Dr. Aaron Ellison,

Executive Editor,

Methods in Ecology and Evolution

Dear Dr. Ellison

We would like to thank the two reviewers for their thoughtful and helpful comments, and for your willingness to consider revisions on our manuscript **“baRulho: an R package to quantify degradation in animal acoustic signals”** MEE-23-12-736. We are grateful for the reviewer’s detailed and constructive input and think that their suggestions substantially improved our manuscript.

Below, we address the reviewers’ comments and suggestions regarding the original submission of our manuscript. We believe we have thoroughly addressed their concerns. Reviewer concerns are shown in italic and our responses in normal font in this letter and have used Microsoft track changes to document revisions throughout the document.

We hope that the revised version of the manuscript proves suitable for MEE and look forward to hearing from you in due course.

Sincerely,

Marcelo Araya-Salas

Centro de Investigación en Neurociencias & Escuela de Biología,

Universidad de Costa Rica, San José, Costa Rica

30-Jun-2024

MEE-23-12-736 baRulho: an R package to quantify degradation in animal acoustic signals  
  
 Dear Dr Marcelo Araya-Salas,  
  
 Thank you for submitting your manuscript to Methods in Ecology and Evolution. I have now received the reviewers' reports and a recommendation from the Associate Editor who handled the review process. Copies of their reports are included below. This manuscript has the potential to make a valuable contribution to the area, but there are a number of significant concerns that need to be addressed. I have considered your paper in light of the comments received and I would like to invite you to prepare a major revision.  
  
 In your revision, please make sure that you take full account of the above comments and those made in the reports below. Please note that Methods in Ecology and Evolution does not automatically accept papers after revision, and an invitation to revise a manuscript does not represent commitment to eventual publication on our part. We will reject revised manuscripts if they are returned without satisfactory responses to the reviewers' comments. When returning the revised paper, please show point-by-point how you have dealt with the various comments in the appropriate section of the submission form.  
  
 We are also offering language editing with Writefull, free of charge, which may be of interest to you. Writefull screens your text for correctness of grammar, spelling, vocabulary, punctuation, style, word order, phrasing, and more. You can use this service by following this link: [https://revise-c7962b5ef21ca52c4163c44e983d5b45e2.writefull.ai](https://revise-c7962b5ef21ca52c4163c44e983d5b45e2.writefull.ai/) This journal offers a number of license options for published papers; information about this is available here: <https://authorservices.wiley.com/author-resources/Journal-Authors/licensing/index.html>. The submitting author has confirmed that all co-authors have the necessary rights to grant in the submission, including in light of each co-author’s funder policies. If any author’s funder has a policy that restricts which kinds of license they can sign, for example if the funder is a member of Coalition S, please make sure the submitting author is aware.  
  
 Please return your revision by 11-Aug-2024. If you need longer, please let us know so we can update our system accordingly. Before resubmitting your manuscript, please read through the resubmission instructions below.  
  
 We look forward to hearing from you in due course.  
  
 Sincerely,  
  
 Aaron Ellison  
 Executive Editor, Methods in Ecology and Evolution  
  
  
 Reviewer(s)' Comments to Author:  
 Reviewer: 1  
  
 Comments to the Corresponding Author  
 The present manuscript describes a much-needed modernization of the old software package SigPro developed by Simon Boel Pedersen in the 1990’es and specifically dedicated to quantifying animal sound signal degradation. baRulho calculates the same four measures of sound degradation as SigPro but has so many new functions including statistics that it can be thought of as a new software package in its own right.  
 I have a few clarifying questions:

*Line 5: Sound does not "degrade" but sound signals do as they lose their information content. Suggestion: Change "sound degrades" to "sound signals degrade"*

**RESPONSE:** Changed as suggested.

*Line 7: I suggest changing the word “transmission” to “propagation” throughout the manuscript. As I understand it, “propagation” has now officially replaced “transmission” in underwater acoustics and probably also in terrestrial acoustics*

**RESPONSE:** Changed here and throughout the manuscript as suggested.

*Line 78: I suggest changing heading to: "Implementation of propagation ..."*

**RESPONSE:** Changed as suggested.

*Table 1. “Create master sound file for playback”: I take it that this means that the experimenter can include song elements from field recordings in the master sound file. Such that the master file contains both computer generated sounds and natural sounds. Is there a limit to the duration of the master file?*

**RESPONSE:** Changed “more sound files” to “more field recordings” and added “or from synthetic sounds made with the function *synth\_sounds()*” for clarification. There is no predefined limit to the duration of the master file. We have added this to the function description in the package: “**There is no predefined limit to the duration of the output master sound file, although file duration is constrained by computer memory. As a reference, master sound files of up to 10 min have been created in a 16GB RAM laptop computer.**” We prefer not to mention specific details as the table is intended to provide a brief description of the overall task that functions are designed to conduct.

*Table 1. “Quantify degradation. envelope\_correlation()”: Nice feature!*

**RESPONSE:** Thank you!

*Table 1. “Quantify degradation. signal\_to\_noise\_ratio()”: I take it that the noise level is measured between test sounds, which means that there should be a certain minimum inter-pulse duration. Where in the playback file is the noise measured? How big are the interpulse intervals?*

**RESPONSE:** Ambient noise measurements can be adjusted according to the user’s preference. For signal-to-noise ratio specifically, users can use a segment of ambient/environmental noise before the signal or alternatively use an ambient noise segment referenced in the selection table (labeled as 'ambient' in the 'sound.id' column). The second option allows users to use the same ambient noise reference for all sounds in a sound file. Because signal-to-noise ratio is one of the most commonly used measures of degradation, we added to the description in Table 1 that “**the duration and location of ambient noise measurements can be adjusted**”.

*Table 1.”Quantify degradation. spectrum\_blur\_ratio()”: Nice feature!*

**RESPONSE:** Thanks!

*Table 1. “Quantify degradation. tail\_to\_signal\_ratio()”: TSR was not implemented in Dabelsteen et al. 1993! The relevant reference here is: Holland J, Dabelsteen T, Pedersen SB, Paris AL (2001) Potential ranging cues contained within the energetic pauses of transmitted wren song. Bioacoustics 12(1):3-20.*

**RESPONSE:** Thank you! Citation adjusted.

*Line 121: What was the total duration of the master sound file? Is there an upper limit to the duration?*

**RESPONSE:** The duration of the master sound file was 254 s but notice that the file also contained test sounds of a different study. The duration of the section with test sound for this study was 194 s. As we mentioned above, there is no predefined limit to the duration of the master file.

*Line 151-152: Nice feature!*

**RESPONSE:** Thank you!

*Line 160 – headlines: What are the time units of start and end? Are they seconds, milliseconds, or minutes? What does, for instance, 6.049203 mean? I suggest that you insert units wherever possible such that the user immediately knows whether a number is a ratio, dB, dB/m, ms ..*

**RESPONSE:** This is a good suggestion. However, the R object format used (object class “selection table”) belongs to a different package (warbleR) so this change will require a modification on that package. The change has been suggested to the warbleR package maintainer. We have modify the main text to let users know the units of the table: “**The output of *align\_test\_files*, (and from *auto\_realign* and *manual\_realign*) contains the time-frequency coordinates *(in s and kHz)* for all test sounds (Fig. 1).**”

*Line 163: Is the mismatch “time.mismatch” measured in time units (e.g. seconds?) or it a unit-less correlation value?*

**RESPONSE:** Time mismatch is in seconds. We have clarified this in the text: “**The output also contains a ‘time.mismatch’ column that compares the time gap between the two markers in the test files against that in the master sound file as a measure of the magnitude of the mismatch (in s). For a perfectly synchronized file the value must be 0 (i.e. the same gap between markers as in the master sound file), although in most cases accurately synchronized files show a time mismatch of a fraction of a second.**”

*Line 169: Rather confusing that the rows overlap. Please change table columns such that each row contains the relevant information.*

**RESPONSE:** We have modified the table so must cell values fit in a single line. We expect the tables to be more readable in the format of the journal.

*Line 169: What does 7.060.315 mean? Is this R notation? If it indicates time, I expect 7.060315 s. I suggest that you include time and frequency units where possible!*

**RESPONSE:** The format of the decimals was changed when we imported the data to Office Word. We have fixed this in the manuscript and rounded the numbers to 3 decimals to make them more readable. As mentioned above, the R object format used (object class “selection table”) belongs to a different package (warbleR) so this change will require a modification on that package. That said, we included the units of the table in the main text. “**The output of *align\_test\_files*, (and from *auto\_realign* and *manual\_realign*) contains the time-frequency coordinates *(in s and kHz)* for all test sounds (Fig. 1)”**.

*Line 169: What does 1.333.333 mean? Is it R notation, or does it mean 1.333333 kHz? I suggest that you include time and frequency units where possible!*

**RESPONSE:** As we indicated in the previous response, the format of the decimals was changed when we imported the data to Office Word. We have fixed this in the manuscript and rounded the numbers to 3 decimals to make them more readable. As mentioned above, the R object format used (object class “selection table”) belongs to a different package (warbleR) so this change will require a modification on that package. We included the units of the table in the main text.

*Line 201: It is advisable always to record at 1 m since this then compares directly with the source level of the vocalizing animal, normally back calculated from recordings in the field*

**RESPONSE:** We agree, particularly for birds. However, some studies have used shorter distances depending on the study system.

*Line 212: “8.999.975” What is the excess attenuation here? Does it mean 9 dB/100 m? I suggest that you include units wherever possible*

**RESPONSE:** Yes. Excess attenuation is given for the particular distance of each test sound (in the visible rows is 100 m). Note that the same error with decimal notation from the previous table is found here. We have fixed this and rounded numbers to 3 decimals to make them more readable.

*Line 231: Fig. 2. Is it possible to choose spectrogram colors? It would be a nice option. In some cases, black and white would be preferable. In other, e.g., to help red-green colorblind people other color combinations would be better.*

**RESPONSE:** Yes, the user can select spectrogram colors. This particular color scheme is part of the R package “viridis”, which offers color palettes suitable for color blindness.

*Line 247: Very educational feature!*

**RESPONSE:** Thank you.

*Line 249: Green line is OK, but it is difficult to see that the other line is purple. Black would be better*

**RESPONSE:** Black would be problematic as the “Sound ID:” title is in black already. We have used a lighter purple to make it easier to differentiate. That said, the argument “colors” in *plot\_blur\_ratio()* function allows users to modify all colors used in the graph.

*Line 255: Seems reasonable to use Bayesian statistics - I am not sure that I can follow all the other stats in detail, but it seems OK to me*

**RESPONSE: Thank you.**

*Line 297: Absolutely - in addition, in SigPro it could be extremely difficult to get the right measure of the tail-to-signal ratio*

**RESPONSE:** Yes! Finding sounds in the waveform is quite hard especially when there is a lot of degradation and ambient noise.

*Line 349: Please observe that a meta-analysis of many studies testing AAH has shown only weak correlations (Boncoraglio and Saino 2007), and some recent studies found no evidence for lower frequencies in forest species (Friis et al. 2021; Mikula et al. 2021).*

**RESPONSE:** We agree that there is mixed evidence on the AAH. We modify the sentence to avoid suggesting that it is supporting the idea that species actually adapt to local acoustic environments: **“Overall, our results are consistent with the notion that specific signal structures can enhance acoustic transmission and that habitat structure influences this transmission in a predictable manner (Morton, 1975).”**

*Line 373: Having spent many, many hours running SigPro analysis, I can see that baRulho is a significant advance*

**RESPONSE:** Thank you for your feedback!  
Reviewer: 2  
  
 Comments to the Corresponding Author  
 This ms introduces an R package ‘baRulho’ to simplify the implementation of sound transmission experiments. The authors present a case study from Mexico City and highlight the package features to test the effects of habitat and acoustic structure on signal transmission. Though the authors claim that this R package ‘baRulho’ provides an open-source, user-friendly suite of tools designed to facilitate analysis of animal sound degradation, there are some issues to be further addressed or explained.  
 *Lines 78-96: The manuscript does not mention whether the experiments were repeated under different environmental conditions. This repetition is essential to verify the stability and reproducibility of the results. The authors should consider conducting the playback experiments under varying environmental conditions to assess the stability and reproducibility of the results, and discuss the findings and how they support the robustness of the baRulho package under different conditions.*

**RESPONSE:** We focused our analysis on habitat structure as it is the most frequently evaluated factor when studying how the environment affects acoustic communication in terrestrial ecosystems (e.g., for birds: Morton 1975, Hunter & Krebs 1979, Gish & Morton 1981, Date & Lemon 1993, Slabbekoorn & Smith 2002, Balsby et al. 2003, Brown & Hanford 2003, Hansen et al. 2005, Leader et al. 2005, Nicholls & Goldizen 2006, Slabbekoorn & Hunk. 2007, Barker et al. 2009, Nemeth & Brumm 2010, Mouterde et al. 2014, Sandoval et al. 2015, Graham et al. 2017, Priyadarshani et al. 2018, Phillips et al. 2020, Trujillo-Torres et al. 2021, Grimes et al. 2024; anurans: Ryan et al. 1990, Penna & Solis 1998, Kime 2000, Penna et al. 2006, Llusia et al. 2013, Zhao et al. 2022; and mammals: Brown et al. 1995, Sugiura et al. 2006, Holzmann & Areta 2019, Arasco et al. 2022; insects: Lang 2000, Couldridge et al. 2004; and synthesized signals: Richards & Wiley 1980, Brown & Hanford 1996, Marten et al. 1977, Brown & Hanford 2000, Naguib 2003, Boycott et al. 2019). Habitat structure is also widely regarded as the most critical factor influencing terrestrial communication systems (Reviewed by Hardt & Benedict 2020; Bradbury and Vehrencamp 2011, Chapter 3). While factors such as temperature, humidity, and wind can influence atmospheric attenuation, the effects are small (Horton et al. 2015) and atmospheric conditions are often incorporated into attenuation estimates as a constant (ISO9613-1, 1993 - Acoustics: Attenuation of Sound During Propagation Outdoors). Therefore, we decided to showcase the package on the most common experimental design used in the field and on two of the most relevant factors affecting sound propagation in natural habitats. Furthermore, we disagree that including variation of other environmental factors would help to *“to assess the stability and reproducibility of the results”*. This would only test for the effect of these additional factors. Reproducibility/stability can only be assessed under the same experimental conditions, or by comparing the results to those from a well-established tool for measuring the same metrics. Therefore, the high congruence between measurements from baRulho and SigPro does demonstrate that results are stable/reproducible. SigPro measurements have been successfully used to study sound propagation in ecological contexts by the scientific community for almost 3 decades. Indeed, much of our knowledge on this topic has been gathered by studies using this software. Hence, the fact that baRulho measurements largely agree with those from SigPro strongly supports the robustness/reproducibility/stability of the package.

*Lines 98-110: The case study relies on a limited variety of synthesized sounds for playback experiments. The manuscript does not discuss the potential impact on the package's performance when applied to sounds from different species of birds or other animals. This limitation raises concerns about the generalizability and robustness of the baRulho package. It is recommended to include a discussion on the expected performance of the baRulho package when using different types of sounds. If possible, the authors should provide additional case studies or simulations incorporating a variety of bird and animal sounds to demonstrate the package's versatility and robustness. This will help strengthen the argument for the package's broad applicability.*

**RESPONSE:** We considered our data set not to be limited when contrasted against similar studies in the field.In fact, with 480 test sounds that vary in 4 structural dimensions (frequency, duration, frequency modulation and amplitude modulation) that resulted in 160 different variants (i.e. signal types), our set of model sounds is among the most structurally diverse ones used in a sound propagation experiment. It stands over most studies using synthetic sounds. For instance, the seminal paper by Morton (1975) used a total of 30 synthetic sounds that vary in only two dimensions (frequency and tonality). This is the case also for more recent papers. Slabbekoorn et al. (2002) used 14 synthetic sounds (repeated 3 times) varying in a single structural dimension (frequency change slope). Tobias et al (2010) use 72 test sounds varying in two dimensions (frequency and gap duration). Most studies using natural (non-synthetic) sounds also show a lower number of signal types. Dabelsteen et al. (2002) used a total of 10 test sounds representing 2 different signal types. Benedict et al. used 60 sound tests from three treatments (female song, male cascade and male “cheet”). Arasco et al. (2022) use 130 test sounds from 13 signal types. Graham et al (2017) used 38 test sounds representing 6 different signal types (terminal syllables, trill syllables and overall for each sex).

The high congruence between measurements from baRulho and SigPro indicates that the package is actually measuring the same aspects of signal degradation as its predecessor. So the question is then whether these degradation metrics can actually quantify degradation of animal acoustic signals in natural environments. The evidence strongly indicates that this is the case. SigPro has been successfully used in a wide range of synthetic and natural sounds from a variety of animal taxa, providing results consistent with theoretical expectations. Therefore, showing that the same SigPro measurements can be taken with baRulho gives confidence to users that similar questions can be answered with this package. We have added to the text that: “**The sound analysis results generated by baRulho and Sigpro are similar, making results comparable across studies using either software. This similarity also provides confidence in the robustness of the results.”**

*Lines 106-110: The manuscript does not address the potential impact of environmental noise on the playback experiments. Environmental noise can significantly affect sound transmission and degradation, which in turn could influence the performance of the baRulho package. The absence of this consideration is a notable gap. It is important to discuss how environmental noise can be measured and controlled during the playback experiments. Additionally, please explain whether and how the baRulho package accounts for environmental noise in its analysis. If the package currently does not include such features, pls add potential modifications or future improvements to incorporate noise considerations into the package.*

**RESPONSE:** We thank the reviewer for raising this point. Controlling environmental noise is a difficult task in transmission experiments. One approach that researchers use to mitigate the potential influence of varying environmental noise is to replicate each test sound several times (Slabbekoorn et al. 2002, Graham et al. 2017). The assumption is that if environmental noise is highly variable, having several replicates of the same sound will let us evaluate degradation of the sound under a more representative sample of the environmental noise. We did this in our study. We replicated each unique combination of acoustic features 3 times.

Another approach to control environmental noise is through experimental design. In our experimental design in which the open and closed understory transect for a given location were done one immediately after the other (the order randomly selected) and one next to the other (in space), aims to control for any particular variation of environmental noise in time and/or space.

In terms of actually measuring environmental noise levels: the package offers the function *noise\_profile().* The function estimates full spectrum sound pressure levels (i.e. noise profiles) of ambient noise. This can be carried out on annotation tables using the segments of background noise right before the test sounds or using dedicated annotations for 'ambient' noise. The function can also estimate noise profiles over complete sound files. This allows users to explore (and perhaps statistically test) differences in the relative level of environmental noise in their recordings. We added to the text that **“Users can explore the variation in background noise across re-recorded files with the function *noise\_profile*, which estimates full spectrum sound pressure levels (i.e. noise profiles) of the ambient noise for annotations or entire sound files.”**

*Moreover, the description of the playback and recording conditions is insufficient. Factors such as environmental noise levels, temperature, and humidity are critical, because they can significantly influence sound propagation and recording quality. My suggestion is providing a detailed description of the environmental conditions during the experiments. This should, at least, include measurements of environmental noise levels, temperature, and humidity at the time of playback and recording, and discuss their potential impact on the results.*

RESPONSE: Environmental variables for temperature and humidity are now reported in the main text: **“The average temperature and relative humidity during the experiment (+/- standard deviation) were 25.86 °C (+/- 1.65 °C), and 23% (+/- 6%) respectively.”**.

In terms of measuring environmental noise levels during the playback experiments, one could take a point measurement with a handheld SPL meter at the start of playbacks, but a signal point measurement in space and time does not capture the variation in noise that occurs throughout the environment. However, it is important to stress that our experimental design in which open and closed understory transects were conducted in pairs, each one next to the other in space and time (a few meters and a few minutes from each other), aims to control for potential variation in environmental noise. This is under the assumption that both transects in a transect pair experience similar levels of environmental noise. This was also taken into account during statistical analysis to emphasize the comparison within transects pairs. We added this to the main text: “**Transect pair and sound replicates were included as varying intercept effects to account for the paired nature of transects and the non-independence of observations, respectively”.**

*Finally, the manuscript should ensure that the experimental design to guarantee the reliability and reproducibility of the results. Please explain the rationale behind choosing specific environments (open and closed forest understory), and describe the specific characteristics of these environments, such as vegetation density, terrain features, and other factors that could influence sound wave propagation. Providing this information will help readers understand the experimental setup and its relevance to ecological acoustic studies.*

**RESPONSE:** Thank you. We added the following sentence to justify why we selected to compare open and closed understories for our experiments. **“We conducted a sound transmission propagation experiment to assess how habitat and signal structure influence the degradation of synthesized sounds. These two factors are among the most commonly evaluated when investigating the impact of the environment on acoustic communication in terrestrial ecosystems. In closed habitats, such as forests, acoustic signal degradation is more pronounced as they reverberate, scatter, or are absorbed depending on the vegetation structure as well as on structural features of the signals themselves (Morton 1975; Marten and Marler 1977) Hence, the study provides an experimental design and results that are familiar and accessible to potential users.”**

The ecological and evolutionary importance of habitat structure on selection of signal structure through transmission patterns is also addressed in the first paragraph of the introduction.

*Lines 119-122, 231-236: The manuscript does not specify the species for which the synthesized sounds are generated. This information is crucial for understanding the ecological relevance and context of the study. Please provide a detailed list of the species whose vocalizations are used to generate the synthesized sounds in the case study. Inclusion of such information will enhance the transparency and ecological context of the research, allowing readers to better assess the study's relevance and applicability to other species.*

**RESPONSE:** Synthetic animal sounds improve the generalizability of sound propagation studies by allowing researchers to create a wide range of controlled acoustic variations including combinations of the varying features. It also allows to increase sample sizes for more robust statistical analysis. This flexibility facilitates hypothesis testing about how specific acoustic features influence transmission, ultimately leading to broader conclusions about animal communication in natural environments (e.g. Morton 1975), rather than specific conclusions on single species as it is usually the case with studies using animal sounds.

The synthesized sounds represent a range of animal vocalizations that vary in duration, frequency, and amplitude. We did not try to resemble vocalizations of any specific taxa, but rather to isolate the effects of signal features with great precision. The playback experiments are therefore applicable to many different species of animals and their calls, rather than limited to a single species. We added this paragraph to the main text: **“The use of synthetic sounds in propagation experiments enables the creation of diverse, controlled acoustic variations that isolate specific signal features. This allows researchers to evaluate the association between signal structure and degradation with high precision through robust statistical inference (Morton 1975, Tobias et al. 2010).”**

**References**

Arasco, A. G., Manser, M., Watson, S. K., Kyabulima, S., Radford, A. N., Cant, M. A., & Garcia, M. (2022). Testing the acoustic adaptation hypothesis with vocalizations from three mongoose species. *Animal Behaviour*, *187*, 71-95. doi.org/10.1016/j.anbehav.2022.02.016.

Balsby TJ, Dabelsteen TS, Pedersen SB. 2003. Degradation of whitethroat vocalisations: implications for song flight and communication. Behaviour. 140:695–719. doi:10.1163/156853903322370634.

Barker NK, Dabelsteen TJ, Mennill DJ. 2009. Degradation of male and female rufous-and-white wren songs in a tropical forest: effects of sex, perch height, and habitat. Behaviour. 146:1093–1122. doi:10.1163/156853909X406446.

Benedict, L., Hardt, B., & Dargis, L. (2021). Form and Function Predict Acoustic Transmission Properties of the Songs of Male and Female Canyon Wrens. *Frontiers in Ecology and Evolution*, *9*, 797.

Boycott TJ, Gao J, Gall MD. 2019. Deer browsing alters sound propagation in temperate deciduous forests. PLoS ONE. 14:e0211569. doi:10.1371/journal.pone.0211569.

Brendan A. Graham, Luis Sandoval, Torben Dabelsteen & Daniel J. Mennill (2017) A test of the Acoustic Adaptation Hypothesis in three types of tropical forest: degradation of male and female Rufous-and-white Wren songs, Bioacoustics, 26:1, 37-61.

Brown CH, Gomez R, Waser PM. 1995. Old world monkey vocalizations: adaptation to the local habitat? Anim Behav. 50:945–961. doi:10.1016/0003-3472(95)80096-4.

Brown TJ, Handford P. 1996. Acoustic signal amplitude patterns: a computer simulation investigation of the acoustic adaptation hypothesis. Condor. 98(3):608–623. doi:10.2307/1369573.

Brown TJ, Handford P. 2000. Sound design for vocalizations: quality in the woods, consistency in the fields. Condor. 102(1):91–92. doi:10.1093/condor/102.1.81.

Brown TJ, Handford P. 2003. Why birds sing at dawn: the role of consistent song transmission. Ibis. 145:120–129. doi:10.1046/j.1474-919X.2003.00130.x.

Couldridge VC, Van Staaden MJ. 2004. Habitat-dependent transmission of male advertisement calls in bladder grasshoppers (Orthoptera; Pneumoridae). J Exp Biol. 207:2777–2786. doi:10.1242/jeb.01092.

Date EM, Lemon RE. 1993. Sound transmission: a basis for dialects in birdsong? Behaviour. 124:291–312. doi:10.1163/156853993X00623.

Dabelsteen, T. and N Mathevon (2002). Why do songbirds sing intensively at dawn? *Springer*, *4*(2), 65–72.

Gill SA, Job JR, Myers K, Naghshineh K, Vonhof MJ. 2015. Toward a broader characterization of anthropogenic noise and its effects on wildlife. Behavioral Ecology, *26*(2), 328-333.

Gish SL, Morton ES. 1981. Structural adaptations to local habitat acoustics in carolina wren songs. Ethology. 56:74–84.

Grabarczyk EE, Gill SA. 2020. Anthropogenic noise masking diminishes house wren (*Troglodytes aedon*) song transmission in urban natural areas. Bioacoustics. 29(5):518-32.

Graham BA, Sandoval L, Dabelsteen T, Mennill DJ. 2017. A test of the Acoustic Adaptation Hypothesis in three types of tropical forest: degradation of male and female Rufous-and-white Wren songs. Bioacoustics. 26:37–61. doi:10.1080/09524622.2016.1181574.

Grimes, S. E., Lewis, E. J., Nduwimana, L. A., Yurk, B., & Ronald, K. L. 2024. Urbanization alters the song propagation of two human-commensal songbird species. *The Journal of the Acoustical Society of America*, *155*(4), 2803-2816. doi.org/10.1121/10.0025765.

Hansen IJ, Otter KA, van Oort H, Holschuh CI. 2005. Communication breakdown? Habitat influences on black-capped chickadee dawn choruses. Acta Ethol. 8:111–120. doi:10.1007/s10211-005-0007-x.

Holzmann I, Areta JI. 2019. Reduced geographic variation in roars in different habitats rejects the acoustic adaptation hypothesis in the black-and-gold howler monkey (Alouatta caraya). Ethology. 126:1–12.

Hunter ML, Krebs JR. 1979. Geographical variation in the song of the great tit (Parus major) in relation to ecological factors. J Anim Ecol. 48:759–785. doi:10.2307/4194

Kime NM. 2000. The transmission of advertisement calls in Central American frogs. Behav Ecol. 11:71–83. doi:10.1093/beheco/11.1.71.

Lang F. 2000. Acoustic communication distances of a gomphocerine grasshopper. Bioacoustics. 10:233–258. doi:10.1080/09524622.2000.9753437.

Leader N, Wright J, Yom-Yov Y. 2005. Acoustic properties of two urban song dialects in the orange-tufted sunbird (Nectarinia Osea). Auk. 122:231–245. doi:10.1093/auk/122.1.231.

Llusia D, Gómez M, Penna M, Márquez R. 2013. Call transmission efficiency in native and invasive anurans: competing hypotheses of divergence in acoustic signals. PLoS ONE. 8:1–17.

Marten K, Quine D, Marler P. 1977. Sound transmission and its significance for animal vocalization: II. Tropical Forest. Behav Ecol Sociobiol. 2:271–290. doi:10.1007/BF00299740.

McKenna MF, Shannon G, Fristrup K. 2016. Characterizing anthropogenic noise to improve understanding and management of impacts to wildlife. Endangered Species Research. 31:279-91.

Morton, E. S. 1975. Ecological Sources of Selection on Avian Sounds. *The American Naturalist*, *109*(965), 17–34. https://doi.org/10.1086/282971.

Mouterde SC, Theunissen FE, Elie JE, Vignal C, Mathevon N. 2014. Acoustic communication and sound degradation: how do the individual signatures of male and female zebra finch calls transmit over distance? PLoS ONE. 9:e102842. doi:10.1371/journal.pone.0102842.

Naguib M. 2003. Reverberation of rapid and slow trills: implications for signal adaptations to long-range communication. J Acoust Soc Am. 113:1749–1756. doi:10.1121/1.1539050.

Nemeth E, Brumm H. 2010. Birds and anthropogenic noise: are urban songs adaptive? Am Nat. 176:465–475. doi:10.1086/656275.

Nicholls JA, Goldizen AW. 2006. Habitat type and density influence vocal signal design in Satin Bowerbirds. J Anim Ecol. 75:549–558. doi:10.1111/j.1365-2656.2006.01075.x.

Penna M, Márquez M, Bosch J, Crespo EG. 2006. Nonoptimal propagation of advertisement calls of midwife toads in Iberian habitats. J Acoust Soc Am. 119:1227. doi:10.1121/1.2149769.

Penna M, Solís R. 1998. Frog call intensities and sound propagation in the South American temperate forest region. Behav Ecol Sociobiol. 42:371–381. doi:10.1007/s002650050452.

Phillips JN, Rochefort C, Lipshutz S, Derryberry GE, Luther D, Derryberry EP. 2020. Increased attenuation and reverberation are associated with lower maximum frequencies and narrow bandwidth of bird songs in cities. J Ornithol. 161:593–608. doi:10.1007/s10336-020-01751-2.

Priyadarshani N, Castro I, Marsland S. 2018. The impact of environmental factors in birdsong acquisition using automated recorders. Ecol Evol. 8:5016–5033. doi:10.1002/ece3.3889.

Richards DG, Wiley RH. 1980. Reverberations and amplitude fluctuations in the propagation of sound in a forest: implications for animal communication. Am Nat. 115(3):381–399. doi:10.1086/283568.

Ryan M, Cocroft R, Wilczynski W. 1990. The role of environmental selection in intraspecific divergence of mate recognition signals in the cricket frog. Evolution. 44:1869–1872. doi:10.1111/j.1558-5646.1990.tb05256.x.

Sandoval L, Dabelsteen T, Mennill DJ. 2015. Transmission characteristics of solo songs and duets in a neotropical thicket habitat specialist bird. Bioacoustics. 24:289–306. doi:10.1080/09524622.2015.1076346.

Slabbekoorn H, Yeh P, Hunt K. 2007. Sound transmission and song divergence: a comparison of urban and forest acoustics. Condor. 109:67–78. doi:10.1093/condor/109.1.67.

Slabbekoorn H. 2002. Habitat-dependent song divergence in the little greenbul: an analysis of environmental selection pressures on acoustic signals. Evolution. 56(9):1849–1858. doi:10.1111/ j.0014-3820.2002.tb00199.x.

Sugiura H, Tanaka T, Masataka N. 2006. Sound transmission in the habitats of japanese macaques and its possible effect on population differences in coo calls. Behaviour. 143:993–1012. doi:10.1163/156853906778623617.

Trujillo-Torres, C. M., González-García, F., & MacGregor-Fors, I. (2022). Say what? On the transmission of acoustic signals in a Neotropical green city. *Urban Ecosystems*, *25*(1), 1-8. doi.org/10.1007/s11252-021-01124-4.

Zhao, L., Liu, Q., Qin, Y., Zhai, X., Tu, F., Wang, T., & Wang, J. 2022. Geographical variation of the acoustic signals in the spot‐legged treefrog (Polypedates megacephalus) of Hainan Island. *Integrative Zoology*, *18*(4), 772-781.