Eur J Wildl Res (2015) 61:177–179
DOI 10.1007/s10344-014-0871-7

SHORT COMMUNICATION

Does understory clutter reduce bat activity in forestry pine plantations?

Annia Rodríguez-San Pedro · Javier A. Simonetti

Received: 9 May 2014 / Revised: 25 September 2014 / Accepted: 6 October 2014 / Published online: 12 October 2014

Abstract Forestry plantations supporting native species exhibit a dense understory, which might reduce bat activity within plantations. We compared bat activity in Monterrey pine plantations with and without an understory in central Chile. Total activity did not differ between plantations with a developed understory and those without it, being higher on-track than off-tracks sites. Trails provide commuting areas for bats within plantations allowing its use regardless of their degree of structural clutter. Promoting understory in plantations provides habitats for bats and might enhance their conservation in human-modified landscapes.

Keywords Chile · *Pinus radiata* · Structural complexity

Introduction

Forestry plantations are often regarded as “biological deserts” and a threat to biodiversity (Hartley 2002). Consequently, environmentally friendly practices are demanded to mitigate their negative effects (Rousseau et al. 2005). Enhancing the occurrence of a developed understory vegetation is one such practice. Plantations with developed understories provide cover, and food for wildlife, which might mitigate their impact upon habitat quality. In such cases, species richness and abundance are higher in forestry plantations with a developed undergrowth than in those without it, enhancing diversity of invertebrates, birds and mammals (Brockerhoff et al. 2008, Simonetti et al. 2013).

A developed understory leads to increased structural clutter within forestry plantations, however, which may adversely affect bats. This structural complexity may influence bats’ choice of foraging habitat, as they may avoid navigating in cluttered habitats (Kusch et al. 2004). Undergrowth in forestry plantations might then reduce flight efficiency or hamper the detection of potential prey for some bat species (Broders et al. 2004; Rainho et al. 2010). Therefore, while the presence of understory might generally enhance forestry plantations as habitat for a wide array of fauna, it might specifically conflict with foraging conditions desirable for aerial insectivorous bats. Clutter, however, might increase the activity of bat species with high maneuverability and FM broadband echolocation calls, while cluttering might reduce activity of low maneuverability and CF narrowband calls (Tibbels and Kurta 2003; Patriquin and Barclay 2003).

Bats may overcome the physical constraints of clutter by using trails in forested areas (Law and Chidel 2002). If bats also use roads and trails in plantations, this may facilitate use of habitats otherwise inhospitable (Law and Chidel 2002; Monadjem et al. 2010), as well as mitigate potential conflict regarding the value of understory between bats and other fauna. Following this framework, we assessed the effect of undergrowth on the occurrence of bats in Monterrey pine (*Pinus radiata*) plantations in central Chile. If well-developed undergrowth reduces the use of forestry plantations by bats, we expected that activity should be lower in plantations with a developed understory than in a stand with no or little understory. Similarly, we expected that bat activity would be higher along plantation trails than away from tracks in both complex and simple plantations, due to reduced vegetation clutter.

Communicated by P. Acevedo

A. Rodríguez-San Pedro (✉) · J. A. Simonetti
Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile
e-mail: sanpedro@ug.uchile.cl

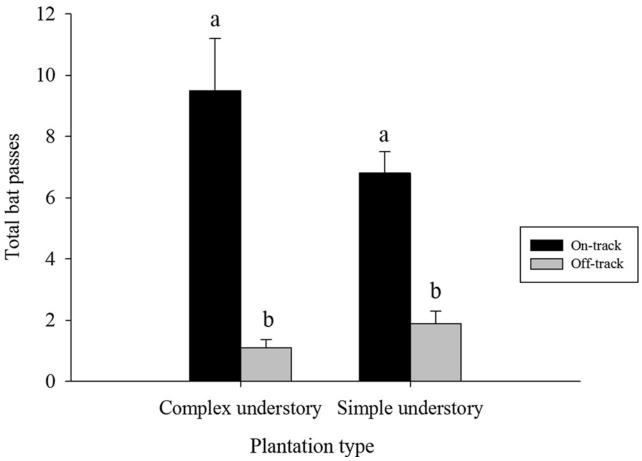


Fig. 1 Total bat activity (mean±SE) in complex and simple pine plantations, on-track and off-track. *Different letters* indicate significant differences at $P<0.001$

Materials and methods

Acoustic surveys were conducted in Monterrey pine plantations located at Tregualemu, central Chile. The area comprises pine plantations, large tracts, and scattered fragments of native forest and surrounding agricultural lands. According to structural complexity, plantations were classified as simple when woody plant density 1 m above ground was less than 0.5 individuals/m^2 and complex when understory density was above 0.5 individuals/m^2. Structurally complex plantations have 2.2 more woody species, an understory density four times higher and vegetation volume 12 times higher (see Poch and Simonetti 2013 for details).

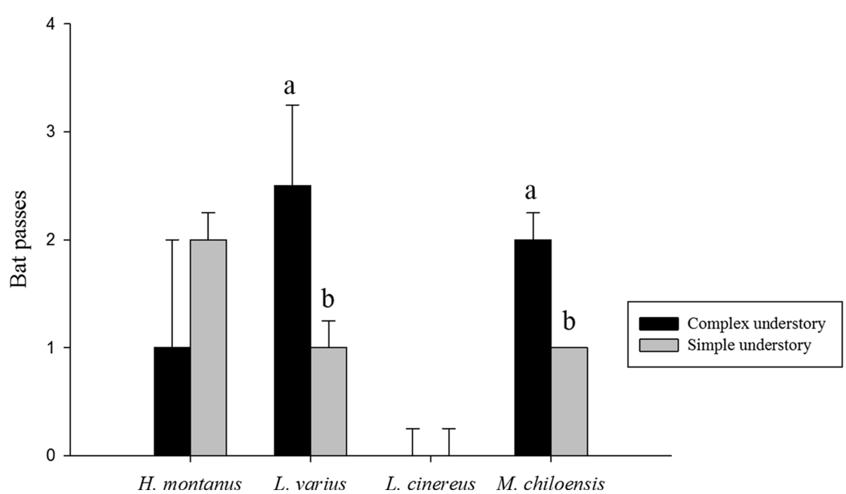
Bat activity was sampled at 10 locations within structurally simple and 10 locations within structurally complex sites. Survey sites were located at different stands and at least 300 m away from each other. Tracks within plantations consisted of linear flyways ranging from 1 to 5 m wide, included trails and dirt roads. At each sampling location, bat activity was recorded for 10 min on-track and 10 min off-track sites per night, moving randomly between sampling locations. Bat activity was recorded using an ultrasound bat detector model D240X (Pettersson Elektronic AB) coupled to a digital recorder MicroTrack II (M-Audio) operated in manual mode. Each sampling point was visited nine times between January 2010 and January 2012. Off-track recordings were set >50 m from tracks and the detector was pointed toward small gaps to minimize bat call attenuation from vegetation (Patriquin et al. 2003). Sampling began at dusk and extended for four hours to coincide with the peak foraging periods of insectivorous bats (Kuenzi and Morrison 2003). Bat activity was quantified by pooling the number of bat passes across nights for each sampling point (Walsh et al. 2004). There was no significant spatial autocorrelation of bat activity (Moran's $I=-0.106$, $P=0.48$).

Bat passes were classified to species using Discriminant Function Analysis (Russo and Jones 2002). Classification functions were computed using a library of validated reference calls from hand-released bats at the study area (Rodríguez-San Pedro and Simonetti 2013). Parameters used in the classification analysis were extracted from Batsound 2.1 software (Pettersson Elektronic AB). A two-way ANOVA (Box-Cox transformation for normality) followed by a post hoc Tukey tests was used to test for differences between overall bat activity according to understory development and track position. Differences between simple and complex plantations in bat activity were tested using a Mann-Whitney U test (individual species data could not be transformed to fit a normal distribution; Zar 2010).

Results and discussion

A total of 193 echolocation passes were recorded. Of these, 84 could not be analyzed at the species level due to the low

Fig. 2 Bat activity per species (median±percentile) in complex and simple pine plantations. *Different letters* indicate significant differences at $P<0.05$



intensity of the recorded calls being classified as "unknown" and were omitted from species-level analysis. The remaining 109 passes were assigned to four of the six species known for the area: *Histiotus montanus* (32 passes), *Lasiurus varius* (32), *Myotis chiloensis* (26), and *Lasiurus cinereus* (19).

Overall bat activity did not differ between complex and simple plantations ($F_{(1, 36)}$=0.001, P=0.97); however, activity was higher on-track than off-tracks ($F_{(1, 36)}$=87.2, $P \leq 0.001$) (Fig. 1). Activity of individual species was quantified by pooling the number of passes recorded at both on-track and off-track positions since most passes (84 %) were recorded on-track. At the species level, *M. chiloensis* and *L. varius* were more frequent in plantations with developed understory than in plantations with scarce understory (U=20.5, $P \leq 0.05$ and U=25.0, $P \leq 0.05$, respectively; Fig. 2). Activity of *H. montanus* and *L.cinereus* did not differ between plantation types ($U \leq 48.0$, $P > 0.07$ in both cases).

Contrary to our predictions, overall bat activity was similar across plantations regardless of understory condition; however, there were differences in bat activity at the species level depicted by bats in other clutter environments (Patriquin and Barclay 2003; Dodd et al. 2012). Wing morphology and echolocation calls constrain bats flights to specific habitats (Norberg and Rayner 1987; Broders et al. 2004). *L. varius*, with high wing loading and aspect ratio, is a fast flying species with low maneuverability, expected to be clutter-sensitive (Schnitzler et al. 2003), but its use of tracks as flyways would explain its use of clutter plantations. Furthermore, it adjusts echolocation calls when flying in cluttered areas (Rodríguez-San Pedro and Simonetti 2014). The short, round wings and frequency modulated calls of *M. chiloensis* enhance its foraging in cluttered habitats (Rodríguez-San Pedro and Simonetti 2013), accounting for its presence in these plantations.

Trails facilitated access and use of forestry plantations regardless of the degree of structural clutter, consistent with bat use of tracks in other forests (Law and Chidel 2002; Monadjem et al. 2010), and provide internal corridors allowing both clutter-sensitive and clutter-tolerant bats to use the edges of densely vegetated plantations.

Our data suggest that plantations with a developed understory can provide suitable habitat for flying bats, in addition to other taxa (Estades et al. 2012). Promoting undergrowth vegetation in Monterrey pine plantations may not only promote biodiversity but may also benefit managers through the ecosystem services provided by insectivorous bats (Williams-Guillén et al. 2008). To the extent that plantations provide wildlife habitat, this production-oriented land use may simultaneously manage for biodiversity conservation.

Acknowledgments Forestal Masisa and CONAF VII Región granted permits to work on their states. Thanks to Y. Cerda, R. Zúñiga, and F. Campos for field assistance. The research supported by FONDECYT 1095046. ARSP is a PhD fellow from CONICYT, Chile.

References

Broders H, Findlay C, Zheng L (2004) Effects of clutter on echolocation call structure of *Myotis septentrionalis* and *M. lucifugus*. J Mammal 85:273–281

Dodd LE, Lacki MJ, Britzke ER et al (2012) Forest structure affects trophic linkages: how silvicultural disturbance impacts bats and their insect prey. Ecol Manag 267:262–270

Estades CF, Grez AA, Simonetti JA (2012) Biodiversity in Monterrey pine plantations. In: Simonetti JA, Grez AA, Estades CF (eds) Biodiversity conservation in agroforestry landscapes: challenges and opportunities. Editorial Universitaria, Santiago, pp 77–98

Hartley MJ (2002) Rationale and methods for conserving biodiversity in plantation forests. Ecol Manag 155:81–95

Kuenzi AJ, Morrison ML (2003) Temporal patterns of bat activity in southern Arizona. J Wildl Manag 67:52–64

Kusch J, Weber C, Idelberger S, Koob T (2004) Foraging habitat preferences of bats in relation to food supply and spatial vegetation structures in a western European low mountain range forest. Folia Zool 53:113–128

Law B, Chidel M (2002) Tracks and riparian zones facilitate the use of Australian regrowth forest by insectivorous bats. J Appl Ecol 39:605–617

Monadjem A, Ellstrom M, Maldonaldo C, Fasel N (2010) The activity of an insectivorous bat *Neoromicia nana* on tracks in logged and unlogged forest in tropical Africa. Afr J Ecol 48:1083–1091

Norberg U, Rayner J (1987) Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. Philos Trans R Soc Lond B Biol Sci 316:335–427

Patriquin KJ, Barclay RMR (2003) Foraging by bats in cleared, thinned and unharvested boreal forest. J Appl Ecol 40:646–657

Patriquin K, Hogberg L, Chruszcz J (2003) The influence of habitat structure on the ability to detect ultrasound using bat detectors. Wildl Soc Bull 31:475–481

Poch TJ, Simonetti JA (2013) Insectivory in *Pinus radiata* plantations with different degree of structural complexity. Ecol Manag 304:132–136

Rainho A, Augusto AM, Palmeirim JM (2010) Influence of vegetation clutter on the capacity of ground foraging bats to capture prey. J Appl Ecol 47:850–858

Rodríguez-San Pedro A, Simonetti JA (2013) Acoustic identification of four species of bats (order Chiroptera) in central Chile. Bioacoustics Int J Anim sound its Rec 22:165–172

Rodríguez-San Pedro A, Simonetti JA (2014) Variation in search-phase calls of Lasiurus varius (Chiroptera: Vespertilionidae) in response to different foraging habitats. J Mammal. (in press)

Rousseau R, Kaczmarek D, Martin J (2005) A review of the biological, social, and regulatory constraints to intensive plantation culture. South J Appl For 29:105–109

Russo D, Jones G (2002) Identification of twenty-two bat species (Mammalia: Chiroptera) from Italy by analysis of time—expanded recordings of echolocation calls. J Zool 258:91–103

Schnitzler H-U, Moss CF, Denzinger A (2003) From spatial orientation to food acquisition in echolocating bats. Trends Ecol Evol 18:386–394

Simonetti JA, Grez AA, Estades CF (2013) Providing habitat for native mammals through understory enhancement in forestry plantations. Conserv Biol 27:1117–1121

Tibbels AE, Kurta A (2003) Bat activity is low in thinned and unthinned stands of red pine. Ecology 33:2436–2442

Walsh A, Barclay R, McCracken G (2004) Designing bat activity surveys for inventory and monitoring studies at local and regional scales. In: Brigham R, Kalko E, Jones G (eds) Bat echolocation research: tools, techniques and analysis. Bat Conservation International, Austin, pp 157–165

Williams-Guillén K, Perfecto I, Vandermeer J (2008) Bats limit insects in a neotropical agroforestry system. Science 80:320–370

Zar JH (2010) Biostatistical analysis. Fifth edit. Pearson Education, United States, 947p