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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):

Haider, N., Cuellar, A. C., Kjær, L. J., Havskov Sørensen, J., & Bødker, R. (2017). Microclimatic temperatures of Danish cattle farms: a better understanding of the variation in transmission potential of Schmallenberg virus. Abstract from 11th Annual meeting Epizone, Paris, France.

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C21: Microclimatic temperatures of Danish cattle farms: a better understanding of the variation in transmission potential of Schmallenberg virus

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Background: Insects inhabiting the surroundings of a cattle farm are exposed to microclimatic temperatures of the habitats surrounding the farm. Microclimatic temperatures are key drivers of the extrinsic incubation period (EIP), the speed by which an infected insect becomes infectious. The objective of this study was to quantify the variation of EIP of Schmallenberg virus among Danish cattle farms and identify possible spatial patterns of the EIPs.

Methods: We quantified 21 different land cover classes within a 500 meter radius of all cattle farms in Denmark (N=22092) using CORINE land cover and regrouped them into four major land cover types: dry meadow, wet meadow, hedges, and forest. We then obtained the meteorological temperatures and other parameters (solar radiation, wind speed, humidity) near the farm from the Danish Meteorological Institute (DMI) for the period of 2000-2016. Using recently developed microclimatic temperature prediction models for those four major land cover types, we calculated the hourly microclimatic temperatures of each farm based on their surrounding habitat types and meteorological parameters. We then modelled the daily EIP of Schmallenberg virus for each farm for each year of the period of 2000-2016 using both hourly DMI and hourly microclimatic temperatures and calculated mean EIP of 17 years for each farm. Finally, we plotted the average spatial pattern of farm level EIP for spring (May-June), summer (July-August) and autumn (September-October) in Denmark for the 17 years.

Results: Of the 22092 cattle farms, we were able to predict the hourly microclimatic temperatures of 22006 farms (99.6%) - the rest of the farms had habitats either not suitable for insects resting or the microclimatic model was not able to calculate the temperature of the surrounding land covers. We found a surprisingly large between-farm variation in EIP between farms on a specific day. For example, in the year 2016, the EIP of all farms varied (5th and 95th percentiles) from 9-19 days on May 1st, 12-23 days on July 1st and 11-21 days on September 1st. The mean EIP of Schmallenberg virus [inter quantile range (IQR)] of all the cattle farms during spring, summer, and autumn for 17 years period were 16 [13-17], 15 [13-16] and 40 [38-42] days respectively, when using microclimatic temperatures. These estimated EIP values were much shorter compared to EIP estimated using DMI temperatures for the same periods of spring (29 [27-30]), summer (21 [19-24]), and autumn (56 [55-58]) days respectively. For the summer period, we observed a large area where farms with shorter EIP for Schmallenberg virus were grouped together, comprising southern Funen and associated islands, Lolland, Falster, and southern Zealand.

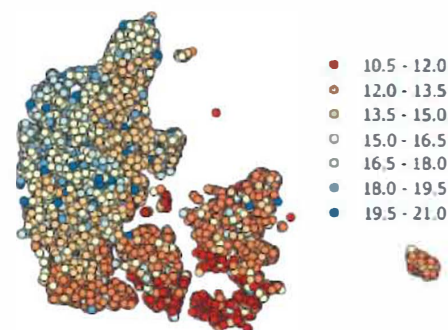


Fig: Map of Danish cattle farms showing the 17 years average EIP of Schmallenberg virus in the summer season. EIPs are generated from our virus development model using estimated microclimatic temperatures. Cattle farms with shorter EIPs are grouped together in the south-eastern part of the country.

Conclusion: Microclimatic temperature is highly important for understanding and predicting insect-borne virus transmission on Danish cattle farms. We were able to predict the daily farm level EIP of Schmallenberg virus for 17 years. We found large variation in EIP between farms and also a spatial pattern with a strong geographical trend suggesting that disease transmission may vary substantially between regions even in a small country like Denmark - and this could be useful for designing risk based surveillance for emerging and reemerging vector-borne diseases.