Vectorial Capacity Of *Culicoides imicola* In A New Colonised Area In Southern Mainland France

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Abstract

Bluetongue (BT) disease occurred for the first time in Corsica, France in 2000. Once the presence and the establishment of *C. imicola* were confirmed in a small area of the southern mainland of France (Var département), the risk of a bluetongue outbreak in this area became higher. In the case of mosquito-borne diseases, the vectorial capacity is a widely and useful adopted estimate used to assess the susceptibility of an area to a particular disease. This integrated approach was applied in the Var context. In this zone, four trapping sites were monitored weekly from mid-April 2005 to mid-November 2005 with a UV light trap. The abundance and the parity of *C. imicola* were collected and analysed in regard with local meteorological data. Expert opinions and previous published results were used to estimate others parameters of the vectorial capacity. Uncertainty and variability were taken into account by using probabilistic distributions. The vector competence of this *C. imicola*'s population was tested through experimental infections under laboratory conditions. The benefits of such an approach are analysed with the purpose of finding few sensitive parameters which could be monitored in routine.

Introduction

Since the emergence of the bluetongue (BT) in Corsica in 2000, the France is confronted by a particular epidemiologic situation. Thus, in Mediterranean area of France, we can distinguish three levels of BT risk: the infected zone (Corsica) where BTV virus and its main vector, *Culicoides imicola* are present, a limited area in Var where only *C. imicola* is known to be established since October 2004 and the zones bordering Italy and Spain where the vector is present. To adapt the surveillance system to areas where the virus is still not present, we test the use of the vectorial capacity as a comparative index [Dye, 1992] to assess the BTV risk transmission. Vectorial capacity gives the number of new infections produced by the vector population per day from one infective case introduced into a naïve host population [Garrett-Jones, 1964]. It synthesizes certain attributes of the vector population in its environment: density of females relative to its hosts, frequency of feeding, host preference, survival rate, the extrinsic incubation period of the virus. The final intended objective is to obtain an integrated approach that combines the different elements involved in the BT transmission, whether they are direct (*C. imicola*, BTV virus and sensitive hosts) or indirect (environmental factors).

Objective

The objective of the research was to use the vectorial capacity to compare the potential risk of BTV transmission in time or/and in space.

Methods

The study took place in the Argens river valley in Roquebrune sur Argens (Var department), the only area in the mainland of France where *C. imicola* is established.

To monitor the vector abundance and its survival rate during its seasonal activity period, 4 trap sites were selected according to the presence of the target animals (only sheep and horses in this particular area) and their geographic situation. The *Culicoides* were trapped weekly with a classical New Jersey light trap slightly modified using UV-light as attractants (fluorescent tubes, type "Atlas" F4T5/BL, 4 Watts). *C. imicola*'s females were classified as either nulliparous or parous according to the presence of pigment deposited in the abdominal cuticle (Dyce, 1969).

The competence study of *C. imicola* was studied in the Institute of Animal Health (Pirbright) according to a published method [Carpenter *et al.* 2006; Venter *et al.*, 2005]. The French *C. imicola* were trapped in large number in Var and transported as soon as possible to Pirbright (UK) where they were orally infected with a BTV 9 (Kosovo) serotype.
The vectorial capacity was determined by the following formula:

$$VC = \frac{ma^2 V p^n}{-\log p}$$

where VC is the vectorial capacity, ma is the number of bites per host per day, a is the host preference divided by the length of time between bloodmeals, V is the vector competence (ability of the vector population for pathogen infection and transmission), p is the daily survival rate of the vector, and n is the extrinsic incubation period of the virus (that is the number of days between the infection of the vector and the time when that insect is capable of transmitting the virus to a host). The estimates for parameters were based either on collected data (ma, p, V, host preference) or on the literature (a, n) and defined by a probabilistic distribution (table I). The output is the result of 10 000 simulations using a Latin hypercube sampling (@risk software).

Symbol	Description	estimation
ma	Number of bites per host per day	= M × •
•	Corrector factor*	Pert(1; 1.6; 5)*
M	Mean number of caught *C. imicola* females	mean(x traps per month)
a	host biting rate per host per day	= h / •
h	Host preference	Pert distribution (0.8; 1; 1)**
•	Duration of the gonotrophic cycle (days)	$•_{mois}$ depending on Tm [Mullens *et al.*, 2004] Triangular($•_{mois}$ - ($•_{mois}$ *0.1); $•_{mois}$; $•_{mois}$ + ($•_{mois}$ *0.1)
•	Parous rate	$•_{mois}$ = total parous females/ total females
p	Daily survival rate	p= = $•_{mois}$ ^(1/µ) Triangular(p_{mois} - (p_{mois}*0.1); p_{mois}; p_{mois} + (p_{mois}*0.1)) truncated at 0.98
n	Extrinsic incubation period (days)	n=0,0069*Tm - 0,0636 [Wittman *et al.*, 2002] Triangular(n_{mois} - (n_{mois} *0.1) ; n_{mois}; n_{mois}+ (n_{mois} *0.1))

Table I: Model parameters and their estimates
*: experimental determination in the field
** in the case of isolated population
Tm: monthly mean temperature

Results

In 30 night traps, a total of 6447 *C. imicola* were collected in a sheep barn in Var between the 1st of May and the 12th of November 2005.

month	may	june	july	august	september	october	november
C. spp	254	283	304	209	488	453	262
C. imicola	11	20	34	197	470	428	224
Females	11	20	23	191	467	427	224
parous	4	5	11	69	226	202	95
nulliparous	7	14	11	123	241	225	129
mini	1	5	1	29	64	94	7
maxi	19	29	48	366	979	743	441

Table II: Monthly mean number of *C. spp* and *C. imicola* caught during the 30 night traps in a sheep barn in Var from May to November 2005

A total of 72 *C. imicola* females were orally infected and kept at 27°C during the extrinsic incubation period. All virus isolations were negative. According to the sample size, the maximum number of positive given that all 72 negative samples is 4,1 % (• = 0,05).
The vectorial capacity estimates calculated monthly in a flock is presented in the table III.

	Fitted distribution	Mean	Std. Deviation
June 2005	Lognorm(0.26907; 0.29568)	0.26907	0.29568
August 2005	Lognorm(4.3367; 4.5047)	4.3367	4.5047
September 2005	Lognorm(34.216; 53.018)	34.216	53.018
October 2005	Lognorm(41.550; 18.553)	41.550	18.553

Table III: Monthly outputs of the vectorial capacity in a sheep barn during the 2005 vector activity period.

Discussion

As the vectorial capacity (VC) synthesizes vector population dynamics, contacts between hosts and vectors and the relationship between virus and vector, this index permits to assess the BT risk in its entirety. However, the biology of this vector is not well-known, certain approximations are necessary for a first attempt. But, as the final objective is not to definite the absolute value of the VC, the comparison of the calculated outputs in time or in space could be fully valuable to determine the period of the year when the risk is higher or to target the surveillance in sites where vectorial capacity's estimates are significantly more important.
The competence of *C. imicola* for BT virus has to be further more investigated. Larger number of wild specimens should be collected to improve the precision of the estimate. However, in view of these results, this competence does not seem to be too different from other published estimates [Venter et al., 2005].
In our example, no BT seroconversion was detected in the monitored flocks. Nevertheless, the VC model shows that the risk is higher in September and October in this French area and that it is different from site to site. Further more analyses will be done to test the pertinence of some key indicators as abundance or host preference to monitor the evolution of this VC index which reflects the BT transmission risk. The aim is to have a geographic information system compiling animals and vector data and significant environmental parameters thanks to the vectorial capacity.

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