Mapping and modelling helminth infections in ruminants in Europe: experience from GLOWORM

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Abstract. Mapping and modelling helminth infections in cattle and sheep in Europe through advanced geospatial research was one of the main task of GLOWORM, a three year project (2012-2014) funded under the European Commission's (EC) seventh framework programme (FP7). Liver flukes as *Fasciola hepatica* and gastrointestinal nematodes, such as *Haemonchus contortus* were chosen for the project since these parasites constitute a major cause of lost productivity in small and large ruminants. The output of the GLOWORM project delivered guidelines for standardized and harmonized cross-sectional surveys of helminth parasites in ruminants allowing the development of updated prevalence maps and multi-scale, spatial models for the European area.

Keywords: helminths, *Fasciola hepatica*, *Haemonchus contortus*, mapping, modelling, ruminants, Europe, GLOWORM.

Helminth infections continue to represent a serious challenge to the health, welfare, productivity and reproduction of grazing ruminants throughout the world. In principle, all grazing animals are such exposed to these infections, in particular to liver flukes as *Fasciola hepatica* and gastrointestinal nematodes (GIN), such as *Haemonchus contortus*. Together, these parasites constitute a major cause of lost productivity in small and large ruminants as is evident by DISCON-TOOLS (http://www.discontools.eu), a programme recently established by the European Union (EU) to prioritize research on animal diseases and identify control tools. The EU is increasingly interested in finding ways and means to limit the impact of these parasites upon animal health, welfare and productivity (Morgan et al., 2013; Charlier et al., 2014; Rinaldi and Cringoli, 2014).

The idea behind the current special issue of Geospatial Health is to broaden interest in geospatial research (mapping and modelling) pertaining to helminth infections in large and small ruminants in Europe.

F. hepatica and GIN (in particular *H. contortus*) were studied in the GLOWORM project: "Innovative and sustainable strategies to mitigate the impact of global change on helminth infections in ruminants", a research consortium running from 2012 to 2014 supported by funds (Grant # 288975) from the European seventh framework programme (FP7). Ten academic institutions and four small and medium-sized enterprises (SME), comprising a multitude of disciplines, such as parasitology, epidemiology, molecular biology, diagnostics, farming systems, remote sensing and geographical information systems (GIS), from various European countries participated in the project.

The output of the project provided practical and scientific approaches to respond to environmental, climatological and parasitological changes occurring in Europe with special emphasis on:

(i) the design of cost-efficient and practical spatial sampling strategies;

(ii) the construction of a spatial database containing

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environmental and climatic variables for mapping helminth infections; and

(iii) the development of multi-scale, spatio-temporal models for parasite occurrence with special reference to climate change.

Sampling for fasciolosis in cattle based on bulk tank milk (BTM) samples and antibody detection by the enzyme-linked immunosorbent assay (ELISA) has proved itself a well-standardized approach to risk mapping (Ducheyne et al., 2015). Naturally, the presence of specific antibodies reflects exposure to the parasite rather than current infection. However, the main reasons for these kinds of nation-wide surveys are less for finding which farms are infected but rather to document the distribution of an infection. In this case, we were interested in establishing risk maps for stakeholders that range from the farmers and local veterinarians to the various political levels, in particular the decision-makers. Importantly, these risk-maps should be regarded as baseline information that needs to be regularly updated in surveillance programmes. GLOWORM enabled us to produce region- or country-specific such maps (Novobilsky et al., 2015; Selemetas et al., 2015a,b) as well as the first pan-European map of *F. hepatica* infection risk in dairy cattle (Ducheyne et al., 2015), a milestone for further work that will be need in the future.

In parallel with the sampling for fasciolosis in dairy cattle, we collected updated and reliable parasitological data for sheep (Rinaldi et al., 2015a,b) through a standardized and harmonized approach based on cost-effi-cient, spatial sampling and diagnostic procedures involving pooled faecal samples and FLOTAC (Cringoli et al., 2010), a highly sensitive and accurate, quantitative and qualitative faecal egg assay.

Parasitological, cross-sectional surveys were conducted using a representative number of cattle and sheep farms in selected pilot areas throughout Europe. The geo-referenced results were used for the creation of maps comprising updated parasitological information on the distribution of *F. hepatica* and *H. contortus* infections in ruminant farms in Europe (Bosco et al., 2015; Ducheyne et al., 2015; Rinaldi et al., 2015a,b). This information was followed by the construction of multi-scale GIS of parasitological, climatic, environmental and farm management data. The data were further subjected to a comparative analysis of parasite occurrence between the study areas distributed throughout Europe using various spatial models, either based on Bayesian geostatistics or advanced machine-learning approaches, such as Random Forests (RF) and Boosted Regression Trees (BRT) with and without environmental and climatic covariates (Ducheyne et al., 2015; Novobilsky et al., 2015; Rinaldi et al., 2015a,b; Selemetas et al., 2015a,b).

Furthermore, the climate-based Ollerenshaw Mt model for *F. hepatica* was expanded (Caminade et al., 2015) and a Q_0 model for *H. contortus* developed, tested and validated (Bolajoko et al., 2015), with a view to the apply these model frameworks on a spatial basis in future.

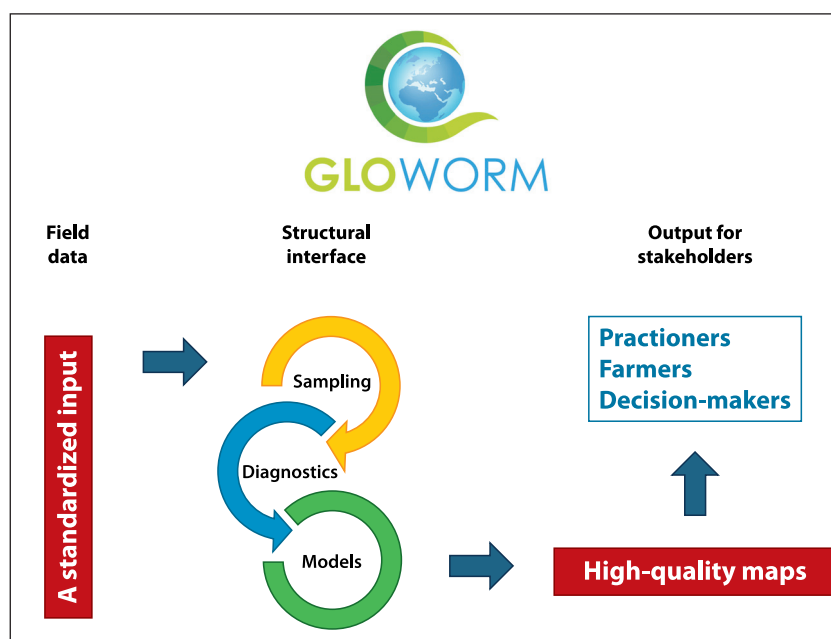The output of the GLOWORM project delivered

Fig. 1. The GLOWORM interface between sampling, diagnostics and maps.

guidelines for standardized and harmonized cross-sectional surveys of helminth parasites in ruminants (Ducheyne et al., 2015; Rinaldi et al., 2015a,b) allowing the development of updated prevalence maps and multi-scale spatial models for the European area (Fig. 1).

The continued functioning of the ecosystem is vital for the future of farms in Europe, and the findings within the GLOWORM framework reflect the ongoing ecological changes we are witnessing at various levels. To investigate ongoing developments with respect to parasites of veterinary importance, we used a range of models and scenarios of climate and land-use change to conduct this Europe-wide assessment. Although some trends are positive, such as increased agricultural productivity (better growing degree days) or offer opportunities for extension of arable land, many changes increase vulnerability as a result of changes in water availability and soil fertility (Schröter et al., 2005).

The current maps and the climate impact studies demonstrate that both *F. hepatica* (Caminade et al., 2015) and *H. contortus* (Bolajoko et al., 2015) already now present an increased risk for health, welfare and productivity of ruminants throughout Europe, a situation that has the potential of becoming worse, even if the climate change of the last 30 years does not undergo further exacerbation as projected by the International Panel on Climate Change (IPCC) (http://www.ipcc.ch/). There are reasons to believe that the spatial occurrence of these parasites, including their transmission periods, will continue to expand in Europe (and other parts of the world). Such a scenario would require increased frequency of prophylactic treatment to control helminth infection, which may well lead to increasing levels of resistance to anthelmintic drugs. Improved control programmes tailored at various multi-scale levels will become a fundamental issue to be seriously considered by animal health authorities. The approaches developed within the GLOWORM project provide important steps towards the application of spatial tools in support of such control programmes.

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