WORKPACKAGE 5

RISK ASSESSMENT

BTV OVERWINTERING BY HORIZONTAL TRANSMISSION IN VECTORS, RUMINANTS OR IN BOTH

CReSA
Centre de Recerca en Sanitat Animal

S. Napp
A. Alba
I. García
A. Allepuz
J. Casal

IZS
G. CAPORALE
TERAMO

P. Calistri
A. Giovannini

Institute for Animal Health

S. Gubbins

INTRODUCTION

Low T^{a} => ⇩ *Culicoides* activity and BTV replication
=> BTV transmission (apparently) interrupted in winter

After winter, BTV transmission re-starts: Overwintering

Several mechanisms proposed:

- Vertical transmission vector
- Vertical (transplacental) transmission host
- Horizontal transmission vectors
- Horizontal transmission host (prolonged viraemia)

INTRODUCTION

Low T^{a} => ⇩ *Culicoides* activity and BTV replication
=> BTV transmission (apparently) interrupted in winter

After winter, BTV transmission re-starts: Overwintering

Several mechanisms proposed:

- Vertical transmission vector
- Vertical (transplacental) transmission host
- Horizontal transmission vectors
- Horizontal transmission host (prolonged viraemia)
- Horizontal transmission vector + host

INTRODUCTION

Low T^a => ⇩ *Culicoides* activity and BTV replication
=> BTV transmission (apparently) interrupted in winter

After winter, BTV transmission re-starts: Overwintering

Several mechanisms proposed:

- Vertical transmission vector
- Vertical (transplacental) transmission host
- Horizontal transmission vectors *Pathway I*
- Horizontal transmission host (prolonged viraemia)
- Horizontal transmission vector + host

INTRODUCTION

Low T^a => ⇩ *Culicoides* activity and BTV replication
BTV transmission (apparently) interrupted in winter

After winter, BTV transmission re-starts: Overwintering

Several mechanisms proposed:

- Vertical transmission vector
- Vertical (transplacental) transmission host
- Horizontal transmission vectors
- Horizontal transmission host (prolonged viraemia) ***Pathway II***
- Horizontal transmission vector + host

INTRODUCTION

Low T^a => ⇩ *Culicoides* activity and BTV replication
BTV transmission (apparently) interrupted in winter

After winter, BTV transmission re-starts: Overwintering

Several mechanisms proposed:

- Vertical transmission vector
- Vertical (transplacental) transmission host
- Horizontal transmission vectors
- Horizontal transmission host (prolonged viraemia)
- Horizontal transmission vector + host ***Pathway III***

INTRODUCTION

Period of Low Vector Activity (PLVA) vs. Vector Free Period (VFP)

In Europe: PLVA rather than VFP

⇩

Assess the effect of (low) transmission during PLVA

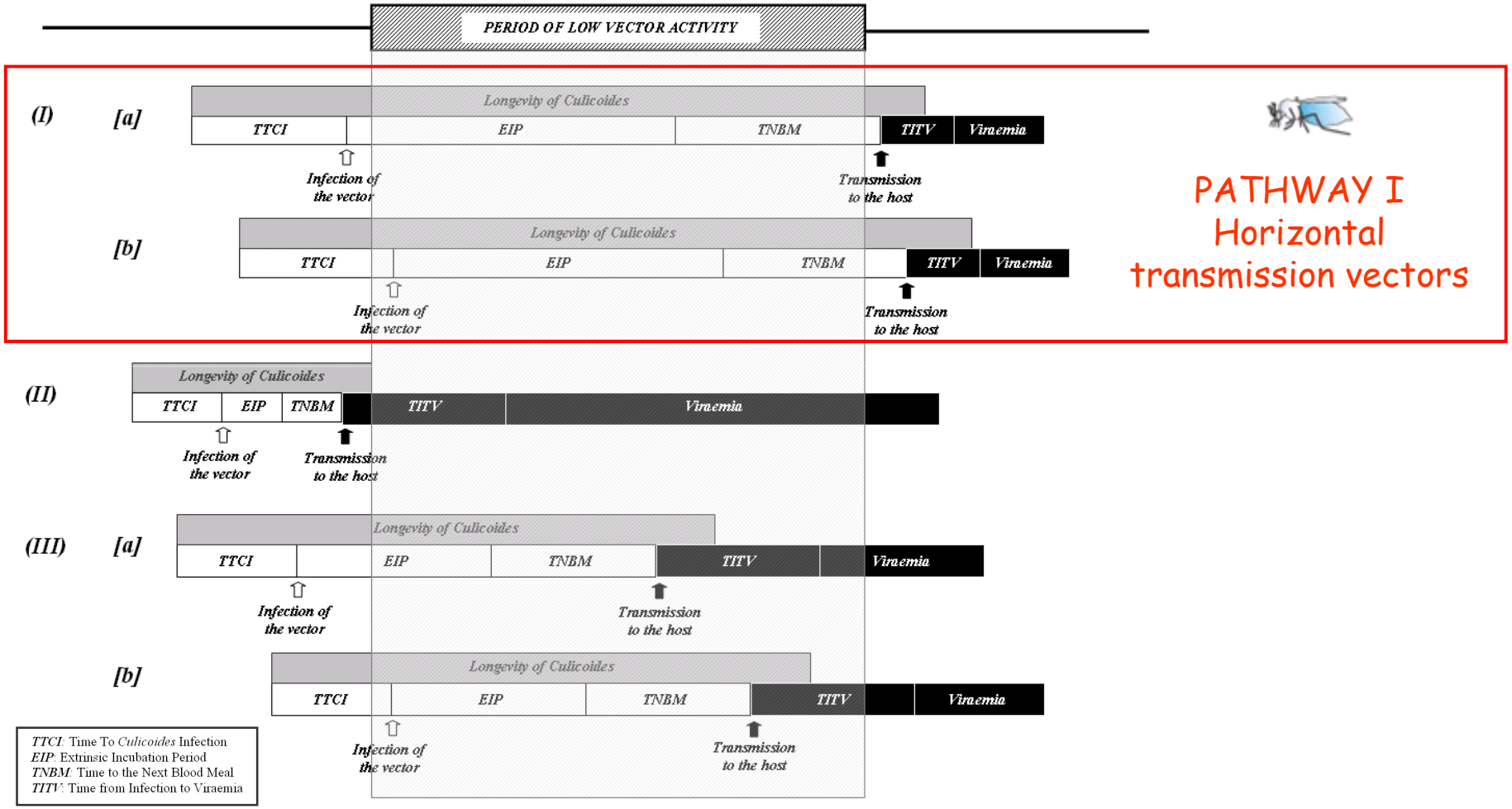
Exophilic vs. endophilic behaviour

In (Northern) Europe: *Culicoides* regularly found inside buildings

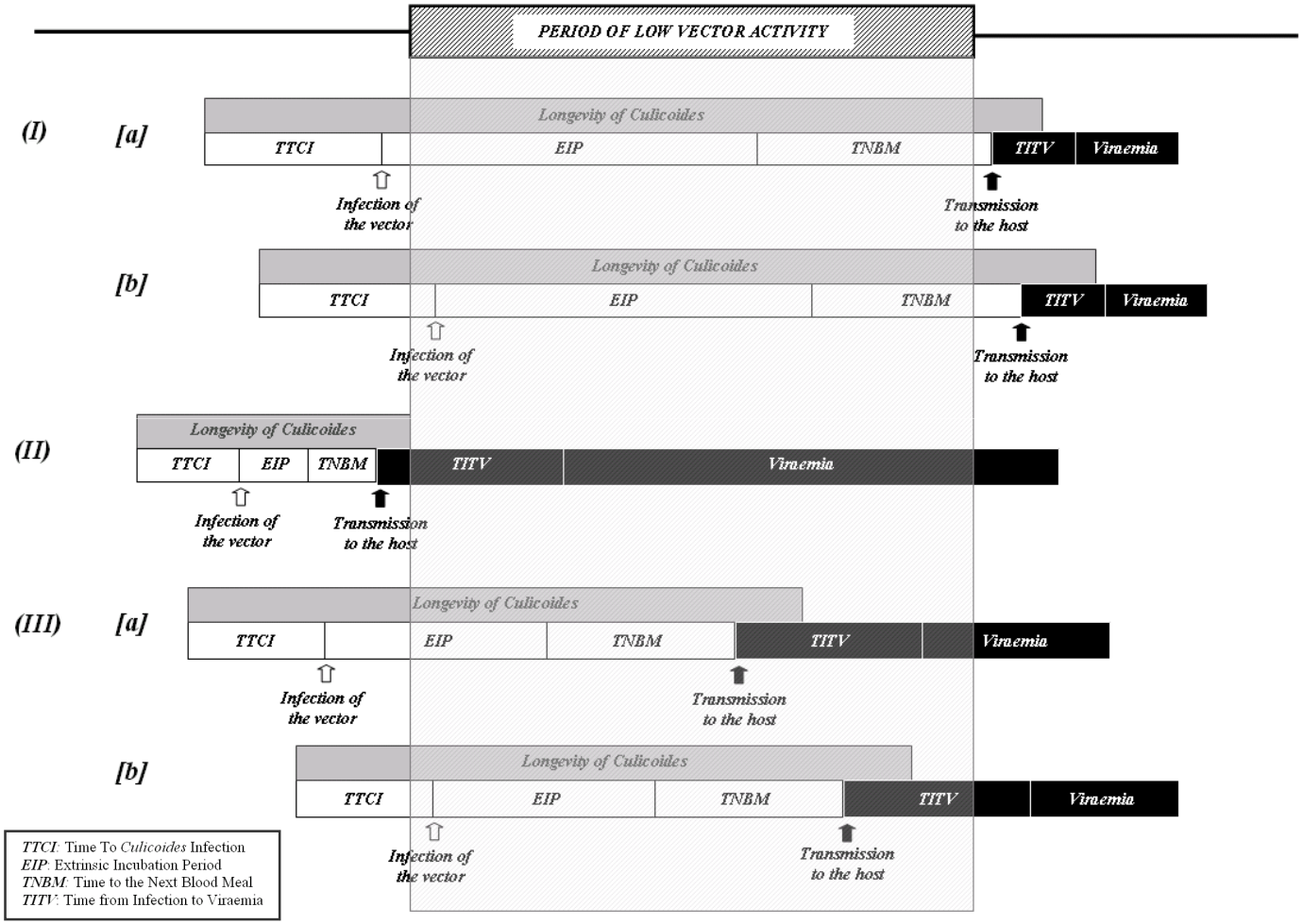
⇩

Assess the effect of endophilic behaviour

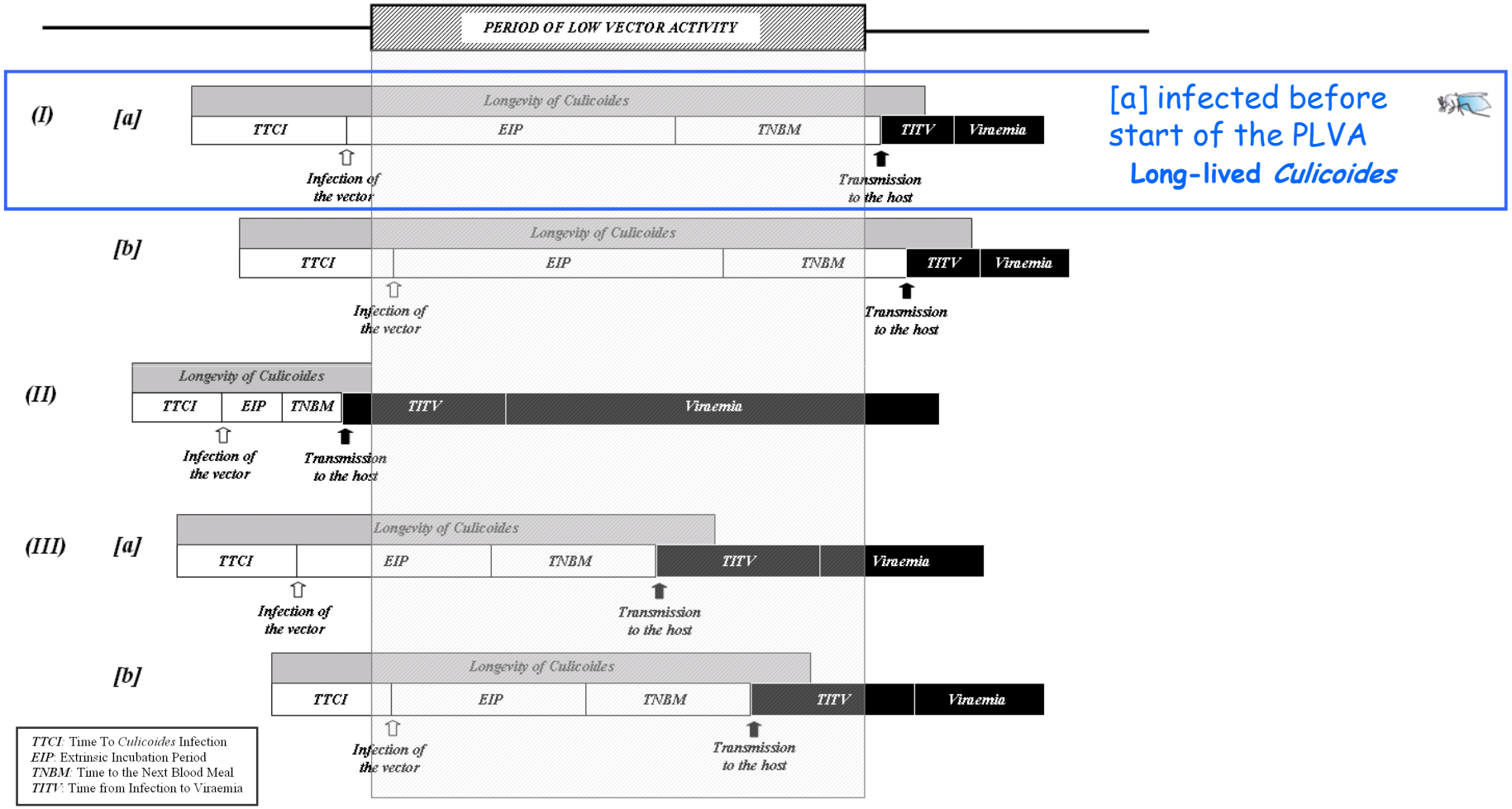
MODEL


PERIOD OF LOW VECTOR ACTIVITY
(I)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
PATHWAY I
Horizontal transmission vectors
(II)
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(III)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
TTCI: Time To Culicoides Infection
EIP: Extrinsic Incubation Period
TNBM: Time to the Next Blood Meal
TITV: Time from Infection to Viraemia

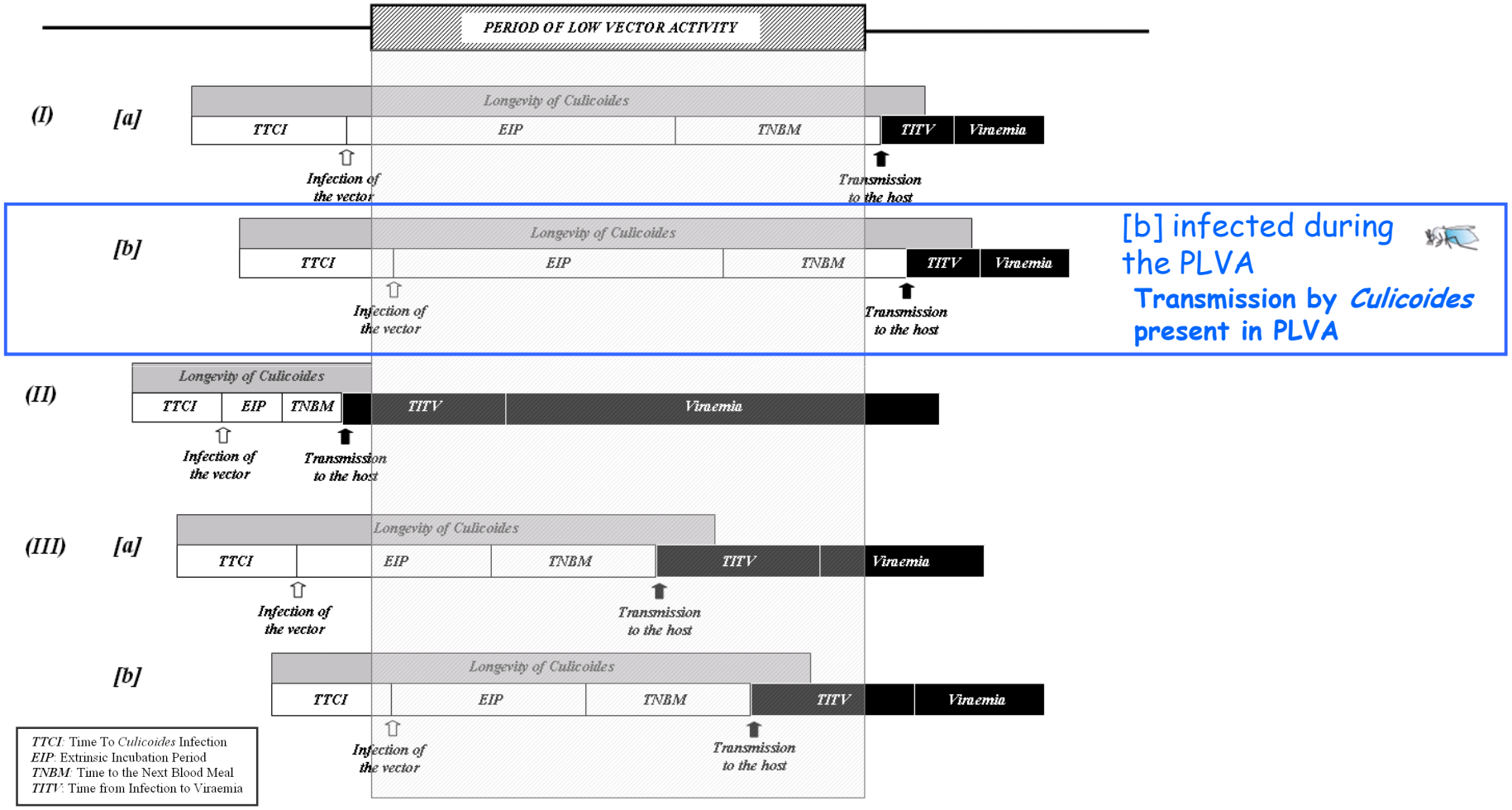
MODEL


PERIOD OF LOW VECTOR ACTIVITY
(I)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(II)
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(III)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
TTCI: Time To Culicoides Infection
EIP: Extrinsic Incubation Period
TNBM: Time to the Next Blood Meal
TITV: Time from Infection to Viraemia

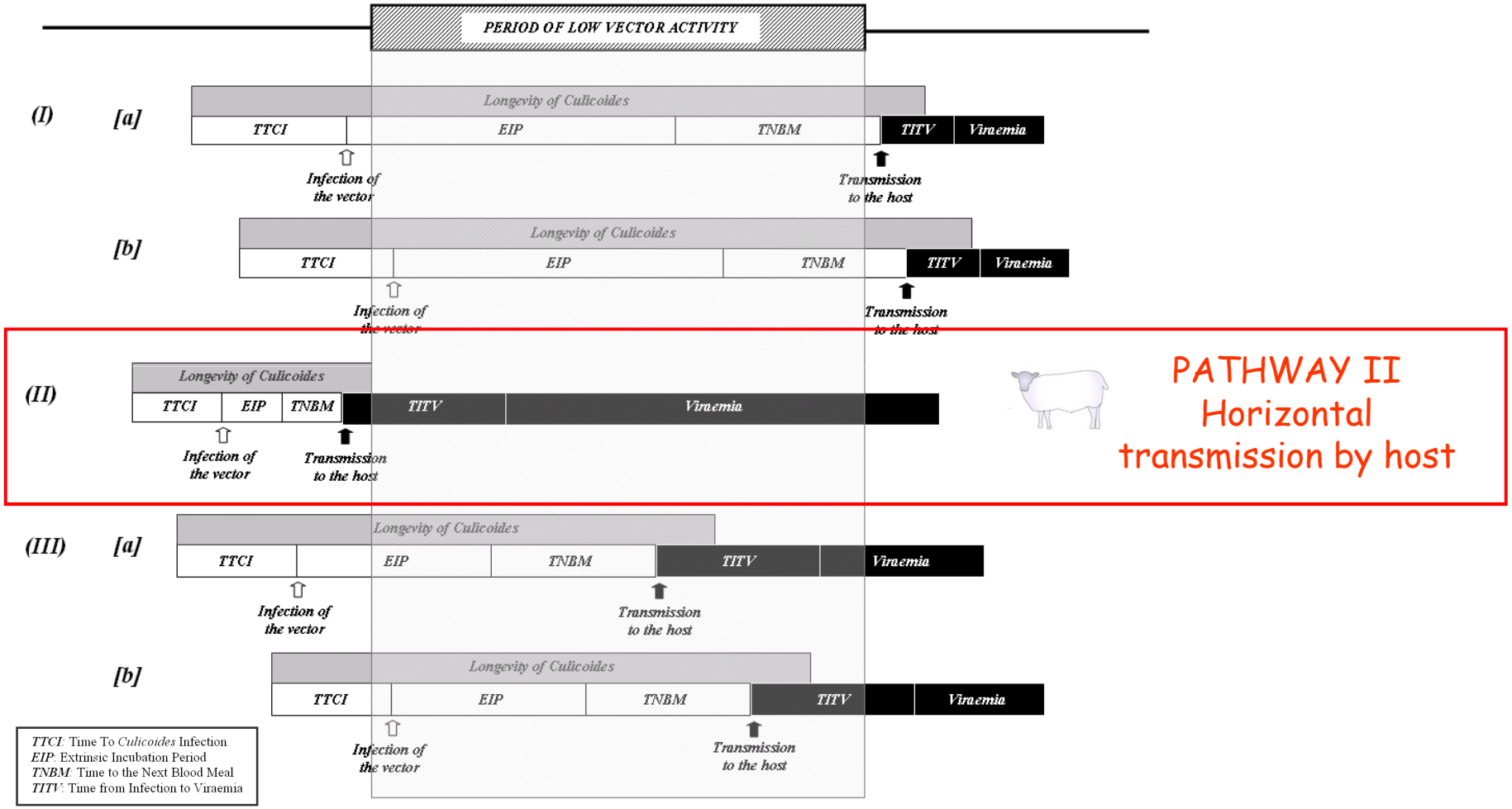
MODEL


PERIOD OF LOW VECTOR ACTIVITY
(I)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[a] infected before start of the PLVA
Long-lived Culicoides
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(II)
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(III)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
TTCI: Time To Culicoides Infection
EIP: Extrinsic Incubation Period
TNBM: Time to the Next Blood Meal
TITV: Time from Infection to Viraemia

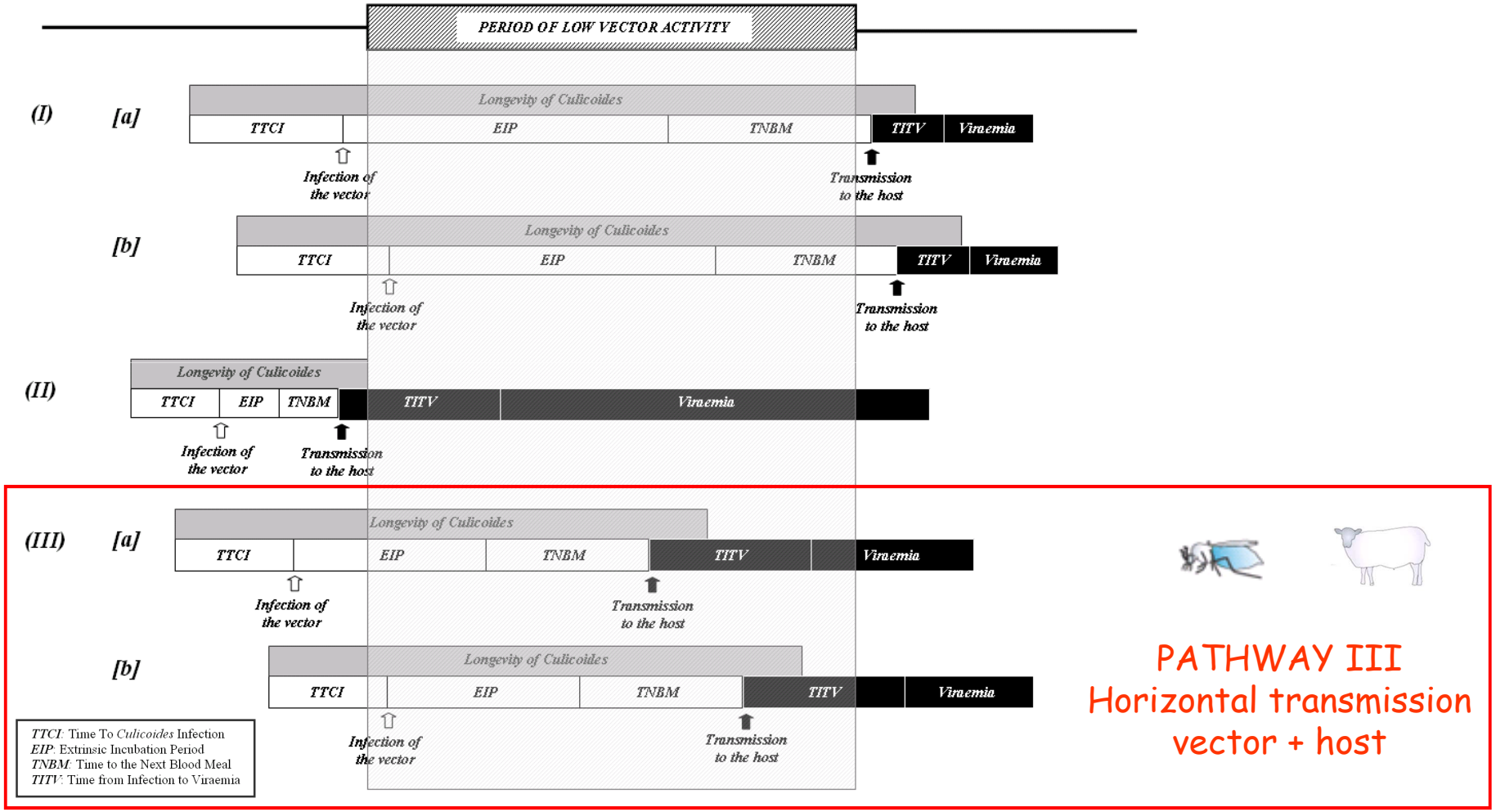
MODEL


PERIOD OF LOW VECTOR ACTIVITY
(I)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b] infected during the PLVA
Transmission by Culicoides present in PLVA
(II)
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(III)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
TTCI: Time To Culicoides Infection
EIP: Extrinsic Incubation Period
TNBM: Time to the Next Blood Meal
TITV: Time from Infection to Viraemia

MODEL

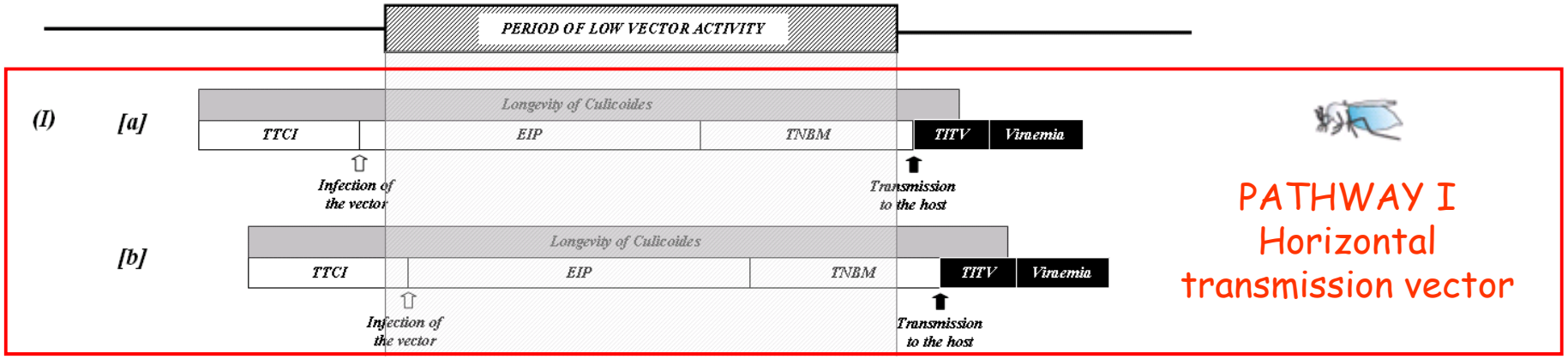

PERIOD OF LOW VECTOR ACTIVITY
(I)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
(II)
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
PATHWAY II
Horizontal transmission by host
(III)
[a]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
[b]
Longevity of Culicoides
TTCI
EIP
TNBM
TITV
Viraemia
Infection of the vector
Transmission to the host
TTCI: Time To Culicoides Infection
EIP: Extrinsic Incubation Period
TNBM: Time to the Next Blood Meal
TITV: Time from Infection to Viraemia

MODEL



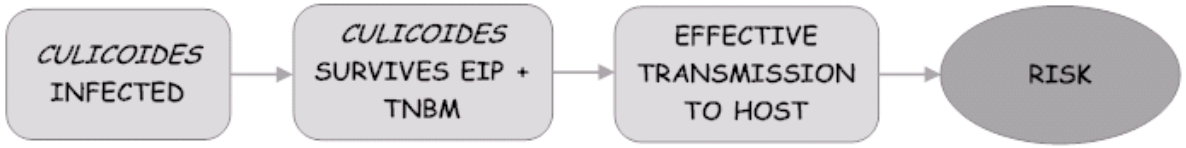
Models run independently for EXOPHILIC AND ENDOPHILIC (%) behaviour

MODEL



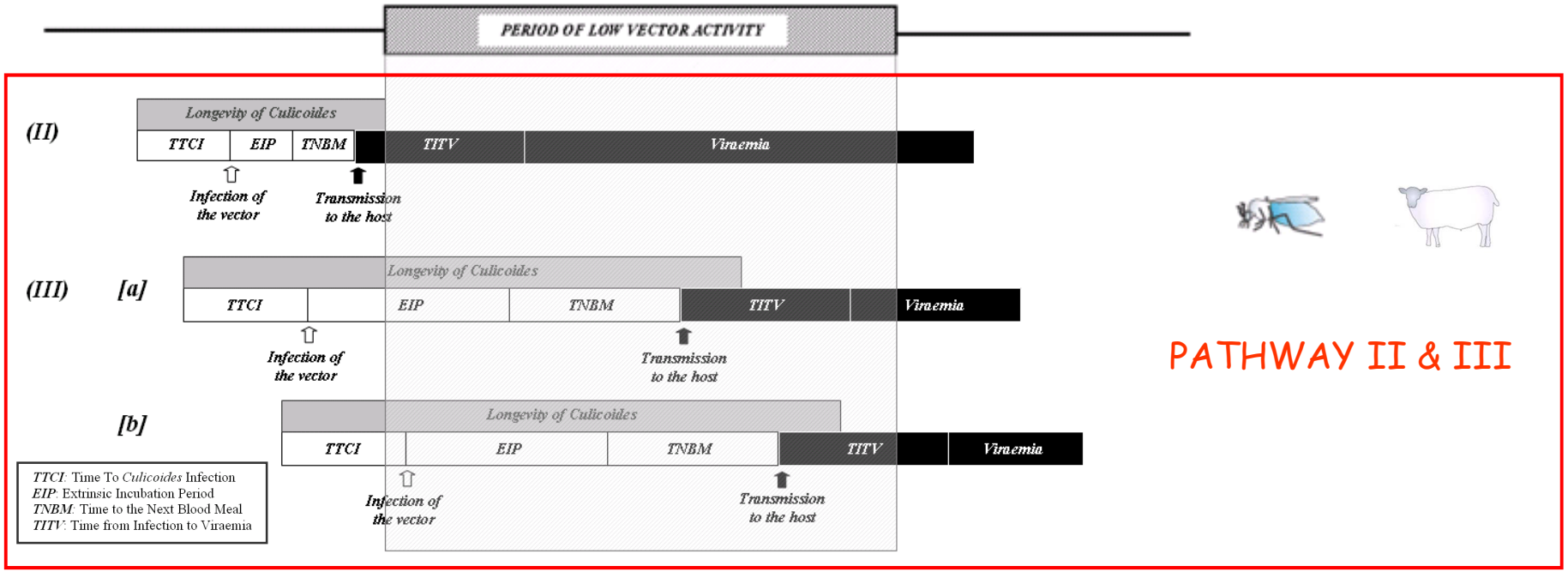
PATHWAY I
Horizontal transmission vector

PATHWAY I



MODEL

PATHWAYS II & III



SCENARIO DESCRIPTION

A) 2006

Emerg Infect Dis. 2009 Mar;15(3):433-5.
Epidemiology of bluetongue virus serotype 8, Germany.
Conraths FJ, Gethmann JM, Staubach C, Mettenleiter TC, Beer M, Hoffmann B.

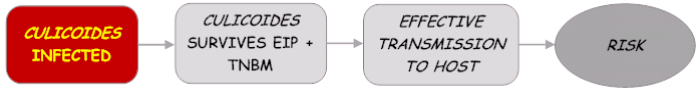
Model applied to a real scenario: Probability of overwintering in Germany (North Rhine-Westphalia) in 2006-2007.

Appendix II: *Specific input parameters (Germany 2006-2007)*

Scenario input parameters (Germany 2006 - 2007)	**Value**	**Source**
Mean daily temperatures (°C)	*NA*	Bundesministerium für Verkher, Bau und Stadtentwicklung. Klimadaten Deutschland (http://www.dwd.de/bvbw/appmanager/bvbw/dwdwwwDesktop?)
Monthly *Culicoides* captures	*NA*	Clausen and collaborators (2009) Hörbrand and collaborators (2009)
Monthly proportion of *Culicoides* captured indoors (versus outdoors)	*NA*	Clausen and collaborators (2009)
Number of cattle farms (North Rhine-Westphalia)	*19,505*	Statische Ämter des Bundes und der Länder (https://www.regionalstatistik.de/)
Number of sheep farms (North Rhine-Westphalia)	*3,485*	Statische Ämter des Bundes und der Länder (https://www.regionalstatistik.de/)
Cattle population (North Rhine-Westphalia)	*1,346,488*	Statische Ämter des Bundes und der Länder (https://www.regionalstatistik.de/)
Sheep population (North Rhine-Westphalia)	*199,762*	Statische Ämter des Bundes und der Länder (https://www.regionalstatistik.de/)
Monthly number of cattle farms affected (2006-2007)	*NA*	EU. Food Safety Regulatory Committees: Presentations: http://ec.europa.eu/food/committees/regulatory/scfcah/animal_health/blue_germany27112006.pdf http://ec.europa.eu/food/committees/regulatory/scfcah/animal_health/bluetongue_germany012007.pdf http://ec.europa.eu/food/committees/regulatory/scfcah/animal_health/presentations/bt_12112008_de.pdf
Monthly number of sheep farms affected (2006-2007)	*NA*	As above
Proportion of immune cattle	*0.01*	Model estimation‡
Proportion of immune sheep	*0.04*	Model estimation‡

NA: Not applicable
‡ The proportion of immune cattle and sheep were obtained based on the estimated number of cattle and sheep infected in 2006 (natural immunity) as vaccination did not start until 2008

MODEL



1-PROBABILITY CULICOIDES GETTING INFECTED

Monthly probability *Culicoides* getting infected after one BM

1. Proportion of bites on a susceptible hosts (P_H)
2. Probability of a susceptible host being viraemic per month (P_{Vi})
3. Proportion of bites on an infectious host that infect a midge (P_B)

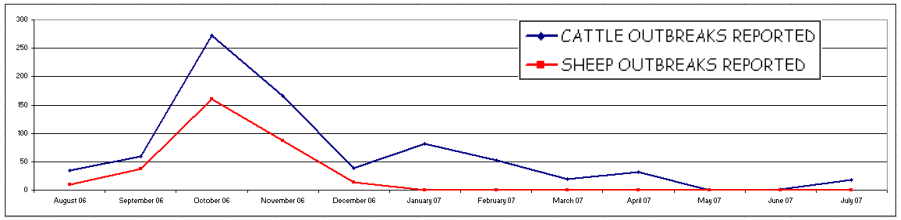
MODEL

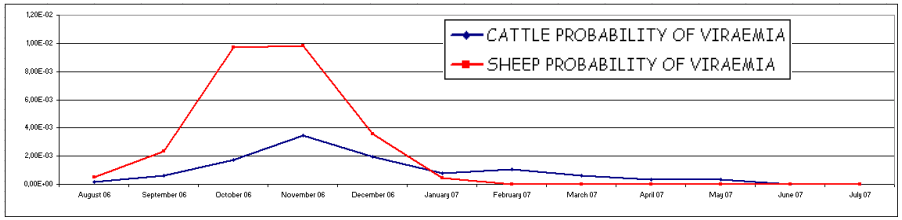
CULICOIDES INFECTED → CULICOIDES SURVIVES EIP + TNBM → EFFECTIVE TRANSMISSION TO HOST → RISK

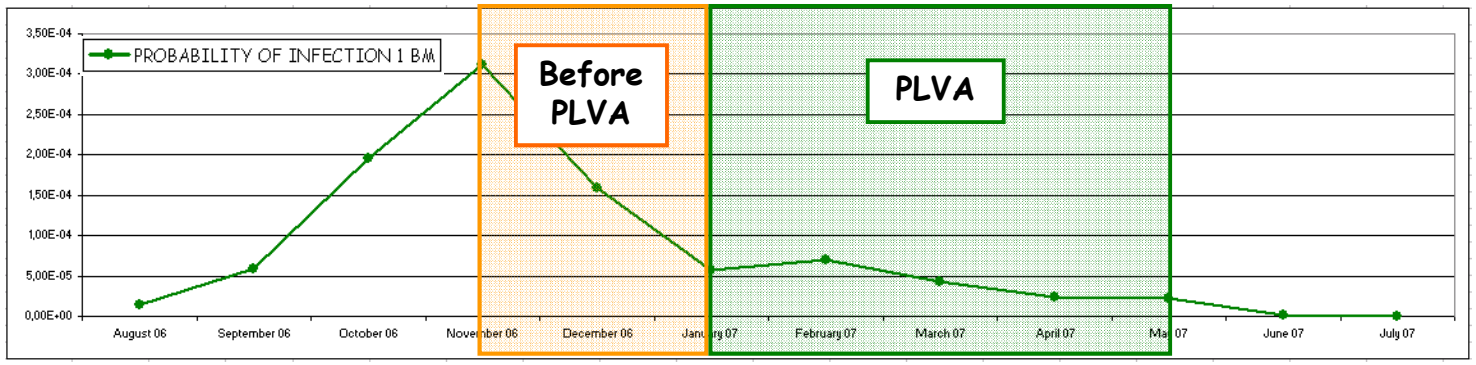
1-PROBABILITY CULICOIDES GETTING INFECTED

Monthly probability *Culicoides* getting infected after one BM

1. Proportion of bites on a susceptible hosts (P_H)
2. Probability of a susceptible host being viraemic per month (P_{Vi})
3. Proportion of bites on an infectious host that infect a midge (P_B)





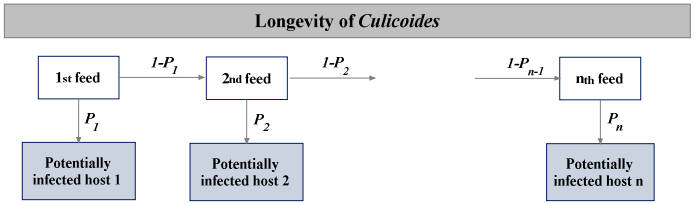


MODEL

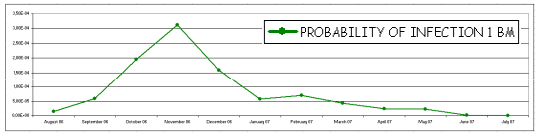
CULICOIDES INFECTED → CULICOIDES SURVIVES EIP + TNBM → EFFECTIVE TRANSMISSION TO HOST → RISK

1- PROBABILITY CULICOIDES GETTING INFECTED

Probability *Culicoides* getting infected after N BMs



A) Probability *Culicoides* getting infected after 1 BM (per month)



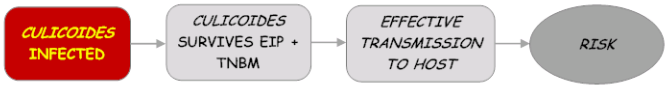
B) Number of BMs

Tª dependent parameters
- Longevity of *Culicoides*
- Biting rate

Estimations based on daily temperatures

TEMPERATURE	January	February	March	April	May	June	July	August	September	October	November	December
1	7,9	5,9	5,9	11,2	13,9	15,2	19,1	16,4	15,6	12,7	8,2	7,7
2	4,5	6,4	5,7	11,3	13,1	16,7	17,0	16,4	16,0	14,0	10,8	8,0
3	5,5	7,2	7,8	7,2	14,2	16,9	14,5	17,0	13,6	15,0	11,5	6,5
4	7,4	5,7	8,8	6,1	15,1	17,8	13,7	19,0	11,4	15,5	9,1	5,7
5	7,6	4,8	8,6	7,9	14,7	18,6	14,6	21,8	11,4	12,6	7,6	9,6
6	8,5	2,3	8,2	10,3	14,4	19,3	15,3	22,1	14,4	10,6	6,9	9,3
7	7,5	1,4	6,9	8,4	12,8	22,3	15,8	17,5	14,9	10,0	7,6	9,1
8	8,3	0,2	6,3	9,3	12,5	23,0	16,9	15,4	14,8	10,0	8,9	5,2
9	12,0	1,0	6,1	10,7	12,0	20,4	14,4	15,9	14,1	10,6	4,5	6,5
10	10,7	3,3	7,9	11,5	15,0	20,0	13,9	17,1	12,6	11,1	5,6	5,5
11	6,9	3,2	9,1	11,9	12,9	19,9	13,9	17,2	13,4	10,1	6,7	4,7
12	8,6	5,5	8,4	13,9	13,2	18,5	15,8	17,8	13,5	11,5	4,3	3,6
13	10,4	7,2	7,7	16,4	16,0	18,8	19,9	17,7	13,2	10,5	3,7	3,2
14	7,1	6,8	7,4	18,2	14,3	19,1	23,2	19,3	13,9	9,8	1,9	1,0
15	5,4	5,6	7,4	18,7	11,2	18,0	24,5	21,6	13,7	11,9	0,8	0,0
16	5,6	6,1	8,2	18,3	10,4	16,4	25,6	17,1	15,1	13,7	1,8	-2,1
17	9,1	5,8	6,6	13,0	9,8	17,9	21,0	14,7	15,5	12,2	2,9	-0,9
18	10,4	6,1	2,6	8,8	13,4	17,7	20,0	15,7	11,1	8,2	3,2	-1,5
19	9,8	4,4	3,0	10,3	15,7	20,4	19,0	16,9	10,3	6,5	2,9	-1,7
20	10,3	4,1	3,0	8,7	17,5	20,9	19,3	15,8	13,1	4,7	5,5	-3,0
21	6,0	5,5	3,1	8,5	19,3	16,5	18,0	15,6	14,7	5,7	7,1	-3,9
22	2,4	6,6	4,2	13,0	18,8	15,8	17,1	16,5	15,0	3,5	7,7	-3,5
23	-3,0	7,5	6,4	15,8	17,4	15,6	16,4	18,0	16,4	4,0	6,0	-1,3
24	-3,4	8,3	8,7	17,4	19,7	17,6	15,9	19,0	15,9	6,2	2,6	-1,0
25	-2,8	8,2	10,5	19,4	20,2	16,7	17,7	19,3	12,0	7,6	4,4	-0,3
26	-2,2	7,3	10,3	19,3	16,8	12,8	20,0	18,4	10,2	7,7	3,0	0,6
27	1,9	6,4	10,5	18,2	15,4	12,8	18,5	16,0	10,6	7,9	3,4	2,5
28	4,3	5,5	9,1	18,4	12,1	14,0	17,4	14,1	12,1	8,1	2,4	4,2
29	5,9	9,0	8,7	15,1	10,7	14,6	14,7	13,4	12,1	8,0	3,0	3,3
30	6,3	7,9	9,3	13,0	12,7	16,2	13,1	13,9	12,6	7,9	5,8	4,3

MODEL



1- PROBABILITY CULICOIDES GETTING INFECTED

Estimation of longevity

TEMPERATURE	January	February	March	April	May	June	July	August	September	October	November	December
1	7,9	5,9	5,9	11,2	13,3	15,2	19,1	16,4	15,6	12,7	8,2	7,7
2	4,5	6,4	5,7	11,3	13,1	16,7	17,0	16,4	16,0	14,0	10,9	8,0
3	5,5	7,2	7,8	7,2	14,2	16,9	14,5	17,0	13,6	15,0	11,5	6,5
4	7,4	5,7	8,8	6,1	15,1	17,8	13,7	19,0	11,4	15,5	9,1	5,7
5	7,6	4,8	8,6	7,9	14,7	18,6	14,6	21,8	11,4	12,6	7,6	9,6
6	8,5	2,3	8,2	10,3	14,4	19,3	15,3	22,1	14,4	10,6	6,9	9,3
7	7,5	1,4	6,9	8,4	12,8	22,3	15,8	17,5	14,9	10,0	7,6	9,1
8	8,3	0,2	6,3	9,3	12,5	23,0	16,9	15,4	14,8	10,0	8,9	5,2
9	12,0	1,0	6,1	10,7	12,0	20,4	14,4	15,9	14,1	10,6	4,5	6,5
10	10,7	3,3	7,9	11,5	15,0	20,0	13,9	17,1	12,6	11,1	5,6	5,5
11	6,9	3,2	9,1	11,9	12,9	19,9	13,9	17,2	13,4	10,1	6,7	4,7
12	8,6	5,5	8,4	13,9	13,2	18,5	15,8	17,8	13,5	11,3	4,3	5,6
13	10,4	7,2	7,7	16,4	16,0	18,8	19,9	17,7	15,2	10,5	3,7	5,2
14	7,1	6,8	7,4	18,2	14,3	19,1	23,2	19,3	13,9	9,8	1,9	1,0
15	3,4	5,6	7,4	18,7	11,2	18,0	24,5	21,6	13,7	11,9	0,8	0,0
16	5,6	6,1	8,2	18,3	10,4	16,4	25,6	17,1	15,1	13,7	1,8	-2,1
17	9,1	5,8	6,6	13,0	9,8	17,9	21,0	14,7	15,5	12,2	2,9	-0,9
18	10,4	6,1	2,6	8,8	13,4	17,7	20,0	15,7	11,1	8,2	3,2	-1,5
19	9,8	4,4	3,0	10,3	15,7	20,4	19,0	16,9	10,3	6,5	2,9	-1,7
20	10,3	4,1	3,0	8,7	17,5	20,9	19,3	15,8	13,1	4,7	5,5	-3,0
21	6,0	5,5	3,1	8,5	19,3	16,5	18,0	15,6	14,7	5,7	7,1	-3,9
22	2,4	6,6	4,2	13,0	18,0	15,8	17,1	16,5	15,0	3,5	7,7	-3,5
23	-3,0	7,5	6,4	15,0	17,4	15,6	16,4	18,0	16,4	4,0	6,0	-1,3
24	3,4	8,9	6,7	17,4	16,7	17,4	18,9	19,0	16,9	4,3	5,4	1,0
25	-2,8	8,2	10,5	19,4	20,2	16,7	17,7	19,3	12,0	7,6	4,4	-0,3
26	-2,2	7,3	10,3	19,3	16,8	12,8	20,0	18,4	10,2	7,7	3,0	0,6
27	1,9	6,4	10,5	18,2	15,4	12,8	18,5	16,0	10,6	7,9	3,4	2,5
28	4,3	5,5	9,1	18,4	12,1	14,0	17,4	14,1	12,1	8,1	2,4	4,2
29	5,9	9,0	6,7	15,1	10,7	14,6	14,7	13,4	12,1	8,0	3,0	5,3
30	6,3	7,9	9,3	13,0	12,7	16,2	15,1	13,9	12,6	7,9	5,8	4,3

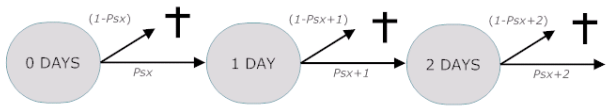
Daily temperatures

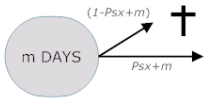
$$m_r(T) = 0{,}009 * exp\ (0{,}16 * T)$$

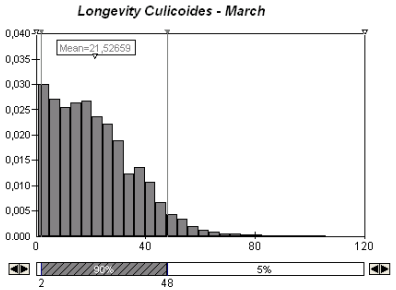
$$P_S = exp\ (-m_r)$$

DAILY PROBABILITY OF SURVIVAL	January	February	March	April	May	June	July	August	September	October	November	December
1	0,97	0,98	0,98	0,95	0,93	0,90	0,83	0,88	0,90	0,93	0,97	0,97
2	0,98	0,98	0,98	0,95	0,93	0,88	0,87	0,88	0,89	0,92	0,95	0,97
3	0,98	0,97	0,97	0,97	0,92	0,87	0,91	0,87	0,92	0,91	0,95	0,97
4	0,97	0,98	0,96	0,98	0,90	0,86	0,92	0,83	0,95	0,90	0,96	0,98
5	0,97	0,98	0,96	0,97	0,91	0,84	0,91	0,75	0,95	0,94	0,97	0,96
6	0,97	0,99	0,97	0,95	0,91	0,82	0,90	0,74	0,91	0,95	0,97	0,96
7	0,97	0,99	0,97	0,97	0,93	0,73	0,89	0,86	0,91	0,96	0,97	0,96
8	0,97	0,99	0,98	0,96	0,94	0,70	0,87	0,90	0,91	0,96	0,96	0,98
9	0,94	0,99	0,98	0,95	0,94	0,79	0,91	0,89	0,92	0,95	0,98	0,97
10	0,95	0,98	0,97	0,95	0,91	0,80	0,92	0,87	0,93	0,95	0,98	0,98
11	0,97	0,99	0,96	0,94	0,93	0,80	0,92	0,87	0,93	0,96	0,97	0,98
12	0,96	0,98	0,97	0,92	0,93	0,84	0,89	0,86	0,93	0,95	0,98	0,98
13	0,95	0,97	0,97	0,88	0,89	0,83	0,81	0,86	0,93	0,95	0,98	0,99
14	0,97	0,97	0,97	0,85	0,91	0,83	0,69	0,82	0,92	0,96	0,99	0,99
15	0,98	0,98	0,97	0,84	0,95	0,85	0,63	0,75	0,92	0,94	0,99	0,99
16	0,98	0,98	0,97	0,85	0,95	0,88	0,58	0,87	0,90	0,92	0,99	0,99
17	0,96	0,98	0,97	0,93	0,96	0,85	0,77	0,91	0,90	0,94	0,99	0,99
18	0,95	0,98	0,99	0,96	0,93	0,86	0,80	0,89	0,95	0,97	0,99	0,99
19	0,96	0,98	0,99	0,95	0,90	0,79	0,83	0,87	0,95	0,97	0,99	0,99
20	0,95	0,98	0,99	0,96	0,86	0,77	0,82	0,69	0,93	0,98	0,98	0,99
21	0,98	0,98	0,99	0,97	0,82	0,88	0,85	0,90	0,91	0,98	0,97	1,00
22	0,99	0,97	0,98	0,93	0,83	0,89	0,87	0,88	0,91	0,98	0,97	0,99
23	0,99	0,97	0,98	0,89	0,86	0,90	0,88	0,85	0,88	0,98	0,98	0,99
24	0,99	0,97	0,96	0,87	0,81	0,86	0,89	0,83	0,89	0,98	0,99	0,99
25	0,99	0,97	0,93	0,84	0,80	0,88	0,86	0,84	0,94	0,97	0,99	0,99
26	0,99	0,97	0,95	0,82	0,88	0,93	0,80	0,84	0,95	0,97	0,99	0,99
27	0,99	0,98	0,95	0,85	0,90	0,93	0,84	0,89	0,95	0,97	0,98	0,99
28	0,98	0,98	0,96	0,84	0,94	0,92	0,86	0,92	0,94	0,97	0,99	0,98
29	0,98	0,96	0,96	0,90	0,95	0,91	0,91	0,93	0,94	0,97	0,99	0,98
30	0,96	0,96	0,96	0,93	0,93	0,89	0,93	0,92	0,93	0,96	0,96	0,96

Daily probabilities of survival







Estimation of biting rate

TEMPERATURE	January	February	March	April	May	June	July	August	September	October	November	December
1	7,9	5,9	5,9	11,2	13,3	15,2	19,1	16,4	15,6	12,7	8,2	7,7
2	4,5	6,4	5,7	11,3	13,1	16,7	17,0	16,4	16,0	14,0	10,9	8,0
3	5,5	7,2	7,8	7,2	14,2	16,9	14,5	17,0	13,6	15,0	11,5	6,5
4	7,4	5,7	8,8	6,1	15,1	17,8	13,7	19,0	11,4	15,5	9,1	5,7
5	7,6	4,8	8,6	7,9	14,7	18,6	14,6	21,8	11,4	12,6	7,6	9,6
6	8,5	2,3	8,2	10,3	14,4	19,3	15,3	22,1	14,4	10,6	6,9	9,3
7	7,5	1,4	6,9	8,4	12,8	22,3	15,8	17,5	14,9	10,0	7,6	9,1
8	8,3	0,2	6,3	9,3	12,5	23,0	16,9	15,4	14,8	10,0	8,9	5,2
9	12,0	1,0	6,1	10,7	12,0	20,4	14,4	15,9	14,1	10,6	4,5	6,5
10	10,7	3,3	7,9	11,5	15,0	20,0	13,9	17,1	12,6	11,1	5,6	5,5
11	6,9	3,2	9,1	11,9	12,9	19,9	13,9	17,2	13,4	10,1	6,7	4,7
12	8,6	5,5	8,4	13,9	13,2	18,5	15,8	17,8	13,5	11,3	4,3	5,6
13	10,4	7,2	7,7	16,4	16,0	18,8	19,9	17,7	15,2	10,5	3,7	5,2
14	7,1	6,8	7,4	18,2	14,3	19,1	23,2	19,3	13,9	9,8	1,9	1,0
15	3,4	5,6	7,4	18,7	11,2	18,0	24,5	21,6	13,7	11,9	0,8	0,0
16	5,6	6,1	8,2	18,3	10,4	16,4	25,6	17,1	15,1	13,7	1,8	-2,1
17	9,1	5,8	6,6	13,0	9,8	17,9	21,0	14,7	15,5	12,2	2,9	-0,9
18	10,4	6,1	2,6	8,8	13,4	17,7	20,0	15,7	11,1	8,2	3,2	-1,5
19	9,8	4,4	3,0	10,3	15,7	20,4	19,0	16,9	10,3	6,5	2,9	-1,7
20	10,3	4,1	3,0	8,7	17,5	20,9	19,3	15,8	13,1	4,7	5,5	-3,0
21	6,0	5,5	3,1	8,5	19,3	16,5	18,0	15,6	14,7	5,7	7,1	-3,9
22	2,4	6,6	4,2	13,0	18,0	15,8	17,1	16,5	15,0	3,5	7,7	-3,5
23	-3,0	7,5	6,4	15,0	17,4	15,6	16,4	18,0	16,4	4,0	6,0	-1,3
24	3,4	8,9	6,7	17,4	16,7	17,4	18,9	19,0	16,9	4,3	5,4	1,0
25	-2,8	8,2	10,5	19,4	20,2	16,7	17,7	19,3	12,0	7,6	4,4	-0,3
26	-2,2	7,3	10,3	19,3	16,8	12,8	20,0	18,4	10,2	7,7	3,0	0,6
27	1,9	6,4	10,5	18,2	15,4	12,8	18,5	16,0	10,6	7,9	3,4	2,5
28	4,3	5,5	9,1	18,4	12,1	14,0	17,4	14,1	12,1	8,1	2,4	4,2
29	5,9	9,0	6,7	15,1	10,7	14,6	14,7	13,4	12,1	8,0	3,0	5,3
30	6,3	7,9	9,3	13,0	12,7	16,2	15,1	13,9	12,6	7,9	5,8	4,3

Daily temperatures

$$b_r(T) = 0{,}000171 * T * (T - 3{,}6966) * (41{,}8699 - T)^{1/2{,}7056}$$

30	0,01	0,00	0,01	0,01	0,01	0,01	0,01	0,00	0,01	0,01	0,01	0,00
29	0,01	0,00	0,01	0,02	0,02	0,02	0,00	0,00	0,00	0,00	0,00	0,00
28	0,00	0,00	0,00	0,01	0,02	0,02	0,01	0,01	0,01	0,01	0,00	0,00
27	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,00
26	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
21	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
18	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
15	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
DURATION	0,97768	1,42768	2,27768	3,75	5,47	7,04	9,87	12,9375	15,96625	17,7125	19,95625	17,9125625

Daily probability of biting

MODEL

CULICOIDES INFECTED → **CULICOIDES SURVIVES EIP + TNBM** → EFFECTIVE TRANSMISSION TO HOST → RISK

2- PROBABILITY CULICOIDES SURVIVES EIP + TNBM

Estimation of the EIP

TEMPERATURE	January	February	March	April	May	June	July	August	September	October	November	December
1	7.9	5.9	5.9	11.2	13.3	15.2	19.1	16.4	15.4	11.7	8.1	7.7
2	4.5	6.4	5.7	11.3	13.1	16.7	17.3	16.4	14.1	14.5	11.8	8.3
3	5.5	7.2	7.3	7.2	14.2	16.9	14.5	17.0	13.4	15.3	10.5	6.5
4	7.4	5.7	6.0	6.1	13.1	17.9	13.7	19.0	12.4	15.5	9.1	5.7
5	7.6	4.8	8.6	7.9	14.7	19.6	14.4	21.9	11.4	12.4	7.4	9.4
6	9.5	2.3	9.2	10.3	16.4	19.5	15.1	23.1	14.4	13.6	6.9	9.3
7	7.5	1.4	6.9	8.4	12.8	22.3	15.8	17.5	14.9	12.8	7.4	9.1
8	6.3	3.0	6.3	9.3	11.5	23.5	16.9	15.4	14.8	11.1	8.9	5.2
9	10.0	1.8	4.1	10.7	12.3	20.4	14.4	15.9	14.1	11.6	4.5	6.5
10	10.7	3.2	4.1	11.3	15.9	19.5	13.8	17.1	13.4	10.1	5.4	5.7
11	6.7	5.5	9.1	11.9	11.7	19.9	13.7	17.2	13.4	10.1	6.7	4.7
12	8.8	5.6	8.1	11.9	11.9	18.5	13.8	17.1	13.4	10.1	6.7	4.7
13	10.4	7.2	7.7	14.4	14.3	18.6	14.3	17.7	13.2	13.5	3.7	3.2
14	7.1	6.0	7.4	18.2	14.3	19.1	23.2	19.3	13.9	9.8	1.9	1.0
15	2.4	5.6	7.4	18.7	11.2	18.6	24.5	21.6	13.7	11.9	0.9	-0.3
16	9.6	4.1	6.2	18.5	10.4	16.4	25.6	17.1	15.1	13.7	1.6	-2.1
17	5.1	5.9	6.6	13.9	9.8	17.9	21.9	16.7	15.9	11.2	2.9	-0.9
18	10.4	4.1	2.6	8.8	15.4	17.7	20.0	15.7	11.1	8.2	3.2	-1.5
19	9.6	4.4	3.0	10.3	15.7	23.4	18.3	16.7	11.3	6.5	2.9	-1.7
20	10.3	4.1	3.0	6.7	17.5	23.9	19.3	15.6	13.1	4.7	5.5	-3.0
21	6.0	5.5	3.1	5.5	19.5	16.5	18.3	15.6	14.7	5.7	7.1	-3.9
22	2.4	6.6	4.2	13.0	19.9	19.6	17.1	16.5	15.9	3.5	7.7	-3.9
23	-3.0	7.5	6.4	15.6	17.4	15.6	16.4	19.0	16.4	4.5	6.3	-1.3
24	-3.4	9.3	6.7	17.4	19.7	17.6	15.9	19.0	15.9	4.2	2.4	-1.0
25	-2.0	8.2	10.5	19.4	20.2	16.7	17.7	19.3	12.8	7.6	4.4	-0.3
26	-2.2	7.3	10.3	19.3	16.9	12.8	20.0	18.4	18.2	7.7	3.3	0.6
27	1.9	6.4	10.5	18.2	15.4	12.9	18.5	16.0	18.6	7.9	3.4	2.5
28	4.5	9.5	9.1	18.4	12.1	14.0	17.4	14.1	12.1	8.1	2.4	4.2
29	5.9	9.0	6.7	15.1	13.7	14.6	14.7	13.4	12.1	8.3	3.3	3.3
30	6.0	7.9	9.3	13.0	12.7	16.2	13.1	13.9	12.4	7.9	5.9	4.3

Daily temperatures

$v_r(T) = 0{,}0003 \times T \times (T - 10{,}4057)$

VIROGENESIS RATE	January	February	March	April	May	June	July	August	September	October	November	December
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Virogenesis rate

$EIP(T) = 1/v_r(T)$

EIP	January	February	March	April	May	June	July	August	September	October	November	December
1	1000	1000	1000	1000	87	44	23	34	40	107	1000	1000
2	1000	1000	1000	1000	94	52	30	34	37	44	1000	1000
3	1000	1000	1000	1000	42	30	57	30	74	48	268	1000
4	1000	1000	1000	1000	47	26	73	20	244	43	1000	1000
5	1000	1000	1000	1000	52	22	54	14	107	123	1000	1000
6	1000	1000	1000	1000	59	19	45	13	59	1000	1000	1000
7	1000	1000	1000	1000	112	13	39	27	58	1000	1000	1000
8	1000	1000	1000	1000	135	11	59	43	70	1000	1000	1000
9	171	1000	1000	1000	179	14	97	38	44	1000	1000	1000
10	1000	1000	1000	277	49	17	44	20	118	459	1000	1000
11	1000	1000	1000	302	164	18	69	29	61	1000	1000	1000
12	1000	1000	1000	74	97	22	59	25	66	345	1000	1000
13	1000	1000	1000	54	91	31	30	26	64	1000	1000	1000
14	1000	1000	1000	55	67	26	31	16	98	1000	1000	1000
15	1000	1000	1000	21	148	24	30	14	79	182	1000	1000
16	1000	1000	1000	23	1000	34	9	29	47	71	1000	1000
17	1000	1000	1000	131	1000	25	15	38	42	149	1000	1000
18	1000	1000	1000	1000	84	26	35	40	445	1000	1000	1000
19	1000	1000	1000	1000	45	18	23	70	1000	1000	1000	1000
20	1000	1000	1000	1000	27	15	39	39	94	1000	1000	1000
21	1000	1000	1000	1000	19	10	28	41	58	1000	1000	1000
22	1000	1000	1000	96	21	39	29	33	49	1000	1000	1000
23	1000	1000	1000	39	27	41	34	25	34	1000	1000	1000
24	1000	1000	1000	28	18	26	38	20	38	1000	1000	1000
25	1000	1000	1000	19	17	32	26	20	171	1000	1000	1000
26	1000	1000	1000	19	31	111	17	23	1000	1000	1000	1000
27	1000	1000	1000	24	43	339	22	37	1000	1000	1000	1000
28	1000	1000	1000	23	147	47	27	63	163	1000	1000	1000
29	1000	1000	1000	43	1000	54	53	82	165	1000	1000	1000
30	1000	1000	1000	99	195	35	34	69	119	1000	1000	1000

EIP

A *Culicoides* infected on day x was assumed to complete a proportion (P_{EIPx+1}) of the *EIP* on the following day

$$P_{EIP\,x+1} = 1/EIP_{x+1}$$

And a proportion (P_{EIPx+2}) of the *EIP* the day after ($x+2$)

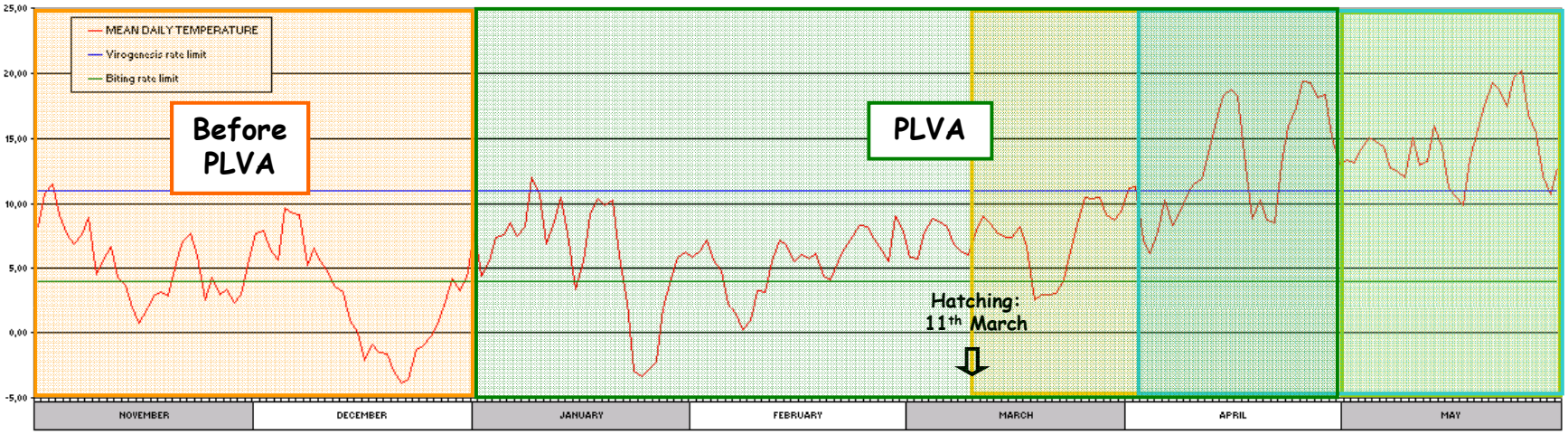
$$P_{EIP\,x+2} = 1/EIP_{EIP\,x+2}$$

EIP given by the sum of the number of days needed so that the summatory of these proportions reaches one (i.e. the *EIP* is completed):

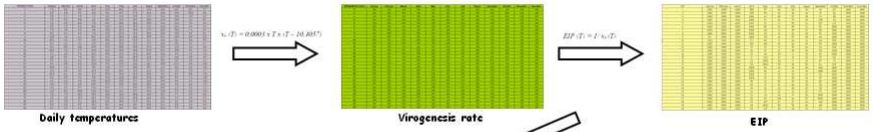
$$\sum_{j=x}^{\infty} P_{EIPj} = 1$$

Estimation of TNBM ≈ to EIP estimation

MODEL



Estimation of the EIP



A *Culicoides* infected on day *x* was assumed to complete a proportion (P_{EIPx+1}) of the *EIP* on the following day

$$P_{EIP\,x+1} = 1/\,EIP_{x+1}$$

And a proportion (P_{EIPx+2}) of the *EIP* the day after (*x+2*)

$$P_{EIP\,x+2} = 1/\,EIP_{EIP\,x+2}$$

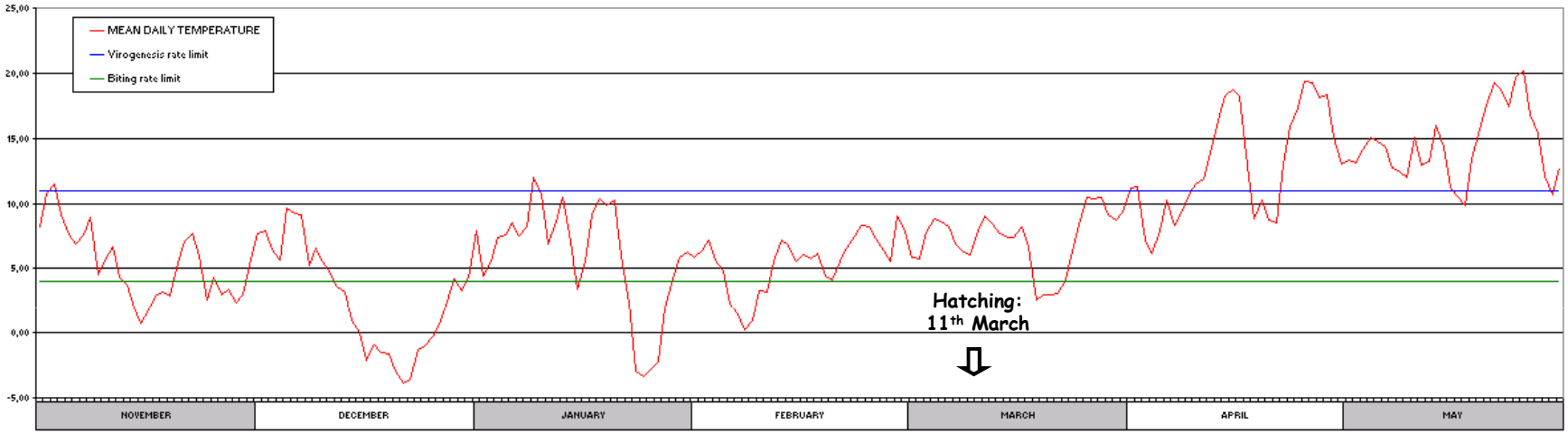
EIP given by the sum of the number of days needed so that the summatory of these proportions reaches one (i.e. the *EIP* is completed):

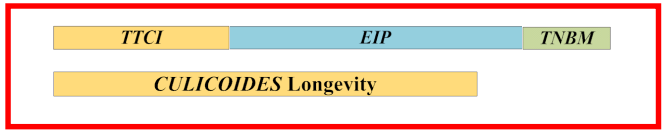
$$\sum_{j=x}^{\infty} P_{EIPj} = 1$$

TTCI	*EIP*	*TNBM*

CULICOIDES Longevity

MODEL





In the majority of cases, *Culicoides* do not live long enough to survive the EIP

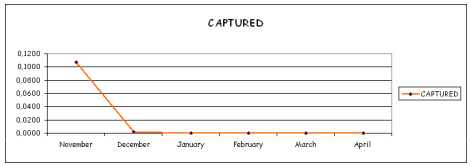
RESULTS

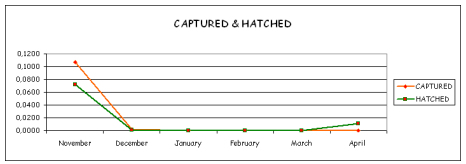
PER VECTOR (1 VECTOR)

Given a *Culicoides* which hatched in a given month, we estimated the probability of overwintering by the different pathways

WEIGHTED

By taking into account the number of *Culicoides* in the different months of study





November or April more weight on the (weighted) prob. of overwintering

EXOPHILY vs ENDOPHILY

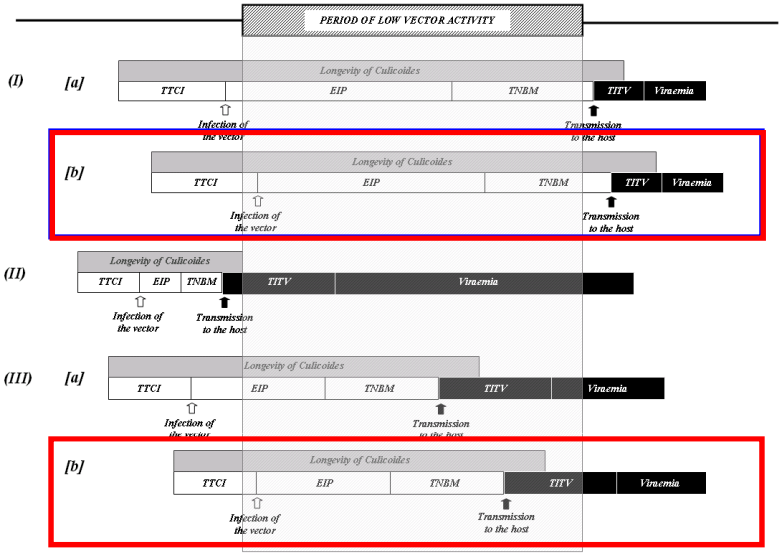
Exophily: *Culicoides* subjected to outside temperatures

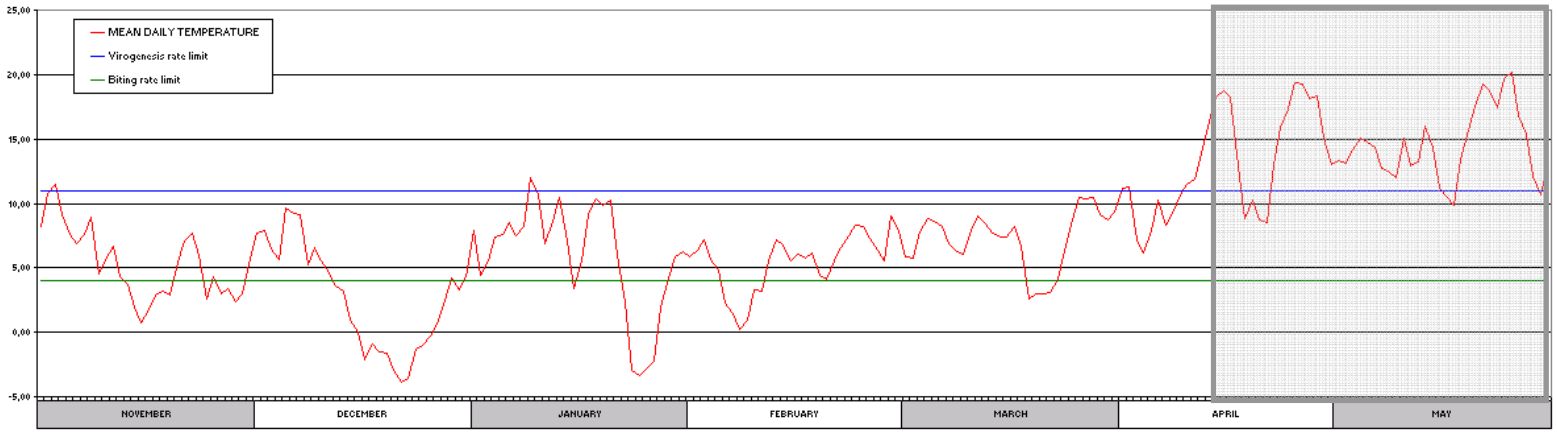
Endophily: A % of *Culicoides* subjected to (milder) inside temperatures

RESULTS

EXOPHILIC (1 vector)	Probability *Ia*	Probability *Ib*	Probability *IIIa*	Probability *IIIb*	TOTAL MONTHS
November	0	0	0	0	0
December	0	0	0	0	0
January	NA	$3,4 \times 10^{-9}$	NA	0	$3,4 \times 10^{-9}$
February	NA	$6,1 \times 10^{-8}$	NA	0	$6,1 \times 10^{-8}$
March	NA	$1,0 \times 10^{-7}$	NA	0	$1,0 \times 10^{-7}$
April	NA	$1,4 \times 10^{-7}$	NA	0	$1,4 \times 10^{-7}$

ENDOPHILIC (1 vector)	Probability *Ia*	Probability *Ib*	Probability *IIIa*	Probability *IIIb*	TOTAL MONTHS
November	0	0	0	0	0
December	0	0	0	0	0
January	NA	$5,4 \times 10^{-9}$	NA	$7,0 \times 10^{-8}$	$7,6 \times 10^{-8}$
February	NA	$3,1 \times 10^{-8}$	NA	$2,4 \times 10^{-7}$	$2,7 \times 10^{-7}$
March	NA	$1,5 \times 10^{-7}$	NA	$1,9 \times 10^{-7}$	$3,3 \times 10^{-7}$
April	NA	$1,9 \times 10^{-7}$	NA	$1,6 \times 10^{-8}$	$2,0 \times 10^{-7}$



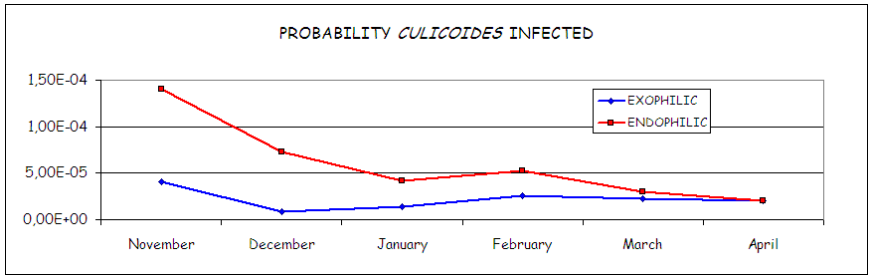


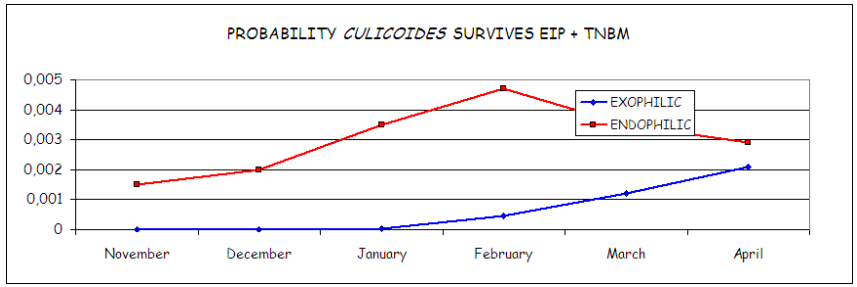
RESULTS

EXOPHILIC (WEIGHTED)	Probability *Ia*	Probability *Ib*	Probability *IIIa*	Probability *IIIb*	TOTAL MONTHS
November	0	0	0	0	0
December	0	0	0	0	0
January	NA	$2,6 \times 10^{-11}$	NA	0	$2,6 \times 10^{-11}$
February	NA	$9,7 \times 10^{-10}$	NA	0	$9,7 \times 10^{-10}$
March	NA	$1,2 \times 10^{-9}$	NA	0	$1,2 \times 10^{-9}$
April	NA	$1,4 \times 10^{-8}$	NA	0	$1,4 \times 10^{-8}$
TOTAL PATHWAYS	0	$1,6 \times 10^{-8}$	0	0	$1,6 \times 10^{-8}$

ENDOPHILIC (WEIGHTED)	Probability *Ia*	Probability *Ib*	Probability *IIIa*	Probability *IIIb*	TOTAL MONTHS
November	0	0	0	0	0
December	0	0	0	0	0
January	NA	$8,9 \times 10^{-10}$	NA	$2,8 \times 10^{-9}$	$3,7 \times 10^{-9}$
February	NA	$3,3 \times 10^{-10}$	NA	$4,2 \times 10^{-9}$	$4,5 \times 10^{-9}$
March	NA	$4,6 \times 10^{-9}$	NA	$4,2 \times 10^{-9}$	$8,8 \times 10^{-9}$
April	NA	$2,6 \times 10^{-8}$	NA	$4,8 \times 10^{-10}$	$2,7 \times 10^{-8}$
TOTAL PATHWAYS	0	$3,2 \times 10^{-8}$	0	$1,1 \times 10^{-8}$	$4,4 \times 10^{-8}$

Endophily seemed to favour overwintering, but its effect was limited





Endophily (milder Tª)

⇧ Number of BMs

⇩ Longevity

Endophily (milder Tª)

⇩ Duration of EIP & TNBM

⇩ Longevity

WORKPACKAGE 5

RISK ASSESSMENT

QUANTITATIVE ASSESSMENT OF THE RISK OF BTV BY CULICOIDES INTRODUCED VIA TRANSPORT AND TRADE NETWORKS

CReSA
Centre de Recerca en Sanitat Animal

S. Napp
A. Alba
I. García
A. Allepuz
J. Casal

IZS
G. CAPORALE
TERAMO

P. Calistri
A. Giovannini

Institute for Animal Health

S. Gubbins

INTRODUCTION

In August 2006, a bluetongue outbreak by BTV-8 was detected in the Netherlands

The strain, of sub-Saharan origin (Maan et al., 2008) entirely bypassed southern Europe (Carpenter et al., 2009).

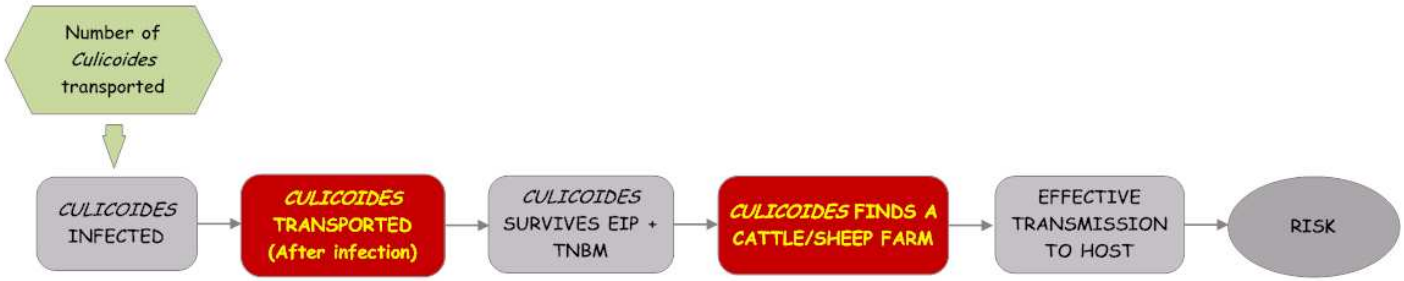
The most obvious mechanisms for BTV incursion into a free area, the importation of infected hosts or the transportation of infected *Culicoides* on airstreams seemed unlikely (Mintiens et al., 2008)

⇩

The potential for *Culicoides* to be imported along with or independently of the import of animals, plants or other 'materials', had to be considered.

MODEL

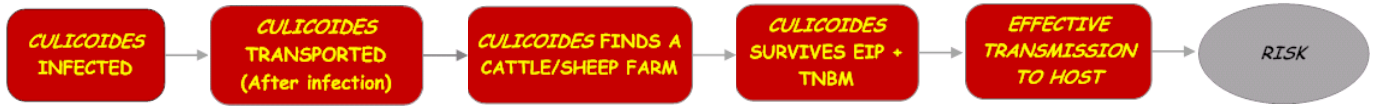
PATHWAY

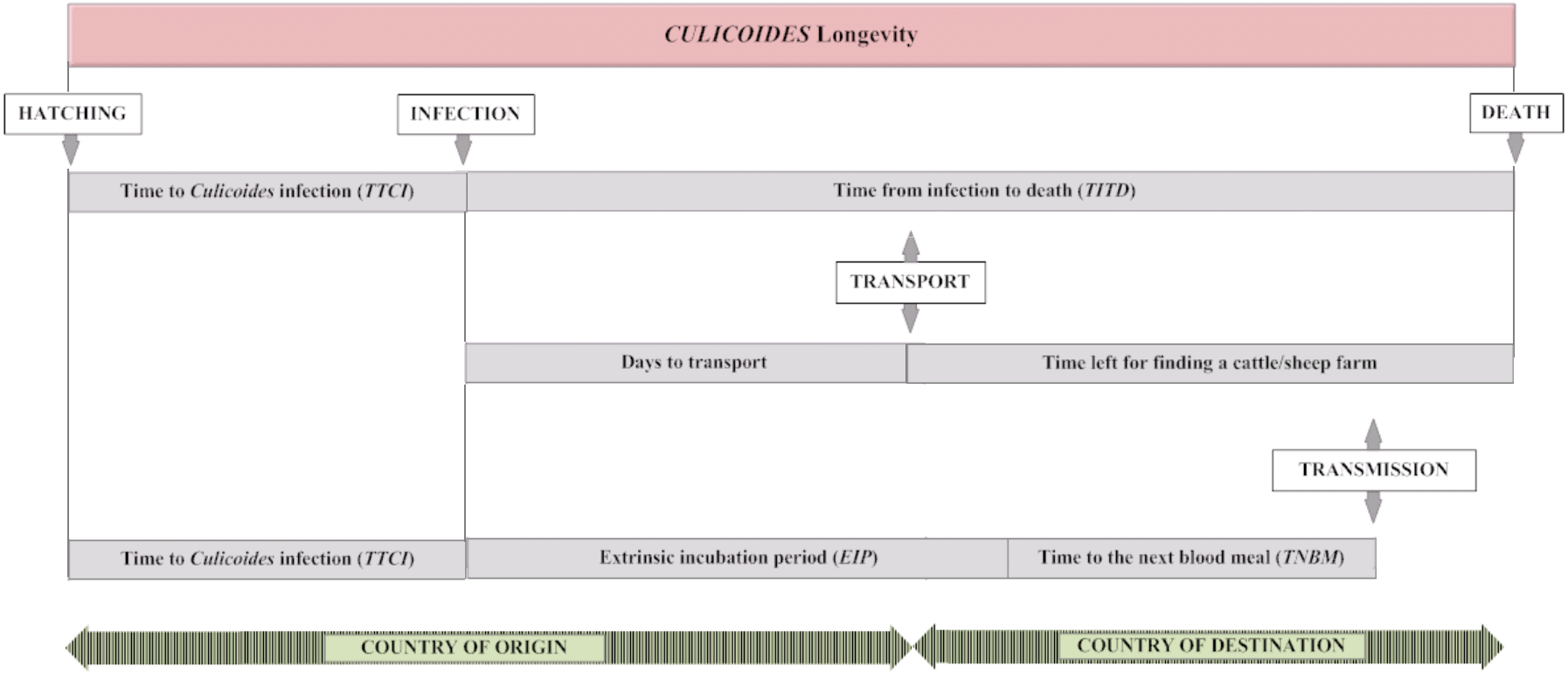


LIMITATIONS

- Number (probability) *Culicoides* carried via ≠ transport and trade networks is unknown
- Complexity of transport and trade networks
- Whether conditions during travel affect the viability of *Culicoides* is unknown
- Many of the parameters that determine the risk would be specific of the *Culicoides* species

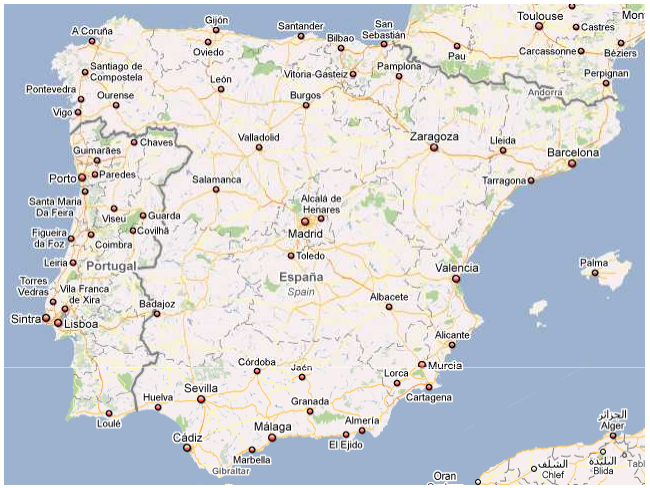
MODEL

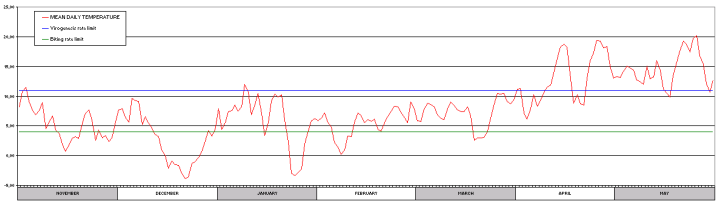

CULICOIDES INFECTED
CULICOIDES TRANSPORTED (After infection)
CULICOIDES FINDS A CATTLE/SHEEP FARM
CULICOIDES SURVIVES EIP + TNBM
EFFECTIVE TRANSMISSION TO HOST
RISK


CULICOIDES Longevity
HATCHING
INFECTION
DEATH
Time to Culicoides infection (TTCI)
Time from infection to death (TITD)
TRANSPORT
Days to transport
Time left for finding a cattle/sheep farm
TRANSMISSION
Time to Culicoides infection (TTCI)
Extrinsic incubation period (EIP)
Time to the next blood meal (TNBM)
COUNTRY OF ORIGIN
COUNTRY OF DESTINATION

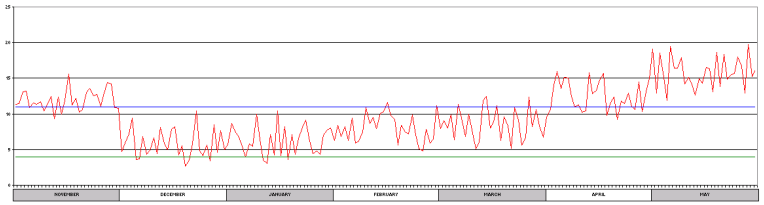
SCENARIO

Given the epidemic in North Rhine-Westphalia in 2006, probability of a BTV outbreak in Spain given transportation of 1 *Culicoides*



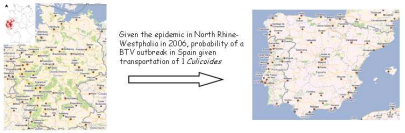


North Rhine-Westphalia

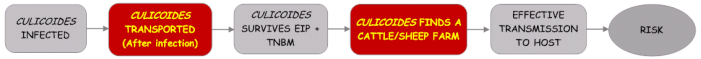


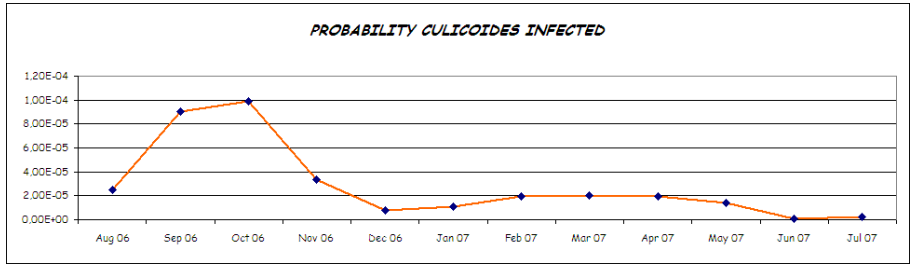
Spain

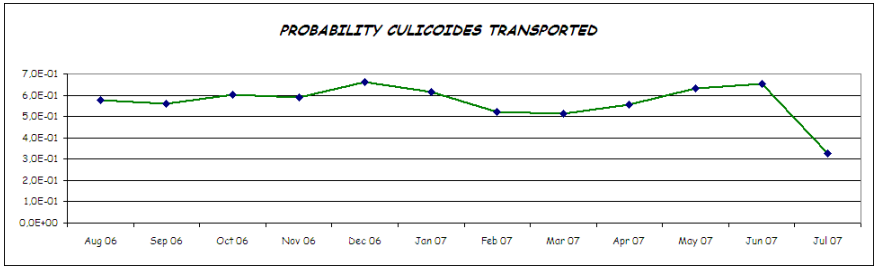

Medreonet
Surveillance Network of Reoviruses, Bluetongue and African Horse Sickness, in the Mediterranean Basin and Europe
Sixth Framework programme
044215
Scientific Support to Policies (SSP)

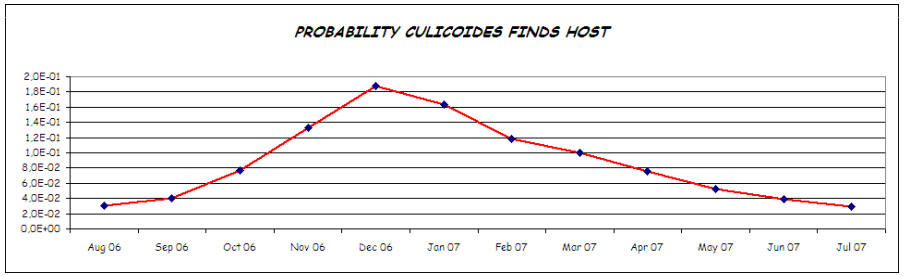

Given the epidemic in North Rhine-Westphalia in 2006, probability of a BTV outbreak in Spain given transportation of 1 Culicoides

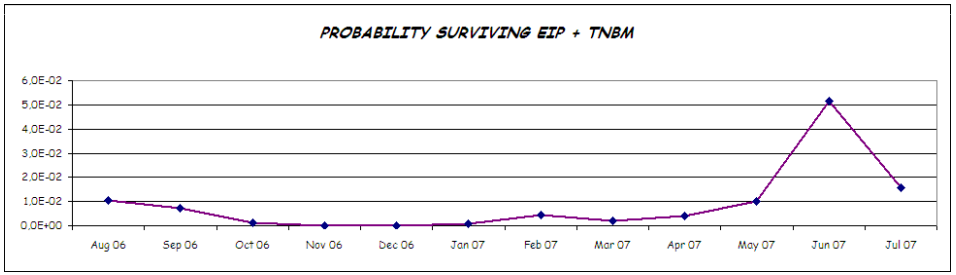
RESULTS

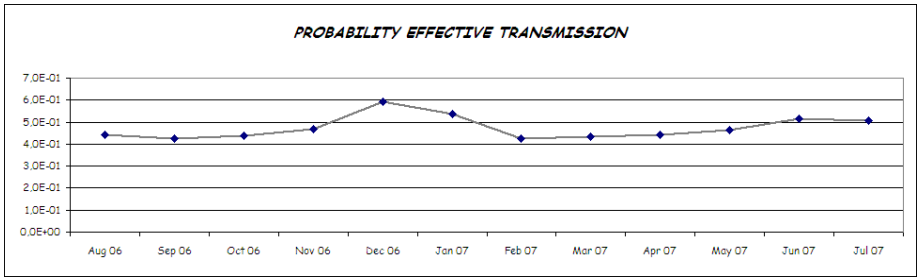

CULICOIDES INFECTED
CULICOIDES TRANSPORTED (After infection)
CULICOIDES SURVIVES EIP + TNBM
CULICOIDES FINDS A CATTLE/SHEEP FARM
EFFECTIVE TRANSMISSION TO HOST
RISK

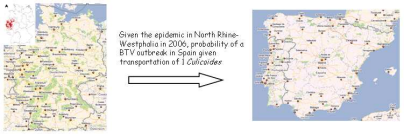

PROBABILITY CULICOIDES INFECTED
1,20E-04
1,00E-04
8,00E-05
6,00E-05
4,00E-05
2,00E-05
0,00E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07


PROBABILITY CULICOIDES TRANSPORTED
7,0E-01
6,0E-01
5,0E-01
4,0E-01
3,0E-01
2,0E-01
1,0E-01
0,0E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07

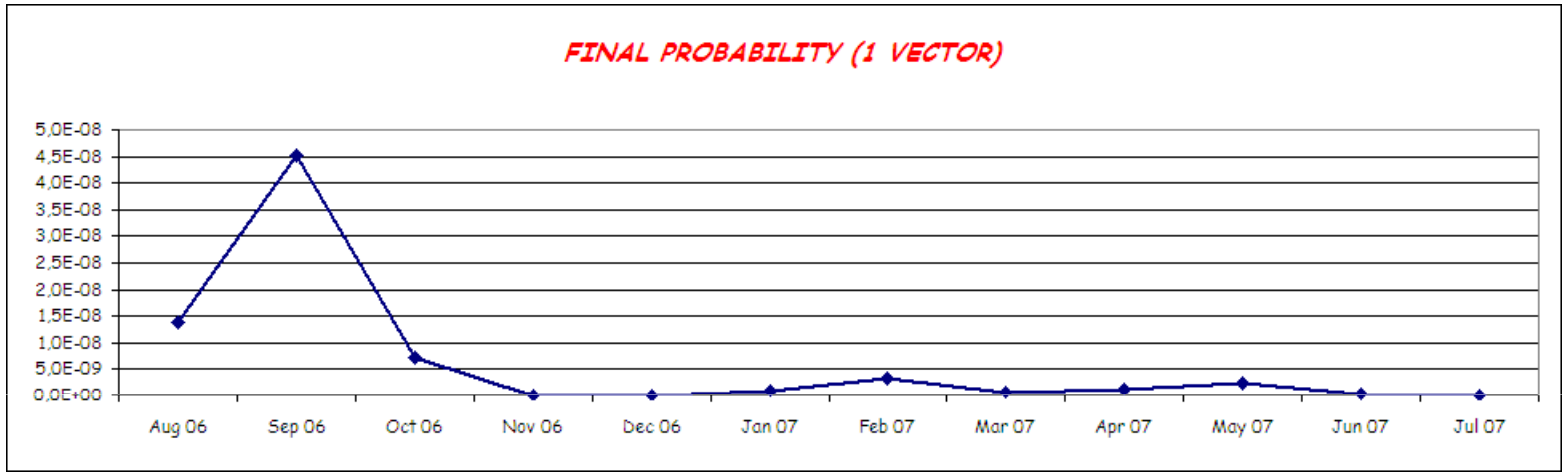

PROBABILITY CULICOIDES FINDS HOST
2,0E-01
1,8E-01
1,6E-01
1,4E-01
1,2E-01
1,0E-01
8,0E-02
6,0E-02
4,0E-02
2,0E-02
0,0E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07

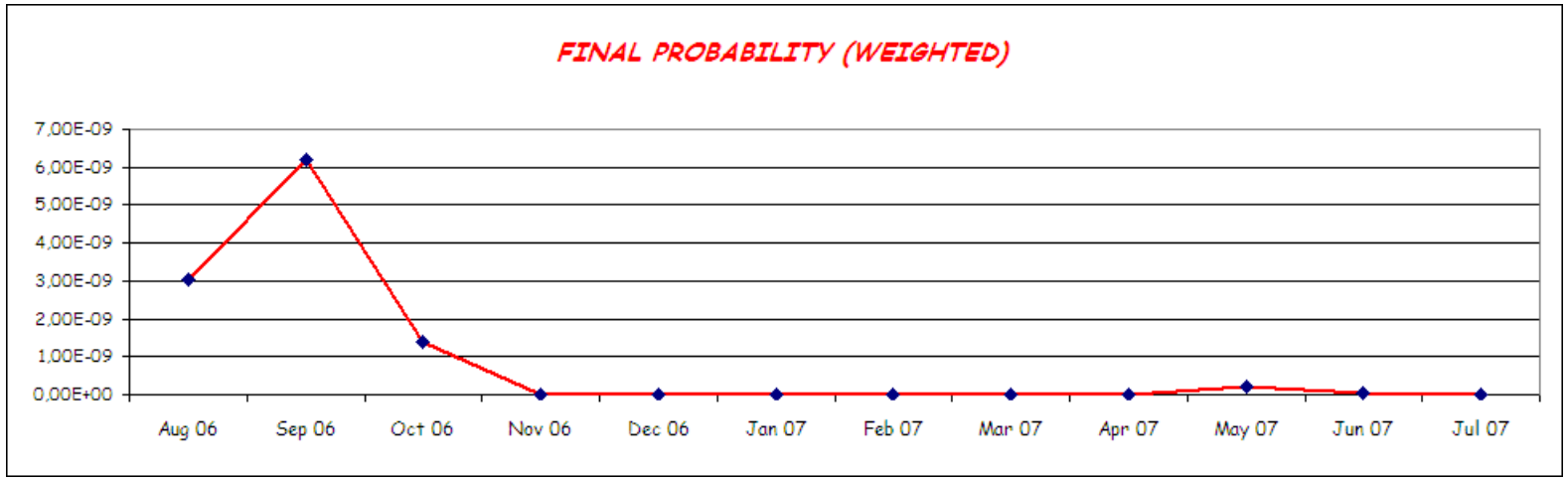

PROBABILITY SURVIVING EIP + TNBM
6,0E-02
5,0E-02
4,0E-02
3,0E-02
2,0E-02
1,0E-02
0,0E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07


PROBABILITY EFFECTIVE TRANSMISSION
7,0E-01
6,0E-01
5,0E-01
4,0E-01
3,0E-01
2,0E-01
1,0E-01
0,0E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07


Given the epidemic in North Rhine-Westphalia in 2006, probability of a BTV outbreak in Spain given transportation of 1 Culicoides

RESULTS


FINAL PROBABILITY (1 VECTOR)
5,0E-08
4,5E-08
4,0E-08
3,5E-08
3,0E-08
2,5E-08
2,0E-08
1,5E-08
1,0E-08
5,0E-09
0,0E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07


FINAL PROBABILITY (WEIGHTED)
7,00E-09
6,00E-09
5,00E-09
4,00E-09
3,00E-09
2,00E-09
1,00E-09
0,00E+00
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07

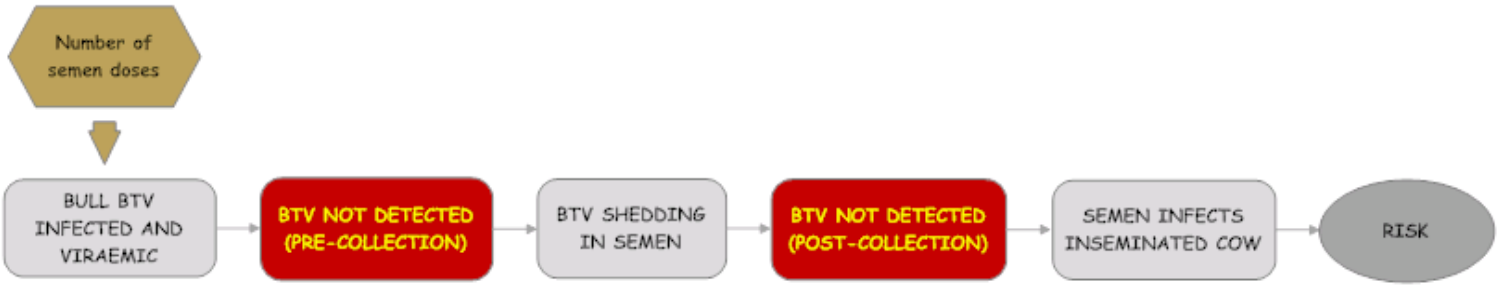
WORKPACKAGE 5

RISK ASSESSMENT

QUANTITATIVE ASSESSMENT OF THE PROBABILITY OF BLUETONGUE VIRUS TRANSMISSION BY SEMEN

MODEL

PATHWAY

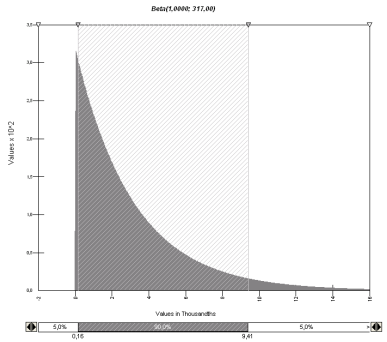


LIMITATIONS

- In the 1970s, Luedke et al., suggested that some bulls may excrete virus in their semen, but since then all the attempts to reproduce this finding failed

- Probability of virus shedding in semen based on the experiments by: Gard et al, (1989), Kirkland et al, (2004) and Phillips et al, (1986):

Out of 316 viraemic bulls, none shed BTV in semen => Beta distribution



INTRODUCTION

Commission Regulation (EC) No 1266/2007 (Annex III): Semen obtained from donor animals that:

(a) kept outside a restricted zone for > 60 days before semen collection

(b) protected against vectors for > 60 days before semen collection

(c) kept during the seasonally vector-free period in a BT seasonally-free zone for > 60 days before semen collection

(d) serological test according to the OIE with negative results, at least every 60 days during the collection period

(e) polymerase chain reaction test according to the OIE with negative results, at least every 28 days

INTRODUCTION

Commission Regulation (EC) No 1266/2007 (Annex III): Semen obtained from donor animals that:

(a) kept outside a restricted zone for > 60 days before semen collection

(b) protected against vectors for > 60 days before semen collection (90%)

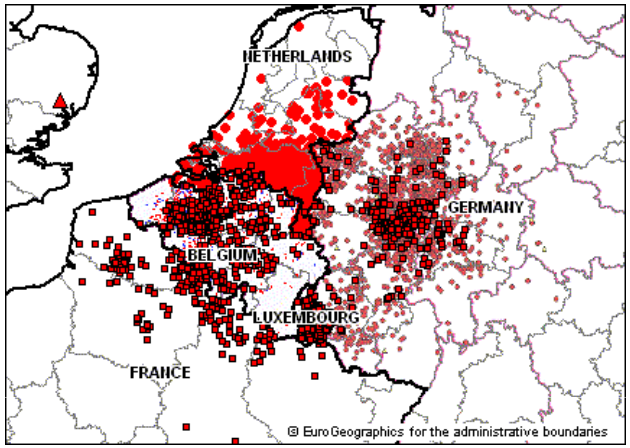
(c) kept during the seasonally vector-free period in a BT seasonally-free zone for > 60 days before semen collection

(d) serological test according to the OIE with negative results, at least every 60 days during the collection period

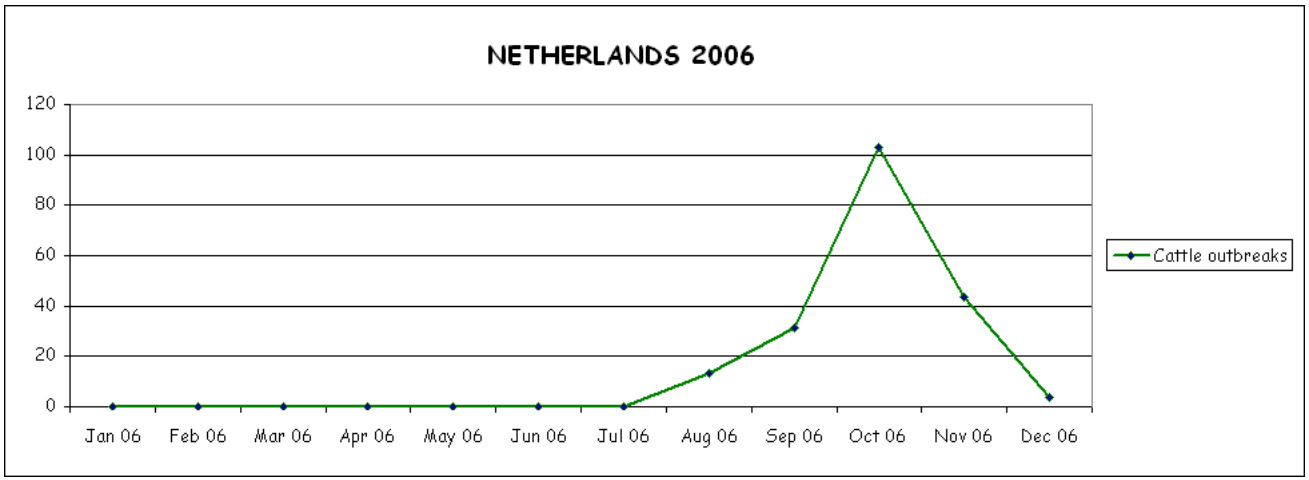
(e) polymerase chain reaction test according to the OIE with negative results, at least every 28 days

Aim: Assess the effectiveness of these preventive measures

SCENARIO

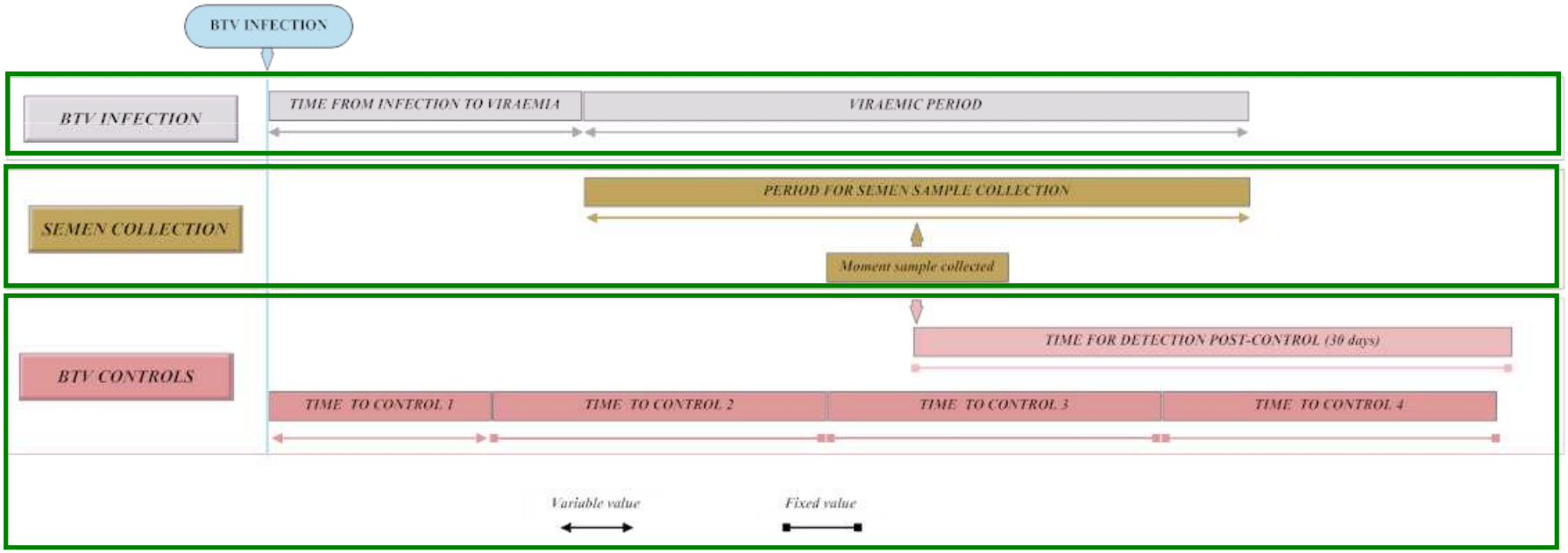


Based on the epidemics of BTV-8 in the Netherlands in 2006, estimation of the probability that results in an outbreak in another location as a consequence of the exportation of that semen



MODEL


BULL BTV INFECTED AND VIRAEMIC
BTV NOT DETECTED (PRE-COLLECTION)
BTV SHEDDING IN SEMEN
BTV NOT DETECTED (POST-COLLECTION)
SEMEN INFECTS INSEMINATED COW
RISK

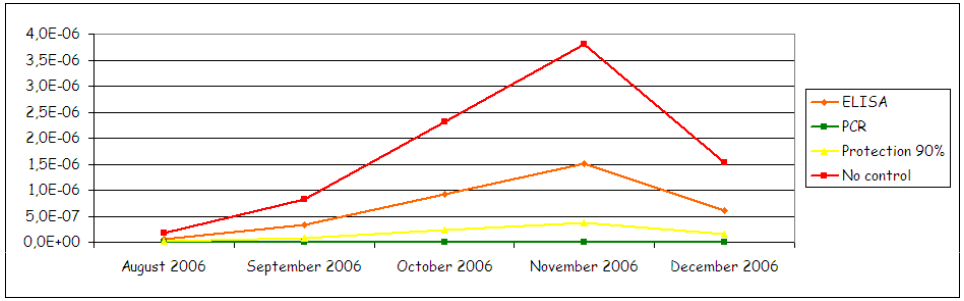

BTV INFECTION
BTV INFECTION
TIME FROM INFECTION TO VIRAEMIA
VIRAEMIC PERIOD
SEMEN COLLECTION
PERIOD FOR SEMEN SAMPLE COLLECTION
Moment sample collected
BTV CONTROLS
TIME FOR DETECTION POST-CONTROL (30 days)
TIME TO CONTROL 1
TIME TO CONTROL 2
TIME TO CONTROL 3
TIME TO CONTROL 4
Variable value
Fixed value

RESULTS

PROBABILITY OF BTV NOT DETECTED (BEFORE SEMEN COLLECTED)

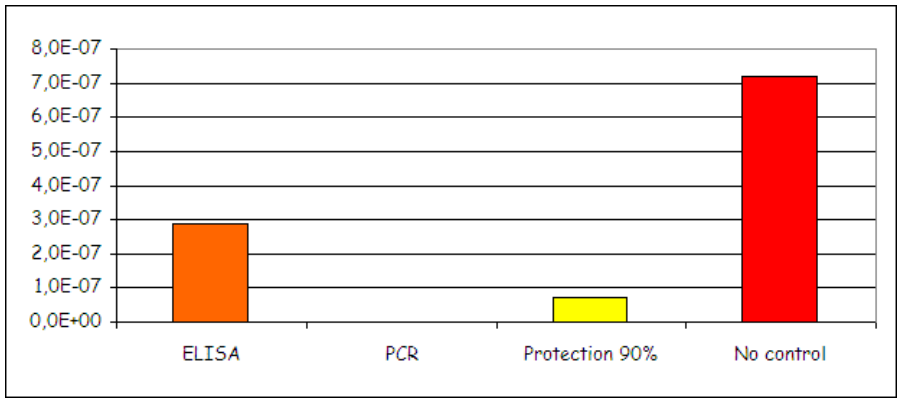
Results per month

NETHERLANDS	ELISA	PCR	Protection 90%	No control
August 2006	$6,8 \times 10^{-8}$	$2,2 \times 10^{-10}$	$1,7 \times 10^{-8}$	$1,7 \times 10^{-7}$
September 2006	$3,2 \times 10^{-7}$	$1,0 \times 10^{-9}$	$8,2 \times 10^{-8}$	$8,2 \times 10^{-7}$
October 2006	$9,1 \times 10^{-8}$	$2,9 \times 10^{-9}$	$2,3 \times 10^{-7}$	$2,3 \times 10^{-6}$
November 2006	$1,5 \times 10^{-6}$	$4,7 \times 10^{-9}$	$3,8 \times 10^{-7}$	$3,8 \times 10^{-6}$
December 2006	$6,1 \times 10^{-7}$	$1,9 \times 10^{-9}$	$1,5 \times 10^{-7}$	$1,5 \times 10^{-6}$



Results per year

NETHERLANDS	ELISA	PCR	Protection 90%	No control
Year 2006	$2,9 \times 10^{-7}$	$9,0 \times 10^{-10}$	$7,2 \times 10^{-8}$	$7,2 \times 10^{-7}$



Option (d): ELISA test: Risk reduction 2,5-fold

Option (e): PCR test: Risk reduction 800-fold

THANK YOU