

# Culicoides, livestock & wild deer

Community ecology to understand midge-borne disease transmission risk in the UK

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NATURAL ENVIRONMENT RESEARCH COUNCIL

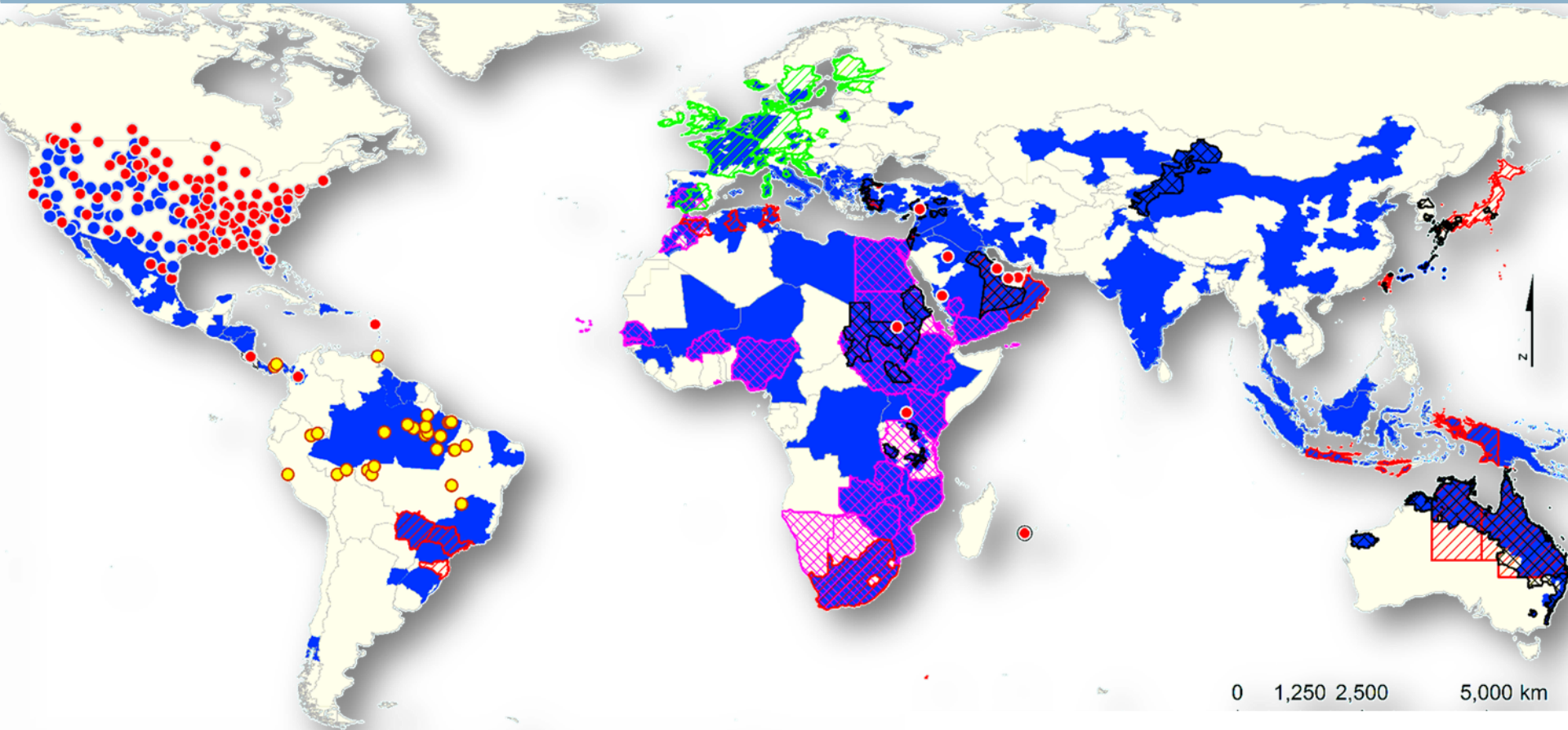


# *Culicoides* biting midges



# Culicoides-borne viral diseases

see *Purse et al 2015 Ann.Rev.Ent.*



Bluetongue virus (BTV)

Epizootic hemorrhagic disease virus (EHDV)

African horse sickness virus (AHSV)

Schmallenberg virus (SBV)

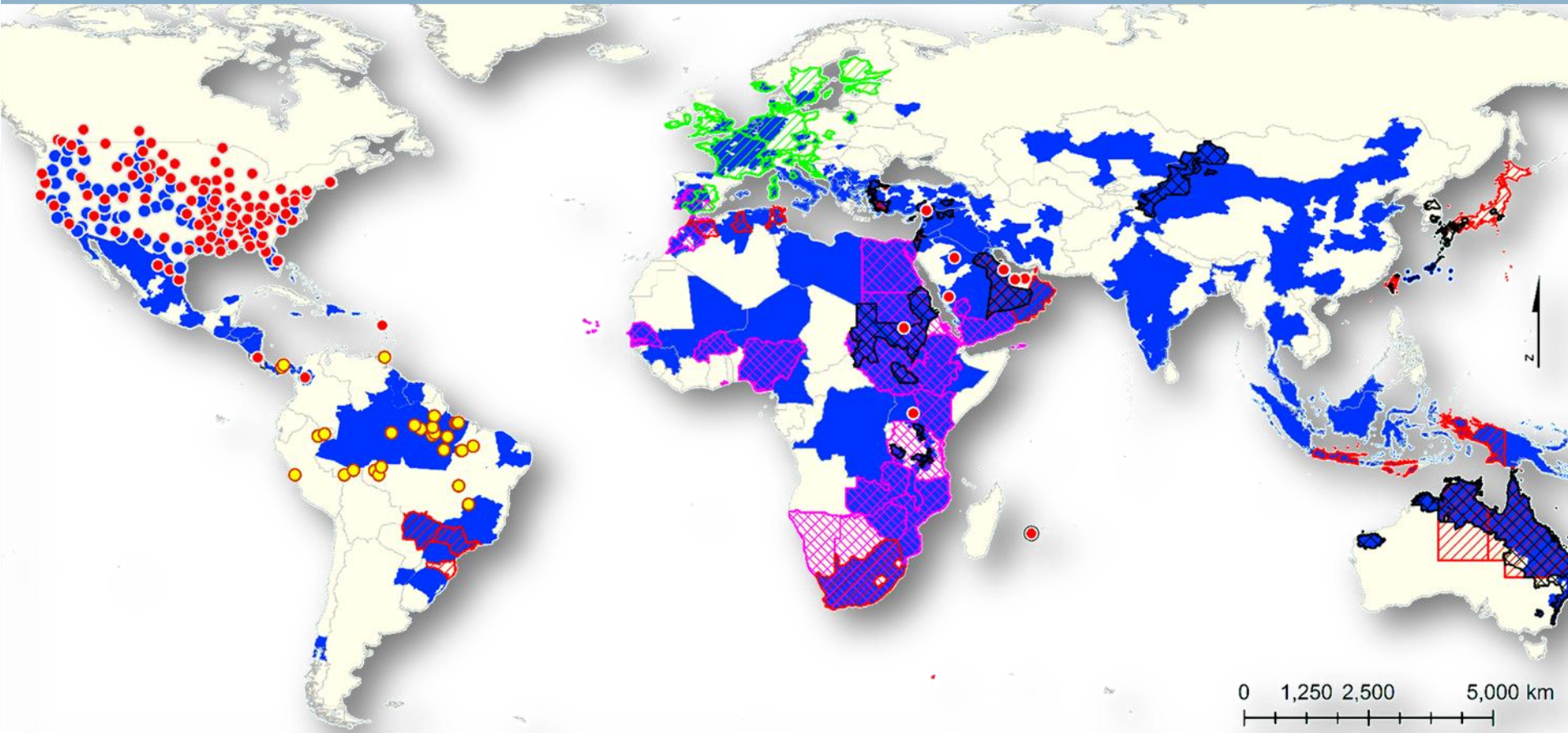
Akabane virus (AKAV)

Oropouche virus (OROV)



# Culicoides-borne viral diseases

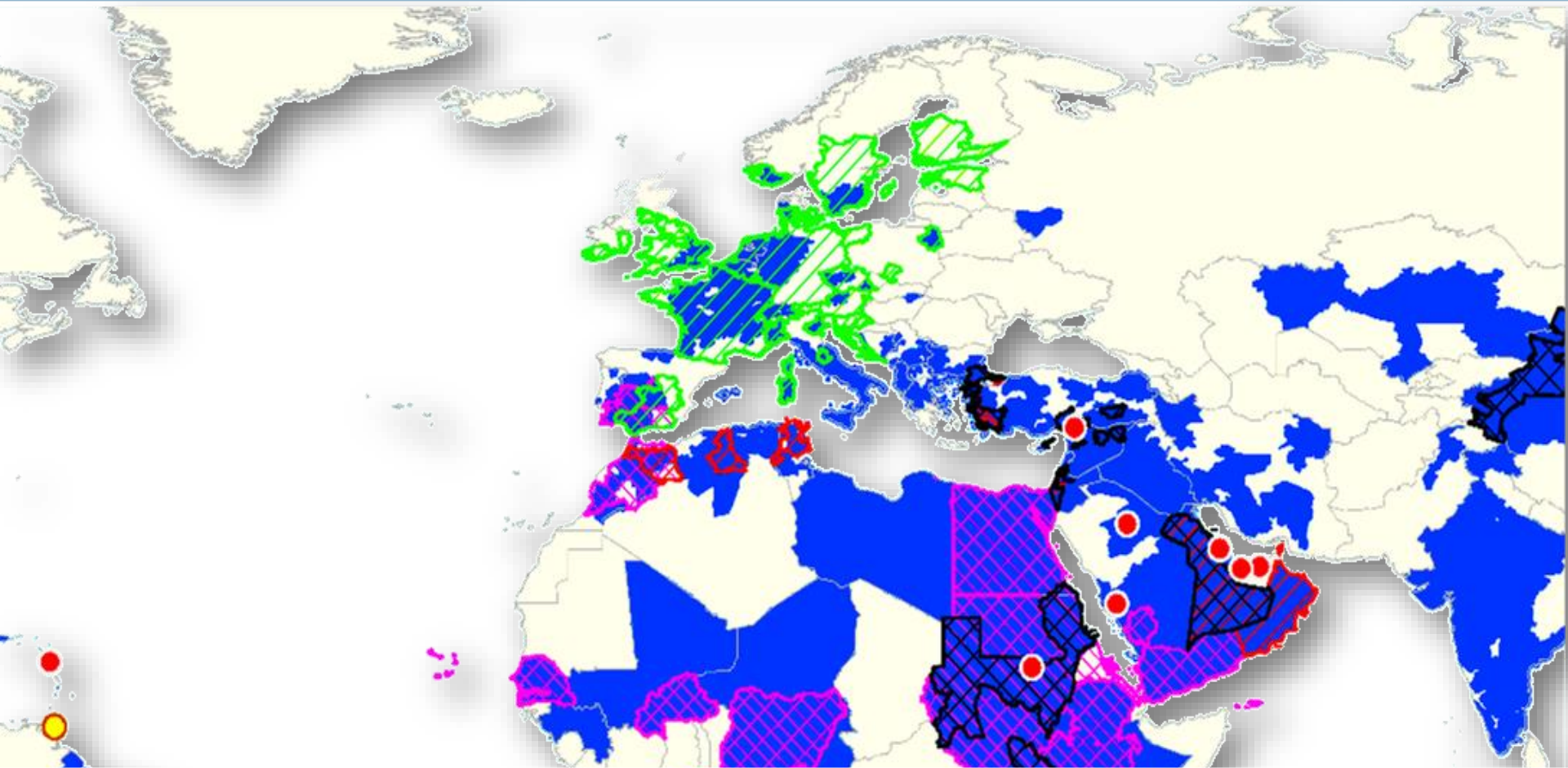
see *Purse et al 2015 Ann.Rev.Ent.*



Recent changes in geographical distribution  
and epidemiology.



# Unexpected disease incursions

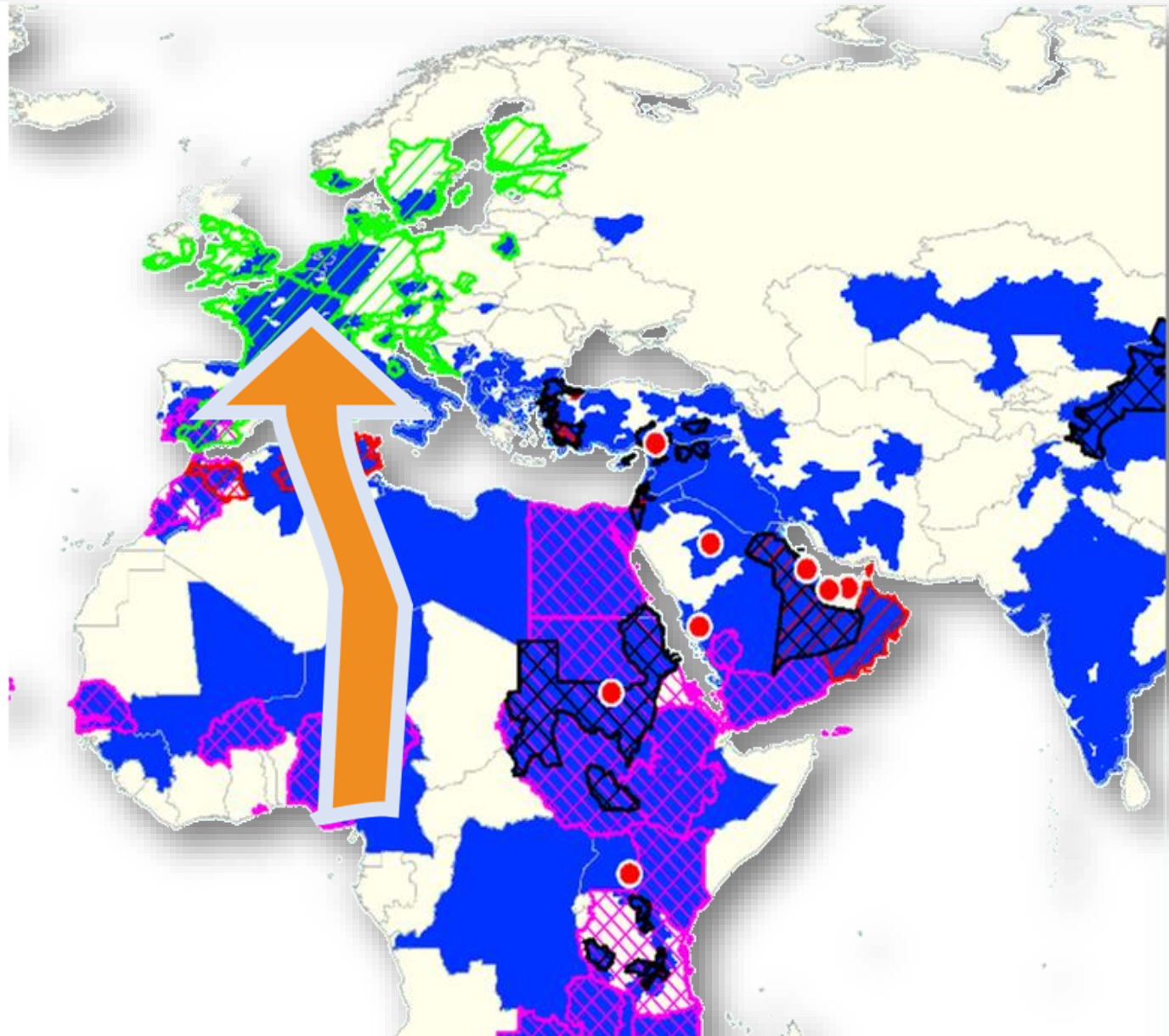


Two midge-borne viruses  
that emerged in Northern Europe.

# Unexpected disease incursions

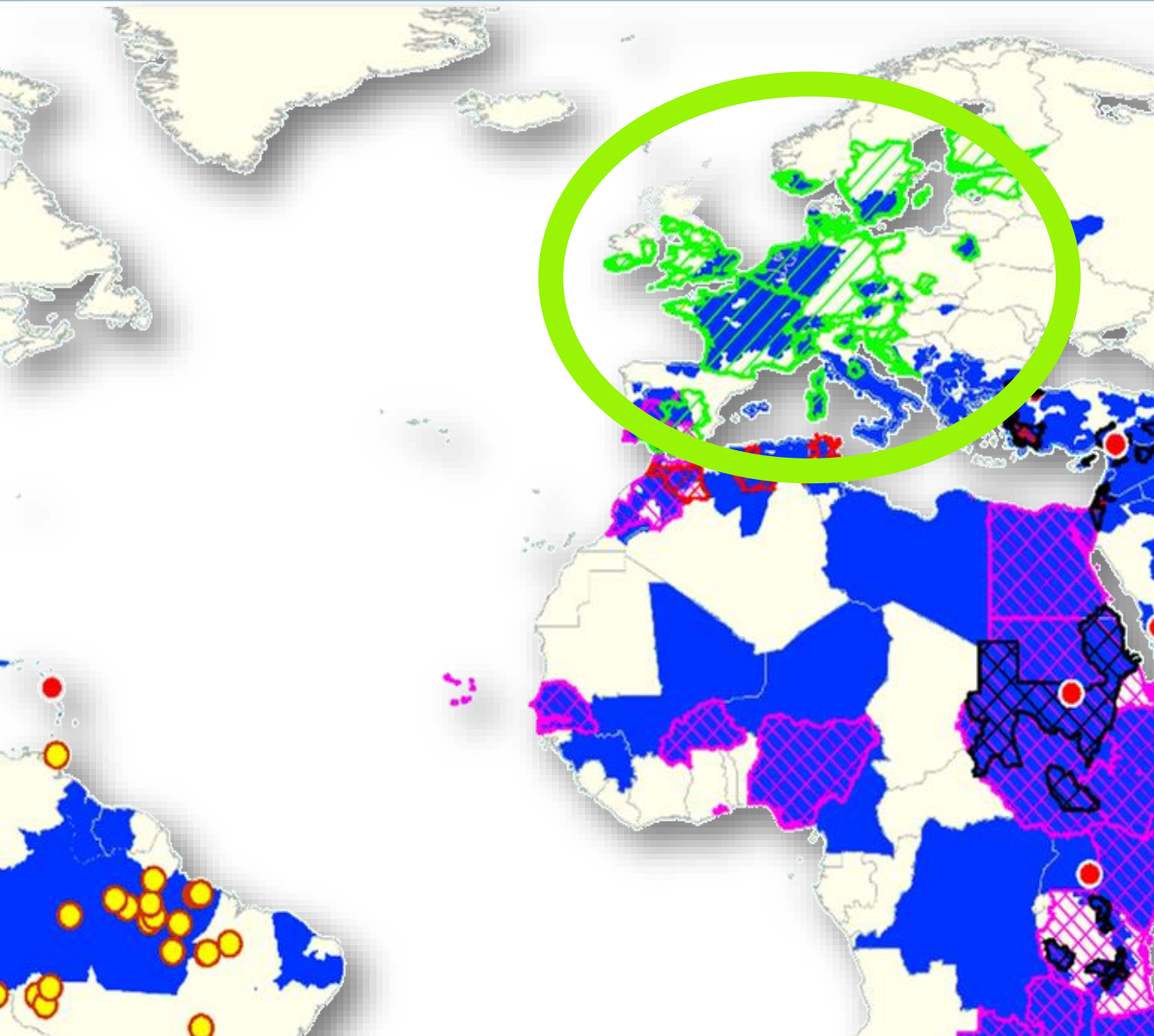
2006-2008:

Exotic  
Bluetongue  
Virus (BTV)





# Unexpected disease incursions



2011:

Novel  
Schmallenberg  
Virus (SBV)

# Midge-borne disease systems are dynamic and complex

- new *Culicoides* species and
- new hosts implicated in arbovirus transmission
- Increasing evidence that wildlife plays a role in livestock disease dissemination and maintenance



# Midge-borne disease systems are dynamic and complex



High infection prevalence of BTV and sustained viraemia in red deer suggests they act as reservoirs for bluetongue disease in Southern Europe.

# Knowledge gaps

Vectorial capacity of some *Culicoides* are not fully understood:

- some key vector species difficult to ID → sparse information on seasonal abundance dynamics



# Knowledge gaps

Vectorial capacity of some *Culicoides* are not fully understood:



Obsoletus group

first BTV isolation  
from *C. obsoletus*  
was from a Cypriot  
specimen

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- feeding behaviour of potential midge vectors not fully understood for all landscape contexts, especially with regards to wildlife.



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Seasonal movement patterns of wild deer populations in agricultural landscapes are understudied.

# CEH's Community Ecology Approach

Empirical field studies to

- assess midge community composition in areas used by domestic and wild ruminants (sheep, roe and red deer)
- quantify relative host preferences and biting rates of *Culicoides* species for sheep & deer

**Aim:** to identify indigenous bridge vectors and hosts.



# CEH's Community Ecology Approach

## Ecological modelling

- of the dynamics of midge populations
- landscape use by hosts
- identify where and when wild and domestic ruminants and key vectors overlap

**Aim: to predict midge-borne disease  
transmission risk hot spots**



# Midge fauna near different vertebrate hosts

Hopetoun House  
southern Scotland

1  2  3   
red deer

4  4   
roe deer 2  1   
3 

sheep  
3  4   
3  4 

Light trapping  
2 seasonal  
snapshots 2013 &  
2014

2   
1   
sheep





# Midge samples



**At least 94 light trap catches per host habitat type were processed**

# Midge samples

**50,610 midges from 289 light trap catches  
IDed morphologically**



# Digital, freely available ID key

www.iikculicoides.net



# IIRC

An Interactive Identification Key for  
(Diptera: Ceratopogonidae) from the



## How to use IIRC ?


IIRC



--> Windows (download  
the two files and run  
Setup\_IIRC.exe):  
[Setup IIRC](#)  
[Setup Xper](#)

--> Linux: [IIRC.tgz](#) / --> MacOS: [IIRC.zip](#)

## How to cite IIRC ?

 Mathieu B., Cêtre-Sossah C., Garros C., Chavernac D., Balenghien T., Carpenter S., Setier-Rio ML., Vignes-Lebbe R., Ung V., Candolfi E., Delécolle JC. Development and validation of IIRC: an interactive identification key for *Culicoides* (Diptera: Ceratopogonidae). *Journal of Medical Entomology* 2011; 48(1): 1-10.

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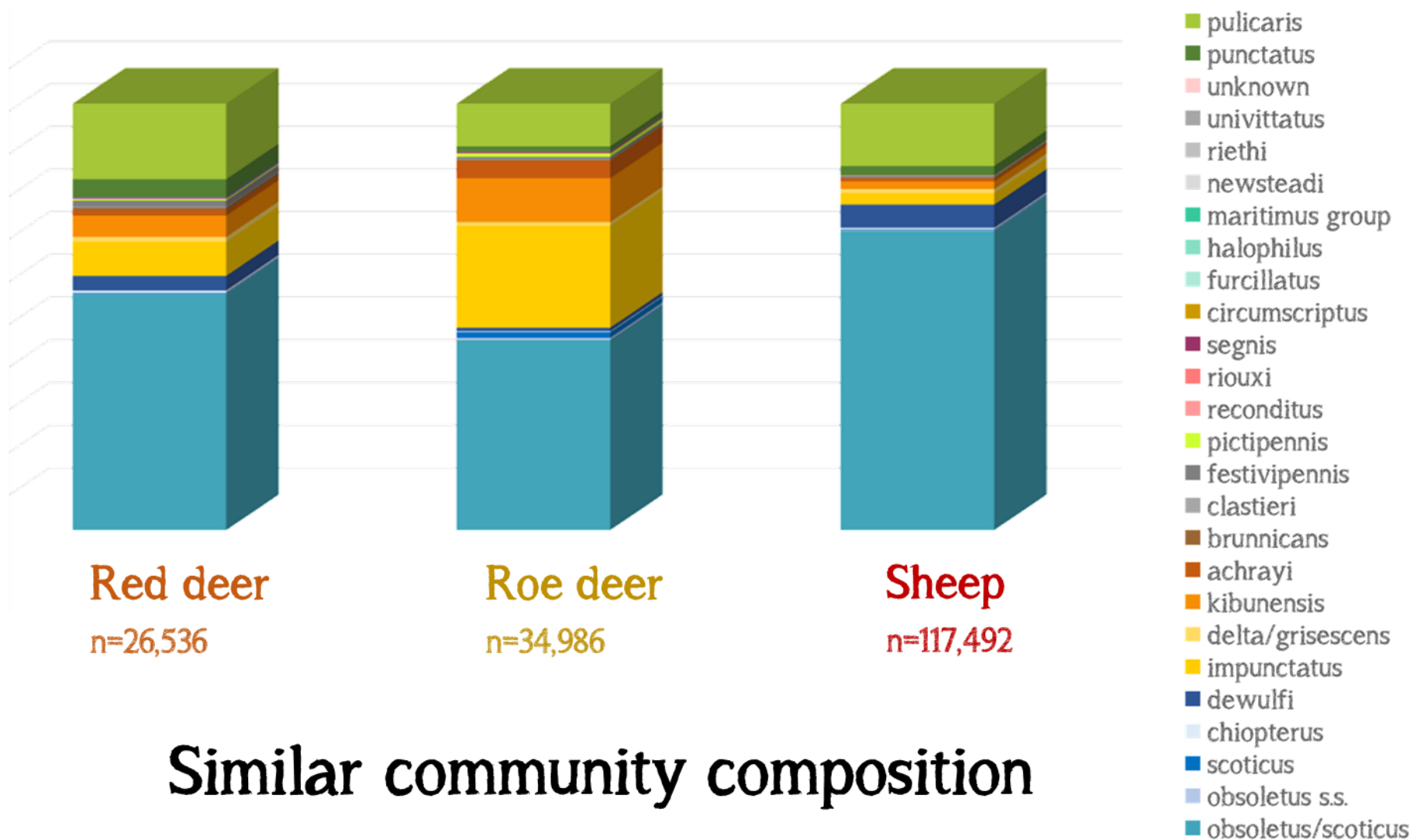
# Diversity of midge populations

**25 *Culicoides* species caught**

**19 of these were found  
near sheep, red and roe deer**

- pulicaris
- punctatus
- unknown
- univittatus
- riethi
- newsteadi
- maritimus group
- halophilus
- furcillatus
- circumscriptus
- segnis
- riouxi
- reconditus
- pictipennis
- festivipennis
- clastieri
- brunnicans
- achrayi
- kibunensis
- delta/grisescens
- impunctatus
- dewulfi
- chiopterus
- scoticus
- obsoletus s.s.
- obsoletus/scoticus

# Diversity of midge populations



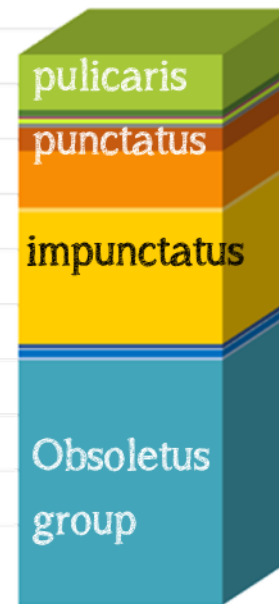
# Diversity of midge communities

- pulicaris
- punctatus
- kibunensis
- delta/grisescens
- impunctatus
- dewulfi
- chiopterus
- scoticus
- obsoletus s.s.
- obsoletus/scoticus



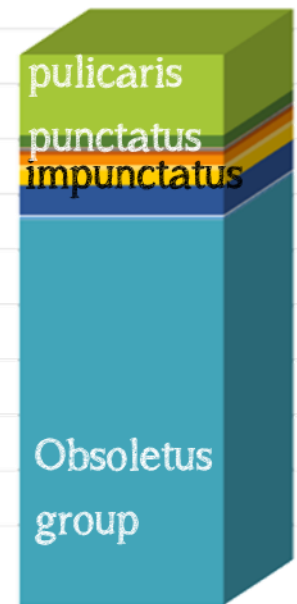
Red deer

n=26,536



Roe deer

n=34,986



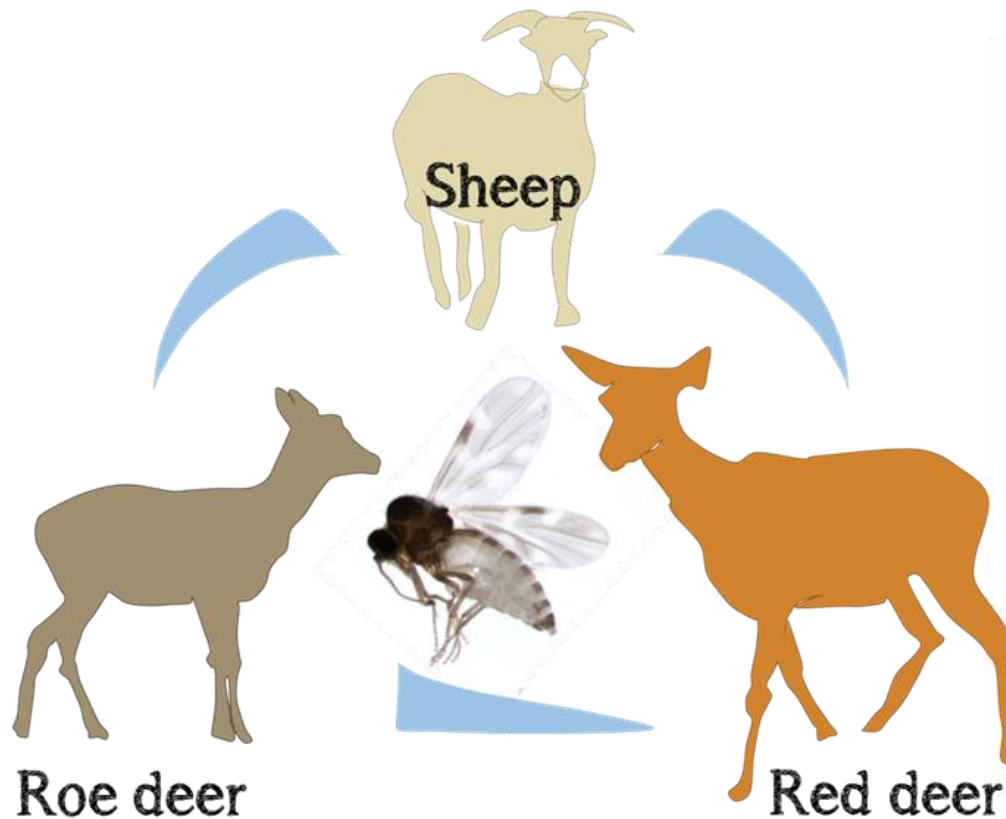
Sheep

n=117,492

**All 7 potential vectors of BTV in northern clines were present in all habitat types.**



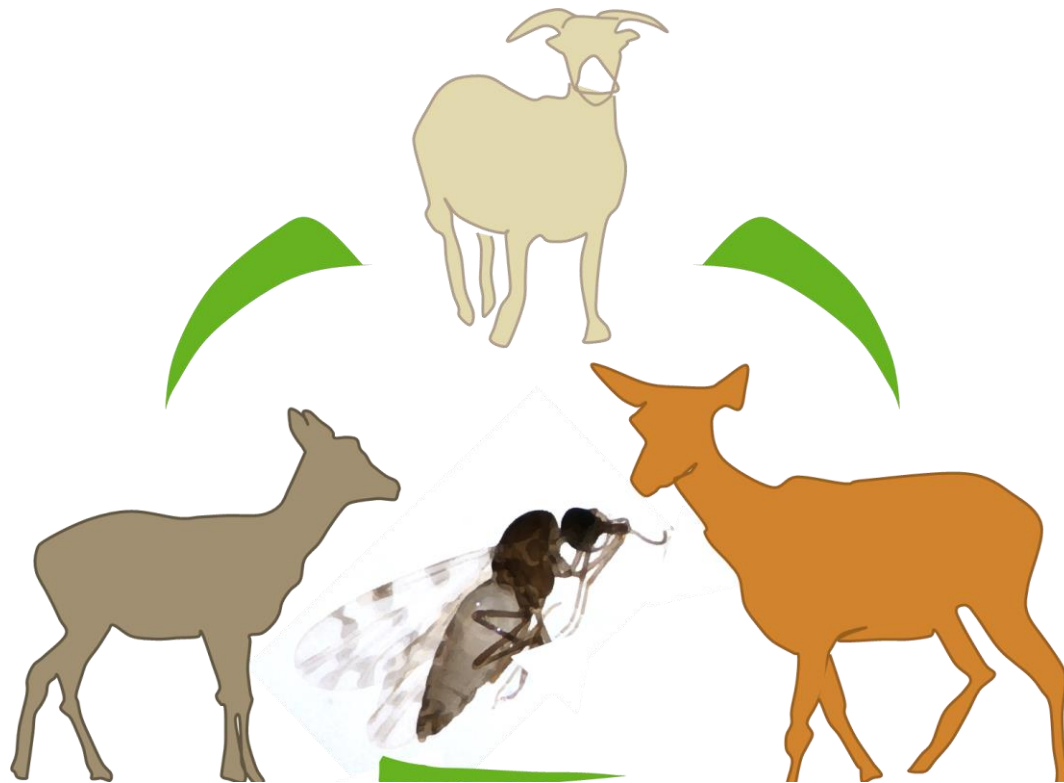
# Abundance – *C. obsoletus/scoticus*



- Most abundant in all habitats
- Abundance significantly higher in sheep habitat than in roe ( $P: < 0.001$ ) & red deer ( $P: < 0.001$ )

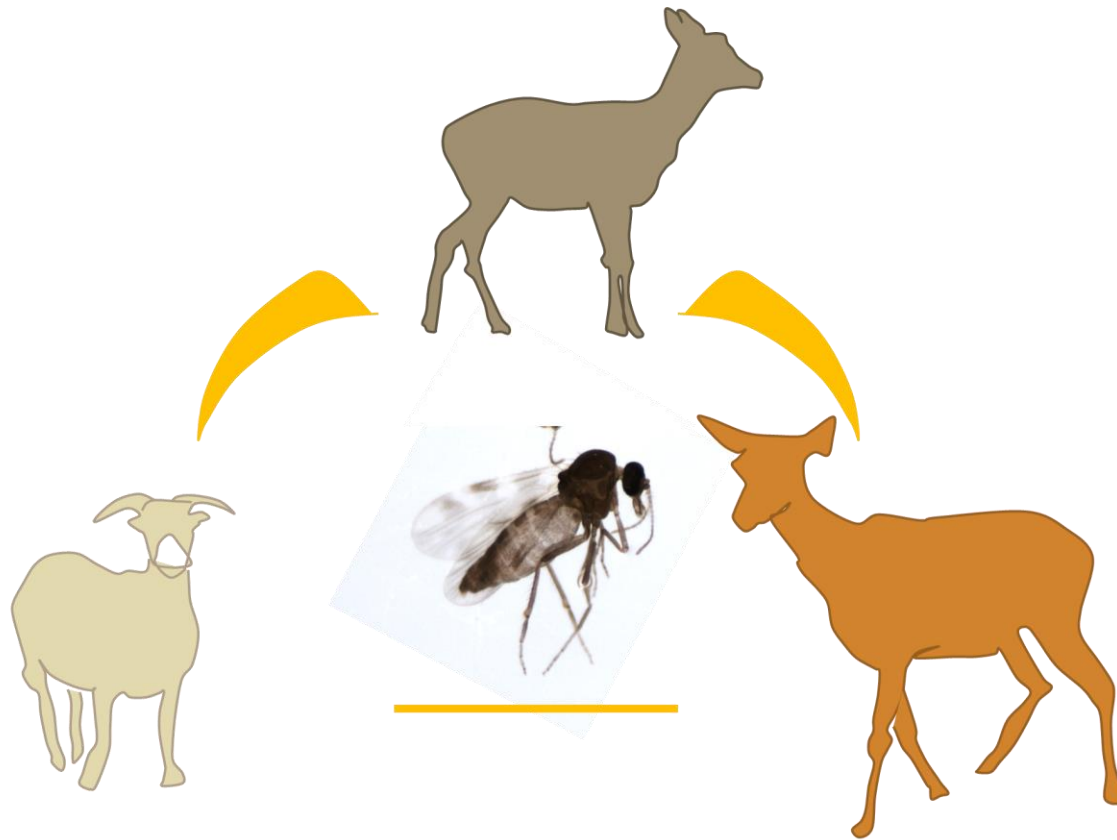
DNA barcoding to ID females to species level

# Abundance – *C. pulicaris*



Abundance significantly higher in sheep habitat than in roe ( $P: < 0.001$ ) & red deer ( $P: < 0.001$ )

# Abundance – *C. impunctatus*



Abundance significantly higher in roe habitat than red and sheep habitat (both  $P: <0.001$ )



# Potential bridge vector species?

- Three putative vectors, *C. obsoletus/scoticus* and *C. pulicaris* are highly abundant all three habitats.
- These 3 species have a broad host range and feed on different livestock species as well as deer.
- This host range overlap suggests there is potential for these midges to act as bridge vectors and transmit pathogens between domestic and wild ruminants.

# Assessing midge feeding behaviour

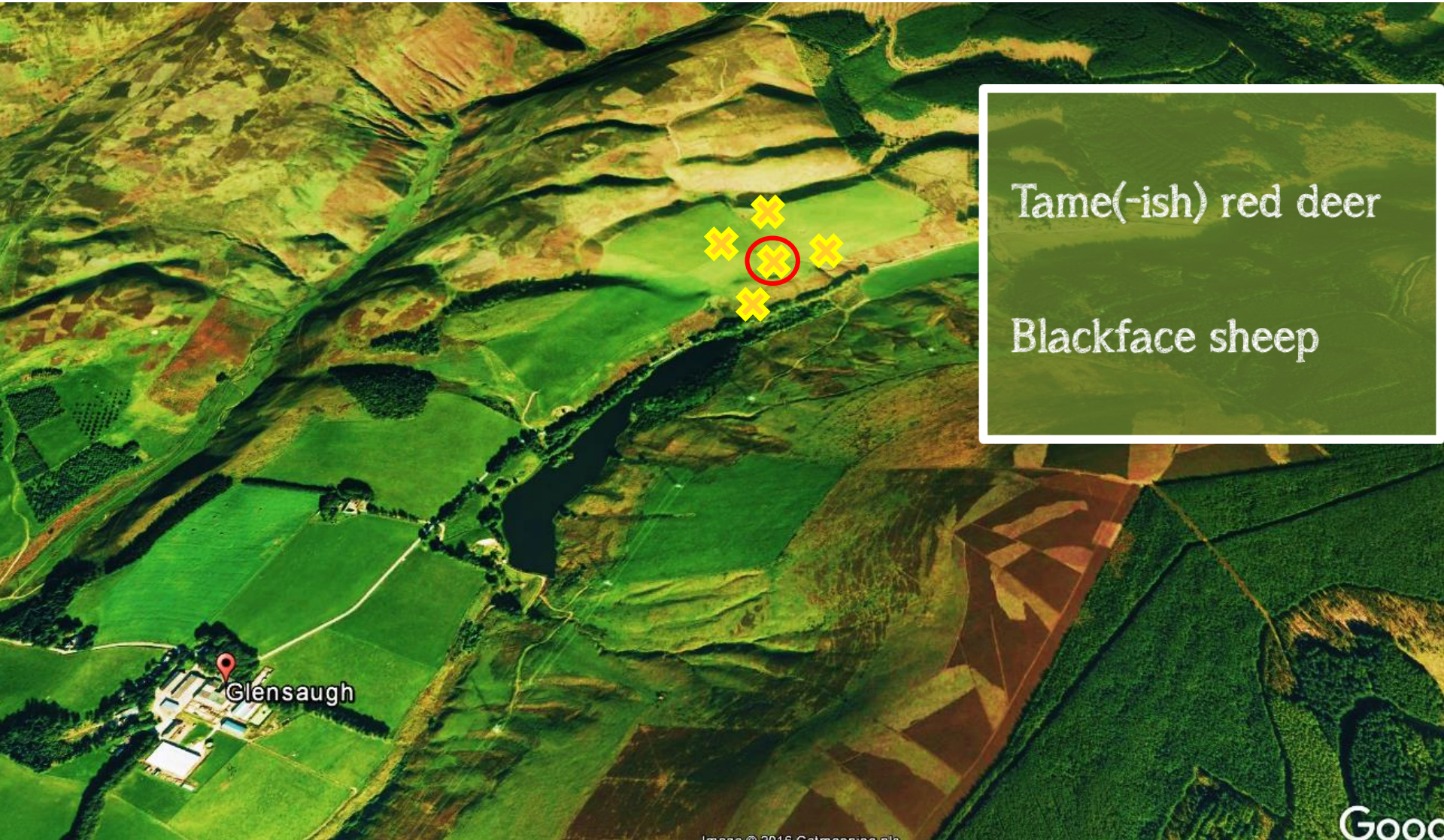
- Summer 2016: field experiment to quantify relative host preferences of *Culicoides* species for sheep *versus* red deer.
- Not previously been assessed in an European agricultural habitat.





# Glensaugh Research Farm

James Hutton Institute



Tame(-ish) red deer

Blackface sheep



# Glensaugh Research Farm

James Hutton Institute

Two adjacent enclosures with drop tents.

Host preference assessed with sheep and deer together and sheep alone.

Enclosures were alternated each night.



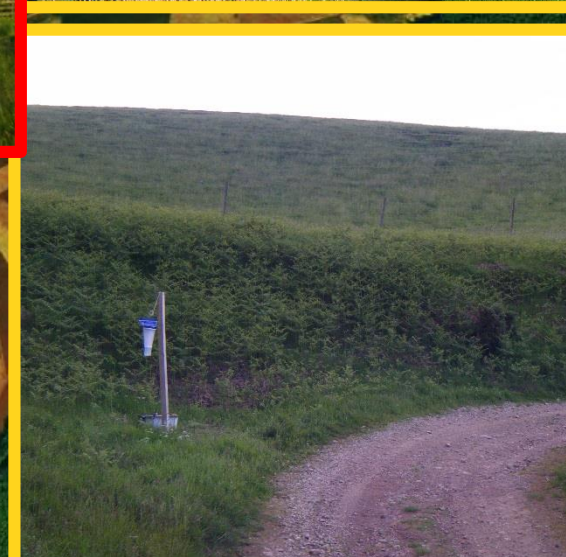


# Glensaugh Research Farm

James Hutton Institute



5 light traps to capture  
local background  
midge abundance.





# Drop tents to quantify relative attack and engorgement rates





# Drop tents to quantify relative attack and engorgement rates



20 min biting/engorgment

# Drop tents to quantify relative attack and engorgement rates





# Drop tents to quantify relative attack and engorgement rates



- 4 observation cycles/night
- 9 nights of deer/sheep comparisons
- 5 nights of sheep only



# Preliminary findings

- At least 13 midge species are on the wing
- The highland midge *C. impunctatus* dominates drop tent & light trap catches
- Putative BTV vectors *C. pulicaris* and Obsoletus group species also abundant
- Obsoletus group males are all *C. scoticus* (so far)

# Conclusions and Outlook

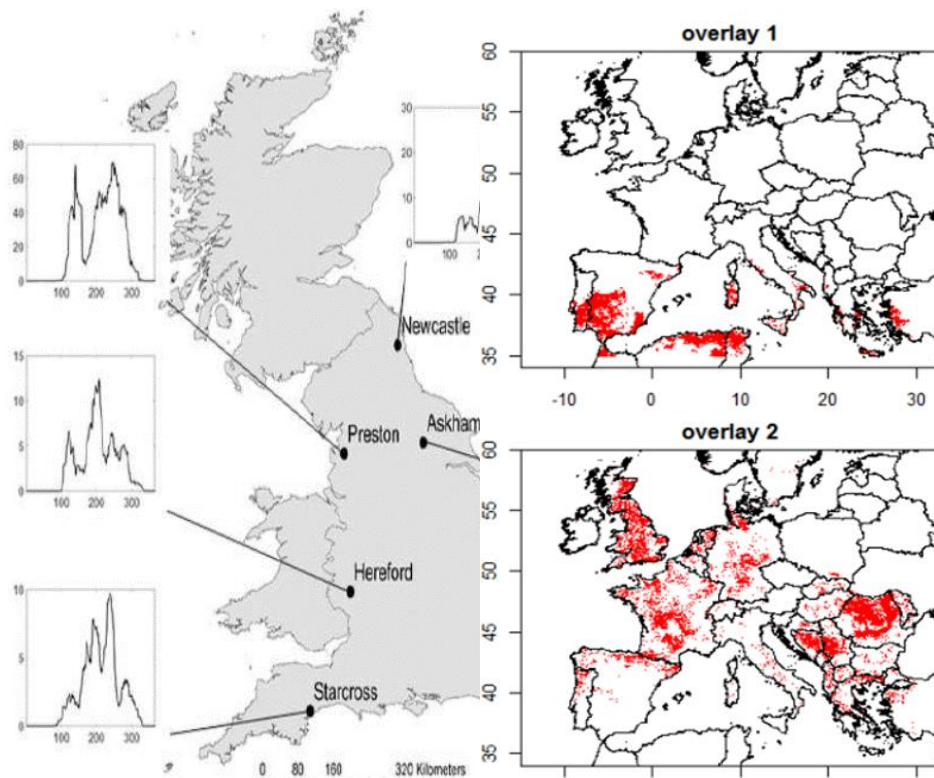
- Habitat dominated by sheep, roe & red deer support populations of several putative *Culicoides* vectors, some of which are highly abundant in all habitats.
- Possibility of those with a broad host range to act as bridge vectors between wild and domestic ruminants.

## Outlook:

- Host preference parameters from the biting rate experiment will inform disease transmission models.

# Spatial & seasonal MBD hot spots

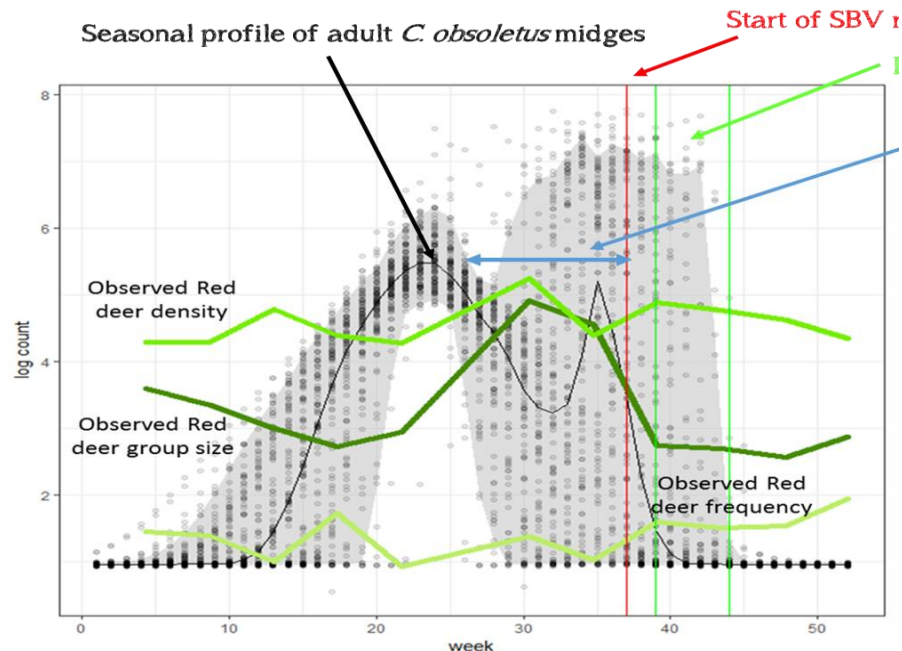
Environmental models of seasonal landscape use by  
midge vectors, wild and domestic ruminants



Midge species – seasonal  
abundance patterns

Ruminant hosts &  
midge vector overlap

Seasonal midge vector – livestock - deer  
interactions: Scotland Landscape





# Many thanks to

Centre for  
Ecology & Hydrology  
NATURAL ENVIRONMENT RESEARCH COUNCIL

CEH colleagues for help with the challenging fieldwork  
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