Spatio-temporal variations of bovine tuberculosis incidence in France, 1965-2000

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Introduction

Bovine tuberculosis (TB) control measures became mandatory in France in 1965. In 2001, France was recognized officially free from bovine TB by the world organization for animal health (OIE). Detection, control and prevention tools remained roughly identical during this 35 years period (tuberculin skin testing, slaughter, movements control and meat inspection). In the meantime, cattle population structure and herd management practices changed dramatically. To analyze the success of TB control, both processes (control measures and population evolution) have to be taken into account.

We analyzed the spatio-temporal variations in the incidence of bovine tuberculosis between 1965 and 2000 in France at the department level (95 areas) to highlight areas of high and low relative risks that remained so throughout the 35 year period. Using a Bayesian space-time model, we studied the association between the evolution of the incidence of bovine tuberculosis and the evolution of cattle population structure and of herd management practices.

Materials & Methods

Data source

➢ For each department and for each year, data was obtained from the French agriculture ministry:
- Cattle population structure and herd management practices:
  surface of permanent grassland (ha), surface of cultivated areas (ha), number of cattle, number of dairy cows, and number of farms housing cattle.
- TB detection and control:
  number of infected farms, frequency of tuberculin skin testing.

➢ Datasets were aggregated over 7 five-year periods.

Model

➢ The relative risk of bovine tuberculosis needs to be estimated.
➢ Covariates: herd size (average), herd density (herds/km2), dairy cows (% of cattle population), permanent grassland (% of cultivated surfaces) and frequency of tuberculin skin testing (years).
➢ We chose the BYM model for the spatial effect and the CAR model for the temporal effect.

Exploitation of fitting the model

➢ Three models including/excluding the spatial and temporal effects were fitted
➢ The deviance information criterion was used to compare models.

➡ **Best model with covariates and temporal effects.**

Figure 1. Herd incidence and prevalence of bovine tuberculosis in France between 1965 and 2000

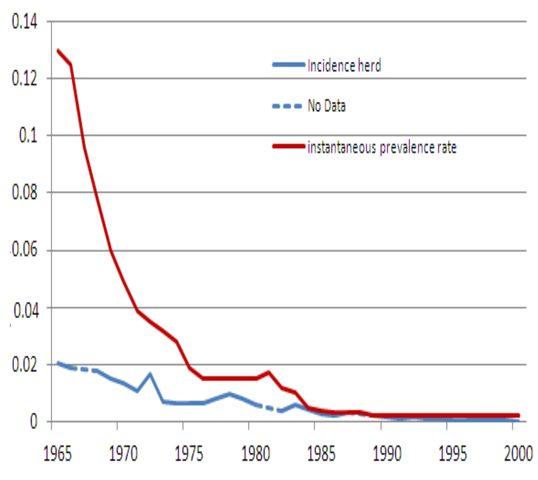
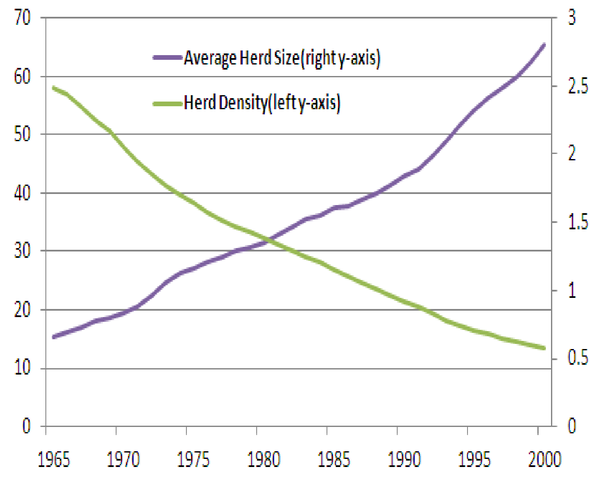


Figure 2. Average herd size and herd density in France between 1965 and 2000



Results

Estimated relative risk (figure3)

➢ South of France remained a high risk area over the analysed period.
➢ North and East regions were medium risk areas.
➢ Central and West regions were low risk areas.

Estimated risk factors

Table 1. Posterior medians and 95% credible intervals (CI) of the estimated incidence ratios associated to the covariates.

Variable	Incidence ratio	95% CI
Permanent grassland (%)	0.58	[0.55-0.6]
Herd size	0.61	[0.58-0.65]
Herd density	1.15	[1.12-1.18]
Dairy cows (%)	1.03	[1.01-1.05]
Frequency of skin testing:		
Every year	*ref*	-
Every two years	1.28	[1.25-1.32]
Other	0.98	[0.93-1.03]

➢ Positive association
- Frequency of tuberculin skin testing
- Herd density /km2 ➡ **Professionalization effect**
- Dairy cows (%) ➡ **Specialization effect**

➢ Negative association
- Herd size ➡ **Professionalization effect**
- Permanent grassland (%) ➡ **Specialization effect**

Figure 3. Geographic variations of the estimated relative risk of cattle TB: number of periods (n=7) for which the department-specific relative risk was >1.

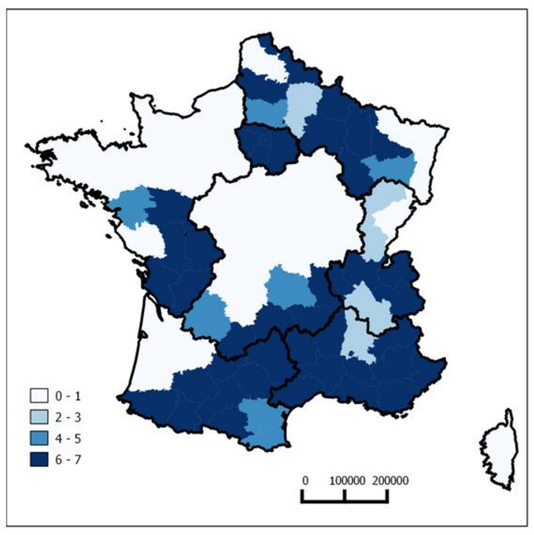
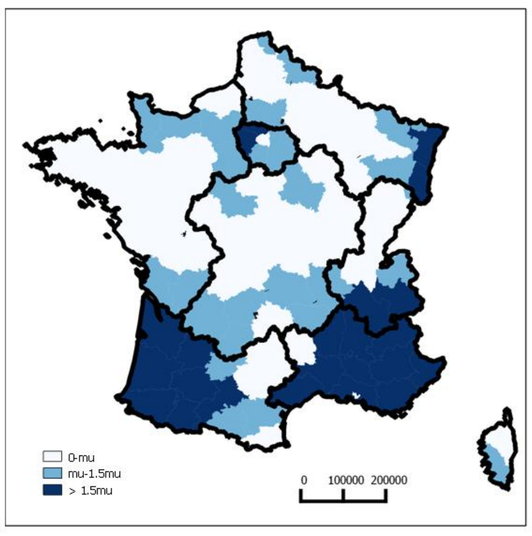


Figure 4. Geographic variations of the percentage of small cattle herds in 2010 (< 20 animals, mu =28% at the country level).



Discussion

➢ Spatial autocorrelation effect: captured by the effect of the explanatory variables.
➢ Professionalization effect: decrease of the age at culling, closer follow-up by a veterinarian, better biosecurity practices (quarantine, skin testing of introduced animals).
➢ Specialization effect: faster within-herd transmission in dairy herds (kept indoors in stables) than in beef herds (kept outdoors on pastures).
➢ In 2010, Southern French regions remain those where professionalization of cattle breeding is the lowest (high proportion of small-size herds) (Figure 4.)

Conclusion

The spatio-temporal variations of bovine TB incidence highlight at-risk areas in southern France, between 1965 and 2000. These variations are associated to indicators of herds professionalization (herd size and density) and specialization (dairy or beef production) with contrasted values between the north and the south of the country, differences that remain apparent nowadays. Besides the efficacy of detection and control measures, the evolution of cattle population structure and of herd management practices explain the success of TB control in France.

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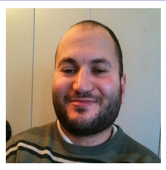

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