



## Technological prospecting on bioacoustic studies in bats

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### INFO

**Keywords**  
echolocation  
chiroptera  
monitoring  
patents

### ABSTRACT

The development of technologies for the study of bats allows for more in-depth research on this essential group for the ecosystem, as they act in the ecological balance, as the main dispersers, pollinators and controllers of agricultural pests in certain regions of the planet. Patent technology for bioacoustics studies of the order Chiroptera, based on data platforms: National Institute of Industrial Property (INPI), European Patent Office (EPO), World Intellectual Property Organization (WIPO) and Google Patents. The search terms were: bat echolocation, bat bioacoustics, bats echolocation and bats bioacoustics. The word “Bats” was predominant in Google Patents 47.8%, EPO 12.5%, WIPO 6.4%. The data obtained suggest that technologies aimed at bat bioacoustics are emerging, having increased in the last decade, an important factor for the applicability of new techniques for conservation and monitoring of fauna.

### RESUMO

#### Palavras-chaves

*chiroptera*  
ecolocalização  
monitoramento  
patentes

#### *Prospecção tecnológica sobre estudos bioacústicos em morcegos*

O desenvolvimento de tecnologias para o estudo dos morcegos permite pesquisas mais aprofundadas sobre esse grupo essencial para o ecossistema, pois atuam no equilíbrio ecológico, como principais dispersores, polinizadores e controladores de pragas agrícolas em determinadas regiões do planeta. O objetivo deste trabalho foi realizar uma prospecção tecnológica de patentes para estudos bioacústicos da ordem Chiroptera, a partir das plataformas de dados: Instituto Nacional da Propriedade Industrial (INPI), European Patent Office (EPO), World Intellectual Property Organization (WIPO) e Google Patents. Os termos de buscas foram: ecolocalização de morcegos, bioacústica de morcegos, bats echolocation e bats bioacoustics. A palavra “Bats” teve predominância no Google Patentes 47,8%, EPO 12,5%, WIPO 6,4%. Os dados obtidos sugerem que tecnologias voltadas à bioacústica de morcegos são emergentes, possuindo aumento na última década, fator importante para a aplicabilidade de novas técnicas de conservação e monitoramento de fauna.

Received 15 January 2021; Received in revised from 02 May 2022; Accepted 11 June 2022



## INTRODUCTION

Bats are the most diverse group of mammals on the planet, with the largest number of population representatives and differentiated components, considering the different feeding habits (frugivores, insectivores, nectarivores, carnivores, piscivores and hematophagous) and the unique flight capacity between the mammals. Despite the various decontextualized interpretations, these animals are fundamental in the ecological balance, being the dispersers, pollinators and controllers of agricultural pests in certain regions of the planet, thus considered by Adams e Pedersen (2013) as the most economically important non-domesticated animals.

In addition to the ability to fly, bats have a unique ability called echolocation. This location system is used for spatial orientation, determining the position of the animal in relation to the environment. Some species use sound frequencies emitted by prey to obtain food, as well as find mates at the time of mating. In this way, these animals combine auditory frequencies and sound emitted, ranging from 20 kHz to 200 kHz. The human audible frequency compared to that of bats varies between 200 Hz and 20,000 Hz, being below the other group of mammals.

Within studies related to the emission of sounds, bioacoustics is considered a line of research within biology, which has increased its scope in recent decades, relating the emission of sounds by animals for the purpose of communication, to other uses, such as echolocation (Rostirolla et al., 2021). Since its effective development in the 1950s, major technological advances leading to portability and autonomy of equipment, as well as storage capacity, have greatly increased the applicability of bioacoustics (Blumstein et al., 2011; Stowell, 2018).

Non-invasive tools for environmental assessment and monitoring prove to be important allies to the conservation of habitats and, consequently, animal and plant species (Rostirolla et al., 2021). The so-called Passive Acoustic

Sampling (PAS) employ autonomous sound recorders that are being used for animal studies, presenting current results with some insects, reptiles and mammals in general, mainly bats, due to the extreme difficulty of visualization in their habitat.

Based on the need to improve studies in the acoustic area with bats, technological industries have increased the production, especially after the year 2000, of specific tools for this purpose: sound recording devices, microphones and computer programs. This work aimed to carry out a technological prospection of patent deposits related to bioacoustics and fauna monitoring technologies applied to the order Chiroptera.

## MATERIALS AND METHODS

The prospection was carried out from patent applications deposited in different national and international databases, respectively: National Institute of Intellectual Property (INPI); European Patent Office (EPO); World Intellectual Property Organization (WIPO); Google Patents. Data collection took place in September 2021, searching for patents in the period from 2000 to 2021, using the following descriptors: Morcegos, Chiroptera, Ecolocalização and Bioacústica for the national database (INPI), using terms in Portuguese and Bats, Chiroptera, Echolocation and Bioacoustics, for international databases (EPO, WIPO and Google Patents), and using English terms. Data were analyzed qualitatively and quantitatively using descriptive statistics.

## RESULTS AND DISCUSSION

Patent applications were first analyzed according to the search descriptors used (Table 1). When using the general search engine, ample results are found, aimed at the most diverse applications, such as the word “Bats” with predominance in Google Patents 47.8% (135,832), EPO 12.5% (35,637), WIPO 6.4% (18,226).

Table 1 - Results for terms separate descriptors.

Descriptors	INPI	EPO	WIPO	Google Patents
Bats	0	35.637	18.226	135.832
Morcegos	5	1	18	0
Chiroptera	0	267	655	81.637
Echolocation	0	1.263	1.275	9.031
Ecolocalização	1	0	0	0
Bioacoustics	0	166	233	1
Bioacústica	2	1	0	0
Total	8	37.334	20.181	226.500
<b>Grand total</b>				<b>284.023</b>

It was observed that the use of combined terms decreases the number of results. Thus, for the present study, advanced search engines were used

in the databases, using "and or e" as word connectors, as shown in Table 2.

Table 2 - Results for combined descriptor terms.

Combined Descriptors	INPI	EPO	WIPO	Google Patents
Ecolocalização de morcegos	1	0	0	0
Bioacústica e Morcegos	0	0	0	0
Bats and Bioacoustics	0	5	14	54
Bats and Echolocation	0	168	120	999
Total	1	173	134	1.053
<b>Grand total</b>				<b>1.361</b>

Among the platforms used, the results of Google Patents stood out in relation to the others, despite having a smaller library, totaling 87 million. Meanwhile, the EPO submitted 107 million results. Pires et al., (2020) attributed the machine translation tool to English as a possible explanation for these results. However, the present study used this language directly for data research, which does not corroborate the cited work. The documents found with the combined terms were gathered and analyzed based on the following categories: distribution of patents by country, year of publication of patents, legal status of patents and international patent classification (IPC).

### Distribution of patents by country

Understanding which countries have the highest number of patent deposits is important to characterize systems of technological innovation around the planet, as well as to observe in which

places studies with certain areas are being carried out. Thus, the country with the most patents registered for bioacoustic studies of the order Chiroptera was the United States, with 9,353 applications filed with WIPO, 337 with Google Patents, 152 with the EPO and 2 with the INPI.

Followed by the UK with 1,975 deposits, and Canada with 1,351 total deposits. Using only WIPO data. Figure 1 was created containing the countries that presented the highest number of patents related to the descriptor Bats Bioacoustics. According to the INPI, Brazil has not filed a patent application related to bat bioacoustics in this database.

The United States had the highest number of registered patents per country, which is consistent with the country's level of economic and technological development. The economic numbers of countries show interesting differences in the number of patent applications, in proportion to their GDP, when analyzing emerging countries.

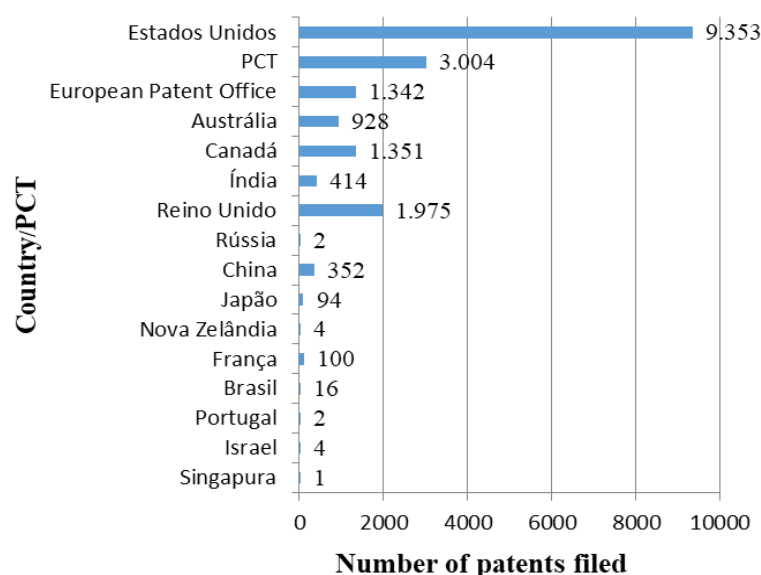


Figure 1 - Distribution of patents by countries on the WIPO platform.

## Year of publication of patents

The present study only considered patents in which the first application was made in 2000 and the last in 2021. Thus, the searches carried out in the INPI, Google Patents, EPO and WIPO banks for

the determinant "Bats Bioacoustics" concluded that the year 2011 had the highest number of applications, with 24 patent applications filed for this term (see Figure 2), while the INPI did not present any results for the search.

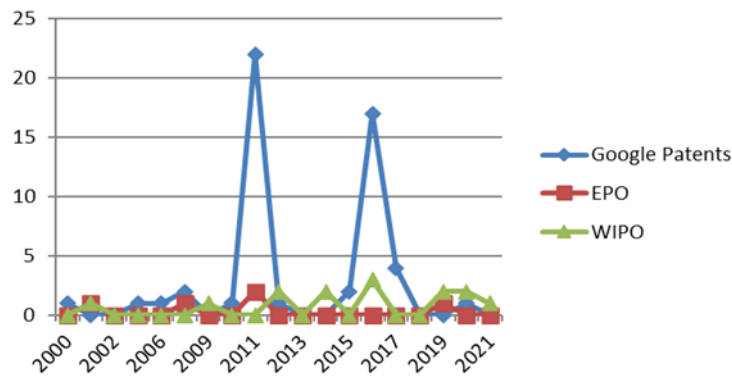


Figure 2 - Patent filing, with "Bats Bioacoustics", by year in Google Patents, EPO and WIPO databases.

However, the use of the descriptor term "echolocation in bats" carried out in the same databases, pointed to a more pronounced number of patents in Google Patents (n = 920), followed by

EPO (n = 154), WIPO (n = 10) and the INPI (n = 0) remained without results. Figure 3 expresses the values found.

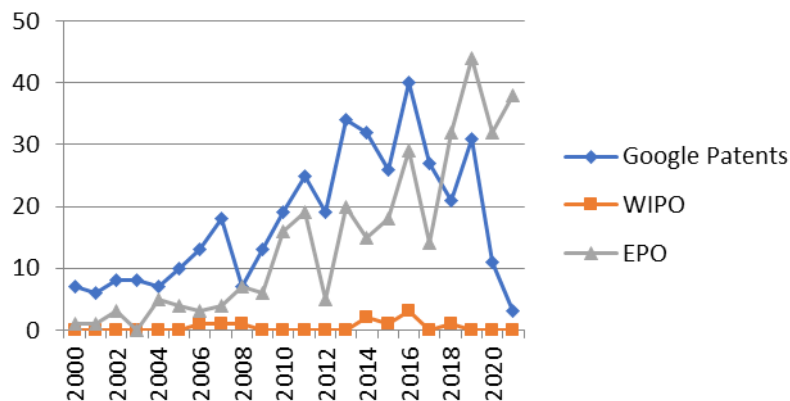


Figure 3 - Patent filing, with "echolocation in bats", by year in Google Patents, EPO and WIPO databases.

The significant increase in the number of patent documents in 2011 may be associated with the expansion of graduate programs in the area, which linked the defense of dissertations and theses to patent applications (Costa et al., 2018; Florencio et al., 2020). However, the decline in recent years can be explained by the unfavorable economic environment or the high level of inventory awaiting analysis, considering that all patent applications have a so-called "secrecy period", which generally lasts up to 18 months from the filing date or the earliest priority date (Santos and Kalid, 2020).

Brazil, for example, shows a significant drop, with a reduction of at least 20% in registrations, according to the Brazilian Intellectual Property

Association (BIPA or ABPI in portuguese) (2021), resulting from the fact that funding for studies developed by technology institutions, universities and some private companies dependent on government loans (França, 2021).

## Patents Legal status

The patents found were analyzed based on their legal status of publication. Thus, from the search in the INPI, EPO, WIPO and Google Patents databases, some applications filed were selected to represent the models found (Table 3).

Table 3 - Patent applications legal Status in the WIPO, INPI, Google Patents and EPO.

Publication Number	Applicant	Legal Status	-IPC	Year
WO2007084122A2	Hickling Robert (US)	Granted	G01S15/88	2007
20090237241	Wildlife Acoustics, Inc.	Granted	G08B 21/00	2009
BR102016 0142903A2	Frontier Wind, LLC (US)	Filed	F03D 80/10 G10K 11/36 G10K 11/18 A01M 29/18	2016
US201662432075P	Research Foundation of State University of New York	Pending	G10K11/1785	2020

Table 3 presented the legal status of the patents selected for exemplification, where most of the companies mentioned work in the area of technology, however, also encompassing the development of mechanisms for expansion of studies in the environmental area. The results presented include the years 2007, 2009, 2016 and 2020.

The company Wildlife Acoustics, Inc. deposited application 20090237241B2 with WIPO, which is a utility model (MU) entitled “Apparatus for Scheduled Low Autonomous Data Recording”. The same was invented by Agranat Ian and corresponds to a method and device that can be programmed to emit an electrical discharge and recharge other devices, it can be programmed to perform this function, being associated with an alarm. This technology helps in monitoring wild animals, such as bats themselves, activating photographic cameras and audio recorders without the need for someone to be present on site.

The patent BR1020160142903A2 at the INPI, by inventors Thomas J. Green and Erick Rickards, entitled “Wildlife Arrest System Arranged on a Wind Turbine Blade”, had its process filed, according to article 36, of the LPI, since there was no manifestation of the depositor regarding the formulated demand, refers to systems and methods that are exposed to wildlife, such as bats and birds, from being drawn too close to an operating wind turbine.

Bats may avoid areas where ultrasonic frequencies are being emitted, either because the emitted ultrasonic frequency interferes with the bat's echolocation, or because encountering the ultrasonic frequency is uncomfortable for the bat. The controller can direct the transmitters to transmit only during periods when wildlife encounters are likely to occur (eg, at night, during migration seasons, during favorable weather conditions, or similar).

The US201662432075P process filed in Google Patents by the Research Foundation of State University of New York, inventor Steven M.

Hoffberg, entitled “Acoustic Metamaterial”, is configured to detect an acoustic vector field within a filled space in response to waves of fluid and produce an electrical signal corresponding to the detected acoustic vector field, presenting current pending status, since the order was placed at the end of the year 2020.

The deposit granted WO2007084122A2 in the EPO database entitled “Method and Apparatus for Echolocation”, invented and recorded by Hickling Robert, is based on bat echolocation by combining a pulsed ultrasound source with an acoustic vector probe (AVP) in a echolocation instrument, together with a data acquisition system, a digital signal processor and an output device. The sound intensity vector points in the direction of the highlight from which the backscattered pulse originates, while the pulse's flight round-trip time determines the distance to the highlight.

### International patent classification

The International Patent Classification (IPC) is an independent symbol classification system configured to order technical production information, subdivided into 8 sections, 21 subsections, 120 classes, 628 subclasses and 69,000 groups (Serafini et al., 2012).

Figure 4 shows the results by section organized respectively: section A (Human Needs) with 8,571 results, section B (Operations) with 735 results, section C (Chemistry) with 3,041 results, section E (Constructions) with 3,518 results, section F (mechanical engineering; lighting) with 1 result, section G (Physics) with 19 results, and section H (Electricity) with 468 patent results searched. This search was carried out in the WIPO database, using the descriptor term “bats”, as the authors of the same considered a broader term for the search, since the addition of more descriptors or combined descriptors resulted in works that associated bioacoustics from other animal groups, which also have this biological peculiarity.

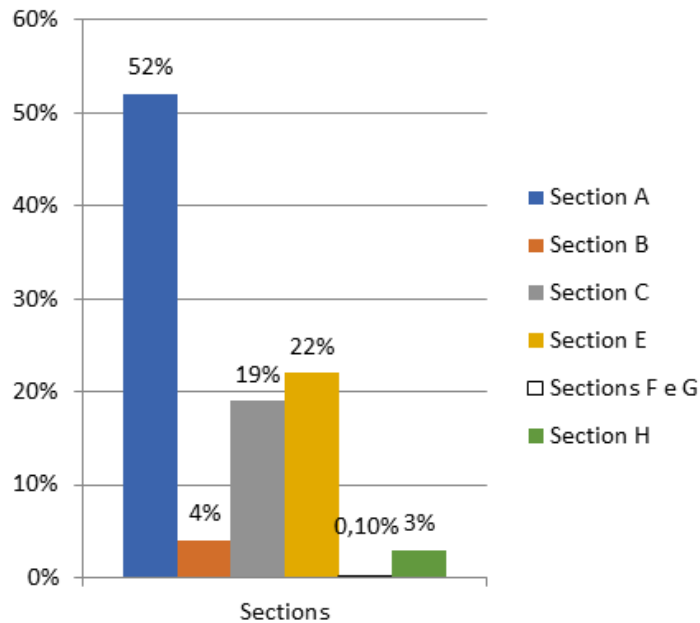


Figure 4 - Patent sections according to the IPC.

It was decided to strictly follow patent deposits that had the flying mammal fauna as a model group. It is worth emphasizing the current importance of studies with these animals, not only with regard to their morphological and anatomical composition, but also about the biotechnological potential that they can play, when associated and used in a beneficial way with advances in technologies developed by humans.

In addition, understanding aspects that associate the use of these animals as pollinators in areas of agronomic development from their senses would be a natural agricultural service for humans, who could also work in the reproduction and conservation of species increasingly threatened by fragmentation of habitats and urban sprawl.

## CONCLUSIONS

Between the years 2000 to 2021, technologies based on bioacoustic characteristics found in the order Chiroptera show a considerable development rate, which is valid for obtaining more accurate studies on this group of mammals. The study on bat bioacoustics devices represents a long-term reflection on the quality of the data that is obtained in this way regarding the conservation status and risks to which these animals have been subjected.

The order Chiroptera was used as an object of study, but this does not prevent the method from being applied or adapted to the monitoring of other animal species, being able to estimate species richness and consequently a positive offer regarding the ecosystem services provided by the

animals in question.

The instruments deposited in the INPI, Google Patents, EPO and WIPO databases can represent an essential tool for discovering new, rare, nocturnal or endangered species. This type of analysis is important to assess faunal acoustic biodiversity, based on the understanding of their vocalization and interspecific and/or intraspecific interactions.

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