Noisy human neighbours affect where urban monkeys live

Marina H. L. Duarte1, Marco A. Vecci2, André Hirsch3 and Robert J. Young1,*

1Conservation, Ecology and Animal Behaviour Group, Prédio 41, Mestrado em Zoologia, Pontifícia Universidade Católica de Minas Gerais, Av. Dom José Gaspar, 500-Coroação Escutaríco, CEP 30535-610 Belo Horizonte, Minas Gerais, Brasil
2Departamento de Engenharia de Estruturas, Laboratório de Acústica e Dinâmica das Estruturas, Universidade Federal de Minas Gerais, Av. Antônio Carlos, 6627-EScola de Engenharia, Pampulha 31270-901 Belo Horizonte, Minas Gerais, Brasil
3Programa Institucional de Bioengenharia Universidade Federal do São João do Rei Rod, MG-424, km 47, UFSJ Campus Sete Lagoua,
CEP 35701-970, Cx.P. 56 Sete Lagoua, Minas Gerais, Brasil
*Author for correspondence (royoung@ipucminas.br).

Urban areas and many natural habitats are being dominated by a new selection pressure: anthropogenic noise. The ongoing expansion of urban areas, roads and airports throughout the world makes the noise almost omnipresent. Urbanization and the increase of noise levels form a major threat to living conditions in and around cities. Insight into the behavioural strategies of urban survivors may explain the sensitivity of other species to urban selection pressures. Here, we show that urban black-tufted marmosets (Callithrix penicillata) living in noisy urban areas may select their home-range based primarily on ambient noise level. We have tested the hypothesis that the noise from vehicular traffic and visitors in an urban park in Brazil influences the use of home-range (space) by urban marmosets. Marmosets even avoided noisy areas with high food availability. In addition, they systematically preferred the quieter areas even with dynamic changes in the acoustic landscape of the park between weekdays and Sundays (no observations were made on Saturdays). These data provide evidence that the use of home-range by wild animals can be affected by a potential aversive stimulus such as noise pollution.

Keywords: marmoset; urban noise; use of space

1. INTRODUCTION

Anthropogenic disturbances are known to alter patterns of behaviour, physiology and morphology of organisms living in cities [1–6] and may lead to population declines [7,8]. For species that occur in cities, it is known that urban challenges such as noise pollution, chemical pollution, lack of vegetation, exotic vegetation, different kinds of parasites and predators may be relatively stressful [1,9,10]. The ongoing expansion of urban areas, roads and airports throughout the world makes noise pollution almost omnipresent [2]. Currently, urban noise is considered a major threat to creatures that inhabit cities. High urban noise levels have for decades received considerable attention from researchers interested in human welfare [11–17], but studies on the effect of noise on animals are much more recent and less common. Recently, researchers have reported animals being affected by anthropogenic noise, or even responding adaptively to noisy environments [2,5,18–21]. However, while most studies have used birds to investigate the impact of noise on the communication of animals, little research has been conducted in urban areas and no study has been conducted on the effect of noise on the use of space by terrestrial animals. Studies on zoo animals have shown that noise has negative effects on animal welfare [22,23]. Specific skills that mitigate the impact of noise may explain how some species but not others can survive in urban conditions [24]. Some species of primates are highly intelligent, opportunistic and easily adjust to anthropogenic environments [25]. The marmoset, Callithrix penicillata, is probably one of the most well-adapted species of the genus Callithrix and is able to adjust to urbanized environments, probably owing to its efficient ability to exploit tree exudates [26,27]. In this study, we explore how urban marmosets adjust their home range in response to a noisy environment. We tested the hypothesis that the noise from vehicular traffic and visitors in a city centre park (Belo Horizonte, Brazil) influences the use of home-range (space) by urban marmosets. We predicted that urban marmosets would prefer to use the quieter areas of the park.

2. MATERIAL AND METHODS

(a) Study area

This study was conducted at Parque Municipal Américo Renmé Giannetti, located in Belo Horizonte city centre, Minas Gerais, Brazil (19°55′24.72″S, 43°56′1.81″W). The park’s area is approximately 18 hectares, it is surrounded by a fence and is situated between avenues of heavy vehicular traffic movements and pedestrian activity in the city. The park comprises vegetation composed of native and exotic species, and is home to approximately 50 species of birds, as well as fish, reptiles and mammals [28].

(b) Data collection

We characterized the acoustic landscape of the environment by measuring the amplitude of noise from 45 points evenly distributed throughout the study area (75 m apart) on weekdays and Sundays (this is a day of lower traffic but higher human visitation; no observations were made on Saturdays), using a sound-level metre (Minipa model 1352C, São Paulo, Brazil). Each point was measured 10 times during the rush hour traffic period in the mornings (06.30–08.30 h), intermediate hours of the morning (09.30–11.30 h), intermediate hours of the afternoon (14.00–16.00 h) and the rush hour traffic of the evening (17.00–19.00 h) and each measurement lasted 15 min. The order of measuring points was chosen randomly but balanced across time and day. Before and after each measurement, the sound-level metre was calibrated (Minipa model MSL 1326). We monitored the urban marmosets daily in the park for a year (September 2008 to August 2009), marking their locations with a global positioning system (GPS) device (Garmin 76CSx, Southampton, UK), and also mapped all the plant species used in the diet of marmosets in the same period.

(c) Data analysis

For each measurement of noise, we calculated the equivalent continuous sound levels (L(Aeq); time averaged level of sound), which gives an overall indication of the level of exposure to sound in an environment [29]. We divided up the area of the park according to the sound levels. To this end, we created 10 classes of noise level in 3 dB intervals (10 classes for weekdays and seven classes for Sunday), because primates can distinguish increases of this magnitude [29]. We calculated the expected frequencies of GPS locations of marmosets and for the number of plants in the diet in each class of noise area in the park (figure 1). Then we analysed the standardized residuals using a χ2-test to determine which classes of noise were more or less perceived by the marmosets.
studies have shown that marmosets select their areas and avoided areas with high food availability when these coincided with high noise levels. Previous areas were the edges of the park, which are close to streets with busy traffic (figure 1). On Sundays, owing to the large concentration of visitors in the park, the internal areas became noisier than on weekdays. We recorded 2950 GPS locations related to the home-range of marmosets (2508 on weekdays and 442 on Sundays). On weekdays, the number of GPS locations varied according to the classes of noise ($X^2 = 6507$, d.f. = 7, $p < 0.001$), and the quieter areas were used significantly more than expected. We identified 785 individuals of 18 species of trees used in the diet of marmosets. The number of trees in the diet also varied with individuals of 18 species of trees used in the diet of marmosets. The number of trees in the diet also varied with

**3. RESULTS**

The equivalent sound levels (L_{Aeq}; sound-level exposure) ranged between 50 and 80 dB between Mondays and Fridays and between 50 and 74 dB on Sundays. Between Mondays and Fridays, the noisiest areas were the edges of the park, which are close to streets with busy traffic (figure 1). On Sundays, owing to the large concentration of visitors in the park, the internal areas became noisier than on weekdays. We recorded 2950 GPS locations related to the home-range of marmosets (2508 on weekdays and 442 on Sundays). On weekdays, the number of GPS locations varied according to the classes of noise ($X^2 = 6507$, d.f. = 7, $p < 0.001$), and the quieter areas were used significantly more than expected. We identified 785 individuals of 18 species of trees used in the diet of marmosets. The number of trees in the diet also varied with the areas as defined by classes of noise, and the noisiest areas had significantly more trees in the diet than expected ($X^2 = 101.39$, d.f. = 7, $p < 0.001$). On Sundays, the frequency of locations of marmosets ($X^2 = 273$, d.f. = 6, $p < 0.001$) and number of trees in the diet ($X^2 = 36.98$, d.f. = 6, $p < 0.001$) also varied according to the noise classes. On these days, the marmosets also preferred the quieter areas of the park, and again the area most used had low availability of the plants in their diet.

**4. DISCUSSION**

On all days, marmosets significantly preferred quieter areas and avoided areas with high food availability when these coincided with high noise levels. Previous studies have shown that marmosets select their home-range based on food availability [30]. We noted no physical barrier preventing access to noisy areas, and as there is only one group of marmosets in the park, we can rule out the possibility that another group was limiting their use of these noisy areas. On Sundays, the marmosets also preferred the quieter areas of the park, and again avoided areas rich in food resources when they had high noise levels. Our results indicate that noise is an important factor influencing marmosets’ choice of home-range, because the marmosets systematically preferred the quieter areas even with dynamic changes in the acoustic landscape of the park between weekdays and Sundays. The density of plants in their diet seemed not to be the most important factor for choosing their home-range. Thus, we have shown once again that anthropogenic disturbances can alter the behaviour patterns of this species [6]. We believe that anthropogenic noise can be stressful, and this directly affected the ecology of the marmosets, forcing them to avoid areas that have abundant food resources. It may also be the case that anthropogenic noise interferes with their vocal communication [2]. Here, we have shown that marmosets preferred quieter areas in their home-range even when the location of such areas changed, as occurred on Sundays; this preference for quieter areas kept them away from their food sources. Thus, this research demonstrates that the use of home-range by wild animals can be affected by a potentially aversive stimulus such as noise pollution.

We would like to thank the Park Foundation of Belo Horizonte and the City Mayor’s Office for their permission to work in the park and for logistical support. M.H.L.D. was supported by a
FAPEMIG postgraduate scholarship during this research. R.J.Y. receives financial support from CNPq and FAPEMIG.


*Biological Letters* (2011)