DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

PhD PROPOSAL FOR THE DOCTORAL SCHOOL « Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Modeling highly pathogenic avian influenza dynamics: interagration of socio-economic factors for control measures evaluation
Acronym: MIASE
Disciplinary field 1: Agronomy **Disciplinary field 2:** Food sciences
Three keywords: Spatio-temporal models; socio-economics; epidemiology
Research unit : Anses – Laboratoire de Ploufragan- Plouzané-Niort - EPISABE
Name of the thesis director HDR required: Dr Nicolas Rose **Email address of the thesis director:** nicolas.rose@anses.fr **Name of the thesis co-director (if applicable): HDR (Habilitation thesis to supervise research) required:** **Email address of the thesis co-director (if applicable):** Mathieu Andraud **Name of the thesis co-supervisor 1 (if applicable):** Mathieu Andraud **Email address of the thesis co-supervisor 1 (if applicable):** mathieu.andraud@anses.fr **Name of the thesis co-supervisor 2 (if applicable):** Legrand Saint-Cyr **Email address of the thesis co-supervisor 2 (if applicable):** legrand.saintcyr@anses.fr
Thesis grant (funding origin and amount): ARED (24 000€) – Saint-Brieuc Armor Agglomération/Département des Côtes d'Armor (24000€)
Contact(s) (mailing address and E-mail): Région Bretagne 283, avenue du Général Patton – CS 21 101, 35 711 Rennes Cedex 7 Saint-Brieuc Armor Agglomération 5 rue du 71ème RI - CS54403 22044 Saint-Brieuc Cedex 2
Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here. This information is needed for proposal publication. ☐ **Doctoral school contest** ☒ **Interview** ☐ **Other (indicate) :**

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

All sections must be filled. Once filled, please save the proposal form in pdf format using the following naming: Supervisor Name_Unit_Subject Acronym_EN.pdf

ED EGAAL
Direction : 65 rue de Saint-Brieuc – CS 84215 – 35042 Rennes Cedex – France
Tél : 02 23 48 52 75
Mail : ed-EGAAL@doctorat-bretagneloire.fr
Site Web : https://ed-egaal.doctorat-bretagneloire.fr

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context : (10 lines)

The successive crises, due to highly pathogenic avian influenza (HPAI) epizootics over the last few years, have had major socio-economic impacts for stakeholders from the poultry production sector, as well as for the public authorities. Despite the strengthening of biosecurity measures, the sector has been heavily affected by a new epizootic since November 2021. Although multiple introductions have been identified in different geographical areas in France, transmission between epidemiological units had undoudtedly played a role in the viral spread. The tranmission routes remain to be analysed to understand their relative roles in order to identify the levers for mitigating the risk of spread between farms. The project aims at the development of an epidemiological model, representing the different transmission routes between farms for HPAI viruses. On the basis of scenarios defined jointly with stakeholders and managers, the model will be used to evaluate the effectiveness of surveillance protocols and control measures with regard to various factors including socio-economic factors.

Assumptions and questions (8 lines)

Despite the strengthening of internal and external biosecurity measures, and in particular indoor rearing of animals during the risk period, the poultry industry faced its largest avian influenza epizootics this winter 2021-2022. Identifying the relative role of transmission routes is essential to better understand the magnitude of successive HPAI epizootics in poultry and to assess the impact of control measures. The project will address the following questions:

What are the transmission routes between farms? What is the relative contribution of each of these routes? What are the socio-economic determinants of the spread of the virus? What levers have been or could be used to limit this spread? Are these technically and economically feasible?

The main steps of the thesis and scientific procedure (10-12 lines)

The project is driven around three complementary axes:

Area 1. Modelling of contact networks

- Analysis of the structural components and nodal characteristics influencing the topology of direct (animal movements) and indirect (rendering plants) contact networks.

- Assess the topological impact of alternative networks

Axis 2. Epidemiological modelling

- Development of a mechanistic model of HPAI virus spread

- Evaluation of surveillance and control measures

- Estimation of transmission parameters and evaluation of the relative role of transmission routes

Axis 3. Integration of socio-economic factors in epidemiological modelling

- Consultation of stakeholders and managers on current prevention and control practices as well as on the feasibility of alternative prevention and control scenarios and the associated technical and socio-economic constraints (in support of axis 2)

- Identification of the socio-economic factors to be integrated into the modelling resulting from axis 2 considered relevant
Methodological and technical approaches considered (4-6 lines) - Social network analysis (SNA, ERGM) - Mecanistic epidemiological modelling. - Parameter inference (Appoximate Bayesian Computation, MCMC, Deep learning) - Participatory approach to understand the technical and socio-economic constraints
Scientific and technical skills required by the candidate - Population dynamics & epidemiology - Programing skills -Survey methodology - Social sciences - Econometrics - Communication

THESIS SUPERVISION[1]

Unit name: Anses Laboratoire de Ploufragan Pouzané Niort	**Team name:** EPISABE
Unit director name: Nicolas Eterradossi	**Team director name:** Nicolas Rose
Mailing address of the unit director: 41 Rue de Beaucemain 22440 Ploufragan	**Mailing address of the team director:** 41 Rue de Beaucemain 22440 Ploufragan
Thesis director Surname, first name: Rose Nicolas Position: Head of Unit, Deputy Director of the laboratory Obtained date of the HDR (Habilitation thesis to supervise research):2009 Employer:Anses Doctoral school affiliation: EGAAL Rate of thesis supervision in the present project (%): 40%	

[1] **In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.**

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Thesis co-director

Surname, first name:

Position:

Obtained date of the HDR (Habilitation thesis to supervise research):

Employer:

Doctoral school affiliation:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Thesis co-supervisor 1 (if applicable)

Surname, first name: Andraud Mathieu

Position: Reasearch fellow

Habilitation thesis to supervise research ☐ yes ☒ no If yes, date diploma received:

Employer:Anses

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 30

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 60

Number of current thesis supervisions/co-supervisions: 2

Thesis co-supervisor 2 (if applicable)

Surname, first name: Saint-Cyr Legrand

Position: Research Fellow

Habilitation thesis to supervise research ☐ yes ☒ no If yes, date diploma received:

Employer: Anses

Doctoral school affiliation:

Rate of thesis supervision in the present project (%): 30

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0

Number of current thesis supervisions/co-supervisions: 0

Private partner (if CIFRE funding, private funding,…)

Surname, first name:

Position:

Employer:

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

International partner (if Cotutelle thesis)

Surname, first name:

Position:

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)

Please provide the following information for each PhD students supervised

Surname, first name: Cador Charlie

Date of PhD beginning and PhD defence: 01/01/2014 -31/12/2016

Thesis supervision: Nicolas Rose; Mathieu Andraud

Professional status and location: Farma pro - Plestan

Contract profile (post-doc, fixed-term, permanent): Permanent

List of publications from the thesis work:

Cador, C., Andraud, M., and Rose, N. (2017a). Contribution of modelling in the study of transmission dynamics of virus in metapopulations: Application to swine influenza A viruses in pig herds. *Virologie* 21(4)**,** 173-187. doi: https://doi.org/10.1684/vir.2017.0703.

Cador, C., Andraud, M., Willem, L., and Rose, N. (2017b). Control of endemic swine flu persistence in farrow-to-finish pig farms: a stochastic metapopulation modeling assessment. *Veterinary Research* 48**,** 58. doi: https://doi.org/10.1186/s13567-017-0462-1.

Cador, C., Herve, S., Andraud, M., Gorin, S., Paboeuf, F., Barbier, N., et al. (2016a). Maternally-derived antibodies do not prevent transmission of swine influenza A virus between pigs. *Vet Res* 47(1)**,** 86. doi: https://doi.org/10.1186/s13567-016-0365-6.

Cador, C., Rose, N., Willem, L., and Andraud, M. (2016b). Maternally Derived Immunity Extends Swine Influenza A Virus Persistence within Farrow-to-Finish Pig Farms: Insights from a Stochastic Event-Driven Metapopulation Model. *PLOS ONE* 11(9)**,** e0163672. doi: https://doi.org/10.1371/journal.pone.0163672.

Surname, first name: Salines Morgane

Date of PhD beginning and PhD defence: 04/09/2016 -05/09/2019

Thesis supervision: Nicolas Rose; Mathieu Andraud

Professional status and location: , BEAD - DRAAF Bretagne/SRAL.

Contract profile (post-doc, fixed-term, permanent): Permanent

List of publications from the thesis work:

Salines, M., Andraud, M., Pellerin, M., Bernard, C., Grasland, B., Pavio, N., et al. (2019a). Impact of porcine circovirus type 2 (PCV2)infection on hepatitis E virus (HEV)infection and transmission under experimental conditions. *Veterinary Microbiology* 234**,** 1-7. doi: https://doi.org/10.1016/j.vetmic.2019.05.010.

Salines, M., Andraud, M., and Rose, N. (2017a). From the epidemiology of hepatitis e virus (HEV) within the swine reservoir to public health risk mitigation strategies: A comprehensive review. *Veterinary Research* 48(1). doi: https://doi.org/10.1186/s13567-017-0436-3.

Salines, M., Andraud, M., and Rose, N. (2017b). Pig movements in France: Designing network models fitting the transmission route of pathogens. *PLoS ONE* 12(10). doi: https://doi.org/10.1371/journal.pone.0185858.

Salines, M., Andraud, M., and Rose, N. (2018a). Combining network analysis with epidemiological data to inform risk-based surveillance: Application to hepatitis E virus (HEV) in pigs. *Preventive Veterinary Medicine* 149**,** 125-131. doi: https://doi.org/10.1016/j.prevetmed.2017.11.015.

Salines, M., Andraud, M., Terrade, F., and Rose, N. (2018b). Are French pig farmers and veterinarians knowledgeable about emerging foodborne pathogens? The case of hepatitis E virus. *Preventive Veterinary Medicine* 156**,** 1-7. doi: https://doi.org/10.1016/j.prevetmed.2018.04.015.

Salines, M., Demange, A., Stéphant, G., Renson, P., Bourry, O., Andraud, M., et al. (2019b). Persistent viremia and presence of hepatitis E virus RNA in pig muscle meat after experimental co-infection with porcine reproductive and respiratory syndrome virus. *International Journal of Food Microbiology* 292**,** 144-149. doi: https://doi.org/10.1016/j.ijfoodmicro.2018.12.023.

Salines, M., Dumarest, M., Andraud, M., Mahé, S., Barnaud, E., Cineux, M., et al. (2019c). Natural viral co-infections in pig herds affect hepatitis E virus (HEV) infection dynamics and increase the risk of contaminated livers at slaughter. *Transboundary and Emerging Diseases* 66(5)**,** 1930-1945. doi: https://doi.org/10.1111/tbed.13224.

Salines, M., Rose, N., and Andraud, M. (2019d). Tackling hepatitis E virus spread and persistence on farrow-to-finish pig farms: Insights from a stochastic individual-based multi-pathogen model. Epidemics. doi: https://doi.org/10.1016/j.epidem.2019.100369.

Salines, M., Andraud, M., Rose, N., Widgren, S., 2020. A between-herd data-driven stochastic model to explore the spatio-temporal spread of hepatitis e virus in the French pig production network. PLoS ONE 15.

Teixeira-Costa, C., Andraud, M., Rose, N., Salines, M., 2020. Controlling hepatitis E virus in the pig production sector: Assessment of the technical and behavioural feasibility of on-farm risk mitigation strategies. Preventive Veterinary Medicine 175.

Five main recent publications of the supervisors on thesis subject:

Rose, N., Andraud, M., Bigault, L., Jestin, A., Grasland, B., 2016. A commercial PCV2a-based vaccine significantly reduces PCV2b transmission in experimental conditions. Vaccine 34, 3738-3745.

Salines, M., Andraud, M., Rose, N., 2017a. Pig movements in France: Designing network models fitting the transmission route of pathogens. PLoS ONE 12.

Andraud, M., Halasa, T., Boklund, A., Rose, N., 2019. Threat to the French Swine Industry of African Swine Fever: Surveillance, Spread, and Control Perspectives. Frontiers in Veterinary Science 6.

Andraud, M., Rose, N., 2020. Modelling infectious viral diseases in swine populations: A state of the art. Porcine health management 6.

Andraud, M., Bougeard, S., Chesnoiu, T., Rose, N., 2021. Spatiotemporal clustering and Random Forest models to identify risk factors of African swine fever outbreak in Romania in 2018–2019. Scientific Reports 11.

Hayes, B.H., Andraud, M., Salazar, L.G., Rose, N., Vergne, T., 2021. Mechanistic modelling of African swine fever: A systematic review. Preventive Veterinary Medicine 191.

Salines, M., Andraud, M., Rose, N., Widgren, S., 2020. A between-herd data-driven stochastic model to explore the spatio-temporal spread of hepatitis e virus in the French pig production network. PLoS ONE 15.

Salines, M., Rose, N., Andraud, M., 2019. Tackling hepatitis E virus spread and persistence on farrow-to-finish pig farms: Insights from a stochastic individual-based multi-pathogen model. Epidemics. DOI: https://doi.org/10.1016/j.epidem.2019.100369.

V. Sicard, M. Andraud, S. Picault (2021). Organization as a multi-level design pattern for agent-based simulation of complex systems. in 13th International Conference on Agents and Artificial Intelligence(ICAART). SCITEPRESS

Hammami, P., S. Widgren, V. Grosbois, A. Apolloni, N. Rose and M. Andraud (2022). "Complex network analysis to understand trading partnership in French swine production." PLoS One 17(4): e0266457.

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

THESIS FUNDING

Origin(s) of the thesis funding: Région Bretagne – Saint-Brieuc Armor Agglomération/Département des Côtes d'Armor
Gross monthly salary: 1758
Thesis funding state : Acquired
Funding beginning date/Funding ending date: December 2022 – Janurary 2023

Date: 20/07/2022

Name, signature of unit director: Eterradossi Nicolas

Name, signature of team director: Rose Nicolas

Name, signature of thesis project director: Rose Nicolas