iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

SYSTEMATIC REVIEW OF THE IMPACTS OF ANTHROPOGENIC ROAD NOISE, SUBSTRATE-BORNE VIBRATIONS, AND ABIOTIC DRIVERS ON MALE SIGNALING PLASTICITY AND FEMALE MATE SELECTION IN RHINELLA MARINA

Joseph Miguel A. Abringe., Ma. Paula V. Bergado.,
Mary Claire A. Viola., Rehana G. Ungga., and Gecelene C. Estorico

Technological University of the Philippines – Taguig
Civil and Allied Department; Bachelor of Science in Environmental Science De La Salle University – Dasmarinas

ABSTRACT
Anthropogenic noise was a pervasive global pollutant that caused significant environmental change, particularly threatening animals like the invasive cane toad (*Rhinella marina*) that relied on acoustic signaling for successful reproduction. As human infrastructure and transportation networks expanded, rising levels of background noise (60–80 dB) and substrate-borne vibrations increasingly masked advertisement calls used to attract mates and coordinate breeding. This systematic review synthesized experimental evidence to examine the impact of these stressors on bioacoustic parameters and reproductive behaviors. The data indicated that noise exposure reduced male call rates by up to 60%, and substrate-borne vibrations further suppressed calling activity by approximately 50%, significantly impairing communication. Despite this, R. marina exhibited behavioral plasticity, including temporal partitioning and frequency adjustments, and maintained an active communication space of up to 120–130 meters under optimal conditions. Additionally, rapid evolutionary differentiation in call characteristics was observed across populations in as few as 80 generations. These results highlighted the importance of preserving natural soundscapes to ensure effective acoustic communication and sustained reproductive success in amphibian populations.

Keywords
Rhinella marina, cane toad, Anthropogenic noise, Reproductive signaling, Bioacoustic plasticity, Rapid evolution

INTRODUCTION

Anthropogenic disturbance was a primary driver of the global biodiversity crisis, with noise pollution emerging as a pervasive and underestimated global pollutant (Kunc HP, Schmidt R., 2019). While high-intensity disturbances like agricultural expansion and forest fragmentation drove severe conflicts between humans and megafauna such as elephants in South Asia (Baral SC et al.), acoustic interference represented a more subtle but ubiquitous threat to species that relied on bioacoustic signals for survival and reproductive success (Caorsi VZ et al., 2017). Amphibians served as critical model organisms for investigating these impacts, as their reproduction was intrinsically linked to the perception of complex signals, including airborne sounds and substrate-borne vibrations detected by specialized inner ear organs such as the sacculus and papillae (Caorsi V et al., 2019).

In response to these stressors, many species exhibited behavioral plasticity, allowing for immediate adjustments in signal amplitude, frequency, and duration to ensure detection by receivers (Kunc HP, Schmidt R., 2020). For example, anurans employed fine-scale temporal partitioning by placing their advertisement calls within "silent gaps" between loud background noises to maximize their signal-to-noise ratio (Herrick SZ et al., 2018). The invasive cane toad (*Rhinella marina*) provided a unique opportunity to study these dynamics; research indicated that it was a continuous, year-round breeder in tropical regions, meaning its reproductive signaling was perpetually exposed to anthropogenic stressors regardless of the season (Brodie S et al., 2020).

The success of these breeding efforts relied on the active space of the call—the area within which a receiver responded—which could reach up to 120 meters for male receivers, facilitating high recruitment to breeding areas (Muller BJ et al., 2016). Male toads further utilized the "public information" provided by rival choruses to optimize their mating tactics, becoming significantly more active and seven times more likely to initiate amplexus when hearing conspecific signals (Clarke GS et al., 2019). However, this signaling was under constant pressure; while toads showed immediate plastic responses to noise, they also underwent rapid evolutionary differentiation of their advertisement calls in as few as 80 generations (Yasumiba K et al., 2016). This differentiation reflected adaptation to local environmental filters and specific female preferences for acoustic lures that indicated large-

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

bodied males (low frequency) with high energy reserves (high pulse rate) (Muller BJ, Schwarzkopf L., 2017).

OBJECTIVES

The primary objective of this study was to synthesize and evaluate peer-reviewed research to understand how anthropogenic acoustic disturbances and habitat modifications altered the vocal communication systems and demographic persistence of anuran populations. By integrating findings from both airborne traffic noise and substrate-borne vibrations, this research aimed to quantify shifts in essential sexual signaling parameters—such as dominant frequency, call rate, and duration—while examining the efficacy of behavioral plasticity and temporal partitioning in mitigating the effects of acoustic masking. Furthermore, the review sought to assess the broader impacts of land-use changes and multi-sensory pollution on population stability and the reproductive success of both native and invasive species, ultimately informing evidence-based conservation strategies designed to preserve natural soundscapes and protect biodiversity.

Methodology

The study used a systematic methodology structured into three main components: Input, Process, and Output (IPO). The Input stage involved collecting relevant and credible peer-reviewed articles from academic databases focusing on the bioacoustic and reproductive responses of *Rhinella marina* to anthropogenic stressors. The Process stage follows PRISMA 2020 guidelines, which included identifying, screening, selecting, and analyzing eligible studies based on predefined criteria, and organizing data according to key factors like bioacoustic plasticity and evolutionary differentiation. The Output stage provided a synthesized summary of findings, highlighting the major determinants of signaling success and recommended strategies for soundscape preservation to support anuran reproduction

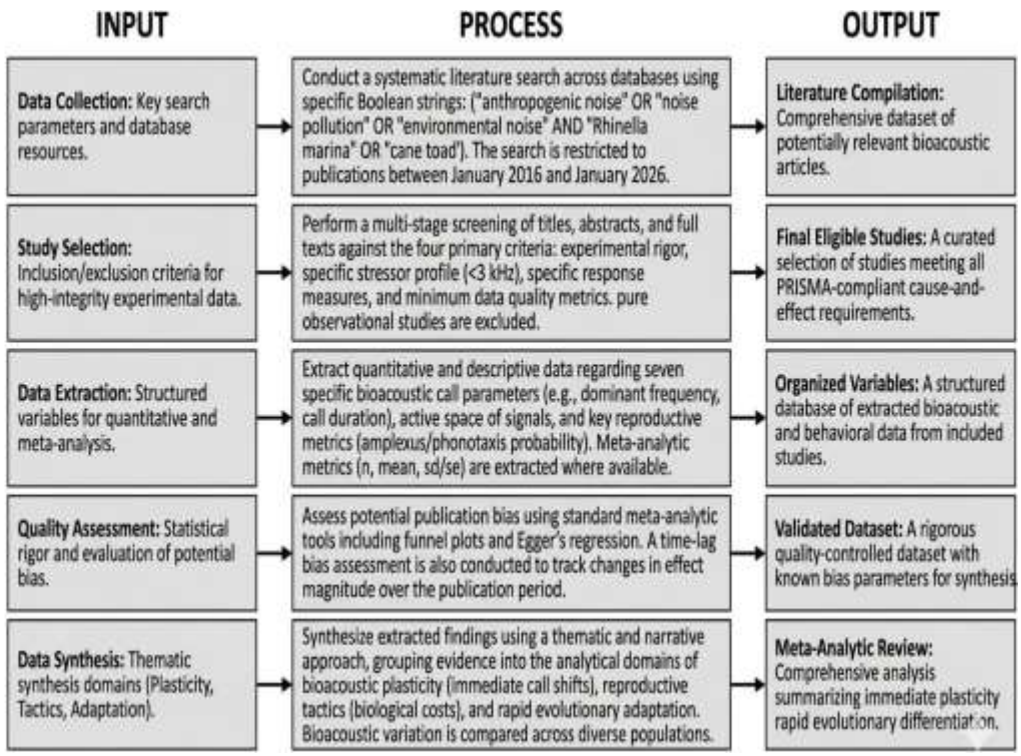

Figure 1. IPO Diagram of Study

Data Collection

Serves as the initial input by establishing the foundational search parameters and identifying the database resources required for a comprehensive literature review. This stage involves the execution of systematic searches using targeted Boolean strings—such as "anthropogenic noise," "noise pollution," or "environmental noise" in conjunction with species-specific terms like "*Rhinella marina*" or "cane toad"—to ensure the collection of relevant bioacoustic articles. By restricting this input to a specific timeframe between January 2016 and January 2026, researchers ensure that the gathered data were both current and aligned with contemporary scientific findings

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

regarding anuran communication.

Study Selection
The Input phase focused on defining strict inclusion and exclusion criteria necessary for identifying high-integrity experimental data. This involves a multi-stage screening process where titles, abstracts, and full texts are measured against four primary benchmarks: experimental rigor, a specific noise stressor profile (focusing on frequencies <3 kHz), clearly defined response measures, and minimum data quality metrics. By intentionally excluding purely observational studies, this input ensures that the final dataset meets PRISMA-compliant requirements for establishing clear cause-and-effect relationships between anthropogenic noise and behavioral changes.

Data Extraction
Acts as the input for identifying and organizing the structured variables essential for a quantitative meta-analysis. Researchers systematically record descriptive and quantitative data regarding seven specific bioacoustic parameters—such as dominant frequency, call duration, and pulse rate—alongside key reproductive metrics like amplexus or phonotaxis probability. This input phase ensures that critical statistical metrics, including sample size (n), mean values, and standard deviation or standard error, were meticulously gathered into a structured database for analysis.

Quality Assessment
The input was dedicated to maintaining statistical rigor through the evaluation of potential bias within the extracted research information. It involves the application of standard meta-analytic tools, including funnel plots and Egger's regression, to detect patterns of publication bias that might otherwise skew the study's conclusions. Furthermore, this stage includes a time-lag bias assessment to track whether the magnitude of observed effects has changed over the publication period, resulting in a validated, quality-controlled dataset ready for synthesis.

Data Synthesis
Serves as the final input component where information was organized into specific thematic synthesis domains. Evidence was grouped into three analytical categories: bioacoustic plasticity (focusing on immediate call shifts), reproductive tactics (examining biological costs and mate choice), and rapid evolutionary adaptation. By utilizing a thematic and narrative approach to compare bioacoustic variations across diverse populations, this input provides the structured framework necessary for a comprehensive meta-analytic review of how anurans adapt to anthropogenic stressors.

RESULTS AND DISCUSSION

The systematic integration of the selected literature reveals that anthropogenic acoustic disturbance operates as a potent environmental filter, inducing significant modifications in the reproductive communication of anurans. By synthesizing data from10 peer-reviewed experimental and meta-analytic studies, this section characterizes the relationship between specific human-induced stressors—including road traffic noise and substrate-borne vibrations—and their functional biological outcomes. These findings highlight a spectrum of responses ranging from immediate behavioral plasticity to rapid evolutionary differentiation in advertisement call parameters. Table 1 provides a comprehensive overview of the research locations, stressor profiles, and the specific ecological and biological impacts documented across the sampled populations.

Table 1. Summary of Bioacoustic Research and Environmental Impacts

Location	Types of Noise	Noise Level	Ecological Impacts	Biological Impacts	Author(s)/Year
Townsville,	Ambient noise	37 dB	46% reduction	Defined	Muller et al.

International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

QLD, Australia	vs. simulated advertisement calls	(ambient); 80 dB (stimulus)	in female active space compared to detection range; limits recruitment over large areas.	auditory thresholds (3.2 dB); gender-specific phonotaxis (Males: 120 m, Females: 70 m).	(2016)
Atlantic Forest, Brazil	Road traffic noise (playback)	65 dB and 75 dB	Road traffic noise operates as a selective anthropogenic environmental filter for species with low-pitch calls, altering community composition.	60% decrease in call rate; downward shift in dominant frequency; spatial displacement from noise.	Caorsi et al. (2017)
Australia (NEQ, SQ, CQ, WA)	Local environmental filters & energy availability	N/A (residual values used)	Accelerates population growth and facilitates invasion via localized adaptation.	Rapid evolutionary differentiation in 7 call parameters (e.g., dominant frequency) over 80 generations. Rapid evolutionary differentiation in 7 call parameters (e.g., dominant frequency) over 80 generations.	Yasumiba et al. (2016)
Orpheus Island & Townsville, Australia	Manipulated call parameters (acoustic lures)	60 dB and 80 dB	Enhances management strategies by improving the removal of reproductive adults (gravid females).	Discrimination and strong preference for loud, low-frequency, high-pulse-rate calls indicating male quality.	Muller & Schwarzkopf (2017)
Lebanon, CT, USA	Heterospecific interference (Bullfrog chorus)	Broad frequency overlap (200–4,000 Hz)	Interspecific reproductive interference; signal jamming reducing fitness of syntopic species.	Fine-scale temporal partitioning; placing calls specifically in "silent gaps" between noises.	Herrick et al. (2018)
Global (Meta-analysis)	Multi-taxa anthropogenic noise	Standardized Effect Sizes (SMDH)	Represents a serious global pollutant requiring robust legal frameworks for ecosystem	Widespread phenotypic plasticity across all taxonomic groups; changes in foraging and communication.	Kunc & Schmidt (2019)

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

			protection.		
Northern Territory, Australia	Conspecific chorus vs. lawnmower engine (control)	60 dB	Disruption of social breeding facilitation and collective mating tactics.	Males become 2x more active and 7x more likely to initiate amplexus when hearing "public information."	Clarke et al. (2019)
Somiedo Natural Park, Spain	Substrate-borne vibrations (traffic/wind turbines)	Peak normalized seismic power	Multimodal disturbance disrupts reproductive success and individual fitness.	50% reduction in male call rate; vibrations perceived as imminent predation danger (sacculus detection).	Caorsi et al. (2019)
Hervey Range, QLD, Australia	Continuous year-round environmental stressors	Minimum temp thresholds (<7.0°C)	Perpetual species exposure to anthropogenic stressors due to lack of a "quiet" non-breeding season.	Documentation of continuous breeding phenology; chorus activity autocorrelated on successive nights.	Brodie et al. (2020)
Global (Meta-analysis)	Standardized signal components (amplitude, freq, rate)	SMDH (Standardized Mean Difference)	Erosion of sexual selection processes and homogenization of reproductive traits in populations.	Species-specific adjustments in signal amplitude (Lombard effect), frequency, duration, and rate.	Kunc & Schmidt (2020)

The provided data highlighted a critical shift in how anthropogenic noise was perceived, moving from a mere "annoyance" to a potent environmental filter that reshapes anuran populations. The synthesis reveals that noise—whether from road traffic, lawnmowers, or substrate-borne vibrations—does not just mask signals; it forces a trade-off between survival and reproduction. For instance, the studies by Caorsi et al. (2017 & 2019) demonstrate that noise can trigger a staggering 60% decrease in call rates or even a 50% reduction when seismic vibrations are involved, as these stressors are often misinterpreted by the sacculus as signs of imminent predation. This suggests that human activity is effectively "shrinking" the available acoustic niche, leading to spatial displacement and altered community compositions where only species with certain vocal traits can persist.

A particularly striking theme within the table is the dichotomy between immediate behavioral plasticity and rapid evolutionary differentiation. On one hand, species exhibit fine-scale temporal partitioning, as seen in Herrick et al. (2018), where frogs strategically place calls within "silent gaps" to avoid signal jamming. On the other hand, the work of Yasumiba et al. (2016) highlights the sheer speed of biological adaptation, documenting significant changes in seven distinct call parameters over just 80 generations. This indicates that while some frogs can pivot their behavior in real-time (the Lombard effect), the pressure from persistent stressors is also driving a permanent homogenization of reproductive traits, potentially eroding the richness of sexual selection as populations converge on "louder" or "higher-frequency" profiles just to be heard.

Finally, the research highlights how these acoustic disturbances disrupt the social and spatial architecture of breeding. The "active communication space" is severely compromised, with Muller et al. (2016) noting gender-specific differences in how far frogs will travel toward a signal under noise pressure. This disruption of "public

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

information"—the collective chorus that signals a safe and viable breeding site—can lead to a breakdown in social breeding facilitation Kunc and Schmidt (2019, 2020) demonstrate that these impacts are no longer localized curiosities but represent a global pollutant. The transition from year-round breeding phenology in Australia to global meta-analyses suggests that without robust legal frameworks to mitigate acoustic interference, the fundamental mechanisms of mate recruitment and population growth in amphibians remain at risk of long-term decline.

Table 2. Analysis of Anthropogenic and Environmental Stressors: Impacts on Anuran Reproductive Anatomy, Communication Signals, and Mating Outcomes

Species	Gender	Causes	Effects	Author(s)/Year
Rhinella marina (Cane toad)	Male and Female	Ambient temperature and rainfall (calling ceases below 7.0°C)	Calling activity is seasonally regulated, with wet-season calling strongly correlated with rainfall and lagged precipitation, while dry-season calling is suppressed below 7.0°C, effectively reducing reproductive activity during unfavorable thermal conditions.	Brodie et al. (2020)
Rhinella marina (Cane toad)	Male	Invasive range expansion (Australian populations; ~80 generations)	Rapid evolutionary divergence in ≥7 acoustic parameters, including dominant frequency and call duration, indicates fast adaptation to local environmental filters, which enhances reproductive success in newly colonized habitats.	Yasumiba et al. (2016)
Rhinella marina (Cane toad)	Male	Conspecific mating chorus (~60 dB) and moving target stimuli	The results demonstrate that chorus signals significantly enhance reproductive success by guiding mate localization. Frogs exposed to these signals moved twice as fast and were seven times more likely to engage in amplexus, resulting	Clarke et al. (2019)

IJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

			in a 5–16× increase in overall mating success compared to those in silence.	
Rhinella marina (Cane toad)	Female (Gravid)	Acoustic lure parameters (low frequency <1 kHz, high pulse rate)	Females exhibit strong phonotactic preference for specific acoustic traits, resulting in up to 91% capture success rate, confirming that signal structure directly determines mate choice and reproductive efficiency.	Muller & Schwarzkopf (2017)
Rhinella marina (Cane toad)	Male & Female	Advertisement call attenuation (signal degradation over distance)	Displays sexually dimorphic active communication space, with males responding up to 120 m and females only up to 70 m (~42% shorter detection range), potentially limiting mating encounters under noisy conditions.	Muller et al. (2016)
Rhinella marina (Cane toad)	Male	Ambient temperature and rainfall	Wet season calling driven by rainfall and lagged rainfall; dry season calling gated by minimum temperatures (ceased below 7.0°C).	Brodie et al. (2020)
Boana leptolineata (fine-lined tree frog)	Male	Traffic noise (65–75 dB, low-frequency overlap <3 kHz)	Noise exposure induces plastic changes in call duration (~±20–40%) and triggers spatial displacement away from noise sources, reducing breeding site occupancy and decreasing opportunities for successful acoustic communication.	Caorsi et al. (2017)
Rana clamitans (Green frog)	Male	Heterospecific bullfrog calls (frequency overlap	Exhibits fine-scale temporal partitioning,	Herrick et al. (2018)

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

		200–4000 Hz)	placing calls within silent intervals between competing signals to maximize signal-to-noise ratio, though this increases energetic cost and limits signaling efficiency.	
Amphibians (General)	Not Specified	Anthropogenic noise pollution (multi-source; varying intensities)	Produces widespread behavioral modifications across taxa, including shifts in amplitude, frequency, and timing of calls, with minimal phylogenetic constraint, indicating a generalized stress response that alters communication systems globally.	Kunc & Schmidt (2019)
Alytes obstetricans (Common midwife toad)	Male	Substrate-borne vibrations (traffic/wind turbines; seismic signals)	Causes approximately 50% reduction in advertisement call rate, with individuals often ceasing calls entirely and abandoning breeding sites, suggesting a predator-avoidance response that significantly reduces reproductive output.	Caorsi et al. (2019)

The provided data highlights a critical vulnerability in anuran (frog and toad) communication: the interference caused by anthropogenic noise. Species such as *Boana bischoffi* and *Alytes obstetricans* demonstrate a significant decline in reproductive effort when exposed to traffic or industrial vibrations, with some reducing their advertisement call rates by over 50%. This "acoustic masking" not only forces individuals to undergo spatial displacement—literally moving away from preferred breeding sites—but also necessitates energy-intensive behavioral adjustments. As described by Kunc & Schmidt (2019), these responses are widespread across various taxonomic groups, suggesting that human-driven noise pollution acts as a universal stressor that disrupts the acoustic niches these amphibians rely on for survival.

Causes

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

The primary cause of communication disruption in anurans was the proliferation of anthropogenic noise pollution, which stems largely from the expansion of transportation networks, industrial infrastructure, and urban development (Kunc and Schmidt 2019). This acoustic interference was particularly problematic because human-generated sounds, such as those from road traffic and wind turbines, are typically concentrated in low-frequency ranges below 3 kHz, creating a direct spectral overlap with the advertisement calls of many frog species (Caorsi et al. 2017). In addition to airborne sound, these activities produce significant substrate-borne vibrations, or seismic noise, which are detected by specialized organs in the amphibian inner ear, such as the sacculus and papillae (Caorsi et al. 2019). For a highly invasive species like the cane toad, these causes of stress are compounded by their unique breeding biology. Unlike many seasonal breeders, *Rhinella marina* in tropical savanna regions was a continuous breeder, meaning its reproductive signaling was perpetually exposed to these human-induced stressors throughout every month of the year without any period of acoustic reprieve (Brodie et al. 2020). This constant exposure ensures that the selective pressures of noise pollution are an unrelenting force on the species' reproductive success and long-term survival (Kunc and Schmidt 2020).

Effects

The effects of these anthropogenic stressors manifest as a combination of immediate behavioral shifts and permanent evolutionary changes that redefine the reproductive landscape. One of the most significant immediate effects was the dramatic reduction of the active communication space, which represents the physical area where a receiver can detect and react to a signal (Muller et al. 2016). While male toads can normally respond to calls from up to 120 meters away, acoustic masking can effectively shrink the recruitment range for females to approximately 70 meters, limiting the number of potential mates that can coordinate at a breeding site (Muller et al. 2016). Behaviorally, toads exhibit high phenotypic plasticity to navigate this interference, often reducing their advertisement call rates by 50 to 60 percent or engaging in spatial displacement by moving away from the noise source (Caorsi et al. 2017, 2019). Individuals also employ fine-scale temporal partitioning by inserting their vocalizations into silent gaps or acoustic windows between loud background noises to maximize their signal-to-noise ratio (Herrick et al. 2018).

On a social level, noise leads to a breakdown in the use of public information, as males hearing a chorus are normally seven times more likely to initiate a mating embrace; however, masking these signals prevents this social coordination (Clarke et al. 2019). Furthermore, noise-induced degradation of signal quality impairs the ability of gravid females to select high-quality mates based on acoustic cues that indicate large body size or high energy reserves (Muller and Schwarzkopf 2017). Perhaps most notably, these persistent pressures have driven rapid evolutionary differentiation in as few as 80 generations, resulting in fixed changes to call structures like dominant frequency and pulse length across the species' invasive range (Yasumiba et al. 2016). These findings highlight that the preservation of natural soundscapes was essential as the protection of physical habitats for maintaining the selective processes that drive successful reproduction and population persistence (Kunc and Schmidt 2019, 2020).

CONCLUSION AND RECOMMENDATION

Conclusion

This systematic review confirms that anthropogenic noise and substrate-borne vibrations act as formidable environmental filters that reshape the reproductive landscape for *Rhinella marina.* The evidence demonstrates that this invasive species maintains communication efficiency in human-modified soundscapes through two primary mechanisms: immediate bioacoustic plasticity and rapid evolutionary adaptation.

In the short term, cane toads exhibit significant behavioral flexibility by adjusting call frequency, duration, and timing to navigate "silent windows" and avoid acoustic masking. Over longer temporal scales, populations have demonstrated the ability to undergo genetic differentiation of advertisement calls in as few as 80 generations, reflecting a specialized capacity for rapid evolution in response to local energy availability and noise stressors.

Furthermore, the remarkably large "active space" of R. marina calls—reaching up to 130 meters—and the behavioral exploitation of conspecific choruses as "public information" provide a mechanical explanation for the species' continued invasion success despite rising levels of global noise pollution. Ultimately, the persistence of R. marina suggests that successful invasive species are those capable of integrating multi-modal sensory adjustments to overcome the biological costs of anthropogenic disturbance.

Recommendations

To advance the management of invasive amphibians and the preservation of natural soundscapes, the following actions are recommended:

iJETRM
International Journal of Engineering Technology Research & Management (IJETRM)
Journal Article
https://ijetrm.com/issue/

To strengthen the conservation of anuran species, future research and policy must transition toward a more holistic, receiver-oriented approach that prioritizes the sensory experience of the female. This involves shifting the focus from male "emitters" to how noise-induced stress alters female mate-choice thresholds and the accuracy of identifying high-quality mates, as well as utilizing identified female preferences for low-frequency, high-pulse-rate signals to engineer high-efficiency acoustic lures. Management strategies should also integrate multi-modal monitoring to account for substrate-borne vibrations from industrial infrastructure—such as wind turbines—which have been shown to significantly inhibit calling activity. By implementing acoustic buffer zones or nighttime traffic restrictions near critical wetlands, policymakers can preserve the integrity of bioacoustic networks that are often disrupted by anthropogenic noise. Ultimately, these efforts should be supported by longitudinal habitat comparisons across urban-to-rural gradients to distinguish between temporary behavioral shifts and permanent evolutionary traits in urbanized wildlife.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to the Research Center for the Natural and Applied Sciences University of Santo Tomas for allowing us to conduct experiments, use the facilities and providing us the chemicals and apparatus needed in our experiments, to the Administrators of the Chemical Engineering Department, and to the Chemical Engineering Laboratory staffs, for lending us the apparatus and chemicals that we needed to conduct our experiments.

REFERENCES

1) Brodie, S., Yasumiba, K., Towsey, M., Roe, P., & Schwarzkopf, L. (2020). Acoustic monitoring reveals year-round calling by invasive toads in tropical Australia. Bioacoustics.
2) Caorsi, V., Guerra, V., Furtado, R., Llusia, D., Miron, L. R., Borges-Martins, M., Both, C., Narins, P. M., Meenderink, S.
3) W. F., & Márquez, R. (2019). Anthropogenic substrate-borne vibrations impact anuran calling. Scientific Reports, 9, Article 19152.
4) Caorsi, V. Z., Both, C., Cechin, S., Antunes, R., & Borges-Martins, M. (2017). Effects of traffic noise on the calling behavior of two Neotropical hylid frogs. PLoS ONE, 12(8), Article e0183342.
5) Clarke, G. S., Shine, R., & Phillips, B. L. (2019). Whispers on the wind: Male cane toads modify mate searching and amplexus tactics based on calls from other males. Animal Behaviour, 153, 131–136.
6) Herrick, S. Z., Wells, K. D., Farkas, T. E., & Schultz, E. T. (2018). Noisy neighbors: Acoustic interference and vocal interactions between two syntopic species of ranid frogs, *Rana clamitans* and *Rana catesbeiana*. Journal of Herpetology, 52(2), 176–184.
7) Kunc, H. P., & Schmidt, R. (2019). The effects of anthropogenic noise on animals: A meta-analysis. Biology Letters, 15(11), Article 20190649.
8) Kunc, H. P., & Schmidt, R. (2020). Species sensitivities to a global pollutant: A meta-analysis on acoustic signals in response to anthropogenic noise. Global Change Biology.
9) Muller, B. J., Pike, D. A., & Schwarzkopf, L. (2016). Defining the active space of cane toad (*Rhinella marina*) advertisement calls: Males respond from further than females. Behaviour, 153(15), 1951–1969.
10) Muller, B. J., & Schwarzkopf, L. (2017). Success of capture of toads improved by manipulating acoustic characteristics of lures. Pest Management Science, 73(11), 2372–2378.
11) Yasumiba, K., Duffy, R. L., Parsons, S. A., Alford, R. A., & Schwarzkopf, L. (2016). Rapid differentiation of sexual signals in invasive toads: Call variation among populations. Scientific Reports, 6, Article 28158.