4pAB4. Impacts of acoustic competition between invasive Cuban treefrogs and native treefrogs in southern Florida

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The natural acoustic environment has undergone substantial changes over the past century due to human activities, creating novel soundscapes. Much research has focused on the impacts of anthropogenic noise on acoustic communication, including noise from transportation, construction, energy development and defense. The impact of acoustic invasive species has been largely overlooked in bioacoustic studies on the behavioral and ecological consequences of noise. We conducted a passive monitoring experiment and a playback experiment to quantify the impact of invasive Cuban treefrog (Osteopilus septentrionalis) acoustic signals on the acoustic environment and on native treefrog acoustic behavior. Preliminary results suggest that the chorusing behavior of the invasive Cuban treefrog altered the ambient soundscape and affected the acoustic behavior of native treefrogs. Collectively, these results suggest that acoustic invasive species are important yet rarely considered sources of noise that can have ecological consequences at scales ranging from the individual to the ecosystem.

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INTRODUCTION

Ambient noise levels are increasing globally. Noise from road, rail and air traffic is audible above baseline noise in most counties in the continental U.S. (Barber et al. 2010). Recent increases in intensity and altered spectral profiles of ambient sound represent novel changes that have occurred rapidly in evolutionary time. Animal communication systems evolved in acoustic environments with vastly different ambient sound profiles and temporal structure. Species that rely on sound for survival and reproduction may not be adapted to these novel acoustic environments and may experience population-level impacts. Therefore, it is important to identify the acoustic changes to natural soundscapes and how species respond to these novel pressures.

To date, nearly all studies of the ecological impacts of novel sound have focused on noise that is a byproduct of human activities. Invasive species are also a source of novel sound, yet their contributions to soundscapes have remained largely overlooked (but see Both & Grant 2012). Invasive species compete with native species for access to resources, including shelter and food. Acoustic space, the multi-dimensional channel through which many species send and receive acoustic signals (Marler 1960), is for many species an equally important resource for finding mates, locating food, maintaining group cohesion, and detecting predators (Bradbury & Vehrencamp 2011), and can be limiting (e.g. Brumm 2006); however, competition for this resource has been largely ignored. Acoustic space represents the features of acoustic signaling available to senders and receivers, including amplitude, frequency, timing and repetition rate (Bradbury & Vehrencamp 2011). The various combinations of these parameters determine species’ acoustic niches (Mossbridge & Thomas 1999, Boquimpani-Freitas et al. 2007). Noise at similar times and frequencies to those used by a species can interfere with its signaling space by reducing its communication range. Competitive exclusion theory predicts that species with identical resource use will do one of two things: (1) species will become competitively excluded from an area, or (2) species will partition their resource use to permit coexistence (Gause 1934). Applied to acoustic competition, species with signals similar to ambient noise may either become excluded from successfully signaling at a particular time or frequency, or may employ plastic or evolved responses to partition their acoustic space to minimize competition (Loftus-Hills & Littlejohn 1992, Taper & Case 1992, Chek et al. 2003, Luther 2009).

The invasion of Cuban treefrogs provides an excellent system in which to study acoustic competition between native and invasive species. The Cuban treefrog is a nonindigenous anuran hylid that was observed in southern Florida by 1931 (Barbour 1931). Presently the Cuban treefrog is patchily distributed throughout most of central and southern Florida (S. Johnson, pers. comm.). In addition to depredating native species (Wyatt & Forys 2004), Cuban treefrogs produce a nocturnal breeding call that has been described as a “grating squawk” (Meshaka 2001), which is similar in frequency to the breeding calls produced by sympatric native treefrogs (J. Tennessen, unpublished data). Acoustic competition between Cuban treefrogs and these native anurans (frogs and toads) may alter or interfere with native anurans’ vocal behavior, potentially resulting in missed mating opportunities. Therefore, our aim was to (1) determine how Cuban treefrogs change the acoustic environment, and (2) test whether native species modify their acoustic behavior to minimize acoustic competition.
FIGURE 1. Spectrogram comparing green treefrog vocal behavior (a) before and (b) during playback of Cuban treefrog chorus. The focal green treefrog’s calls are represented by broadband pulses from 0.5 – 22 kHz, and the Cuban treefrog playback stimulus is the narrowband energy between 0.5 – 4 kHz appearing in panel b. Lighter shades indicate greater acoustic energy at corresponding frequencies. Insect noise is present in both recordings, as energy between 5 – 7.5 kHz.
EXPERIMENTS

Passive Acoustic Monitoring

Twenty-three sites were selected in central and southern Florida that varied in Cuban treefrog density but were otherwise similar in ambient anthropogenic noise. At each site a two-channel acoustic recording system (Song Meter SM2+ Terrestrial Acoustic Package, Wildlife Acoustics, Inc.) sampling at 16,000 Hz, with one to two omnidirectional microphones (20 – 20,000 Hz flat frequency response) was deployed. A weather station (4500NVTAN Portable Weather Station Kit, Kestrel) was mounted in an adjacent tree 1-3 meters above the ground, and simultaneously recorded temperature, wind speed, barometric pressure and relative humidity throughout the duration of the acoustic recordings. Both units recorded overnight, ranging from 1 day to 3 months between July and November 2012.

Acoustic Playback

Acoustic stimuli (Cuban treefrog chorus, white noise, or silence) were broadcast to native treefrogs in uninvaded sites in central Florida, and native treefrogs’ responses were recorded. To broadcast signals, an Apple ipod nano connected to an Anchor Audio AN Mini Speaker (100 – 15,000 Hz flat frequency response) was used. Playback treatments began shortly after sunset, and consisted of a 5-minute baseline period, a 2-minute playback period, and a 3-minute post-stimulus recovery period. A Sennheiser ME-66 shotgun microphone (40 – 20,000 Hz flat frequency response), sampling at 44,100 Hz, connected to a Marantz PMD 661 portable digital recorder was used to record native treefrog acoustic behavior in response to playback stimuli. A weather station and a two-channel acoustic recording system (described above) was mounted 1 meter above the ground near the playback site to continuously record ambient environmental data throughout the playback experiment.

RESULTS

Approximately 579 hours of passive acoustic recordings were obtained. Cuban treefrog calls were detected in 328 hours of these recordings. Ambient sound in sites with and without Cuban treefrogs differed in spectral properties. Native anuran species detected included the barking treefrog (*Hyla gratiosa*), green treefrog (*Hyla cinerea*), pine woods treefrog (*Hyla femoralis*), squirrel treefrog (*Hyla squirella*), little grass frog (*Pseudacris ocularis*), southern cricket frog (*Acris gryllus*), American bullfrog (*Lithobates catesbeianus*), pig frog (*Lithobates grylio*), southern leopard frog (*Lithobates sphenoecephalus*), eastern narrow-mouthed toad (*Gastrophyryne carolinensis*), oak toad (*Anaxyrus quercicus*), and southern toad (*Anaxyrus terrestris*).

Approximately 5 hours of recordings of focal anuran vocal responses to acoustic playback were obtained. Of these recordings, 33 and 284 minutes were from green and pine woods treefrog vocal responses to playback stimuli, respectively. Preliminary results suggest native treefrogs alter calling effort in response to Cuban treefrog breeding choruses (Figure 1).
DISCUSSION

These data suggest invasive species are a source of novel sound that alters ambient acoustic environments and impacts acoustic behavior of native species that rely on sound for survival and reproduction. Specifically, native treefrogs may compete for acoustic space with invasive Cuban treefrogs in Florida. Studies of the impacts of noise on wildlife should consider acoustic invaders as sources of novel sound that may impact populations. Future research should explore how acoustic invasive species alter ambient soundscapes of their invaded habitats, the impacts of these changes on wildlife, and whether native species employ compensation strategies to avoid acoustic competition.

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