ParaCalc® - open access web tools to support the control of parasitic diseases in cattle

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Abstract

Parasitic infections of cattle are a major constraint on efficient livestock production globally. A crucial role for assessing their economic impact will be reserved for diagnostic and computational tools used to detect these infections and their impact on farm performance. Here we will describe ParaCalc®, a web-site (www.ParaCalc.com) providing tools to support the control of parasitic infections in livestock. The original idea of ParaCalc® was to integrate diagnostic test information with farm information in order to monitor the economic impact of parasitic infection on a specific farm. As such, ParaCalc® now offers 4 different tools that can support the veterinary advisor in tackling parasitic infections of cattle: (i) cost of worm infections in dairy herds; (ii) cost of mange infections in Belgian Blue beef cattle; (iii) treatment strategies against gastrointestinal worms in adult cows and (iv) a decision tree to detect the source of liver fluke infection on a dairy farm and to target control measures. These tools have emerged directly from published research and more work needs to be done in order to develop tools that closely fit with the specific user needs of a veterinary advisor or to integrate them in more holistic management software. However, we hope that with the continuing support of veterinary advisors and academic researchers from different institutions, ParaCalc® can become an important tool in veterinary medicine.

Key words: Cattle, nematode, liver fluke, mange, decision support, cost of disease

1. Introduction

Parasitic infections of cattle are a major constraint on efficient livestock production globally. Most cattle are infected by a variety of endo- and ectoparasites, which negatively impact on feed intake, growth rate, carcass weight, carcass composition, fertility and milk yield (Fitzpatrick, 2013). Important parasitic infections in cattle in Western Europe include infections with gastrointestinal protozoa (*Cryptosporidium parvum*, *Giardia duodenalis*, *Eimeria* spp.) gastrointestinal nematodes (mainly *Ostertagia ostertagi*, *Cooperia oncophora*), liver fluke (*Fasciola hepatica*), lungworm (*Dictyocaulus viviparus)* and mange (*Psoroptes ovis, Chorioptes bovis*). The impact of parasitic infections on animal productivity is well accepted, but farm productivity depends on multiple other factors such as farm scale, other diseases and management (Wilson, 2011). It is thus a major challenge to assess the farm-specific importance of parasite infections and prioritize the available resources to the interventions that have the largest impact on the farm economic performance.

A crucial role for assessing the economic impact of parasitic infections will be reserved for diagnostic and computational tools used to detect these infections and to assess their impact on farm performance. New and more automated laboratory diagnostic methods are emerging (Hunt and Lello, 2012). However, the evaluation of these tests remains very much focused on detecting presence/absence of infection, with some of the more recent tests attempting to quantify the actual parasite burden. What is now required is to use these diagnostic methods to understand their production and economic impact on a farm (Charlier et al., 2014).

This was the original idea of ParaCalc®: integrating diagnostic test information with farm information in order to monitor the economic impact of parasitic infections on a specific farm. In this paper, we will describe the origins of ParaCalc®, its current status and discuss future developments.

2. History and mission of ParaCalc®

The origin of ParaCalc® dates back to 2010. Its creation was a logical consequence of new developments in the field of worm diagnostics. Several studies appeared that quantified the impact of gastrointestinal nematode and liver fluke infections on dairy productivity. Moreover, reasonable correlations were observed between diagnostics quantifying the exposure to the worm infections (i.e. bulk tank milk ELISAs) and measures of performance such as milk yield and growth. The logical next question was how this diagnostic information could be used to assess the economic impact of the considered parasitic infections? The result was a simple spread sheet model where the results of pepsinogen assay and (bulk-tank milk) ELISA for gastrointestinal nematodes and liver fluke could be used to estimate the yearly cost of worm infection in a dairy herd (Charlier et al., 2012a).

Since then, other questions emerged such as: (i) Can similar tools be developed for other diseases?; (ii) Can the tool also predict the impact of intervention strategies?; (iii) What is the uncertainty around the estimated costs? Answering such questions can take years of research and more than a single research team. Thus, ParaCalc® evolved further and is now providing a platform for researchers with the idea that they can contribute and post their tools online. A prerequisite is that the tool has a sound scientific basis and that the underlying models are published in peer-reviewed scientific literature. ParaCalc® can thus be seen as a step stone for researchers to translate their scientific results into practical tools for a larger public. It is an intermediate step before the most successful tools may be integrated in more holistic software packages. As such, ParaCalc® now offers four different tools that support the veterinarian to tackle parasitic infections in cattle. All tools are freely available online. In the next section, we will elaborate on the functionalities of each of the four tools.

3. Available tools

3.1 Cost of worm infections

This was the first tool available on ParaCalc® and was developed from the insight that the test results from bulk tank milk ELISAs measuring exposure to gastrointestinal nematodes and liver fluke were negatively correlated with milk production. The aim of the tool is to provide herd-specific estimates of the costs of gastrointestinal nematode and/or liver fluke infections on dairy farms (Fig 1). It is a deterministic model where results from diagnostic methods to monitor the helminth infection status in young stock (pepsinogen assay, *F. hepatica* ELISA) and adult cows (bulk tank milk ELISA for *O. ostertagi* and *F. hepatica*) and anthelmintic usage are used as input parameters (Charlier et al., 2012a). Default values are provided to describe the effects of the infections on production and the cost of these production losses, but the latter can be adapted to improve the herd-specificity of the cost estimate. After applying the tool on 93 Belgian dairy herds, the estimated median [25th-75th percentile] cost per year per cow was € 46 [29-58] and € 6 [0-19] for gastrointestinal nematode and liver fluke infection, respectively. Large variations in the costs between individual farms were seen, with some farms suffering losses > € 150 per cow when the 2 parasites are considered together. The data can be stored in a password-protected database and a number of basic graphical tools are available. The tool was evaluated by practitioners who considered it to be a useful tool for raising the farmer's awareness on the costs of worm infections, providing added value for their services. However, they also indicated that the user experience could be improved by further simplifying the tool and increasing user friendliness.

Coûts des verminoses dans votre élevage				
	Vers gastro-intestinaux		Grande douve	
	Génisses	Vaches adultes	Génisses	Vaches adultes
Pertes de production	€ 429,00	€ 4 340,00	€ 2 417,00	€ 1 976,00
Coûts des anthelmintiques	€ 300,00	€ 0,00	€ 0,00	€ 0,00
Au total	€ 729,00	€ 4 340,00	€ 2 417,00	€ 1 976,00

	Par an	Par an et par vache
Coûts totaux dus aux vers gastro-intestinaux	€ 5 069,00	€ 34,00
Coût totaux dus à la grande douve	€ 4 393,00	€ 29,00

Fig 1. Example of the output from the tool "Cost of worm infections"

3.2 Cost of mange infections

In the search of creating similar tools for other important diseases there was one major condition: diagnostic tools that show a good and robust correlation with measures of productivity need to be available. A nice example is psoroptic mange in cattle. The mite *Psoroptes ovis* causes skin lesions and important economic losses in Belgian Blue cattle. Lonneux et al. (1998) observed a significant and negative correlation between the surface of the induced skin lesions (clinical index) and daily weight gain. Hence, a tool was developed showing 4 photographs representing different intensities of skin lesions, from not affected (0% of body surface) to severely affected (30-70% of body surface). When the proportion of animals in a flock is entered for each category, we can thus estimate the lost weight gain over the fattening period if no control measures are applied. The 95% credible interval shows the uncertainty in the impact and is also based on the uncertainty in the relationship between weight gain and clinical index observed by Lonneux et al. (1998). In the example given in Fig. 2 (flock size= 100; fattening period of 60 days) the estimated loss was € 2243 (95% credible interval: 796 – 3891) in total or € 22 (95% credible interval: 8-39) per cow over the fattening period. This number calculation can thus be used to discuss the room for investment in control measures with the herd owner.

The model underlying this tool is based on a single study in a single breed (Belgian Blue). Further development of this tool should involve more production impact studies in different farm settings and different breeds.

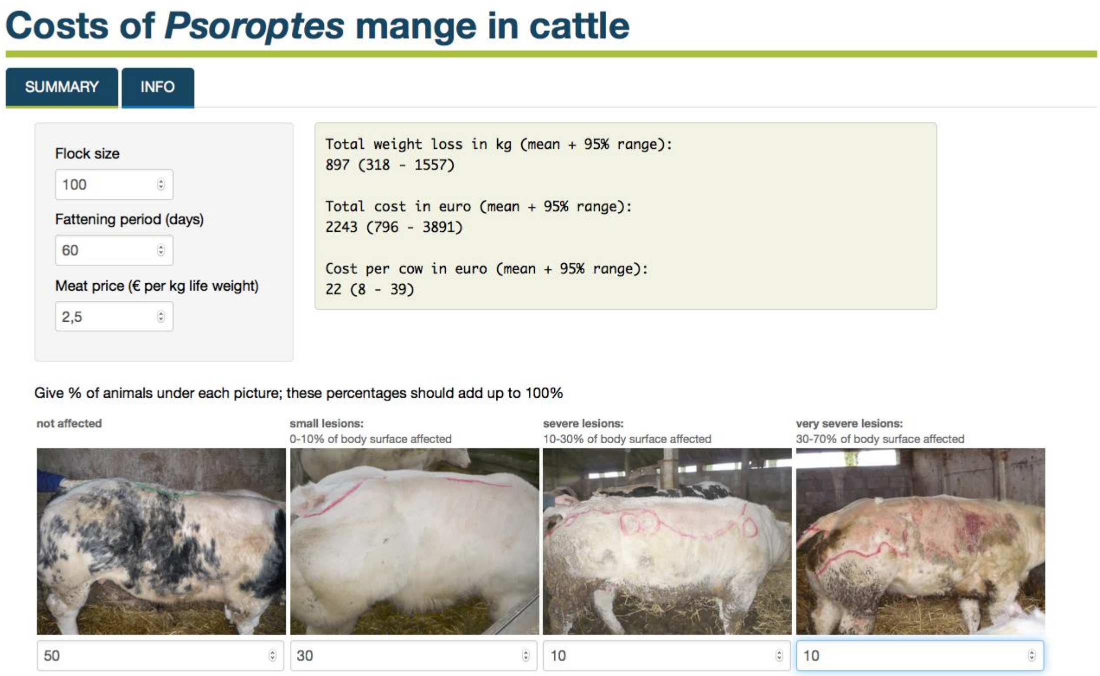

Fig 2. Example of the output of the tool “Cost of psoroptic mange in cattle”

3.3 Treatment strategies against gastrointestinal worms in adult cows

The previous tools estimate the cost of a specific disease over a specific period. One could say these are of limited interest because rather than knowing the cost of disease, a farmer may be interested in how much of this cost is avoidable through the implementation of a specific control measure. The tool “Simulation of anthelmintic treatment strategies” takes this issue into account by the use of a Monte Carlo simulation. The model is fed by the current epidemiological and economical knowledge to estimate the expected economic effects and possible variation of different anthelmintic treatment strategies in adult cattle under Belgian conditions (Charlier et al., 2012b). Four different treatment strategies are compared with a baseline situation where no treatments are applied: whole-herd treatment at calving (S1), selective treatment at calving with (S2) or without (S3) treatment of the first-calf cows and whole-herd treatment when animals are moved from grazing to the barn in the fall (= "housing" treatment, S4). The benefits per lactation for an average dairy herd vary between € -2 and € 103 for S1, € -2 and € 101 for S2, € -14 and € 82 for S3 and € -33 and € 57 for S4. The financial risk the farmer is taking by implementing a treatment strategy can be evaluated by the width of the 95% credible intervals. For instance, it becomes smaller with increasing herd size. This tool can therefore be seen as a decision support system that takes multiple cow, epidemiological and economic factors into account and helps to select the economically optimal treatment strategy for a specific farm. An example of the output of the tool is given in Fig. 3.

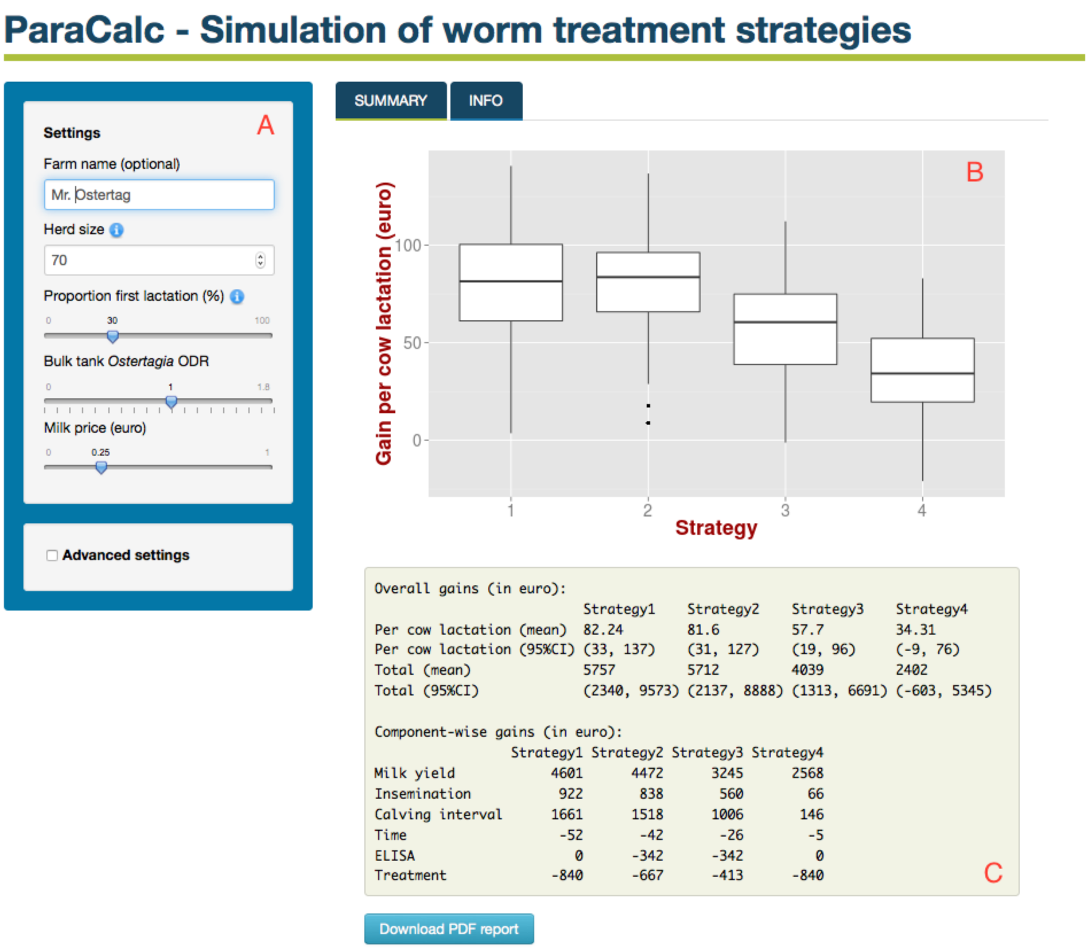

Fig 3. Example of the output of the tool "Treatment strategies against gastrointestinal worms". In **box A**, farm specific data need to be provided; in **box B** the results of the simulations are presented graphically. In this case, strategy 1 is predicted to have the largest economic impact with a median **[**95% credible interval**]** predicted benefit of €82 **[**33-137**]** per cow lactation; in **box C** the results are presented in more detail.

3.4 Liver fluke decision tree: detecting the source of infection and targeting control measures

This tool was developed by Gabriëla Knubben-Schweizer (Unversity of Munich) and Paul Torgerson (Universität Zürich) (Knubben-Schweizer and Torgerson, in press), who offered to make the tool available through ParaCalc®. It provides the users with information on how to approach the control of fasciolosis on a single dairy farm. It is based on identification of the source of infection by examination of definite hosts and pastures on a farm. The use of decision tree leads to identification of one of the following epidemiological situation on a farm:

(1) Snail habitats are present on pastures used for young stock (prior to first calving) or dry cows only. Pastures for dairy cows are not affected.

(2) Snail habitats are present on all pastures for dairy cows.

(3) Snail habitats are present on single pastures used for dairy cows.

(4) Snail habitats are present on hay fields.

For each of these epidemiological situations an individual control strategy is advised. By visualizing the decision tree in a single web page, the idea is to make the tree easily consultable on farm by the use of a smartphone or tablet. In contrast to the previous tools, this tool does not estimate the cost/benefit of the proposed control strategies.

4. Further developments

In the future, it is envisaged to make new tools available on the site. These tools include improved economic assessments based on efficiency analysis (van der Voort et al., 2014), a tool to assess anthelmintic efficacy based on the faecal egg count reduction test (Torgerson et al., 2014; Levecke et al., in press) or transmission models that can simulate the effect of different treatment strategies on the pasture infectivity

(Rose et al., 2015). However, additional research will be required before they are of practical value.

In addition, the tools that are available on ParaCalc® have emerged directly from published research. We acknowledge that more work needs to be done in order to develop tools that closely fit with the specific users needs of a veterinary advisor. Therefore, focus groups with a co-creation session were organized to identify the user needs for software applications on helminth control in cattle. Two groups: (1) farmers and (2) their veterinarian were selected for this requirement analysis. In general farmers appeared to be more willing to embrace new technologies. Their main requirement was the compatibility of the new product with other existing or novel technologies. Software to support parasite control should be able to fit in an all-round technology were all data of their herd is implemented and visible. If a system as such would be available, the adoption would be certainly positive. The time-managing component was important for both groups; ‘a new application should be able to end a day’s work in the stable’. All kind of data should be available on the spot. For the private veterinarian, the importance of linkage with his billing system emerged, so that delivered advices can be properly accounted. We concluded that two different software applications should be developed in order to address the needs of both groups.

5. Conclusion

From its first description as a deterministic model to estimate the yearly cost of worm infections on a dairy farm, ParaCalc® has evolved to a broader platform offering several tools to support the veterinary advisor in the control of parasitic infections of cattle. The site has attracted over 600 users from around the world in the last year. It is hoped that with continuing support from academic researchers and veterinarians in the field, ParaCalc® will continue to grow. This will allow the development of new analytic tools, adaptation of the tools to fit specific user requirements as well as integration into more holistic herd management software.

References

CHARLIER J, VAN DER VOORT M, HOGEVEEN H, VERCRUYSSE J. ParaCalc®

- a novel tool to estimate the costs of worm infections on the dairy herd. *Veterinary Parasitology,* 2012a;184:204-211.

CHARLIER J, LEVECKE B, DEVLEESSCHAUWER B, VERCRUYSSE J, HOGEVEEN H. The economic effects of whole-herd versus selective anthelmintic treatment strategies in dairy cows. *Journal of Dairy Science,* 2012b;95:2977-2987.

CHARLIER J, VAN DER VOORT M, KENYON F, SKUCE P, VERCRUYSSE J. Chasing helminths and their economic impact on farmed ruminants. *Trends in Parasitology,* 2014;30:361-367.

FITZPATRICK, JL. Global food security: The impact of veterinary parasites and parasitologists. *Veterinary Parasitology,*2013;195:233-248.

HUNT PW, LELLO J. How to make DNA count: DNA-based diagnostic tools in veterinary parasitology. *Veterinary Parasitology,* 2012;186:101-108.

KNUBBEN-SCHWEIZER G, TORGERSON PR. Bovine fasciolosis: Control strategies based on the location of *Galba truncatula* habitats on farms. *Veterinary Parasitology,* in press.

LEVECKE B, ANDERSON RM, BERKVENS D, CHARLIER J, DEVLEESSCHAUWER B, SPEYBROECK N, VERCRUYSSE J, VAN AELST S. Mathematical inference on helminth egg counts in stool and its applications in mass drug administration programmes to control soil-transmitted helminthiasis in public health. *Advances in Parasitology,* in press.

LONNEUX JF, NGUYEN TQ, DETRY J, FARNIR F, LOSSON BJ. The relationship between parasite counts, lesions, antibody titres and daily weight gains in *Psoroptes ovis* infested cattle. *Veterinary Parasitology,* 1998;76:137-148.

ROSE H, WANG T, VAN DIJK J, MORGAN ER. GLOWORM-FL: a simulation model of the effects of climate and climate change on the free-living stages of gastro-intestinal nematode parasites of ruminants. *Ecological Modelling,* 2015;297: 232-245.

TORGERSON PR, PAUL M, FURRER R. Evaluating faecal egg count reduction using a specifically designed package "eggCounts" in R and a user friendly web interface. *International Journal for Parasitology*, 2014;44:299-303.

VAN DER VOORT M, VAN MEENSEL J, LAUWERS L, VERCRUYSSE J, VAN HUYLENBROECK G, CHARLIER J. A stochastic frontier approach to study the relation between gastrointestinal nematode infections and technical efficiency of dairy farms. *Journal of Dairy Science*, 2014;97:3498-3508.

WILSON P. Decomposing variation in dairy profitability: the impact of output, inputs, prices, labour and management. *The Journal of Agricultural Science*, 2011;149:507-517.