Modelling the TB spatial risk in a complex multi-host system assessed by drones

Barasona JA[1]*, Mulero-Pázmány M[2], Acevedo P[1], Negro JJ[2], Torres MJ[3], Gortázar C[1], Vicente J[1]

[1] Sabio IREC, National Wildlife Research Institute (IREC; CSIC-UCLM-JCCM), Ciudad Real, Ronda de Toledo s/n, 13005, Spain
[2] Department of Evolutionary Ecology, Doñana Biological Station, CSIC, Seville, Spain
[3] Department of Microbiology, Universidad de Sevilla, Seville, Spain

*Corresponding author: joseangel.barasona@uclm.es

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CONCERN

Complex ecological and epidemiological systems require multidisciplinary research [1], which may benefits from innovative technologies. Low cost unmanned aircraft systems (UAS) have potential to provide the spatial pattern of hosts' aggregation [2], which is crucial to model the determinants of disease transmission and persistence at a fine spatial-scale [3]. Nowadays, the application of UAS for epidemiology remains unexplored.

STUDY CASE

We studied the spatial epidemiology of tuberculosis (TB) in the ungulate community of Doñana National Park (DNP, Southwest of Spain; Fig 1). By using UAS high-resolution images, we used spatially explicit models **(1) to determine the spatial pattern of local abundances** and **(2) to asses the spatial risk for TB across the ungulate community.**

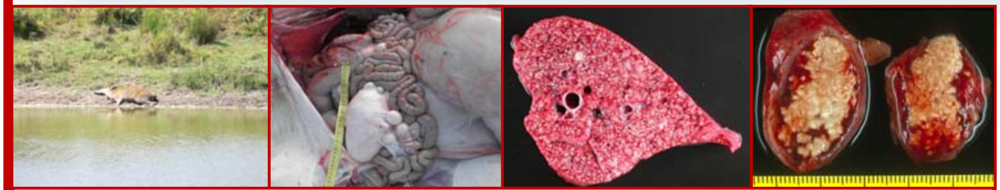

Figure 1. ***Sampling and tuberculosis diagnosis :*** From 2006 to 2012, 949 wild ungulates comprising wild boar (n = 570), red deer (n = 190) and fallow deer (n = 189) were randomly captured and necropsied in the context of the DNP health-monitoring programme. Necropsies, detailed inspection of lymph nodes and abdominal and thoracic organs, and cultures were performed in order to confirm TB.

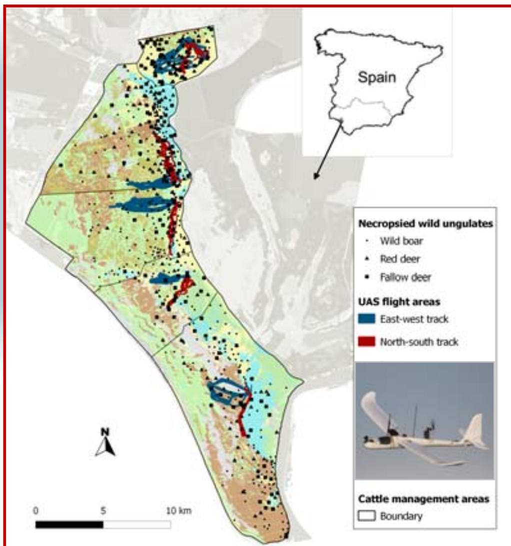

Figure 2. ***Map of DNP.*** Locations of the necropsied wild ungulates and of the UAS tracks at the five cattle management areas are shown.

(1) MODELLING AND OUTCOME (2)

Table 1. ***Results of the generalised lineal models*** (negative binomial error distribution and logarithmic link function) used to predict red deer, fallow deer and cattle abundance in DNP. * Reference value of the parameter estimator was 0 for "cattle management area 1 (MA1)".

Predictor coefficients of the best-fitting models (< AIC)		
Red deer abundance	**Fallow deer abundance**	**Cattle abundance**
~ -0.001·Distance to ecotone -2.96· Dense shrubland+0.78·Grassland +0.44·*MA2 +2.15·MA3 +1.1·MA4 +0.4·MA5	~ -2.17·Distance to ecotone -2.25·Dense shrubland +2.9·Grassland +7.22·Woodland -1.42·*MA2 +2.73·MA3 +3.68·MA4 -1.34·MA5	-1.19·Dense shrubland +2.93·Grassland +3.36·*MA2 +6.6·MA3 +9.17·MA4 -3.41·MA5

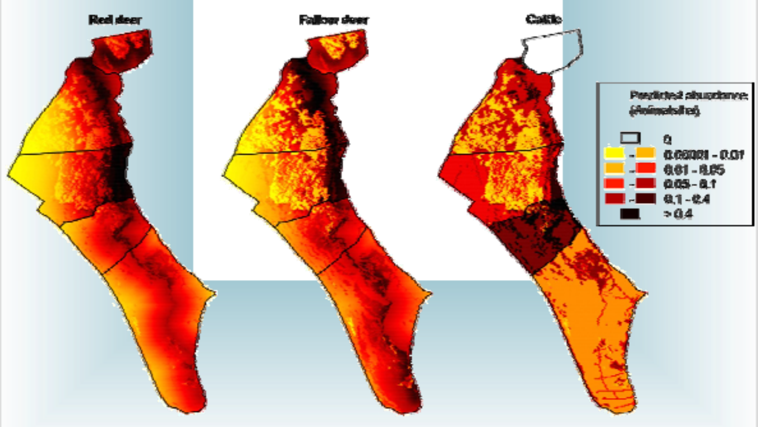

Figure 3. ***Predicted patterns of species relative abundance*** (animals/ha) in DNP obtained by modelling abundance data obtained from UAS.

Table 2. ***Results of the multivariable logistic regression models*** used to determine the most relevant factors explaining species positivity as regards tuberculosis. Predicted abundances (PA) obtained with the first approach were included as explanatory variables

Predictor coefficients of the best-fitting models (<AIC)		
Wild boar infection	**Red deer infection**	**Fallow deer infection**
~ -0.10·Sampling year -1.85·Waterpoint density +0.37·Red deer PA	~ 0.16·Sampling year -2.60·Waterpoint density +0.41·Red deer PA	~ 0.01·Distance to water -2.55·Waterpoint density +0.06·Fallow deer PA

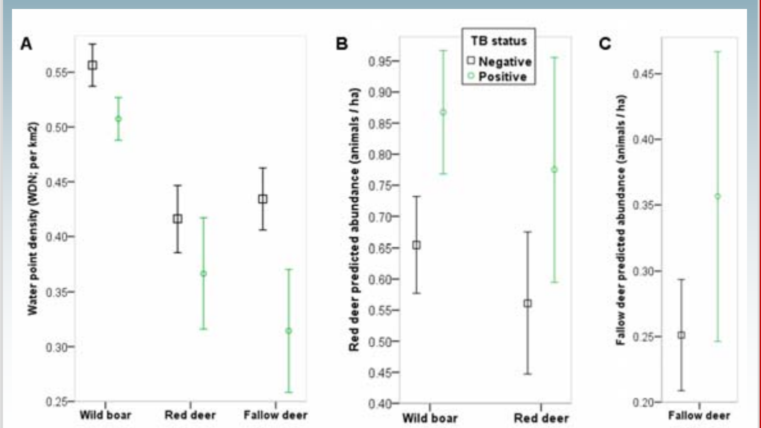

Figure 4. ***Risk for TB presence in wild ungulates*** in relation to (A) water point density, (B) predicted abundance for red deer, and (C) predicted abundance for fallow deer. Error bars (95% IC) are included.

DISCUSSION AND CONCLUSIONS

On the methodological approach → The use of UAS high-resolution images has allowed us to identify the environmental determinants of host (red deer, fallow deer and cattle) abundance, and proved to be a reliable tool for assessing fine-scale species distribution.

Spatial risk factors for TB infection → The outcome of TB in a complex multi-host pathogen system depends on environmental factors and host distribution patterns. The areas in which ungulates aggregate when resources became limited enhance disease transmission [4] because they act as important sources of TB and favour increased individual contact rates intra- and interspecific.

Implications → These findings are relevant for planning and implementing research, but fundamentally when managing disease in multi-host systems, and focusing on risky areas. Managers can therefore prioritise where to implement control strategies in order to reduce the transmission of diseases of conservation, economic and social relevance.

References
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Acknowledgements
We would like to thank E. Guerrero and M.A. Aguilar, the pilots and technicians who controlled the UAS and prepared the image mosaic. The present work has benefited from the financial aid of research grants JCCM (PEII10-0262-7673), MINECO (AGL2010-20730-C02-01), Aeromab Project (P07-RNM-03246), and the PLANET Project (EU, Cooperation, 7th FP, 2010). J.A.B. holds an FPU pre-doctoral scholarship. P.A. is supported by MINECO-UCLM through 'Ramón y Cajal' contract (RYC-2012-11970) and partly by EMIDA-ERA-NET grant APHAEA (219235-FP7-ERA-NET-EMIDA; www.aphaea.eu).