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Tools and Technology

An Automated Device for Provoking and Capturing Wildlife Calls

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ABSTRACT Some animals exhibit call-and-response behaviors that can be exploited to facilitate detection. Traditionally, acoustic surveys that use call-and-respond techniques have required an observer's presence to perform the broadcast, record the response, or both events. This can be labor-intensive and may influence animal behavior and, thus, survey results. We developed an automated acoustic survey device using commercially available hardware (e.g., laptop computer, speaker, microphone) and an author-created (JS) software program ("HOOT") that can be used to survey for any animal that calls. We tested this device to determine 1) deployment longevity, 2) effective sampling area, and 3) ability to detect known packs of gray wolves (*Canis lupus*) in Idaho, USA. Our device was able to broadcast and record twice daily for 6–7 days using the internal computer battery and surveyed an area of 3.3–17.5 km^2 in relatively open habitat depending on the hardware components used. We surveyed for wolves at 2 active rendezvous sites used by closely monitored, radiocollared wolf packs and obtained 4 responses across both packs over 3 days of sampling. We confirmed reproduction in these 2 packs by detecting pup howls aurally from the resulting device recordings. Our device can broadcast and record animal calls and the computer software is freely downloadable. This automated survey device can be used to collect reliable data while reducing the labor costs traditionally associated with acoustic surveys. © 2011 The Wildlife Society.

KEY WORDS acoustic, automated, call, *Canis lupus*, gray wolf, howling, monitoring, northern Rocky Mountains, response, survey.

Detecting wild animals for population monitoring or research can be logistically difficult and expensive. Although a suite of methods may exist for documenting a given species of interest, many methods are labor-intensive and require the presence of ≥1 observer. Technological advances such as remote cameras and sound-recording devices have permitted the use of noninvasive and less labor-intensive means for sampling animal populations (Kays and Slauson 2008; e.g., Cornell Lab of Ornithology). Animals that communicate using calls and responses lend themselves to acoustic sampling because elicited responses can be used to establish presence or abundance (Harrington and Mech 1982, Payne et al. 2003). Acoustic sampling has been used to study bird behavior and estimate population size using devices to broadcast prerecorded songs, with observers then listening for possible responses (Sliwa and Sherry 1992, Clark and Lee 1998, Conway and Gibbs 2005, Molles and Waas 2006, Hahn and Silverman 2007). Additionally, amphibian behavior has been studied using call playbacks (Castellano et al. 2000, Bee and Gerhardt 2002, Marquez et al. 2008). Sampling for animals that call and respond, however, has traditionally required an observer's presence to broadcast the animal's call and record potential responses (Harrington and Mech 1982, Castellano et al. 2000, Robbins and McCreery 2003). Additionally, detection rates can be affected by the observer's hearing and recording equipment capability.

The required presence of an observer increases the cost of acoustic sampling, limits duration and frequency of sampling, and may disturb targeted animals, which can affect response rates. An automated device that would repeatedly broadcast calls and record responses without an observer would minimize these issues with acoustic sampling. Our goal was to create a simple device with few components, which was relatively inexpensive and easily obtained commercially, while remaining light and portable for use in the field.

We built an automated acoustic survey device that broadcasts sounds and records responses using commercially available hardware (Table 1; Fig. 1) and computer software, Program HOOT, created by author JS of the University of Montana's Computer Sciences Department. We tested the performance capability of our acoustic survey device under laboratory and field conditions to determine 1) overall reliability, 2) deployment duration potential, and

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Table 1. Components used to build an automated acoustic survey device. Cost estimates developed in 2010.

Component	Manufacturer and model no.	Cost (US$)	Frequency response
Computer (netbook)[a]	ASUS (Alameda, CA) 1005PE-PU17	364–406	
Speaker(s)	20-W Yamaha (Buena Park, CA) NXU10	99–179	90–20,000 Hz
	40-W Pyle (Brooklyn, NY) PMP-40	23–38	Not specified
Microphone	Samson (Hauppauge, NY) CO3U	129–149	40–18,000 Hz
Software	Univ. of Montana (Missoula, MT) "HOOT"	Free from author[b]	

[a] current available model is 1015 PEM-PU17.
[b] http://www.umt.edu/mcwru/Hoot%20Software.aspx.

3) minimum sampling area. We then evaluated the ability of our device to detect wild animals by deploying it near active rendezvous sites of radiocollared gray wolves (*Canis lupus*) in central Idaho, USA. Wolf-pack rendezvous sites provided an opportunity to test our device because these areas are focal points for the pack while pups are relatively stationary. Additionally, multiple members of the pack are likely to be present over several days of sampling and wolves are highly responsive to howl surveys near rendezvous sites (Harrington and Mech 1982).

STUDY AREA

We tested deployment duration and device reliability in a laboratory setting at average temperatures of 18.0° C and 0.0° C. We tested 20-W speaker broadcast distance outdoors in an approximately 1.4-km linear meadow system (0.35 km wide) near Lolo Pass, Idaho in October, 2010. The meadow contained mixed grass species (Poaceae), abundant desiccated camas (*Camassia quamash*), and patchy stands of willow (*Salix* spp.) in its northern end. Surrounding forest was Englemann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*). Elevation was 1,595 m and air temperature was approximately −4.0° C with no wind or precipitation. Additionally, we tested a 40-W speaker (required 6 D-size batteries) broadcast distance and microphone recording distance in both forested and meadow habitat in central Idaho, July 2011. Forested stands consisted of mature lodgepole pine and were relatively flat. Stands contained periodic patches of burned forest with dense, brushy undergrowth. We used expansive (2.0–4.0-km widest breadth) meadow systems in Bear Valley, Idaho that consisted of mixed grass species, camas, and occasional stands of willow with an elevation of approximately 1,940 m. Air temperature was 10.0° C with little wind and no precipitation. We used our device to survey for gray wolves in 2 packs (Honey Jones and Marble Mountain; Mack et al. 2010) at 2 active rendezvous sites in northern Idaho during August, 2010. Both wolf-pack rendezvous sites were in mature stands of western red cedar (*Thuja plicata*) and Englemann spruce with small pockets of open-canopy wet areas containing grass and sedge (Cyperaceae) species. Elevation at rendezvous sites ranged from 1,075 m to 1,143 m. There was no precipitation during surveys and mean temperature was 15.0° C (range = 14.0–17.0° C).

Figure 1. Photograph of netbook computer, microphone, and 20-W speaker used as an acoustic wildlife survey device in Idaho, USA, 2010.

METHODS

Program HOOT can be downloaded onto any personal computer (http://www.umt.edu/mcwru/Hoot%20Software.aspx; date accessed 9 Aug 2011) with a Windows™ XP, Vista, or 7 operating system (Microsoft Corporation, Redmond, WA). The program includes a user-interface (Fig. 2) that can be used to program the computer to broadcast any sound file, record (.wav format) at times and for durations set by the user, then enter a "sleep" mode between scheduled events to conserve battery power. The computer lid remains shut and the screen does not illuminate during operation. We chose a computer that had a relatively fast wake-up time from "sleep" mode, a low level of power consumption, and the longest lasting lithium-ion battery system available that discharges slowly and would weaken only marginally in cooler temperatures. We used Universal Serial Bus (USB) wired components that could be powered using the computer's battery. The software allows for both "call-and-respond" sampling as well as passive recording surveys.

We measured charge life of the internal battery in our device over multiple trials by programming it to broadcast a human-simulated wolf howl that followed the pattern recommended by Harrington and Mech (1982; 48 s) and record (2 min) twice daily (0600 hours and 1800 hours) at 18.0° C and 0.0° C until power was depleted. Program Hoot installs a power-management regime that causes the computer to hibernate when battery power drops to 5% so that the internal battery is never fully depleted. We also measured battery charge life when not broadcasting but only recording for 2 min twice daily (0600 hours and 1800 hours) at 18.0° C and −4.0° C. Speakers and microphones were weatherproofed by covering them with 2-mil plastic bags and we measured the distance at which our device could detect responses by having a person simulate wolf howls

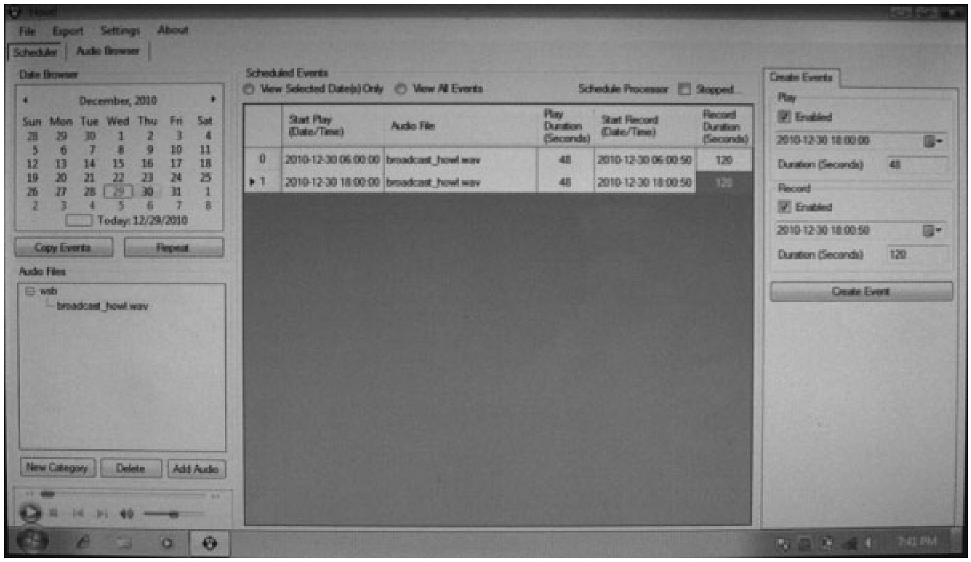

Figure 2. Screenshot of software program HOOT developed to control the acoustic wildlife survey device.

(200–350 Hz; 84 decibels [dB] at 2 m) at 250-m intervals up to 4.0 km. We measured the maximum distance at which our device could broadcast calls effectively using a decibel-meter placed at 2 m and 100 m in front of the unidirectional speaker during the call. At distances >100 m background noise in the environment interfered with the decibel-meter; therefore, we used an observer to listen at 250-m intervals up to 4.0 km and subjectively determined whether calls were audible; in doing this, we assumed human hearing is a minimum measure of hearing ability in animals that communicate with calls and responses. We also performed this same test behind the 20-W speaker.

To test the ability of our device to detect wild animals, we deployed them 0.5–1.0 km from active rendezvous sites of gray wolves that were also monitored using radiotelemetry. We placed the computer portion of the device in a dry bag and affixed the 20-W speaker and microphone to the outside of the bag with duct tape. We used duct tape to seal the areas where cables emerged from the dry bag. We weatherproofed speakers and microphones with 2-mil plastic bags sealed at the opening with duct tape. The device was then hung in a tree 2–3 m off of the ground. We programmed the device to broadcast a simulated wolf howl (48 s) that followed the pattern recommended by Harrington and Mech (1982) at 0200 hours, 0600 hours, and 2200 hours and record for 2 min after each broadcast using the omni-directionally engaged microphone. We retrieved the device after 3 days of sampling at each rendezvous site (Harrington and Mech 1982) and downloaded recordings. We used free software for spectral analysis of the recordings (Raven Lite, Cornell Lab of Ornithology, NY; http://www.birds.cornell.edu/brp/raven/RavenOverview.html). We considered distinct temporally overlapping fundamental frequencies at the beginning of chorus howls to be representative of individual adult wolves howling at slightly different frequencies (Harrington 1989, Harrington and Asa 2003). Because harmonics of adult howls can resemble howls of wolf pups on spectrograms, we used both spectrograms and auditory inspections of recordings to verify pup howls.

RESULTS

Total cost of the components we used to build our device was approximately US$ 480–550, depending on the speaker used, and total weight was 2.7 kg (4.1 kg with 40-W speaker). At room temperature in a laboratory setting our automated device broadcast and recorded twice daily for an average of 6.8 days (range = 6.0–7.5; $n = 8$) using only the internal battery provided with the computer. Potential deployment time was extended to an average of 7.3 days (range = 7.0–7.5; $n = 3$) when only recording passively twice daily. Colder temperatures (0.0° C) decreased deployment duration nominally ($\bar{x} = 6.6$, range = 6.5–7.0 days; $n = 4$) when broadcasting and recording twice daily and when just recording twice daily ($\bar{x} = 7.3$, range = 7.0–7.5 days; $n = 2$). The size of the (.wav) file after recording for 2 min was 10.3 Mb.

At maximum settings, the 20-W speaker broadcast at 76 dB at 2 m, 52 dB at 100 m, and was heard by an observer at a maximum distance of 1.25 km. This distance decreased to 0.75 km when the speaker broadcast in the direction opposite the observer. The estimated broadcast area of the 20-W speaker was 3.3 km^2. At maximum settings, the 40-W speaker broadcast at 90 dB at 2 m, 64 dB at 100 m, and was heard by observers at an average distance of 1.56 km in forest and 3.17 km in open meadow habitat (Fig. 3). The microphone detected and recorded simulated wolf howls at an average distance of 1.63 km (8.3 km^2) in forest and 2.36 km (17.5 km^2) in open meadow habitat (Fig. 3).

We received 1 response over 6 sampling events from the Honey Jones wolf pack and 3 responses over 6 sampling events from the Marble Mountain wolf pack. Initial detections of both adults and pups occurred within 12 hr of deployment, with Marble Mountain responding to the first broadcast event and Honey Jones responding to the

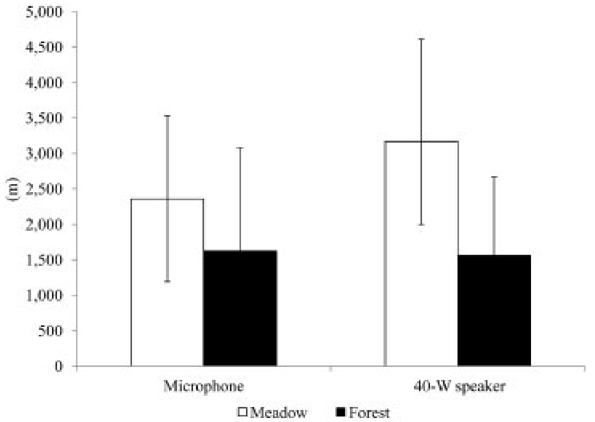

Figure 3. Average distance (m) human-simulated wolf howls (being broadcast by 40-W speaker and acoustic sampling device) were heard by an observer, and average distance (m) human-simulated wolf howls were recorded by acoustic sampling device, in both meadow and forested habitat, central Idaho, USA, in July 2011. Error bars represent standard deviations between the 4 observers.

second broadcast event. Adult responses were visible on spectrograms and ≥ 2 individuals could enumerated at the beginning of chorus howls (3–12 s; Fig. 4a,b). Higher frequency traces (>1.2 kHz) on spectrograms coincided with times where pups could be heard on recordings (16 s, Fig. 4a; 12 s, Fig. 4b).

DISCUSSION

Our device can be used for automated surveys of animals that communicate through calls and can both elicit and record responses from an animal without an observer present, thereby lowering survey costs. Currently there are commercially available devices that record only (e.g., Marice Stith Recording Services, Cortland, NY) and broadcast and record (e.g., SoundID, Maleny, Queensland, Australia). In contrast, our device is designed from simple, easily obtained electronics and the HOOT software is freely downloadable. Similarly, Farrell and Campomizzi (2011) recently introduced a broadcast-only device made from simple, easily obtained components.

The sampling area of our device when broadcasting and recording wolf howls was substantially larger than remote-camera sampling area (≤ 10 m; Swann et al. 2004). We could potentially increase the sampling area of the device by adding louder (though heavier) speakers, or more sensitive and expensive microphones. Because our device had only one speaker, the broadcast of our device was unidirectional; thus, the maximum effective distance was about 50% less in the direction opposite to the direction the speaker was facing. Using a USB-wired 2-directional speaker design (Logitech V20, Fremont, CA) would permit broadcast in 2 directions, but would decrease the area sampled because the broadcast would not be as powerful as the unidirectional 20-W or 40-W speakers we used. Using >1 speaker would increase the sampling area at the expense of increased cost, weight, connection points, and cables. On several occasions, our simulated howls were not audible; however, traces could be seen on spectrograms and this increased the detection ability of the microphone an average of 187 m.

Our device recorded chorus-howl responses from gray wolves, allowing us to document wolf presence as well as reproduction from the resulting recordings. Because howls of adult wolves consist of both low-frequency components and higher frequency harmonics, presence of pups should not be inferred from the presence of higher frequency traces on spectrograms alone. Additionally, because pups are smaller, their howls carry less energy than adults and may not register on a spectrogram. Aural interpretation of recordings by an experienced observer is the most reliable way to detect pup howls on recordings because the human auditory system can readily distinguish the higher harmonics of lower pitched adult howls from the similar but unrelated higher fundamental frequencies of pup howls. Spectrograms can then be used as a secondary record of pup howls. For adult wolves, spectrograms may be used to obtain a minimum count by counting temporally overlapping fundamental frequencies during the first 5–10 s of the response (Harrington 1989). This technique will generally deteriorate at a count of 3–4 adult wolves (>10 s; Harrington 1989) because the wolves that initiated the chorus howl will have begun their second howl, and one can no longer assume each frequency represents a unique individual.

Although we used our automated device to detect gray wolves, its flexibility makes it useful for other species. For example, many amphibian species will cease calling when observers approach breeding ponds; our device could be deployed well before sampling needs to begin and scheduled to begin broadcasting breeding calls and recording at prime calling times, thus negating the need for an observer's presence and potential disturbance. Additionally, our device can be used to inventory multiple calling species simultaneously because it can broadcast calls of different species at appropriate times of day or night, and it can support a mixed schedule of record-only and broadcast-and-record events. Finally, the design of our device was intended to be general and economical, but it can be adapted to a wide variety of applications because Program HOOT is based on the Windows™ operating system, which recognizes most commercially available, plug-in components, thus allowing customization of hardware (e.g., alternative speaker or microphone designs, external battery or hard drive, solar panel, etc.) appropriate to any field application.

Deployment Recommendations

Our automated device can reduce survey costs for wildlife monitoring and research. To make the most of our design, we offer the following recommendations for deployment:

1. Ensure speaker(s) and microphone(s) are free of obstructions.
2. Where feasible, place device in open habitat and face speaker toward open area so sound waves going to and from the device are less attenuated by the environment.

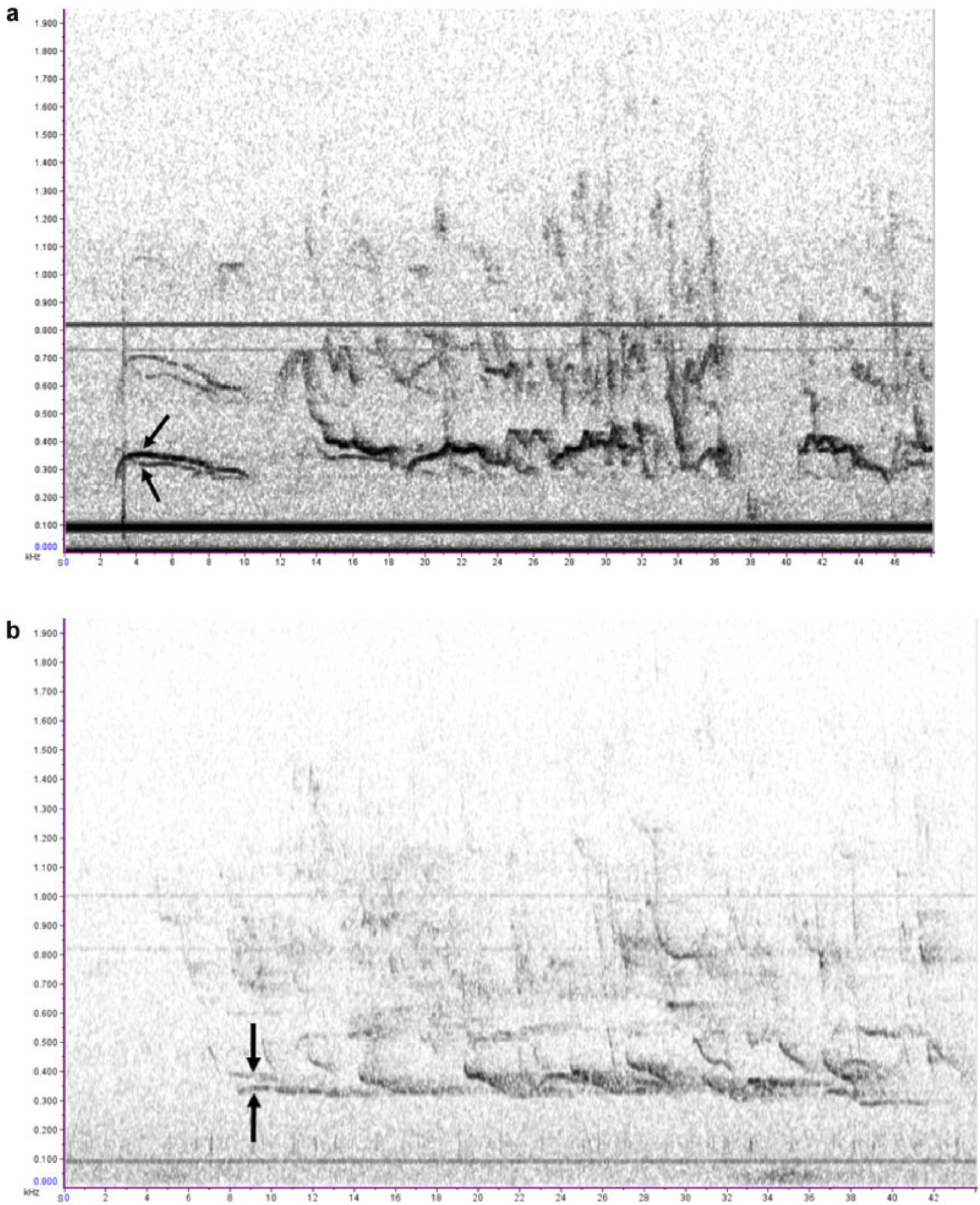

Figure 4. a,b: Spectrograms of wolf pack chorus howls recorded by acoustic wildlife survey device, Idaho, USA, in August 2010. Black arrows indicate individual adult wolves during chorus howl. Spectrograms were generated using RavenLite 1.0 software.

3. If possible, do not sample in typically windy areas or during especially windy times because this will greatly affect performance of both speaker and microphone.
4. Use >1 speaker if direction of responding animals cannot be anticipated.
5. Use sound analysis software and spectrograms to minimize the chance that vocalizations go undetected.
6. If a solar panel or other extended battery system is used to power the device for long sampling periods, periodic data downloads may be necessary to avoid exceeding the capacity of data storage devices.

7. Our design was kept intentionally simple to minimize risk of hardware failures. Addition of external cords, batteries, and other components when expanding upon our design creates added potential for technical difficulties (i.e., loose connections, dead batteries). Modified designs should, therefore, be evaluated under field conditions extensively before deployment to minimize risk of failed survey attempts.
8. Components that use lithium-ion batteries are generally preferable because they perform well at cooler temperatures, have low discharge rates during storage, and do not have to be completely depleted to recharge fully.

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