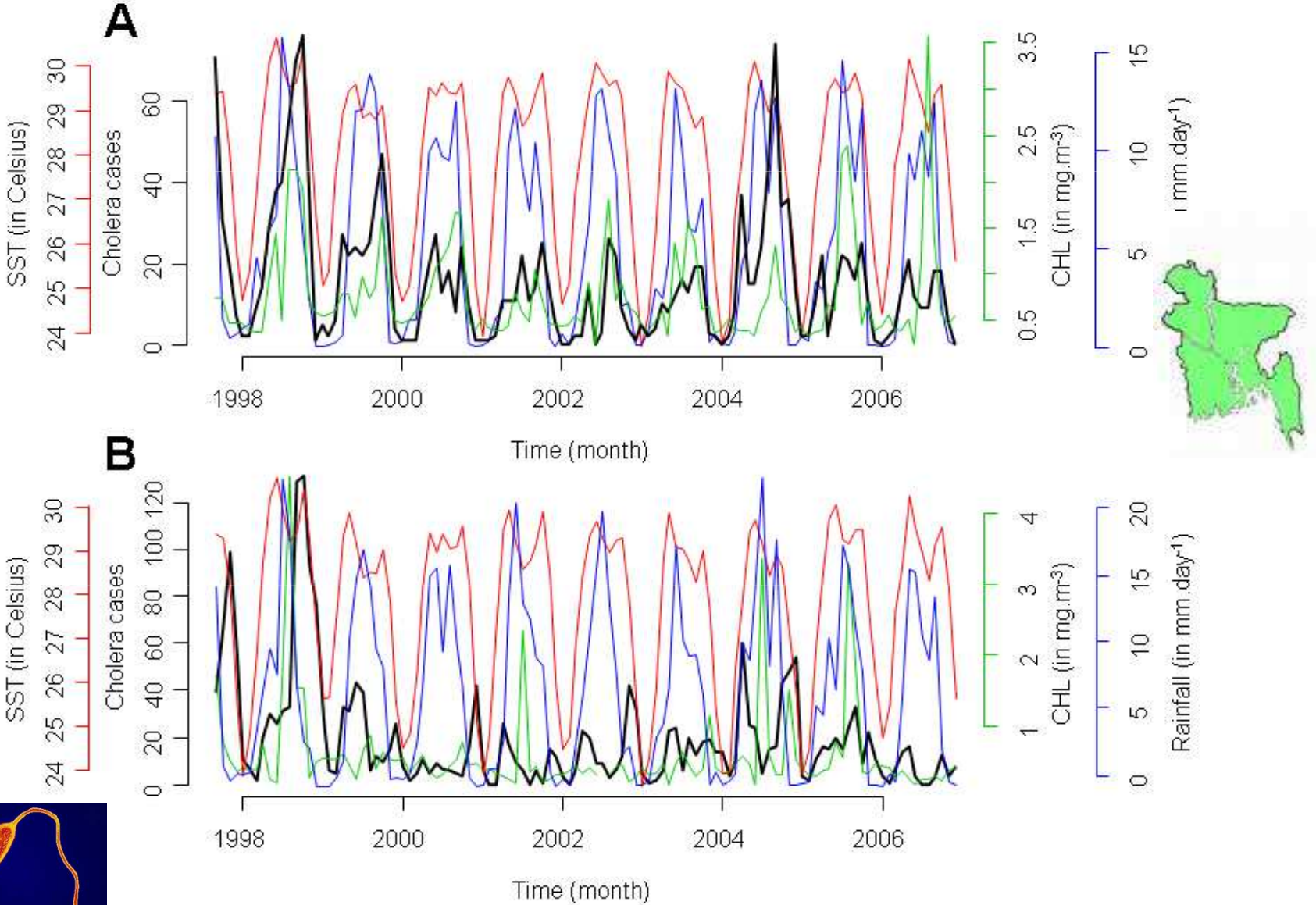
Diagramme causal pour expliquer l'émergence du virus Hendra



Plowright et al. (2008).
Frontiers in Ecology and the Environment



Séries chronologiques de cas de choléra au Bangladesh



De Magny et al. (2010).
PNAS



Séries spatiales de cas et hiérarchie d'échelles

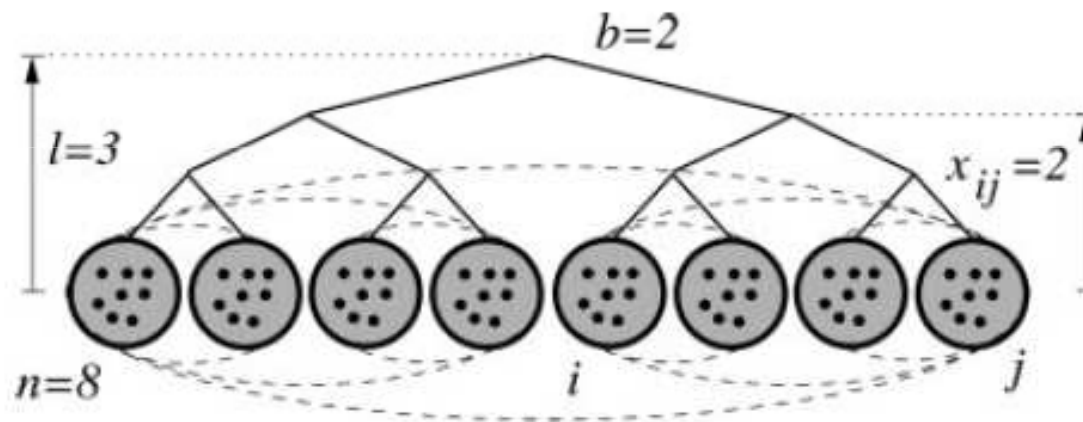
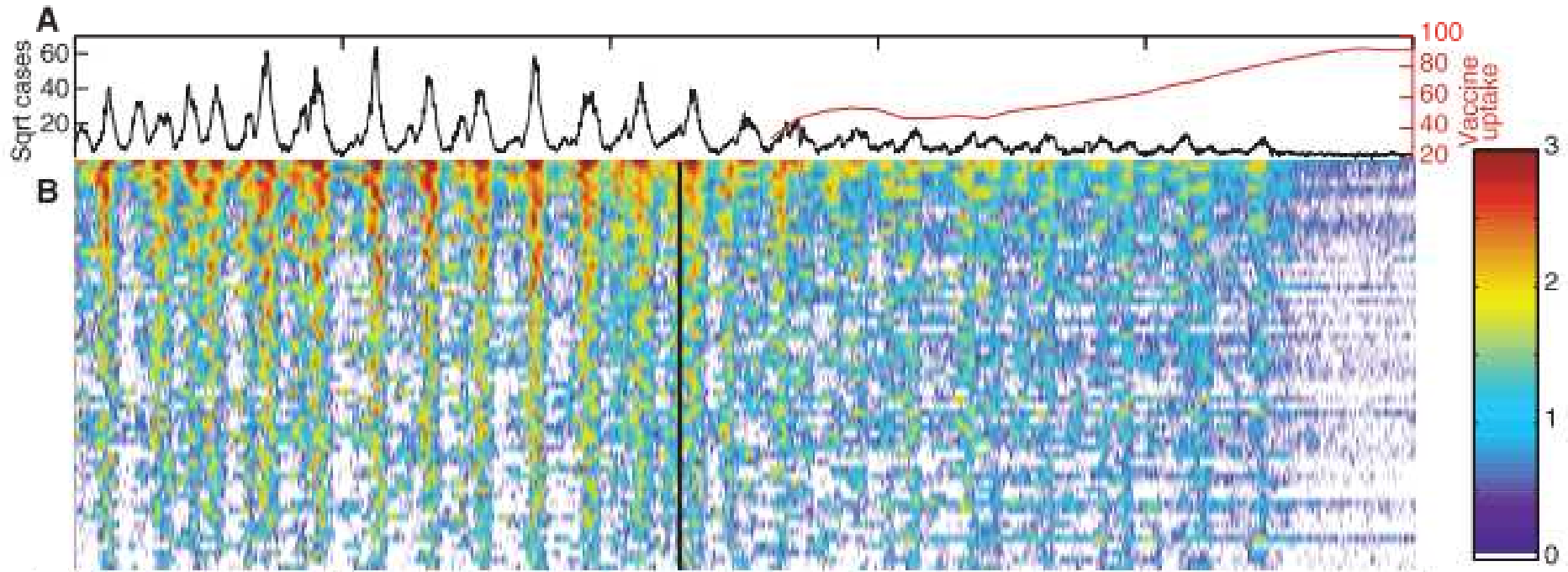


Fig. 1. Hierarchical metapopulation model of disease spreading. In our model, individuals (dots) belong to groups (solid circles) that in turn belong to groups of groups, and so on, giving rise to a hierarchy of scales. Alternatively, one can imagine the hierarchy as a nested set of subpopulations of increasing size, as indicated schematically by the dashed boundaries.

Multiscale, resurgent epidemics in a hierarchical metapopulation model

Duncan J. Watts^{*†‡§}, Roby Muhamad^{*}, Daniel C. Medina[¶], and Peter S. Dodds[†]

Séries spatiales de cas et hiérarchie d'échelles ; cas de la rougeole en Grande-Bretagne

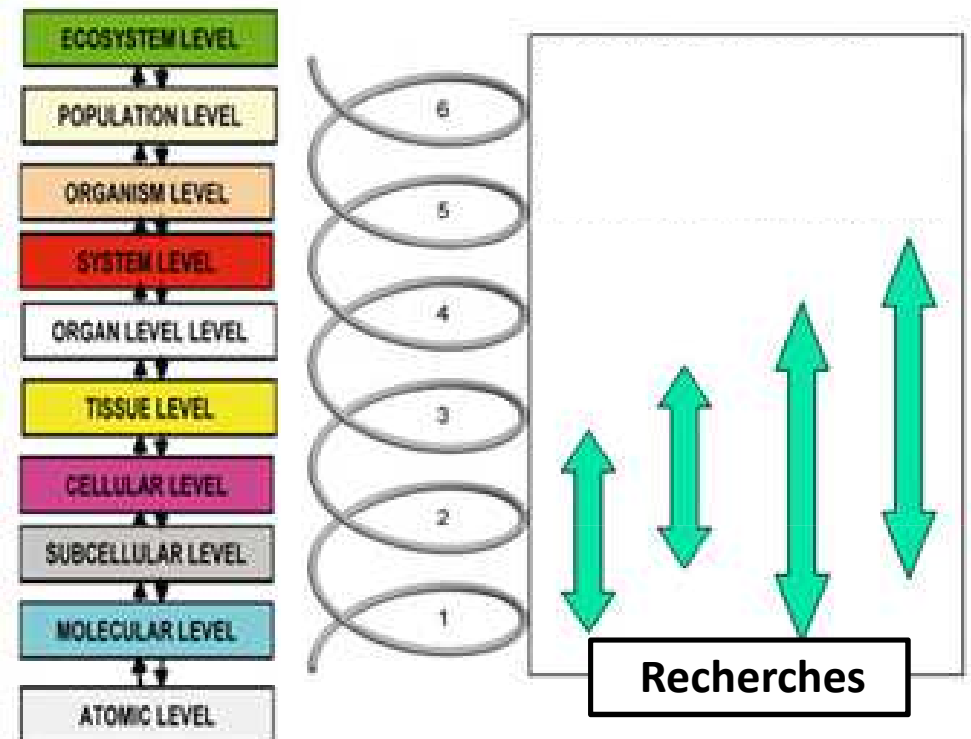


Opposite Patterns of Synchrony in Sympatric Disease Metapopulations

Pejman Rohani,* David J. D. Earn,† Bryan T. Grenfell

29 OCTOBER 1999 VOL 286 SCIENCE www.sciencemag.org

Les déterminants et autres facteurs (de risques) sont
« capturés » en fonction des niveaux d'organisation étudiés



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The High-Pathogenic and Low-Pathogenic avian flu viruses saga!



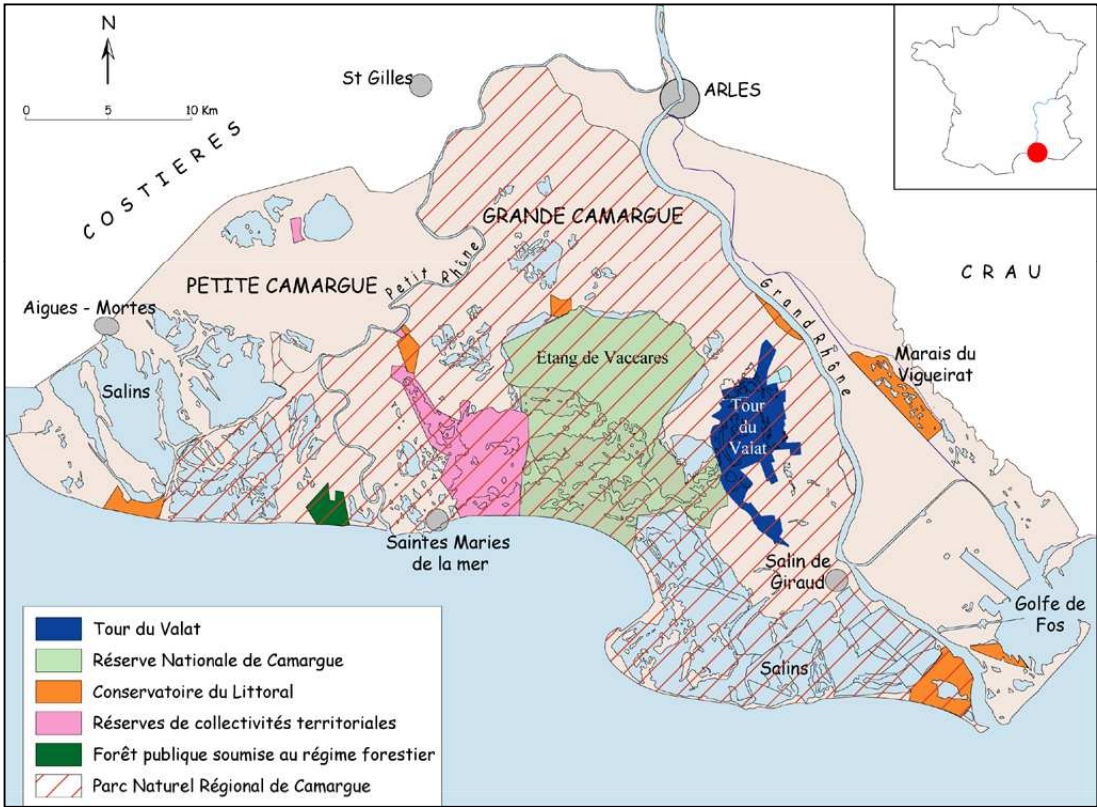
Study area. The Camargue bird sanctuary

Rhone delta (South of France)

145,500 ha

Large diversity of aquatic ecosystems and land-uses

c.a. 280 bird species



Wildlife reserves



Hunting marshes



Rice farming



Salt marshes

Bird species and LPAI viruses data

Catching birds:

- 89 species collected
- Species selected for easy catching, aquatic status, and occasionally from hunting
- From September 2005 to July 2006
- 2,389 faecal samples collected



Counting avian population:

- Airplane counting




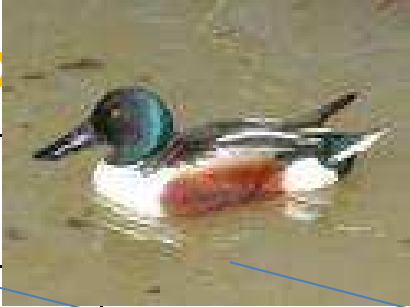

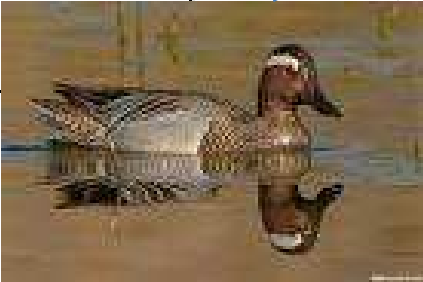
Looking for viruses:

- AIV persistence by RT-PCR
- When AIV found, test for H5N1
- No H5N1 found
- Mean prevalence *c.a.* 3%

Bird species positive to LPAI virus (Sept. 2005-Dec. 2008-)

Species	Prevalence 2005	Prevalence 2006	Prevalence 2007	Prevalence 2008	Prevalence 2005/2008	Sampling size 2005/2008
<u>Anseriformes</u>						
Canard pilet (<i>Anas acuta</i>)	0%	0%	4,3%	0%	1%	109
Canard souchet (<i>Anas clypeata</i>)	3,9%	1,8%	15,4%	16,7%	4,5%	311
Sarcelle d'hiver (<i>Anas crecca</i>)	4,4%	4,1%	6,4%	6,9%	5,6%	1957
Canard colvert (<i>Anas platyrhynchos</i>)	3,5%	4,8%	5,3%	17%	8,6%	1064
Sarcelle d'été (<i>Anas querquedula</i>)	20,0%	7,7%	9,1%	8%	9,3%	54
Canard chipeau (<i>Anas strepera</i>)	0%	2,3%	0%	5,4%	1,8%	274
Fuligule milouin (<i>Aythya ferina</i>)	0%	1,1%	0%		0,3%	294
<u>Charadriiformes</u>						
Mouette mélanocéphale (<i>Larus melanocephalus</i>)		3,0%	0%		2,8%	71
Goéland leucophée (<i>Larus michahellis</i>)		0%	1%	0%	0,5%	369

Bird species and LPAI virus (Sept. 2005-Dec. 2008-)

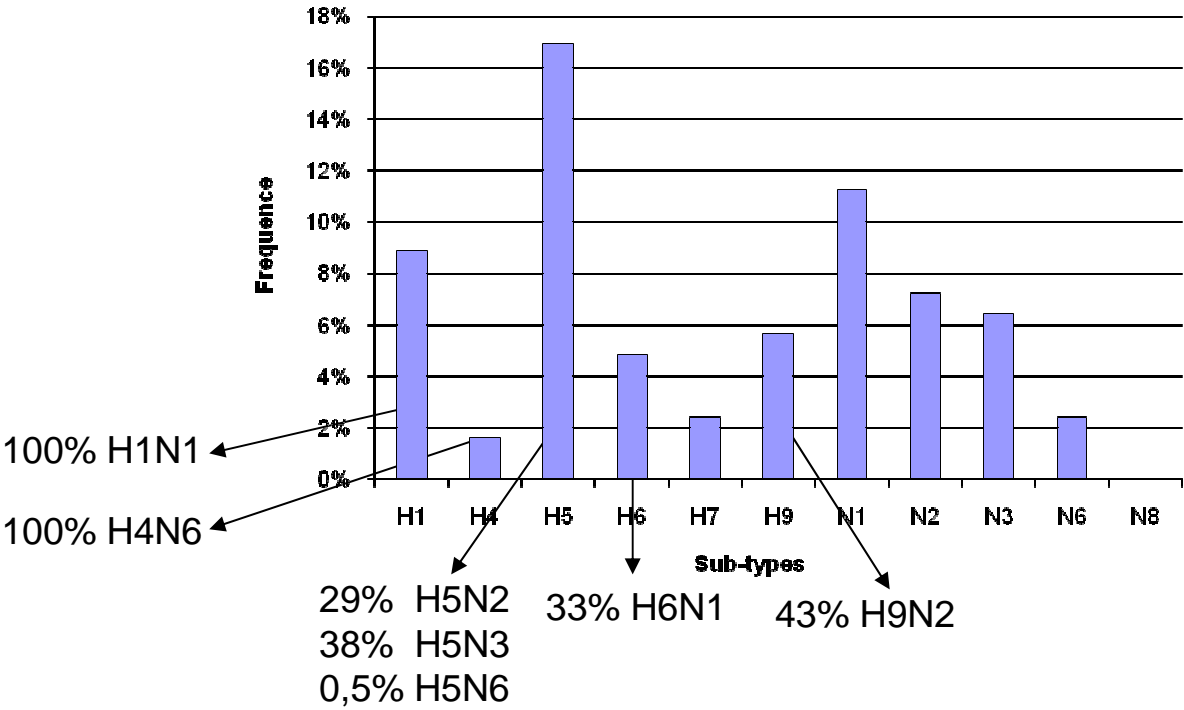
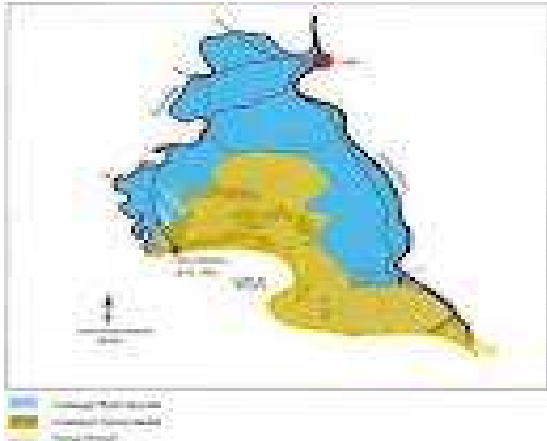
Species	Prevalence 2006	Prevalence 2007	Prevalence 2008	Prevalence 2005/2008	Sampling size 2005/2008
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LPAI virus sub-types identified in Camargue

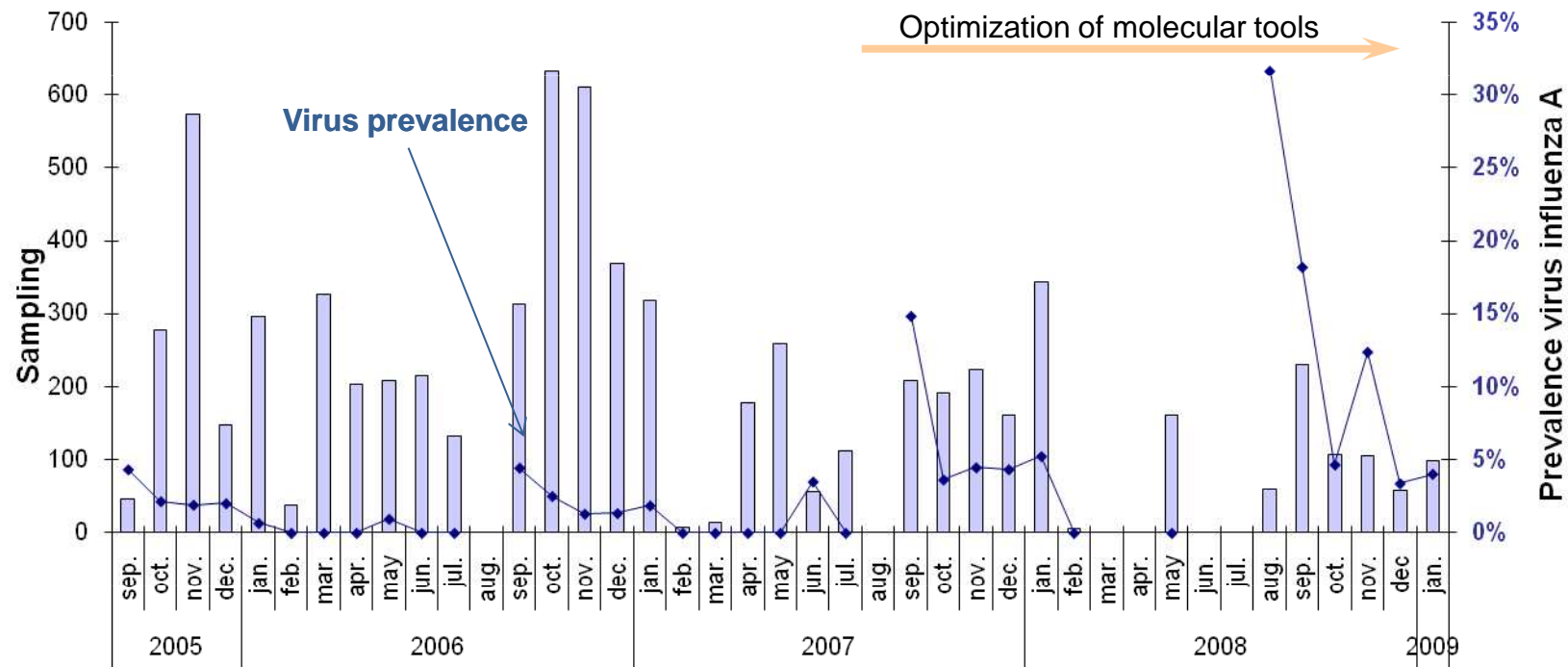
No HPAI H₅N₁ identified

Diversity of H₅ non N₁ LPAI virus sub-types

17% of sampled birds positive to AIV type A



LPAI virus dynamics in time (Sept. 2005-Jan. 2009)



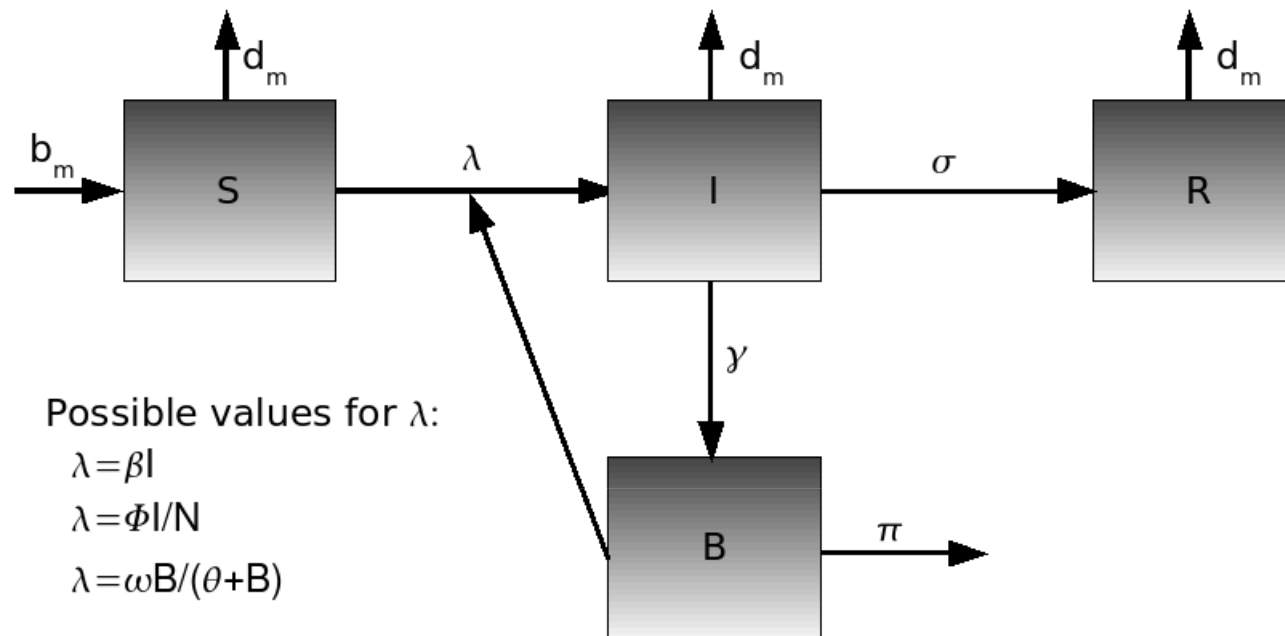
Seasonal pattern of infection observed, with a higher prevalence during the winter season (Sep. to Feb.)

Importance of molecular tools in characterizing the presence of virus

Modelling LPAI virus transmission

We assumed an average behaviour between all bird species

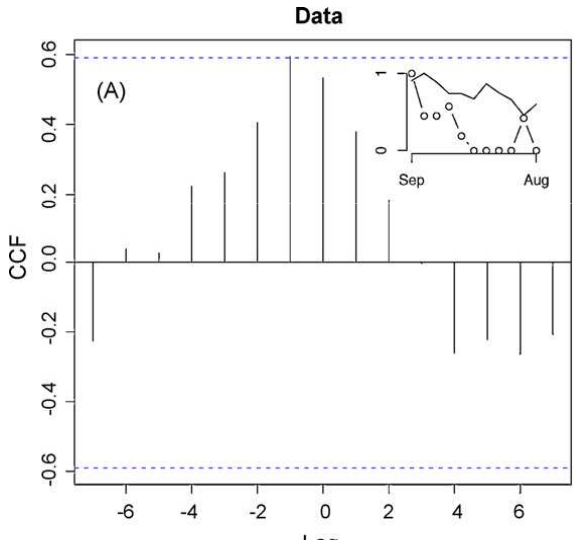
- Average water contact rate
- Average inter-individual contact rate



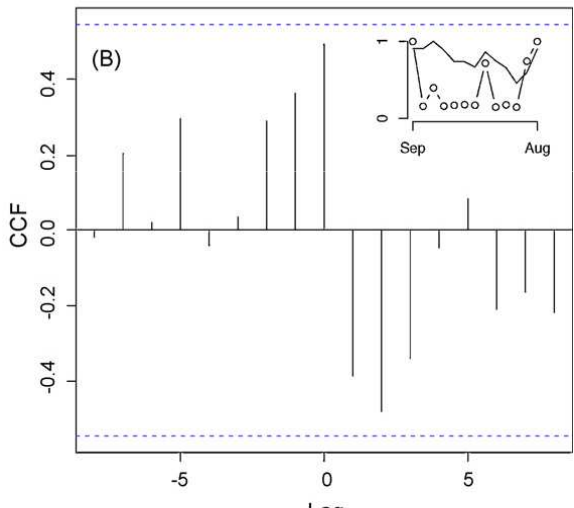
Water-borne transmission roughly mimics a recent model on cholera transmission by GEMI
Integration of host species population dynamics by forced demographic parameters

Cross-correlations between LPAI viruses and bird species communities

Field data

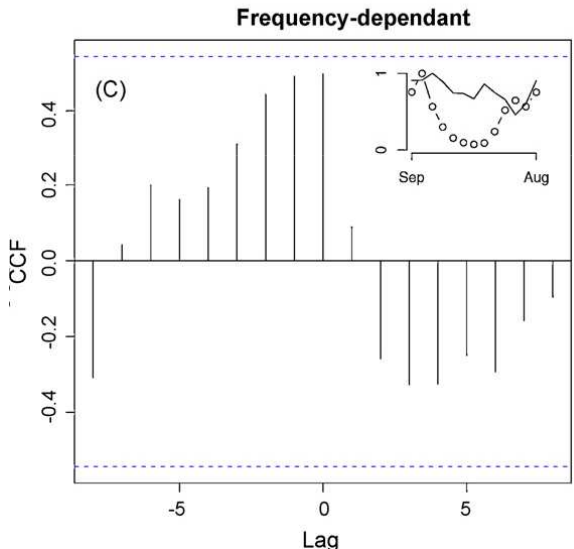


Density-dependant

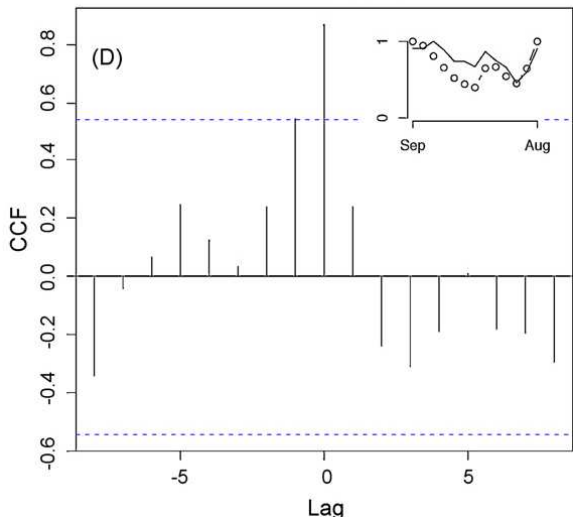


Density-dependent transmission

Frequency-dependent transmission



Water-borne

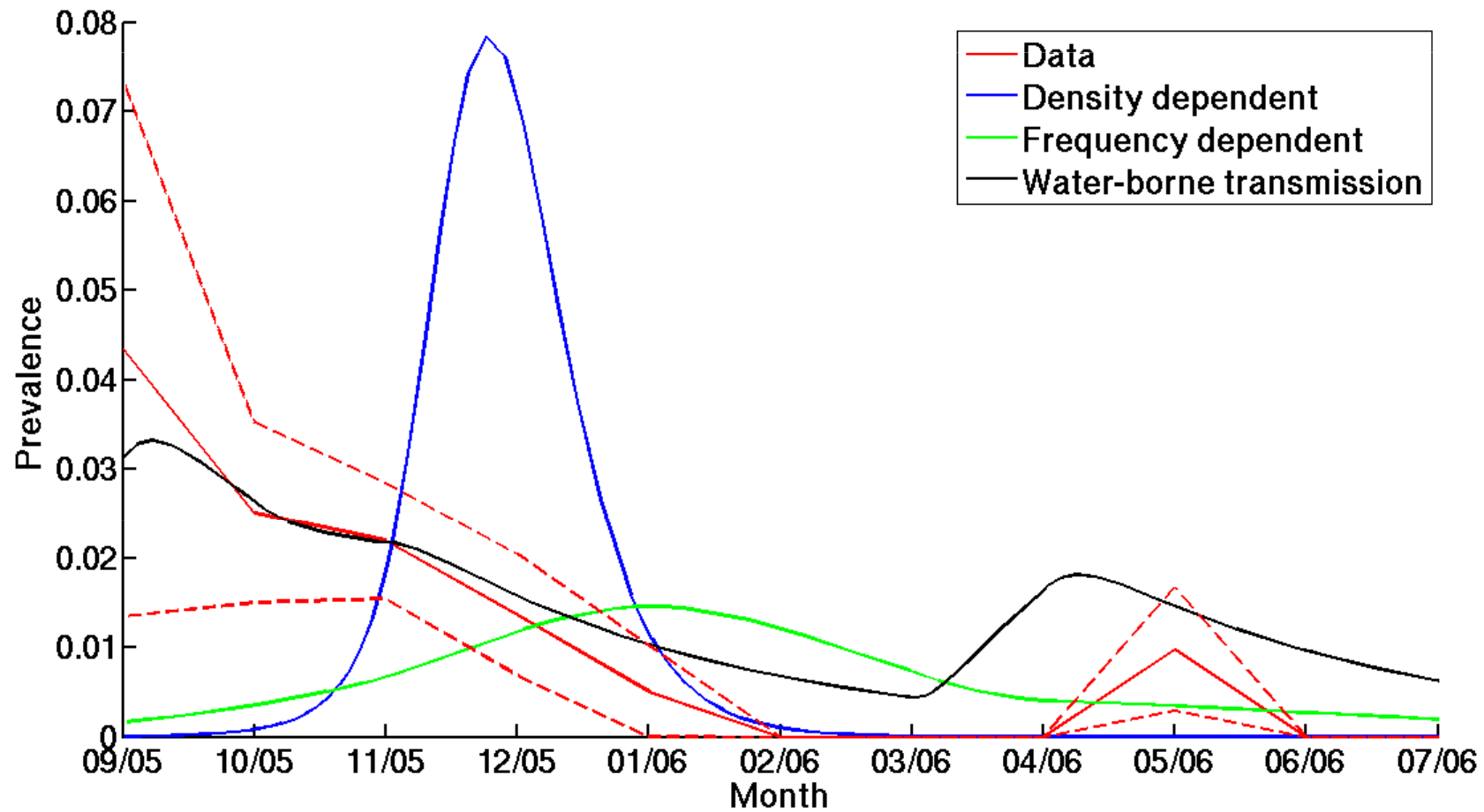


Water-borne disease transmission

Inserted plots represent bird species community dynamics (solid lines) and LPAI virus dynamics observed (A) and predicted (B–D) (dotted lines)

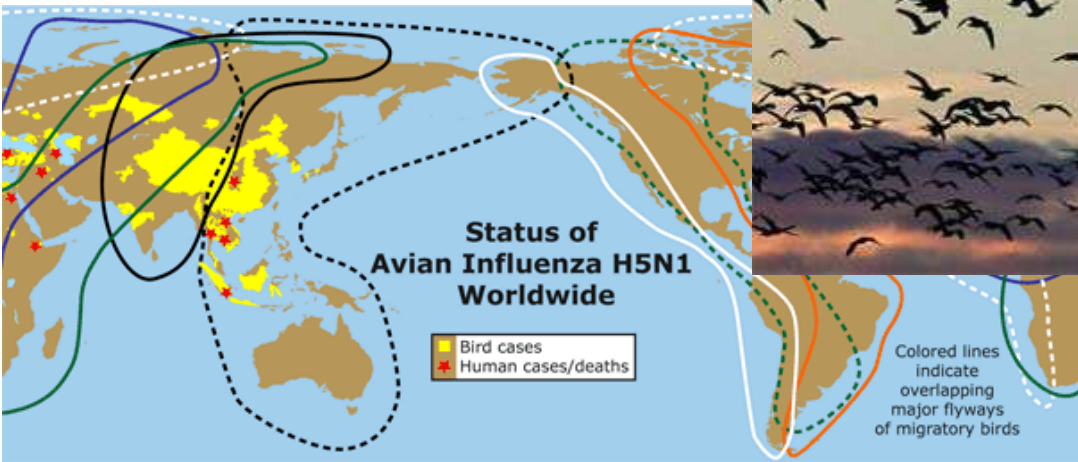
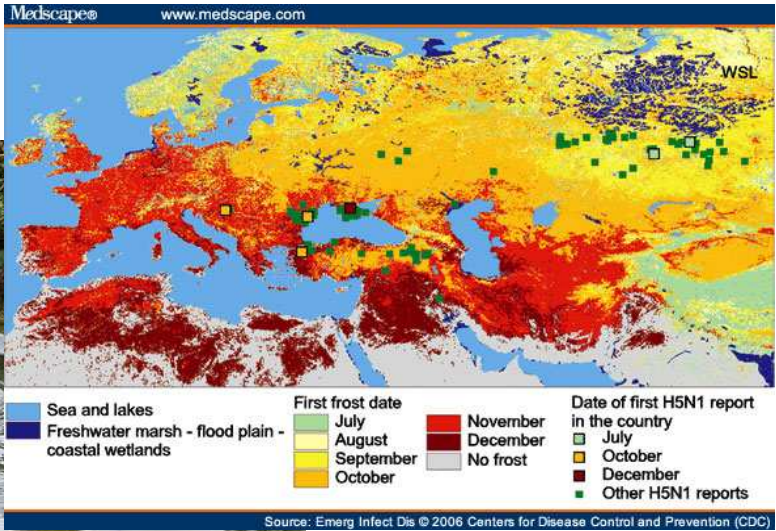
Model outputs for the best scenario of transmission according to empirical data

Time-series generated with best parameters



Clearly, water-borne transmission modelling exhibits the highest adequacy to the real data

Capacités de persistance importante de ce type de virus dans l'environnement



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Biol. Rev. (2004), 79, pp. 849–869. © Cambridge Philosophical Society
DOI: 10.1017/S1464793104006475 Printed in the United Kingdom

849

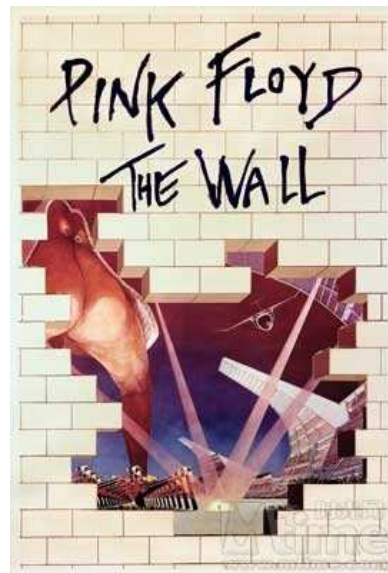
Pathogen survival in the external environment and the evolution of virulence

Bruno A. Walther^{1,2,3*} and Paul W. Ewald¹

¹ Department of Biology, Amherst College, Amherst, MA 01002-2237, USA

² Department of Zoology, Oxford University, Oxford, OX1 3PS, UK

³ Zoological Museum, University of Copenhagen, Universitetsparken 15, 2100 København Ø, Denmark



La sélection naturelle intervient en sélectionnant un trade-off entre virulence et capacité de persistance dans l'environnement

Plot of mean survival time *versus* mean per cent mortality for 16 human respiratory pathogens

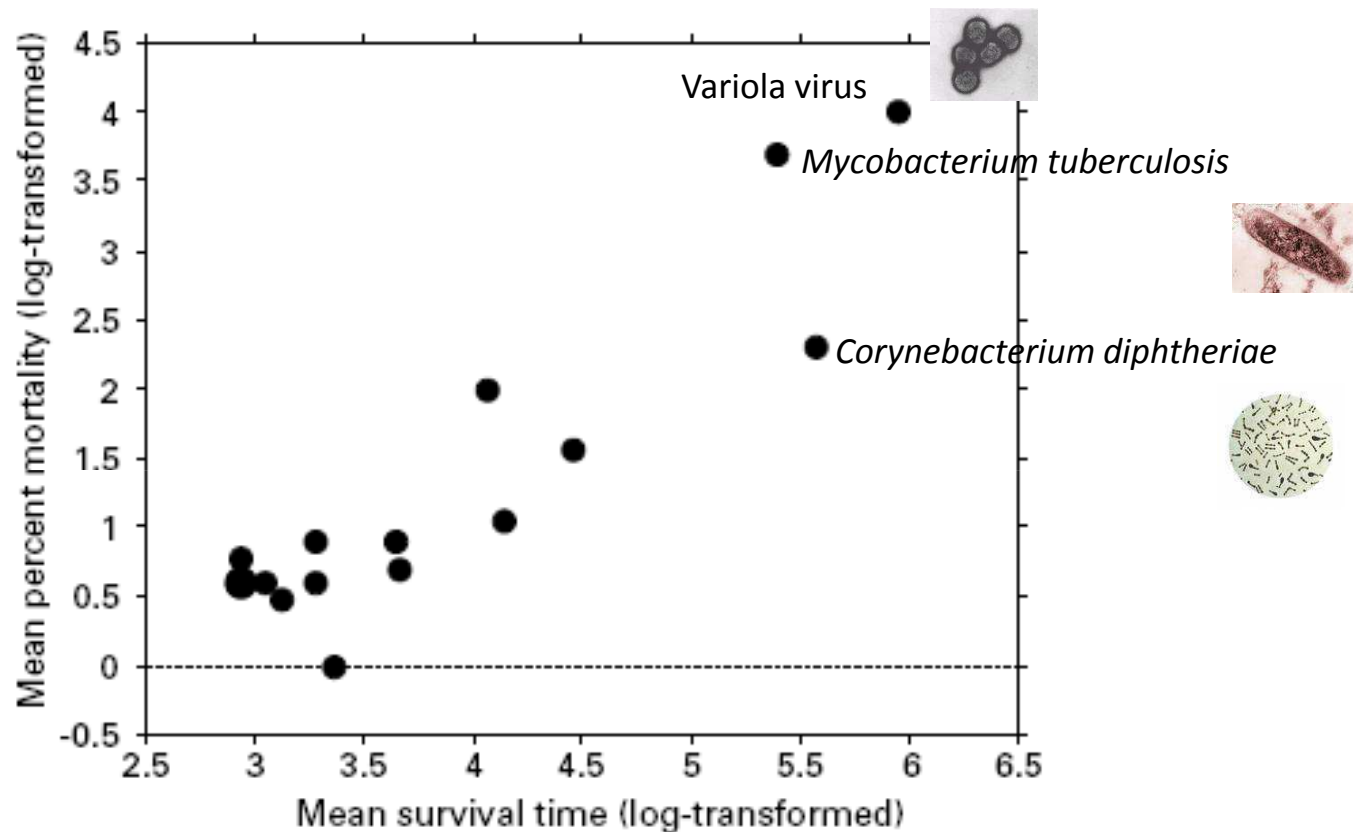


Table 2. The maximum durability of respiratory pathogens under different environmental conditions. References for durability of mumps, rubella and varicella-zoster virus are given in the text

Substrate*†	Immediate source	Light†	Temperature‡†	Durability§	References
<i>Variola virus</i>					
exudate	patient	dark	R (15–30 °C)	\$13 y	Wolff & Croon (1968)
exudate	patient	dark	R	97–417 d	Downie & Dumbell (1947)
exudate	patient	indirect	R (20–24 °C)	\$530 d	MacCallum & McDonald (1957) ←
exudate	patient	indirect	R	\$196 d	Downie & Dumbell (1947)
exudate	patient	dark?	30 °C	60–185 d	MacCallum & McDonald (1957)
glass	vesicle fluid	dark	R	84 d	Downie & Dumbell (1947)
glass	vesicle fluid	indirect	R	35 d	Downie & Dumbell (1947)
<i>Corynebacterium diphtheriae</i>					
exudate	patient	indirect	R	63–150 d	Mitscherlich & Marth (1984)
glass	suspension	indirect	R	<1–175 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949)
dust	floor	indirect	R	<61–112 d	Crosbie & Wright (1941)
dust	floor	dark	R	7–102 d	Engley (1955)
dust	suspension	indirect	R	104–175 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949)
sand	suspension	indirect	R	18–189 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949)
soil	suspension	indirect	R	10–208 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949) ←
fabric	suspension	indirect	R	2–175 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949)
fabric	suspension	indirect	R	8–140 d	Mitscherlich & Marth (1984)
paper	suspension	indirect	R	91–175 d	Laurell <i>et al.</i> (1949); Ouchterlony (1949)
wood	patient	dark	R	180 d	Mitscherlich & Marth (1984)
aerosol	suspension	dark	R (21–27 °C)	2.2 d¶	Wells & Stone (1934)
<i>Mycobacterium tuberculosis</i>					
glass	sputum	dark	R	90–142 d	Smith (1942)
glass	sputum	dark	R	42–309 d	Soparkar (1917); Abe (1949) ←
glass	sputum	indirect	R	6–124 d	Soparkar (1917); Twichell (1905)
glass	suspension	dark	R	41 d	Mitscherlich & Marth (1984)
glass	suspension	indirect	R	1.3 d	Mitscherlich & Marth (1984)
dust	fabric & floor	dark?	R	10–120 d	Mitscherlich & Marth (1984)
sand	sputum	indirect	R	30–123 d	Mitscherlich & Marth (1984)
fabric	sputum	indirect	R	10–75 d	Mitscherlich & Marth (1984)
paper	sputum/ suspension	dark	15–30 °C	14–135 d	Smith (1942); Mitscherlich & Marth (1984)

paper	sputum	indirect	R	1-31 d	Kenwood & Dove (1915); Smith (1942) Mitscherlich & Marth (1984); Twichell (1905)
wood	sputum	indirect	R	70 d	
<i>Streptococcus pneumoniae</i>					
glass?	sputum	dark?	R	6 d	Williams & Kauffman (1978)
glass	suspension	dark	27 °C	1-11 d	Mitscherlich & Marth (1984)
glass	suspension	indirect	27 °C	<1-10 d	Mitscherlich & Marth (1984)
dust	sputum	dark?	15-20 °C	20 d	Mitscherlich & Marth (1984)
dust	pus	dark?	15-20 °C	12 d	Mitscherlich & Marth (1984)
soil	sputum	dark?	15-20 °C	100-140 d	Mitscherlich & Marth (1984)
soil	pus	dark?	15-20 °C	16 d	Mitscherlich & Marth (1984)
fabric	suspension	dark	27 °C	2-15 d	Mitscherlich & Marth (1984)
fabric	suspension	indirect	27 °C	1-10 d	Mitscherlich & Marth (1984)
aerosol	suspension	dark	R (21-27 °C)	1.5 d¶	Wells & Stone (1934)
aerosol	suspension	indirect	33 °C	0.4-0.7 d¶	Dunklin & Puck (1948)
aerosol	suspension	indirect	22 °C	0.03-0.7 d¶	Dunklin & Puck (1948)
aerosol	suspension	indirect	14 °C	0.02-0.4 d¶	Dunklin & Puck (1948)
<i>Influenza virus</i>					
glass	mucin suspension	dark	R	0.13-45 d	Parker <i>et al.</i> (1944)
glass	suspension	dark	R	<0.08-45 d	Parker <i>et al.</i> (1944); Edward (1941)
glass	suspension	dark?	20 °C	0.12-0.25 d¶	Buckland & Tyrrell (1962)
glass	suspension	dark	22 °C	28 d	Edward (1941)
glass	suspension	dark	37 °C	3 d	Edward (1941)
glass	droplet nuclei	dark	R	0.21 d	Edward (1941)
dust	suspension	dark	R	14 d	Edward (1941)
talc	suspension	dark	R	4 d	Parker <i>et al.</i> (1944)
fabric	suspension	dark	R	7-14 d	Edward (1941)

Table 2 (cont.)

Substrate*†	Immediate source	Light†	Temperature‡†	Durability§	References
fabric	droplet nuclei	dark	R	21 d	Edward (1941)
fabric	suspension	dark	22 °C	3–< 7 d	Edward (1941)
fabric	suspension	dark	37 °C	<1 d	Edward (1941)
fabric	suspension	indirect	R	1 d	Edward (1941)
skin	suspension	indirect	R	0.03 d	Parker & MacNeal (1944)
aerosol	suspension	dark	32 °C	0.15–2.1 d¶	Harper (1961, 1963)
aerosol	suspension	dark	R	0.02 d	Wells & Brown (1936)
aerosol	suspension	dark?	R	0.03–0.51 d¶	DeJong & Winkler (1964); Schaffer <i>et al.</i> 1976)
aerosol	suspension	dark	21–24 °C	0.54–8.3 d¶	Harper (1961, 1963)
aerosol	suspension	dark	10 °C	2.1–5.6 d¶	Harper (1963)
aerosol	suspension	dark	7–8 °C	2.4–24 d¶	Harper (1961)
<i>Bordetella pertussis</i>					
glass	suspension	indirect?	R	<0.04h–5 d	Ocklitz & Milleck (1967)
plastic	suspension	indirect?	R	3–5 d	Ocklitz & Milleck (1967)
rubber	suspension	indirect?	R	<0.04–0.2 d	Ocklitz & Milleck (1967)
fabric	suspension	dark	17–20 °C	6 d	Ocklitz & Milleck (1967)
fabric	suspension	indirect?	R	<0.04–4 d	Ocklitz & Milleck (1967)
paper	suspension	dark	17–20 °C	2 d	Ocklitz & Milleck (1967)
paper	suspension	indirect?	R	0.2–1 d	Ocklitz & Milleck (1967)
skin	suspension	indirect?	R	<.04–0.25 d	Ocklitz & Milleck (1967)
aerosol	suspension	dark	17–20 °C	0.83 d	Ocklitz & Milleck (1967)
Rubeola virus					
aerosol	suspension	dark?	R	0.05–0.8¶	DeJong & Winkler (1964)
<i>Neisseria meningitidis</i>					
glass	suspension	dark	R	<1 d	Flügge (1906)
glass	suspension	indirect	R	<0.42 d	Flügge (1906)
fabric	patient	indirect	7–11 °C	0.17–0.29 d	Downie & Aberd (1940)
fabric	patient	indirect	17–18 °C	0.29 d	Downie & Aberd (1940)
fabric	suspension	dark	20–25 °C	0.13 d	Mitscherlich & Marth (1984)
fabric	suspension	indirect	R	0.29–1.25 d	Mitscherlich & Marth (1984); Flügge (1906)

Parainfluenza virus

glass	suspension	dark?	20 °C	0.5–0.7 d¶	Buckland & Tyrrell (1962)
glass	suspension	dark?	R	4.3–6.7 d¶	Parkinson <i>et al.</i> (1983)
plastic	suspension	indirect	R	0.02 d	Brady <i>et al.</i> (1990)
steel	suspension	indirect	R	0.08 d	Brady <i>et al.</i> (1990)
fabric	suspension	indirect	R	0.25 d¶	Brady <i>et al.</i> (1990)
paper	suspension	indirect	R	0.08 d	Brady <i>et al.</i> (1990)
skin	mucin suspension	indirect	R	0.04 d	Ansari <i>et al.</i> (1991)
skin	suspension	indirect	R	0.04 d¶	Brady <i>et al.</i> (1990)
aerosol	suspension	dark?	24 °C	0.12–1.7 d¶	Miller & Artenstein (1967)

Mycoplasma pneumoniae

aerosol	suspension	dark	38 °C	0.11–0.44 d¶	Wright <i>et al.</i> (1969)
aerosol	suspension	dark	27 °C	0.17–2.1 d¶	Wright <i>et al.</i> (1968)
aerosol	suspension	dark	15 °C	2.8–4.2 d¶	Wright <i>et al.</i> (1969)
aerosol	suspension	dark	10 °C	1.7–3.3 d¶	Wright <i>et al.</i> (1969)

Respiratory syncytial virus

plastic	suspension	dark?	R	1–3 d	Kingston (1968)
plastic	suspension	dark?	R	2.1–2.8 d¶	Kingston (1968)
plastic	nasal secretion	indirect	22–25 °C	0.25–0.29 d	Hall <i>et al.</i> (1980)
rubber	nasal secretion	indirect	22–25 °C	0.04–0.17 d	Hall <i>et al.</i> (1980)
fabric	nasal secretion	indirect	22–25 °C	0.02–0.08 d	Hall <i>et al.</i> (1980)
paper	nasal secretion	indirect	22–25 °C	0.02 d	Hall <i>et al.</i> (1980)
skin	nasal secretion	indirect	22–25 °C	0.01–0.02 d	Hall <i>et al.</i> (1980)
aerosol	suspension	dark?	20.5 °C	0.08–0.3 d¶	Rechsteiner & Winkler (1969)

rugge (1900)

Table 2 (cont.)

Substrate*†	Immediate source	Light†	Temperature‡†	Durability§	References
plastic	mucus suspension	indirect	23 °C	0.06–1 d	Hendley <i>et al.</i> (1973)
plastic	suspension	indirect	23 °C	0.13–2.5 d	Reed (1975); Hendley <i>et al.</i> (1973)
steel	suspension	indirect	23 °C	0.04–3 d	Reed (1975); Hendley <i>et al.</i> (1973)
glass	suspension	dark?	20 °C	0.5–2.1 d¶	Buckland & Tyrrell (1962)
fabric	suspension	indirect	23 °C	0.04–1 d	Reed (1975); Hendley <i>et al.</i> (1973)
paper	suspension	indirect	23 °C	0.04 d	Reed (1975); Hendley <i>et al.</i> (1973)
wood	suspension	indirect	23 °C	0.04–0.13 d	Hendley <i>et al.</i> (1973)
skin	suspension	indirect	23 °C	0.04–0.13 d	Reed (1975); Hendley <i>et al.</i> (1973)
aerosol	suspension	dark?	19–21 °C	0.02–7.6 d¶	Karim <i>et al.</i> (1985)
<i>Haemophilus influenzae</i>					
glass	suspension	indirect	R	0.29 d	Mitscherlich & Marth (1984)
sputum	patient	?	R?	2 d	Burrows (1968)
fabric	suspension	?	R?	<1 d	Burrows (1968)
fabric	patient	indirect?	R?	0.25 d	Mitscherlich & Marth (1984)
wood	suspension	indirect	R	0.08 d	Mitscherlich & Marth (1984)
aerosol	suspension	dark	R (21–27 °C)	0.03 d¶	Wells & Stone (1934)

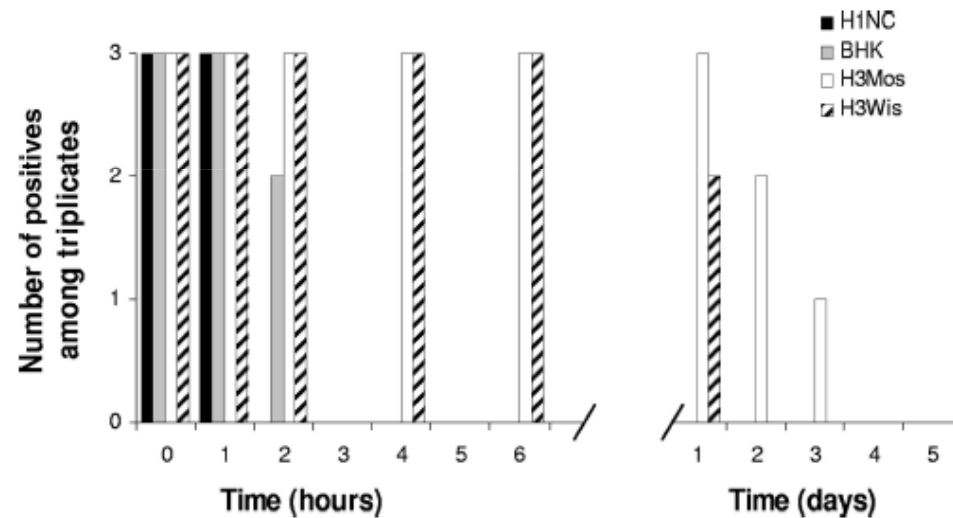
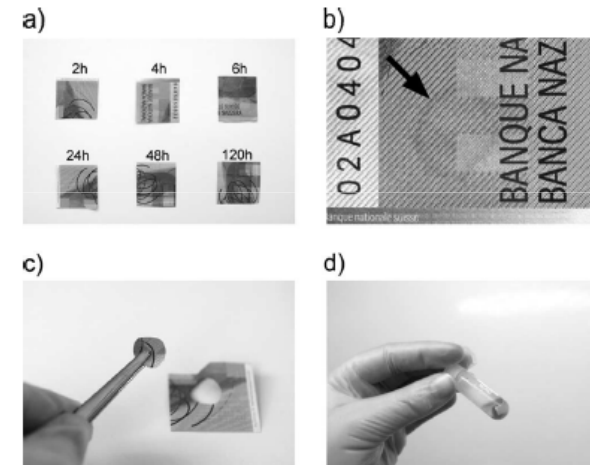
APPLIED AND ENVIRONMENTAL MICROBIOLOGY, May 2008, p. 3002–3007
 0099-2240/08/\$08.00+0 doi:10.1128/AEM.00076-08
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Vol. 74, No. 10

Survival of Influenza Virus on Banknotes[∇]

Yves Thomas,^{1,2*} Guido Vogel,³ Werner Wunderli,^{1,2} Patricia Suter,² Mark Witschi,⁴ Daniel Koch,⁴
 Caroline Tapparel,¹ and Laurent Kaiser^{1,2}

*Central Laboratory of Virology, Division of Infectious Diseases, University Hospitals of Geneva, Geneva, Switzerland¹;
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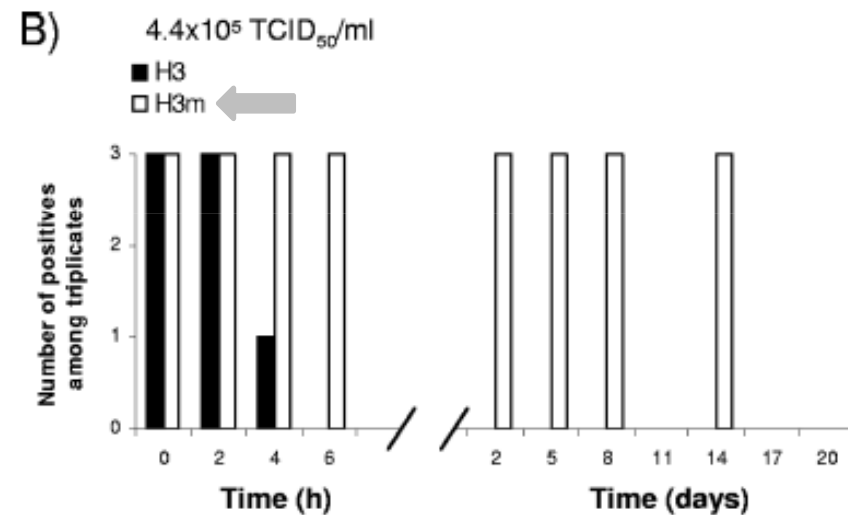
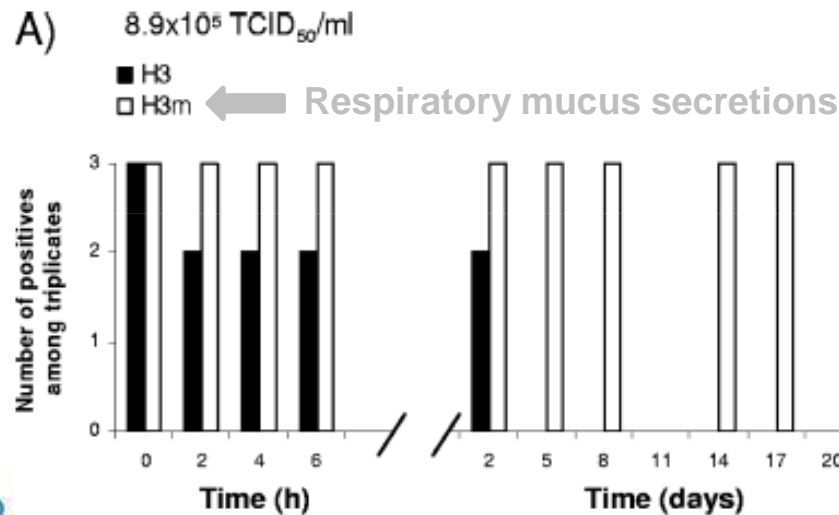
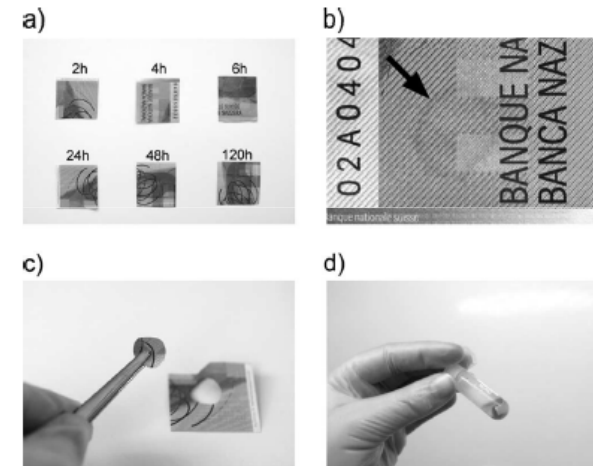
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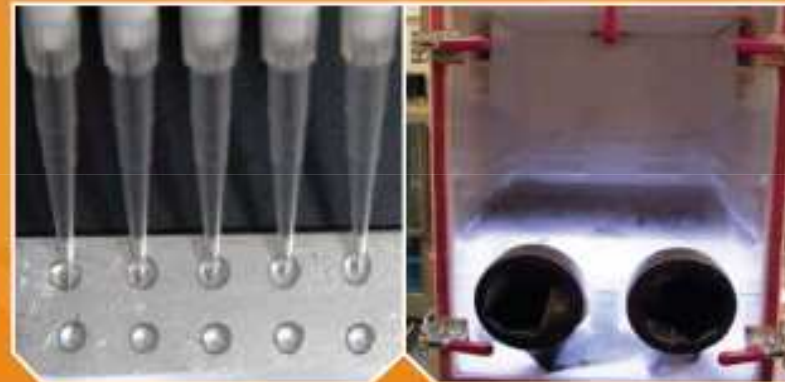




EPA 600/R-09/054 | October 2009 | www.epa.gov/ord

Highly Pathogenic Avian Influenza H5N1 Virus Persistence Testing and Evaluation of Liquid Decontamination Technologies

INVESTIGATION AND TECHNOLOGY EVALUATION REPORT

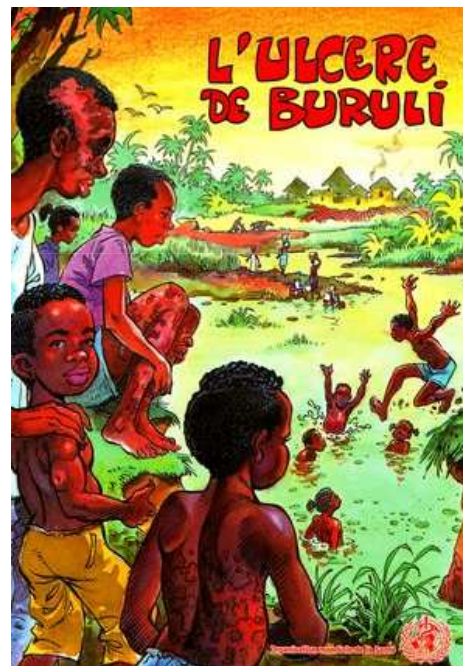


Office of Research and Development
National Homeland Security Research Center

Plan de la présentation

- ✓ Quelques éléments de définition
- ✓ Compréhension actuelle de la transmission de virus de grippe aviaire faiblement pathogènes
- ✓ Persistance dans l'environnement de micro-organismes et traits associés
- ✓ **Transmission infectieuse et réseaux écologiques**
- ✓ Quelques éléments de discussion

Transmission dans les réseaux écologiques de l'agent responsable de l'ulcère de Buruli, *Mycobacterium ulcerans*,



Une transmission vectorielle très possible mais pas unique !

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Sept. 2002, p. 4623-4628
0099-2240/02/\$04.00+0 DOI: 10.1128/AEM.68.9.4623-4628.2002
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Vol. 68, No. 9

Aquatic Insects as a Vector for *Mycobacterium ulcerans*

Laurent Marsollier,¹ Raymond Robert,² Jacques Aubry,³ Jean-Paul Saint André,⁴
Henri Kouakou,⁵ Pierre Legras,¹ Anne-Lise Manceau,¹ Chetaou Mahaza,¹
and Bernard Carbonnelle^{1*}

Laboratoire de Bactériologie-Virologie-Hygiène¹ and Laboratoire d'Anatomie, Pathologique,⁴ CHU,
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U.463, Institut de Biologie & Faculté de Pharmacie, 44035 Nantes,³ France, and
Laboratoire de Bactériologie, Institut Raoul Follereau, Adzopé, Ivory Coast⁵

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Perspectives

Aquatic Insects and *Mycobacterium ulcerans*: An Association Relevant to Buruli Ulcer Control?

Manuel T. Silva^{*}, Françoise Portaels, Jorge Pedrosa

PLOS Medicine | www.plosmedicine.org

0229

February 2007 | Volume 4 | Issue 2 | e63



Une transmission vectorielle très possible mais pas unique !



A potential mode of transmission of *M. ulcerans*.

M. ulcerans may form a biofilm on aquatic plants ingested by phytophagous prey of water bugs. The water bug may then transmit the bacteria to humans by biting.



Les rencontres scientifiques de l'Anses

Restitution du programme national de recherche environnement santé travail

Echantillonnage de 30 écosystèmes aquatiques au Ghana, et prélèvements de 70 taxa différents

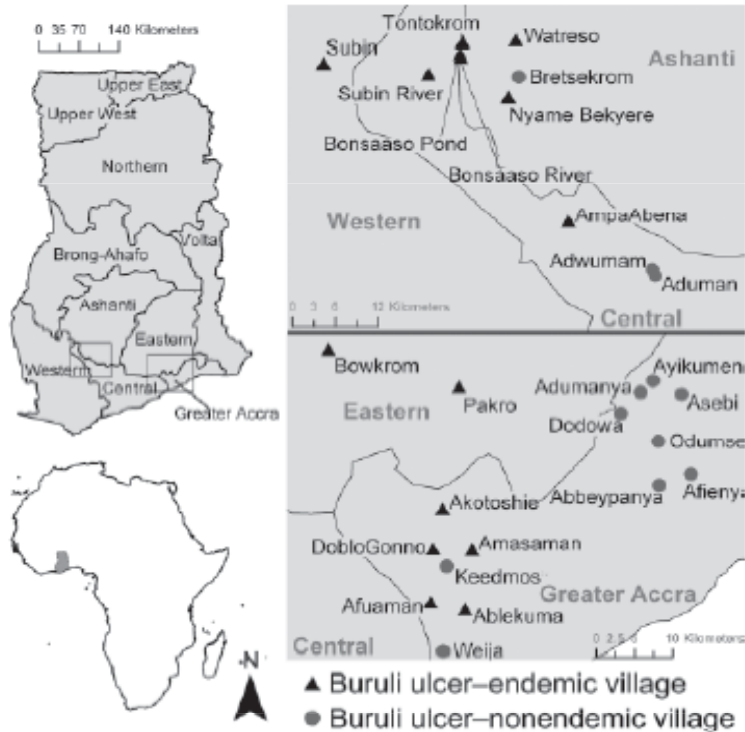
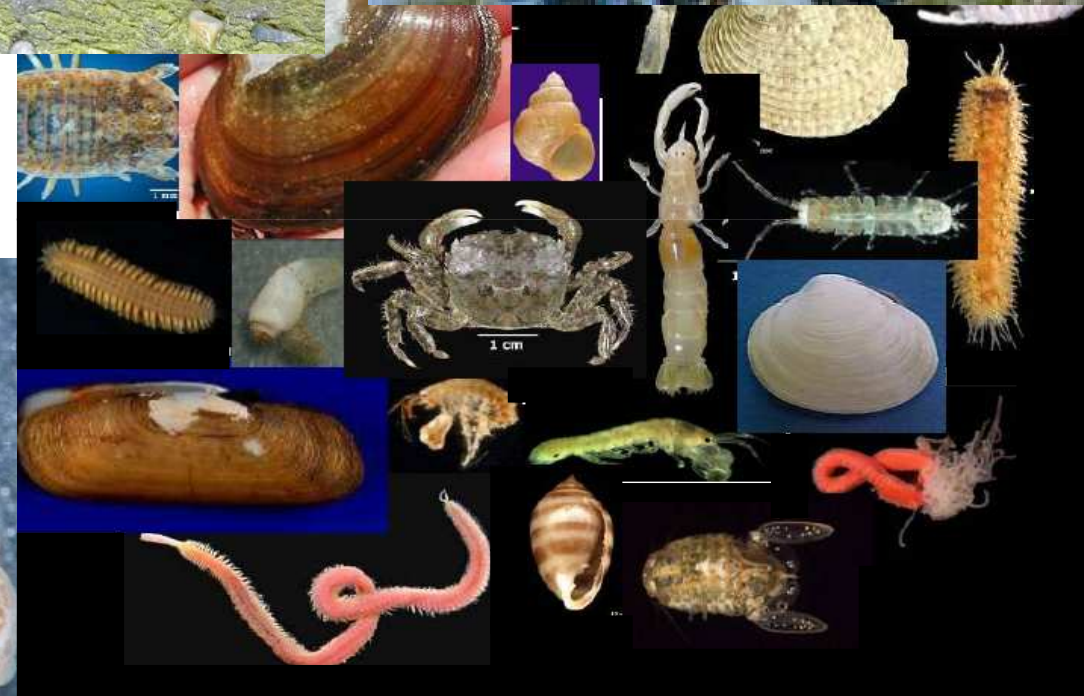


Figure 1. Regional site map of water bodies sampled in Ghana for aquatic invertebrates during 2004, 2005, or both. Small maps on left show location of Ghana in Africa and location of regions sampled within Ghana (boxes).



Quelle place pour les parasites et autres agents pathogènes dans les écosystèmes ?

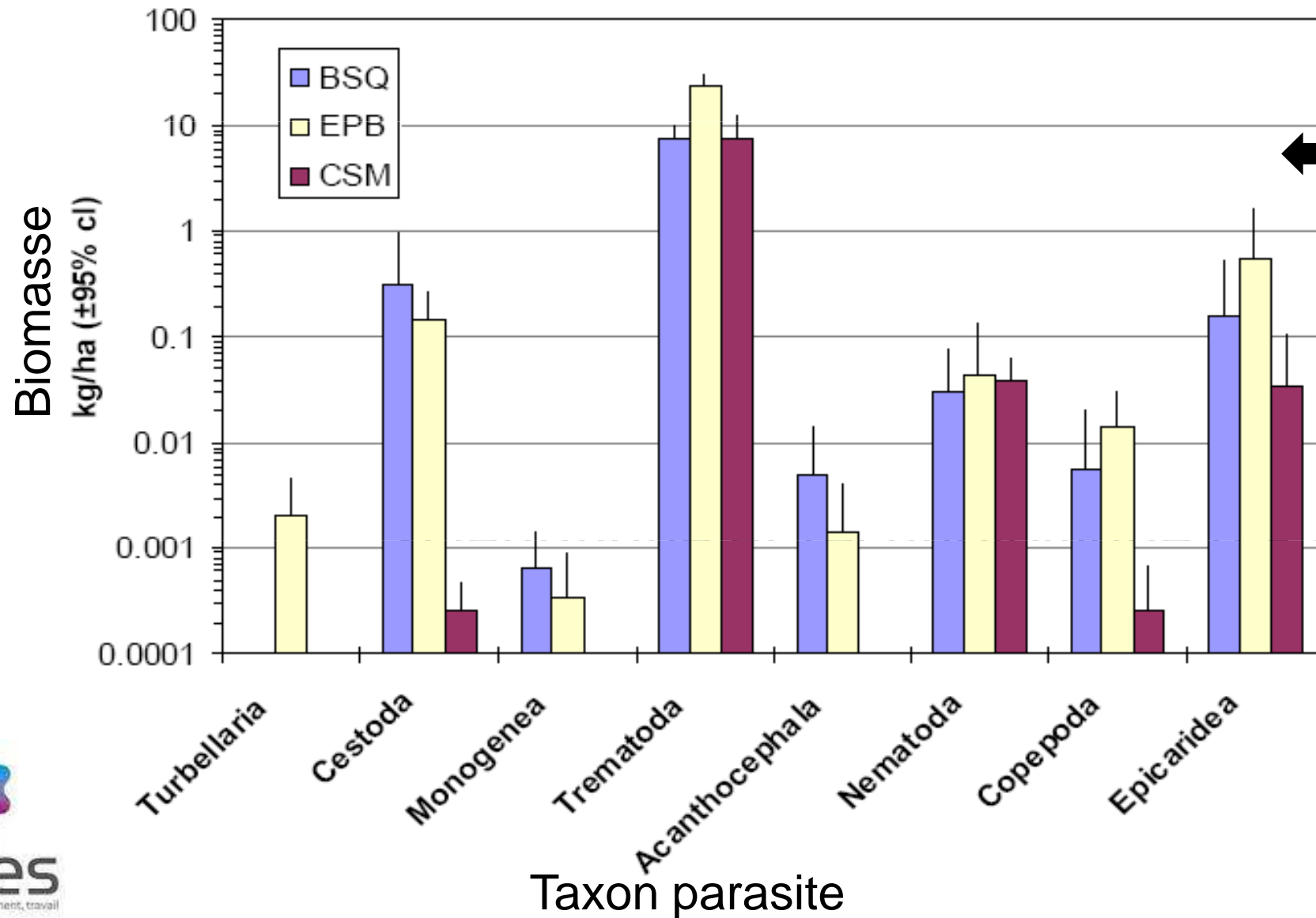


Les rencontres scientifiques de l'Anses

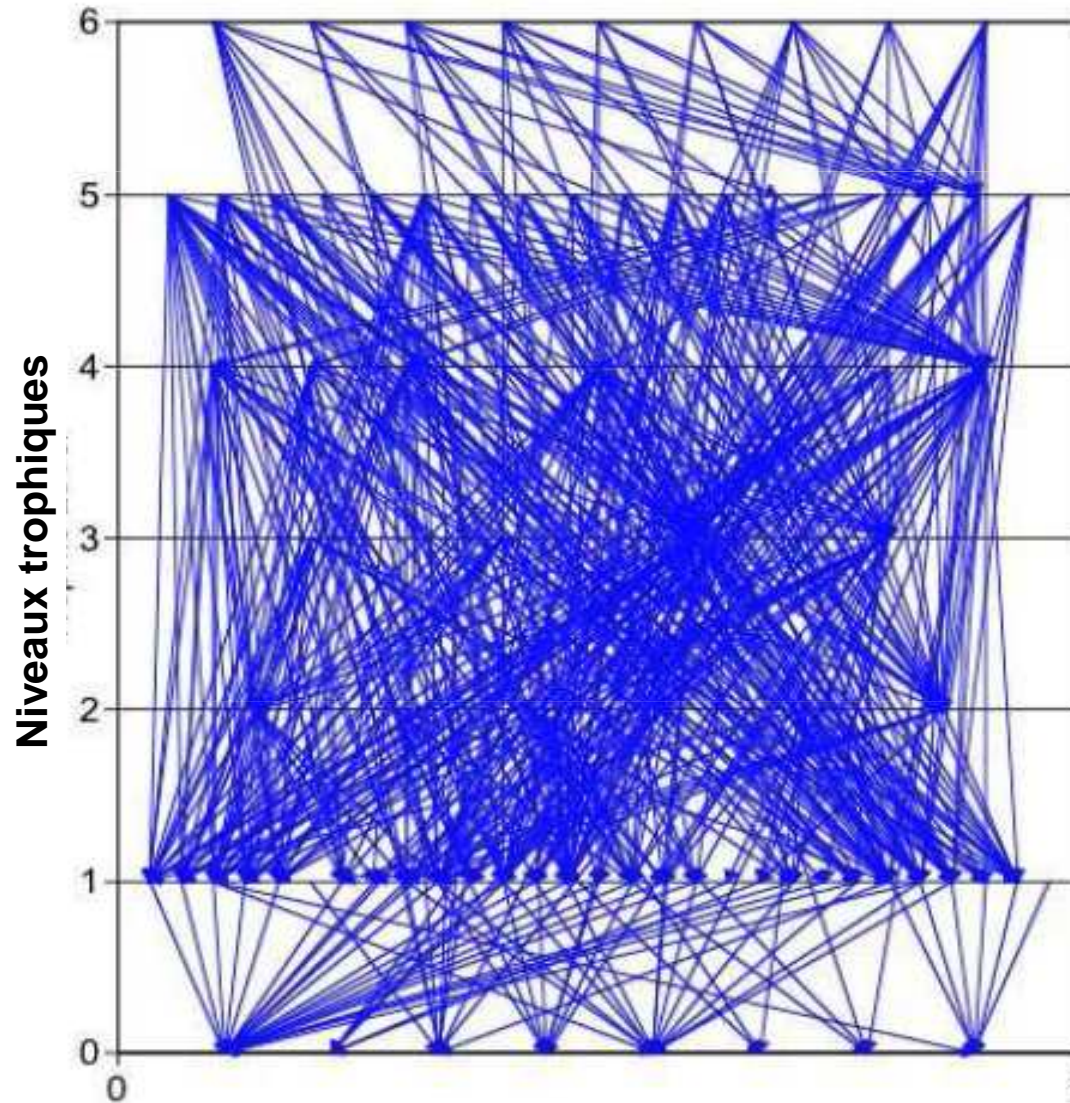
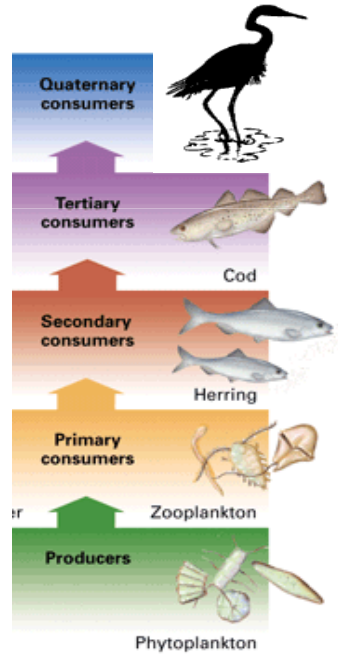
Restitution du programme national de recherche environnement santé travail



La biomasse en parasites est égale voire supérieure à celle des vertébrés !



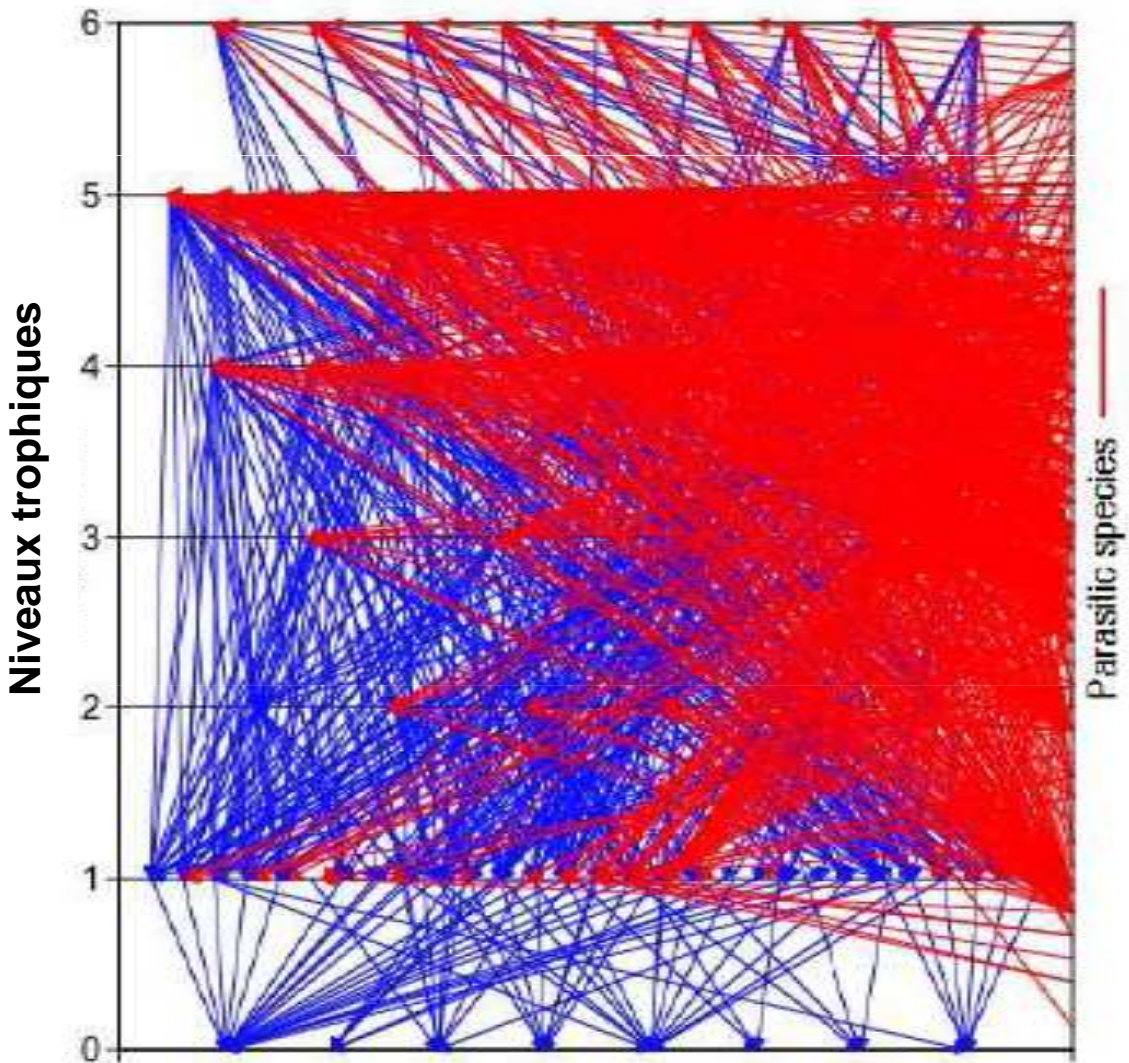
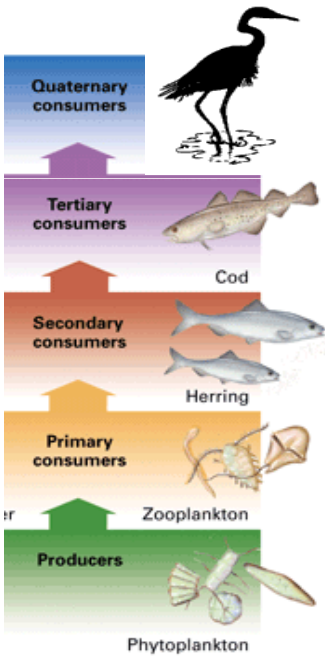
Organisation des liens trophiques, ou « qui mange qui ? » dans le marais de Carpinteria



Lafferty *et al.* (2006). *PNAS*

En considérant uniquement les espèces « libres »

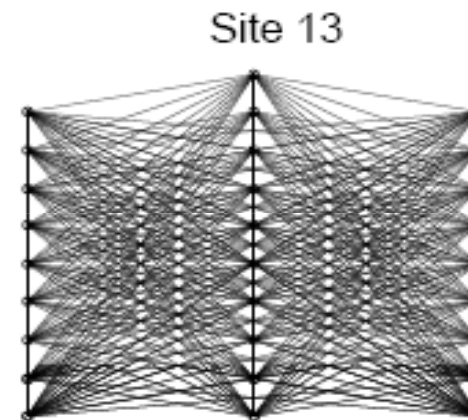
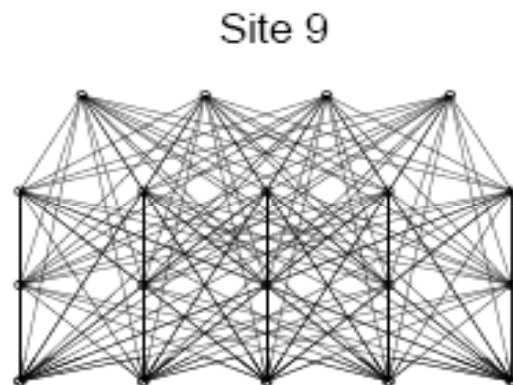
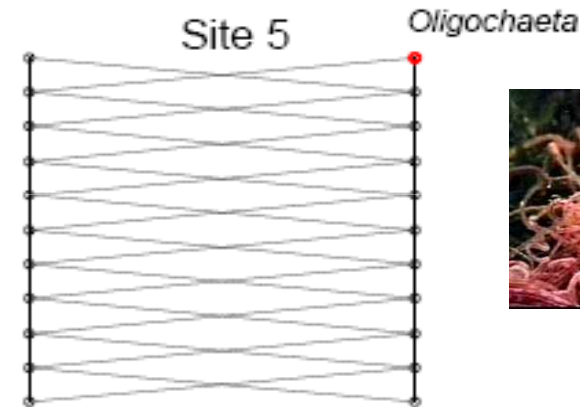
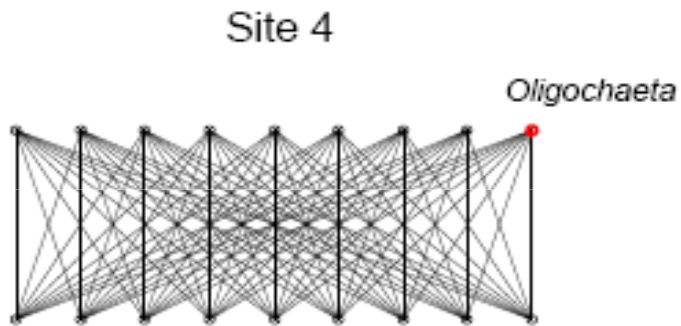
Organisation des liens trophiques, ou « qui mange qui ? » dans le marais de Carpinteria



Avec les formes parasites

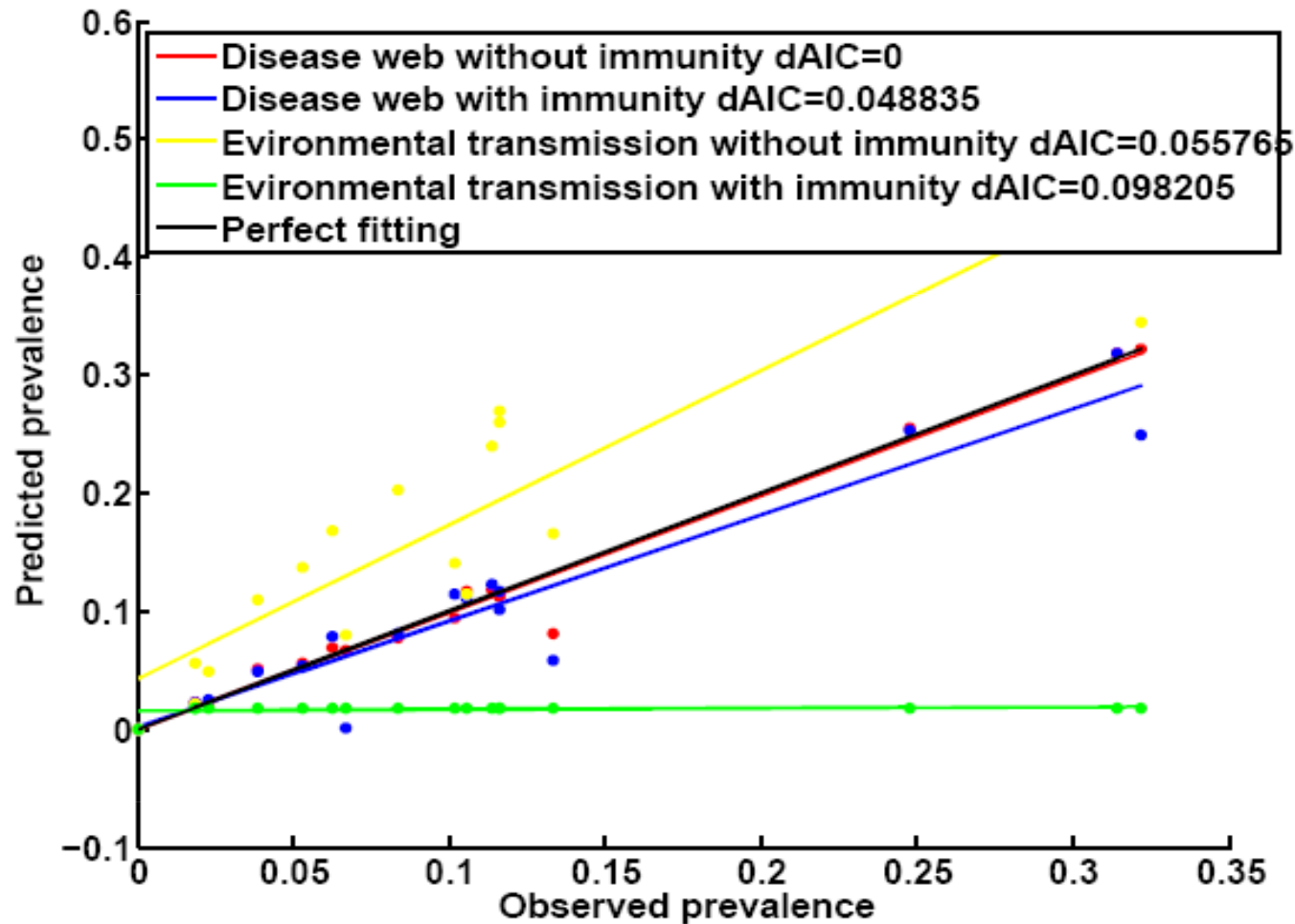
A collection of scientific illustrations of parasites, including a long, thin, segmented worm; a shorter, wider, segmented worm; a spherical organism with a textured surface; two oval-shaped organisms with internal structures; and a cluster of five small, dark, circular organisms.

Quelques illustrations pour représenter des systèmes trophiques plus ou moins complexes



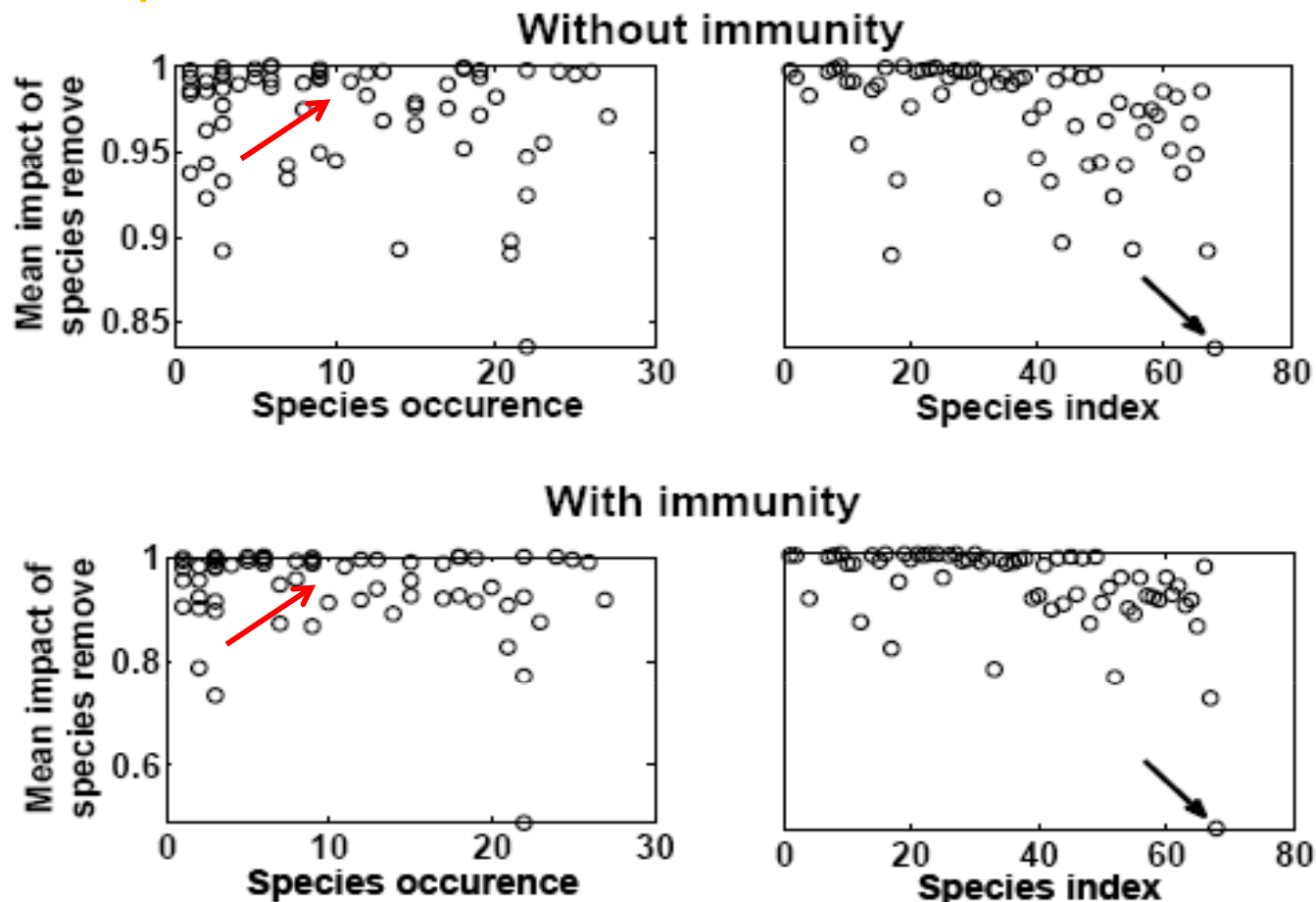
The red circles show the taxon *Oligochaeta*. The sites have been selected to represent different shapes of disease webs. The intra-taxon transmission is not shown here





The environmental transmission model clearly does not exhibit the highest fit to the observations. Indeed, the environmental transmission model without immunity tends to over-estimate the predicted values (yellow line), and the one with immunity is wrong (green line). The ecological interactions transmission model shows an almost perfect fitting (correlation coefficient : $r=0.9975$ with $p\text{-value}<0.00001$ for the model with immunity, and $r=0.9761$ with $p\text{-value}$ for the model without immunity). The colored lines represent the linear regression between observed and predicted transmission prevalence means for the different hypothesis tested in the present work. The black line represents the perfect fitting

Relationships between stability of *M. ulcerans* transmission and host taxon occurrence (left) and index (right) across aquatic communities

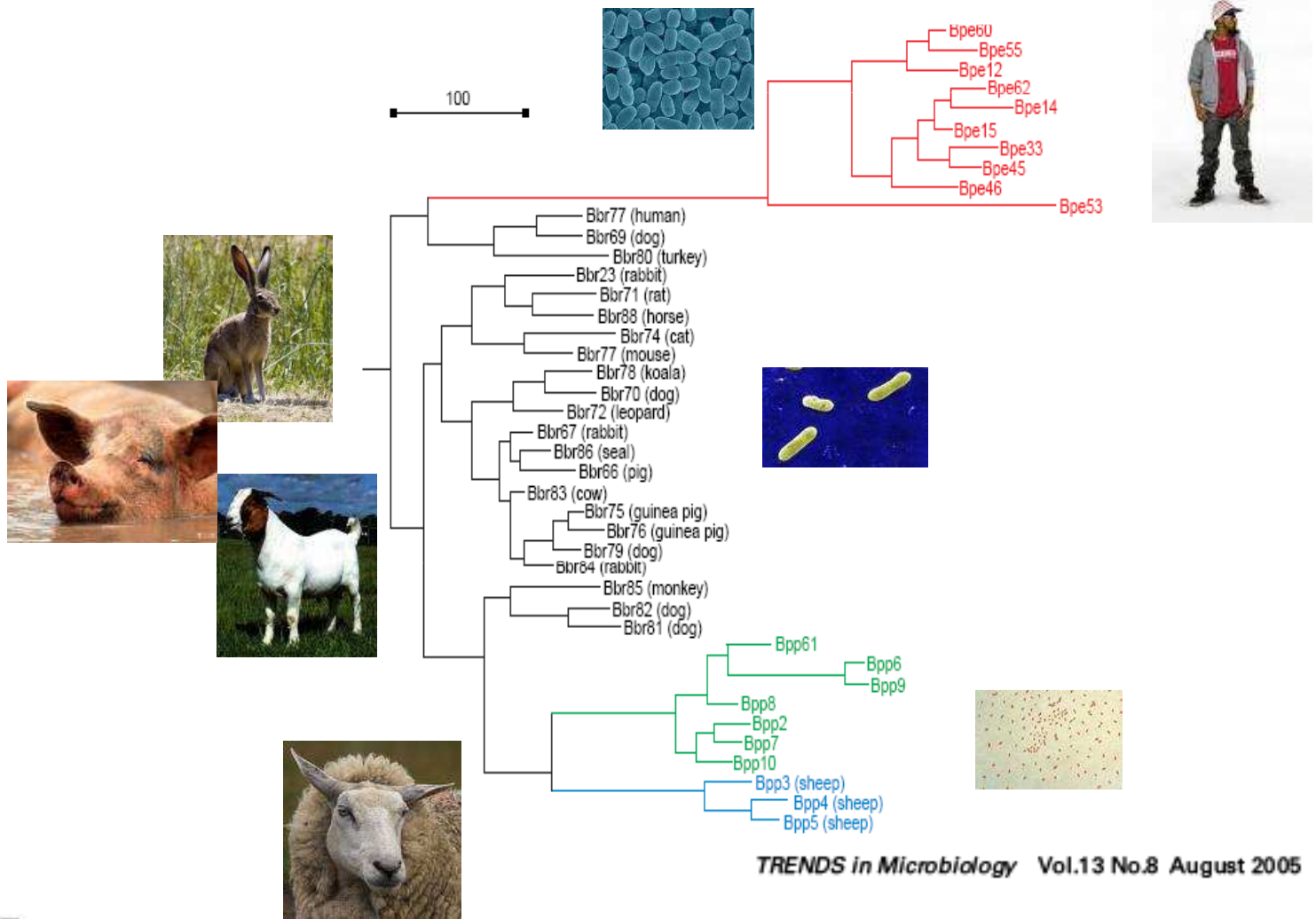


(Left panels). The mean impact of taxon removal indicates the decrease of disease prevalence across different communities (a value of 1 means no change whereas a value of 0.5 indicates a decrease of 50% of disease prevalence across all communities). (Right panels) Relationships between stability of *M. ulcerans* transmission and host taxon index across aquatic communities, in which the taxon index represents a specific number for each taxon.

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- ✓ **Quelques éléments de discussion**

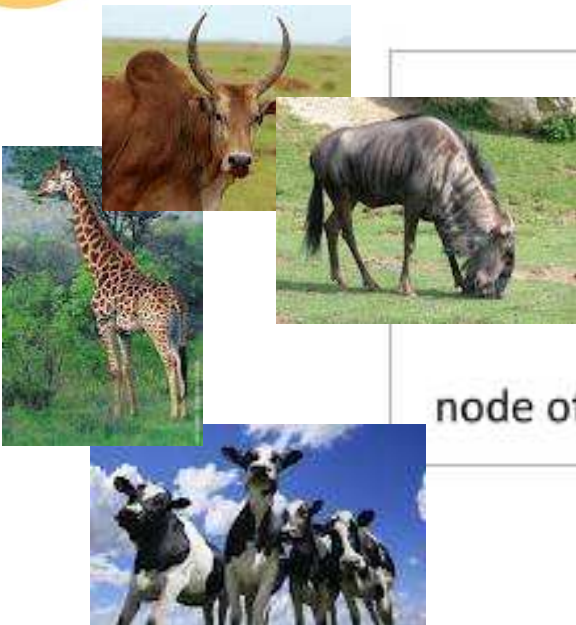
La transmission infectieuse d'un ou de plusieurs animaux réservoirs à l'humain peut être plus récente que prétendue



TRENDS in Microbiology Vol.13 No.8 August 2005

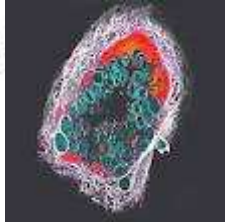
Les rencontres scientifiques de l'Anses

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peste des petits ruminants virus

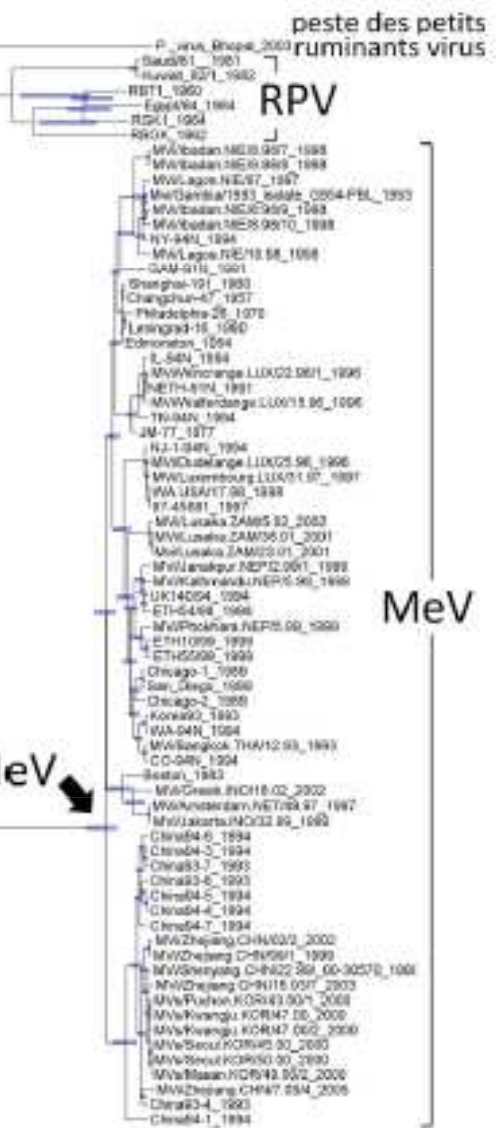
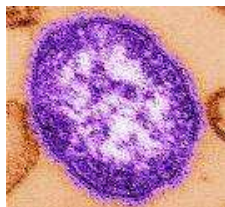
RPV



node of MeV and RPV

node of current MeV

MeV



400 600 800 1000 1200 1400 1600 1800 2000

Furuse et al. *Virology Journal* 2010, 7:52
<http://www.virologyj.com/content/7/1/52>

Figure 1 Bayesian estimates of divergence time. Maximum a posteriori (MAP) tree of the N gene. Tip times reflect the year of sampling. Internal nodes have error bars of 95% credible intervals on their date.

Quelques éléments de conclusion

- ✓ En croisant les dynamiques d'espèces d'oiseaux (dont migratrices) avec les dynamiques de virus LPAI en Camargue, l'hypothèse d'une capacité importante de ce type de virus à persister dans l'eau plusieurs semaines/mois est hautement probable
- ✓ Des associations entre traits d'histoire de vie, *e.g.* virulence versus persistance à devoir mieux être connues
- ✓ De multiples routes de transmission possibles lorsqu'une seule est acceptée exister ou prévaloir

Quelques éléments de conclusion

- ✓ Des infections polyspécifiques ou des environnements plus ou moins riches en micro-organismes dont il faut aujourd'hui mieux tenir compte
- ✓ Des acceptations fausses ou des dogmes trop marqués qu'il nous faut sérieusement reconsidérer
- ✓ L'apport de la modélisation mathématique et des tests de scénarii au service de la santé/santé publique/santé environnementale afin d'écartier des hypothèses peu probables

Quelques références bibliographiques

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- Contribution de l'UMR MIVEGEC
- IRD – CNRS – Universités de Montpellier 1 et 2



Introduction à l'épidémiologie intégrative des maladies infectieuses et parasitaires

Jean-François Guégan , Marc Choisy

Broché

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