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The effect of sound on bird behavior application in wind farms

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Abstract

Bird strikes with man-made structures and vehicles cost the lives of millions of birds globally. Despite of the perfect visual abilities of most bird species, many of them are sensitive and often collide with operational wind turbines (May, 2015; Aschwanden et al, 2018).

An efficient sound signal which does not invoke stress and is not susceptible to habituation is crucial for the effective application of automated bird deterrent systems. For this reason, we set out to test and calibrate a custom-made sound capable of successfully deterring birds from a given zone. In our study we have investigated the behavioural response of birds when subjected to a specific sound, designed to induce an innate acoustic startle reflex (ASR) but no stress (Walsh et al. 2009, Crowell et al. 2015).

A special ASR signal was previously shown to have permanent effect on bird behaviour without inducing the production of cortisol – the stress hormone (May et al. 2015). In the field of zoology, breath rate is often used as an indicator for acute stress (Carere & Van Oers, 2004). Upon sensing danger, adrenaline is released in the circulatory system. This process initiates the fight-or-flight response. The increase in adrenaline also raises an animal's metabolic rate and therefore its respiratory rate. Hence, a sharp increase in breath rate can be used as a proxy for strong stress stimulus (Torné-Noguera et al. 2014). Throughout the literature, it is widely accepted that the peak auditory sensitivity frequency is around 3 kHz. The ASR sound designed by VOLACOM was created through experimentation and testing, and is based on information from published peer-reviewed studies (Brittan-Powell & Dooling, 2004; Arnett & May, 2016).

We have modified the sound in order to test both the behavioural and physiological responses of great reed warblers (*Acrocephalus arundinaceus*). The behavioural response of each bird was quantified and analyzed using behavioral ethograms and a strength of reaction scale from 1 to 5. This allowed an assessment of the impact of an acoustic signal with a certain frequency of transmission and the level of stress in passerine birds (Okanoya & Dooling, 1987). Our results showed that when compared to another sound of similar amplitude, Volacom's ASR initiated a stronger behavioural response. The sound is designed to raise alertness and signal birds that the protected zone is not safe. The sound utilizes our knowledge of bird auditory sensitivity not only in terms of frequency, but of amplitude, modulation and wavelength (Klump, 2000).

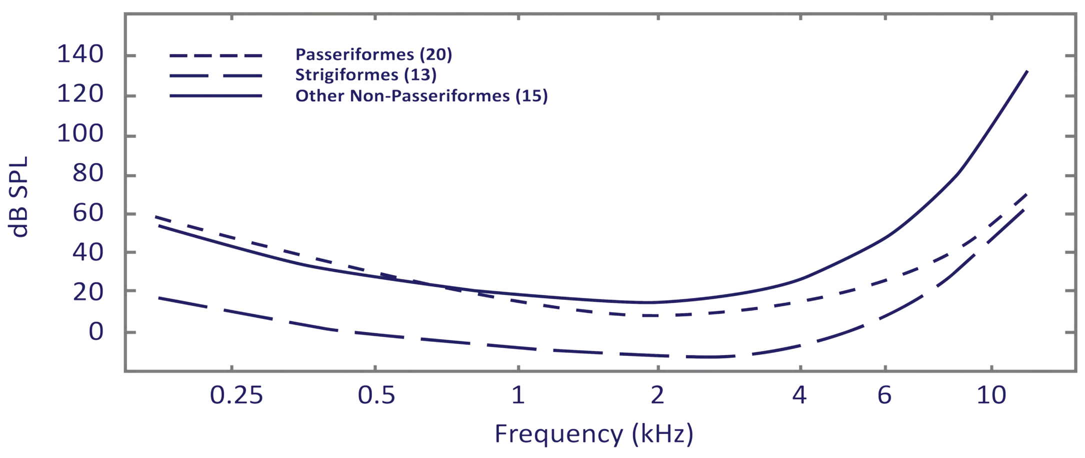


Figure 1. Median audibility curve of birds (adapted from Dooling 2002).

Figure 2. Examples of non passeriform birds often passing through wind farm areas: a) Montagu's harrier *(Circus pygargus)*; b) white storks *(Ciconia ciconia)*; c) ferruginous duck *(Aythya nyroca)*; d) marsh harrier *(Circus aeruginosus)*.

Objectives

The need for an efficient sound signal, which does not invoke stress, and, at the same time, does not lead to habituation in birds, is crucial for the effective application of automated bird deterrent systems. Experimental studies focused on sound efficiency often have a small number of test subjects. Small sample sizes are often subjected to individual behavioural variation in birds. This is why every new study advancing the knowledge in the field of bird strike prevention is of great importance for reducing both the human-associated bird mortality and the impact of collisions on human industry.

Methods

Nineteen adult great reed warblers (*Acrocephalus arundinaceus*), cough with mist nets as juveniles in 2018, were tested between July 6th 2020 – July 11th 2020 at Biological experimental station "Kalimok", Institute of Biodiversity and Ecosystem Research, BAS.

Each bird was exposed to three different treatments after being placed in a new cage (40 x 40 x 60) and left to habituate for 30 minutes:
1) Control test (no signal);
2) Emission of an acoustic signal with a duration of 15 seconds, with a frequency of 2.5 kHz at a sound intensity of 92 dB;
3) Emission of an acoustic signal with a duration of 15 seconds, with a frequency varying between 1 and 3 kHz at a sound intensity of 92 dB (ASR sound, designed by VOLACOM).

The birds' behavior was recorded using cameras.
Behavioural responses in each treatment were assigned to a 5-level rank scale:
1) Looking around - the signal provokes curiosity, without any visible manifestation of a stress response.
2) A sharp change in head direction - the signal causes a sudden change in the orientation of the head and body posture.
3) A single wing flap – in addition to the behavioural responses 1 and 2, the signal provokes a single reflex action, involving wings (flapping).
4) Multiple wing flaps – repeated flapping of the wings, associated with an attempt to maintain the balance of the body after the change of posture in response to the novel sound.
5) Take-off – a jump and vertical take-off powered by uplift from the wings.

The breath rate, an indicator of stress, was measured by the same researcher just before the bird being placed in the test cage and immediately after the sound emission stopped. A McNemar Test of Overall Bias or Direction of Change and Repeated Measures ANOVA were used to test for differences in response intensity and breath rate, respectively, between all treatments.

Figure 3. a) great reed warbler (*Acrocephalus arundinaceus*); b) experimental setup; c) breath rate measurement.

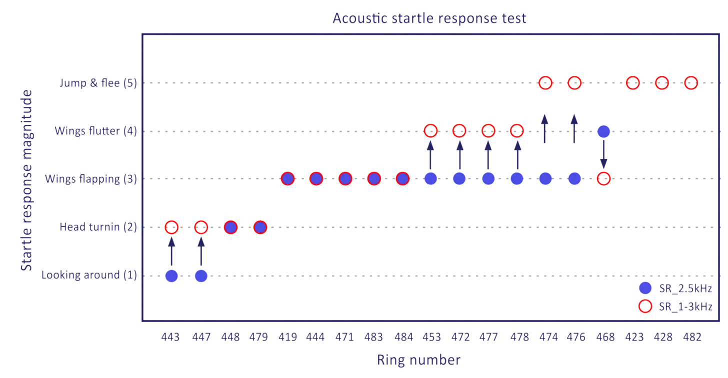
Results

Behavioural response

A significant difference in birds' response to ASR sound compared to the treatment with the other test sound of the same amplitude was found ($p = 0.039$, Table 1, Fig. 4). Prior to sound emission, birds were most often perched (resting) or active (moving between perches). The most common reactions to ASR were 1) a single wing flap (6/19 individuals), multiple flaps (4/19 individuals), and 3) flight initiation (5/19 individuals).

Table 1. Individual rank values of 19 great reed warblers to a 2.5 kHZ sound (Sound 1) and 1-3 kHz sound, designed by Volacom (ASR).

Ring number	Behavioural response	
	Sound 1	ASR
1-555443	1	2
1-555447	1	2
1-555448	2	2
1-555479	2	2
1-555419	3	3
1-555444	3	3
1-555471	3	3
1-555483	3	3
1-555484	3	3
1-555453	3	4
1-555472	3	4
1-555477	3	4
1-555478	3	4
1-555474	3	5
1-555476	3	5
1-555468	4	3
1-555423	5	5
1-555428	5	5
1-555482	5	5
Total	**58**	**67**



Test statistics:
Number of cases when sound 1 emitted a stronger response: 1
Number of cases when the ASR emitted a stronger response: 8
$p = 0.0391$ (exact test)

Figure 4. Graphical representation of the direction of change of the individual rank values of the recorded behavioral categories in each of the two tests with emission of an acoustic signal. Each dot represents the behavioural responses of 19 great reed warblers to a 2.5 kHZ sound (blue) and 1-3 kHz sound, designed by Volacom (ASR; white dots red outline). Blue dots with red outlines show that an individual had the same response to both sounds.

Breath rate

No statistically significant differences in breath rate between the three treatments were found ($F(2, 36) = 0.86$, $p = 0.43$) (Figure 5).

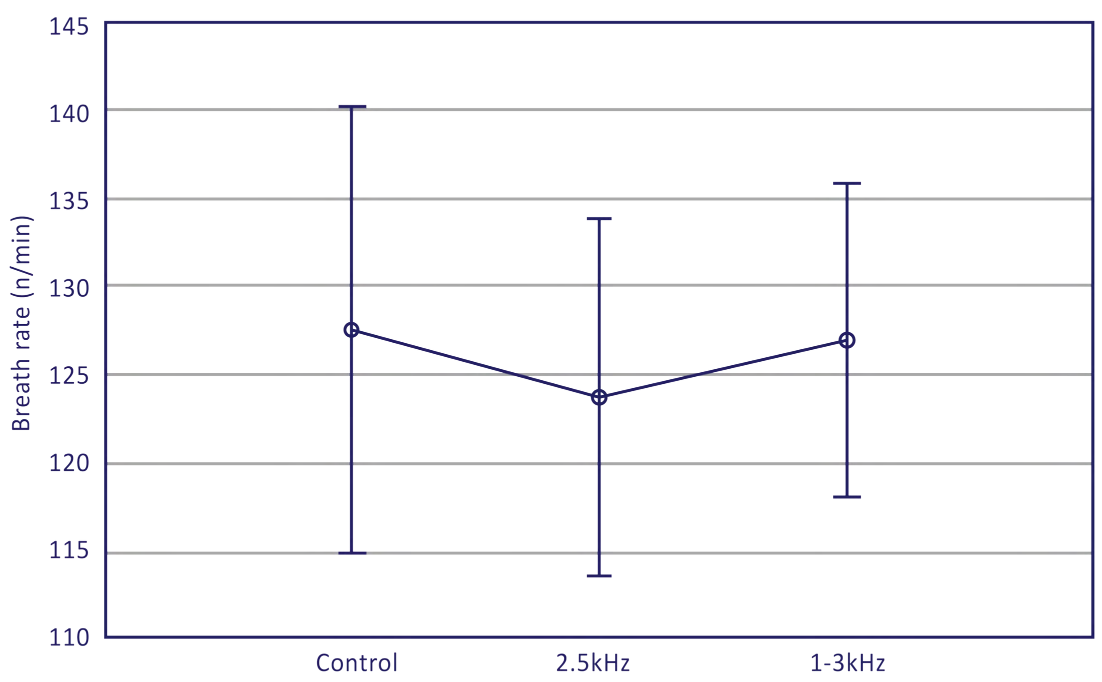


Figure 5. Repeated measures ANOVA of breath rate in 19 adult great reed warblers, conducted after 1) control test (without acoustic signal); 2) test with acoustic signal 2.5 kHz; and 3) test with acoustic signal 1-3 kHz (ASR). Vertical bars denote 0.95 confidence intervals.

Conclusions

New experimental studies on sound efficiency have concluded doubtlessly that certain specially designed sounds invoke acoustic startle reflex (ASR) in birds resulting in immediate physical reaction. Our experiments in a controlled environment concluded 1) 100% bird reaction to ASR sound and 2) 16% better efficiency (stronger response) of ASR sound compared to other sound with the same intensity. Additionally, the ASR sound emission did not raise stress levels, indicated by the breath rate, while at the same time inducing a strong behavioural response.

In conclusion, our study confirmed the ASR sound signal as a bird-friendly and permanent way of deterring birds away from WTGs, thus preserving and supporting biodiversity while reducing loses for the industry.

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