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Disease Risk Assessment and Invasive Alien Species: developing a methodological approach to evaluate the risk of introduction of new infections and spread of local ones

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Invasive alien species (IAS) represent one of the main global threats to biological conservation and can even exert a great impact on human activities. To cope with this issue, the European Community has recently approved a Regulation (Reg. EU No 1143/2014) to define a common intervention line. According to this Regulation, a list of invasive alien species considered to be of Union concern has been defined and will be regularly updated in order to define priority interventions. Although infectious diseases may play a relevant role in the establishment of IAS and have dramatic impacts on human health, economic sustainability of animal farming and biodiversity conservation, diseases are rarely included into evaluations due to the methodological complexities of their risk assessment. Every mammal species can be indeed infected by up to hundreds of different parasites which can be transmitted to humans, domestic animals and other wildlife. Alien species may thus act as carriers of new infections in the area of release, or as new competent hosts for autochthonous infections, amplifying their local transmission and maintenance. Here we used raccoon (*Procyon lotor*), coypu (*Myocastor coypus*) and grey squirrel (*Sciurus carolinensis*) as model species to develop a qualitative methodology for Disease Risk Assessment that allows to assign each IAS into one out of four discrete risk categories.

Assignment to these categories is obtained by scaling the likelihood of infection occurrence over its impact, with each of these two elements defined in turn through four discrete categories.

Hazard assessment, determined through the analysis of existing scientific literature, identified a total of 377 parasite species reported in 388 scientific papers.

Thus, for each infection, we defined the impact and likelihood of their introduction or local amplification in relation to transmission to humans, domestic animals or other wildlife. Based on these data, for each of the three IAS we assessed the risk towards humans, domestic animals and other wildlife relative to the introduction of new parasites and the amplification of local ones. Additionally, for each host species we obtained a total disease risk evaluation that included all these partial aspects. Concurrently, we also carried out evaluations to determine the uncertainty level associated with each of the risk estimates.

Our analyses showed that the raccoon is the IAS infected by the highest number of parasite species (n=198), followed by grey squirrel (n=136) and coypu (n=44). The risk of introducing new parasites is thus higher for the raccoon, which may carry 37 high risk parasites: 16 zoonotic, 12 transmissible to domestic animals and 9 to wildlife. On the contrary, coypu presents the lowest risk of introducing new parasites with only 2 high risk parasites transmissible to humans and wildlife and 1 to domestic animals. Similarly, even the risk of amplifying local parasites is highest in raccoon, which may be infected by 16 parasite species that represent a high risk for humans and 6 for domestic and wild animals. Coypu resulted again the least risky species, with 4 high risk infections for humans and wildlife and 2 for domestic animals.

As a consequence, the overall disease risk is higher for raccoons with 27 high risk infections for humans, 15 for domestic animals and 12 for wildlife, whereas coypu is the least risky species with 5 infections for humans and wildlife and 2 towards domestic animals. Finally, the risk estimates relative to raccoon shows the highest level of uncertainty and respect the coypu's the lowest level.

These results show that some alien species, despite having a relatively low impact on biodiversity and human economy, might indeed entail high disease risks, whereas species with a high environmental impact may pose negligible disease risks.

The present methodological approach represents a first step towards a broader development of a disease risk analysis on a more comprehensive number of invasive alien species. Other than providing information on disease risk, the output of this assessment can serve as a guideline to indicate those knowledge gaps that should be covered. In particular, disease risk assessment should integrate experts' opinions that define likelihoods of infection of less investigated parasite species with a participated involvement of stakeholders to better incorporate the perceived impacts. Once these results will be achieved, risk management plans to mitigate the potential disease impact posed by IAS could be defined.

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