BAT ECHOLOCATION DATABASE

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1   ABSTRACT

A database that facilitates collection, archiving and retrieval of key information from literature relating to bat species is proposed. Its basic uses are as (1) a portal to finding species-specific information, not just for bat species mentioned in the title or abstract of a resource, but anywhere within its body, (2) a basis for statistical analysis of how much literature exists on each species or group of species sharing common characteristics and (3) a quick reference showing key information. Presently, fields exist on the "signal type" used, "diet", "hunting method and characteristics", "global distribution" and "common name". By linking the "signal type" with the other fields, it is hoped that patterns across species will be easier to spot. Taxonomical information is also shown but this is dependant on the taxonomy being used by the database and can easily be changed.

2   INTRODUCTION

Bats exhibit huge biodiversity both in terms their ecology and the number of identified species in their taxonomical order, currently more than 1100. Additionally, *microchiroptera* (microbats) possess the rare sensory capability of active echolocation, by which information on an object can be obtained by analysis of echoes from self-generated sounds. An understanding of the acoustical and physiological processes underlying the capability may be of benefit for sonar array design (Rees et al. 2008). The compilation of knowledge on active bat echolocation has been largely non-systematic and it is not easy to identify which species have been extensively studied and in what areas. This prevents data from newly conducted research being easily integrated into the wealth of data that already exists and may result in a failure to recognize that species or groups of species sharing common characteristics are under-represented in the current research.

3   METHOD

The database consists of a data file and a collection of applications that are used for entering data into the data file as well as querying and reporting data from that file. In the current state of development all these functionalities are implemented in Matlab. The system is flexible, allowing the selection of different categorization structures, from which the taxonomical details are provided for each species. The user selects a species and enters details of the literature source in which it was found. The tool is designed to allow individual users to input data that can be shared through an online system. This is likely to involve an institution hosting it and a small amount of administration. Additional fields can also be inputted by individual users. Clarifying classification issues would also need to be done centrally.

The data fields are intended to provide as much information as possible and are, in the main, not mutually exclusive. For example, the "signals used" field makes use of a division of *microchiroptera* in Grinnell (1995) into categories of purely frequency modulated (FM) bats and those that also use

either a long or a short constant frequency (CF) element in their signals, categorized as long and short CF/FM bats. While not all sources subdivide CF/FM bats as such, Grinnell suggests that there may be a difference in function of the CF signal element between the groups, with short CF/FM bats being less specialized for the use of the CF component than long CF/FM bats. Because the majority of references (especially the earlier works) do not make this dichotomy, the category "unspecified CF/FM" has also been added, though it is hoped that as the database is increasingly populated, bats in this category can be reclassified. Other signal categories are "click" and "non-echolocating". The "hunting methods and characteristics" tab includes the categories of "arial hawking", "gleaning", "hunting in clutter" and "passive echolocation" while the "diet" field is broadly based on Schnitzler and Kalko, 2001.

Information on species contained in numerous sources including papers from the website of Biologically Inspired Acoustic Systems (BIAS), a multi-disciplinary group investigating echolocation, and from textbooks on echolocating bats has been entered.

An example of output from the database in its present form is given in Figure 1.

Figure1:   Output from the database for the species *Eptesicus fuscus*

The top scrollbar was used to select from a list of species while the scroll bars at the bottom of the figure allow the researcher to access the full list of references for the species.

4   RESULTS

The tool has been used to investigate a number of questions, two of which are detailed below:

4.1   WHAT PROPORTION OF SPECIES WITHIN THE IN THE DATABASE USE A SHORT CF/FM STRATEGY?

Grinnell (1995) notes that short CF/FM bats have been comparatively little studied. Results suggest that "short CF/FM" bats are under represented in the database, with 2% of the species and 1% of papers. However, because the database is not fully populated, it does not yet show the proportion of species that actually use each signal type. Thus, it cannot be ruled out that the low number of papers reflects a low number of existing species using the signal type rather than a low proportion of papers per species having been entered. When looking at average number of papers per species, as in Figure 2, it can be seen that in addition to having a small number of species entered, short CF/FM bats have comparatively little data entered per species, with an average of just 2 papers on each short CF/FM species.
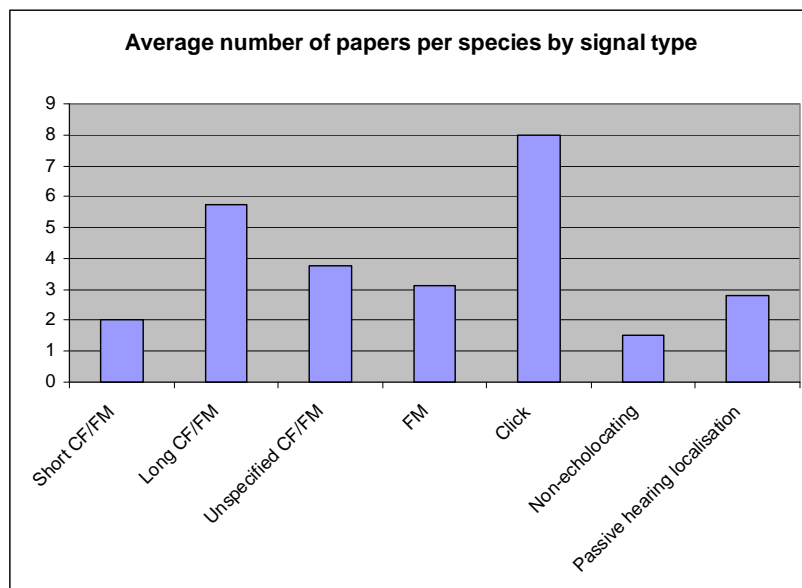

Figure2:   Average number of papers per species by signal type

The present lack of papers before 1995 makes it impossible to determine whether they were under represented at that time. Few papers before Grinnell's (1995) work refer to species using a short CF/FM strategy since it was partly through his writing that others were encouraged to use the classification. However, the inclusion of both short/long and unspecified categories means that with sufficient entries, species previously referred to as "unspecified duration CF/FM" signals can be reclassified.

4.2 IS THERE A BIAS TOWARDS THE STUDY OF SPECIES IN NORTH AMERICA AND EUROPE?

Even if details of every known species were entered into the database, it would not be possible to conclusively answer this question since there may be many undiscovered species. However, some indication is given even from the limited information presently in the database.

Of the 95 species in the database for which there is some information on global distribution, 28 are native to North America and 24 to Europe. Within this, 19 species are only described as being distributed in North America and 11 only in Europe. From the current data, it does not appear that species relating to either area are over represented. In fact, with a third less citations than species entered, initial results indicate that European species are under represented.

5 DISCUSSION

There is a danger that blind statistical analysis of the number of studies conducted on each species will imply a high quality of research based on the number of citations and result in a failure to question the integrity of the data that has been entered. However, any statistical analysis should be seen as just a starting point and the database makes it easy to quickly identify and examine that research.

The database is designed to provide a systematic compilation of data on bat species, ecology and behaviour that can be easily retrieved and that will lend itself to limited statistical analysis which may direct further study on echolocation. A key strength is that it contains details of all species mentioned within any source. Early analysis of the database has given some interesting results and with further data entry, it should prove an increasingly valuable resource for both biologists and engineers. Once populated and established as a useful and user-friendly instrument, users may wish to add further advanced fields tabs or even recordings of bat signals. For example, a researcher into echolocation may be interested in the size of prey, distance between ears and frequency components of a bats' signal. However not all such fields will be of interest to all users and the need to check the reliability of sources necessitates the focusing on key data fields, at least in the early stages of the database.

ACKNOWLEDGEMENTS

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