05-Aug-2019

Dear Dr Adiga:

Your manuscript has now been peer reviewed and the reviews have been assessed by an Associate Editor. The reviewers’ comments (not including confidential comments to the Editor) and the comments from the Associate Editor are included at the end of this email for your reference. As you will see, the reviewers and the Editors have raised some concerns with your manuscript and we would like to invite you to revise your manuscript to address them.

We do not allow multiple rounds of revision so we urge you to make every effort to fully address all of the comments at this stage. If deemed necessary by the Associate Editor, your manuscript will be sent back to one or more of the original reviewers for assessment. If the original reviewers are not available we may invite new reviewers. Please note that we cannot guarantee eventual acceptance of your manuscript at this stage.

To submit your revision please log into http://mc.manuscriptcentral.com/prsb and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions”, click on "Create a Revision”. Your manuscript number has been appended to denote a revision.

When submitting your revision please upload a file under "Response to Referees" - in the "File Upload" section. This should document, point by point, how you have responded to the reviewers’ and Editors’ comments, and the adjustments you have made to the manuscript. We require a copy of the manuscript with revisions made since the previous version marked as ‘tracked changes’ to be included in the ‘response to referees’ document.

Your main manuscript should be submitted as a text file (doc, txt, rtf or tex), not a PDF. Your figures should be submitted as separate files and not included within the main manuscript file.

When revising your manuscript you should also ensure that it adheres to our editorial policies (https://royalsociety.org/journals/ethics-policies/). You should pay particular attention to the following:

Research ethics:

If your study contains research on humans please ensure that you detail in the methods section whether you obtained ethical approval from your local research ethics committee and gained informed consent to participate from each of the participants.

Use of animals and field studies:

If your study uses animals please include details in the methods section of any approval and licences given to carry out the study and include full details of how animal welfare standards were ensured. Field studies should be conducted in accordance with local legislation; please include details of the appropriate permission and licences that you obtained to carry out the field work.

Data accessibility and data citation:

It is a condition of publication that you make available the data and research materials supporting the results in the article. Datasets should be deposited in an appropriate publicly available repository and details of the associated accession number, link or DOI to the datasets must be included in the Data Accessibility section of the article (https://royalsociety.org/journals/ethics-policies/data-sharing-mining/). Reference(s) to datasets should also be included in the reference list of the article with DOIs (where available).

In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should also be fully cited and listed in the references.

If you wish to submit your data to Dryad (http://datadryad.org/) and have not already done so you can submit your data via this link http://datadryad.org/submit?journalID=RSPB&manu=(Document not available), which will take you to your unique entry in the Dryad repository.

If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link.

For more information please see our open data policy http://royalsocietypublishing.org/data-sharing.

Electronic supplementary material:

All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI. Please try to submit all supplementary material as a single file.

Online supplementary material will also carry the title and description provided during submission, so please ensure these are accurate and informative. Note that the Royal Society will not edit or typeset supplementary material and it will be hosted as provided. Please ensure that the supplementary material includes the paper details (authors, title, journal name, article DOI). Your article DOI will be 10.1098/rspb.[paper ID in form xxxx.xxxx e.g. 10.1098/rspb.2016.0049].

Please submit a copy of your revised paper within three weeks. If we do not hear from you within this time your manuscript will be rejected. If you are unable to meet this deadline please let us know as soon as possible, as we may be able to grant a short extension.

Thank you for submitting your manuscript to Proceedings B; we look forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Best wishes,

Dr Sasha Dall

mailto: proceedingsb@royalsociety.org

</$details>

<$details summary="Associate editor">

Associate Editor

Board Member: 1

Comments to Author:

Two experts have now reviewed your paper “Assessing the Multi-pathway Threat from an Invasive Agricultural Pest: Tuta absoluta in Asia” (RSPB-2019-1159). Reviewer 1 is quite positive on the paper and indicates the need of only formal changes in the text, mostly aimed at clarifying methods and making a more complete review of the literature. Reviewer 2 is more critical, particularly on the models and related decisions. In my opinion all his/her comments are highly relevant, but you should pay particular attention those regarding the predictive nature of the study, and those related to CA models detailed in the third paragraph of the review.

</$details>

<$details summary="Reviewer 1">

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)

I found the manuscript very interesting and well-written. Data are presented in great detail (especially in the supplementary material), as well as the methodology and the results. I appreciate the huge effort in collecting and sharing such a complex body of data on international trades, climate, crop production and other relevant variables. The proposed methodology is very innovative and allows to discover new insights into the spread of Tuta absoluta and on possible ways of controlling the pest.

Invasive-species dynamics are hard to predict and model, especially when dispersal can be mediated by human transport over large regions. The authors consider a multi-pathway dynamic and actually find two possible spreading pathways: with and without long-distance human-mediated transport of the insect pest. The fitted models of short and long-distance transport (based on past detections in Bangladesh) are then applied to the rest of the study region in order to predict the future spread of Tuta absoluta. Finally, a simple control strategy is proposed (quarantine in high-outflow regions) and its effect is estimated by means of the constructed model.

The methodology used in the paper is rather new and involves a novel way of exploring the parameter space by means of surrogate machine learning techniques. My only concern is that such novel practices are rather unknown to the general public and may deserve more explanation. In my opinion Figure S5 in the Supplementary Materials could easily be included in the main text since it helps understanding the methodology.

Other few remarks are listed in the following:

1. In Section ‘Parametrization and experiment design’, right after Eq.4, the sentence about the use of CART model is rather misleading since it’s only after 1) selecting outputs with similarity over 75% and 2) clustering of outputs (as explained in S4 of SM) that the classification via CART is used. I suggest to remove it from there or explain the entire process before CART.

2. The advantage of the proposed methodology is that it allows to determine the influence of the different parameters of the model on the final output (seen as a machine learning problem where parameters are features or independent variables and the outcomes are the dependent one). Nonetheless, most reader will find this technique overly complicated w.r.t. a classical optimization (gradient descent, genetic algorithm or any other heuristic and meta-heuristic technique). In my opinion the authors should stress more the relevance of the proposed technique.

3. In Section ‘Influence of domestic trade on spread pattern and rate’, you find a rather well-known result in network theory, i.e. that hubs of the networks are facilitators of epidemic spread. There exists an extensive literature on the subject that should be cited.

4. Towards the end of the first paragraph of the Discussion (page 13, before Section ‘Literature Survey’), you mention Nopsa et al. as one of the few works ‘[…] Identifying the optimal set of nodes in a network to reduce infectious disease’. This is not true. Lot of works in plant epidemiology based on a network approach have used ‘important’ nodes for developing surveillance and control strategies: just a couple of examples on another major plant pest (Xylella fastidiosa) are Strona et al. 2017 ‘Network analysis reveals why Xylella fastidiosa will persist in Europe’ and Martinetti at al. 2018 ‘Identifying Lookouts for Epidemio-Surveillance: Application to the Emergence of Xylella fastidiosa in France’.

</$details>

<$details summary="Reviewer 2">

Referee: 2

Comments to the Author(s)

This paper studies the relationship between exotic species invasions and trade and human mobility. This is a data-driven modelling approach to human-mediated spread which poses two interesting modelling challenges: (1) model complexity due to multiple drivers of epidemic dispersal and (2) model validation issues derived from existing data limitations. The paper is interesting and potentially relevant to the community of agricultural pest management. In particular, this seems like a useful means to visualise and recapitulate previous epidemics (a kind of “post-mortem” analysis) but it is somehow lacking in terms of predictions.

An interesting novelty of the paper is the application of a machine learning framework to calibrate the model best model parameters (see ‘Analysis of spread pattern’, pp. 7). In effect, this applies a method originally develop in the community of agent-based models to the modelling of epidemic spread. My main concern is not the parameter fitting (but one should recall that the workings of clustering algorithms are difficult to understand) but the novelty of the modelling approach, which is unclear.

I found the modelling terminology a bit confusing. The model is called “stochastic multi-scale propagation” or “multi-pathway spread” but a more apt classification seems “old-school cellular automata” (CA) model of epidemic spreading. The authors should review similar CA models and tell us what is really new in this case. Perhaps merging the “literature review” section with the introduction can help in this regard. In addition, some of the modelling decisions are unclear or require additional empirical support/justification. Each cell of the CA can be in one of three states: susceptible(S) => exposed (E) => infectious (I). Transitions from one state to another are governed by simple stochastic rules. For example, Infectiousness is a simple linear function of density. However, I cannot judge if this choice is realistic enough or not. Many complex systems show non-linear effects with varying population sizes. An empirical curve correlating infectiousness and density will support the current model (or some explanation of why this has been chosen).

Another aspect is the long-distance dispersal kernel (see equation 1). This is different from the standard CA model, which presupposes an unrealistically local Moore neighbourhood (see Table 1). Again, it is unclear why the exponential form was chosen instead of other possibilities. Such exponential kernels are typical of gravity models employed for example in socio-economics. I concede this a more realistic approach than the Moore definition, but still it does not seem an accurate model for global trade networks, e.g., a power-law distribution (see paragraph starting at pp 5, line 11).

The analysis reveals the role of human-assisted spread of the pest of tomato, which quickly expands its range through city-to-city trade routes (see Fig 3). This is hardly surprising, but the analysis shows a potential to discriminate between different factors driving the epidemic spreading (e.g., role of markets).

In this context, it will be interesting to move from detailed reconstructions (and visualisations) of previous epidemics (like the present manuscript) to accurate predictions.

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Journal Name: Proceedings of the Royal Society B

Journal Code: RSPB

Print ISSN: 0962-8452

Online ISSN: 1471-2954

Journal Admin Email: proceedingsb@royalsociety.org

MS Reference Number: RSPB-2019-1159

Article Status: SUBMITTED

MS Dryad ID: RSPB-2019-1159

MS Title: Assessing the Multi-pathway Threat from an Invasive Agricultural Pest: Tuta absoluta in Asia

MS Authors: McNitt, Joseph; Chungbaek, Young Yun; Mortveit, Henning; Marathe, Madhav; Campos, Mateus ; Desneux, Nicolas; Brevault, Thierry; Muniappan, Rangaswamy; Adiga, Abhijin

Contact Author: Abhijin Adiga

Contact Author Email: abhijin@gmail.com, abhijin@virginia.edu

Contact Author Address 1:

Contact Author Address 2:

Contact Author Address 3:

Contact Author City: Charlottesville

Contact Author State: Virginia

Contact Author Country: United States

Contact Author ZIP/Postal Code: 22903-1738

Keywords: biological invasion, insect pests, human-mediated spread, spread model, epidemic network models, agent-based modelling

Abstract: Modern food systems facilitate rapid dispersal of pests and pathogens through multiple pathways. The complexity of spread dynamics and data inadequacy make it challenging to model the phenomenon and also to prepare for emerging invasions. We present a generic framework to study the spatiotemporal spread of invasive species as a multi-scale propagation process over a time-varying network accounting for climate, biology, seasonal production, trade, and demographic information. Machine learning techniques are used in a novel manner to capture model variability and analyse parameter sensitivity. We applied the framework to understand the spread of a devastating pest of tomato, Tuta absoluta, in South and Southeast Asia, a region at the frontier of its current range. Analysis

with respect to historical invasion records suggests that even with modest self-mediated spread capabilities, the pest can quickly expand its range through domestic city-to-city vegetable trade. Our models forecast that within five to seven years, T. absoluta will invade all major vegetable growing areas of Mainland Southeast Asia assuming unmitigated spread. Monitoring high consumption areas can help in early detection, and targeted interventions at major production areas can effectively reduce the rate of spread.

EndDryadContent

</$details>