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Weather conditions and moon phase influence on Tropical Screech Owl and Burrowing Owl detection by playback

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Sampling owls in a reliable and standardized way is not easy given their nocturnal habits. Playback is a widely employed technique to survey owls. We assessed the influence of wind speed, temperature, air humidity, and moon phase on the response rate of the Tropical Screech Owl *Megascops choliba* and the Burrowing Owl *Athene cunicularia* in southeast Brazil. Tropical Screech Owl occurs in scrubland and wooded habitats, whereas the Burrowing Owl inhabits open grasslands to grassland savannah. Sixteen survey points were systematically distributed in four different landscape types, ranging from open grassland to woodland savannah. Field work was conducted in 2004 from June to December, the reproductive season of the two owl species. Our study design consisted of eight field expeditions of five nights each; four expeditions occurred under full moon and four under new moon conditions. At each survey station, we performed a broadcast/listening sequence involving several calls and vocalizations from each species, starting with Tropical Screech Owl (the smaller species). From 112 sample periods for each species within their respective preferred habitats, we obtained 54 responses from Tropical Screech Owl (48% response rate) and 30 responses (27% response rate) from Burrowing Owl. We found that the response rate of Tropical Screech Owl increased under conditions of higher temperature and air humidity, while the response rate of Burrowing Owl was higher during full moon nights.

Key words: playback surveys, *Athene cunicularia, Megascops choliba*, wind speed, temperature, moon phase, air humidity, southeast Brazil

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INTRODUCTION

Raptors and owls typically occur in low densities, have large home ranges and are able to move fast between areas (Craighead & Craighead 1969, Fuller & Mosher 1981, Takats & Holroyd 1997). As usual methods for sampling birds are generally not suitable for raptors and owls, studies have been conducted trying to develop a reliable method for sampling this group (Fuller & Mosher 1981, Fuller & Mosher 1987, Smith 1987). Moreover, given the nocturnal behaviour of most owls, this group is particularly difficult to sample in the wild (Smith 1987). Thus, vocal calls are broadly employed in owl studies, either in counting and locating individuals, or in species identification and ecological and behavioural studies (Gerhardt 1991, Clark & Anderson 1997). One of the most used methods is counting spontaneous calls along transects or in point-counts (Haug & Diduik 1993, Rodríquez-Estella & Ortega-Rubio 1993, Conway & Simon 2003). Many studies have revealed that the use of playback calls increase the detection of owl species (Johnson *et al.* 1981, Gerhardt 1991, Haug & Diduik 1993, Conway & Simon 2003, Flesch & Steidl 2007). However, aspects such as wind speed, moon phase, seasonality, precipitation, behaviour, ecological and geographical aspects could potentially influence an owls' vocal activity, and thus their response rate and detectability (Fuller & Mosher 1981, Johnson *et al.* 1981, Smith 1987, Ganey 1990, Gerhardt 1991, Morrell *et al.* 1991, Clark & Anderson 1997, Takats & Holroyd 1997, Hardy & Morrison 2000, Enriquéz-Rocha & Rangel-Salazar 2001, Seavy 2004).

Studies that analyse aspects that influence species response rates and/or detectability are key in developing rigorous methods for sampling raptors (Flesch & Steidl 2007). For population studies (Pardeick *et al.* 1996, Flesch & Steidl 2007), monitoring programs (Conway & Simon 2003) and behavioural studies (Ritchison *et al.* 1988) a reliable and standardized method is needed, with a high detection capacity and with low variation in the detection probability (Conway & Simon 2003). Hence, a better understanding of the variation in response rate and detectability of owls could give insights in how to use playbacks to count and study them (Pardeick *et al.* 1996, Clark & Anderson 1997, Takats & Holroyd 1997, Enriquez-Rocha & Rangel-Salazar 2001, Seavy 2004, Flesch & Steidl 2007).

The Tropical Screech Owl *Megascops choliba* and Burrowing Owl *Athene cunicularia* are two small-sized owls with a wide geographic distribution (Sick 1997). The Burrowing Owl occurs in open grassland regions from Canada to Argentina (del Hoyo *et al.* 1999, König *et al.* 1999), whereas the Tropical Screech Owl occurs roughly all over South America, except in southern Argentina and Chile, and part of Central America (Sick 1997, König *et al.* 1999). Both Tropical Screech Owl and Burrowing Owl occur in the Brazilian savannah (Cerrado vegetation). While the Tropical Screech Owl inhabits mainly dense savannah habitats, the Burrowing Owl prefers open fields (Braga, unpubl. data).

Neotropical owls have not received much attention (Clark *et al.* 1978, König *et al.* 1999) and there is little information about their detectability and/or vocal activity. The few studies that focused on species that also occur in tropical areas were conducted for the Burrowing Owl in temperate regions (Haug & Didiuk 1993, Conway & Simon 2003). Thus, studies addressing sampling methods are rare and few of them employed playback techniques (Gerhardt 1991, Enriquez-Rocha & Rangel-Salazar 2001, Borges *et al.* 2004). Moreover, studies that investigate environmental influences on response rates of Tropical Screech Owl and Burrowing Owl are virtually absent in the tropical region. Furthermore, this study was conducted in the Brazilian savannah, one of the 25 world's 'top hotspots' (Myers *et al.* 2000), which has been deforested at an alarming rate (Silva *et al.* 2006). In this context, our objectives were to investigate the influence of climatic factors and moon phase on the response rates of Tropical Screech Owl and Burrowing Owl in the savannah of southeast Brazil.

METHODS

Study site

This study was conducted in the Estação Ecológica Itirapina (EEI), located in the municipalities of Itirapina and Brotas, State of São Paulo, Brazil (22°07'S to 22°17'S, 47°46'W to 47°56'W). The reserve has approximately 2300 ha and is one of the last Brazilian savannah remnants in the State of São Paulo. We also sampled two other fragments of cerrado vegetation near the EEI. The largest (266 ha) was located 3000 m from the EEI, and the second (122 ha) was located 2300 m from the EEI. The natural Cerrado vegetation in the study area ranges from open grasslands to woody habitats: 'campo limpo' where only the ground layer is present, with no evident woody plants rising above the grass layer; 'campo sujo' is grassland, just like 'campo limpo' but with a few scattered low shrubs; 'campo cerrado', is a xeromorphic semideciduous low-tree and scrub savannah with short grass or tallgrass; 'cerrado *sensu stricto*', is a xeromorphic semideciduous low arboreal woodland (open canopy), low forest (closed canopy), open or closed scrub, or tree and scrub woodland (Eiten 1974, Oliveira-Filho & Ratter 2002).

The higher elevations in the region range from 705 to 750 m and the climate is typified by mild temperatures with dry winter. The average annual precipitation is 1376 mm, with a dry season from April to September, when monthly averages range from 32 to 88 mm, while in the wet season, from October to March, the monthly averages range from 117 to 257 mm. The monthly average temperature in the dry season ranges from 16.2 to 20.1°C, and in the wet season from 19.5 to 22.3°C (DAEE Meteorological station D4-014, Itirapina, São Paulo).

Field surveys

The field work was conducted from June to December 2004, the reproductive season of the study species in Brazil. This is the time of the year when owl species respond more to the playback calls (Bosakowski 1987, Ritchison *et al.* 1988, Gerhardt 1991, Clark & Anderson 1997). We did not conduct observations during heavy cloud nights and nights with rain because of the presumed lower vocal activity (McGarigal & Fraser 1984, Mosher *et al.* 1990, Gerhardt 1991, Currie *et al.* 2004, Seavy 2004). We conducted eight field expeditions with five nights each, divided in four expeditions during full moon and four in new moon. We started precisely three days before complete full moon and complete new moon, extending until the second day after each start of the moon phase.

We systematically set 16 survey points at least 500 m from each other, to insure statistical independence of the data (Takats *et al.* 2001, Currie *et al.* 2004). The points were equally distributed in four different cerrado habitats of the region: 'campo limpo', 'campo sujo', 'campo cerrado' and 'cerrado *s.s*.'. Each vegetation type was sampled 56 times, equally divided between dry and wet season and along the study months. All points were visited the same number of times, and the order that they were visited varied within the observed days in a systematic way in order to avoid sampling bias related to a periodic variation (Krebs 1999). Six or seven points were sampled per night. As a result, a majority of the points were sampled twice in each field trip, which served to reduce seasonal bias.

We sampled during the time of the day when the species are most active, starting 30 min after sunset and ending approximately 3 h later (Smith 1987, Clark & Anderson 1997, Holroyd 1997). The *Athene cunicularia grallaria* subspecies that occurs in the region has its peak of activity in the beginning of the night, and less activity during the day (pers. obs.). In each sampling event we used several calls and vocalizations from each species, to potentially increase the detection probability (Conway & Simon 2003). We used previously recorded vocalizations and calls from the same area and from other localities, in order to avoid the effect called 'dear enemy' (Fisher 1958 in Lovell & Lein 2004), which reflects a more aggressive response to individuals that have territories further away as compared with the ones that are nearby (Lovell & Lein 2004). However, we used the same vocalization sequence every time, which was played in a mini-amplifier (Pignose) connected to a portable cassette player. The sequence consisted of a 3-min listening period, 2 min of Tropical Screech Owl playback, 2 min of listening, 2 min of Burrowing Owl playback, 2 min of listening, and an extra and final 3 min listening period. The first 3 min were used to identify any individual that was already calling or vocalizing, and also for avoiding any influence from the observers' approach to the survey point. Also, the last 3-min listening period was used to detect late responses from any individual. We always played Tropical Screech Owl playback first, since it is the smaller species and the playback of the larger one could influence the smaller owls' response (Marshal 1939, Smith 1987). Thus, we considered each 14-min point as a sampling unit.

During the sampling units we recorded the number of individuals from each species (Tropical Screech Owl or Burrowing Owl), from any sex, seen or heard in a radius of 200 m around the sampling point (Mosher *et al.* 1990), and hence obtained the response rate, which is the number of records per unit of time (Flesch & Steidl 2007), in this case 14 min. During the sampling unit the individuals were localized using the quadrant method to avoid recounting in the event individual owls moved during the sampling period. Playback volume level was set audible for a human 200 m apart, which is a common procedure (Pardeick *et al.* 1996, Currie *et al.* 2004).

Environmental factors

In each sampling point, during each sampling period, three climatic variables were recorded with a Kestrel-3000 Pocket Weather Meter/NK. We used air temperature (°C), relative air humidity (%) and wind speed (km/h) (Table 1). Moon phase was also recorded in each night of sampling.

Table 1. Weather conditions during the sampling sessions.

	Burrowing Owl			Tropical Screech Owl		
	Max	Min	Mean	Max	Min	Mean
Temperature (°C)	24.7	3.3	15.7	26.0	6.7	17.5
Wind speed (km/h)	2.0	0.0	0.5	2.4	0.0	0.5
Humidity (%)	100.0	39.0	73.8	98.0	31.0	69.0

Statistical analysis

The dependent variable was the number of individuals of each species responding to the playback (response rate), which was modelled as a function of climatic and moon phase variables. We employed an analysis similar to Zabel *et al.* (2003), Glenn *et al.* (2004) and Martensen *et al.* (2008); the best fit models were obtained by likelihood with Poisson error distribution with the General Linear Model (GLM) package in R 2.8.1 (2008). We built 15 models (all possible variable combinations of main effects without interactions) for each species and used the Akaike Information Criterion (AIC, Burnham & Anderson 1998), generating a rank from the best to the least likely model. Differences in

AIC larger than 2 (ΔAIC) were considered as low support to the model presenting the higher AIC (Burnham & Anderson 1998) Correlations between independent variables were tested, showing low and non-significant correlations ($0.20 < r < 0.03$). To analyse the influence of each independent variable we used models with a single variable.

To avoid bias due to habitat effects (Sheick 1997, Flesch & Steidl 2007), we only considered data of the most preferred habitats for either species (the two most open habitats for Burrowing Owl, the two most dense habitats for Tropical Screech Owl). Since the species differ in behaviour we did not compare response rates between the species.

RESULTS

From 112 sample periods for each species within their respective preferred habitats, we obtained 54 positive responses from Tropical Screech Owl (48%) and 30 positive responses (27%) from Burrowing Owl.

Tropical Screech Owl

The response rate by Tropical Screech Owl was best explained by temperature and humidity (Table 2). The parameter estimates suggested that in nights with higher temperature and humidity the Tropical Screech Owl was more vocally active (Table 2).There was relatively good support ($\Delta AIC \le 2$) for models that included – besides temperature and humidity – moon phase or wind speed as well (model 2 and 3). However, effects of latter parameters in the models seemed weak.

Burrowing Owl

The Burrowing Owl response rate appeared to be sensitive to variation in all independent variables, as the model with all four main effects was the third best model with $\Delta AIC \le 2$ (Table 3). All four models that were reasonably supported by the data ($\Delta AIC \le 2$) included moon phase and wind speed as independent variables, while models that included only temperature and humidity had the lowest support. Parameter estimates suggested that in full moon nights the Burrowing Owl was more responsive to the playback, and in windy nights less responsive.

DISCUSSION

Most of our records of Burrowing Owls and Tropical Screech Owls resulted from the use of playback. After playing the sounds, the number of individuals vocalizing and the intensity of calls increased substantially for both species, thus the playback method appears to be a useful tool for improving the detection of both owl species.

Weather

We found that the response rate of Tropical Screech Owl increased with temperature and air humidity. This relationship was also found in Northern Saw-whet Owl *Aegolius acadicus* (Clark & Anderson 1997) and Eastern Screech Owl *Megascops asio* (Smith 1987). However, we did not find a similar relationship in the Burrowing Owl, which is in line with observations in Long-eared Owl *Asio otus* and Boreal Owl *Aegolius funereus* (Clark

Table 2. Top-ranking models ($\Delta AIC \le 2$) for Tropical Screech Owl response rates in relation to air temperature (Temp), relative air humidity (Hum), wind speed (Wind) and moon phase (Moon). Models are ranked based on AIC. Parameter estimates (B), SE and associated *P*-values are given.

Model	Parameter	B	SE	*P*	AIC	ΔAIC
Temp + Hum	intercept	–2.78	0.81	<0.005	239.8	0.00
	Temp	0.06	0.03	0.03		
	Hum	0.02	0.01	0.03		
Temp + Hum + Moon	intercept	–2.72	0.85	<0.005	241.7	1.94
	Temp	0.06	0.03	0.03		
	Moon	–0.06	0.24	0.81		
	Hum	0.02	0.01	0.04		
Temp + Hum + Wind	intercept	–2.78	0.81	<0.005	241.8	2.00
	Temp	0.06	0.03	0.03		
	Wind	–0.00	0.20	0.98		
	Hum	0.02	0.01	0.03		

& Anderson 1997). Insects are important in the diets of both Tropical Screech Owl and Burrowing Owl (Motta-Junior 2002, Motta-Junior & Bueno 2004), although the hunting strategies of these owls are quite different. Tropical Screech Owl frequently captures invertebrates during flights within the tree canopy (del Hoyo *et al.* 1999, König *et al.* 1999). Burrowing Owl, instead, forages in open habitats, capturing prey on the ground (Thomsen 1971; Braga, unpubl. data). Insects are more active when temperature and/or air humidity is high (Delinger 1980), and hence this could have affected owl activity. We cannot exclude the possibility, though, that physiological aspects played a role as well (Robbins 1981).

Little is known about the influence of wind speed on owl activity (Gerhardt 1991). Several authors suggested that in high winds owl activity drops because of difficulties in flying and foraging (e.g. Smith 1987, Fisher *et al.* 2004). Therefore, beyond the apparent difficulty in detecting owl calls in high winds (Smith 1987, Morrell *et al.* 1991, Gerhardt 1991, Takats & Holroyd 1997), response rate might drop because of a change in behaviour of the owls.

Moon phase

The response rate of Burrowing Owl was higher in full moon nights, which corresponds to observations in several other species (Morrell *et al.* 1991, Pardieck *et al.* 1996, Clark & Anderson 1997, Takats & Holroyd 1997, Hardy & Morrison 2000, Enriquez-Rocha & Rangel-Salazar 2001, Seavy 2004). On the other hand, other studies suggested that owls were more calling in darker nights (Ganey 1990, Sará & Zanca 1989), or that response rates were independent of moon phase (Clark & Anderson 1997, Enriquéz-Rocha & Rangel-Salazar 2001, Tropical Screech Owl in this study). However, as Seavy (2004) pointed out, there is not always a close relation between moon phase and luminosity. In this sense, response rates could be associated with luminosity rather than with moon phase. The ability to catch prey might increase the activity of owls and thus their vocalizations or, alternatively, it could increase their vulnerability to predation, especially in small owl species (Seavy 2004).

The reason why an influence of weather and moon phase on response rate varies among species can be manifold (Ganey 1990, Enriquéz-Rocha & Rangel-Salazar 2001, Crozier *et al.* 2003). For example, there may be an effect of geography, and studies conducted in temperate regions might by incomparable to studies in tropical environments because weather fluctuates less in the tropics than in temperate regions (Pardeick *et al.* 1996). Secondly, variation in results may arise due to differences in habitat where the studies took place (Sheick 1997). Hence, the differences in response rate that we observed between Burrowing Owl and Tropical Screech Owl might have resulted from the preferred habitat used by each species. Species that use more open habitats as the Burrowing Owl might be more exposed to variation in wind speed and

Table 3. Top-ranking models (ΔAIC ≤ 2) for Burrowing Owl response rates in relation to air temperature (Temp), relative air humidity (Hum), wind speed (Wind) and moon phase (Moon). Models are ranked based on AIC. Parameter estimates (B), SE and associated *P*-values are given.

Model	Parameter	B	SE	*P*	AIC	ΔAIC
Wind + Moon + Temp	intercept	–2.44	0.67	<0.005	156.2	0.00
	Temp	0.06	0.03	0.11		
	Wind	–1.18	0.38	<0.005		
	Moon	1.45	0.39	<0.005		
Wind + Moon	intercept	–1.56	0.34	<0.005	156.9	0.71
	Wind	–1.00	0.36	0.01		
	Moon	1.37	0.39	<0.005		
Wind+ Moon + Temp + Hum	intercept	–1.55	1.26	0.22	157.5	1.34
	Temp	0.05	0.04	0.15		
	Wind	–1.13	0.38	<0.005		
	Hum	–0.01	0.01	0.42		
	Moon	1.41	0.39	<0.005		
Hum + Wind + Moon	intercept	–0.50	1.03	0.63	157.7	1.56
	Wind	–0.96	0.36	0.01		
	Hum	–0.01	0.01	0.28		
	Moon	1.36	0.39	<0.005		

moon phase, and less to effects of temperature and air humidity. Conversely, Tropical Screech Owl, inhabiting woody habitats, might be 'protected' in relation to these variations and be more affected by temperature and air humidity that influences its prey activities.

Future playback efforts should try to improve response rates (and eventually establish detection probabilities) for owls. In order to improve response rates using playback experiments, we suggest that survey designs take into consideration aspects of habitat preferences, geographical variation, season and behaviour, along with potential influences of weather and moon conditions. The overall owl diversity, loss and degradation of habitats, and the lack of basic biological information on owls, especially in the Neotropics, make rigorous survey methods and monitoring protocols even more urgent. More studies are critically needed.

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SAMENVATTING

Omdat uilen overwegend ’s nachts actief zijn is het inventariseren ervan lastig. Om uilen te lokaliseren wordt daarom veel gebruik gemaakt van de zogenaamde ‘playback’-methode, het uitlokken van uilen door hun roep af te spelen. Dit onderzoek ging in op de vraag in hoeverre de reactie van uilen afhangt van de windsnelheid, temperatuur, luchtvochtigheid en maanstand. Dit werd onderzocht bij de Choliba Schreeuwuil *Megascops choliba* en de Holenuil *Athene cunicularia* in het zuidoosten van Brazilië. De Choliba Schreeuwuil komt voor in besloten landschap met struiken of bomen, terwijl de Holenuil open graslanden en savannes prefereert. Er werden 16 waarnemingspunten geselecteerd in vier verschillende landschapstypes, variërend van open grasland tot bossavanne. Het veldwerk vond plaats van juni tot december 2004 en viel samen met het voortplantingsseizoen van de uilen. Viermaal werd gedurende vijf opeenvolgende nachten geïnventariseerd tijdens volle maan en viermaal tijdens nieuwe maan. Tijdens de 112 afspeel- en luistersessies kwam er 54 maal (48%) respons van de Choliba Schreeuwuil en 30 maal (27%) van de Holenuil. De kans op respons door de Choliba Schreeuwuil nam toe met temperatuur en luchtvochtigheid, terwijl de Holenuil het meest riep tijdens nachten met volle maan.

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