WHAT DO WE KNOW ABOUT NOISE IMPACTS ON BIRDS? A SYSTEMATIC REVIEW FOCUSING ON ACOUSTIC METHODOLOGY

Margret S. Engel[a], Adam Scott[b], David C. Waddington[c], William J. Davies[c], Michael D. Wood[a], Robert J. Young[a]

[a] Environmental Research & Innovation Centre, University of Salford, Salford M5 4WT, UK
[b] Horae Lea Consulting Engineers, M2 7FL Manchester, UK
[c] Acoustics Research Centre, University of Salford, Salford M5 4WT, UK

*Corresponding author: m.s.engel@salford.ac.uk

ABSTRACT

In recent years, several studies have shown how anthropogenic noise impacts wildlife. The methodologies used to quantify noise appear to influence data reliability and subsequent findings. Therefore, it is appropriate to review the robustness of acoustic measurement procedures to understand the extent to which studies can be relied upon. In 2023, the UK Acoustics Network produced "Good practice guidelines for long-term ecoacoustic monitoring in the UK". These guidelines will be used for the methodological parametrisation of our investigation. This study quantifies the reliability of existing studies on anthropogenic noise impacts on birds without confounding factors (on an acoustic basis only) through a systematic literature review. The criteria investigated are: equipment used, calibration, frequency range and duration. Additionally, data on how birds are influenced by anthropogenic noise and the indices used were extracted to quantify and qualify noise impact. The screening of manuscripts will follow the Prisma procedure for systematic reviews, and the results will be clustered according to geographical location. This work expects to summarises how anthropogenic noise impacts birds worldwide and how the robustness of the acoustic measurements influences these results.

Keywords: Birds, Anthropogenic noise, Noise impact, Systematic review.

1 INTRODUCTION

In recent years, noisy environments have changed significantly and rapidly, where areas with animal abundance are now quieter or substituted by non-natural sound sources, e.g., electric vehicles, drones, and heat pumps (Waddington et al., 2022).

At the beginning of 2023, the Acoustics Network of the UK, Manchester Metropolitan University and Baker Consultants released a "Good practice guidelines for long-term ecoacoustic monitoring in the UK", which provides recommendations about hardware (equipment and sensors) to use, study protocol (temporal and spatial considerations, audio settings, metadata and data storage) (Metcalf et al., 2023).

Some essential information regarding equipment and settings for long-term ecoacoustic monitoring are stated in the guideline, such as type of equipment, sampling rate, bit depth, duration and periodicity. The guideline focuses on passive acoustic monitoring and recommends using Autonomous Recording Units (ARU), recording bit depth of 16 bits and with a 48kHz sampling rate. The recordings should have 1-minute length files, with one recording every five minutes (1 minute on - 4 minutes off) through the full 24-hour daily cycle. The periodicity should be one week and take place four times per year, one in each season. In terms of acoustic indices were highlighted: Acoustic Complexity Index (ACI), Acoustic Diversity Index (ADI), Acoustic Evenness (AEve), Activity (ACT), Acoustic Space Use (ASU), Background noise (BGN), Bioacoustic Index (Bio), Spectral entropy (Hs), Temporal entropy (Ht), Acoustic entropy (H), Events per second (EVN), Median of the amplitude envelope (M), Normalised Difference Soundscape Index (NDSI), Number of frequency peaks (NP), Signal-to-Noise ratio (SNR), and Soundscape Saturation (Sm) (Metcalf et al., 2023).

Another critical factor in conducting long-term ecoacoustic measurements is the knowledge of the investigated species. There is still a lack of understanding about how animals hear across taxa. Few studies have investigated in-depth the hearing system and audible thresholds across animal families and orders. As an example of auditory system studies of avian species, Dooling and Fay (2000) investigated the function of each part of the avian auditory system. Recently, Peacock et al. (2020) undertook measurements of the avian middle ear and estimated hearing thresholds for the investigated species.
This study is part of a project and will show through a systematic review of 50 peer-reviewed journal papers which noise sources are causing noise impact on avian species and how birds are impacted. It will also analyse which equipment and their settings are adopted to investigate noise impacts on birds.

2 METHODOLOGY

This study analysed through a meta-analysis the impacts caused by anthropogenic noise on birds. As a study case base, we focused on the bird orders considered by Peacock et al. (2020). The literature searches were done through the following search engines such as Google Scholar, Pub-Med, SCOPUS, Taylor and Francis, Springer, Wiley online library, Elsevier, ResearchGate, and Academia. the overall systematic review was conducted following the PRISMA methodology for systematic meta-analysis (Moher et al., 2009). After the search on 701757 works, we focused on 50 journal papers published over the last 44 years, which matched with the keywords “noise impact” + “noise effect” with species “nominal name” + “common name”. The PRISMA flow diagram for paper selection is shown in Figure 1.
After selecting the final 50 papers, which indicated one of the indicated species in the work of Peacock et al. (2020), a noise source, and an impact caused by this noise source, the following parameters were verified with the intention of comparison with the “Good practice guidelines for long-term ecoacoustic monitoring in the UK”, as well as understanding how anthropogenic noise impact assessment is done regarding avian species: ‘order’, ‘species nominal name’, ‘species common name’, ‘location’, ‘noise source’, ‘equipment’, ‘frequency range’, ‘measurement duration’, ‘playback duration’, ‘noise impacts’, ‘indices’ and ‘references’.
The type of physiological, behavioural or communication alteration was observed as noise impacts. Regarding physiological response, it is considered the ‘decrease of survival success’, ‘decrease of reproductive/breeding success’, and ‘reduction of cognitive performance’. For behavioural responses, the classifiers are ‘density/abundance of population and ‘behavioural changes/response’. As communication alteration, the classifiers are ‘vocal plasticity’, ‘repetition of calls’ and ‘masking of calls’.

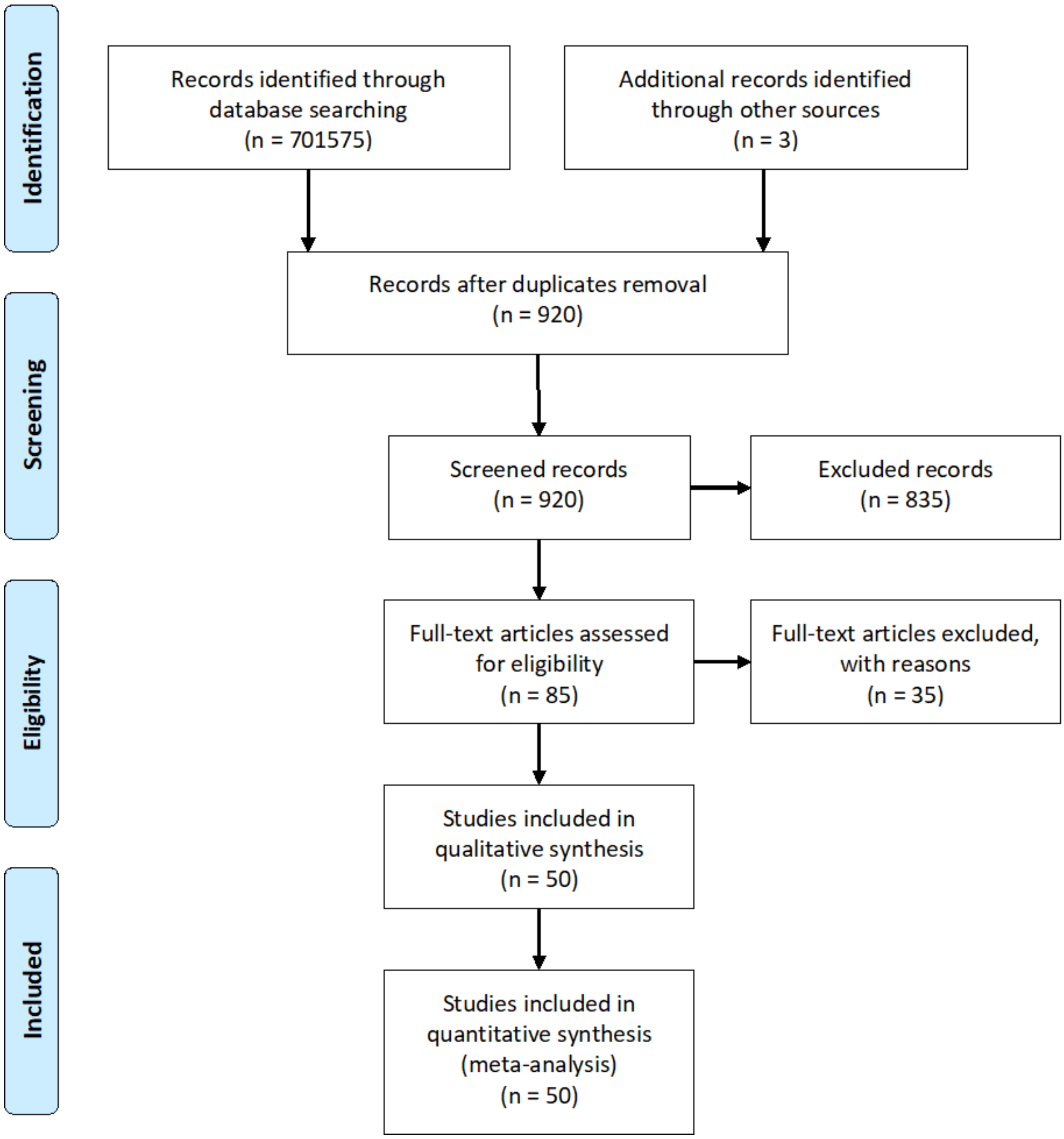

Figure 1. PRISMA flow diagram for anthropogenic noise impact on birds' studies meta-analysis

3 RESULTS

Ten percent of the selected papers included in the meta-analysis, (Table 1) were of reviewed data, from works about the great blue heron (*Ardea herodia*), turkey vulture (*Cathartes aura*), inca tern (*Larosterna inca*), common grackle (*Quiscalus quiscula*), and American crow (*Corvus brachyrhnchos*) (Carlos & McLean, 1996; Madders & Whitfield, 2006; Lima, 2009; Bodenchuk & Bergman, 2020; Bray & Mengak, 2020).

The most observed noise source is from anthropogenic sources (human activity, including mechanical sounds like transport networks and industry) (3), followed by wind farms (1) and background sources (the opposite of foreground, including animal noises or principal sound signals under investigation) (1). These caused impacts such as 'decrease of reproductive/breeding success', 'reduction of cognitive performance' and 'behavioural changes/responses'.

Table 1. Review papers screened in the meta-analysis concerning the impact of noise on birds.

Order	Species Nominal Name	Species Common Name	Noise source	Noise impacts	Reference
Pe	*Ardea herodia*	great blue heron	Anthropogenic	Decrease reproductive/ breeding success	Carlson & McLean, 1996
Ch	*Larosterna inca*	inca tern	Background	Reduction of cognitive performance	Lima, 2009
Ac	*Cathartes aura*	turkey vulture	Wind farm	Behavioural changes/responses	Madders & Whitfield, 2006
Pa	*Quiscalus quiscula*	common grackle	Anthropogenic	Behavioural changes/responses	Bodenchuk and Bergman, 2020
Pa	*Corvus brachyrhnchos*	American crow	Anthropogenic	Behavioural changes/responses	Bray & Mengak, 2020

Legend: Pelecaniformes (Pe) Charadriiformes (Ch), Accipitriformes (Ac), and Passeriformes (Pa).

Another part, 23 papers (46%), contained data collected through observational analysis (Table 2) of the referred avian species, mallard duck - *Anas platyrhynchos* (Gunmarson et al., 2006; Vas et al., 2015), Indian peafowol - *Pavo cristatu*s (Rathaure, 2016), Chilean flamingo - *Phoenicopterus chilensis* (Luque-Fernandez et al., 2021), western grebes - *Aechmophorus occidentalis* (Nuechterlein & Buiton, 2006), American coot – *Fulica americana* (Novic, 2022), great blue heron – *Ardea herodia* (Vos et al., 1985; Butler & Baudin, 1999), white-faced ibis - *Plegadis chihi* (Mueller & Glass, 1989); black-crowned night heron - *Nycticorax nycticorax* (Burger, 1981; Lang et al., 2022), common murre – *Uria aalge* (Rojek et al., 2007), turkey vulture – *Cathartes aura* (Watson & Simpson, 2014; Villegas-Patraca et al., 2014; Pontalti & Barreto, 2022), hairy woodpecker - *Picoides villosus* (Rotternborn, 1999; Harding, 2015); American kestrel - *Falco sparverius* (Rotternborn, 1999; Strasser & Heath, 2011; Strasser & Heath, 2013), common raven - *Corvus corax* (Helldin and Seiler, 2003), American crow - *Corvus brachyrhnchos* (Barron et al., 2012), and Steller's jay - *Cyanocitta stelleri* (Rottenborn, 1999).
The highlighted noise sources in observational studies were: traffic (7), drone/UAV (3), background (2), anthropogenic (2), human (2), aircraft (2), wind farm (2), mining (1), drilling (1), construction (1), and military activity (1). These generated the following impacts: 'behavioural changes/responses' (7), 'density/abundance of population' (6), 'decreased reproductive/breeding success' (6), 'decrease of nesting success' (2), and 'repetition of calls' (1).

Table 2. Screen bird papers for the meta-analysis with observational data collection.

Order	Species Nominal Name	Species Common Name	Noise source	Noise impacts	Reference
An	*Anas platyrhynchos*	mallard	Background	Decrease of density/abundance of population	Gunnarson et al., 2006
			Drone	Behavioural changes/responses	Vas et al., 2015
Ga	*Pavo cristatus*	Indian peafowl	Mining	Behavioural changes/responses	Rathaure, 2016
Ph	*Phoenicopterus chilensis*	Chilean flamingo	UAV	Behavioural changes/responses	Luque-Fernandez et al., 2021
Po	*Aechmophorus occidentalis*	western grebes	Background	Repetition of calls	Nuechterlein & Buiton, 2006
Gr	*Fulica americana*	American coot	Anthropogenic	Decrease reproductive/breeding success	Novcic, 2022
Pe	*Ardea herodia*	great blue heron	Human	Decrease of nesting success	Vos et al., 1985
			Anthropogenic	Decrease reproductive/breeding success	Butler & Baudin, 1999

	Plegadis chihi	white-faced ibis	Drilling	Decrease reproductive/breeding success	Mueller & Glass, 1989
	Nycticorax nycticorax	black-crowned night heron	Aircraft	Decrease of density/abundance of population	Wang et al., 2022
			Human	Decrease reproductive/breeding success	Burger, 1981
Ch	*Uria aalge*	common murre	Aircraft	Decrease reproductive/breeding success	Rojek et al., 2007
Ac	*Cathartes aura*	turkey vulture	Traffic	Decrease of density/abundance of population	Watson and Simpson, 2014
			Wind farm	Behavioural changes/responses	Villegas-Patraca et al., 2014
			UAV	Behavioural changes/responses	Pontalti & Barreto, 2022
Pi	*Picoides villosus*	hairy woodpecker	Construction, traffic, human	Decrease of reproductive/breeding success	Harding, 2015
			Traffic	Decrease of density/abundance of population	Rottenborn, 1999
Fa	*Falco sparverius*	American kestrel	Traffic	Decrease of density/abundance of population	Rottenborn, 1999
			Traffic	Decrease of nesting success	Strasser & Heath, 2011
			Traffic	Decrease of reproductive/breeding success	Strasser & Heath, 2013
Pa	*Corvus corax*	common raven	Traffic	Decrease of density/abundance of population	Helldin and Seiler, 2003
	Corvus brachyrhnchos	American crow	Military activity	Decrease of density/abundance of population	Barron et al., 2012
	Pavo cristatus	Steller's jay	Traffic	Decrease of density/abundance of population	Rottenborn, 1999

Legend: Anseriformes (An), Galliformes (Ga), Phoenicopteriformes (Ph), Podicipediformes (Po), Gruiformes (Gr), Pelecaniformes (Pe) Charadriiformes (Ch), Accipitriformes (Ac), Piciformes (Pi), Falconiformes (Fa), and Passeriformes (Pa), unmanned aerial vehicle (UAV).

The other 22 papers (44%) screened in the meta-analysis covered audio collection and/or audio reproduction (Table 3). Most of the works were from: North America (USA = 10, Canada = 2 and Mexico = 1), followed by Europa (UK = 2, Germany = 2, Iceland = 2, Spain = 1), Africa (Marocco =1), Asia (China = 1) and Oceania (Australia = 1).
Four recent studies, one of which presented results for two bird species, reported the use of autonomous recording units (ARU) as recommended in the best practices guide (Uebel et al., 2021; Daria et al., 2022; Smith et al., 2023; Mullet et al., 2023).
Thirteen studies used sound level meters, nine omnidirectional microphones, seven loudspeakers, five auxiliary software for audio recording and reproduction, four digital recorders, two amplifiers, attenuators, mp3 players, and iPad mini player (one each), one used converter, windshield, wave generator, white noise generator, headphones and directional microphones (one each).
Normally, the recordings used a sampling rate of 44.1 kHz with 16-bit resolution, and the analysed frequency range depended on the species investigated. No study followed the exact sampling rate and resolution recommended in the best practices guidelines (2023).

Only the studies from Conomy et al. (1998) and Goudie & Jones (2004) had long-term measurements, but even so they were deviated from the best practices guideline. There was great variation in the duration of the measurements from 50 milliseconds to 3 ½ hours.

Regarding the adopted acoustic indices, seven studies used SPL(A), four SPL, three LAMax, two Leq, and one Sound Intensity, LAeq, SPL(C) and PSD (each). There was no indication indices to use in the best practices guideline.

The noise sources observed as causes of impact on birds were: traffic (9), background (6), aircraft (2), white noise (2), human, anthropogenic, fireworks, UAS and snowmobile (one each). As a physiological response, there was observed (Table 3) a 'decrease of reproductive/breeding success' (one observation) and a 'reduction of cognitive performance' (five observations). The 'density/abundance of population' (two observations) and 'behavioural changes/response' (11 observations) were highlighted as behavioural responses. As communication alteration 'vocal plasticity' (two observations), 'and 'masking of calls' (two observations).

Table 3 – Screen bird papers for the meta-analysis with audio data collection or reproduction.

OD	Species Nominal Name	Species Common Name	Location	Noise source	Equipment	Freq. range	Measurement duration	Playback duration	Noise impacts	Indices	Reference
An	*Anas platyrhynchos*	mallard	Max Planck Institute for Ornithology Radolfzell, Germany	White noise	omnidirectional microphone digital recorder amplifier loudspeakers sound level meter	44.1 kHz and 16-bit resolution	Integration time of 50 milliseconds	-	Vocal plasticity	SPL	Dorado-Correa et al.,2018
	Aix sponsa	wood duck	North Carolina State University (NCSU) Island (PI) North Carolina, USA	Aircraft	loudspeakers	-	1) Field: 71/day, 24 hours each	30 min	Behavioural changes/ responses	Leq	Conomy et al.,1998
			Fig River, Canada Crooked River, USA	Jet	sound level meter	-	Recorded every 60 s and as mean values every 30 min. Data were logged daily from 0500 h to 2100 h local time; 'passby' event was 64 s or 128 s, depending on whether a 0.5 s or 1.0 s time-history.	-	Behavioural changes/ responses	Lmax	Goudie & Jones, 2004
Ga	*Pavo cristatus*	Indian peafowl	Assiniboine Park Zoo (APZ), Winnipeg, Manitoba, Canada	Background	QTC50 microphone DAQ-6062E PC Card A/D converter Avisoft's Recorder software	Infrasonic (3-20 Hz) Audible (85 Hz-20 kHz)	approximately 30 min		Vocal plasticity	SPL	Freeman & Hare, 2015
Ph	*Phoenicopterus chilensis*	Chilean flamingo	Paignton Zoo, UK Bristol Zoo, UK	Human	recording device Zoom H4nPro omnidirectional XY microphone microphone windshield	44.1 kHz	20-min	-	Behavioural changes/ responses	-	Rose et al., 2021
Cl	*Streptopelia decaocto*	Eurasian collared dove	Rabat, Marocco	Urban background	sound level meter	-	5-min	-	Behavioural changes/ responses	SPLA	Eddajiani et al. 2022

Gr	*Fulica americana*	American coot	Lagoon of Zumpango, Valley of Mexico	Fireworks	sound level meter	31.5 Hz to 8 kHz	recorded noise levels during 10 min at 5 sec intervals		Density/ Abundance of population	SPL	Rodriguez-Casanova et al. 2023
Ch	*Uria aalge*	common murre	Westfjords, Iceland	Traffic, human speech, airplanes	LabView program from a laptop computer connected to a NI PCMCI-6062E analog-digital data acquisition (DAQ) board (National Instruments). HP350D 5 W, 600DC attenuator Type-4189 microphone Type-2250 hand-held analyzer Olympus LS-12 Linear PCM **Autonomous recordings**: dual-channel Song Meter (SM4) acoustic recorder 2 omni-directional A2 microphones	Sampling rate recording of 24 kHz.			Masking of calls		Smith et al. 2023
Ac	*Cathartes aura*	turkey vulture	Erie County Landfill, Milan, Ohio, USA	AUS	HP-882A Digital Sound Level Meter LCD Noise Measuring Instrument Digital Sound Level Meter's LCD screen iPad mini (5th generation).	-	-	-	Behavioural changes/ responses	SI (Sound intensity)	Pfeifer et al. 2021

	Trichoglossus moluccanus	rainbow lorikeet	Brisbane, Australia	Traffic	**Autonomous recordings:** Song Meter 4 acoustic recorder	-	recorded 5 minutes	-	Density/ population abundance	Leq	Uebel et al., 2021
Ps	*Melopsittacus undulatus*	budgerigar	University of Maryland, USA	Traffic	KEF 60S speaker Tucker-Davis Technologies (TDT) waveform generator module (WG1) two TDT programmable filter (PF1) IGNAL digital signal processing software TDT DD1 stereo analogue interface attenuaters (TDT PA4 modules) mixed (TDT SM3 module) Crown D-75 amplifier Larson-Davis System 824 sound level meter	0.9–8kHz	-	The first peck 1–6 s. A peck on the report key within 2 s A peck at the report key during a sham trial was scored as a false alarm, 5-s time-out .	Behavioural changes/ responses	Laeq	Lohr et al., 2002
Pa	*Taeniopygia guttata*	zebra finch	Westfjords, Iceland	Traffic	LabView program from a laptop computer connected to a NI PCMCI-6062E analog-digital data acquisition (DAQ) board (National Instruments).	Sampling rate recording of 24 kHz.	-	-	Behavioural changes/ responses		Smith et al., 2023

					HP350D 5 W, 600DC attenuator Type-4189 microphone Type-2250 hand-held analyzer Olympus LS-12 Linear PCM recorder **a autonomous recording**: dual-channel Song Meter (SM4) acoustic recorder 2 omni-directional A2 microphones						
			Pacific University, USA	Traffic	Cel-246 SPL meter Pignose Legendary 7–100 speaker Sennheiser ME66/K6 microphone Marantz PMD660 digital recorder Adobe AUDITION 3.0	-	-	-	Reduction of cognitive performance	LAFmax	Osbrink et al., 2021
			University of Western Ontario, USA College of William and Mary, Williamsburg, Virginia, USA	Traffic	**Study 1:** iPod touch amplified computer speakers (Logitech S11) Directional microphone (Sennheiser ME67) **Study 2:** speaker (Memorex ML622)	**Study 2:** 0.1–3 kHz pink noise (white noise bandpass filtered at 3 kHz)	-	**Study 1:** over a period of one hour Study 2: for 24 h per day	Reduction of cognitive performance	SPLA	Potvin et al., 2016

					mp3 player (Sandisk Sansa) Digital Sound Level Meter (407727) directional microphone (Sennheiser ME67) Marantz PMD661MKII recorder.						
			Atlantic University, Davie, FL, USA	Anthropogenic	**Stimuli: automated recorders** type 2 digital sound level meter **Playback:** omnidirectional audiospeaker (Sanag model X1)s.	-	-	Each trial of each cognition task lasted 2 min, with 20 min between the trials for each bird.	Reduction of cognitive performance	SPLA	Daria et al., 2022
			University of Exeter, UK	Background	two MP3 players portable speakers	Artificial broadband noise centred around a 450-Hz tone (ranging from 200-Hz to 800-Hz) Female zebra finch contact calls (400 Hz to 500 Hz)	-	-	Behavioural changes/ responses	SPLA	Evans et al., 2018

			Institute for Integrative Bird Behavior Studies, Biology Department, College of William and M, USA	Background	portable speakers digital sound meter	-	-	-	Decrease of reproductive/ breeding success	SPLC	Swanddle and Page, 2007
Pa	*Sturnus vulgaris*	European Starling	Saint Mary's University in Halifax, Nova Scotia, Canada	Traffic	SONY stereo headphones (Model number: MDRE820LP.AE) Hipstreet Prism 4 GM MP3 player (Model Number: HS-636-4GBBL) CheckMate sound pressure level (SPL) meter NexxTech omnidirectional 'Tie Clip' microphone (Model number: 3303013) Zoom H1 Handy recorder	44.1 kHz and with a sample size of 16 bits	**Sound signals:** 3.5 hours in each of the morning and after noon. **Measurements:** 30-second intervals for a total of 3 minutes for each of Nestling: 40 minutes		Reduction of cognitive performance	SPLA SPL	Dharmasiri et al., 2021
			Berlin, Germany	Background	Sound level meter digital tape with a Sony TCD-D3 DAT recorder omnidirectional microphone (Sennheiser Me 62)	1- 8 kHz	10 s		Behavioural changes/ responses	LAMax	Brumm, 2004
	Corvus corax	Common Raven	Iberian Peninsula, Spain	Urban	type II sonometer (LABBOX)	-	5 min	-	Density/ population abundance	SPLA	Patón et al., 2012

			Kenai National Wildlife Refuge, USA	Snowmobile	**autonomous recorders** (Song Meter SM2)	Sampling rate of 22,050 Hz	1 minute every 30 minutes	-	Masking of calls	PSD (Power Spectral Density) SPL	Mullet et al., 2023
	Pica hudsonia	Black-billed Magpie	Guangzhou (Guangdong), Changsha (Hunan), Panjin (Liaoning) Harbin (Heilongjiang) China	Traffic	CEM Sound Level Data-Logger DT-173	-	Every 2 min	-	Behavioural changes/ responses	SPLA	Zhao et al., 2022
	Cyanocitta cristata	Blue Jay	Lincoln, Nebraska, USA	White noise	White noise generator	-	-	50 to 500ms	Behavioural changes/ responses	-	Dukas and Kamil, 2000

Legend: Order (OD), Anseriformes (An), Galliformes (Ga), Phoenicopteriformes (Ph), Columbiformes (Cl), Gruiformes (Gr), Charadriiformes (Ch), Accipitriformes (Ac), Psittaciformes (Ps), and Passeriformes (Pa).

4 CONCLUSIONS

This work aimed to realise a systematic review of 50 peer-reviewed papers based on the species selection of the work of Peacock et al. (2020). It investigated noise sources that have been found to cause noise impacts on avian species and the nature of these impacts. The review also evaluates the acoustic equipment and settings adopted to investigate noise impacts on birds.

Of the papers reviewed, 10% provided impact information from literature reviews, 46% from observational studies and 44% from audio measurements and reproduction. The primary noise sources were classified as 'traffic', 'anthropogenic' (from human and non-human activities), background (human, non-human and natural sounds), and drones/UAV/UAS. Impacts identified included 'behavioural changes/responses', 'decrease of reproductive/breeding success' and 'decrease of density/abundance of population.

Few studies adopted autonomous recording units (ARU); most use sound level meters and recording devices with omnidirectional microphones and recording in a sampling rate of 44.1kHz, while the recommended sampling rate by the "Good practice guidelines for long-term ecoacoustic monitoring in the UK" is 48kHz. Most studies also do not characterise long-term assessments or report using the recommended indicators to assess wildlife. The most used indicators are SPL, SPLA, LAMax and Leq. Some of them, like the A-weighted indicators, are most suitable for human hearing.

Investigations on avian hearing, noise impact assessments and developing suitable indicators and methodologies are the subject of increasing focus for the academic community, industry, environmental regulators and decision-makers. Most of the findings from current studies are observational and potentially influenced by human bias. More objective approaches are needed to advance this broad area of research, integrating multiple disciplines into the development of study methods that allow meaningful determination of noise impacts on birds across a broad range of anthropogenic noise exposure contexts.

5 ACKNOWLEDGEMENTS

This work was funded by the University of Salford (via the 'Habitats project' and by UKRI through the EC REFMAP project).

6 REFERENCES

Waddington, D., Wood, M., Davies, B., & Young, R. (2023, February). Habitats: Managing the ecological impacts of noise on wildlife habitats for sustainable development. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 265, No. 2, pp. 5247-5251). Institute of Noise Control Engineering.

Metcalf, O., Abrahams, C., Ashington, B., Baker, E., Bradfer-Lawrence, T., Browning, E., ... & Smyth, S. (2023). Good practice guidelines for long-term ecoacoustic monitoring in the UK.

Dooling, R. J., & Fay, R. R. (Eds.). (2000). Comparative hearing : Birds and reptiles. Springer.

Peacock. J.. Spellman. G. M.. Greene. N. T.. & Tollin. D. J. (2020). Scaling of the avian middle ear. Hearing Research. 395. 108017.

Moher D, Liberati A, Tetzlaff J, Altman DG. (2009). The PRISMA group. Preferred reporting items for systematic reviews and metaanalyses: the PRISMA statement. PLoS Med;6(7):e1000097. https://doi.org/10.1371/journal.pmed1000097.

Carlson, B. A., & McLean, E. B. (1996). Buffer zones and disturbance types as predictors of fledging success in great blue herons, Ardea herodias. Colonial Waterbirds, 124-127.

Lima, S. L. (2009). Predators and the breeding bird: behavioral and reproductive flexibility under the risk of predation. Biological reviews, 84(3), 485-513.

Madders, M., & Whitfield, D. P. (2006). Upland raptors and the assessment of wind farm impacts. Ibis, 148, 43-56.

Bodenchuk, M. J., & Bergman, D. L. (2020). Grackles.U.S. Department of Agriculture: Animal and Plant Health Inspection Service. Wildife Damage Management Technical Series.

Bray, A., & Mengak, M. T. (2020). Managing Wildlife Damage: American Crow (Corvus brachyrhynchos). WSFNR-20-60A, August 2020.

Gunnarsson, G., Elmberg, J., Sjöberg, K., Pöysä, H., & Nummi, P. (2006). Experimental evidence for density-dependent survival in mallard (Anas platyrhynchos) ducklings. Oecologia, 149, 203-213.

Vas, E., Lescroël, A., Duriez, O., Boguszewski, G., & Grémillet, D. (2015). Approaching birds with drones: first experiments and ethical guidelines. Biology letters, 11(2), 20140754.

Rathoure A.K. (2016). Baseline status of flora and fauna at Thesil Neem Ka Thana District Sikar, Rajasthan and Impact due to Sand / Bajini mining at Kantali river. Oct. Jour. Env. Res. 4(2): 122-145.

Luque-Fernández, C. R., Caballero, K., Pauca, G. A., Villegas, L., Alcelay, I., & Machaca, J. (2021). Unmanned aerial vehicle, and GIS tools, to monitor the reproduction of the flamingo Phoenicopterus chilensis (Aves: Phoenicopteridae). Revista de Biología Tropical, 69(2), 733-742.
Nuechterlein, G. L., & Buitron, D. (2006). Advertising by western grebes: bout-length variability and signal confusion in a multiple-use call. Behaviour, 1547-1562.
Novčić, I. (2022). Behavioural responses of grey herons Ardea cinerea and great egrets Ardea alba to human-caused disturbance. Journal of Vertebrate Biology, 71(22026), 22026-1.
Vos, D. K., Ryder, R. A., & Graul, W. D. (1985). Response of breeding great blue herons to human disturbance in northcentral Colorado. Colonial Waterbirds, 13-22.
Butler, R. W., & Baudin, P. (1999, February). Status and conservation stewardship of the Pacific Great Blue Heron in Canada. In Proc. Conf. on the biology and management of species and habitats at risk. LM Darling (editor). Kamloops, BC (pp. 247-250).
Mueller, A. J., & Glass, P. O. (1988). Disturbance tolerance in a Texas waterbird colony. Colonial Waterbirds, 119-122.
Wang, J., Liu, W., Lin, Q., & Hou, J. (2022). Effects of Flight Disturbance on Bird Communities at Airports: Predatory Birds Rise to the Challenge.
Burger, J. (1981). Effects of human disturbance on colonial species, particularly gulls. Colonial Waterbirds, 28-36.
Rojek, N. A., Parker, M. W., Carter, H. R., & McChesney, G. J. (2007). Aircraft and vessel disturbances to Common Murres Uria aalge at breeding colonies in central California, 1997-1999. Marine Ornithology, 35, 61-69.
Watson, K. A., & Simpson, T. R. (2014). Relationship of vehicular traffic flow and roadside raptor and vulture abundance in South-Central Texas. Texas Ornithological Society, 47, 17-23.
Villegas-Patraca, R., Cabrera-Cruz, S. A., & Herrera-Alsina, L. (2014). Soaring migratory birds avoid wind farm in the Isthmus of Tehuantepec, southern Mexico. PLoS One, 9(3), e92462.
Pontalti, M., & Barreto, A. S. (2022). Use of Unnamed Aerial Vehicles (UAVs) to monitor marine megafauna strandings in beach monitoring programs. Journal of Coastal Conservation, 26(6), 80.
Harding, B. C. An Urban-Wildland Interface in Claremont Canyon, Berkeley, CA: Change in Avian Species Richness Over Time.
Rottenborn, S. C. (1999). Predicting the impacts of urbanization on riparian bird communities. Biological conservation, 88(3), 289-299.
Strasser, E. H., & Heath, J. A. (2013). Reproductive failure of a human-tolerant species, the A merican kestrel, is associated with stress and human disturbance. Journal of Applied Ecology, 50(4), 912-919.
Strasser, E. H., & Heath, J. A. (2011). Effects of developmental conditions on nestling American Kestrel (Falco sparverius) corticosterone concentrations. General and Comparative Endocrinology, 173(1), 164-170.
Helldin, J. O., & Seiler, A. (2003). Effects of roads on the abundance of birds in Swedish forest and farmland. Wildlife Biology, 6, 111-120.
Barron, D. G., Brawn, J. D., Butler, L. K., Romero, L. M., & Weatherhead, P. J. (2012). Effects of military activity on breeding birds. The Journal of Wildlife Management, 76(5), 911-918.
Dorado-Correa, A. M., Zollinger, S. A., & Brumm, H. (2018). Vocal plasticity in mallards: multiple signal changes in noise and the evolution of the Lombard effect in birds. Journal of Avian Biology, 49(1), jav-01564.
Conomy, J. T., Dubovsky, J. A., Collazo, J. A., & Fleming, W. J. (1998). Do black ducks and wood ducks habituate to aircraft disturbance?. The Journal of wildlife management, 1135-1142.
Goudie, R. I., & Jones, I. L. (2004). Dose-response relationships of harlequin duck behaviour to noise from low-level military jet over-flights in central Labrador. Environmental Conservation, 31(4), 289-298.
Freeman, A. R., & Hare, J. F. (2015). Infrasound in mating displays: a peacock's tale. Animal Behaviour, 102, 241-250.
Rose, P., Badman-King, A., Hurn, S., & Rice, T. (2021). Visitor presence and a changing soundscape, alongside environmental parameters, can predict enclosure usage in captive flamingos. Zoo Biology, 40(5), 363-375.
Eddajjani, A., Hanane, S., Kandry, A. E., & Qninba, A. (2022). The association strength of landscape composition and spatial structure governs occurrence of invasive Eurasian collared-doves and expanding woodpigeons in a Mediterranean urban environment. Landscape Ecology, 37(8), 2007-2024.
Rodríguez-Casanova, A. J., Zuria, I., & Hernández-Silva, D. A. (2023). Effect of Firework Festivities on Bird Richness and Abundance at a Natural Protected Wetland in Central Mexico. Waterbirds, 45(3), 277-286.
Smith, A. B., Fischer-McMorrow, I., Kolbeinsson, Y., Rasmussen, M., Shero, M. R., McElwaine, J. N., ... & Mooney, T. A. (2023). Sensitive aerial hearing within a noisy nesting soundscape in a deep-diving seabird, the common murre Uria aalge. Marine Ecology Progress Series, 714, 87-104.
Pfeiffer, M. B., Blackwell, B. F., Seamans, T. W., Buckingham, B. N., Hoblet, J. L., Baumhardt, P. E., ... & Fernández-Juricic, E. (2021). Responses of turkey vultures to unmanned aircraft systems vary by platform. Scientific reports, 11(1), 21655.
Uebel, K., Bonn, A., Marselle, M., Dean, A. J., & Rhodes, J. R. (2021) Park and Landscape Features Influence Urban Park Soundscapes. People & Nature 3(3), Available at SSRN 3969910.
Lohr, B., Wright, T. F., & Dooling, R. J. (2003). Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal. Animal behaviour, 65(4), 763-777.
Osbrink, A., Meatte, M. A., Tran, A., Herranen, K. K., Meek, L., Murakami-Smith, M., ... & Templeton, C. N. (2021). Traffic noise inhibits cognitive performance in a songbird. Proceedings of the Royal Society B, 288(1944), 20202851.
Potvin, D. A., Curcio, M. T., Swaddle, J. P., & MacDougall-Shackleton, S. A. (2016). Experimental exposure to urban and pink noise affects brain development and song learning in zebra finches (Taenopygia guttata). PeerJ, 4, e2287.
Daria, C., Slevin, M. C., & Anderson, R. C. (2022). Effects of anthropogenic noise on cognition, bill color, and growth in the zebra finch (Taeniopygia guttata). acta ethologica, 1-15.
Evans, J. C., Dall, S. R., & Kight, C. R. (2018). Effects of ambient noise on zebra finch vigilance and foraging efficiency. PloS one, 13(12), e0209471.
Swaddle, J. P., & Page, L. C. (2007). High levels of environmental noise erode pair preferences in zebra finches: implications for noise pollution. Animal behaviour, 74(3), 363-368.
Dharmasiri, M. E., Barber, C. A., & Horn, A. G. (2022). Nestling European Starlings (Sturnus vulgaris) adjust their begging calls in noise. Bioacoustics, 31(5), 594-613.

Brumm, H. (2004). The impact of environmental noise on song amplitude in a territorial bird. Journal of animal ecology, 434-440.
Patón, D., Romero, F., Cuenca, J., & Escudero, J. C. (2012). Tolerance to noise in 91 bird species from 27 urban gardens of Iberian Peninsula. Landscape and Urban Planning, 104(1), 1-8.
Mullet, T. C., Morton, J. M., Gage, S. H., & Huettmann, F. (2017). Acoustic footprint of snowmobile noise and natural quiet refugia in an Alaskan wilderness. Natural Areas Journal, 37(3), 332-349.
Zhao, Y., Pagani-Núñez, E., Liu, Y., Xing, X., Zhang, Z., Pan, G., ... & Safran, R. J. (2022). The effect of urbanization and exposure to multiple environmental factors on life-history traits and breeding success of Barn Swallows (Hirundo rustica) across China. Avian Research, 13, 100048.
Dukas, R., & Kamil, A. C. (2000). The cost of limited attention in blue jays. Behavioral Ecology, 11(5), 502-506.