Dear Editor,

Below we have provided full responses (in red text) to each of the two reviewers and would like to thank them for their useful comments which we very much appreciated. In order to accommodate these comments we have added some text as well as a number of references which should help the interested reader to be able to follow up on some of the issues raised. We sincerely hope that this revision meets your requirements and look forward to your, hopefully positive, response.

Sincerely

Nicolas Friggens, Delphine Destoumieux, Pascal Bonnet

Response to review comments by Kao

I found this a very interesting paper to read. The general subject area is a very useful one and the advocacy for cross-disciplinary integration and learning is important. While I think the context could be generalised to include other disciplinary areas (this is already alluded to in different areas) there is considerable merit to considering in particular the relationship between livestock production and animal ecology as a specific interaction. I also like the discussions of each of the individual sections.

We are very pleased that you found the paper interesting, useful, and important. Thank you for the effort that you put into the reviewing. We hope that the changes we have made meet with your approval.

However, the relationship between the broader philosophical sections aims of the paper on the intersection between animal production and animal ecology, and the individual sections could use some further development, and the specific examples they choose do not in my view, fully develop the ideas being proposed.

We have done our best to try to rectify this, in truth this is difficult because the dialogue between the disciplines is rather new and as such has not fully matured, indeed this was our main impetus for writing the paper. An example of the changes we propose in this direction is at L164 (revised text) "Determining the theoretical bases of how natural and artificial selections actually modulate adaptive (and therefore, sustainable) responses of these populations to these new selective pressures is a corner-stone objective. This will pave the way of resolving how we may improve (i) our management of agro- and wild ecosystems by increasing biodiversity and/or within populations' genotypic/phenotypic diversity, (ii) thereby improving resilience capacity of individuals, populations, and systems, and (iii) reducing viability-risks of our farmed and wild environments." Others are described below

Thus while the overall aim of unification is a very good one, in practice the scientific alliances they propose are considerably less ambitious than is embedded in the title and the broader discussion. A specific point that I think could be expanded upon is that, while there is some attention paid to the 'human factor' the role of social sciences and economics could be included in a more integrated way. Also, , I get more of a sense in the paper of how animal production science can learn from animal ecology. I get less on how animal ecology learns from production, though the importance of considering wildlife and livestock at the same time is clear throughout the paper.

Again, we have tried to improve these aspects in so far as the nascent dialogue between our disciplines allowed, and addressed the specific related points below. We fully recognize that our improvements are not perfect but have done what is within our collective capacity and in keeping with the spirit of a position paper, i.e. not an exhaustive review and a text that should remain accessible to the widest possible readership across the two disciplines.

More specific comments follow:

Line 28/29: This is a relatively limited list of the impacts of the species and of course the central purposes from an anthropocentric viewpoint about food production and animal products. Otoh, the role of wildlife species is also much broader. The list of course is only an example, but perhaps a broader range or how they relate to all of agricultural systems, ecosystem services, and ecological conservation. These are brought in later, but it would be useful to allude to them here.

As suggested, we have added the phrase "within the broader roles they play in contributing to biodiversity and to every category of ecosystem services" to make it clear that the list is just to provide examples. In the Introduction (L74) we have also adjusted to better spell out the cultural element of ecosystem services.

Line 37 In terms of animal diversity, it isn't clear at this point whether within species or between-species is being considered. Later it becomes clear that it is both, however it would be useful to also make it clear here at first discussion.

Clarified as suggested by adding "(both within and between species)"

Line 42. It is not clear to mean at this point what is meant by 'elementary' cycles – does it mean 'fundamental'. If this is a discipline-specific terminology, given the inter-disciplinary thrust of the paper, it would be worth defining.

We agree that 'elementary cycles' may be confusing so we have changed this to "nutrient cycles" throughout the document, and added at this first use of the term "i.e. recycling nitrogen (N), phosphorus (P), and carbon (C) through, for example, contribution to soil fertility and carbon sequestration"

Line 75 – should that be 1.43m species?

Corrected to 1.43 million catalogued species

Line 97 onwards. The discussion of natural vs. artificial selection is a good one, highlighting the different aims of the two types of activity. However, it becomes less clear how this dichotomy feeds into the broader questions of the subject of the paper. The discussion seems quite specific, without strong ties to those broader questions and themes. I think this could be done better by bringing it closer to the section on viability, which I think addresses similar issues but with some of those broader implications and putting the two in proximity would make those broader arguments clearer.

We agree with this suggestion and consequently have moved the section "Agro-ecosystems and farmed animal management versus ecosystems and wild animal management" down below "Viability risks for farmed systems versus natural ecosystems".

Line 119. I'm not familiar with the Darwin argument about why domestication leads to an increase in diversity. Is this because the domesticated variants developed independently across different communities led to a diversity in breeds? In any case, it would be helpful to have further clarification here.

As suggested this has been briefly clarified by indicating that historically there have been two tendencies in artificial selection, and adding "After domestication, selection in different places and with different goals first led to a huge increase in diversity between populations (Darwin, 1859). However, the recent changes in livestock production breeding led to the opposite"

Line 119-120. Of course the number of species we farm is also being reduced (or at least, that the biomass of particular domesticated species is becoming proportionately larger compared to others). It could be argued that this is a different form of 'artificial selection' at a higher scale. Also, while the

point regarding within-species and indeed within-breed diversity reduction is a good one, it isn't clear how this is occurring. For example, it could be that the range of traits that are valued commercially is becoming more limited over time, especially as large producers start to dominate, and the role of supermarket chains in setting requirements becomes ever more important (in the UK at least). However, it could be that we are simply better at artificial selection, without the underlying aims themselves having changed – i.e. we've always aimed for the same traits but improved and more widespread knowledge means that we've narrowed down to a relatively limited number of breeds to do it with. Both of these arguments are I think consistent with what is discussed in lines 112-116 and there could be others. It would be helpful for the authors to expand on what the drivers are.

Whilst we agree that this is interesting, we consider that to do this particular element justice would take up too much space relative to its importance to the overall thrust of the paper. Therefore, we have not made any changes in respect to this suggestion.

Line 123 onwards and especially from line 126. I think this might be the point where the argument about the relationship between animal science and animal ecology is being made. I.e. understanding the importance of fitness has led to fundamental conceptual improvements in how we approach artificial selection. This is hinted at in line 126, but a deeper discussion is merited, as I am left with a sense of 'what', but not a good understanding of 'why'.

As suggested we have added to the discussion of this point, and included a recent reference on this point: "Indeed, current livestock selection programs are increasingly seeking to optimise animal fitness in the production environment by putting more emphasis on functional traits and including robustness and adaptability traits alongside production (Berghof et al., 2019). Taking into account such trade-offs is particularly important in the context of global changes where resource availability and variability will be strongly affected."

Line 129 onwards. The link between 'living with environmental change' and humans as the evolutionary force is not entirely clear to me here. Very true that both natural populations and livestock will need to respond (or be managed) to respond to these changes. It is less clear that this is achieved by synthetic understanding generated between disciplines – is there direct evidence or a strong direct line of reasoning to suggest this? Does it mean, for example, that improvements in general population fitness is a better way to handle these changes, than increased intensity of trait selection for example (therefore requiring better knowledge of ecological factors), or does it mean that, because the ability of humans to select for traits is such a strong effect, that we can more or less breed our way out of the problem by selecting for appropriate traits if we do it efficiently enough (requiring more and better livestock breeding genetics knowledge, i.e. within the context of production)? Or possibly something else.

The revision proposed above for L123 in part clarifies this, we have also expanded the text to make explicit the issue for artificial selection by adding "For example, because genotypes can perform differently under different environmental conditions (gene by environment interactions, G*E) there is a strong risk that individuals with high breeding values for traditional production traits in protected environments will tend to be negatively impacted by adverse environments, leading to poorer breeding values for those animals that are most environmentally sensitive. Conversely, animals with poorer breeding values for production traits may be the individuals best equipped to deal with environmental perturbations, so that the selection criteria ought to be multivariate and in multiple environments"

Also, as mentioned in the general comments, this seems mostly be about how animal production science learns from ecology – are there arguments in the other direction?

As suggested we have added an example going in the other direction (in addition to the above revisions indicating the importance of concepts that originated in the ecology field such as trade-offs) ". In terms of animal ecology, understanding how the environment affects selection pressures will be key to understanding potential adaptive responses (e.g. Siepielski et al. 2017). Animal ecology may also benefit from the rapid advances in quantifying the genetic bases of phenotypic/performance robustness of animals to environmental variability (quantitative genetics, epigenetic regulation), a field that is likely to advance much more rapidly in animal

production science because of easier access to controlled genetic materials, advanced control of environmental backgrounds, rapid expansion of multivariate massive phenotyping (including omics), and the ability to account for social interactions between conspecifics (Wade et al. 2010)..”

Line 162 onwards. The European example seems to be a good one, but as previously, the text supplies the ‘what’, but does not illuminate me on how the scientific communities are interacting and why. Other examples, if they exist, would also be welcome, particularly where they might highlight different approaches.

Of the examples that we could find, the Natura 2000 is by far the most developed so we do not see any benefit from including others in this position paper. However, we have added text to emphasize the example by adding a component on inclusive governance which leads to recognizing the involvement of several disciplines (scientists) and of the civil society in governance of such areas, including provision of evidence on their impact on ES. We have also added two references that are relevant to this subject

Line 165. This is a welcome mention of societal considerations. My view would be that it should be given a greater and earlier prominence in the paper.

See response to general comments

Line 170 onwards. This section is a good discussion of how wildlife and livestock must respond to a variety of viability risks, and how the measures of risk differ between the two. It also discusses how the two interact but I think could go deeper on this – in particular what the trade-offs and synergies are between the goals of production, and the goals of wildlife management. Also, where it is
considerably less clear is where the communities and their approaches would benefit from each other.

We agree with this request but it is dealt with across the other sections, namely; Agro-ecosystems and farmed animal management versus ecosystems and wild animal management, The importance of animal diversity for system resilience, and The concept of agro-ecology as a sustainable and responsible way forwards. It is also evident in the second example on nutrient cycles.

Line 171. Ecosystem services are hinted at, but not discussed explicitly (or at least the term and its implications are not discussed). It might be worth doing so here given the traction the terminology seems to have (I note that it is mentioned later, but w/o definition).

We have added the following in response to this request: “The framework of ecosystem services links both types of systems by considering them as essential for sustainable development, but viability of natural populations for their own sake also needs to be integrated (Martin et al 2016).”

Line 212 onwards. The discussion of rigidity of behavior in both human and animal populations is interesting, but I am not convinced by the arguments here of how they are related except in the broadest sense.

The text here has been modified with respect to comments by the other reviewer, taking into account this remark.

Line 228. The co-viability analysis sounds interesting but more detail is needed here to understand what ithe analysis aims to do.

The following information on the aims has been supplied to support the reference: “which aim at finding compromises where viability of both farmed and natural systems can co-exist by coupling economic and biodiversity models”

Line 232 onwards. I think this is a really interesting discussion. It does seem to be closely related to the discussion of artificial vs. natural selection (line 97 onwards) on several point, but the fact that it is

separated by several sections means that it is harder to see these links. I would suggest reorganizing so that they are discussed more coherently.

Having already moved the "viability risks" section up to be beside the "Artificial vs Natural selection" section we did not see how we could easily comply with this request. Further, we did not wish to separate the sections on animal diversity and animal adaptability. Therefore, no change has been made.

Line 257. Its not clear with the term 'big data' is relevant here. Its generally held that it refers to data that are exceptional in terms of all of volume, velocity (i.e. rapid accumulation but importantly the importance of rapid analysis and decision-making) and variability (i.e. data complexity).

Changed to "complex data"

Line 257. I think it should read 'that are concomitantly'

Corrected as indicated

Line 293 onwards. This addresses resilience at a species by species level, but I think could be expanded by addressing the question of how the interactive network amongst species may shift as a whole - i.e. not so much whether or not a single species can be replaced by another (or groups) but where a reconfiguration of the entire system is possible that maintains sufficient resemblance to the previous system so as to allow it to be recognizably similar. In essence, can we define 'functional units' within ecosystems that could be re-arranged within themselves, w/o disturbing the larger whole (functional analogues?)

The text has been expanded to accommodate this issue as follows: "However, the maintenance of a particular assemblage is not a necessary requirement for the resilience of ecosystem functions (Oliver et al. 2015). Functions could be resistant to change or recovered following disturbance with taxonomically different assemblages of species, while exhibiting rather similar sets of traits (Gladstone-Gallagher et al. 2019) or maintaining interactions with sufficient resemblance to the previous system so as to allow it to be recognizably similar (Bregman et al., 2017)."

Line 303. First mention of 'ecosystem services' – as noted in an earlier comment, this could be expanded upon, and defined earlier.

Is expanded on here "(i.e. the varied benefits that humans freely gain from the natural environment and from properly-functioning managed ecosystems, including provisioning, regulating, cultural and habitat and ecosystem functioning services)" and has been highlighted earlier

Line 347. This is a useful point to be making and I think could be expanded upon – for example, this seems like an area where there is likely to be much to be learned from game theory – i.e. can we identify 'strategic complements' where positive actions reinforce the adoption of those actions.

Whilst we agree with the reviewer that this could be of interest we consider this to be a topic that is too detailed to expand on in the current paper

Line 363 onwards. While I can see this is an area of important interest, this section has a very different tone and direction to the previous sections - those were largely conceptual, this seems largely
practical - the transition jars a bit.

We have smoothed the transition by adding the following at the start of this section "In the context of agro-ecology, understanding the variability with which individuals respond to their environment is a key entry for understanding most of the issues raised above. Similarly, study of this variability also help to assess animal welfare at individual level, an issue which is now a necessary respond to the societal demand to improve animal welfare."

Line 414 onwards. The two examples are useful but seem somewhat limited in scope. They don't really address the breadth of discussion of the entire paper. I realise that this may be difficult to do as such broadly comprehensive examples may not exist. A possible approach might be to create some sort of table or matrix which lists the different foci discussed here, with examples that pertain to one
or more of them (preferably ones that cut across multiple foci) with some brief discussions in the text.

This is an interesting suggestion that we indeed considered whilst writing the paper. However, when we started looking at the kind of table proposed we quickly realized that we could not produce a meaningful table using only "brief discussions" (without effectively producing a book). Therefore, we chose to take two specific examples that could be discussed in sufficient depth, even though these cannot cover all aspects.

In regards to the avian flu example, it does capture some important points, however much of the paper is about how stresses in our systems are becoming greater and create greater problems. Its not clear to me that avian flu is a particularly good example of this. Possibly a better one would be to discuss the current problem of African swine fever. The illustrates the problem of increasing wild boar populations across Europe, the role of a particularly climate dependent tick in transmission, and the interactions between wildlife and livestock. It's also a massive global problem.

We have now included in the manuscript a paragraph dedicated to the link between the stress in our systems and the expression or sensitivity to diseases. We comment on changes in duck densities and breeding methods that lead to an increase in the sensitive population on the one hand and stress due to the concentration of this population on the other. We believe this is a good example, as the problem is the same in Asia where densification of livestock and their coexistence with a population of migratory wild birds increases the ratio of domestic transmission to wild. Although we agree that the example of the African swine fever is very interesting, it was not additionally developed in this section as it would increase substantially the length of the manuscript.

I am less able to comment on the second example. It has broader implications, but it isn't clear here to me how this is about animal ecology learning from animal production – its more about animal production bringing in other disciplines to solve a particular (albeit very large) problem. As before, the synergistic element seems to be missing. As a minor point,, this report (and paper mentioned therein) might be useful here: https://www.oxfordmartin.ox.ac.uk/downloads/reports/Climate-metrics-for-ruminant-livestock.pdf

In this section, we emphasize the importance of changing scale (valuation of environmental service and disservices at individual animal level *versus* considering interactions between animals in their ecosystem as a whole). We stress the importance of an alliance between sciences that work at both these scales, e.g. animal ecology and animal science.
One example we gave highlights the need to encompass all components that contribute to carbon sequestration, from termites to bovine. In order to enhance the demonstration we added a point on the Australian case on dung beetles that has given evidence of the importance of considering ecosystems as a whole. In Australia changing dung resources thanks to import of bovine animals, has altered the provision of ecosystem services by local population of dung beetles, highlighting the fact that ecological processes have already been disrupted by historical lack of collaboration between the two science communities.
Moreover we would like to thank the reviewer for the useful reference he provided which derives from the following one: " *Allen, MR, Shine, KP, Fuglestvedt, JS, Millar, RJ, Cain, M, Frame, DJ, & Macey, AH: A solution to the misrepresentations of CO2-equivalent emissions of shortlived climate pollutants under ambitious mitigation. npj Climate and Atmospheric Science, 1(1), 16. doi.org/10.1038/s41612-018-0026-8 (2018)."* A reference that we decide to use in our paper. Thus in this section, we now emphasize not only the collaboration between ecological science and animal science but also the need for inviting other disciplines namely climate and atmospheric Science in valuating environmental impact of animals GHG emissions on global warming.

Response to review comments by anonym

OneARK: Strengthening the links between animal production science and animal ecology

In this review, the authors identified similarities between animal production science and animal ecology, which may appear at the first glance to stand distinctly from one another. The authors argue that focusing on these similarities can mutually benefit one another, which will in tun help solving complex societal problems we are facing. The attempt to identifying similarities in these two disciplines is somewhat new and interesting, and this is potentially useful for many readers in both disciplines. Some topics are however heavily written in the view of one of the two disciplines, and hence lack detailed explanations/examples on what it means in the other discipline. As I commented below, I think this article can be easily more interesting for a wider population by deepening some discussions.

We agree with the reviewer that there is not complete evenness in the treatment of the different topics from the animal science and animal ecology perspectives. This in part reflects the very difficulties of two separate scientific communities writing the paper, and thus the need to bring them together that we aim to highlight with this paper. We have done our best to rectify the unevenness by adding text, for example at L164 (revised text) "Determining the theoretical bases of how natural and artificial selections actually modulate adaptive (and therefore, sustainable) responses of these populations to these new selective pressures is a corner-stone objective. This will pave the way of resolving how we may improve (i) our management of agro- and wild ecosystems by increasing biodiversity and/or within populations' genotypic/phenotypic diversity, (ii) thereby improving populations' resilience capacity and (iii) reducing viability-risks of our farmed and wild environments."

L 94: Could you add one sentence which explains the structure of this paper before you finish Introduction? E.g. We first discuss seven concepts… then highlight these points using two examples… This may not be the common practice in your discipline, but I believe it will improve the readability of this paper.

As suggested, we have added "We first discuss seven topics that are common to both communities but viewed from differing perspectives, in order to show their potential for synergy and then highlight these points using two examples."

L124: "lower resistance to environmental variability, particularly stress and disease"
Variability itself may not be the largest problem but unconventional variations would be. For instance, some livestock breeds kept on natural pastures are adapted to frequent weather fluctuations. But they may not be resistant to draughts which do not occur previously. Please rewrite this sentence to make it clear that you are talking about adaptive potential to something unknown.

Corrected as suggested by adding "particularly to new stress and disease challenges"

L129: "collorative"
Typo? Corrected
L136: "and whether populations are able to respond"

If I understood correctly, you are discussing how global environmental changes may affect the performance of artificial breeding. Could you add more precise explanations/examples on the impact of the environment conditions on how artificial breeding works? Does this mean some environmental changes would hinder the intended breeding of a specific breed? Please clarify.

We have expanded the text here to make explicit the issue for artificial selection by adding "For example, because genotypes can perform differently under different environmental conditions

(gene by environment interactions, G*E) there is a strong risk that individuals with high breeding values for traditional production traits in protected environments will tend to be negatively impacted by adverse environments, leading to poorer breeding values for those animals that are most environmentally sensitive. Conversely, animals with poorer breeding values for production traits may be the individuals best equipped to deal with environmental perturbations, so that the selection criteria ought to be multivariate and in multiple environments. In terms of animal ecology, understanding how the environment affects selection pressures will be key to understanding potential adaptive responses (e.g. Siepielski et al. 2017). Animal ecology may also benefit from the rapid advances in quantifying the genetic bases of phenotypic/performance robustness of animals to environmental variability (quantitative genetics, epigenetic regulation), a field that is likely to advance much more rapidly in animal production science because of easier access to controlled genetic materials, advanced control of environmental backgrounds, rapid expansion of multivariate massive phenotyping (including omics), and the ability to account for social interactions between conspecifics (Wade et al. 2010)."

L187: "direct effects that reduce resource availability"

The impact of climate change seems to be complex: a predicted warmer climate is expected to increase the agricultural resources in some parts of the world.

We agree with the reviewer that climate change at local scale may shift resource availability in both directions and have accordingly change "reduced" to "alter"

L188: "typically impact the stocking densities"

True if it is the short-term climate change. For a longer term, I would not think this would be necessarily the case however. Perhaps farmers convert from dairy to sheep farms, or change the breed they milk. I would rephrase something like 'these will impact farm management systems such as stocking densities that are sustainable'.

Changed in line with the suggestion to "In farmed systems, the impact on animals will be less direct in the longer term se will impact farm management systems e.g. typically impacting the stocking densities of animals that are sustainable in extensive systems, and incurring greater costs for intensive systems (e.g. cooling systems)."

L200: "They are particularly prevalent and successful in highly anthropized habitats such as peri-urban and…"

Please add a reference. I note that in New Zealand we have observed the most important exotic species, possum, are very fond of native forestry areas as well

As suggested we have added two references to this

L212: "There are also viability risks due to rigidity of human behaviour"

This part till Line 222 felt slightly a repetition of what has been discussed in 'Artificial selection versus natural selection' because both discuss the impact of human behaviours on selection pressures posed on animals. Also, the sentence starting from Line 216 looks slightly out of place, particularly because you were discussing human behaviours immediately before. Would it be a problem if you moved this part into 'Artificial selection versus natural selection' part, and would mention there that this human behaviour also relates to viability risks described below?

We have added text that makes the point that it is not just selection pressures that are involved and provided an example for wild animals, and also with respect to feeding resources: "Rigidity in farm management, such as failing to adapt fodder cropping practices to changing seasonal patterns, can also increase the viability risks for the animals that depend on this fodder."

L274: “The importance of animal diversity for system resilience”

This section is quite informative, detailing why biodiversity is important for building resilient system. Nevertheless, for readers outside ecology discipline, including myself, it is slightly difficult to translate what your argument really means in animal production science. It will help readers if you could explain what diversity and resilience represent in farm systems; e.g. is it genetic diversity among livestock or is it diversity of organisms (e.g. livestock, plant, soil microorganisms) on farm? Or is it functional diversity you mentioned? In which way does such a diversity help farm systems? Please add more explanations, preferably citing several works in this field if available.

As suggested we have added a couple of paragraphs to provide examples about diversity and resilience in farm systems: “The concept of animal diversity can be applied in various ways within livestock farming systems. A first aspect of animal diversity is the diversity of species, with for instance a mixed farm exploiting sheep and cattle or an aquaculture farm exploiting different fish species. The benefit of species diversity in the farm is generally based on the ability of various species to exploit different resources. Sheep and cattle in grazing systems are using different patches of grass, with plant different selection strategies. The same type of complementarity is used in recirculated aquaculture systems with fishes that feed in different levels of the water column. Complementarity of species can also go beyond complementarity of resources used, with farming systems based on the complete trophic chain such as integrated multi-trophic aquaculture systems (IMTA). The benefit of species diversity in a farm can also rely on the diversity of products commercialized. For instance, small ruminants can be used as cash flow while larger ruminants have a role of savings.
A second aspect of animal diversity is the diversity of individuals of the same species. Animals may be diverse in terms of their adaptive profiles, with for instance a type of cows that copes with heat stress and another type that cope with feed shortage. Having these two types of individuals in a herd can enlarge the range of perturbations that the livestock system can absorb. Animals can also be diverse in terms of their lifetime trajectories, with for instance females that have different types of reproductive rhythms (e.g. extended lactation in dairy production, accelerated lambing in sheep production). This diversity of trajectories within the herd can be useful to cope with environmental challenges (portfolio effect) or to have different types of products answering to different market needs (e.g. heavy/light lambs).”

L419: “Circulation and reassortment of potential zoonotic pathogens…”

While I am totally with you that this first example is a topic that argues the need of an interdisciplinary approach. However, by reading this section I could not really see how those 7 points you identified are important in this HPAI example. What I mean is that HPAI has been discussed a lot in One Health and other aspects, and your discussion here seems to be not much different from what have been discussed elsewhere. The perspective you take in this article (i.e. marriage between production science and ecology) is somewhat distinct (and I think your second example really makes a point why this marriage is important), thus it would be really helpful if you could deepen your discussions on HPAI by focusing on how some of 7 points you identified would help tackling this zoonotic problem.

As recommended, a paragraph was introduced at the end of the section to illustrate how some points developed in the review can help tackle zoonotic diseases and epizooties: “In that sense, several points discussed in this article may be considered to tackle epizooties and zoonotic diseases. This starts with a required knowledge on the ecology of pathogens of interests (environmental niches, hosts, reservoirs and vectors), which may be complex for multi-host pathogens. While reliable and efficient tools for pathogen monitoring are usually rapidly available, complex pathogen transmission routes are often poorly characterized. New technologies for the monitoring animal contact data, including social networks give now access to this knowledge. Network modeling should help understanding transmission dynamics in wild animal and livestock populations, which is needed to predict and reduce pathogen transmission (Craft, 2015). Adapting livestock management according to ecological principles is also an important avenue to improve animal health. By reducing contacts, low

density farming has provenbeen shown to limit pathogen transmission (Tendencia et al., 2011). Beyond respectful cultural practices, introducing genetic diversity in livestock should be considered as a sustainable way to reduce disease spread. Indeed, genetically homogenous populations (monocultures) are more vulnerable to infection than genetically diverse populations, which have the potential to buffer populations against epidemics in nature (King and Lively, 2012; Ekroth at al., 2019). Finally, new avenues remain to be explored to increase the adaptability of farmed animals. If selective breeding (artificial selection) remains largely used in animal farming, recent studies have shown that new prophylaxiesprophylaxes that increase animal adaptability can be envisioned to confer resistant phenotypes to otherwise susceptible animals without affecting the genetic diversity of the livestocks. Indeed, several invertebrates (e.g. oysters, shrimp, honey bees) can be protected from pathogen infections by immune priming, which confers the potential to control infections and limit pathogen transmission, even in species that cannot be vaccinated (Lafont M. et al., 2017). A high interest is currently paid to immune priming, which has proven to be trans-generational in a series of cultured invertebrate species (Tetreau et al., 2019). However, the epidemiological consequences of trans-generational immune priming and its impact on the evolution of parasite/pathogen virulence are still debated (Tidbury et al., 2012) and remain to be studied."

L538: Period(.) missing in the end of the sentence.
Corrected.

L541: "…in natural populationsand ecosystem"
Please correct the typo.
Corrected.
L529: Conclusion

Some part of Discussion seem to be redundant and readability can be improved. For instance, L546 and L557 can be merged.

We have reviewed the Conclusions section in the light of this comment and made minor changes to avoid redundancy