NAT CONSERVACAO. 2014;12(2):106–111

Natureza & Conservação
Brazilian Journal of Nature Conservation
Supported by Boticário Group Foundation for Nature Protection
http://www.naturezaeconservacao.com.br

Research Letters

Blown in the wind: bats and wind farms in Brazil

Enrico Bernard[a,*], **Adriana Paese**[b], **Ricardo Bomfim Machado**[c], **Ludmilla Moura de Souza Aguiar**[c]

[a] *Laboratório de Ciência Aplicada à Conservação da Biodiversidade, Departamento de Zoologia, Universidade Federal de Pernambuco – UFPE, Recife, PE, Brazil*
[b] *Instituto Amigos da Reserva da Biosfera da Mata Atlântica, São Paulo, SP, Brazil*
[c] *Departamento de Zoologia, Instituto de Ciências Biológicas, Universidade de Brasília – UnB, Brasília, DF, Brazil*

ARTICLE INFO

Article history:
Received 29 January 2014
Accepted 15 August 2014
Available online 11 November 2014

Keywords:
Chiroptera
Clean energy
Environmental Impact Assessment
Renewable energy
Wind energy
Wildlife interaction

ABSTRACT

The number of wind turbines in operation in Brazil will triple in five years, raising concern for the conservation of Brazilian bats. We analyzed the status of bat species richness and occurrence in areas with high wind potential in Brazil. By crossing datasets on species records and wind potential we identified 21 hotspots and 226 data gap areas. Overall, 70% of the areas with the highest wind potential are data gaps, lacking elementary information about species presence. Current Environment Impact Assessments system for wind farms in Brazil has relaxed regulations and questionable effectiveness. Environmental agencies should require *de facto* Environment Impact Assessments in data gap areas, with technical rigor proportional to the investment under course. At least for bats, the Brazilian wind power sector must raise the bar, adopting a more rigorous licensing. Alliances to minimize bat mortality at wind farms are necessary and this goal should be pursued in Brazil.

Introduction

Wind power generation is a major source of renewable energy and has gained increasing attention due to lower greenhouse gases emissions (Jacobson, 2009). The installation of hundreds of wind farms in different parts of the world has brought the need to assess the impact of wind turbines on bats (e.g. Kunz et al., 2007a; Rodrigues et al., 2008). Such studies indicated the occurrence of collisions with blades and towers, causing the death of animals in several countries (e.g. Arnett et al., 2008; Baerwald and Barclay, 2009; Hayes, 2013). Towers can reach heights equivalent to 30-story buildings, blades cover large areas when moving, and larger turbines can reach the airspace of migratory bats (Barclay et al., 2007; Voigt et al., 2012). Some studies have shown that while bats collide with other man-made structures, the frequency and magnitude of these collisions are minor when compared to collisions associated with wind turbines (Arnett et al., 2008).

* *Corresponding author at*: Laboratório de Ciência Aplicada à Conservação da Biodiversidade, Departamento de Zoologia, Universidade Federal de Pernambuco, 50670-420 Recife, PE, Brazil.
E-mail address: enrico.bernard@ufpe.br (E. Bernard).
http://dx.doi.org/10.1016/j.ncon.2014.08.005
1679-0073/

The current knowledge about the causes of bat collisions with wind turbines is unsatisfactory (Kunz et al., 2007a), but the cumulative effects of this mortality can have significant impacts on long-term populations of species affected (Kunz et al., 2007b; Arnett et al., 2008). Bats are long-living, low reproductive rate organisms, projecting a slow population growth and limited ability to recover from population declines, increasing the risk of local extinctions (Arnett et al., 2008). In fact, the American Society of Mammalogists points to the imperative need of scientific studies pre- and post-installation of wind farms (Arnett et al., 2008).

Wind energy production is now booming in some biodiversity rich tropical countries (WWEA, 2013). This is the case of Brazil. Although the country relies mainly on hydroelectricity, the *Atlas do Potencial Eólico do Brasil* (Amarante et al., 2001) indicates more than 71,000 km^2 with wind speeds suitable for power generation, with an estimated potential of 143 gigawatts (GW). Currently, wind energy accounts for only 2% of the electricity produced in Brazil, with a vast potential for growth in the country. The Brazilian government has been promoting the installation of new wind farms, and the construction of new parks is in full speed. Currently in Brazil there are at least 119 wind farms in operation, producing about 2.8 GW (ABEE, 2013). The prediction of wind power installed for the country is 8.7 GW in 2017 (ABEE, 2013), indicating that the number of farms and turbines in Brazil will triple in the next five years.

The knowledge on the impacts of wind turbines on bats in Brazil is very scarce, usually restricted to gray literature (Sovernigo, 2009; Rui and Barros, 2012). With a rich and diversified bat fauna (nearly 180 species – Paglia et al., 2012), the interaction with wind turbines is already considered one of the 10 most relevant issues for the conservation of bats in Brazil (Bernard et al., 2012). To document the existence and patterns of bat fatalities associated with wind farms is critical to (1) better understand this interaction and classify its environmental impacts as neutral or negative, (2) quantify and qualify environmental impacts so far little measured in the country, (3) contribute to the local and cumulative mitigation of impacts on the flying wildlife, and (4) generate quantitative and qualitative data useful for improving the environmental licensing of future wind projects in the country.

We analyzed the status of bat species richness and occurrence in areas with high wind potential in Brazil. We address

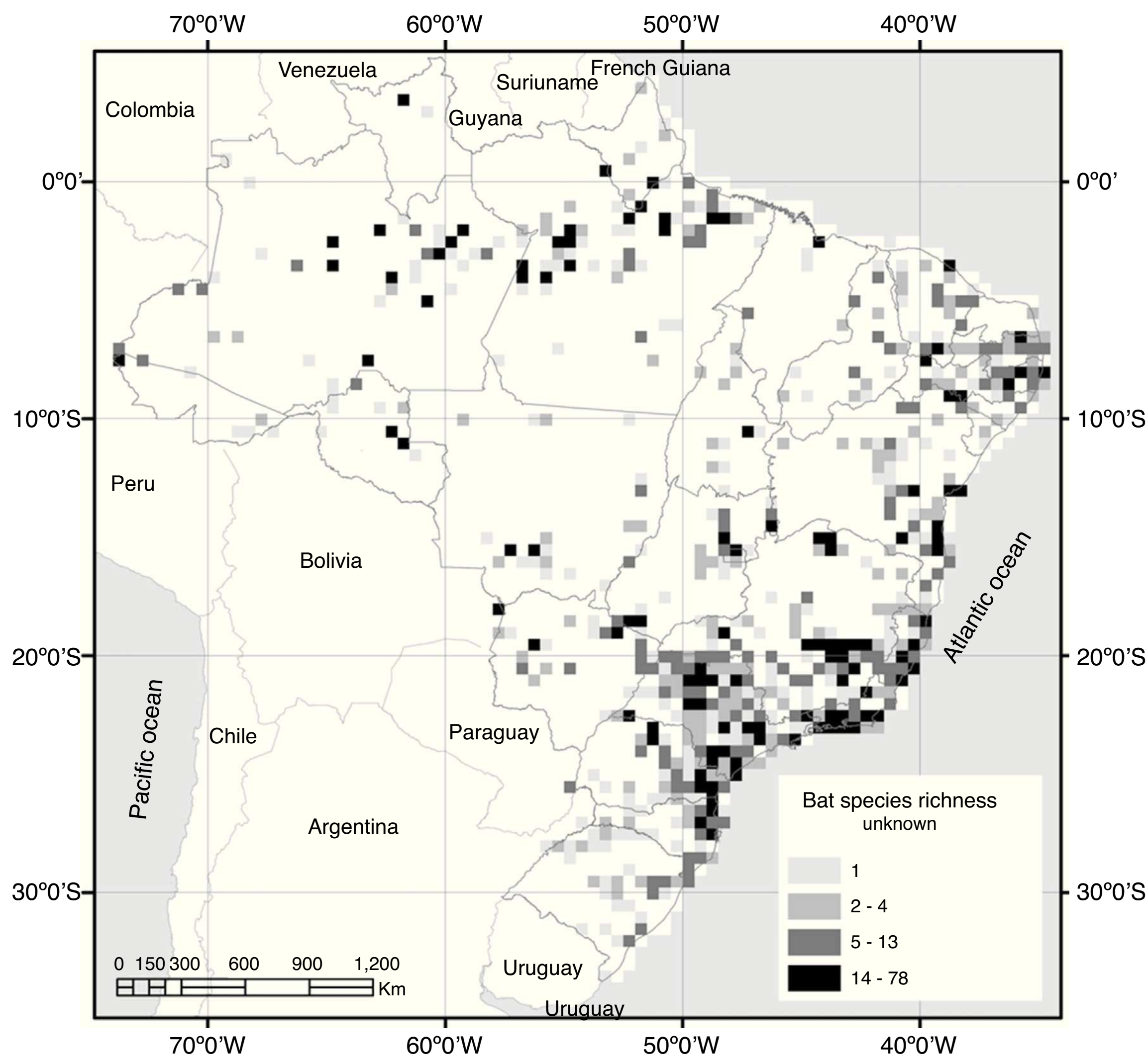

Fig. 1 – Bat species richness in Brazil grouped in cells with 0.5° of latitude × 0.5° of longitude.

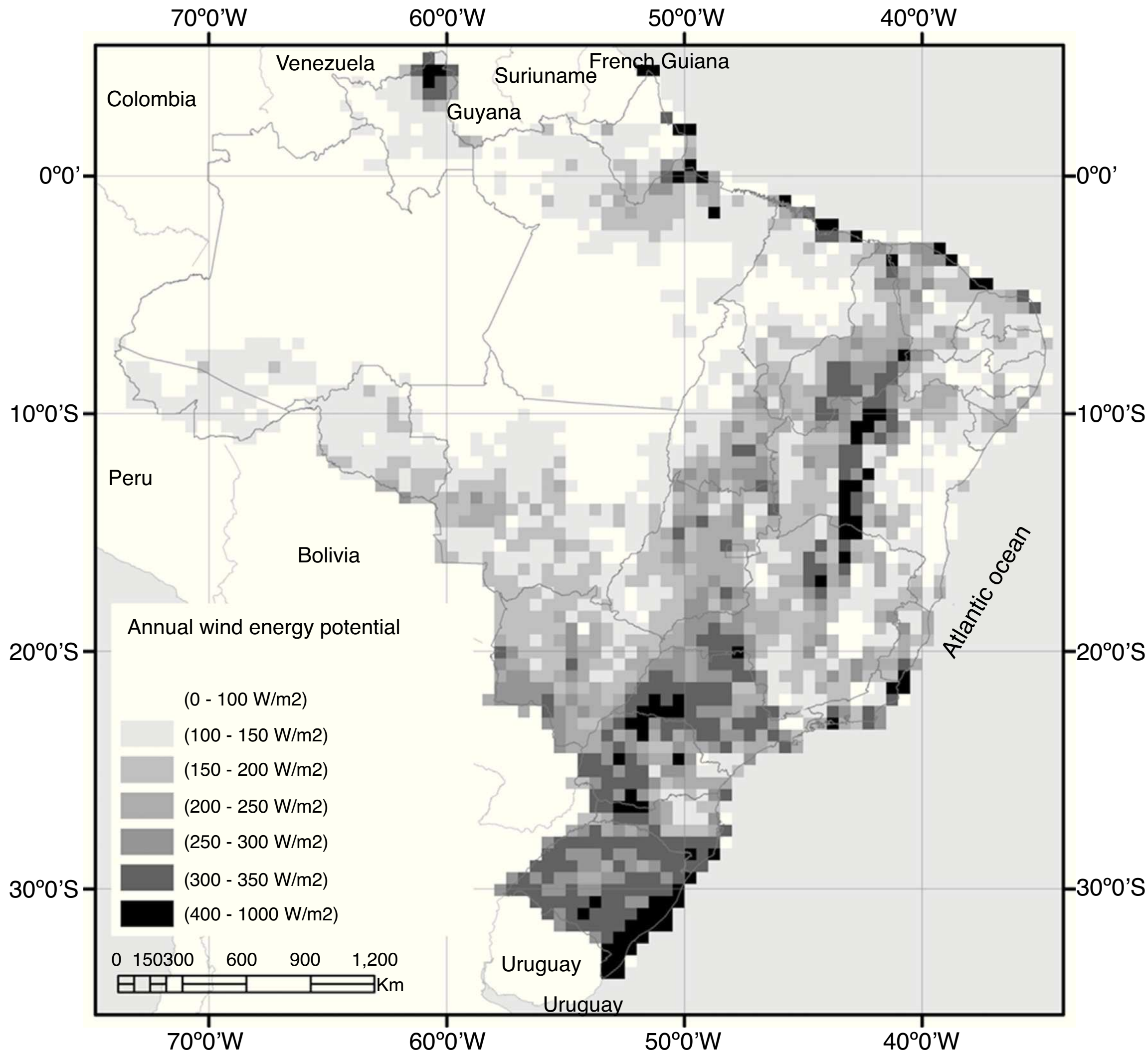

Fig. 2 – Estimated annual wind energy potential (in W/m^2) in Brazil, based on data from *Atlas do Potencial Eólico do Brasil* (Amarante et al., 2001). Data presented in cells with 0.5° of latitude × 0.5° of longitude.

data gaps, suggest priority areas for research on the interaction of bats and wind farms in the country, and discuss caveats in the environmental licensing, contributing to the discussion about the impacts of electricity generation in Brazil, a megadiverse country.

Materials and methods

We used a data bank on the occurrence of bats in Brazil (see Bernard et al., 2011) and plotted coordinates on a map, grouping them in 1° latitude × 1° of longitude grid cells. Using ArcGIS v10 (www.esri.com), we summarized data sets into the grid cells, with the respective number of species inside. We used the "Spatial Join" command to overlap the maps containing single records and grid cells, and the program RStatistical Package (R Core Team, 2013) to calculate the total number of species inside each cell (Fig. 1).

We then considered the atlas with the wind potential for the entire country (Amarante et al., 2001), which presents the average wind speed for Brazil. Since the original atlas used a finer scale, we adopted the maximum wind speed detected in each cell for that entire cell, producing a map at the same scale of that with species richness (Fig. 2). We then sorted the cells with a potential ≥300 W/m^2, and considered them as with the highest wind potential in the country (hereafter, CHP).

We crossed data from both maps and evaluated the current status of the knowledge on bat records along the CHP. We considered as data gaps the CHP with no data for bats, and as hotspots the CHP with richness ≥10 spp., a very conservative threshold considering that nearly 180 species of bats are known in the country.

Results

We considered 5502 records of bats in Brazil which resulted in data for 330 of the 804 cells covering the country. Species-rich areas are scattered along the country, most as single cells (Fig. 1). South-eastern parts of Brazil had the highest density

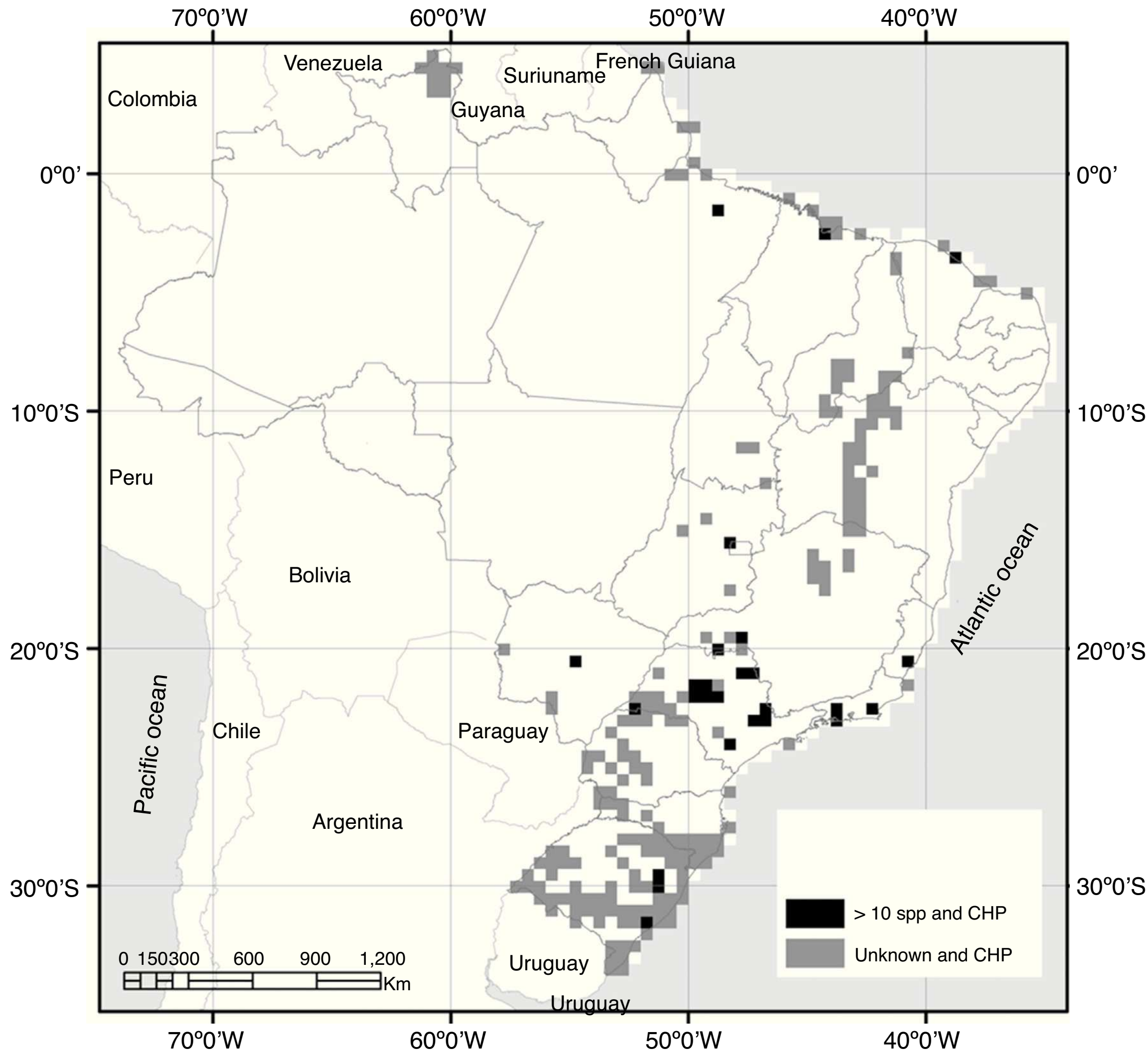

Fig. 3 – Hotspots and data gap areas for bats and wind farms in Brazil. Cells with the highest wind potential (≥300 W/m^2) but with no data for bat species richness were classified as data gaps (gray); those with richness ≥10 species were considered hotspots (black). Data presented in cells with 0.5° of latitude × 0.5° of longitude.

of records. Considering the total number of cells within each of the terrestrial Brazilian biomes, there were records for 80% of the Atlantic Forest, 67% of Caatinga, 47% of Pantanal, 41% of Cerrado, 40% of Pampa, and 24% of Amazonia. However, <10% of the country is minimally surveyed, and for nearly 60% of Brazil there is not a single record of bat species (for more details see Bernard et al., 2011). The wind potential is basically concentrated along a diagonal crossing the country from its Southern cone, through Central Brazil, up to the Northeastern coast (Fig. 2).

Based on the wind potential, we identified 321 CHP, mainly located in the southern cone of Brazil, and along the central portion of Bahia and northern Minas Gerais, along the north-eastern coast – especially in Rio Grande do Norte and Ceará – and in the extreme north of Roraima (Fig. 2). Crossing species richness data against CHP indicated 21 hotspots and 226 data gap areas (Figs. 3 and 4). Overall, 70.4% of the CHP are data gaps for bats in Brazil.

Discussion

Our analysis indicates that 70% of the areas with the greatest potential for wind energy generation in Brazil are data gaps for bats, with a complete lack of elementary information about their species richness and occurrence. In those areas are being built the largest wind farms in the country and due to such striking absence of data we recommend that data gap areas here identified should be listed as priorities for bat inventories in Brazil. This is the case of parts of the states of Rio Grande do Sul, Bahia, Rio Grande do Norte and Ceará.

Even within the data gap areas there is a need for prioritization. The strip of coastal dunes of Rio Grande do Norte and Ceará have a tendency of lower bat species richness. The situation in Bahia and Rio Grande do Sul raises special concern. In Bahia, about 20 species of bats have been recorded in the Chapada Diamantina (Oliveira and Pessôa, 2005), but the vegetation of the region, a mosaic of *campo rupestre*, hillside forests,

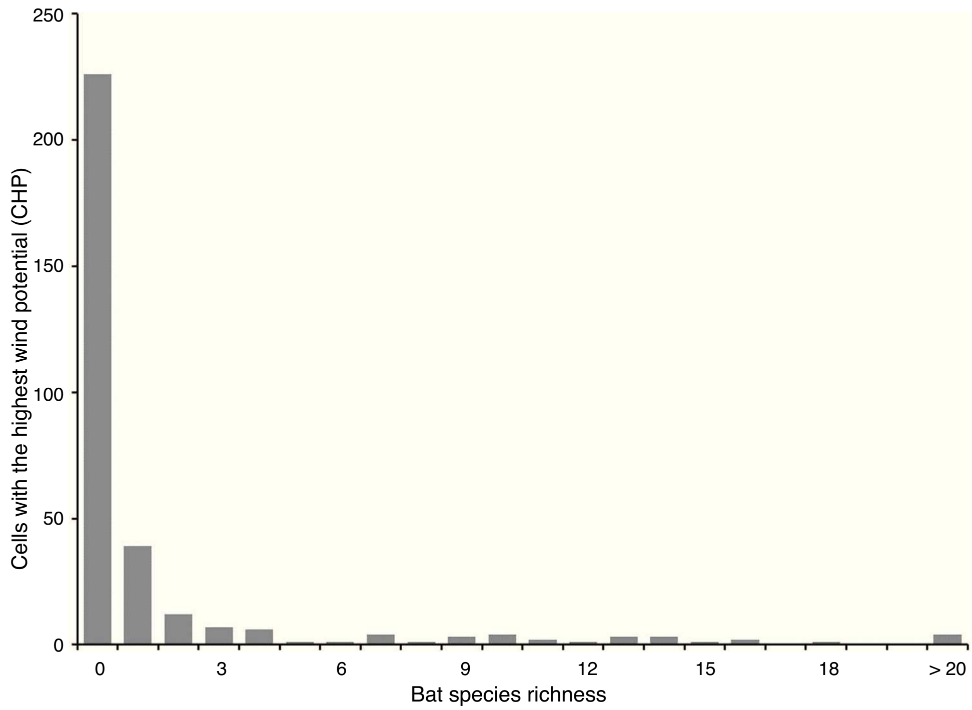

Fig. 4 – Bat species richness in 321 areas with the highest wind potential in Brazil. Areas consisted of a cell with 0.5° of latitude × 0.5° of longitude.

semi-deciduous seasonal forest, *cerrados*, *caatinga* and gallery forests points to a higher species potential. The real local bats richness may be underestimated, requiring more inventories (Bernard et al., 2011).

The chiropterofauna of Rio Grande do Sul, dominated by insectivorous from Vespertilionidade and Molossidae families, resembles the bat fauna affected by wind farms in other temperate regions (Barclay et al., 2007; Arnett et al., 2008). Further, the possibility of migratory species in southern Brazil – and the lack of data about it – need to be considered. In Germany, bats killed in wind farms in the summer and autumn were originated from Scandinavia, the Baltic countries, Belarus or Russia, showing that wind turbines kill bats not only of sedentary local populations but also of distant populations (Voigt et al., 2012).

A vicious circle

Poorly conducted Environmental Impact Assessments (hereafter EIA) may underestimate the real impact of wind farms on the flying wildlife (Kunz et al., 2007a). Studies on bird mortality in wind farms in Spain indicated a weak relationship between risk assessment studies and recorded mortality, with significant differences in birds effectively recorded flying in the wind farms and the lists presented in their EIA (Ferrer et al., 2012). In the U.S., an analysis of 49 EIA for wind parks indicated that 66% failed to provide high levels of preconstruction avian and bat survey information, compared to recommended factors from state guidelines (Chang et al., 2013). Improving the quality and technical rigor of EIA in wind farms is crucial, especially those oriented to evaluate the impact on bats.

In Brazil, the current EIA for wind farms raises concerns, since they may underestimate the real impact affecting Brazilian bats. This may result from a combination of factors: (1) poor bat information in the pre-construction phase; (2) post-construction surveys primarily designed for avian fatalities; (3) the lack of acoustical inventories and standardized sampling protocols; (4) poorly designed monitoring programs; (5) the difficulty of finding the carcasses of dead bats, their removal by scavenger animals and the lack of calibration estimates; (6) the type of vegetation surrounding the turbines; and (7) the search efficiency for dead animals (see Homan et al., 2001; Camina, 2012).

For the Northeastern region of Brazil, which has the largest potential for wind generation and also the largest wind farms installed in the country, there are no published data on the mortality of bats by wind turbines. The environmental agencies of six states with wind facilities (including Bahia, Ceará and Rio Grande do Norte) require only a simplified environmental report (*Relatório Ambiental Simplificado*), frequently ignoring bats among the potentially affected fauna (MMA, 2009). Further, in order to simplify the licensing, they allow the fragmentation of larger farms in smaller sub-farms, ignoring the cumulative effect of dozens of wind turbines in one location. Due to such relaxed regulations, and based on our analysis, we strongly recommend the state environmental agencies in Brazil to require *de facto* inventories in the licensing of wind farms in data gap areas. Agencies should not accept EIA with species lists artificially generated based on distant and/or questionable data obtained in the literature. In the case of the data gap areas we detected, these documents will clearly and unambiguously underestimate the actual local bat species richness. Moreover, EIA based solely on mist netting at ground level, or those without a well-designed protocol to evaluate carcass removal, are unacceptable considering they could grossly underestimate the local bat species richness and the effective number of bats killed (Kunz et al., 2007a,b; Rodrigues et al., 2008).

Other countries have already adopted – mandatorily or voluntarily – more rigorous sampling and monitoring protocols when dealing with bats and wind farms (e.g. Rodrigues et al., 2008; González et al., 2013). The technical rigor of environmental agencies licensing wind farms in Brazil should be proportional to the significant expansion experienced by the sector, as well as to the volume of financial resources being invested and to the prominent position wind energy will have in the Brazilian supply in the near future. Brazilian environmental agencies have key-roles to improve standards, but, in order to advertise itself as a low environment impact industry, at least for bats, the national wind power sector must raise the bar and should voluntarily adopt a more rigorous environmental licensing. Alliances of state and federal agencies, private industry, academic institutions and non-governmental organizations committed to finding solutions to minimize bat-mortality at wind-power turbines are necessary (e.g. Bats and Wind Energy Cooperative – www.batsandwind.org) and this goal should be pursued in Brazil. In a win–win situation, the black box of EIA for wind farms in operation in Brazil must be opened; the data on the current impacts, the mitigation approaches, and management propositions must be openly accessible for a peer-review process. Anyway, solutions to this problem will require cooperation and willingness of all parts involved.

Conflicts of interest

There are no conflicts of interest.

Acknowledgements

We thank the Departamento de Zoologia – UFPE, and the Departamento de Zoologia – UnB for supporting our research on bats in Brazil. R.B.M. receive research productivity grant awarded by the CNPq (Process 304613/2010-0).

REFERENCES

Amarante, O.A.C., et al., 2001. Atlas do Potencial Eólico Brasileiro, http://www.cresesb.cepel.br/index.php?link=/atlas_eolico_brasil/atlas.htm

Arnett, E.B., et al., 2008. Patterns of bat fatalities at wind energy facilities in North America. J. Wildl. Manage. 72, 61–78.

Associação Brasileira de Energia Eólica, 2013. Nosso setor, http://www.abeeolica.org.br/novo-site/index.php/nosso-setor.html

Baerwald, E.F., Barclay, R.M.R., 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. J. Mammal. 90, 1341–1349.

Barclay, R.M.R., Baerwald, E.F., Gruver, J.C., 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Can. J. Zool. 85, 381–387.

Bernard, E., et al., 2012. Uma análise de horizontes sobre a conservação de morcegos no Brasil. In: Freitas, T.R.O., Vieira, E.M. (Eds.), Mamíferos do Brasil: Genética, Sistemática. Ecologia e Conservação, vol. II. Sociedade Brasileira de Mastozoologia, Rio de Janeiro, pp. 19–35.

Bernard, E., Aguiar, L.M.S., Machado, R.B., 2011. Discovering the Brazilian bat fauna: a task for two centuries? Mammal Rev. 41, 23–39.

Camina, A., 2012. Bat fatalities at wind farms in northern Spain – lessons to be learned. Acta Chiropterol. 14, 205–212.

Chang, T., et al., 2013. A quantitative method to analyze the quality of EIA information in wind energy development and avian/bat assessments. Environ. Impact Assess. 38, 142–150.

Ferrer, M., et al., 2012. Weak relationship between risk assessment studies and recorded mortality in wind farms. J. Appl. Ecol. 49, 38–46.

González, F., Alcalde, J.T., Ibáñez, C., 2013. Directrices básicas para el studio del impacto de instalaciones eólicas sobre poblaciones de murciélagos en España, SECEMU. Barbastella 6, 1–31.

Hayes, M.A., 2013. Bats killed in large numbers at United States wind energy facilities. BioScience 63, 975–979.

Homan, H.J., Linz, G., Peer, B.D., 2001. Dogs increase recovery of passerine carcasses in dense vegetation. Wildl. Soc. Bull. 29, 292–296.

Jacobson, M.Z., 2009. Review of solutions to global warming, air pollution, and energy security. Energy Environ. Sci. 2, 148–173.

Kunz, T.H., et al., 2007a. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. J. Wildl. Manage. 71, 2449–2486.

Kunz, T.H., et al., 2007b. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Front. Ecol. Environ. 5, 315–324.

Ministério do Meio Ambiente, 2009. Consolidação da Pesquisa Sobre Licenciamento de Parques Eólicos, http://www.mma.gov.br/estruturas/164/_publicacao/164_publicacao26022010101115.pdf

Oliveira, J.A., Pessôa, L.M., 2005. Mamíferos. In: Juncá, F.A., Funch, L., Rocha, W.<ed> (Eds.), Biodiversidade e Conservação da Chapada Diamantina. Ministério do Meio Ambiente, Brasília, pp. 376–405.

Paglia, A.P., et al., 2012. Lista Anotada dos Mamíferos do Brasil, vol. 6., 2nd ed. updated Occasional Papers in Conservation Biology, pp. 1–75.

R Core Team, 2013. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/

Rodrigues, L., et al., 2008. Guidelines for Consideration of Bats in Wind Farm Projects, vol. 3. UNEP/EUROBATS Publication, pp. 1–51.

Rui, A.M., Barros, M.A.S., 2012. Distribuição espacial da mortalidade de morcegos em parques eólicos no Sul do Brasil. In: Anais do VI Congresso Brasileiro de Mastozoologia. Sociedade Brasileira de Mastozoologia, Rio de Janeiro.

Sovernigo, M.H., (B.Sc. thesis) 2009. Impacto dos aerogeradores sobre a avifauna e quiropterofauna no Brasil. Universidade Federal de Santa Catarina, Florianópolis, pp. 1–61.

The World Wind Energy Association, 2013. 2013 Half Year Report, http://www.wwindea.org/webimages/Half-year_report_2013.pdf (accessed 25.10.13).

Voigt, C.V., et al., 2012. The catchment area of wind farms for European bats: a plea for international regulations. Biol. Conserv. 153, 80–86.