

## Spatio-temporal variation in the wintering associations of an alpine bird

María del Mar Delgado, Raphaël Arlettaz, Chiara Bettega, Mattia Brambilla, Miguel de Gabriel Hernando, Antonio España, Ángel Fernández-González, Ángel Fernández-Martín, Juan Antonio Gil Sergio Hernández-Gómez, Paola Laiolo, Jaime Resano-Mayor José Ramón Obeso, Paolo Pedrini, Isabel Roa-Álvarez, Christian Schano, Davide Scridel, Eliseo Strinella, Ignasi Toranzo and Fränzi Korner-Nievergelt

### Article citation details

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### Review timeline

Original submission: 24 November 2020  
1st revised submission: 23 March 2021  
2nd revised submission: 20 April 2021  
3rd revised submission: 27 April 2021  
Final acceptance: 28 April 2021

Note: Reports are unedited and appear as submitted by the referee. The review history appears in chronological order.

## Review History

### RSPB-2020-2942.R0 (Original submission)

Review form: Reviewer 1

#### Recommendation

Major revision is needed (please make suggestions in comments)

**Scientific importance: Is the manuscript an original and important contribution to its field?**

Good

**General interest: Is the paper of sufficient general interest?**

Good

**Quality of the paper: Is the overall quality of the paper suitable?**

Good

**Is the length of the paper justified?**

No

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

Yes

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

No

**Is it clear?**

N/A

**Is it adequate?**

N/A

**Do you have any ethical concerns with this paper?**

No

### **Comments to the Author**

This is an interesting manuscript that reports on some environmental variables that affect group dynamics and sizes of snow finches. The role of group dynamics as a behavioral tactic and the relationship to environmental conditions is an interesting and - possibly - understudied one, especially in alpine environments, and this paper could be a useful contribution. Furthermore, I thought the tidy definition of "fission" and "fusion" as the straightforwardly estimated inflection points of GAM splines, was a novel and highly promising use of widely available observation data. Methodologically, this is a terrific (and simple) innovation that I think will be of interest to people studying social ecology in other taxa as well. The paper is very clearly written (though I identify some minor English language points in the comments below).

I do, however, have a few concerns. First, with respect to the data, more detail would be welcome (I was not able to access the data to get a sense of its structure myself). How many observations and what was the length of time series from each (broad) study area? What are some general similarities / differences across the four study areas? How were the data distributed spatially? E.g. were there a few dedicated study sites? Or was, e.g., the citizen science data collected opportunistically over larger areas? This information is important, especially since (as the authors are fully aware) there can be very large differences within relatively small areas in alpine environments.

In Fig. 1bc, for example, it is not clear what the points represent. I assume - sites? If so, how many were there? And why not identify them by study area / mountain range?

(A side note - since the data are essentially, presence-only, group size counts, isn't there a significant introduction of bias, due simply to the fact that larger group sizes are easier to observe? Perhaps this doesn't have too much impact on the fission / fusion dynamics, but probably needs to be considered.)

With respect to the modeling, I am wondering why not test directly whether there are differences across study area by including area as a main effect (there are only 4, so no great loss in degrees of freedom). This would allow to test directly for differences in patterns across and within "areas". In line 275, the authors make a statement regarding locally idiosyncratic responses to

variation, but it was unclear to me how that statement was supported by the modeling structure (where, e.g., the random effect of site area was removed) or in the results. But it is interesting!

In the post-hoc analysis (as noted in the detailed comments below), I am also not convinced by the linear regression of fission date against temperature, as it looks like there is a plateau at higher temperatures, which may have some biological / behavioral interpretation.

Finally, with respect to the interpretation of results, I found the discussion to be a bit short and superficial, beyond reporting that weather has an effect on group dynamics. For example, foraging dynamics and behavior are cited as potentially important factors. But - as a non-expert on snow finch diets - I have absolutely no idea how. Certainly, this must depend to some extent on the available resources. Likely those resources must vary across (and within) study areas in some meaningful way. The notion that ski tourism may be an important seasonally discrete source of resource provisioning is also intriguing - but isn't there good and reliable data on locations with and without ski tourism, and can't that (shouldn't that) simply be included as an explanatory factor?

Overall, I think the methodological innovation here is promising, and the application to snow finches would make an interesting contribution. But I feel the authors overly compressed their findings, whereas this article would benefit from more detail (esp. in the materials and results sections), and could develop their analysis further.

Other comments (mostly minor, but a few substantive - e.g. with respect to figures) are in the comments below.

l. 63: "seek shelter"

l. 71: "that is must have ..."

l. 149: some standard ref for GLM's would be useful (e.g. Wood, S.N. (2004) Stable and efficient multiple smoothing parameter estimation for generalized additive models. *J. Amer. Statist. Ass.* 99:673-686, or Wood, S.N., N. Pya and B. Saeften (2016), Smoothing parameter and model selection for general smooth models (with discussion). *Journal of the American Statistical Association* 111, 1548-1575 for more reference to mixed models).

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l. 176: Capitalization unnecessary, e.g. "as a gamma distributed variable ... as two normally distributed response variables". That said, the number of snow-finches should be Poisson (discrete) not gamma (continuous). Or - for more flexibility - an over-dispersed Poisson.

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Discussion:

- I. 261: maybe "indicate" rather than "highlight".
- II. 264-270: Difficult to interpret the feeding explanation / hypothesis without a better idea of the main food and feeding behavior of the snow finches (in winter), and how that varies across the study areas.
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Fig. 1:

- a) consider adding a horizontal zero line, and perhaps even labeling the positive region as "larger group size" and the negative region "smaller group size".
- b) The regression line is somewhat unconvincing. Among fission days occurring after about day 140 (or past, say, 6C), the relationship would be very weak, if any. It looks more like a "hockey-stick" type relationship, i.e. fission dates appear to "flatten" after a certain temperature threshold. Also - in (b) and (c), is each point a site? So - how many sites were there? How are they distributed across areas?
- d) I find these surface plots difficult to interpret, especially since there are no scales on the axes, and no sense of where the coefficient is positive or negative. Better an image or contour plot.

Fig. 2:

I am completely confused by the the meaning of the colors here, or what the main takeaway is (are they means? trends? both?). The caption is not very helpful, and the bin numbers are very odd. I'd recommend a simpler and discrete color scaling, and more detail. Also, wouldn't a West to East ordering for a-b-c-d make more sense?

## Review form: Reviewer 2

### Recommendation

Major revision is needed (please make suggestions in comments)

### Scientific importance: Is the manuscript an original and important contribution to its field?

Acceptable

### General interest: Is the paper of sufficient general interest?

Good

### Quality of the paper: Is the overall quality of the paper suitable?

Marginal

### Is the length of the paper justified?

Yes

### Should the paper be seen by a specialist statistical reviewer?

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

Yes

**Is it clear?**

Yes

**Is it adequate?**

Yes

**Do you have any ethical concerns with this paper?**

No

### **Comments to the Author**

General comments

The authors report on 23 years of observations of group sizes of snowfinches in four mountain areas in central and southern Europe, and relate those to air temperatures in these areas. They claim that groups separate later when spring arrives early. This might cause a phenological mismatch with their food, possibly lowering their breeding performance.

While the study has the potential to be interesting to a wider audience, I think the authors have to put much more effort in introducing their problem and presenting their findings. No specific hypotheses are presented. A priori, I would not expect the groups to form later when springs are warmer, and I would like to see some more thoughts on this already in the Introduction. Most importantly, however, the results are poorly presented. Specifically, figures are far from self-explanatory, which makes them hard to understand, and to see the results.

Specific comments

55) "ultimately affecting its population dynamics". Replace this with "... breeding performance" (as mentioned in the Discussion), because the step to population dynamics is way more complicated. See for instance Reed et al. (2013) Science doi: 10.1126/science.1232870

64) rephrase: "sedentary animals, such as mammals"; some mammals are migratory (especially in mountainous areas, i.e. altitudinal migration).

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Fig. 1B,C and Fig. S1B) . I've read that areaID was eventually left out of the statistical models, but I would still like to see the four areas represented by a different symbol.

Fig. 2) Please relabel mountain areas such that A, B, C, D are in the proper order (to simplify the figure).

## Decision letter (RSPB-2020-2942.R0)

12-Jan-2021

Dear Dr Delgado:

I am writing to inform you that your manuscript RSPB-2020-2942 entitled "Spatio-temporal variation in the wintering associations of an alpine bird" has, in its current form, been rejected for publication in Proceedings B.

This action has been taken on the advice of referees, who have recommended that substantial revisions are necessary. With this in mind we would be happy to consider a resubmission, provided the comments of the referees are fully addressed. However please note that this is not a provisional acceptance.

The resubmission will be treated as a new manuscript. However, we will approach the same reviewers if they are available and it is deemed appropriate to do so by the Editor. Please note that resubmissions must be submitted within six months of the date of this email. In exceptional circumstances, extensions may be possible if agreed with the Editorial Office. Manuscripts submitted after this date will be automatically rejected.

Please find below the comments made by the referees, not including confidential reports to the Editor, which I hope you will find useful. If you do choose to resubmit your manuscript, please upload the following:

- 1) A 'response to referees' document including details of how you have responded to the comments, and the adjustments you have made.
- 2) A clean copy of the manuscript and one with 'tracked changes' indicating your 'response to referees' comments document.
- 3) Line numbers in your main document.
- 4) Data - please see our policies on data sharing to ensure that you are complying (<https://royalsociety.org/journals/authors/author-guidelines/#data>).

To upload a resubmitted manuscript, 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 Resubmission." Please be sure to indicate in your cover letter that it is a resubmission, and supply the previous reference number.

Sincerely,  
 Professor Gary Carvalho  
 mailto: proceedingsb@royalsociety.org

Associate Editor  
 Board Member: 1  
 Comments to Author:

The ms has been seen by two expert referees, one of whom is quite skeptical if the topic and results are suitable and important enough for a broad audience. I think group fission and fusion dynamics in winter is a highly interesting topic, but I fully agree with the referees that the presentation is sub-optimal and needs further clarification, especially for a broader audience. I have major difficulties in understanding what the figures actually represent and so may other readers that might be interested in the results but are no specialists in the area. The editor might think of considering a revision of the manuscript, if the authors can address this issue and make both the topic and the data presentation more suitable and appealing for a more general audience. As presented now, the ms is more appropriate for a more specialized ecological journal.  
 Wolfgang Goymann

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)

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Referee: 2

Comments to the Author(s)

General comments

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Fig. 2) Please relabel mountain areas such that A, B, C, D are in the proper order (to simplify the figure).

## Author's Response to Decision Letter for (RSPB-2020-2942.R0)

See Appendix A.

## RSPB-2021-0690.R0

### Review form: Reviewer 1

#### **Recommendation**

Major revision is needed (please make suggestions in comments)

#### **Scientific importance: Is the manuscript an original and important contribution to its field?**

Excellent

#### **General interest: Is the paper of sufficient general interest?**

Excellent

#### **Quality of the paper: Is the overall quality of the paper suitable?**

Good

#### **Is the length of the paper justified?**

Yes

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

Yes

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

Yes

**Is it clear?**

Yes

**Is it adequate?**

Yes

**Do you have any ethical concerns with this paper?**

No

#### **Comments to the Author**

The authors have done a good job responding to the comments on the first draft, and many aspects are more clear in the revision. The attached document contains some in-line comments - mainly minor - on the text, which are worth going through.

However, I am still not quite satisfied with the responses to two of my major concerns.

First - for all of the analysis and results, I am still unclear on the foraging ecology of the snow finches in winter, and fundamentally what drives the group dynamics. The new section in the discussion alludes to partial migration and following insect phenology (I assume - emergence) in spring, but there is very little information on the spatial distribution or even general description of the main winter resource. I'm assuming the main winter food source is grains or seeds. Are these alpine forbs or shrubs that need to be exposed to be accessible? Do they feed on conifer cones, which are maybe easier to access? Are there any known differences across these - presumably - very different mountain ranges that explains some of the divergence in the responses? What happened to the speculations regarding human supplementation at ski resorts? What, exactly, is the benefit of social aggregation? Does it help groups find bare patches? Under what conditions? I understand that there may not be data to answer these questions, but the authors are evidently knowledgeable about the social and foraging ecology of snow finches and should be able to speculate - building off of some of the more non-trivial results from the statistical analysis - beyond merely pointing vaguely to environmental gradients.

This reviewer's main point of reference is Arctic-boreal ungulates (esp. *Rangifer tarandus*), and within the species, gregariousness and general foraging ecology depends on whether they are wintering in tundra, and need to find areas where terrestrial lichens and mosses can be accessed via pawing and digging shared craters, or in mature boreal forests with abundant arboreal lichen. The former is, necessarily, a more social aggregated behavior than the latter.

Second, Figure 2 remains deeply confusing and largely uninformative. As I understand, it is attempting to show trends (and not means?) of temperature and precipitation. The main source of confusion is the odd sets of 11 color ramps beneath the figures, labelled (in an illegibly minuscule font) with rather odd intervals (-0.115, -0.075, -0.020, -0.015, 0.046) etc., each with a slightly different color ramp, which is nearly impossible to match to the areas in the map. It appears

there is some variation within the sites in these trends, but the areas are all so small on the maps there isn't any usable information to parse here, especially since there's no specific indication of where the data were collected within those sites. I still don't understand why there can't be a pair of high-contrast color ramps (ideally, ones that make 0 white, e.g. blue-white-red for temperature purple-white-orange for precipitation), so that larger, smaller, positive and negative trends can be seen more clearly. Also, the sites don't need to be on a map of Europe, but could be juxtaposed in adjacent panels. But - ultimately - this figure doesn't provide too much useful information for the paper. For one thing, it has nothing at all to do with the snow finches themselves, and the overall trends could just as well be relegated to a table. If needed - the figure could simply be moved to the supplementary materials.

That said, the Supplementary Figure 1 is a terrific figure that actually identifies the study sites and usefully illustrates the group size data. In my opinion - should absolutely be included in the main text. I would consider adding a panel that includes the main GAMM fit from supplementary figure 2A. The whole analysis hinges on the identification of inflection points in a gamm fit, and that seems a key thing to illustrate.

The concerns above are (to my mind) fairly important, but easily remedied. The first with (a little) more text, the second - mainly - by reshuffling figures.

## Decision letter (RSPB-2021-0690.R0)

12-Apr-2021

Dear Dr Delgado:

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. Thank you for the revisions to your manuscript, and there is a collective opinion that most of the primary concerns have been addressed satisfactorily. However, you will find remaining issues that require your considered attention, most notably, issues relating to the foraging ecology of the snow finches in winter, and the clarity and interpretation of figure 2, with further details provided below. We look forward to hearing from you at your earliest convenience as soon as possible.

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 (<https://royalsociety.org/journals/authors/author-guidelines/#data>). 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=\(Document not available\)](http://datadryad.org/submit?journalID=RSPB&manu=(Document%20not%20available)), which will take you to your unique entry in the Dryad repository.

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#### 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,  
Professor Gary Carvalho  
mailto: proceedingsb@royalsociety.org

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s).

The authors have done a good job responding to the comments on the first draft, and many aspects are more clear in the revision. The attached document contains some in-line comments - mainly minor - on the text, which are worth going through.

However, I am still not quite satisfied with the responses to two of my major concerns.

First - for all of the analysis and results, I am still unclear on the foraging ecology of the snow finches in winter, and fundamentally what drives the group dynamics. The new section in the discussion alludes to partial migration and following insect phenology (I assume - emergence) in spring, but there is very little information on the spatial distribution or even general description of the main winter resource. I'm assuming the main winter food source is grains or seeds. Are these alpine forbs or shrubs that need to be exposed to be accessible? Do they feed on conifer cones, which are maybe easier to access? Are there any known differences across these - presumably - very different mountain ranges that explains some of the divergence in the responses? What happened to the speculations regarding human supplementation at ski resorts? What, exactly, is the benefit of social aggregation? Does it help groups find bare patches? Under what conditions? I understand that there may not be data to answer these questions, but the authors are evidently knowledgeable about the social and foraging ecology of snow finches and should be able to speculate - building off of some of the more non-trivial results from the statistical analysis - beyond merely pointing vaguely to environmental gradients.

This reviewer's main point of reference is Arctic-boreal ungulates (esp. *Rangifer tarandus*), and within the species, gregariousness and general foraging ecology depends on whether they are wintering in tundra, and need to find areas where terrestrial lichens and mosses can be accessed via pawing and digging shared craters, or in mature boreal forests with abundant arboreal lichen. The former is, necessarily, a more social aggregated behavior than the latter.

Second, Figure 2 remains deeply confusing and largely uninformative. As I understand, it is attempting to show trends (and not means?) of temperature and precipitation. The main source of confusion is the odd sets of 11 color ramps beneath the figures, labelled (in an illegibly minuscule font) with rather odd intervals (-0.115, -0.075, -0.020, -0.015, 0.046) etc., each with a slightly different color ramp, which is nearly impossible to match to the areas in the map. It appears there is some variation within the sites in these trends, but the areas are all so small on the maps there isn't any usable information to parse here, especially since there's no specific indication of where the data were collected within those sites. I still don't understand why there can't be a pair of high-contrast color ramps (ideally, ones that make 0 white, e.g. blue-white-red for temperature purple-white-orange for precipitation), so that larger, smaller, positive and negative trends can be seen more clearly. Also, the sites don't need to be on a map of Europe, but could be juxtaposed in adjacent panels. But - ultimately - this figure doesn't provide too much useful information for the

paper. For one thing, it has nothing at all to do with the snow finches themselves, and the overall trends could just as well be relegated to a table. If needed - the figure could simply be moved to the supplementary materials.

That said, the Supplementary Figure 1 is a terrific figure that actually identifies the study sites and usefully illustrates the group size data. In my opinion - should absolutely be included in the main text. I would consider adding a panel that includes the main GAMM fit from supplementary figure 2A. The whole analysis hinges on the identification of inflection points in a gamm fit, and that seems a key thing to illustrate.

The concerns above are (to my mind) fairly important, but easily remedied. The first with (a little) more text, the second - mainly - by reshuffling figures.

## Author's Response to Decision Letter for (RSPB-2021-0690.R0)

See Appendix B.

## RSPB-2021-0690.R1 (Revision)

### Review form: Reviewer 1

#### **Recommendation**

Accept with minor revision (please list in comments)

#### **Scientific importance: Is the manuscript an original and important contribution to its field?**

Excellent

#### **General interest: Is the paper of sufficient general interest?**

Excellent

#### **Quality of the paper: Is the overall quality of the paper suitable?**

Excellent

#### **Is the length of the paper justified?**

Yes

#### **Should the paper be seen by a specialist statistical reviewer?**

No

#### **Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

Yes

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

#### **Is it accessible?**

Yes

**Is it clear?**

Yes

**Is it adequate?**

Yes

**Do you have any ethical concerns with this paper?**

No

### **Comments to the Author**

Thanks for the revisions. The foraging ecology section in the discussion is very illuminating and helpful (at least to me). Overall, this version looks great to me and I need not look at another revision.

A few minor text comments are below, as well as as some important issues in the new Figure 1 (e.g. mixed labelling).

That said, it occurs to me that group size is count data, modeled as a Poisson, but with no zeros. So it should technically be considered a zero-truncated Poisson regression. There are ways to deal with that, but probably none is more straightforward than to simply model  $(\text{Group Size} - 1)$ , such that the predicted response in a straightforward Poisson regression is  $\log(\text{Group Size} - 1)$ . This is particularly important for interpreting the spline regression in Fig1C (which should be D - and maybe should be back-transformed to expected group size). But it should have zero impact otherwise on the results or conclusions.

Minor text comments:

1. 151, 203: Poisson should be capitalized

1. 316-318: Grammar is funny. Maybe: "The occurrence and intensity of artificial feeding vary among the snowfinch populations, and is much more common in the Alps than in other snowfinch populations."

Figure 1: I think the letters D and C should be flipped - according to the caption. In (current) panel D: y-label should be "group size" (I think it's showing the same thing as panel B). And the caption should also explain what the vertical dotted lines are. Panel C: rather than  $s(\text{Day in Year}, 7.42)$  - that is - ylab should be  $\log$  of expected group size - no? (Or  $\log(\text{Group Size} - 1)$  as per comment above?) Maybe that figure would be better transformed to actual expected group size? Also, the x-axis is only half-hiding the Julian days ... that could be tidied.

## **Decision letter (RSPB-2021-0690.R1)**

21-Apr-2021

Dear Dr Delgado:

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.

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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,  
Professor Gary Carvalho  
Editor, Proceedings B  
mailto:proceedingsb@royalsociety.org

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)

Thanks for the revisions. The foraging ecology section in the discussion is very illuminating and helpful (at least to me). Overall, this version looks great to me and I need not look at another revision.

A few minor text comments are below, as well as as some important issues in the new Figure 1 (e.g. mixed labelling).

That said, it occurs to me that group size is count data, modeled as a Poisson, but with no zeros.

So it should technically be considered a zero-truncated Poisson regression. There are ways to deal with that, but probably none is more straightforward than to simply model (Group Size - 1), such that the predicted response in a straightforward Poisson regression is  $\log(\text{Group Size} - 1)$ .

This is particularly important for interpreting the spline regression in Fig1C (which should be D - and maybe should be back-transformed to expected group size). But it should have zero impact otherwise on the results or conclusions.

Minor text comments:

1. 151, 203: Poisson should be capitalized

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## Author's Response to Decision Letter for (RSPB-2021-0690.R1)

See Appendix C.

## Decision letter (RSPB-2021-0690.R2)

28-Apr-2021

Dear Dr Delgado

I am pleased to inform you that your manuscript entitled "Spatio-temporal variation in the wintering associations of an alpine bird" has been accepted for publication in Proceedings B.

You can expect to receive a proof of your article from our Production office in due course, please check your spam filter if you do not receive it. PLEASE NOTE: you will be given the exact page length of your paper which may be different from the estimation from Editorial and you may be asked to reduce your paper if it goes over the 10 page limit.

If you are likely to be away from e-mail contact please let us know. Due to rapid publication and an extremely tight schedule, if comments are not received, we may publish the paper as it stands.

If you have any queries regarding the production of your final article or the publication date please contact [procb\\_proofs@royalsociety.org](mailto:procb_proofs@royalsociety.org)

### Data Accessibility section

Please remember to make any data sets live prior to publication, and update any links as needed when you receive a proof to check. It is good practice to also add data sets to your reference list.

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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.

Thank you for your fine contribution. On behalf of the Editors of the Proceedings B, we look forward to your continued contributions to the Journal.

Sincerely,  
Professor Gary Carvalho  
Editor, Proceedings B  
mailto: [proceedingsb@royalsociety.org](mailto:proceedingsb@royalsociety.org)

Comments to Author:

Thank you very much for the constructive response to comments on the previous version. All is clear, and are now happy to recommend publication of your manuscript. We appreciate the constructive tone and comprehensive nature of your engagement in the PRSB peer-review process. We look forward to seeing your manuscript published soon.



## Appendix A

Mieres (Spain), 22nd of March 2021

Gary Carvalho  
Editor-in-Chief  
Proceedings of the Royal Society of London B

Dear Professor Carvalho,

Thank you very much for your decision concerning our manuscript **MS# RSPB-2020-2942** entitled *Spatio-temporal variation in the wintering associations of an alpine bird*. In your kind letter, you allowed us to resubmit a revised version that constructively addressed all of the concerns raised in previous critique. As detailed in our responses below, we have now done our utmost to account for every one of these comments. Thus, we enclose a thoroughly revised manuscript as a new submission, in the hope that you will consider it for publication in PRSLB.

Yours Sincerely,  
Dr. Maria Mar Delgado and co-authors  
Research Unit of Biodiversity  
University of Oviedo, Spain



Point-to-point responses to the comments by the reviewers are given below. For clarity, the original comments are identified *in italics*, followed by our responses in regular font.

## Responses to Editor

*Comments to Author:*

*The ms has been seen by two expert referees, one of whom is quite skeptical if the topic and results are suitable and important enough for a broad audience. I think group fission and fusion dynamics in winter is a highly interesting topic, but I fully agree with the referees that the presentation is sub-optimal and needs further clarification, especially for a broader audience. I have major difficulties in understanding what the figures actually represent and so may other readers that might be interested in the results but are no specialists in the area. The editor might think of considering a revision of the manuscript, if the authors can address this issue and make both the topic and the data presentation more suitable and appealing for a more general audience. As presented now, the ms is more appropriate for a more specialized ecological journal.*

We thank the Editor Wolfgang Goymann for his encouraging comment. In the revised version we have paid particular attention to some confusing parts (see our comments below) related with the manuscript with the aim to make both the topic and the data presentation suitable and appealing for a general audience.

## Responses to Reviewers

**Reviewer #1:**

*This is an interesting manuscript that reports on some environmental variables that affect group dynamics and sizes of snow finches. The role of group dynamics as a behavioral tactic and the relationship to environmental conditions is an interesting and - possibly - understudied one, especially in alpine environments, and this paper could be a useful contribution. Furthermore, I thought the tidy definition of "fission" and "fusion" as the straightforwardly estimated inflection points of GAM splines, was a novel and highly promising use of widely available observation data. Methodologically, this is a terrific (and simple) innovation that I think will be of interest to people studying social ecology in other taxa as well. The paper is very clearly written (though I identify some minor English language points in the comments below).*

We appreciate the revision made by the Reviewer#1, we have enjoyed very much addressing her/his constructive comments. We have done our utmost to account for every one of the comments, especially in clarifying further our data and paying particular attention to the confusing parts related with the figures.

*I do, however, have a few concerns. First, with respect to the data, more detail would be welcome (I was not able to access the data to get a sense of its structure myself). How many observations and what was the length of time series from each (broad) study area? What are some general similarities / differences across the four study areas? How were the data distributed spatially? E.g. were there a few dedicated study sites? Or was, e.g., the citizen science data collected opportunistically over larger areas? This information is important, especially since (as the authors are fully aware) there can be very large differences within relatively small areas in alpine environments.*



We have now provided more information about the data, included now in the new version of the supplementary file as a new text, table and figures. In particular, we made a new table where we are summarising data collection in the different study areas and over the months by providing the number of observations, the numbers of years when data were collected every month, the mean ( $\pm$  SD), the median and the 1<sup>st</sup> and 3<sup>rd</sup> interquartiles. We are supporting this table with a new text, where we describe in more detail the structure of the data. Finally, we have illustrated the numbers in the table and the words in the text by a couple of figures.

*In Fig. 1bc, for example, it is not clear what the points represent. I assume - sites? If so, how many were there? And why not identify them by study area / mountain range?*

In addition to the new information provided to better explain the data (in the supplementary file), which we hope it will help to understand the figures, we have also now better explained in the legend of Figure 1 what the points represent (please see the detailed comments below). We also expanded this part of the analyses in the Method section because we think it was not well explained in the previous version (see detailed comments below, please). With the new legend and the modifications made both in the text and in the figures, we hope to have made them self-explanatory and understandable for a general audience.

*(A side note - since the data are essentially, presence-only, group size counts, isn't there a significant introduction of bias, due simply to the fact that larger group sizes are easier to observe? Perhaps this doesn't have too much impact on the fission / fusion dynamics, but probably needs to be considered.)*

This was also for us a reason to worry when we started to analyse the data. However, we would like to note here that the fact that we have presence-only data does not introduce a bias in our case because we are not interested in the density of the birds (for which zero values would be important), but in the characteristic (group size) of an observation. Presence-only data are problematic for species distribution modelling, but not for relating group size to environmental variables. Further, when we figured out that ca. 37% of the total dataset and ca. 34% of the winter observations were single individuals, we were sure that detectability should not be a major problem in our data. Alpine environments are completely open, and there are not as many bird species as we could find in other habitats like forests. Also, snowfinches are easy to be spotted and distinguished because they have a relatively big size compare with other alpine species (e.g. wheatear or redstarts), reducing the potential bias due to detectability, if any.

We found important to clarify this potential issue in the manuscript, so we have added the above argument in the revised version (Page 6, L158-L166): "There may be a potential introduction of bias due simply to the fact that larger group sizes are easier to observe. However, we discarded this potential bias due to detectability to be a major problem in our data, if any, because (1) ca. 37% of the original dataset and ca. 34% of the observations during the winter were single individuals, (2) alpine environments are open habitats, and there are not as many bird species as we could find in other habitats like forests, and (3) snowfinches are easy to be spotted and distinguished compared to other alpine bird species because they have a relatively bigger size and a conspicuous coloration."

*With respect to the modeling, I am wondering why not test directly whether there are differences across study area by including area as a main effect (there are only 4, so no great loss in degrees of freedom). This would allow to test directly for differences in patterns across and within "areas".*



*In line 275, the authors make a statement regarding locally idiosyncratic responses to variation, but it was unclear to me how that statement was supported by the modeling structure (where, e.g., the random effect of site area was removed) or in the results. But it is interesting!*

We agree with the Reviewer that it could have been interesting to compare differences in patterns between areas by directly including it as a fixed factor. However, due to the huge unbalance in the data (please see the new table in supplementary material) we dealt with, we think it is not statistically correct to include it as a fixed factor. Our decision to include the area as a random factor was thus not based on saving degrees of freedom, but thinking on how to best accommodate the heterogeneity of our data (i.e. repeated measurements within areas but unbalanced data between them). Still, by including site mean temperature and site mean precipitation we think we are looking at differences between areas but related with the main aim of the study, i.e. to understand whether and how group dynamic might be influenced by local weather conditions.

*In the post-hoc analysis (as noted in the detailed comments below), I am also not convinced by the linear regression of fission date against temperature, as it looks like there is a plateau at higher temperatures, which may have some biological / behavioral interpretation.*

Our first modelling approach to study fission and fusion dates was to build GAMs. However, as EDFs for these variables were  $< 2$ , we modelled their linear effects. As we also stated below (see detailed comments), we do not see that there is a clear plateau in the fission date variable after the day 140. It is true, however, that after day 140 the CIs are a bit wider, yet the relationship is significant (i.e. the CI do not cross the zero, See Table S1). Therefore, we think it is correct to model fission dates as a linear response variable against climatic variables.

*Finally, with respect to the interpretation of results, I found the discussion to be a bit short and superficial, beyond reporting that weather has an effect on group dynamics. For example, foraging dynamics and behavior are cited as potentially important factors. But - as a non-expert on snow finch diets - I have absolutely no idea how. Certainly, this must depend to some extent on the available resources. Likely those resources must vary across (and within) study areas in some meaningful way.*

We have now expanded the Discussion section in two ways. First, we are providing more details about how snowfinches behave to locate prime feeding grounds, differentiating patterns between breeding and non-breeding periods (Page 10, L276-L283). Second, we are now adding a new argument that might be related with the observed changes in group fission-fusion dynamic and group size (Page 10, L293-P11, L301). This second argument is based on a paper we recently published where we demonstrate that, when snowfinches aggregate in large flocks during the winter, they adopt a partial-migration strategy. Stable isotope data suggest that individuals are moving from Switzerland to the Spanish Pyrenees and to the Cantabrian mountains, being the probability and magnitude of those migratory movements related to the local winter conditions in Switzerland. In particular, the migratory propensity of snowfinches is higher in winters with low average monthly temperature in the Alps. As the migratory propensity of snowfinches depends on climate, we can expect the migratory behaviour, and consequently, the size of the groups of snowfinches to decrease under the ongoing global warming.





*The notion that ski tourism may be an important seasonally discrete source of resource provisioning is also intriguing - but isn't there good and reliable data on locations with and without ski tourism, and can't that (shouldn't that) simply be included as an explanatory factor?*

We agree with the Reviewer that the potential effect of artificial feeding in e.g. ski resorts are very interesting. Unfortunately, we do not have enough data to include this potential effect in the current study. It is actually one of the main objective of the next project we recently applied for. If we get funded, we hope to be able to disentangle the effect of artificial feeding on e.g. individual physical condition, movement behaviours, etc.

*Overall, I think the methodological innovation here is promising, and the application to snow finches would make an interesting contribution. But I feel the authors overly compressed their findings, whereas this article would benefit from more detail (esp. in the materials and results sections), and could develop their analysis further.*

Once again, we thank the Reviewer for her/his encouraging general comments.

*Other comments (mostly minor, but a few substantive - e.g. with respect to figures) are in the comments below.*

*l. 63: "seek shelter"*

Ok

*l. 71: "that is must have ..."*

Ok

*l. 149: some standard ref for GLM's would be useful (e.g. Wood, S.N. (2004) Stable and efficient multiple smoothing parameter estimation for generalized additive models. J. Amer. Statist. Ass. 99:673-686, or Wood, S.N., N. Pya and B. Saefken (2016), Smoothing parameter and model selection for general smooth models (with discussion). Journal of the American Statistical Association 111, 1548-1575 for more reference to mixed models).*

Thank you, we added both references.

*l. 149: I'm confused about the spatial scale of the analysis. Is a "grid cell" the same as a "site"? Or do you mean the 30 arc-sec resolution cell? Surely, there aren't group sizes available at every 30 arc-second scale? Later you refer to "areas". Are those the same / different? Better to stick with one term, define it clearly, and be consistent.*

Sorry for the misunderstanding, for "grid cell" we meant "site/area". We have used the term "area" to be consistent throughout the text.

*l. 166: I guess "mean precipitation" "means mean daily precipitation" or "mean annual precipitation"? And "mean monthly precipitation" means "mean daily [or annual] precipitation per month"? It might be simpler to use total precipitation (annually / seasonally / monthly). The use of "mean temperature" for "mean monthly temperature" is, in any case, confusing, especially since these are obtained for each site.*



Thanks for this suggestion. Here indeed we estimated two different weather variables: (1) to globally characterise each site (i.e. which were in general the colder sites vs warmer sites), we estimated the mean temperature and precipitation over the observation period (i.e. over the years we had observations); and (2) for each observation, we recorded the mean monthly temperature and mean monthly precipitation. Following the Reviewer suggestion, we have kept the terms for (1), i.e. mean site temperature and mean site precipitation, but changed the terms for (2) i.e. now termed as mean monthly temperature and mean monthly precipitation.

*l. 176: Capitalization unnecessary, e.g. "as a gamma distributed variable ... as two normally distributed response variables". That said, the number of snow-finches should be Poisson (discrete) not gamma (continuous). Or - for more flexibility - an over-dispersed Poisson.*

We have removed the capital letters for the distributions. We really appreciate the comment about the distribution of the response variable. Yes, the Reviewer is totally right that, because the number of snowfinches is a count variable, it follows a Poisson (discrete) instead a Gamma (continuous) distribution. When building this model, we had to deal with many difficulties and pay attention to many details at the same time...so we really overlooked this important detail. Sorry. We have now re-built this model, specifying a Poisson distribution (and changed accordingly the text). The competitive models are now only two, which has simplified the new TableS2 (previous TableS1), but otherwise the Results are qualitatively the same. We only modified some numbers in the previous TableS1 (actual Table S2).

*l. 197: Random intercept, or some random coefficients?*

We have clarified that our random factors only include the intercept

*l. 219: "occurring slightly earlier" ... "abundant precipitation" ... "low precipitation" (precipitation does not take the plural in English, here and elsewhere).*

Thanks, done

*l. 222: With such a skewed distribution, more helpful to report medians and inter-quartile ranges.*

We are now providing the medians and the IQRs

*l. 223: Delete "being" and break simply into a new sentence: "The number of individuals within a group WAS also related to ..."*

Done, thanks

*l. 227: "tended"*

Thanks, done

*l. 241: "suggests" rather than "evidences" (not a word)*

OK

*l. 242: "determining" rather than "rule".*

OK



*Discussion:*

*I. 261: maybe "indicate" rather than "highlight."*

OK

*II. 264-270: Difficult to interpret the feeding explanation / hypothesis without a better idea of the main food and feeding behavior of the snow finches (in winter), and how that varies across the study areas.*

As stated above, we are now providing further details about snowfinch behaviours for locating feeding areas in the hope to make this part clearer.

*I. 282: "weather" rather than "climate" improves. That said "improves" is relative (e.g. this reviewer loves winter)! Better, simply, "warms".*

Thanks, the first author also loves winter! So very happy with this change

*I. 283: I'm assuming the presense of ski tourism is not a factor everywhere? But is knowable? Couldn't this be included directly in the analysis?*

Please see our reply in the General comments. Thanks

*I. 289-290: How do you know the costs of living with a group are not compensated by the benefits of cooperation? This seems like such a bold, broad statement.*

We have modified the sentence (Page 10, Line 298-300): As the costs of living in a group may not be compensated by the benefits of cooperation under warming weather conditions, individuals might coordinate decisions to fuse into a short-term group)

*I. 315: "with the exception of" rather than "notwithstanding".*

Done

*I. 316: "Given ongoing rapid ..."*

OK

*Fig. 1:*

*a) consider adding a horizontal zero line, and perhaps even labelling the positive region as "larger group size" and the negative region "smaller group size".*

We added the horizontal zero line and labelled the positive and negative regions as suggested by the review.

*b) The regression line is somewhat unconvincing. Among fission days occurring after about day 140 (or past, say, 6C), the relationship would be very weak, if any. It looks more like a "hockey-stick" type relationship, i.e. fission dates appear to "flatten" after a certain temperature threshold.*



Sorry, but we do not see that the relationship between fission and temperature is flattering after the day 140. Indeed, if that would be the case, the response surface would have fit better an additive model. As stated in the first version of the manuscript, that was always our first approach to accommodate any non-linear relationship. When  $edp = 1$ , as it was the case for the variable fission, we instead built linear models. It is true, however, that after day 140 the CIs are a bit wider, yet the relationship is significant (i.e. the CI do not cross the zero, See Table S1). Therefore, we don't find incorrect to model fission dates as a linear response variable against climatic variables.

*Also - in (b) and (c), is each point a site? So - how many sites were there? How are they distributed across areas?*

We have detailed in the Legend of Figure 1 that each point (for panels B and C) corresponds, respectively, to each fission and fusion date for each year of each site considered (i.e. Cantabrian Mountains ( $n = 9$ ), Italy ( $n = 9$ ) and Switzerland ( $n = 15$ )).

We think this part of the analyses was confused in the previous version of the manuscript, and so we have also now expanded the explanations of this analyses in the Method section (Page 5, L148-154: "We could not include the Pyrenees area because for some months there was only one observation (see Data Collection in electronic supplementary material), and thus we could not build the GAM to estimate the internal knots. After removing some potential influential observations, and considering those observations for which we had information on climatic variables, our final dataset consisted on a total of 33 observations (Cantabrian Mountains = 9, Italy = 9 and Switzerland = 15)."

*d) I find these surface plots difficult to interpret, especially since there are no scales on the axes, and no sense of where the coefficient is positive or negative. Better an image or contour plot.*

We modified the surface plot to a counterplot, and modified the legend accordingly.

Fig. 2:

*I am completely confused by the the meaning of the colors here, or what the main takeaway is (are they means? trends? both?). The caption is not very helpful, and the bin numbers are very odd. I'd recommend a simpler and discrete color scaling, and more detail. Also, wouldn't a West to East ordering for a-b-c-d make more sense?*

We have re-ordered the panels of this figure (from West to East), as also suggested by the Reviewer #2, and have expanded the legend of the figure to explain better each component of this graph. We are sorry we could not simplify the colours of the maps, as they are the minimum to represent all the different trends estimated for bot climatic variables, in each site and for the three different months represented.

#### **Reviewer #2:**

*The authors report on 23 years of observations of group sizes of snowfinches in four mountain areas in central and southern Europe, and relate those to air temperatures in these areas. They claim that groups separate later when spring arrives early. This might cause a phenological mismatch with their food, possibly lowering their breeding performance.*



*While the study has the potential to be interesting to a wider audience, I think the authors have to put much more effort in introducing their problem and presenting their findings. No specific hypotheses are presented. A priori, I would not expect the groups to form later when springs are warmer, and I would like to see some more thoughts on this already in the Introduction.*

As suggested by the Reviewer, we are now providing more arguments for introducing the problems of our study by presenting our hypothesis in the Introduction (Page 5, L126-L134): “In mountain areas with harsh and long wintering conditions, where living in groups might benefit individuals for e.g. locating food resources, large group sizes are predicted to occur. However, since within-group individual competition is expected to increase with group size, we can expect individuals in large groups to stay together for shorter times. If flocking behaviour is sensitive to climate variation across winter, we can expect that ongoing changes in climate might be impacting the gregarious behaviour of this alpine bird species. In particular, we predict mild winters could lead to a decrease in the size of snowfinch wintering associations, and to a reduction of the time individuals stay together.” We have modified the Discussion section according to these hypothesis (see also comments and replies to Reviewer#1 about this section).

*Most importantly, however, the results are poorly presented. Specifically, figures are far from self-explanatory, which makes them hard to understand, and to see the results.*

We have done our utmost to improve the presentation of our results, especially by following all the comments suggested by Reviewer #1 (please see his/her comments and our replies above). In particular, we paid special attention to the presentation of our findings by re-working on the figures. We think that with the changes we made on them (and their legends), and with the additional details we have now included in the text, the revised version has improved much in its clarity.

#### *Specific comments*

55) *“ultimately affecting its population dynamics”. Replace this with “... breeding performance” (as mentioned in the Discussion), because the step to population dynamics is way more complicated. See for instance Reed et al. (2013) Science doi: 10.1126/science.1232870*

OK

64) *rephrase: “sedentary animals, such as mammals”; some mammals are migratory (especially in mountainous areas, i.e. altitudinal migration).*

Done, we have removed “such as mammals” from the original sentence

78) *“with individuals gathering together or separating (i.e. fission-fusion dynamics)”; change into: “with individuals separating or gathering” to match order of “fission-fusion”.*

Thanks, done

88-95) *too many words on migration, which is not where the paper is about.*



We have now shortened the text about migration (Page 3, L86-L91): “Animal life-history strategies are adapted to local and global climate conditions [15–18]. In birds, there is good evidence that the changes in climatic conditions (e.g. temperature, precipitation) affect the migratory behaviour of many species in several ways [19–22]. Also, the timing of reproduction is affected by climatic changes [23–25]. Such behavioural adjustments frequently have severe negative effects on species distribution, abundances and may lead to local extinctions [15,25].”

156) *“for studying the spatio- temporal variation in group size during winter, we considered only those observations when more than 5 individuals were simultaneously observed”; please justify this number.*

Thank you very much for this comment. We forgot to explain in the manuscript that we considered groups larger than 5 individuals because this number corresponds with the mean of the first interquartile range during winter (please see new Table S1 in supplements). We have now included this criterion in the text (Page 6, L164-L165) for discarding the impression that we are selecting this number arbitrarily.

215-217) *where can I see the ranges given here?*

We have now provided the mean of snowfinch group size and the interquartiles, as suggested

219) *“with group formation slightly occurring earlier at warmer sites with abundant precipitations (electronic supplementary material, table S1) and group separation occurring later at warmer sites with low precipitations”; I would like to see a figure.*

We added the suggested figures in the supplementary material

225) *“At locations with lower mean site temperatures, especially when associated with abundant mean site precipitation, winter groups tend to be larger (figure 1A)”; unclear how I can see this in figure 1A.*

Following the suggestion of the Reviewer #1, we have now added a horizontal zero line to label the positive and negative regions, which we believe it is helping now to read the figure

*Fig. 1B,C and Fig. S1B) . I’ve read that areaID was eventually left out of the statistical models, but I would still like to see the four areas represented by a different symbol.*

We think the readers will be confused if we represent each area with different symbols if the area is not included as a fixed factor in our model. Note, however, that we have now expanded the explanations of this part of the analyses in the Method section (see also reply to Reviewer #1), specifying how many points correspond to each area. We hope this clarify the sample size considered in these models.

*Fig. 2) Please relabel mountain areas such that A, B, C, D are in the proper order (to simplify the figure).*

Done (please see also reply to Reviewer #1)



## Appendix B

Mieres (Spain), 20th of April 2021

Gary Carvalho  
Editor-in-Chief  
Proceedings of the Royal Society of London B

Dear Professor Carvalho,

Thank you very much for your second decision concerning our manuscript **MS# RSPB-2021-0690** entitled *Spatio-temporal variation in the wintering associations of an alpine bird*. In your decision letter, you gave us the kind opportunity to revise our manuscript a second time. As detailed in our responses below, we have now accounted for each critical comment raised by yourself and the Reviewer #1.

Yours Sincerely,  
Dr. Maria Mar Delgado and co-authors  
Research Unit of Biodiversity  
University of Oviedo, Spain



Point-to-point responses to the comments by the Reviewer are given below. For clarity, the original comments are identified *in italics*, followed by our responses in regular font.

## Responses to Editor

*Comments to Author:*

*Thank you for the revisions to your manuscript, and there is a collective opinion that most of the primary concerns have been addressed satisfactorily. However, you will find remaining issues that require your considered attention, most notably, issues relating to the foraging ecology of the snow finches in winter, and the clarity and interpretation of figure 2, with further details provided below. We look forward to hearing from you at your earliest convenience as soon as possible.*

We thank the Editor for his encouraging comment. As detailed below, in the revised version we have paid particular attention to the issues relating the foraging ecology of the snowfinches in winter, and have followed all the suggestions regarding the figures.

## Responses to Reviewer #1

*The authors have done a good job responding to the comments on the first draft, and many aspects are more clear in the revision. The attached document contains some in-line comments - mainly minor - on the text, which are worth going through.*

We have accounted for all the suggestions in the attached document. Thank you so much for helping us to improve the text.

Thank you so much for this positive comment. As said in the first revision round, we both enjoyed and learned very much while addressing all your useful previous comments.

*However, I am still not quite satisfied with the responses to two of my major concerns.*

*First - for all of the analysis and results, I am still unclear on the foraging ecology of the snow finches in winter, and fundamentally what drives the group dynamics. The new section in the discussion alludes to partial migration and following insect phenology (I assume - emergence) in spring, but there is very little information on the spatial distribution or even general description of the main winter resource. I'm assuming the main winter food source is grains or seeds. Are these alpine forbs or shrubs that need to be exposed to be accessible? Do they feed on conifer cones, which are maybe easier to access? Are there any known differences across these - presumably - very different mountain ranges that explains some of the divergence in the responses? What happened to the speculations regarding human supplementation at ski resorts? What, exactly, is the benefit of social aggregation? Does it help groups find bare patches? Under what conditions? I understand that there may not be data to answer these questions, but the authors are evidently knowledgeable about the social and foraging ecology of snow finches and should be able to speculate - building off of some of the more non-trivial results from the statistical analysis - beyond merely pointing vaguely to environmental gradients.*

We have now included a paragraph in the Discussion section about the foraging ecology of snowfinches in winter, to point out which might be the benefits of this species for gathering in large groups to locate feeding grounds that need to be exposed to be accessible. This is because,





as we are detailing now, snowfinches in winter exclusively feed on seeds of alpine plants, so individuals might easily find them when they forage together in large groups. In addition, we have also evidenced our thoughts/speculations regarding artificial feeding, leaving this important question as an open question that needs further research.

*This reviewer's main point of reference is Arctic-boreal ungulates (esp. Rangifer tarandus), and within the species, gregariousness and general foraging ecology depends on whether they are wintering in tundra, and need to find areas where terrestrial lichens and mosses can be accessed via pawing and digging shared craters, or in mature boreal forests with abundant arboreal lichen. The former is, necessarily, a more social aggregated behavior than the latter.*

Very interesting, thanks for making this important point clear to us.

*Second, Figure 2 remains deeply confusing and largely uninformative. As I understand, it is attempting to show trends (and not means?) of temperature and precipitation. The main source of confusion is the odd sets of 11 color ramps beneath the figures, labelled (in an illegibly minuscule font) with rather odd intervals (-0.115, -0.075, -0.020, -0.015, 0.046) etc., each with a slightly different color ramp, which is nearly impossible to match to the areas in the map. It appears there is some variation within the sites in these trends, but the areas are all so small on the maps there isn't any usable information to parse here, especially since there's no specific indication of where the data were collected within those sites. I still don't understand why there can't be a pair of high-contrast color ramps (ideally, ones that make 0 white, e.g. blue-white-red for temperature purple-white-orange for precipitation), so that larger, smaller, positive and negative trends can be seen more clearly. Also, the sites don't need to be on a map of Europe, but could be juxtaposed in adjacent panels. But - ultimately - this figure doesn't provide too much useful information for the paper. For one thing, it has nothing at all to do with the snow finches themselves, and the overall trends could just as well be relegated to a table. If needed - the figure could simply be moved to the supplementary materials.*

We decided to remove the maps of this figure, and place it in the supplementary file.

*That said, the Supplementary Figure 1 is a terrific figure that actually identifies the study sites and usefully illustrates the group size data. In my opinion - should absolutely be included in the main text. I would consider adding a panel that includes the main GAMM fit from supplementary figure 2A. The whole analysis hinges on the identification of inflection points in a gamm fit, and that seems a key thing to illustrate.*

We have now included these figures (new figure 1 in the revised version) in the main text.

*The concerns above are (to my mind) fairly important, but easily remedied. The first with (a little) more text, the second - mainly - by reshuffling figures.*

Thank you again for your revision. It was a pleasure for us to have all these discussions with Reviewer #1 during the revision rounds.

## Appendix C

Mieres (Spain), 27th of April 2021

Gary Carvalho  
Editor-in-Chief  
Proceedings of the Royal Society of London B

Dear Professor Carvalho,

Thank you very much for your second decision concerning our manuscript **MS# RSPB-2021-0690.R1** entitled *Spatio-temporal variation in the wintering associations of an alpine bird*. In your decision letter, you gave us the kind opportunity to revise our manuscript another time. As you can find below, we have accounted for each minor comment raised by the Reviewer #1.

Yours Sincerely,  
Dr. María Mar Delgado and co-authors  
Research Unit of Biodiversity  
University of Oviedo, Spain

Point-to-point responses to the comments by the Reviewer are given below. For clarity, the original comments are identified *in italics*, followed by our responses in regular font.

## **Responses to Reviewer #1**

*Thanks for the revisions. The foraging ecology section in the discussion is very illuminating and helpful (at least to me). Overall, this version looks great to me and I need not look at another revision.*

As before, we are hugely grateful to the Reviewer #1 for his/her useful comments, as well as for the time and effort he/she spent in revising our manuscript.

*A few minor text comments are below, as well as some important issues in the new Figure 1 (e.g. mixed labelling).*

*That said, it occurs to me that group size is count data, modeled as a Poisson, but with no zeros. So it should technically be considered a zero-truncated Poisson regression. There are ways to deal with that, but probably none is more straightforward than to simply model (Group Size - 1), such that the predicted response in a straightforward Poisson regression is  $\log(\text{Group Size} - 1)$ . This is particularly important for interpreting the spline regression in Fig1C (which should be D - and maybe should be back-transformed to expected group size). But it should have zero impact otherwise on the results or conclusions.*

We have now modelled the response variable Group Size -1 to treat our variable as a zero-truncated Poisson regression, and changed Stable2 accordingly. Thank you very much for pointing out this technical detail. As the Reviewer was expecting, we did not find any different results (please see new Stable2).

*Minor text comments:*

*I. 151, 203: Poisson should be capitalized*

Done.

*I. 316-318: Grammar is funny. Maybe: "The occurrence and intensity of artificial feeding vary among the snowfinch populations, and is much more common in the Alps than in other snowfinch populations."*

We modified the sentence accordingly.

*Figure 1: I think the letters D and C should be flipped - according to the caption. In (current) panel D: y-label should be "group size" (I think it's showing the same thing as panel B). And the caption should also explain what the vertical dotted lines are. Panel C: rather than  $s(\text{Day in Year}, 7.42)$  - that is - ylab should be log of expected group size - no? (Or  $\log(\text{Group Size} - 1)$  as per comment above?) Maybe that figure would be better transformed to actual expected group size? Also, the x-axis is only half-hiding the Julian days ... that could be tidied.*

We have now explained in the legend of the Figure what the vertical lines represent, and have changed the y-axis and x-axis as suggested. We, however, believe that we had the right labelling for panels C and D (Fig. 1). In order to make them clearer and fully in accordance with the legend caption, we have now expanded a bit the legend caption.

We would like to note here that when running again the GAMs with Group Size-1, and re-working on Figure 1, we noticed that panel C was not updated and was still the representation of the previous model with Gamma distribution. The new panel is the right one, with Poisson distribution. It has the same shape, but CI are much tighter because the Poisson model performed better, as already discussed in previous revision rounds.