OneBAT Training on Bat Sanitary Surveillance

20-21 May 2026 | Padova (Italy)

Lyssaviruses in Europe

Emmanuelle Robardet (ANSES)

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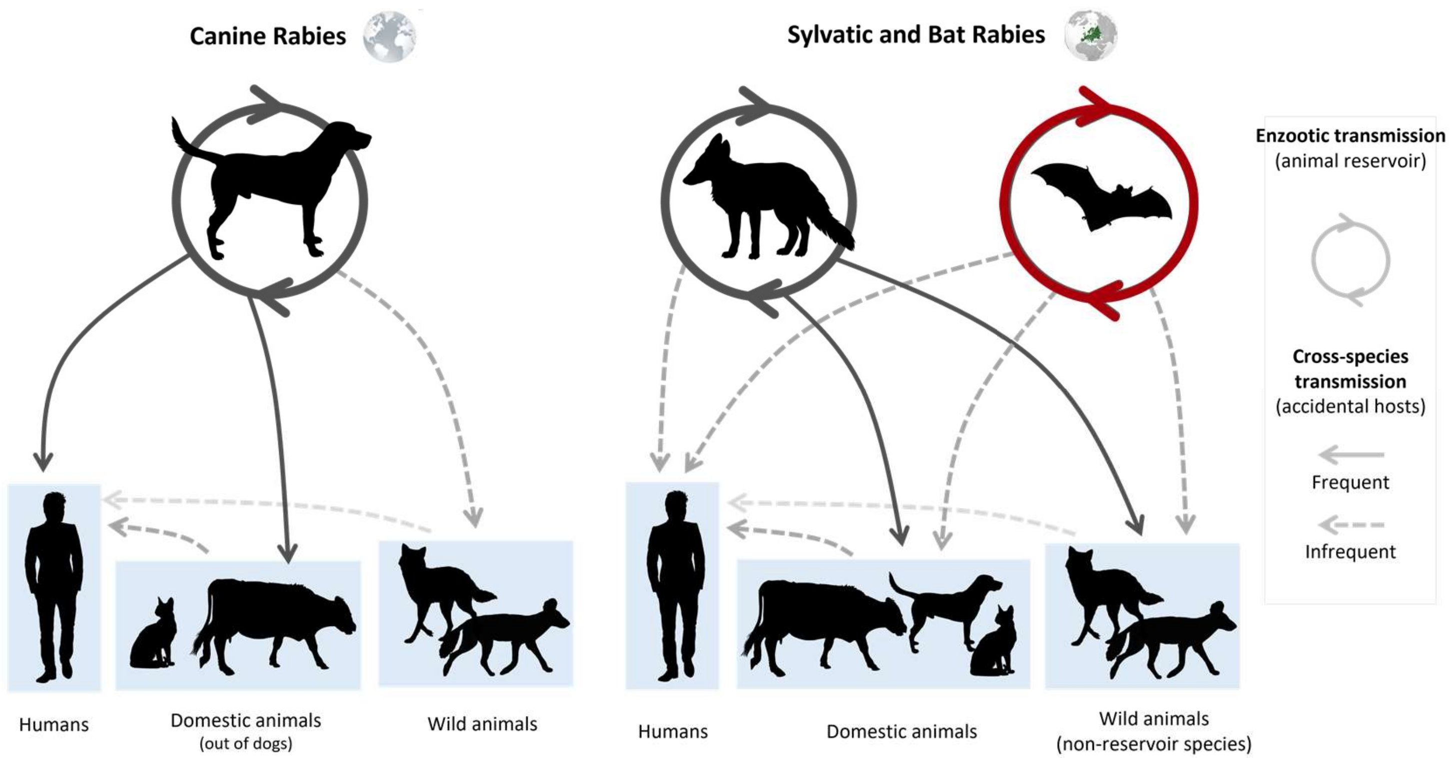
Rabies epidemiological cycles



Adapted from Crozet, 2021

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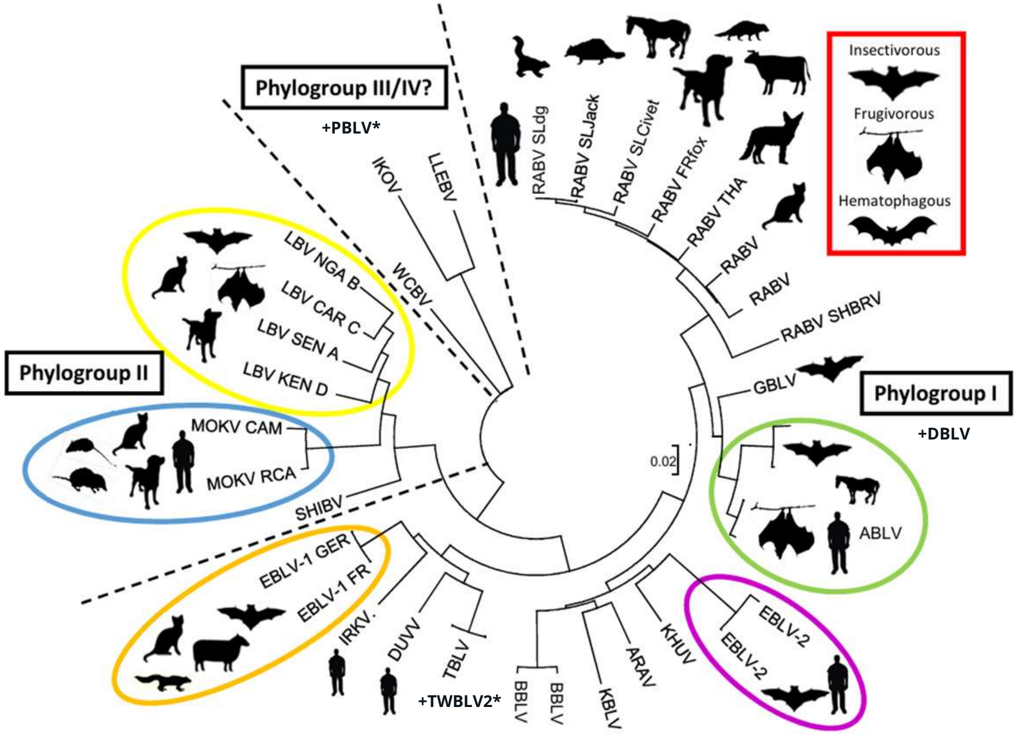
Diversity of Lyssaviruses



Shipley et al., 2019
Updated with ICTV, 2026

- RNA viruses belonging to Rhabdodviridea family.
- High viral diversity (19 species) + 2 not yet recognised*.
- Most have bats as their natural reservoirs.
- Current vaccines are primarily based on classical rabies virus and provide strong protection against lyssaviruses that are antigenically closely related.
- Some bat-associated lyssaviruses show significant genetic and antigenic divergence that may result in uncertain cross-protection.

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Lyssavirus bat species detected in Europe

Myotis daubentonii

Eptesicus serotinus

Myotis nattereri

Miniopterus schreibersii

Myotis capaccinii

Myotis brandtii

Miniopterus schreibersii

Pictures source https://www.sfepm.org/presentation-des-chauves-souris.html

1985

EBLV-2: European Bat Lyssavirus type 2
Daubenton's bat *(Myotis daubentonii)* isolated in 1985 (Swiss bat biologist infected in Finland)

1992

EBLV-1: European Bat Lyssavirus type 1
Serotine bat *(Eptesicus serotinus)* sequenced in 1992 (cases dated from 1989 in France)

2009

BBLV: Bokeloh bat lyssavirus
Natterer's bat (*Myotis nattereri*) collected in Germany (2009) and France (2012)

2011

LLEBV: Lleida bat lyssavirus
Common bent-winged bat *(Miniopterus schreibersii)* collected in Spain (2011) and in France (2017)

2012

2014

DBLV: Divača bat lyssavirus
Long-fingered bat *(Myotis capaccinii)* collected in 2014 in Slovenia (Cerne et al., 2019)

2017

KBLV: Kotalahti bat lyssavirus
Brandt's bat (*Myotis brandtii*) collected in Finland in 2017
(Nokireki et al., 2018)

2020

WCBV: West Causasian bat lyssavirus
Common bent-winged bat *(Miniopterus schreibersii)*
Antibodies in bats, virus **isolated in a cat (2020)**
in Italy (Leopardi et al., 2021)

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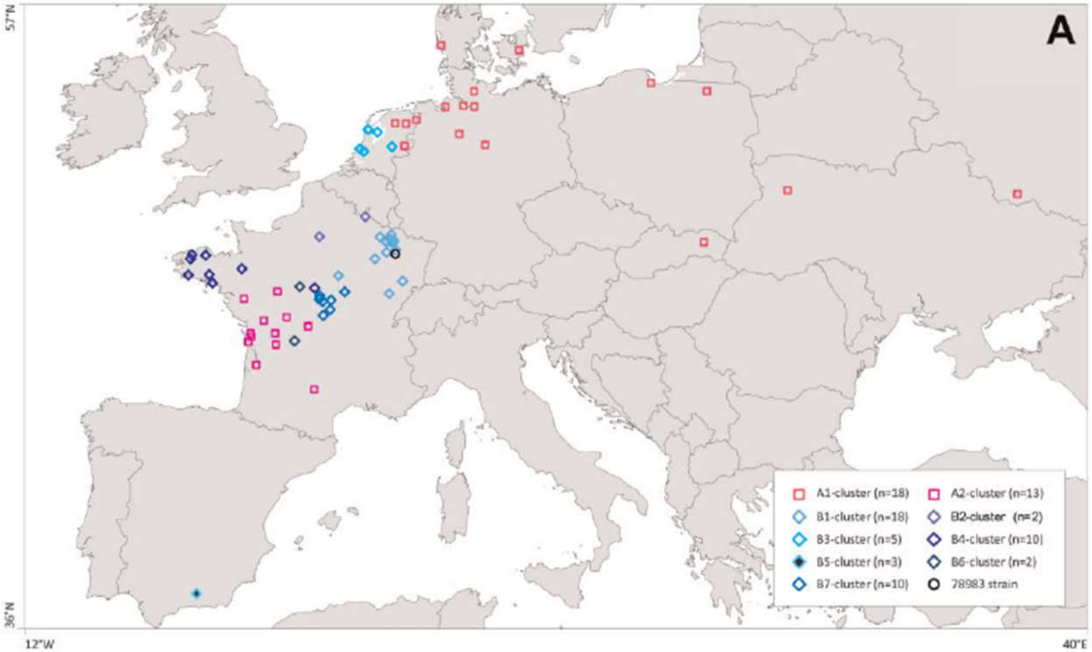
Lyssavirus hambourg - European Bat Lyssavirus 1 (EBLV-1)

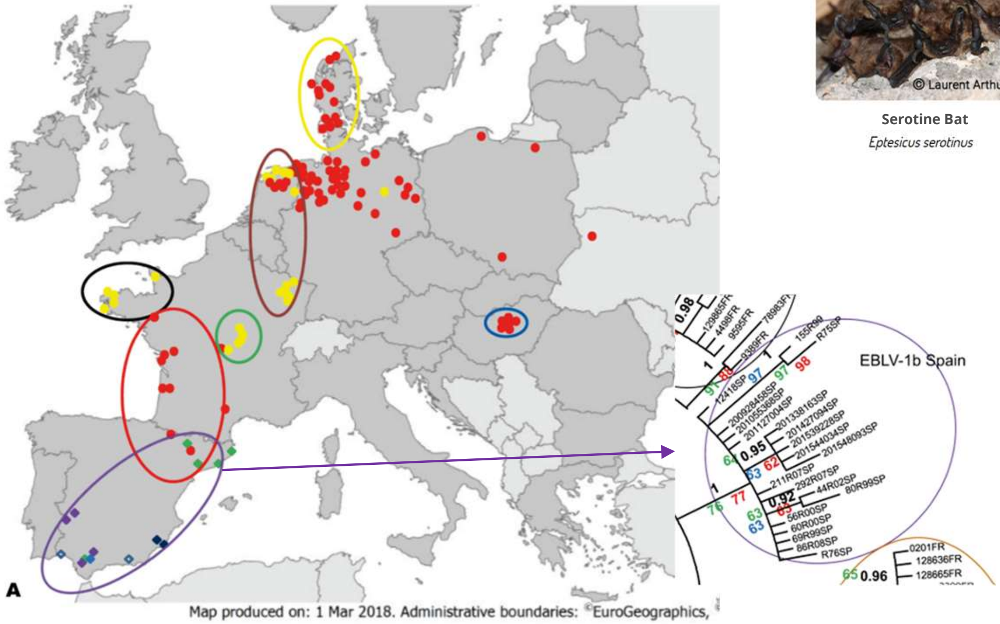
- Anthropophilic ecology
- Low migratory behaviour
- Strong roost fidelity

Serotine Bat
Eptesicus serotinus



Troupin et al., 2017

EBLV-1a EBLV-1b



Mingo-Casa et al., 2018

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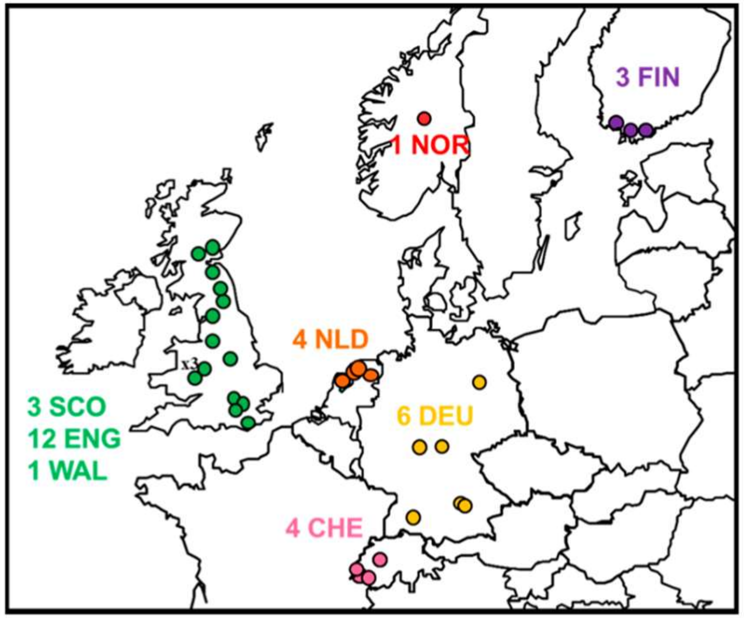
Lyssavirus helsinki - European Bat Lyssavirus 2 (EBLV-2)

- Specialized aquatic foraging ecology
- Moderate seasonal movements
- Strong roost fidelity

Daubenton's bat
Myotis daubentonii

Figure 1. Distribution of 34 confirmed cases of EBLV-2 (**Table 1**) in Europe between 1985 and 2017 (WHO Rabies Bulletin Europe).



McElhinney et al., 2018

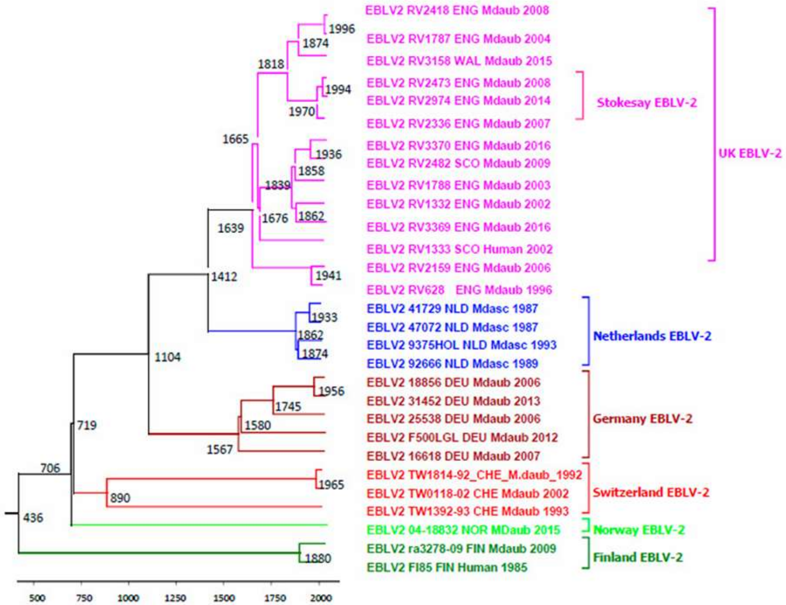


Figure 3. Bayesian maximum clade credibility (MCC) tree of 29 EBLV-2 concatenated gene sequences (10818 nucleotide sites comprising the nucleoprotein, matrix, phosphoprotein, glycoprotein, and polymerase genes) with branch lengths scaled in time by enforcing a relaxed molecular clock. The EBLV-2 strains are coloured to indicate the location of sampling. Mean substitution rate of the dataset was 1.7×10^{-5}.

McElhinney et al., 2018

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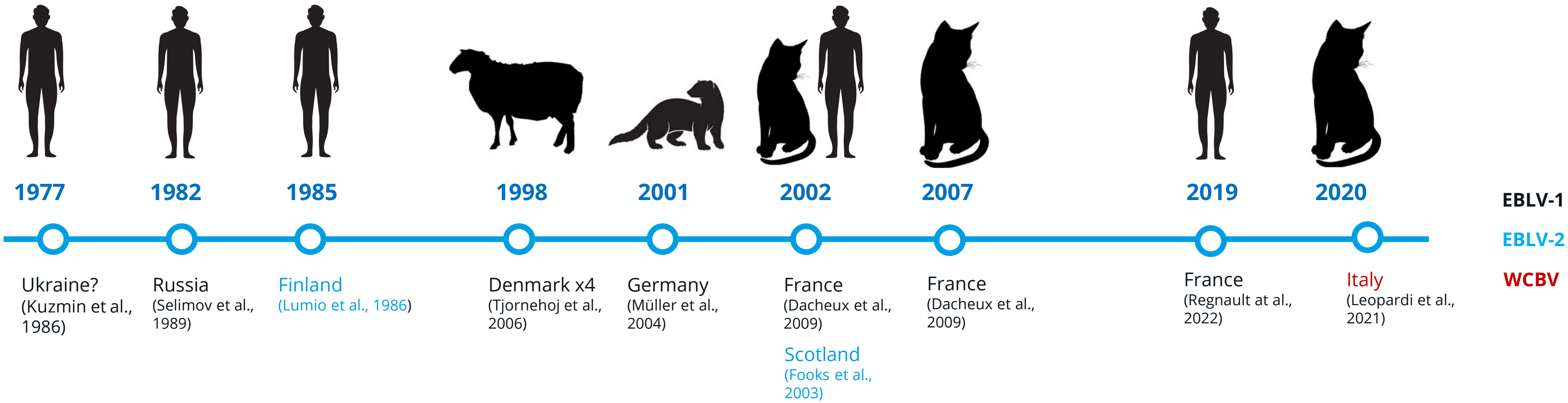
Cross species transmission (CST) & Spillovers (out of bat species)

"Zoonotic spillover requires several factors to align, including the ecological, epidemiological and behavioural determinants of pathogen exposure, and the within-human factors that affect susceptibility to infection."
Plowright, 2017

► **Encounter filter** (ecology-behavior) and **compatibility filter** (metabolism, immunology) (C. Combes, 2001)



No lyssavirus sustained transmission outside bats ever detected

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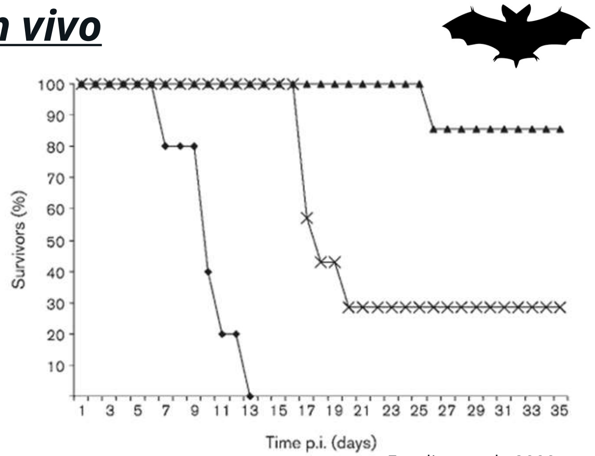
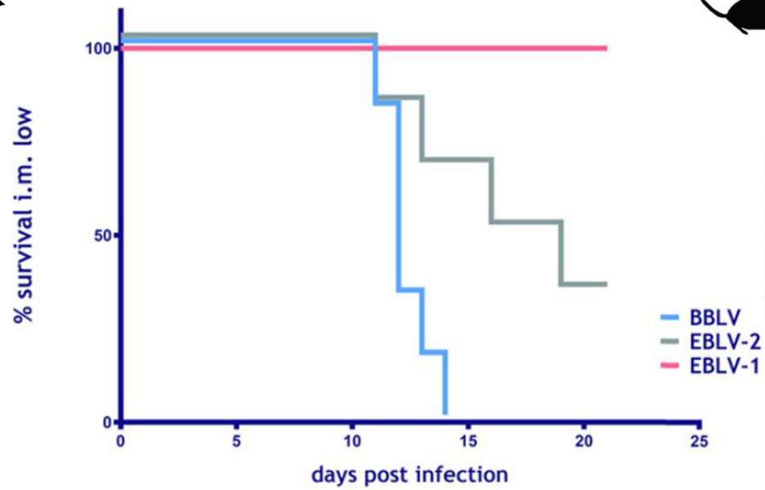
Experimental studies and infection/pathogenicity understanding (EBLV-1 and others)

In vivo

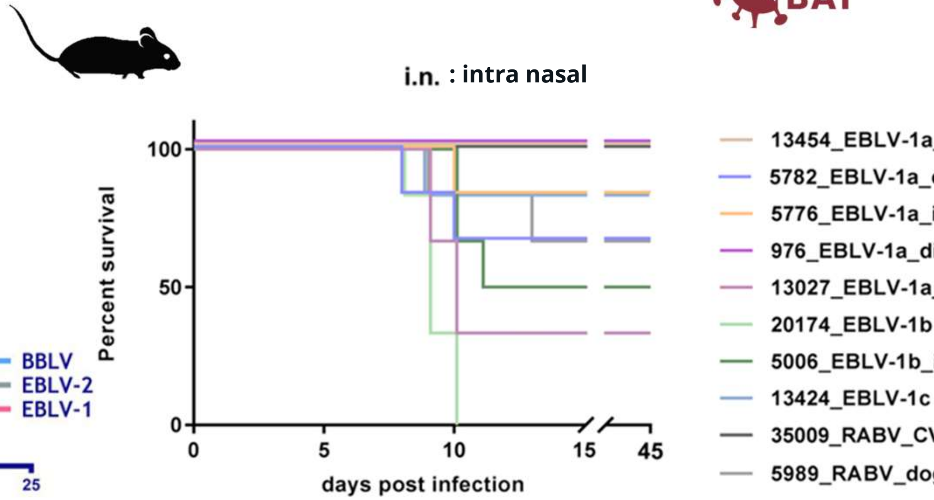


Freuling et al., 2009

Fig. 1. Survival graph of infected groups (◆, i.c.; ▲, i.m.; ×, s.c.). The remaining groups (i.n., all infected; control, none infected) have been omitted for better visualization.



Klein et al., 2022



Eggerbauer et al., 2017

- ✓ Dose
- ✓ Site of Inoculation
- ✓ Virus species
- ✓ Strains
- ✓ Animal model (sheep, ferret, fox, etc.)

In vitro

Impact of euthermia and hibernation?

✓ ↓ Temperature: Increase of viral tolerance

During recent years, the development and increasing use of immortalized bat cell lines have marked the emergence of European bat cell models.

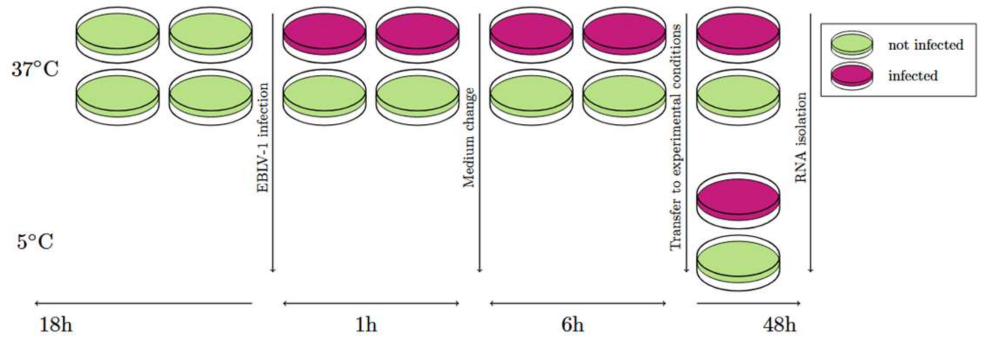


Fig. 1 Experimental design of cultivation of bat cells at temperatures simulating euthermia and torpor. Green—untreated cell culture, magenta—cell culture infected with EBLV-1

Harazim et al., 2023

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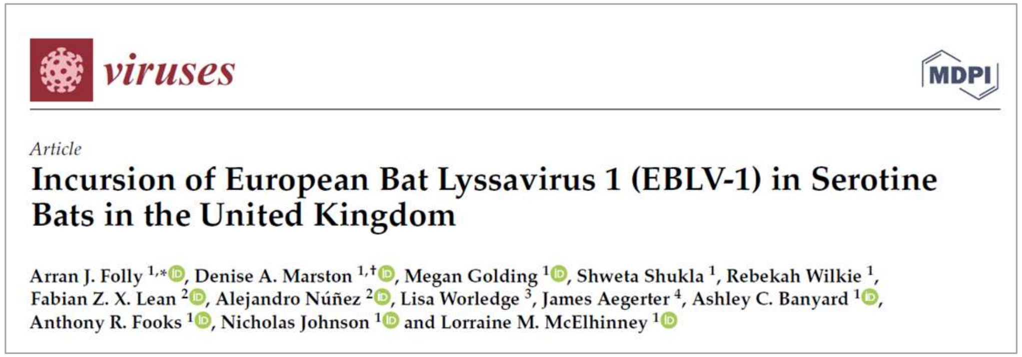
Effect of migrations on viral dispersion


viruses

MDPI

Article

Incursion of European Bat Lyssavirus 1 (EBLV-1) in Serotine Bats in the United Kingdom

Arran J. Folly [1,*], Denise A. Marston [1,†], Megan Golding [1], Shweta Shukla [1], Rebekah Wilkie [1], Fabian Z. X. Lean [2], Alejandro Núñez [2], Lisa Worledge [3], James Aegerter [4], Ashley C. Banyard [1], Anthony R. Fooks [1], Nicholas Johnson [1] and Lorraine M. McElhinney [1]

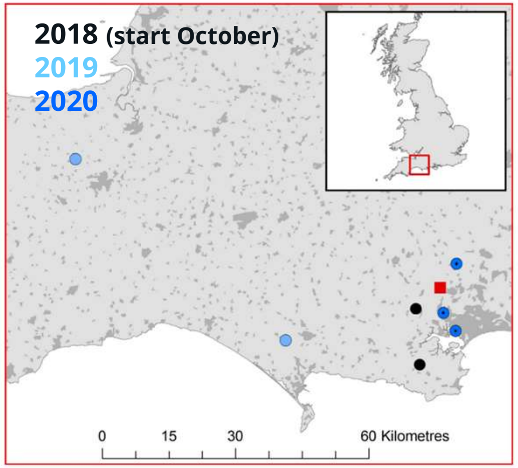


Figure 1. Location of the seven EBLV-1 positive serotine bats (*E. serotinus*) (black circles =2018, filled dark blue circles = 2019, and open light blue circles = 2020) and one lyssavirus FAT positive soprano pipistrelle (*P. pygmaeus*) (red square) in England. The base map highlights urban areas in dark grey.

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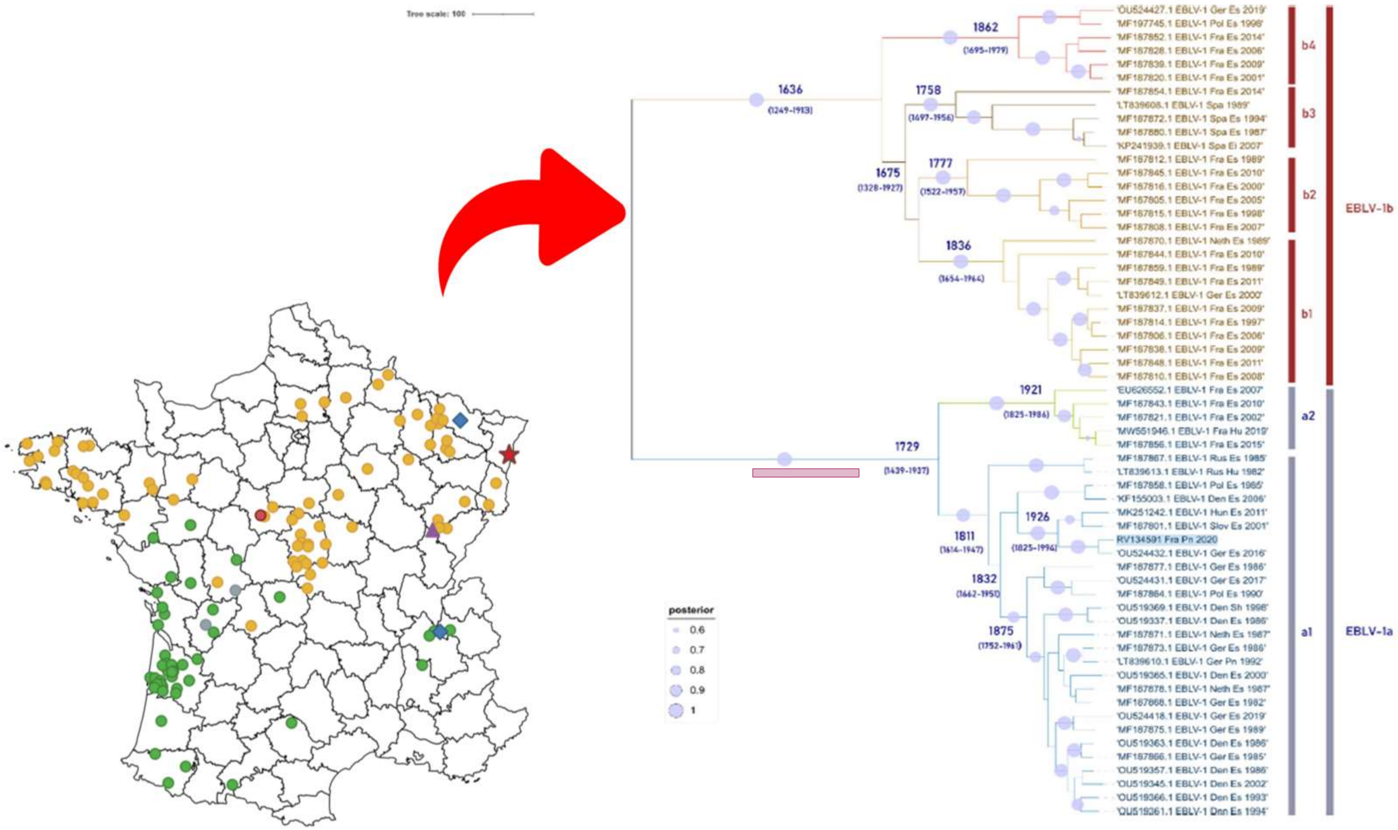
Effect of migrations on viral dispersion



Picard-Meyer et al., 2026

Pipistrellus nathusii

Figure 4: Nathusius' Pipistrelle distribution and migration (From collection: Living Planet: Connected Planet, Rapid Response Assessment, Riccardo Pravettoni, UNEP/GRID-Arendal, 2011).

Ad Figure 4: Note: We use this illustration because it gives a quit good overview, but since 2011 new data is available. Please note that no maternity groups are ever discovered in Norway, nor were any of the captured Nathusius' Pipistrelles females (J. v.d. Kooij, pers. com.). A possible flux from Sweden to Norway (J. v.d. Kooij, pers. com.) is not depicted in this illustration.[]

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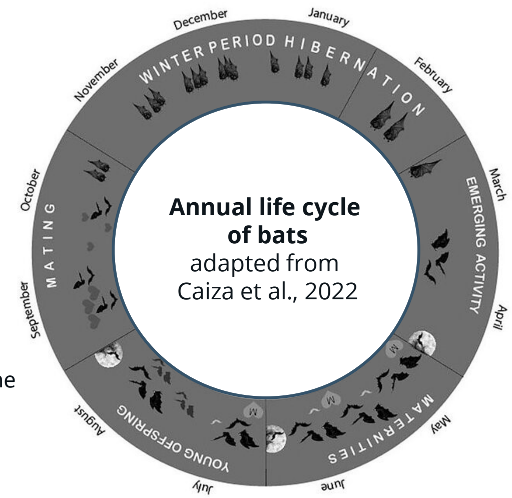
Active surveillances studies on EBLV-1

Table 4. Sero-surveillance and detection of lyssavirus neutralizing antibodies in European bats

Bat species	Region	*N*	VNA pos.	Seroprevalence (%)	Reference
Unspecified	Slovenia	216	0	0	Hostnik et al., 2010
B. barbastellus	France	2	1	9.5–90.5	Picard-Meyer et al., 2011
E. isabellinus	Spain	626	51	9	Vazquez-Moron et al., 2008b
E. serotinus	Germany	98	5	5	unpublished data
	France	28	7	11.4–45.2	Picard-Meyer et al., 2011
	Spain (Balearic)	99	0	0	Serra-Cobo et al., 2002
	Spain	175		0-74	Perez-Jorda et al., 1995
	Switzerland	17	0	0	Megali et al., 2010
	UK (England)	299	1	0.001–1.6	Harris et al., 2009
E. nilssonii	Sweden	47	0	0	SVA, 2009
M. blythii	France	5	1	1.0–70.1	Picard-Meyer et al., 2011
	Spain (Balearic)	23	0	0	Serra-Cobo et al., 2002
M. capaccinii	Spain (Balearic)	3	0	0	Serra-Cobo et al., 2002
M. daubentonii	Switzerland	124	3	2.4	Megali et al., 2010
	Sweden	77	8	10,39	SVA, 2009
	UK (England)	329	7–13	1.0–4.1	Harris et al., 2006
	UK (Scotland)	198 (88)	6–18	0.05–3.8	Brookes et al., 2005
	UK (Scotland)	>900	~27		SNH, 2009
M. emarginatus	Spain (Balearic)	16	0	0	Serra-Cobo et al., 2002
M. myotis	Belgium	8	2	25	Klein et al., 2007
	France	37	5	5.1–29.6	Picard-Meyer et al., 2011
	Spain (Balearic)	371	167		Amengual et al., 2007
	Spain (Balearic)	295	66	18	Serra-Cobo et al., 2002
	Switzerland	47	0	0	Megali et al., 2010
M. myotis/blythii	France	11	2	3.2–52.2	Picard-Meyer et al., 2011
M. nattereri	Belgium	8	2	25	Klein et al., 2007
	Spain (Balearic)	1	0	0	Serra-Cobo et al., 2002
	UK (Scotland)	20	0	0	Brookes et al., 2005
	UK (Scotland)	Unknown	2		SNH, 2009
Mi. schreibersii	France	17	2	2.1–37.7	Picard-Meyer et al., 2011
	Spain (Balearic)	168	6		Serra-Cobo et al., 2002
N. noctula	Switzerland	14	0	0	Megali et al., 2010
P. kuhlii	Spain (Balearic)	1	0	0	Serra-Cobo et al., 2002
P. pipistrellus	Spain (Balearic)	234	0	0	Serra-Cobo et al., 2002
	UK (Scotland)	6	0	0	Brookes et al., 2005
Plecotus spp.	Belgium	8	1	13	Klein et al., 2007
Pl. austriacus	Spain (Balearic)	12	0	0	Serra-Cobo et al., 2002
R. ferrumeqinum	France	10	1	0.5–45.9	Picard-Meyer et al., 2011
	Spain (Balearic)	58	2		Serra-Cobo et al., 2002
R. euryale	Spain (Balearic)	16	0	0	Serra-Cobo et al., 2002
R. hipposideros	Spain (Balearic)	16	0	0	Serra-Cobo et al., 2002
Tadarida teniotis	Spain (Balearic)	34	2		Serra-Cobo et al., 2002

Schatz et al., 2013

- **Factors that might drive transmission:**
- Seroprevalences higly variable according to site, species and sampling period.
- Seroprevalence higher in summer and in late summer in Spain and Italy in *Myotis myotis* and in France in *Eptesicus serotinus*. (Serra-Cobo at al., 2013; Leopardi at al., 2020; etc.)
- Higher seroprevalence was linked to large, multispecies colonies indicating that roosting behavior and inter-/intraspecific contacts are key drivers of EBLV-1 transmission. (Serra-Cobo at al., 2013)



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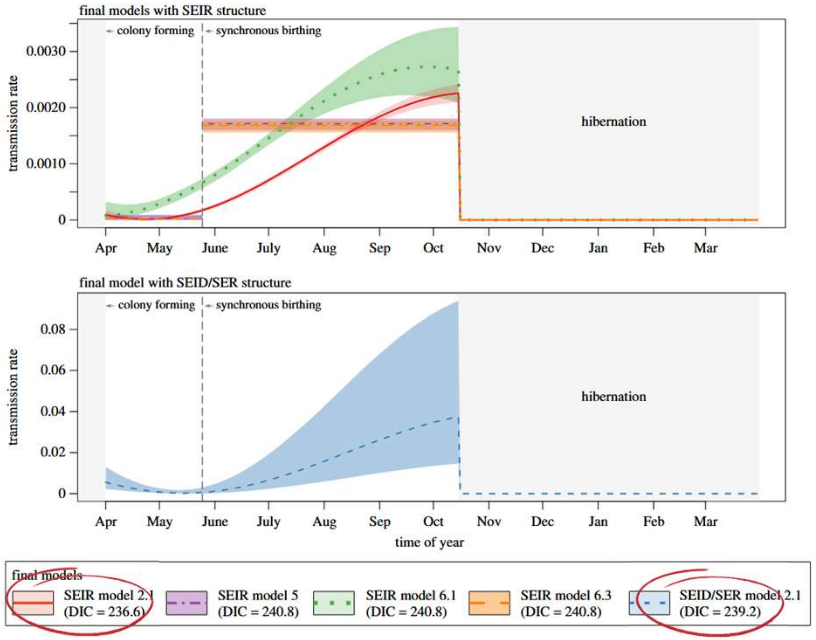
Assessing infection dynamics through longitudinal studies

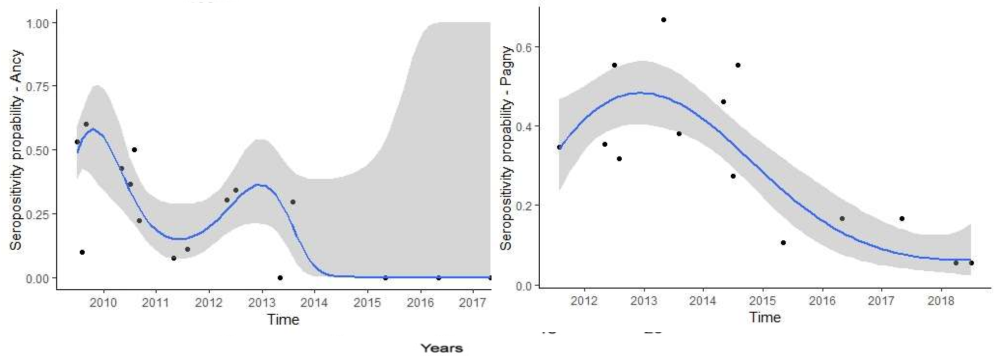
Annual time scale



S = Susceptible
E = Exposed
I = Infectious
D = Dead
R = Recovered

Kim et al., 2023 **Myotis myotis**

Multi Annual time scale



Robardet et al., 2017 **Eptesicus serotinus**

Table 3. Serological transitions observed in multiple capture/recapture sessions of bats (inconclusive statuses are excluded and consecutive identical statuses were merged to improve clarity).

n individuals on site A	n individuals on site B	Serological transitions observed			
123*	108	NEG			
50**	56	POS			
5	9	NEG	POS		
10	21	POS	NEG		
1	6	NEG	POS	NEG	
1	1	POS	NEG	POS	
0	1	NEG	POS	NEG	POS
0	1	POS	NEG	POS	NEG

* one individual detected with EBLV-1rabies RNA in the saliva (potentially excreting the virus)
** one individual detected with EBLV-1RNA in the saliva; and one individual excreting the virus (both PCR and RTCIT were found positive).

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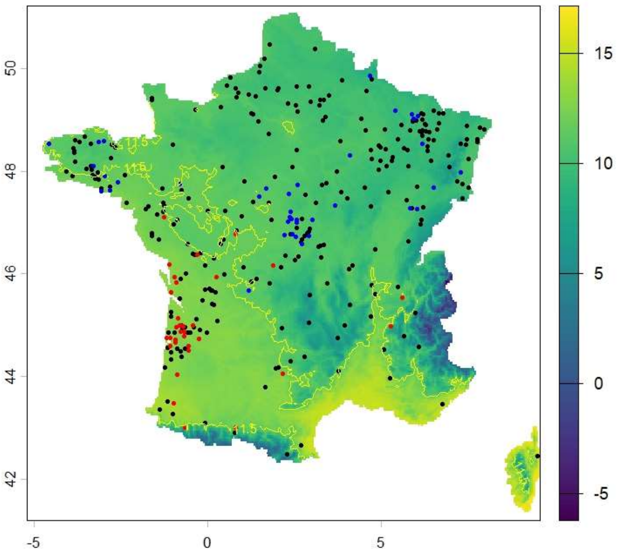
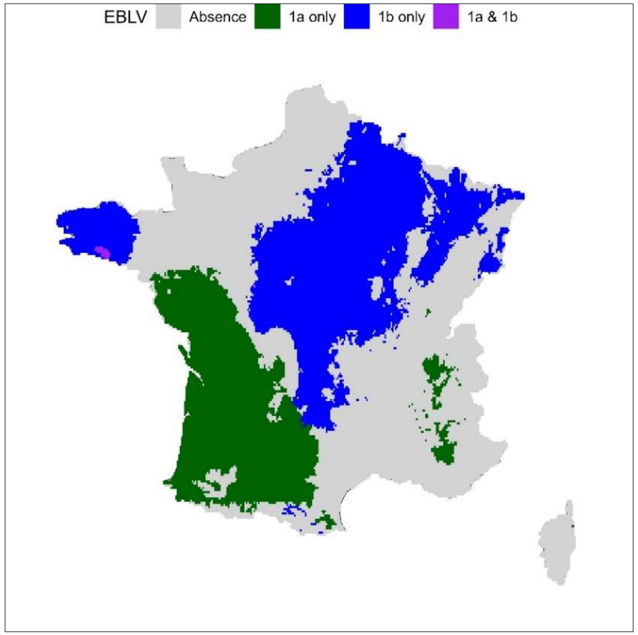
Impact of Environmental factors (ex Climate) on EBLV-1 transmission

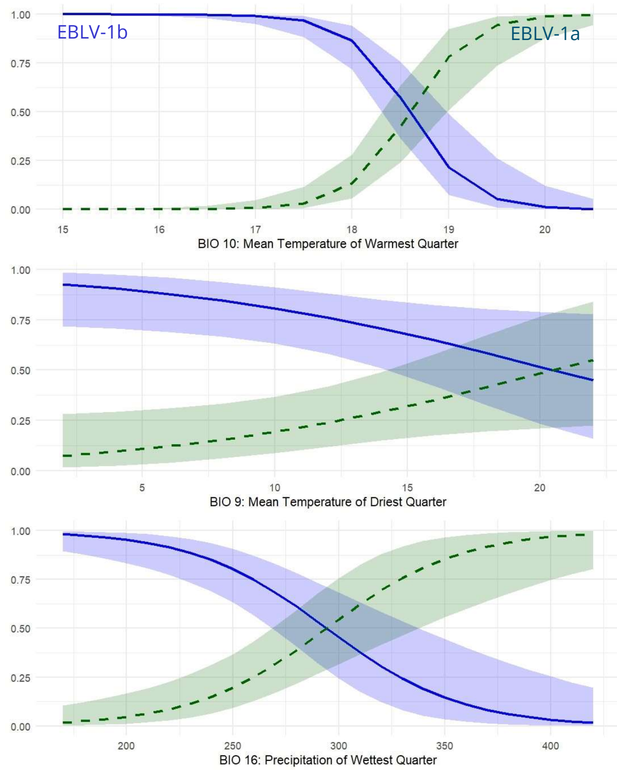
Occurrence of EBLV-1 cases vs 15 bioclimatic factors



Adeossi et al., submitted

Species Distribution Modelling





Influence of 15 bioclimatic factors on the expected probability of EBLV-1a and EBLV-1b infection among positive samples.

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Conclusion

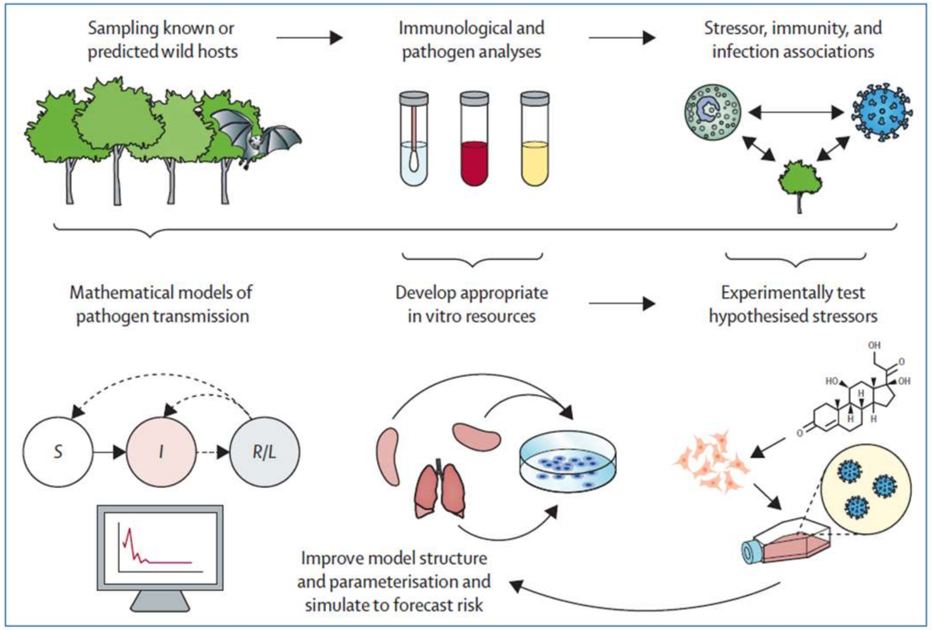

Figure: **Proposed iterative pipeline for coupling wildlife field studies and mechanistic molecular investigations in the laboratory**

Becker, 2023

Important gaps persist in our understanding of Bat lyssavirus transmission mechanisms in europe.

- Impact of environmental stressors (ressources, habitat change, pollution) on infections and CST occurence?
- Impact of climatic change?
- Impact of pesticides ?
  - Example: SPAIR Project (2026-2030)**: Study of Pesticide effects on Animal Immunological Resistance**
    ↳ Assess the role of pesticides as risk factors for zoonoses in animal reservoirs sharing human habitats
- etc.

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