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Mobile Application Support for Analog Radio Telemetry Localisation of Bats

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Zusammenfassung

Mobile Anwendung zur Unterstützung der Telemetrie von Fledermäusen

Telemetrieuntersuchungen an Fledermäusen sind ein wesentlicher Bestandteil von umweltplanerischen und ehrenamtlichen Fragestellungen. Je nach Aufgabenstellung ist diese Methode ein adäquates Mittel um z. B. die Raumnutzung oder aber Wochenstuben zu ermitteln. Die Herausforderung ist es, einen effektiven Telemetrieablauf und zuverlässige Ergebnisse zu gewährleisten. Bis heute werden alle Messungen, z. B. bei einer Kreuzpeilung, manuell aufgeschrieben. Die Koordinierung der einzelnen Telemetrie-Teams ist meist mühsam und die Verfolgung des Tieres ist je nach Fledermausart unterschiedlich anspruchsvoll. Diese Ausgangssituation war Grundlage für die Idee zur Entwicklung einer mobilen Anwendung. Das dafür notwendige Know-how liegt bei den Informatikern. Studenten der Technischen Universität Prag konnten im Sommersemester 2014 einen entsprechenden Prototyp entwickeln, welcher auf dem mobilen Betriebssystem Android läuft. Bei kleineren Tests konnte die Funktionalität und der Mehrwert dieser Anwendung unter Beweis gestellt werden. Auf den mobilen Geräten der einzelnen Teammitglieder werden deren aktuelle Positionen und die entstandenen Schnittpunkte aus der Kreuzpeilung dargestellt. Aufgrund der Echtzeit-Darstellung auf dem Display ist für alle Teilnehmer eine Einschätzung der vorliegenden Situation möglich und somit auch ein besseres Vorgehen bei der Verfolgung der Fledermaus.

Abstract

Telemetry studies are an essential component within environmental planning issues, but also in the voluntary sector. Depending on the task, this method is an adequate means to for instance gain knowledge of the use of home ranges or to determine nursery roosts. The challenge is to ensure an effective workflow of the telemetry and reliable results. Untill now, all measurements are manually written, for example, at a cross bearing. The coordination of individual telemetry teams is usually painstaking and the following of the animal is sophisticated and varies depending on the kind of bat. This initial situation was the basis of the idea to develop a mobile application. Only computer scientists have the necessary know-how. Students of the Czech Technical University (CTU) in Prague were able to develop a corresponding prototype in the summer semester 2014, which runs on the mobile operating system Android. In smaller tests the functionality and the added value of this application have been demonstrated. The user's current position and the resulting intersecting points of the cross bearing can be displayed on the mobile devices of the individual team members. Through the real-time display on the screen an assessment of the present situation is possible for all participants, and thus a better approach in following of the bat.

Keywords

Bats, radio telemetry, radio tracking, android, mobile application, tag, cross bearing.

Introduction

The ability to localize and track animals in the wild was always a basic requirement to study the behavior of a particular species. Initially, animals were localized and tracked visually, but such an approach was not practical due to the inability to follow the animal without being detected and therefore disturbing the natural process of animal behavior. The radio-tracking of wild animals was one of the first methods used, followed by others like GPS technology. In the case of bats, specific questions about the home range, flight routes or about the roosts, detecting nursery colonies or finding an individual bat can be done using a transmitter (a tag) attached to a bat and a receiver that can detect the location of the bat. But with the development of more advanced technologies, radio-tracking has raised considerable interest from the scientific community again.

When using radio-tracking methods, animals like bats are equipped with a 150 MHz transmitter (i.e. are tagged) and are free in their movements. The user localizes the tagged animal with a receiver unit, which consists of a receiver and antenna (Kenward R. 2001; Millspaugh & Marzluff 2001). It depends on the technology used, how much the performance of the receiver unit and the transmitter is limited. It's recommended to keep the loading below 5 to 10 % of animal weight (Schober & Grimmberger 1998). For example, if we look at the one of the biggest European bats - the Greater Mouse-eared Bat (*Myotis myotis*), it has an average weight of between 20 and 27 grams (Dietz & Kiefer 2014). Clearly the transmitter will have to weigh far less than 3 grams. The transmitters used today for bats weigh mostly less than 1 gram including battery (e.g., transmitter of the company Biotrack or of the company Telemetrie-Service-Dessau). Since 2014, Biotrack offers one of the smallest GPS tags which can store a total of 10 GPS fixes with a total weight of 1.1 g (including cell).

In studying the use of habitat by bats, it is recommended to capture the bat position every 5 minutes. During a fair night, up to 96 different positions can be determined in a duration of 8 hours. Unfortunately, this is impossible with present GPS transmitters. Another approach examined a large community of researchers in Erlangen, whose project (BATS 1508)[1] is funded by the German Research Foundation DFG. They intend to develop a transmitter-receiver unit. Bats should be equipped with a small tag. This radio-transmitter has its own mini processor, so you can specifically analyze the bats three dimensional use of its habitat. But it will be a few years until the transmitter is available to the consumer.

Therefore radio-tracking is still the most suitable method. To determine a single position of a bat, a cross bearing of two or more simultaneous measurements is carried out. That is accomplished by two or more independent users, each with a receiver and antenna, who will take simultaneous measurements at agreed time intervals. They are looking for the bearing of the transmitter's strongest signal. Each simultaneous measurement consists of the user location, as well as the direction (azimuth), where he/she gets the strongest signal. During or after the measurement session the data is written on the map, so the users can easily see the bats route and can more conveniently analyze the collected data.

The challenge is, to follow the animal at night and stay in range of the transmitters and determine the location of all the teams as well as the bat at the time the measurements are taken and with as little expenses as possible. When dealing with a bat species with a small home range (e.g., 10 sq km) and a range of approx. 500 – 1,000 m between transmitter and receiver (it depends on the terrain and obstacles in the way), there is not much time to find orientation in the darkness and get ready to follow the animal. Usually you can follow the animal only for a short time. Bearing, orientation and pursuit of the bat has to be realized in a small time frame. In the best case, the communication runs between the different participants only by telephone or via citizens band radio (CB-Funk) to transmit the flight direction and bearing number (azimuth). In most cases creating the intersection to allow the exact position of a bat to be marked on a map is hindered by the absence of the second telemetry team's exact location. Consequently the position inquiry is connected with difficulties.

These days, smartphones or tablets are very convenient replacement for laptops. In the best case they have high speed internet connection, GPS localization, built-in compass and with the appropriate software may make huge improvements to this process. For this purpose students of the Czech Technical University in Prague have developed the first prototype of such an application. The application is called Bat Tracker (codenamed ASA-ART, which stands for Analog Radio Telemetry Result Collection). It is being developed by Pavel Valach, Martin Vrábeľ and Danylo Tkachenko under the supervision of Ivo Maly and Robert Drangusch. The main focus is both on seamless cooperative measurement and also on gathered data analysis and visualization.

Related Work

David Hellmann has already taken up this challenge some years ago and made an application GTacs for Windows XP/Windows 7. Our own tests showed that the operability was clear. But carrying notebooks in a stretch of open country or in the front passenger seat still seemed particularly difficult and uncomfortable. The external GPS module that was used, showed a rather bad and unstable result in comparison to the GPS modules, which are available in more recent smartphones.

In case of mobile applications, there are numerous mobile mapping tools that can provide current location using GPS, like Google Maps. Unfortunately, these tools do not allow the storing of position and bearing of the user. One of the exceptions is Locus Map[2] application that can store and draw custom data onto maps. But still, there is a need for communication between teams that must be provided by another dedicated application. Switching between applications during the measurement is possible, but not convenient.

An application with an interesting approach is Tracker developed by Tracker Inc[3]. It's used for real-time visualization of dogs during hunting on mobile devices. We would like to use similar real-time communication between teams during the measurement sessions.

Application Description

The ultimate goal of the mobile application is to capture and share location and angles of all teams (team members), view location of teams in real time and create intersections of two or more angles that point to the location of the bat. We were trying to make a simple and efficient application, which will be fast and help measure bat locations and their movements. The application is developed so that it will run on any Android device equipped at least with Android 2.3.

Our design considerations were to provide as streamlined a user interface as possible focused on quick and understandable data acquisition, which is crucial and not repeatable. Therefore any discomfort may lead to unsuccessful measurement and wasting of time.

Client and Server Structure

The application is divided into two parts, client application run on mobile device and server application providing the data storage and synchronization. Therefore each user is asked to enter his/her e-mail address which allows him to log in (see Fig. 1). If the user has no internet connection, he will be notified, as well as when he enters an invalid e-mail adress. After a valid login the user is switched to the start screen of the application.

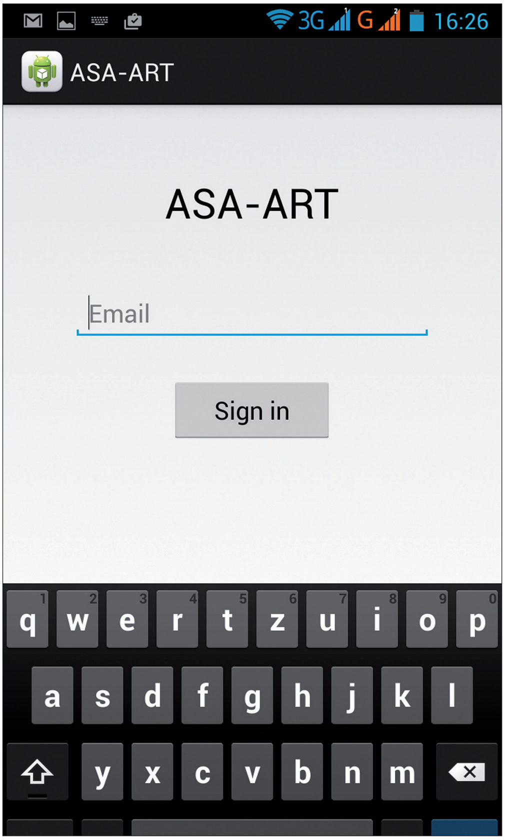

Fig. 1: Login Screen of the application.
Abb. 1: Anmeldeoberfläche der Anwendung.

Measurement Preparation

After the user logs into the application, he/she needs to prepare a measurement session, also called Adventure in the application. To do that, he/she will just press the *Start new adventure* button and he/she will be presented with a dialog (see Fig. 2), asking them to enter a name of the session, bat species and tag frequency. Afterwards, the session will be created and the user will be taken to the *map screen* (see next section). This measurement session is prepared by one user, other users will only be able to join an existing session (adventure).

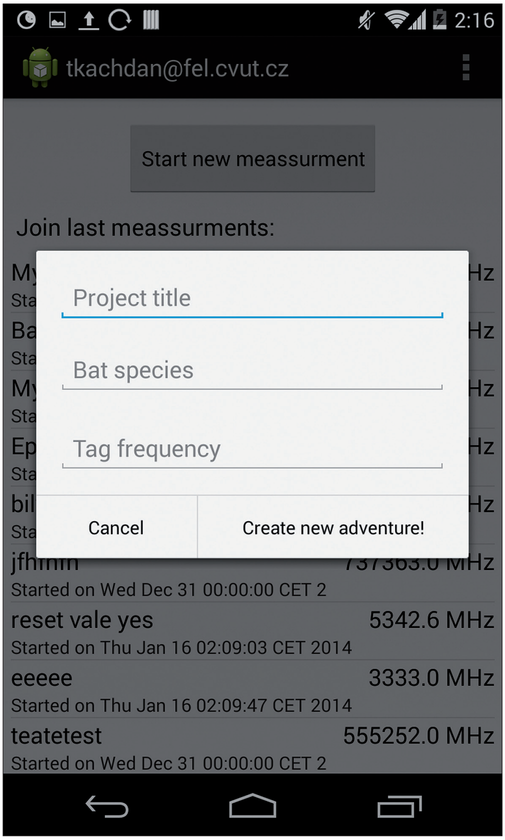

Fig. 2: Start Screen of the application with necessary information.
Abb. 2: Startoberfläche mit notwendigen Informationen.

Measurement session

When a new measurement session is started, the users are provided with *map screen* (see Fig. 3). The key point in it is the map with the position of all users in this measurement session. It also contains data and team information fragments (screens).

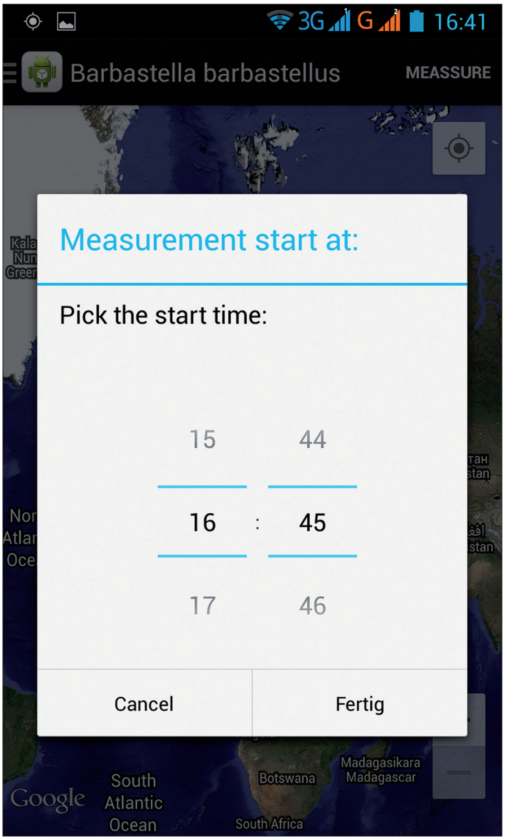

Fig. 3: Measurement dialog with countdown to the next measurement; Map data © 2014 Google - pictures © 2014 NASA, TerraMetrics, map data © 2014 INEGI, Google.
Abb. 3: Dialogfeld mit dem „Countdown" für die nächste Peilung; Kartendaten © 2014 Google - pictures © 2014 NASA, TerraMetrics, Kartendaten © 2014 INEGI, Google.

The navigation between fragments is done using navigation drawer. In order to open the drawer, the user can swipe from the left part of the screen. Pressing the option button in action bar the user can select a different map layout to be displayed. In doing so the user is enable to switch between hybrid view, satellite view and normal map view.

After pressing the *Measure* button, the user will be asked to pick a time, when the measurement will be started. A dialog describing how much time is left will appear at the bottom of the screen. After that, other teams will be asked to prepare to perform a measurement at that chosen time and the countdown will be started on other devices too.

The devices time has to be synchronized (either from Internet or by using GPS time), otherwise the same time on devices will not be assured. Some Android devices have various bugs affecting automatic time updates, which is a source of severe trouble.

The countdown timer will be displayed in the bottom panel of the screen to notify the user how much time is remaining. After the time has peaked, a straight line from the user position will be shown, displaying directions, consequently a yellow marker will appear on the intersection (see Fig. 4 right).

After the countdown, the current positions and the azimuth are captured and the intersection will be computed. Then, it will be displayed in the form of a yellow marker. Tapping on it shows the precise location.

Data visualization

During and after the session the user can observe the data both on the map or he/she can look at the data screen with all intersections and detailed information about the current session (see Fig. 5). This screen is used to provide a convenient data overview.

Evaluation

The application was evaluated under controlled settings by CTU team and then also in simulated sessions by Robert Drangusch.

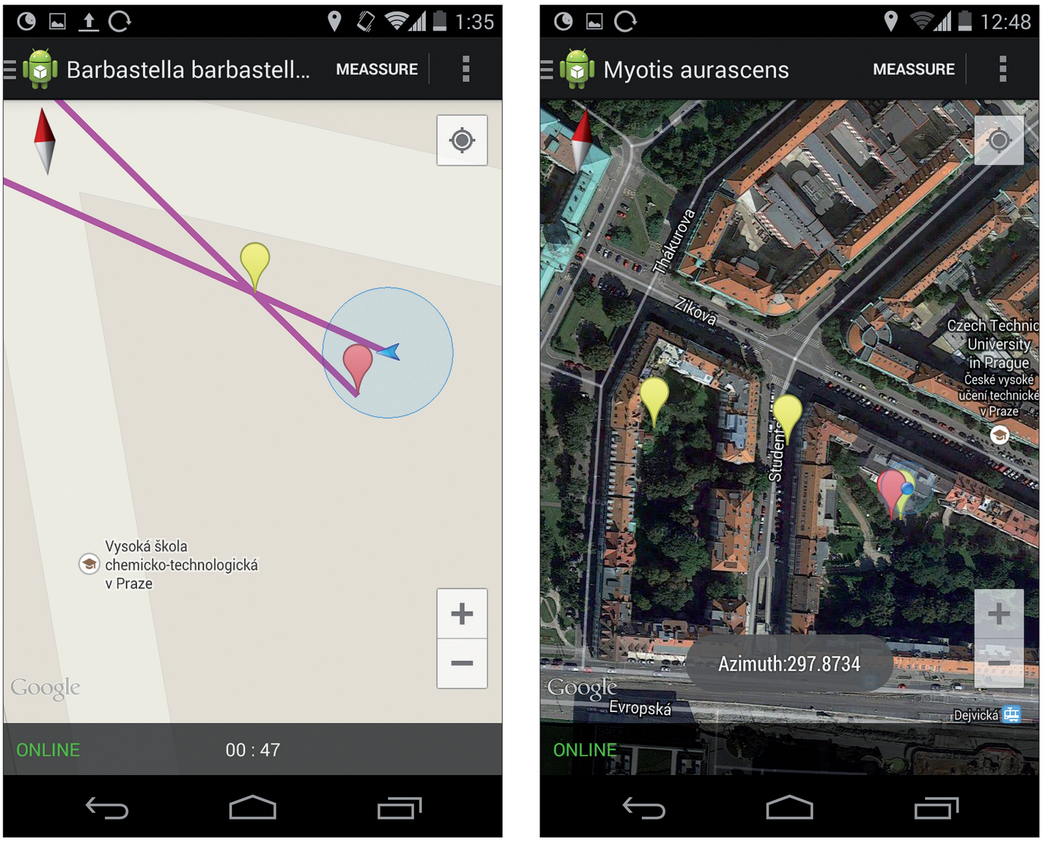

Fig. 4: Map Screen of the application; left: cross bearing (pink lines) with one intersection (yellow marker), right: different intersections; Map data © 2014 Google.
Abb. 4: Kartenoberfläche der Anwendung; links: Kreuzpeilung (pinke Linien) mit einem Schnittpunkt (gelber Marker), rechts: verschiedene Schnittpunkte, Kartendaten © 2014 Google.

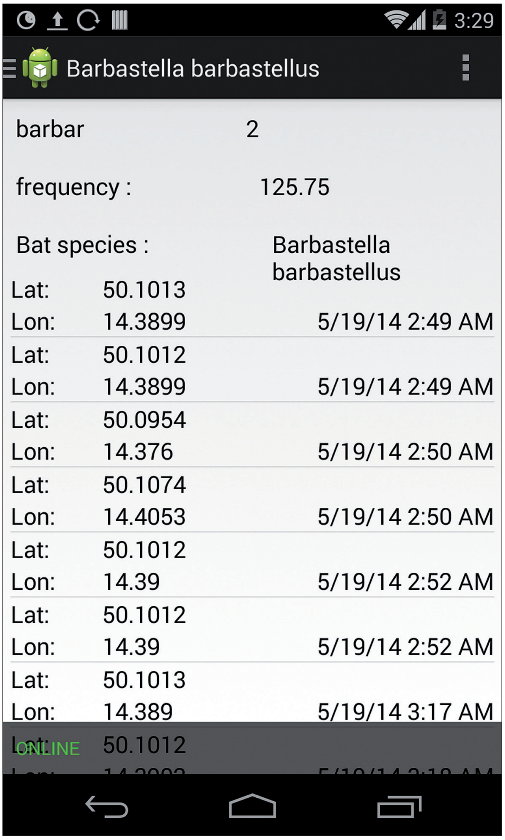

Fig. 5: Data Screen of the application with coordinates from each intersection sorted by date.
Abb. 5: Datenoberfläche der Anwendung mit Darstellung der Koordinaten zu jedem Schnittpunkt in zeitlicher Reihenfolge.

Initial tests were focused on evaluation of functionality and connectivity between clients and server. Test measurements were done in an urban area and most of them were successful. We were able to identify the location of imaginary bats and to store this data for future analysis. In total the test group made more than 100 measurements using our application.

The app was tested on several mobile devices. The prototype was installed on 5” Smartphone G 700-10 HUAWEI Android 4.2.1, 5,5” Smartphone HTC Desire 816 Android 4.4, 4,7” Smartphone Nexus 4 Android 4.4 and 10” Tablet Samsung Galaxy Tablet GT-P7500 Android 4.0.4. In terms of supporting the radio-telemetry, the application fulfills its purpose.

The essential task of the app is to display the locations of participants and intersections, as well as to calculate the intersections. This allows an easy orientation in the field and faster interaction between users. Even on a relatively small 5” display the menu guide and map display are clear.

The usability for a new user is not difficult, because the app has a simple structure and has a manageable menu. A project is launched by one participant and other users are free to join in.

During login the application crashed frequently and in measurements only occasionally. We observed that it may be difficult to hold the device in the right direction from which the signal comes as the line jumps slightly.

Results and Discussion

The current state of technology is to analyze the habitat use of bats with the analog radio telemetry (cf. Tab. 1). Necessary are at least two, preferably three, teams. As described in the chapter “Introduction”, the strongest signal is detected simultaneously by all of the teams. The angle (azimuth) is determined with the compass and every team note their own position. This information must be communicated between the teams, so that the individual values can be marked on a map. The result should be an intersection point or a triangle. Because of the limited time between the measurements, an immediately marking on the map and analyzing of data is not possible until the next morning. Each team tries to move in the direction of the signal without knowing exactly where the animal is located at the moment based on the bearing. The tracking of the bat is based on an assumed position.

With the help of mobile application to support the radio telemetry, specific equipment is no longer required (cf. Tab.1). The necessary material is provided by the mobile device and the application. Smartphones already have GPS available. In the app, the individual components are fused together. One team launches a telemetry project and specifies the interval for the measurements before. Then the countdown starts, so that every participant can simultaneously perform the bearing. The Location of all teams and the direction in which they measure is displayed on the screen. If the countdown reaches zero and all the lines converge, a point of intersection is generated and displayed automatically. However, everyone immediately gets to see the current location of the bat. Each team can individually track the animal and obtain an optimal starting position for the next measurement. The individual positions and bearings are stored on a server and are available for further analysis.

Advantages and disadvantages of the mobile Application to support the radio telemetry (digital) over analog telemetry:

Advantages

You only need one device (smartphone or tablet) per team.

All other components such as maps, compass, GPS, are integrated in the device.

The synchronous measurement and a constant interval are ensured by the countdown.

By showing all the team members on the display, the user receives a real-time visual impression and can thus adapt to the situation.

The background map allows optimal navigation on site. Central data storage will be provided on a server.

Disadvantages

Device dependent on battery power.

An internet connection is required for the data transfer. Currently we do not have a 100 % Internet coverage e.g. in Germany.

Program crashes prevent a continuous data collection (e.g. when the Internet connection is unstable).

Power failure can result in data loss.

There may be large differences in accuracy, for example because of poor GPS reception or compass sensitivity.

If only one component such as the GPS breaks down, the application does not work properly. The measurement does not work correctly when a different time is set on each device.

Conclusion and Prospects

In this article, we have presented a mobile application for analog radio telemetry in the localization of bats. We analyzed current processes of bat localization and equipment used and developed an easy to use application that covers

Tab. 1: compare necessary equipment for radio telemetry.

Requirements	Radio telemetry	
	without mobile application to support the radio telemetry	with mobile application to support the radio telemetry
	„Analog“	„Digital“
Antenna + Receiver + Transmitter	X	X
Compass	X	
Analog maps	X	
GPS	X	
Mobile Phone or via citizens band radio	X	
Paper & Pencil	X	
Smartphone or Tablet with internet connection		X
Application (including map, GPS, etc.)		X

most of the required functionality. As the application is still in the development phase, we hope to continue the work on it and provide stability in the running of the application. However, the initial evaluation showed that the potential provided by current mobile technologies can be successfully implemented to improve the process of bat localization.

For future work, we are thinking about the implementation of new features to improve the user experience. We are planning to reorganize data collection tables and make them more informative and comfortable. Also we are trying to fix bugs, which were found during real measurements, especially the run of application when an internet connection is not stable. This way we will eliminate most of the known disadvantages.

[1] http://www.for-bats.de/
[2] http://www.locusmap.eu
[3] http://www.tracker.fi/en

The development team is also thinking about an offline mode when other teams are not available. Besides that, we would like to improve the design of the app in order to make it more presentable and user-friendly.

Literature:

Dietz, C., Kiefer, A. (2014): Die Fledermäuse Europas: kennen – bestimmen –schützen. Franckh-Kosmos Verlag, Stuttgart.

Kenward, Robert E. (2001): A Manual for Wildlife Radio Tagging, Academic Press, London, 2 Edition.

Millspaugh J., Marzluff J. M. (2001): Radio Tracking and Animal Populations, Academic Press, London.

Schober, W., Grimmberger, E. (1998): Die Fledermäuse Europas: kennen – bestimmen – schützen. 2. Auflage, Franckh-Kosmos Verlag, Stuttgart.

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