Cost of Advertising: Long-Tailed Weasels (*Mustela frenata*) as Potential Acoustically-Orienting Predators of Neotropical Singing Mice (*Scotinomys*)

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COST OF ADVERTISING: LONG-TAILED WEASELS (*MUSTELA FRENATA*) AS POTENTIAL ACOUSTICALLY-ORIENTING PREDATORS OF NEOTROPICAL SINGING MICE (*SCOTINOMYS*)

Bret Pasch* and Jorge L. Pino

Department of Biology, University of Florida, Gainesville, FL 32611 (BP, JLP)
Florida Museum of Natural History, University of Florida, Gainesville, FL 32611 (BP, JLP)
Present address of BP: Section of Integrative Biology, University of Texas at Austin, Austin, TX 78712
Correspondent: bpasch@utexas.edu

Abstract—We report on three interactions between long-tailed weasels (*Mustela frenata*) and Neotropical singing mice (*Scotinomys*). Our observations suggest that weasels are potential acoustically-orienting predators of singing mice. We speculate that differences in pressure from eavesdropping by weasels may contribute to differences in length and complexity of songs between sister species of Neotropical singing mice.

Resumen—Reportamos tres interacciones entre la comadreja de cola larga (*Mustela frenata*) y los ratones cantores neotropicales (*Scotinomys*). Nuestras observaciones sugieren que las comadrejas potencialmente escuchan las vocalizaciones y así favorecen la depredación de estos ratones. Especulamos que diferencias en la presión de escuchar subrepticiamente por comadrejas pueden contribuir a las diferencias en duración y complejidad de la vocalización entre especies hermanas de los ratones cantores neotropicales.

Conspicuous displays are hallmark features of male sexual behavior in a variety of species (Bradbury and Vehrencamp, 1998). Sexual selection for flashy signals is often opposed by pressure to avoid detection by predators and parasites (Andersson, 1994). Interceptive eavesdropping, or the exploitation of signals by unintended receivers, is a major factor shaping signaling behavior across numerous sensory modalities, including vision, olfaction, and audition (Zuk and Kolluru, 1998).

Airborne sound signals that propagate over long distances are especially subject to eavesdropping. Acoustic orientation of signals from prey by predators has been described in numerous taxa, including insects and anurans. For example, songs of the decorated cricket

(*Gryllodes supplicans*) attract Mediterranean house geckos (*Hemidactylus tursicus*; Sakaluk and Belwood, 1984), and foliage-gleaning bats (Phyllostomidae) exploit calls of forest-dwelling katydids (Tettigoniidae; Belwood and Morris, 1987). Similarly, the fringe-lipped bat (*Trachops cirrhosus*) locates túngara frogs (*Physalaemus pustulosus*) through their mating calls (Tuttle and Ryan, 1981). Adaptations to evade acoustic eavesdropping include reductions in calling activity (Spangler, 1984) and signal complexity (Rand and Ryan, 1982; Ryan et al., 1982) and shifts in frequencies of signals (Morris et al., 1994) or communicative modalities (Henry, 1994).

Neotropical singing mice (*Scotinomys*) are diurnal, insectivorous rodents distributed throughout the highlands of Central America. Alston's singing mouse (*S. teguina*) is a widespread species inhabiting mid-altitude to high-altitude forests from southeastern México to western Panamá (1,000–2,900 m), whereas the Chiriquí singing mouse (*S. xerampelinus*) is restricted to the highest forested summits and páramo of Costa Rica and Panamá (2,200–3,300 m; Hooper and Carleton, 1976; Wilson and Reeder, 2005). The two ecologically similar congeners occupy parapatric distributions in the Cordillera de Talamanca and Cordillera Central, where the upper distribution of *S. teguina* contacts the lower distribution of *S. xerampelinus* between 2,200–2,900 m (Enders and Pearson, 1939; Hooper, 1972; Hooper and Carleton, 1976). Males of both species commonly produce a series of rapidly repeated notes termed trills (Miller and Engstrom, 2007; Campbell et al., 2010) that are used to attract mates and in aggression between males (Pasch et al., 2011*a*, 2011*b*, 2013). Trills contain elements that facilitate localization, including multiple notes of short duration, fast rise and fall times, and a broad range of frequencies (Marler, 1955). Relative to *S. xerampelinus*, *S. teguina* vocalizations are characterized by a greater increase in amplitude and duration of notes over the course of a longer trill with more notes (Campbell et al., 2010; Pasch et al., 2013). Similarly, *S. teguina* has higher rates of songs than does *S. xerampelinus* (Miller and Engstrom, 2007). There is no documented predator for either species. Thus, chance observations of predation or related interactions are critical to identifying selection pressures faced by prey species.

As part of a larger expedition investigating the biology of acoustic communication in Neotropical singing mice, we documented three observations of long-tailed weasels (*Mustela frenata costaricensis*: Goldman, 1912) associating with *Scotinomys*. On 27 May 2007 at 0930 h, BP was checking a trapline for *S. xerampelinus* at 2,700 m on Volcán Barú, Chiriquí Province, Panamá, when he observed a weasel chasing a mouse through the forest. The mouse was hopping erratically and dove beneath a shrub-covered log. The weasel abruptly fled upon hearing the observer. Shrews (*Cryptotis*) are the only other active small mammal during this time but have distinctively

blackish dorsal pelage (Pine et al., 2002) compared to the brownish coloration of >50 *S. xerampelinus* captured at this site. Similarly, shrews (*n* = 9) did not hop when fleeing upon release from live-traps, increasing the likelihood of correct identification.

On 1 July 2007 at 0800 h, BP was checking a trapline for *S. xerampelinus* at 3,300 m on Cerro de la Muerte, San José Province, Costa Rica, and observed a weasel sniffing and clawing at a live-trap containing a male *S. xerampelinus*. The weasel fled upon hearing the observer.

Finally, on 4 August 2008 at 0745 h, BP was seated quietly conducting playback-experiments at 2,900 m on Volcán Irazú, Cartago Province, Costa Rica. Upon broadcast of a song by *S. xerampelinus*, a weasel was observed emerging from the forest edge and orienting toward the speaker. The stimulus was rebroadcast, and the weasel continued toward the speaker until the animal saw the observer and rapidly fled back into the forest.

Small mammals typically comprise a large proportion of the diet of long-tailed weasels in temperate regions (Sheffield and Thomas, 1997). Although not well studied, tropical *M. frenata* is thought to feed on small mammals and rabbits and on birds and their eggs (Emmons and Feer, 1990). In their tabulation of potential vertebrate predators sympatric with singing mice in Costa Rica, Hooper and Carleton (1976) list weasels for *S. xerampelinus* only. In all cases, our observations occurred at altitudes where *S. xerampelinus* occurs in allopatry (Volcán Barú and Cerro de la Muerte) or where the two species meet (Volcán Irazú). Weasels are thought to be more abundant at higher altitudes in the tropics (Emmons and Feer, 1997) and, thus, may place greater predatory pressure on *S. xerampelinus*.

Weasels and other mustelids are known to hunt primarily by sound (Gillingham, 1986; King and Powell, 2007). Narrow interaural distances permit detection of high frequencies that characterize vocalization by rodents (Hefner and Hefner, 1985; Powell and Zielinkski, 1989). Behavioral audiograms of least weasels (*M. nivalis*) suggest that their hearing extends to 61 kHz but is most sensitive between 1–16 kHz (Hefner and Hefner, 1985). Interaural distances of *M. frenata* are similar to that of *M. nivalis*, indicating they have similar hearing sensitivities (Hall, 1951; Sheffield and King, 1994; Sheffield and Thomas, 1997). Thus, long-tailed weasels are likely able to detect vocalizations of Neotropical singing mice and may be more sensitive to trills from *S. xerampelinus* that have lower dominant frequencies (16–20 kHz) compared to those from *S. teguina* (22–26 kHz; Miller and Engstrom, 2007; Campbell et al., 2010).

As noted, *S. xerampelinus* has shorter, less complex vocalizations compared to *S. teguina*. Geographic analyses suggest that acoustic divergence between species is significantly greater than that predicted from variation within either species (Campbell et al., 2010), indicating that selection plays an important role in shaping species

differences in trills. Alternative (but not exclusive) hypotheses owing to such differences include acoustic adaptation to different environments, divergent regimes of sexual selection, and divergent pressures of predation. For example, signal adaptation for efficient transmission through structurally distinct habitats may contribute to acoustic divergence as occurs in many birds (Morton, 1975; Boncoraglio and Saino, 2007; Tobias et al., 2010). However, vocalizations by *S. teguina* do not appear to differ between fallow pastures with dense understory and primary forest with relatively sparse ground cover, and both species are captured in primary forest (Campbell et al., 2010).

Alternatively, interspecific differences in altitudinal distribution are consistent with ecological potential for weaker sexual selection in *S. xerampelinus*. Some birds from higher elevations with less resources sing shorter songs with fewer notes due to less intense sexual selection (and greater monogamy) relative to their congeners at low altitudes (Badyaev and Ghalambor, 2001; Snell-Rood and Badyaev, 2008). However, our radiotelemetric studies indicate that *S. xerampelinus* exhibit spacing patterns typical of promiscuous rodents (Blondel et al., 2009). Current research efforts aim to better characterize the mating systems of both species in the field.

Lastly, the simplified trill of *S. xerampelinus* may provide a less localizable stimulus to minimize acoustic eavesdropping (Marler, 1955). Understanding whether such acoustic simplification is predator-mediated will require future studies that investigate the importance of *Scotinomys* in the diet of neotropical weasels, assess their response to vocalizations of mice via playback-experiments, and quantify the sensitivity of their hearing.

Our observations suggest that long-tailed weasels prey and potentially eavesdrop on Chiriqui singing mice (*S. xerampelinus*). Interspecific differences in length and complexity of trills may be due in part to divergent pressures of eavesdropping at different altitudes. Given the importance of acoustic communication in mediating social interactions in a variety of rodents (Miller and Engstrom, 2007, 2010; Kalcounis-Rueppell et al., 2010; Musolf et al., 2010; Pasch et al., 2011*a*, 2013), our observations bring attention to the role of predators in shaping their vocal behavior.

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JUVENILE RAZORBACK SUCKERS DOCUMENTED IN WETLANDS IN THE GREEN RIVER, UTAH

P. AARON WEBBER

Colorado River Fish Project, United States Fish and Wildlife Service, 1380 South 2350 West, Vernal, UT 84078
Correspondent: aaron_webber@fws.gov

ABSTRACT—The razorback sucker (Xyrauchen texanus) is a federally-endangered, large-bodied catostomid found in the Green River, Utah, a tributary to the Colorado River. Although populations of adults in the Green River appear to be increasing through stocking, recruitment has been minimal or nonexistent for several decades. Flows in the Green River in 2011 were the fourth highest in 66 years of records. These environmental conditions were favorable for survival of young-of-year razorback suckers. The purpose of this study was to determine if wild young-of-year razorback suckers occurred during fall 2011 in wetlands in the middle Green River; such observations had not been achieved since 1996. Fyke and trammel nets, minnow traps, and seines were used to sample 15 wetlands in the middle Green River (Flaming Gorge to Desolation Canyon). A total of 18 wild juvenile razorback suckers were captured in two of the wetlands.

RESUMEN—El matalote jorobado (Xyrauchen texanus) es un catostómido grande en peligro de extinción a nivel nacional que se encuentra en el río Verde, en Utah, un afluente del río Colorado. Aunque poblaciones

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