

# Impact of an outbreak of RHDV2 on a semi-natural population of European rabbits (*Oryctolagus cuniculus*) in France

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# Evolution of Rabbit hemorrhagic disease (RHD) virus

Rabbit hemorrhagic disease (RHD) is one of the several causes of decline of wild rabbit populations in Europe.

## Emergence of the variant RHDV2 in 2010

A new variant of the RHD virus (RHDV), called RHDV2, has emerged in 2010 \*.

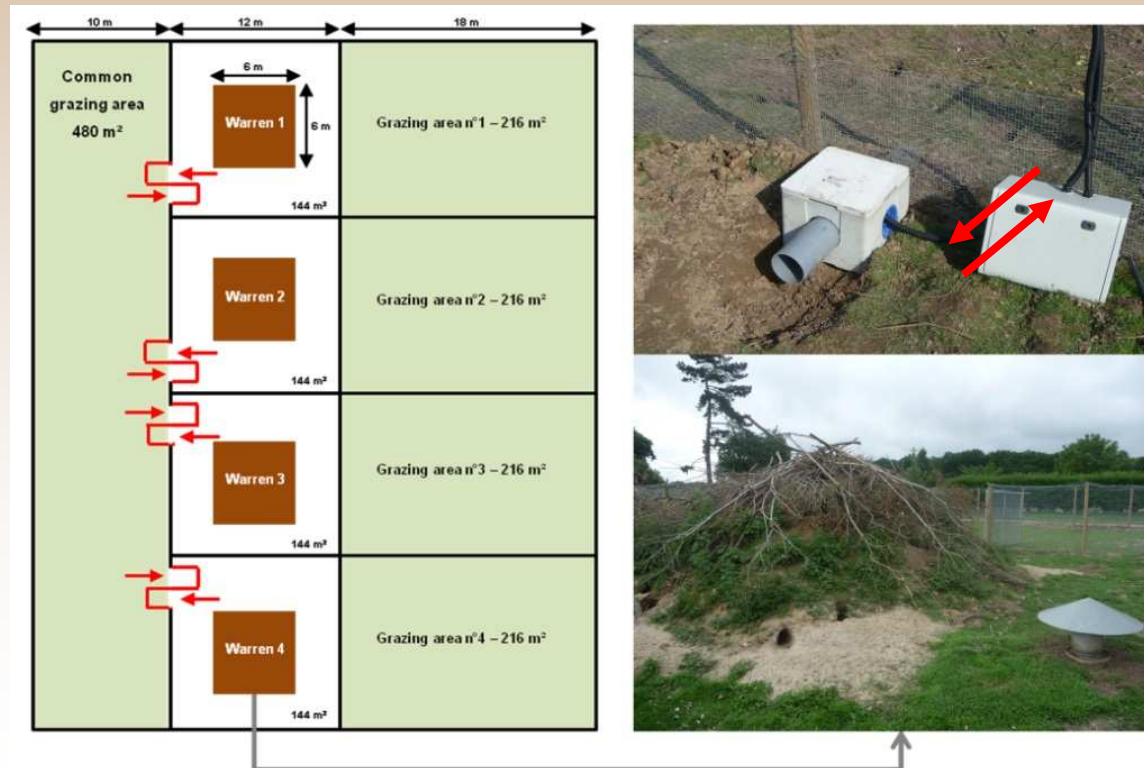
It can infect individuals immunized against classical strains of RHDV and is responsible for >95% of the RHD outbreaks from 2012 in France.

We assessed the demographic impact of a RHDV2 outbreak on the survival of wild rabbits in a semi-natural population.

\* Le Gall-Reculé G. et al. (2013). Emergence of a new lagovirus related to rabbit haemorrhagic disease virus. *Veterinary Research* 44(1): 81.

# Rabbit population monitoring

- continuous monitoring from 2009 to 2014
- a 40 m x 50 m enclosure (4 warrens and grazing areas)
- rabbits were marked with RFID microchips
- automatic recording of individuals (gates with electronic detection device)



# Rabbit population monitoring

- 198 rabbits were monitored (101 ♀, 97 ♂)
- 3 or 4 physical captures each year
- vaccination against classical strains (myxomatosis and RHDV1)
- Microchip tagging

SAMPLE SIZE	YEAR of first capture					Total
	2009	2010	2011	2012	2013	
<b>AGE at first capture</b>						
<b>1 month &lt; 350 g</b>	12	3	1	11		27
<b>2 month &lt; 600 g</b>	14	23	9	14		60
<b>3 month &lt; 750 g</b>	8		2	6		16
<b>subadults &lt; 1 kg</b>	7			8		15
<b>adults &gt; 1 kg</b>	45		6	27	2	80
<b>Newly monitored</b>	<b>86</b>	<b>26</b>	<b>18</b>	<b>66</b>	<b>2</b>	<b>198</b>
Newly captured	156	201	39	66	2	
Released outside	93	174	15			

- Management of population size around 80 by removing surplus juveniles

# Estimation of survival / CMR modelling

- Multi-event capture-recapture modelling using **E-SURGE** \*
- Monthly data: either physical captures or automatic RFID detections
- Model selection (QAICc)
- Effect of time (year, **period of outbreak**) and of sex (♀, ♂)
- Model for capture probability
- Monthly estimates of survival according to states of individuals
- **Age model of survival probability:**
  - Real age: 1 month → 2 month → 3 month → 4 month (subadult) → adult
  - **Age model:** juvenile (1 to 4-month-old) → adult

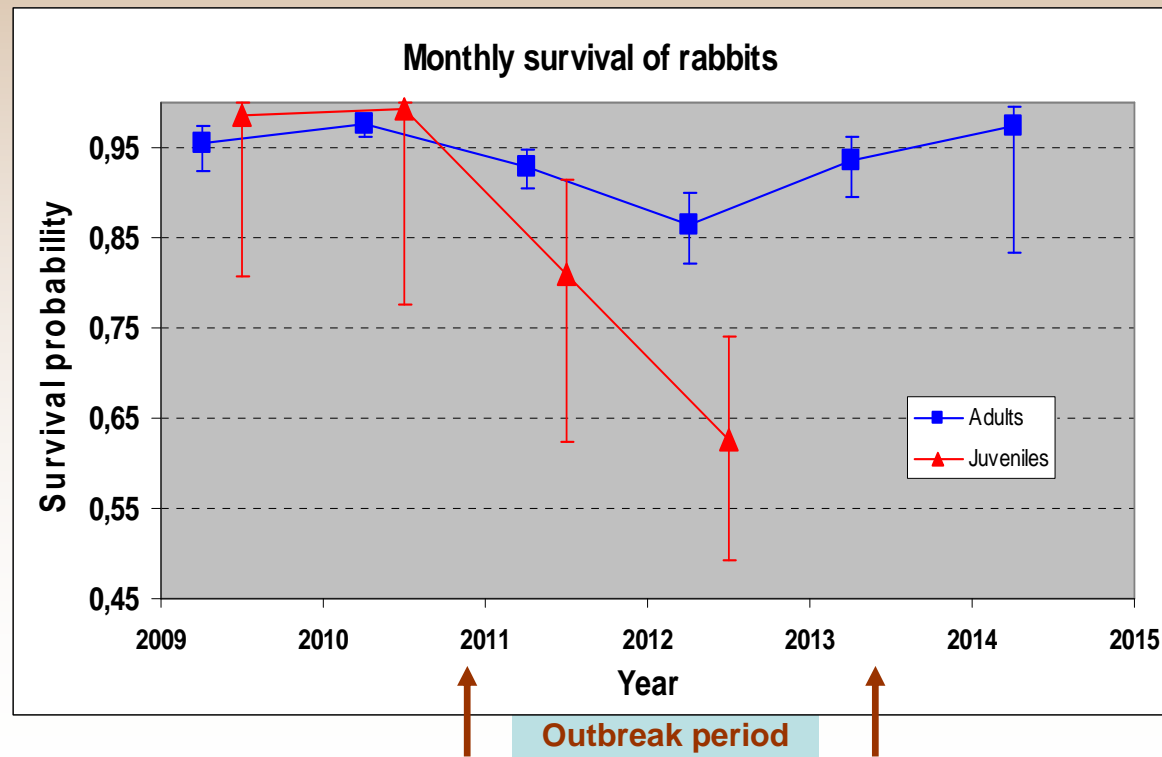
\* Choquet R. and Nogué E. (2011). E-surge 1-8 user's manual.  
CEFE-CNRS UMR 5175, Montpellier, France (<http://ftp.cefe.cnrs.fr/biom/soft-cr/>).

# Monthly survival rates

The RHDV2 outbreak apparently lasted around 2 years.

Monthly survival estimates dropped below 95% from 2011 to 2013 in both young and adults.

This is consistent with the RHDV2 outbreak observed from spring 2011: Several cases of mortality due to RHDV2 were confirmed.



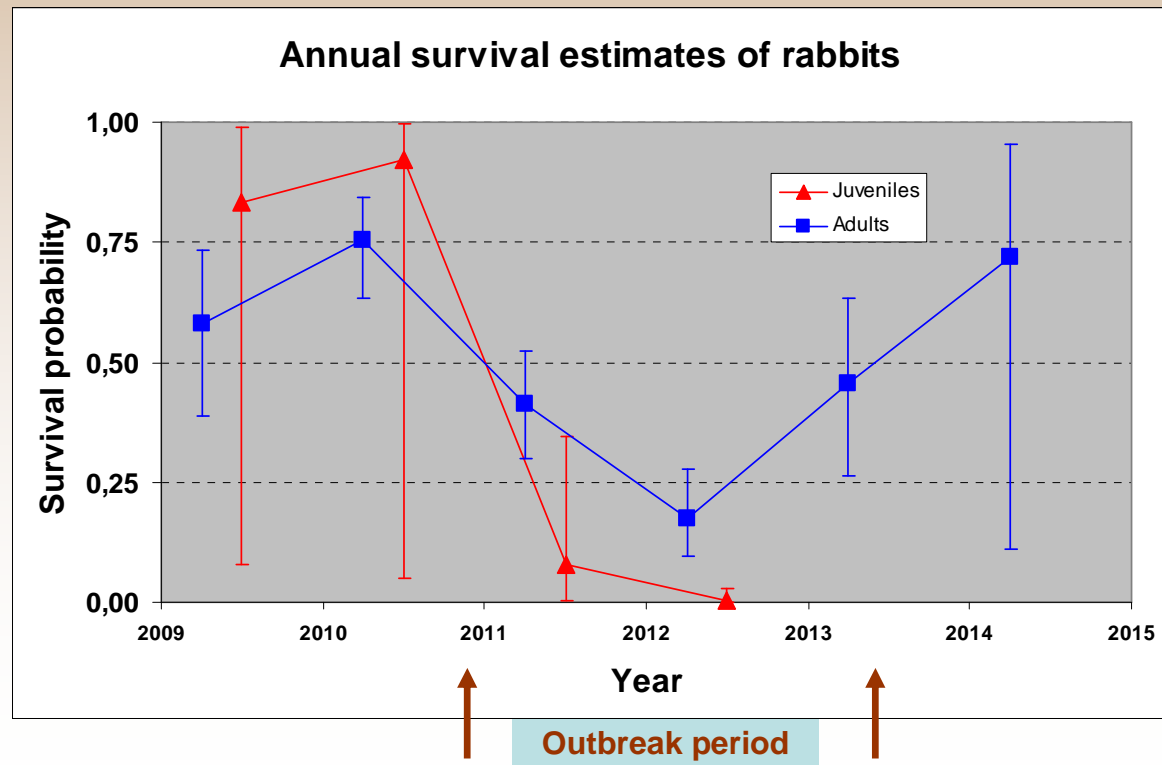
# Annual survival rates

The RHDV2 outbreak apparently lasted around 2 years.

**Annual survival estimates dropped below 50% from 2011 to 2013 in both young and adults.**

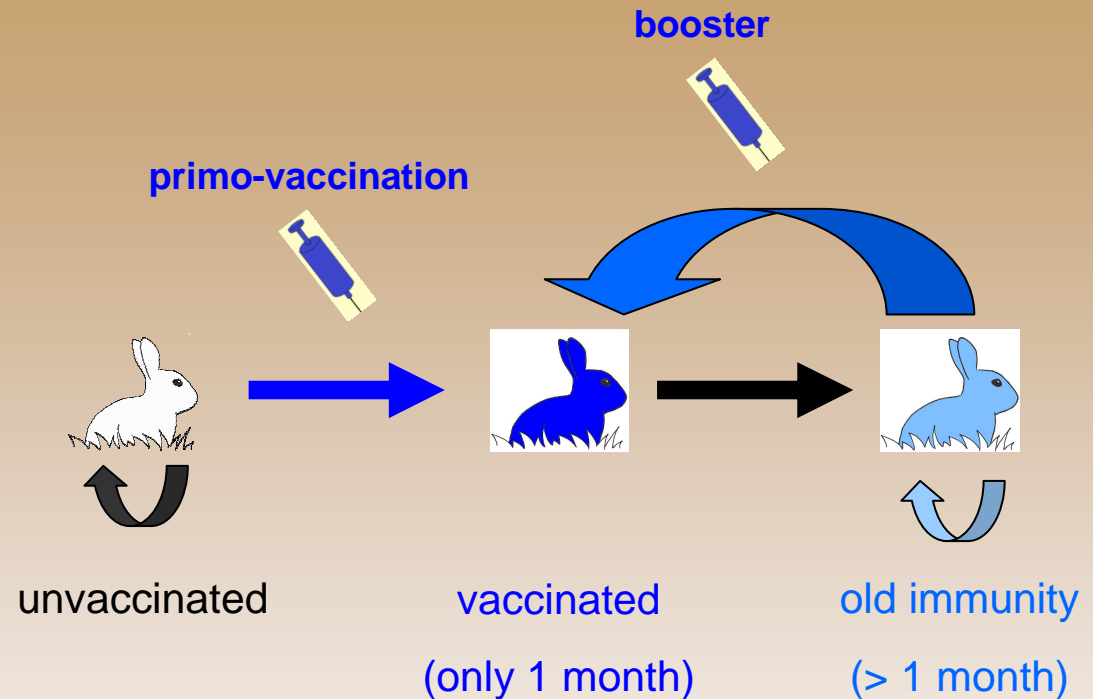
Only 11 of the 70 adults known alive before the RHDV2 outbreak survived.

No recruitment of young in 2013.



# Modelling of monthly vaccination state

- **Vaccination states**



- **Models of vaccine effect:**

- only a short-term during 1 month:      primo-vaccination = booster
- a boosting effect:                      primo-vaccination  $\neq$  booster
- a permanent effect:                      primo-vaccination = booster = old immunity
- a decreasing effect:                      primo-vaccination = booster  $\neq$  old immunity



# Effect of Myxomatosis-RHDV1 vaccination

The model selection revealed that survival depended on age class, vaccination status and period (OUTBREAK: 2011-2013).

The best model includes a short-term effect of vaccination (only during 1 month). However the model with a permanent effect of vaccine is competitive and suggests a longer effect of vaccination.

Survival Model	Deviance	Param.	QAICc
<b>AGE * OUTBREAK * VACCINE [ short-term 1 month ]</b>	<b>7300,50</b>	<b>13</b>	<b>7326,60</b>
AGE * OUTBREAK * VACCINE [ boosting: primo-vac ≠ booster ]	7292,92	17	7327,09
AGE * OUTBREAK * VACCINE [ permanent ]	7302,26	13	7328,36
AGE * OUTBREAK * VACCINE [ decreasing: primo-vac = booster ≠ old ]	7294,76	17	7328,92
AGE * OUTBREAK	7312,55	9	7330,60
AGE * SEX * OUTBREAK	7306,20	13	7332,29
AGE * SEX * OUTBREAK * VACCINE [ short-term 1 month ]	7291,30	21	7333,55
OUTBREAK * VACCINE [ short-term 1 month ]	7332,77	9	7350,82
AGE * VACCINE [ short-term 1 month ]	7390,11	9	7408,16
AGE * SEX * VACCINE [ short-term 1 month ]	7386,98	13	7413,08

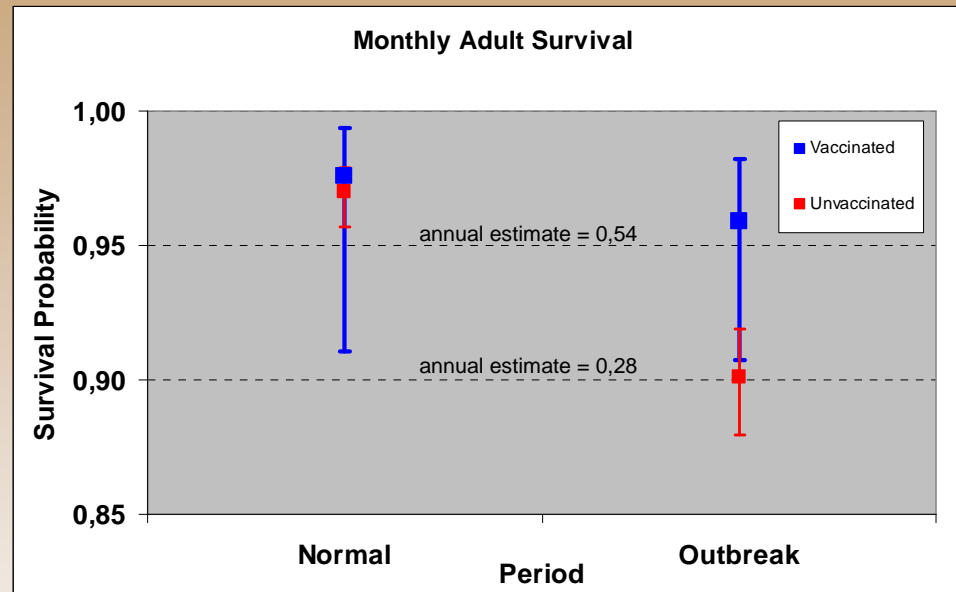
# Effect of Myxomatosis-RHDV1 vaccination

Vaccination increased survival in the short-term only during the outbreak period.

During the normal period, likely not any virus occurred and vaccination had no effect.


During the outbreak period, the slightly lower survival of vaccinated rabbits suggests that anti-RHDV1 vaccination provided only partial protection against RHDV2.

**The difference in survival due to vaccination during the outbreak confirms that the lower survival observed from 2011 to 2013 was due to RHDV2.**




When extrapolating juvenile survival over the 1 to 5-month-old period, it was at least of 93% during the normal period, but only of 74% and 17% in vaccinated and unvaccinated young during the outbreak.

# Discussion




Higher mortalities, likely due to the RHDV2 outbreak, impacted the population over 2 years.

Afterwards, there were apparently very few births in the population, but a causal link with the outbreak is not proven.



Classical vaccination, by boosting non-specific immunity, improved survival during the outbreak, at least in the short-term.

Possibly, this short-term gain in survival provided by vaccination may have played some part in the prolongation of the outbreak of RHDV2.



Finally the overall mortality due to an RHDV2 outbreak could be equivalent to the mortality caused by previous classical RHDV strains \*

\* Marchandeu S. et al. (1998). Impact of viral hemorrhagic disease on wild population of European rabbits in France. Journal of Wildlife Diseases 34: 429-435.