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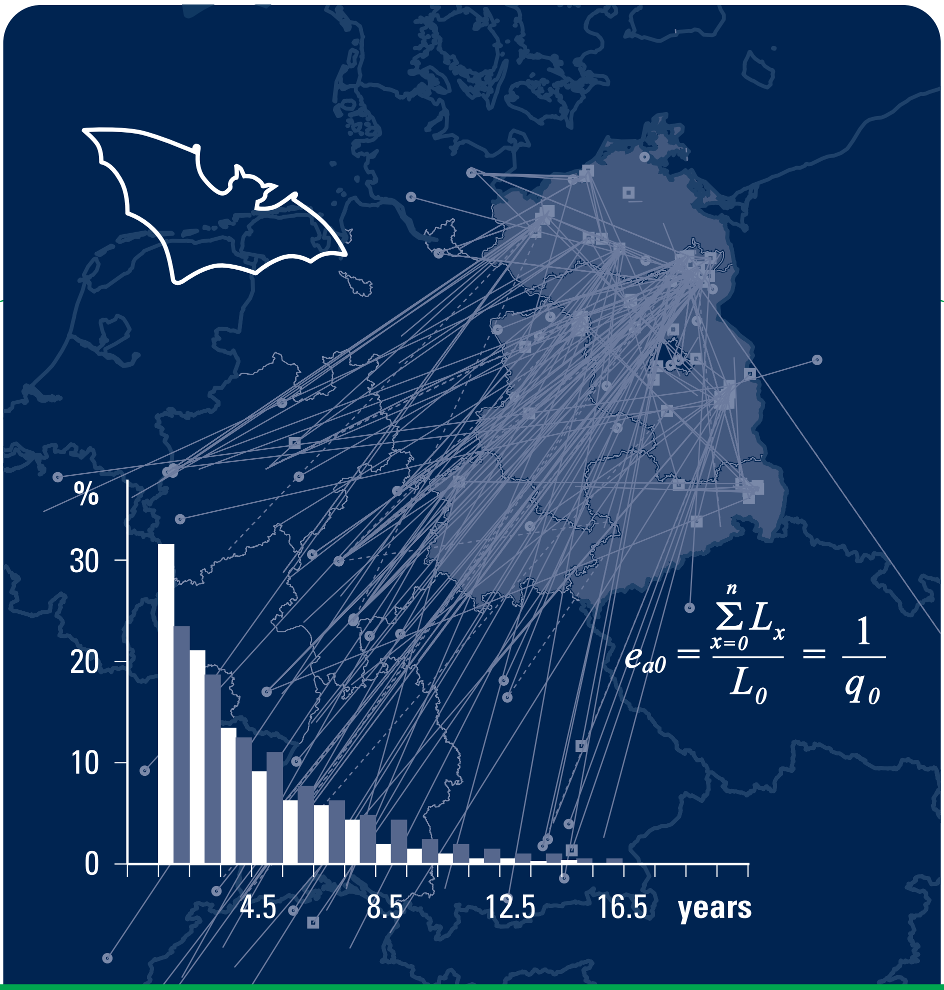

40th Anniversary Bat Marking Centre Dresden –

Evaluation of Methods and Overview of Results

Materialien zu Naturschutz und Landschaftspflege

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Zur Wetterwarte 11, D-01109 Dresden
E-mail: Abteilung4.lfug@smul.sachsen.de
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Authors:
Rolf Steffens, Ulrich Zöphel, Dagmar Brockmann
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Contents

Preface

Bats belong to one of the most threatened groups of organisms largely due to their biology. Information on migration and roosting, survival rates, population trends, and factors that influence them are difficult to collect because of their secretive life and their nocturnal activity. Bat marking is an important tool to collect the information necessary for the understanding of these important aspects.

The centralised data registration and analysis of marking data is traditionally performed in marking centres. The Bat Marking Centre Dresden has been active in this field for more than 40 years. The Saxon State Agency for Environment and Geology has responsibility for this in East Germany through bilateral contracts in 1992.

As a result of the work of voluntary markers and the reports of interested people from Germany and abroad the Bat Marking Centre Dresden collected a dataset that is unique in Europe. Migration routes of 1,500km and an age of up to 30 years are some of the most astonishing results. This report contains a comprehensive data analysis and allows the comparison of such extreme values with the range of a given species. In addition the value of the marking method for a lot of vital work such as monitoring and reporting obligations according to NATURA 2000 is shown.

I hope that the markers will pick up the methodological aspects for their analyses of the local data and that the comparison of smaller datasets with the general tendencies that are presented in this report will result in interesting discussions. The reported gaps in knowledge will hopefully initiate further studies. Once we succeed in continuing and stressing the importance of our common project – the marking of bats – future analyses will lead to even further reaching and more accurate results that form an important contribution for our understanding of the ecology and the protection needs of this fascinating animal group.

The Saxon State Agency for Environment and Geology is grateful for all suggestions and help with this report.

Hartmut Biele
President of the Saxon State Agency
for Environment and Geology

Introduction

On the occasion of the 40th anniversary of the Bat Marking Centre Dresden in 2004 the results of the marking and refinds of bats from 1964 to 2000 were analysed and are summarized in this report. For species with a small data base in particular newer results were also included.

The basis for this analysis comes from the highly qualified and laborious work of the bat markers, which is most often performed as research in their own free time and closely linked to bat protection. The markers collected approximately 90 % of all refinds marked animals thereby collecting the majority of data on which this report is based. We would like to thank all the markers of the Bat Marking Centre Dresden for their considerable and worthwhile collaboration and dedicate this publication to those whose life-time work has shaped the profile of bat marking and is still doing so.

Important records are delivered by the coincidental refinds of marked bats. Therefore our special thank to those people that were not hindered by the expenditure to convey the data to the marking centre.

Bat marking has been established in Germany for approximately 70 years. Under the specific conditions in the former GDR it won its own profile, which was favourable for long-term and continuous work. By the joining with institutional nature protection it was closely linked to bat protection. This is how a data base that is unique in Europe could be collected.

The aim of this report is it to present a review of the results as well as to give methodical suggestions for data preparation and evaluation. Survival and/or mortality rates of bat populations as well as local changes under seasonal aspects are the core part. From the results and experiences the emphasis for the development of further work is derived. It becomes clear that the marking method can among other things supply contributions to the conservation situation and to the conservation prognosis of bat populations. This supplies substantially deeper insights than solely inventory counting's and e.g. in connection with monitoring and reporting obligations attained by FFH guidelines, gain special nature protection importance.

The evaluation of marking results from individual investigation areas is primarily reserved to the markers. It will be interesting to be able to compare these data in the future with the evaluation on the basis of a more uniform methodical standard as presented here.

1 Marking method and characteristics

Bat marking is not an aim in itself, but is a methodical instrument. With its assistance many fundamental and surprising insights into autecological and population-ecological relations of the individual bat species are obtained (Fig. 1, see also Chap. 3.2 and 3.3).

The marking of bats as carried out today was developed in Germany by M. Eisentraut (1932). A small metal clip is put around the lower arm of the bat, and this gives the code of the marking centre and an identification number (Fig. 2). In this way, the animal can easily be recognized again later.

This individual marking data can provide information on the life history of single animals (e.g. habitat and especially change of roosts, age). The age data are even more valuable, when the birth date can be estimated, which is often possible for young animals in the birth year. Beyond the level of the single animal, insights into the whole marked bat population (e.g. spatial groupings, survival and/or mortality rates, age structure) can be achieved.

The manufacturing of arm clips is subject to high quality requirements and they may not exhibit a burr, in order to minimize flight skin injuries. In addition the competence of the markers contributes substantially to minimizing injuries when putting on the ring. Under these circumstances approx. 1 % of the animals suffer from impairments by the marking, which can be accompanied with inflammatory processes. Most animals are completely unaffected by the marking ring. If reactions occur at all, e.g. by biting on the ring, then it is more likely with old as with young animals.

Coincidental refinds of marked animals require many favourable circumstances. The appropriate refind rate is therefore usually less than 1 %. Therefore in order to reach a sufficiently large sample, many animals must be marked. Due to different reasons this cannot be achieved in mass-marking-actions, but only by a continuous follow-up over many years. Since bats are very faithful to their roosts and relatively long-lived, substantially higher recapture rates can be obtained with regular records in the framework of investigation programs (with sometimes up to 30 % of the marked individuals).

A disadvantage of the method is the fact that the animals actually have to be recaptured in order to read off the ring. This is certainly connected with disturbance of the

Bat marking –

methodical instrument for investigations

Behaviour in space

● Migration

● Settlement / dispersal

● Accommodation change / fidelity to colony site

○ Habitat choice

Population characteristics

● Age structure

○ Threats / causes of death

○ Reproduction rate

○ Social behaviour

○ Population / density

Behaviour in time

● Age

● Survival / Mortality rate

● Start of reproduction

○ Phaenology

Fig. 1: Bat marking as research method
(● marking as main method, ○ marking as a contribution)

animal. By the employment of coloured anodized rings (e.g. different colours for individual classes) or a sex specific marking (♂♂ right, ♀♀ left, s. Barclay & Bell 1990) there are possibilities to work on certain questions with observation from a distance and to read off the individual identification without catching the animals.

Modern marking methods (e.g. direction-finding transmitters, transponder) possess special advantages, but at present there are no alternative to the lifelong individual marking of bats by the arm clips.

The arm clips used in East Germany carry the following identifications (see also Fig. 2).

The arm clips used at present have weights of 0.097 g (A-Ring), 0.044 g (B-Ring) and 0.038 g (C-Ring). They are only half as heavy as the Ω-rings used up to 1980. Their proportion to the mass of the marked animals amounts to only approx. 0.24 to 0.95 %.

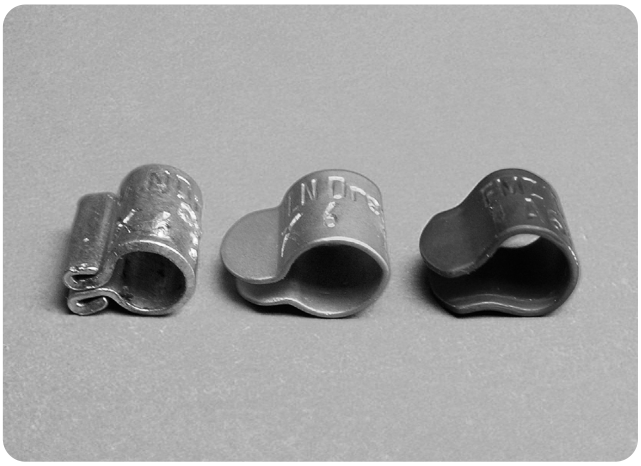

Fig. 2: Examples of the type of rings used and delivered by the Bat Marking Centre Dresden (left: model 1965–1980, Ω-Form, middle: period 1980–1993, right: period after 1993)

Tab. 1: Clips used in East Germany for bat marking

Marking centre	**Identification**	**Ringseries**	**in use**
M. Eisentraut	none	none	1932–1933
Zoologisches Museum der Universität Berlin (current Humboldt-Universität)	Zool. Mus. Berlin	A	1934–1945
Vogelwarte Radolfzell	Vogelwarte Radolfzell	X; Z	1952–1961
Museum Alexander Koenig Bonn	Mus. Koenig Bonn Mus. Bonn	X Z	1961–1964
Institut für Landschaftsforschung und Naturschutz, AG Dresden	ILN Dresden	X; O; Z	1965–1993
Sächsisches Landesamt für Umwelt und Geologie Dresden	SMU Dresden FMZ Dresden	A; B; C A; B; O; C	1993–1999 1999–now

2 Development of bat marking in East Germany

2.1 Beginnings until 1950s

Over seventy years after the beginning of bat marking it is difficult to imagine the knowledge available at that time. Bats were quite common, but due to their hidden way of life little attention was paid to them. It was known that bat species in Middle Europe visit different summer and winter roosts and exhibit a pronounced annual rhythm. Thus it was easy to assume that bats undertake regular migrations just like birds. Questions about fidelity to roost site and orientation ability, as well as about age, the differences in the behaviour of the sexes and the dispersal of young animals (EISENTRAUT 1943) were considered as important, and these all required the marking of individual animals. Bird ringing was common since 1899 and so there already existed a method suitable for this purpose. Therefore for the first markings of bats bird rings were simply used and the American zoologist, A. A. ALLEN, began first to put the ring on the lower part of a hind leg.

In Europe, Martin EISENTRAUT introduced bat marking in 1932. As he regarded the marking of a leg as too large a handicap, he decided to put an aluminium clip around the lower arm. First he marked mainly Greater mouse-eared bats, which were easily caught in the winter roosts of the Mark Brandenburg. In the first three years 5,830 animals were ringed. Smaller species were only ringed in lesser numbers in order to test the method.

In order to obtain as much as possible refind information M. EISENTRAUT published calls for co-operation and numerous popular essays about bat marking. Wilhelm MEISE who ringed approximately 900 wintering Common noctules from 1935 to 1939 in the Dresdner Frauenkirche also used his wing clips. Soon informative data on the migrations of Greater mouse-eared bats and Noctules could be presented (EISENTRAUT 1936, MEISE 1951).

Within a short time bat marking with wing clips had proven to be a successful and investigation method with much further potential. The number of the co-workers became rapidly larger, so that in the first ten years 30 people altogether marked 10,887 bats in Germany and Austria, of which 236 were refound during this time (EISENTRAUT 1943). The task of acting as the centre for the distribution of the rings and the support of the co-workers was taken over by the Zoological Museum of the University Berlin, where EISENTRAUT was working. One of the co-workers was E. HUMMITZSCH, who from 1938 examined above all Greater mouse-eared bats in the area of Leipzig. Similar results to EISENTRAUT concerning the roost site fidelity and migration distance were found by him and he also observed individual roost site changes between different nursery colonies (HUMMITZSCH 1960).

The Vogelwarte Radolfzell became the central office for the bat marking in Germany in 1951. At the same time Willi ISSEL for a private society called "Arbeitsgemeinschaft für Fledermausforschung" created his own rings. After M. EISENTRAUT moved to Bonn the Museum „Alexander Koenig" in Bonn became the central institution for bat marking from 01. 01. 1960.

Also in 1960 the results of the first 30 years of bat marking were compiled and published in a special edition of the Bonner Zoologische Beiträge, in which HUMMITZSCH and NATUSCHKE also presented their results. Günter NATUSCHKE from Bautzen had started to mark bats in the Oberlausitz in 1952 and was already able to analyse 278 refinds of a total of 2,118 ringed animals from 6 species.

EISENTRAUT (1960a) performed a comprehensive evaluation of the importance of the marking method for the scientific research made and also considered the occasional impairments of ringed bats.

2.2 1960s until the early 1990s

At the end of the 1950s it was suggested in the GDR to regulate the marking of bats similar to the decree-law for bird banding (Vogelberingungsverordnung) from 1956. The Institut für Landschaftsforschung und Naturschutz Halle (ILN) proposed an appropriate regulation draft in October 1959, in which the Museum of Natural History in Berlin was supposed to be the centre of all bat marking. The task was however finally transferred to the ILN, branch office Dresden in November 1960. The ILN was given the task because of the high protection needs of bats, and the Dresden branch mainly because of their strong zoological orientation and background. In addition 15 people received a special permission from the agency for nature conservation in Berlin for bat marking.

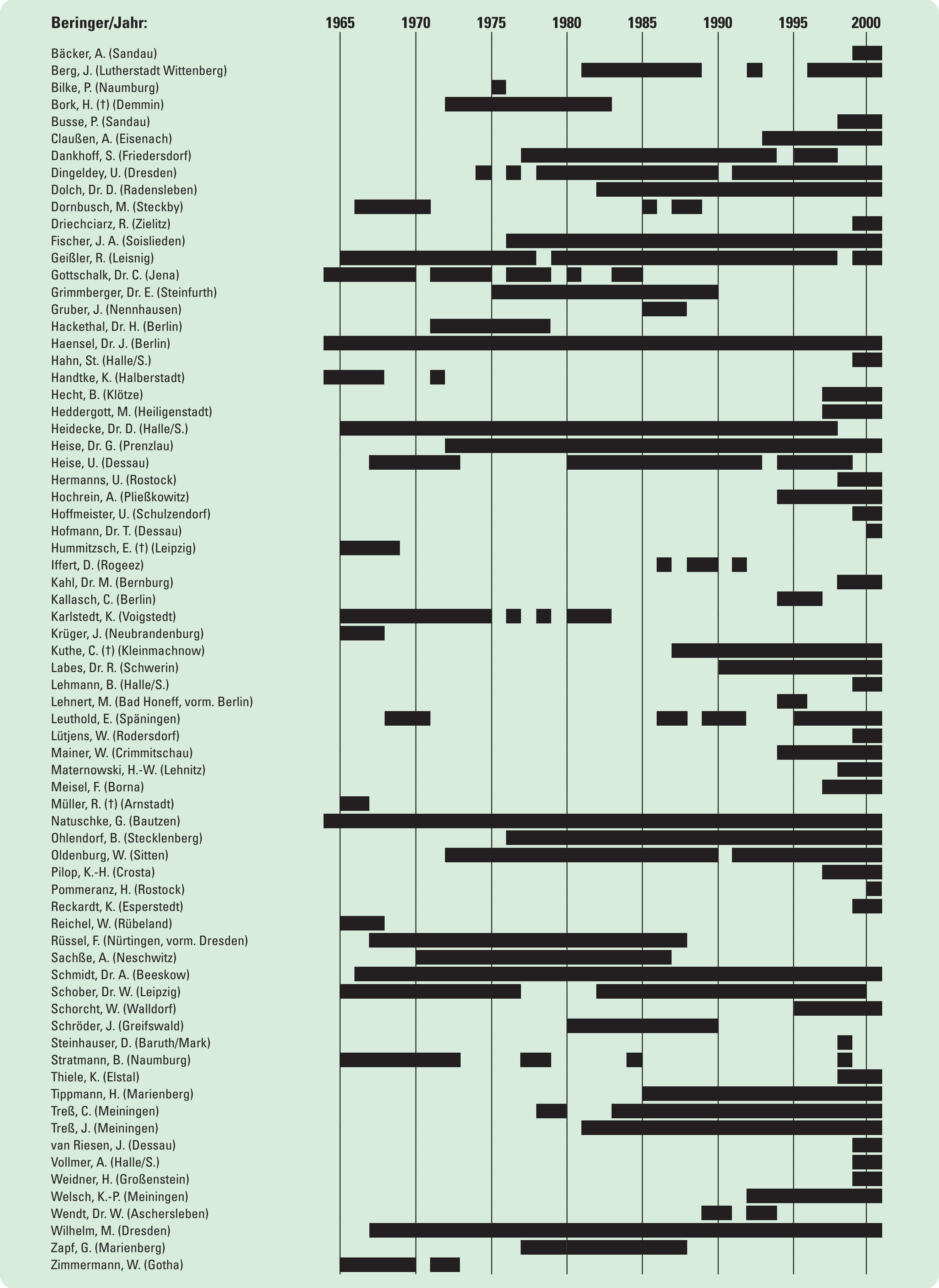

Fig. 3: Bat markers of the bat marking centre Dresden and period of activity

The bat marking centre Dresden coordinated the marking activity in the GDR first (1960–1963) in coordination with the Museum Alexander Koenig in Bonn. On the basis of a specific decree law (Beringungsanordnung) of the GDR dated 30. 01. 1964 it later became active as an independent marking centre.

The technical and organizational aspects of bat marking in Dresden were supervised by H. Richter from 1960–71, and by H. Hiebsch from 1971 until 1990. Up to 1992 all lists on marking and refinds were collected in files as well as refinds in a species specific index card system

The bat marking centre Dresden first used two ring sizes (X and Z) in Ω–form (similar to Bonn) with out bent latches in order to minimize danger of injury due to burrs. The regular use of their own design took place from 1965 but demands for a third, smaller ring size for the *Pipistrellus* species could not be fulfilled before 1979. From 1972 the use of anodized rings took place. The surface-hardening connected with this technology led at the same time to an improvement in ring quality and the legibility of the numbers. By using a harder aluminium alloy that allowed rings of thinner material to be produced with out bent latches the overall weight of the rings was considerably reduced in 1980 and their quality was further improved. Special services were rendered by M. Wilhelm, who apart from his highly appreciated activity in the bat research also supported the material procurement of the manufacturing firm and finally took over the bending and subsequent treatment of the rings.

During the period from 1964–1990 41 people were active for the bat marking centre (Fig. 3) and they marked 83,926 animals from 18 species. 36,420 refinds were registered involving 15,904 animals.

A characteristic feature is that bat marking is almost exclusively voluntary, in the context of the amateur research in East Germany. Satisfactory results were thereby obtained by the permission of the applicants, which was regulated in 1971 (Schiemenz & Stratmann 1971). The applicants were expected to have been active in bat protection for some time. Thus mostly good previous knowledge exists and the concept of protection becomes a fact that is self evident. In addition test discussions were carried out with the candidates. From 1978 it became a condition for obtaining permission to act as a marker to complete a two-day training course, ending with an examination (species knowledge, talents for marking, legal bases, personal suitability). So far seven such training courses have been held (Tab. 2).

Marking seminars with certain central topics of interest have been held every two years since 1963 at different venues and these were very important to ensure continuous and technically highly-qualified work in the GDR (Tab. 3). In addition to the report of the bat marking centre the emphasis was on the discussion of arising problems, exchange of experience, excursions and specialized lectures. Some of these lectures were preliminary versions of manuscripts that were later published in the bat journals NYCTALUS and/or NYCTALUS (N. F.).

As a result the programme succeeded in connecting the marking work with systematic refind records and concentrating on certain topics of special interest. The extensive number of refinds in the bat marking centre Dresden, with approximately 90 % of refinds done by the markers as well as numerous publications over bat marking and refind results (see bibliography) are an eloquent proof of the success of the programme. Initially the marking and record activities concentrated particularly on winter roosts and/or building-inhabiting species (e.g. Haensel 1973a, 1974, Handtke 1968, Rüssel 1970b, 1971). Soon after came the first experiences with forest-inhabiting species (e.g. Schmidt 1977, Stratmann 1968, 1978). Their treatment was substantially supported by the development of bat boxes, a development to which the marker contributed a substantial proportion (e.g.

Tab. 2: Overview on the marking courses (1979 – 2001) of the bat marking centre Dresden

year	date	place	comments / supervisor
1979	25.–27.07.	Steckby	5 participants, of which 5 passed (D. Heidecke)
1981	21.–24.07.	Steckby	6 participants, of which 5 passed (D. Heidecke)
1983	24.–26.02.	Steckby	5 participants, of which 4 passed (D. Heidecke)
1987	22.–24.04.	Neschwitz	8 participants, of which 8 passed (H. Hiebsch)
1997	12.–17.09.	Zippelsförde	10 participants, of which 8 passed (U. Zöphel)
1999	12.–14.03.	Mansfeld	18 participants, of which 16 passed (U. Zöphel)
2001	27.–29.09.	Zippelsförde	12 participants, of which 9 passed (U. Zöphel)

Tab. 3: Overview on the bat marker seminars of bat marking centre Dresden

nr.	year	date	place	comment resp. reference
1	1963	21.11.	Leipzig	Richter (1963); 29 participants
2	1965	17.06.	Leipzig	Richter (1965, 1966); 23 participants
3	1967	11.–12.02.	Berlin	Richter (1967a, 1968)
4	1969	18.10.	Leipzig	
5	1971	15.05.	Leipzig	Hiebsch (1971), Schiemenz & Stratmann (1971)
6	1972	29.–30.04.	Halle/S.	
7	1973	05.–06.05.	Halle/S.	
8	1975	21.–22.02.	Halle/S.	
9	1976	29.–31.10.	Thale	Hiebsch (1975)
10	1977	26.–28.08.	Gräfenhain	
11	1979	04.–06.05.	Müritzhof	15 participants
12	1981	27.–29.11.	Kelbra	26 participants
13	1983	21.–23.10.	Hildburghausen	22 participants
14	1985	17.–19.05.	Prenzlau	27 participants
15	1987	15.–17.05.	Olbernhau	25 participants
16	1990	09.–11.02.	Ballenstedt	27 participants
17	1992	20.–22.11.	Lindow	21 participants
18	1994	28.–30.10.	Beeskow	20 participants
19	1997	11.–13.04.	Eschefeld	19 participants
20	2000	10.–12.11.	Neschwitz	30 participants; Schmidt (2001a)
21	2004	19.–21.11	Gnewikow	38 participants

Hackethal & Oldenburg 1983, Heise 1980, Schmidt 1990). Important contributions to the ecology of the Noctule (e.g. Heise 1985, 1989a, Heise & Schmidt 1979, Oldenburg & Hackethal 1986, Schmidt 1988a, Stratmann 1978) and Nathusius' pipistrelle (e.g. Hackethal & Oldenburg 1984, Haensel 1985a, Heise 1982, Schmidt 1984, 1985) were the results.

Apart from the research on migration and roost-interrelations an increasing number of new questions came forward such as dispersal, fidelity to roost site, age distribution of roost communities and/or survival rates of appropriate age groups (i.e. Grimmberger & Bork 1978, Heise 1985, Schmidt 1984).

Bat marking and the record of marked animals was never an aim in itself and/or exclusive purpose in the activity of the bat marking centre Dresdner and their voluntary co-workers. Roost investigations and population checks in the roosts contributed substantially to the improvement of the knowledge of distribution, existence and endangerment of native species of bats (i.e. Schober 1971, Hiebsch 1983, Hiebsch & Heidecke 1987). A central data file was kept updated at the ILN Dresden until 1991 and was then handed over to the Federal States.

There was a close co-operation with the Working Group for Bat Protection and Research that was founded in 1965 within the ILN and this was later followed up by the section Special Zoology of the Biological Society of the GDR. Bat markers and the bat marking center took a leading part in the practical roost protection and in the support of bat roosts. On the basis of the Cavity Regulation of the GDR from 1985, the ILN Dresden together with many voluntary and official nature protection co-workers, collected country-wide data on bat winter roosts, classifying the roosts in their priority for bat protection and appropriate information was passed on to the responsible authorities. The fact that many nursery roosts in buildings and winter roosts in cellars and mine shaft were assigned as "protected bat accommodation" and that mine shafts were kept bat-friendly was an additional success of the bat markers together with bat conservationists. Unfortunately the category "protected bat accommodation" has so far not been transferred into Federal Law. However the FFH guideline is reviving the issue again.

2.3 1990s

Following the reunification of Germany, contacts on a technical level led to the realization that the marking centres in Bonn and Dresden and their markers had been specifically organized and technically formed in the meantime. The continuation of the work of both institutions can best serve the responsibility for bat research and protection. With the completion of certain institutions of the GDR on 31.12.91 the bat marking centre Dresden was moved to the Saxon State Agency for Environment and Geology (LfUG) at department for nature conservation. In the transitional phase the Free State Saxony secured the capacity of the marking centre Dresden to proceed with its work. Since 1999 bilateral contracts of the LfUG with the nature protection agencies of the Länder Thuringia, Saxony-Anhalt, Brandenburg and Mecklenburg-Western Pomerania form basis for the work. In the phase of the re-organization of the bat marking in East Germany the bat markers actively supported the preservation of the marking centre on the level of the Länder of the Federal Republic and on the general federal level thereby using voluntary committees, and in particular the Federal Working Group (BAG) Bat Protection within the German Society for Nature Conservation (NABU).

The bat marking centre is technically led by U. Zöphel since 1990, who is, however, within the framework of the new organisational structure only responsible for the scientific supervision in addition to his main activity within the zoological protection of species. The entire technical-organizational completion and data documentation is the responsibility of Mrs. D. Brockmann.

All marking and refind data are collected in an electronic data base since 1993. First the data base programme was dbase®, and then later ACCESS® was used. From 1994/95 collection and presentation of the refinds as well as the relevant markings from 1993 and later has been performed by means of the ACCESS data base FLEDER. In the year 1999 the binding of the data base to a geographical information system for the representation of the local changes in maps could be realized. In 2000 all remaining marking data available in the bat marking centre were imported into the data base. On the basis of the available experience the data acquisition and analysis programme BatBase was used from 2002 by T. Kohbach. It offers the possibility of substantially simplifying the data exchange between markers and the bat marking centre.

Ring production by the manufacturing company in Chemnitz was unfortunately stopped after 1989 and the tools were scrapped. Therefore since 1993 the bat marking centre uses rings produced in England (Tab. 1). Thereby the weight of the rings in small sizes could again be clearly reduced (see chapter 1). However no more progress concerning the ring quality has been obtained since then.

The investigations into roost behaviour, roost fidelity, age distribution of roost communities and survival rates of appropriate age groups that were made in the 1980s were continued and represent the principal aspect of the work after 1990. For these purposes above all continued work over many decades on concrete subjects as well as a shift in emphasis on marking juvenile animals is promising, and more markers committed themselves to the work. Therefore the above mentioned workshops for markers were an important forum (see Tab. 3). The first intensive evaluations (e. g. Heise & Blohm 2003, v. Riesen & Dolch 2003, Schmidt 1994a,b) confirm that this method has indeed been the most appropriate. Preliminary results for a whole number of similar projects are expected shortly. At the same time studies on reproduction success (excluding work e.g. Dolch 2003, Dolch et al. 1997, Haensel 2003, Schorcht 1998) permit more complex views on the modelling of population development. The research and development project "Studies and Recommendations for the Conservation of Bats living in Forests" of the Federal Agency for Nature Conservation (BfN) (12/1995 to 05/1998) contributed in addition to the current investigations to strengthen markings of Noctules and Nathusius' pipistrelle. By the increasing number of known nursery roosts of Leisler's bat and Natterer's bat in various areas as well as Brandt's bat in the northwest of Saxony-Anhalt, more extensive markings of juveniles of these species became possible (i.e. Fischer 1999, Ohlendorf et al. 2002, Schorcht 1998, Weidner 2001). In addition species from which only few roosts were known have been marked more frequently since 1990, which is often connected with large expenditure. This particularly concerns the Pond bat (R. Labes) and the Parti-coloured bat (U. Hoffmeister). Since the species separation of Common pipistrelle and Soprano pipistrelle a new investigation emphasis arises here, which is being tackled particularly by T. Blohm, D. Dolch, G. Heise, U. Hermanns und J. Teubner. Whenever data sets were collected before the two species were separated, the abbreviation Common pipistrelle "sensu lato" (s. l.) is used.

In the 1990s the mist netting was recommended as a catch method. As a result of pilot studies of D. Dolch and the support of the ILN, AG Dresden doll shedding nets were made economically available to a large extent in 1990. They were used for catches mainly along or over waterways as well as in the entry area of underground roosts. In this way investigations of Daubenton's bat were strengthened in the summer season (Dolch 1995, Labes & Labes 1993, Treß et al. 2004) and finally also the Pond bat was discovered (Labes 1992, Dolch et al. 2001), which provided a basis for marking this species. On the other hand investigations at underground roosts, which were otherwise limited to the wintering phase, could be substantially extended seasonally. Late summer flights of Common pipistrelle (s.l.) were in former times successfully observed in the church of Demmin (Grimmberger & Bork 1978, 1979) and Daubenton's bat was observed around the Spandau Citadel in Berlin (Klawitter 1980). Such investigations took place and continue to do so particularly in Brandenburg (i.e. Haensel 2004b, Haensel & Ittermann 1998), Saxony-Anhalt (B. Ohlendorf et al.) and Saxony (Frank 2004, Zöphel et al. 2001). They were partly a component of the research and development project of "Hibernacula on Both Sides of the Oder" accomplished on behalf of the Federal Environment Ministry by EURONATUR, in which the conversion of military objects to safe bat winter roosts was a main objective (11/1999 to 11/2001). Markings with rings from the Dresden marking center also took place in Poland. In addition the markings and records in East Germany brought substantial contributions and additions to the investigation project on the Spandauer Zitadelle (Kallasch & Lehnert 1995).

Investigations at mating roosts of different species were also strengthened into the 1990s. So far these studies concentrate on occurrences in bat boxes particularly with Nathusius' pipistrelle (i.e. Haensel & Wendorf 2004, Kuthe & Ibisch 1994, Schmidt 1994a, b), Lesser noctule (Ohlendorf & Ohlendorf 1998) and Greater mouse-eared bat (Schmidt 2003b).

53 markers were active for the bat marking centre in the period of 1990–2000, of which in the year 2000 43 are still active. It is remarkable that many older markers succeeded in training a new generation. It is to be hoped that by co-operation between the younger and the older generation the continuity of long-term programmes can become secured in the future.

In this period the amount of data increased substantially. 103,526 animals from 18 species were marked and 34,828 refinds of 19,250 animals were registered. The extent of the markings particularly increased in the second half of the 1990s. Thus the responsibilities of the bat marking centre regarding guidance and coordination also increased. First the markers were asked to present the results of the work programmes in a given form. Since 2000 the programmes have been present at the bat marking centre in an updated form. At the same time complex evaluations of the data collected since 1964 began and the most substantial results are now presented in this publication. Among other things they show that bat marking strongly fulfils the report obligations of the FFH guideline, and optimizes the relevant number of markers and prioritizing the appropriate marking programmes.

In addition evaluations, in particular with regard to the migration behaviour for the whole of Germany and Europe, are desirable. In 2002 a research and development project "Bat Migrations in Central Europe" was therefore assigned by the BfN to the Museum Alexander Koenig in Bonn and a co-operation with the bat marking centre Dresden was agreed upon.

3 Overview of results

3.1 Marking and record statistics

From 1964 to 2000 in East Germany (including East Berlin), which is the area of responsibility for the bat marking centre, 187,452 bats were marked, and of these 35,154 animals (18.7 %) have provided 66,056 records (35.2 %). During this time 201 bats from other marking centres, which were marked predominantly outside the area, were recorded with 265 refinds. After a start-up phase lasting until the beginning of the 1970s the number of animals ringed annually reached a level of between 3,000 and 4,000 markings at beginning of the 1990s. Since 1992 the annual marking numbers rose clearly and achieved over 19,000 markings with the highest value in the year 2000 (Fig. 4).

For the population statistics juvenile animals, whose birth years are known, have a special importance. The bat marking centre therefore already encouraged an increase in the proportion of these group within the markings. This was accompanied by a reduction in the marking cover in winter roosts. Since the middle of the 1970s a proportion of approximately 40 % juveniles of the marked animals was reached, and around 1990 it even reached 50 % (Fig. 5).

The sites where markings of bats take place in the eastern provinces of the Federal Republic of Germany are spatially relatively well distributed (Fig. 6). Also, in the future, it is intended that a spatially balanced distribution of the marking and record activity will be achieved, because this will identify regional differences in the behaviour of the species (i.e. migration, survival rates) and such evaluations result in more reliable considerations and generalizations.

The statistical data concerning the different species are shown in Tab. 4 and 5. It has to be noted that the opinion on the species status for Central European bats changed during the reported period. Since the re-discovery of the Grey long-eared bat (*Plecotus austriacus*) by Bauer (1960) this species is separated from the Brown long-eared bat (*Plecotus auritus*). It has to be assumed that there were still some difficulties with the differen-

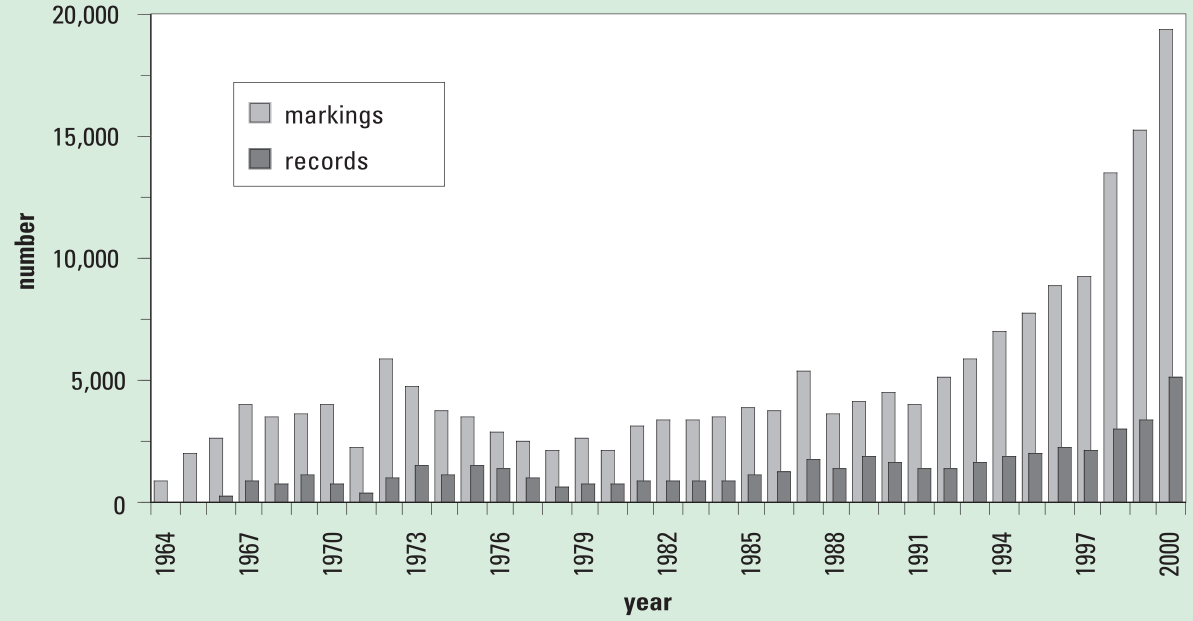

Fig. 4: Number of bats marked annually and of reported records of marked invidivuals

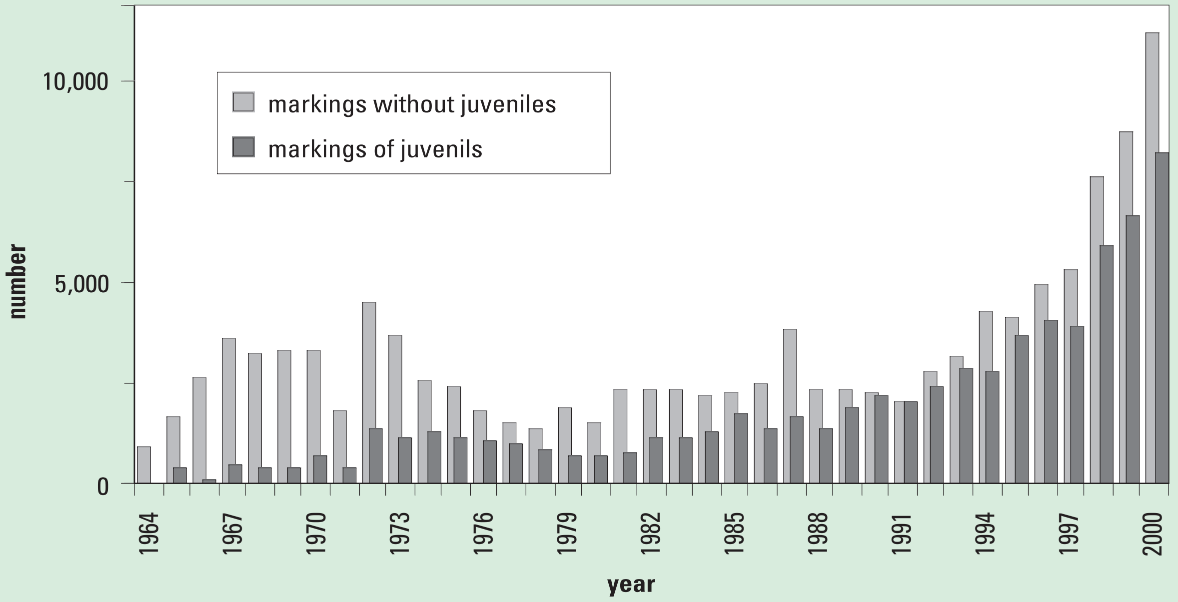

Fig. 5: Proportion of juveniles to adults within the marked bats in East Germany

tiation of both species up to the middle of the 1960s, in particular with young animals. Gauckler & Kraus (1970) recognized the species status and the occurrence of Brandt's bat and Whiskered bat in Germany. Therefore up to autumn 1972 the Brandt's bat and Whiskered bat were not differentiated and all observations were registered as Brandt's bat (*Myotis mystacinus* [s.l.]).

With the differentiation of the Soprano pipistrelle (*Pipistrellus pygmaeus*) from the Common pipistrelle (*Pipistrellus pipistrellus*) and particularly since morphologic differences are also known (Häussler et al. 1999), distinct markings of both kinds began in 1999.

In many cases species differentiation from later records of living or dead animals could still clarify retroactively the species affiliation. For Soprano pipistrelles and the Common pipistrelle the revision of results from the past represents a task for the future.

Furthermore it has to be considered that the Lesser horseshoe bat was excluded from the marking according to the special decree-law (Beringungsanordnung) the GDR. Only on the exceptional occasion of a rescue action in 1970 on behalf of the nature protection authority, were animals marked when they were shipped to another roost site for success.

In the period 1964 to 2000 Nathusius' pipistrelle and Daubenton's bat were most frequently marked, followed by Noctule, Greater mouse-eared bat and Common pipistrelle s.l., with Brown long-eared bat and Natterer's bat ringed to a lesser extent. All other species were ringed in much smaller numbers.

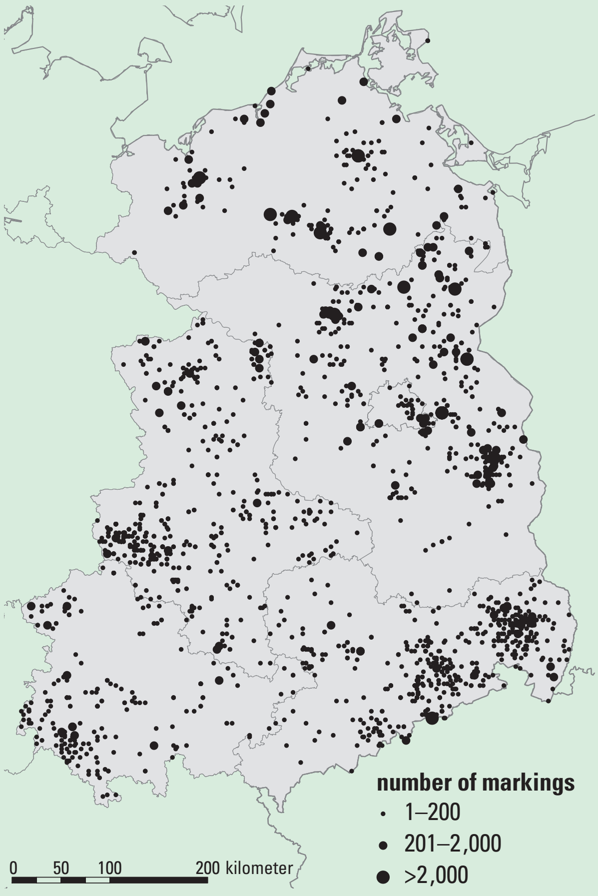

Fig. 6: Distribution of marking locations in East German Länder

Tab. 4: Overview of marked bats and refinds obtained from 1964 - 2000 in the area of responsibility of the bat marking centre Dresden

	marking												recapture									refinds dead								
	total				juvenils				adults				total			juvenils			adults			total			juvenils			adults		
species	♀	♂	nd	sum	♀	♂	nd	sum	♀	♂	nd	sum	♀	♂	sum	♀	♂	sum	♀	♂	sum	♀	♂	sum	♀	♂	sum	♀	♂	sum
B.BAR	786	923	9	1,718	168	203	0	371	618	720	9	1,347	410	475	885	102	79	181	308	396	704	3	4	7	0	0	0	3	4	7
E.NIL	1,169	275	6	1,450	161	157	1	319	1,008	118	5	1,131	862	63	925	123	35	158	739	28	767	7	3	10	1	2	3	6	1	7
E.SER	1,704	767	11	2,482	508	468	4	980	1,196	299	7	1,502	213	60	273	51	13	64	162	47	209	18	12	30	5	5	10	13	7	20
M.BEC	297	348	1	646	61	56	1	118	236	292	1	529	49	143	192	2	37	39	47	106	153	0	0	0	0	0	0	0	0	0
M.BRA	2,768	1,991	5	4,764	553	576	0	1,129	2,215	1,415	4	3,634	1,674	788	2,462	198	73	271	1,476	715	2,191	9	7	16	1	0	1	8	7	15
M.DAS	313	167	1	481	149	127	1	277	164	40	0	204	34	15	49	21	7	28	13	8	21	0	0	0	0	0	0	0	0	0
M.DAU	17,710	14,790	64	32,564	2,701	2,785	3	5,489	15,009	12,005	61	27,075	4,547	3,274	7,821	405	244	649	4,142	3,030	7,172	39	58	97	5	7	12	34	51	85
M.M&B	140	182	0	322	1	4	0	5	136	178	0	314	0	9	9	0	0	0	0	9	9	0	1	1	0	0	0	0	1	1
M.MYO	14,566	9,964	43	24,573	6,365	6,479	13	12,857	8,201	3,485	30	11,716	11,952	5,293	17,245	6,251	2,706	8,957	5,701	2,587	8,288	143	102	245	68	65	133	75	37	112
M.MYS	860	1,156	0	2,016	90	120	0	210	770	1,036	0	1,806	170	236	406	12	15	27	158	221	379	3	9	12	0	0	0	3	9	12
M.NAT	6,169	6,446	27	12,642	1,208	1,282	2	2,492	4,961	5,164	25	10,150	3,698	2,653	6,351	1,248	402	1,650	2,450	2,251	4,701	18	26	44	1	3	4	17	23	40
N.LEI	2,792	1,149	4	3,945	1,205	1,000	0	2,205	1,587	149	4	1,740	1,717	628	2,345	957	351	1,308	760	277	1,037	10	3	13	4	2	6	6	1	7
N.NOC	16,816	10,866	74	27,756	7,279	7,037	27	14,343	9,537	3,829	47	13,413	5,255	2,100	7,355	2,858	1,110	3,968	2,397	990	3,387	28	28	56	10	10	20	18	18	36
P.ARI	7,381	5,347	25	12,753	1,791	1,902	3	3,696	5,590	3,445	22	9,057	4,963	1,721	6,684	1,879	865	2,744	3,084	856	3,940	44	35	79	16	14	30	28	21	49
P.AST	730	500	11	1,241	102	112	1	215	628	388	10	1,026	154	73	227	15	10	25	139	63	202	8	4	12	0	1	1	8	3	11
P.NAT	22,176	12,372	59	34,607	9,827	7,870	27	17,724	12,349	4,502	32	16,883	3,339	3,446	6,785	1,882	763	2,645	1,457	2,683	4,140	37	29	66	15	20	35	22	9	31
P.PIP	13,640	9,132	42	22,814	2,490	2,905	0	5,395	11,150	6,227	42	17,419	2,603	2,428	5,031	701	1,072	1,773	1,902	1,356	3,258	116	110	226	28	45	73	88	65	153
P.PYG	96	38	0	134	52	33	0	85	44	5	0	49	0	2	2	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
R.HIP	15	4	0	19	0	0	0	0	15	4	0	19	0	5	5	0	0	0	0	5	5	2	0	2	0	0	0	2	0	2
V.MUR	304	219	2	525	182	166	0	348	122	53	2	177	64	23	87	43	21	64	21	2	23	0	1	1	0	1	1	0	0	0
	110,432	**76,636**	**384**	**187,452**	**34,893**	**33,282**	**83**	**68,258**	**75,536**	**43,354**	**301**	**119,191**	**41,704**	**23,435**	**65,139**	**16,749**	**7,803**	**24,551**	**24,956**	**15,632**	**40,588**	**485**	**432**	**917**	**154**	**175**	**329**	**331**	**257**	**588**

Tab. 5: Number of markings and refinds for different bat species in the period 1964 to 2000

bat species		**marking**	**refound animals**		**total refinds**	
			number	**%**	**number**	**%**
Lesser horseshoe bat *Rhinolophus hipposideros*	(R.hip)	19	2	10.5	7	36.8
Whiskered and Brandt's bat *Myotis mystacinus* et *brandtii*	(M.m&b)	322	8	2.5	10	3.1
Whiskered bat *Myotis mystacinus*	(M.mys)	2,016	303	15.0	418	20.7
Brandt's bat *Myotis brandtii*	(M.bra)	4,764	1,167	24.5	2,478	52.0
Natterer's bat *Myotis nattereri*	(M.nat)	12,642	2,321	18.4	6,395	50.6
Bechstein's bat *Myotis bechsteinii*	(M.bec)	646	88	13.6	192	29.7
Greater mouse-eared bat *Myotis myotis*	(M.myo)	24,573	5,919	24.1	17,490	71.2
Daubenton's bat *Myotis daubentonii*	(M.dau)	32,564	3,865	11.9	7,918	24.3
Pond bat *Myotis dasycneme*	(M.das)	481	23	4.8	49	10.2
Parti-coloured bat *Vespertilio murinus*	(V.mur)	525	73	13.9	88	16.8
Northern bat *Eptesicus nilssonii*	(E.nil)	1,450	474	32.7	935	64.5
Serotine *Eptesicus serotinus*	(E.ser)	2,482	143	5.8	303	12.2
Noctule *Nyctalus noctula*	(N.noc)	27,756	4,592	16.5	7,411	26.7
Leisler's bat *Nyctalus leisleri*	(N.lei)	3,945	1,018	25.8	2,358	59.8
Common pipistrelle s.l. *Pipistrellus pipistrellus* s.l.	(P.pip)	22,814	3,271	14.3	5,254	23.0
Soprano pipistrelle *Pipistrellus pygmaeus*	(P.pyg)	134	1	0.7	2	1.5
Nathusius' pipistrelle *Pipistrellus nathusii*	(P.nat)	34,607	3,491	10.1	6,851	19.8
Barbastelle *Barbastella barbastellus*	(B.bar)	1,718	444	25.8	892	51.9
Brown long-eared bat *Plecotus auritus*	(P.ari)	12,753	2,307	18.1	6,763	53.0
Grey long-eared bat *Plecotus austriacus*	(P.ast)	1,241	123	9.9	239	19.2
sum		**187,452**	**29,633**	**15.8**	**66,056**	**35.2**

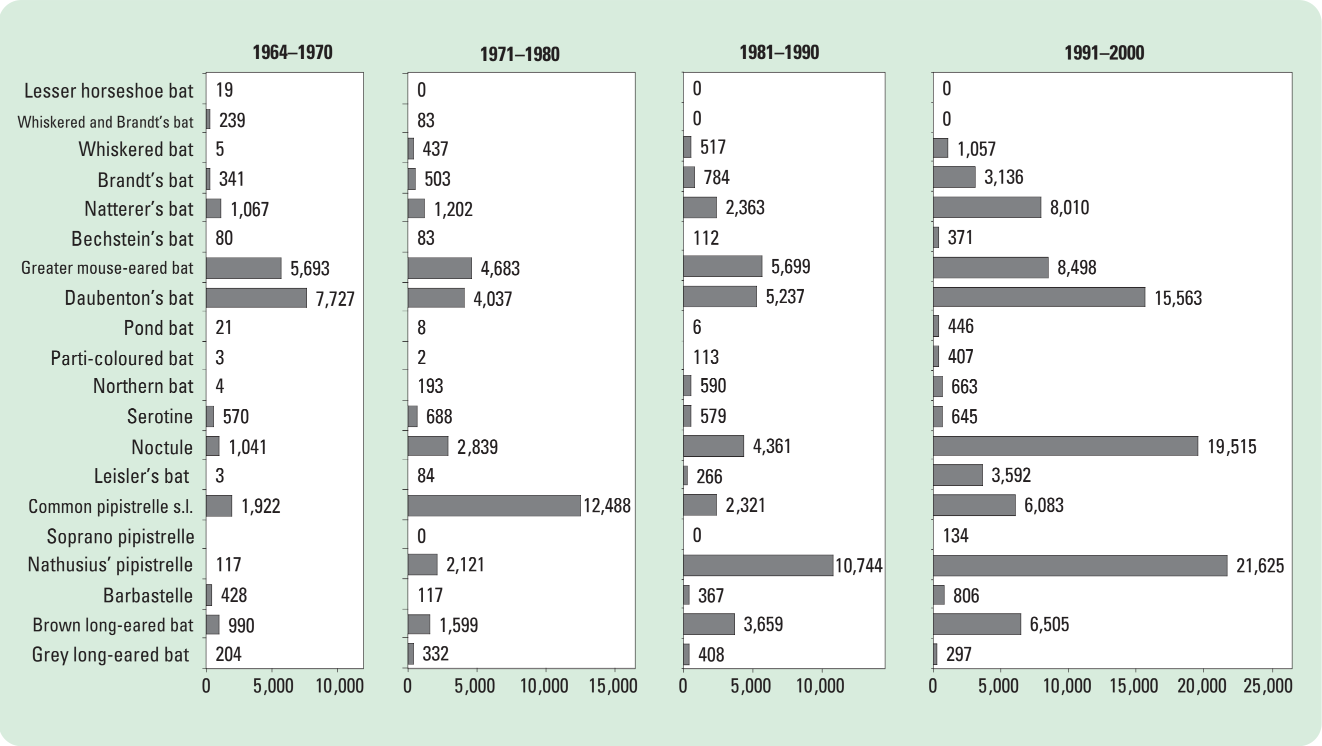

Fig. 7: Marking extent of different bat species in East Germany over different time periods

When shorter time periods are examined, then there are shifts in the proportion of the individual species (Fig. 7) within the markings, which can be explained by changed locations and emphasis of markers respectively, changes in the population of bat species and in part by the intensity of marking activity. In the period 1964–1970 Daubenton's bat and Greater mouse-eared bat dominated clearly, whereas later the Common pipistrelle s.l., especially as a result of the high marking activity during several years of the ministry of Reverend Bork in the church of Demmin. In the period 1981–1990 the spectrum is somewhat more balanced with clear increases especially for all forest bats (bat boxes) and among them Nathusius' bat. In the 1990s the marking numbers of almost all species increased; in particular of Noctule and Nathusius' bat (bat boxes, population increase, intensified marking programme) as well as Daubenton's bat and Natterer's bat (net catches, population increase). Over the total time the Greater mouse-eared bat was the species most continuously worked on, followed by Daubenton's bat.

The ratio between ♂♂ and ♀♀ is dominated with markings in favour of ♀♀ (Fig. 8). This is mainly because markings often take place in the summer season, when adult ♀♀ have an increased accessibility because of their use of nursery roosts. In this period ♂♂ usually spend their resting time at unknown roosting sites. For Whiskered bat, Natterer's bat, Bechstein's bat and Barbastelle the ratio is opposite. For these species markings in winter roosts are higher for different reasons [roosts choice, life expectancy (?) etc. – see also chapter 3.2 and 3.3], and in the winter roosts often a surplus of males in recorded.

Also the refind rate for ♀♀ is predominantly higher than those for ♂♂ (Fig. 9). The chance of refinding males that were mostly marked as juveniles in the nursery roost (juveniles) and in the winter roosts (subadults and adults) in the following summers is lower due to the above reasons. Exceptions here are again the Whiskered bat and Bechstein's bat as well as Common pipistrelle s.l. and Nathusius' pipistrelle. For the Whiskered bat the higher marking percentage of ♂♂ in the winter roosts results also in relative higher refind percentages. For Bechstein's bat ♂♂ both in the winter and in the summer higher refind rates are obtained. For the Common pipistrelle s.l. the generally smaller local roost site fidelity of ♀♀ (see Tab. 8) results in higher percentage of refinds in males. For Nathusius' pipistrelle beside nursery roosts mainly mating roosts are examined. For the latter species above all the ♂♂ are faithful to roost sites resulting in higher refind rates.

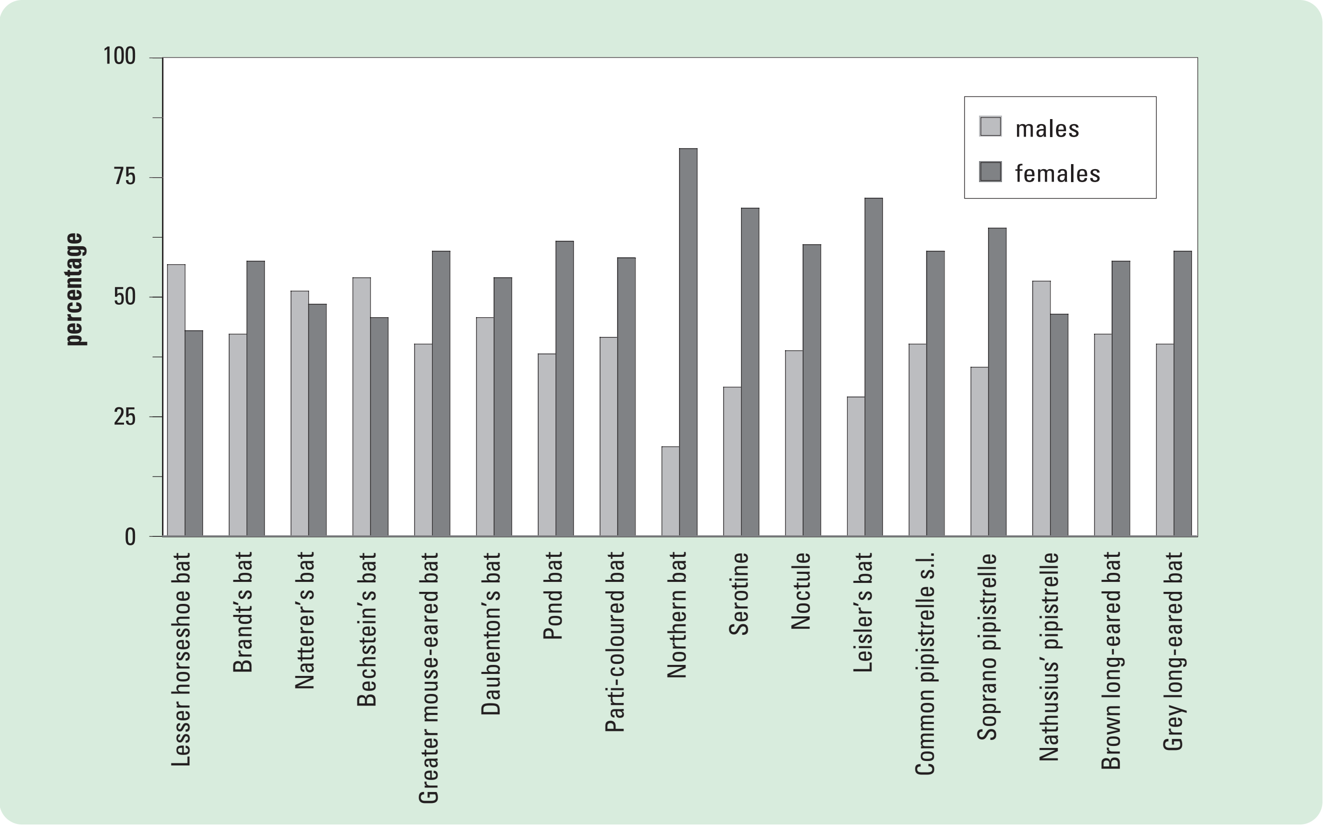

Fig. 8: Proportion of marked male and female bats in East Germany

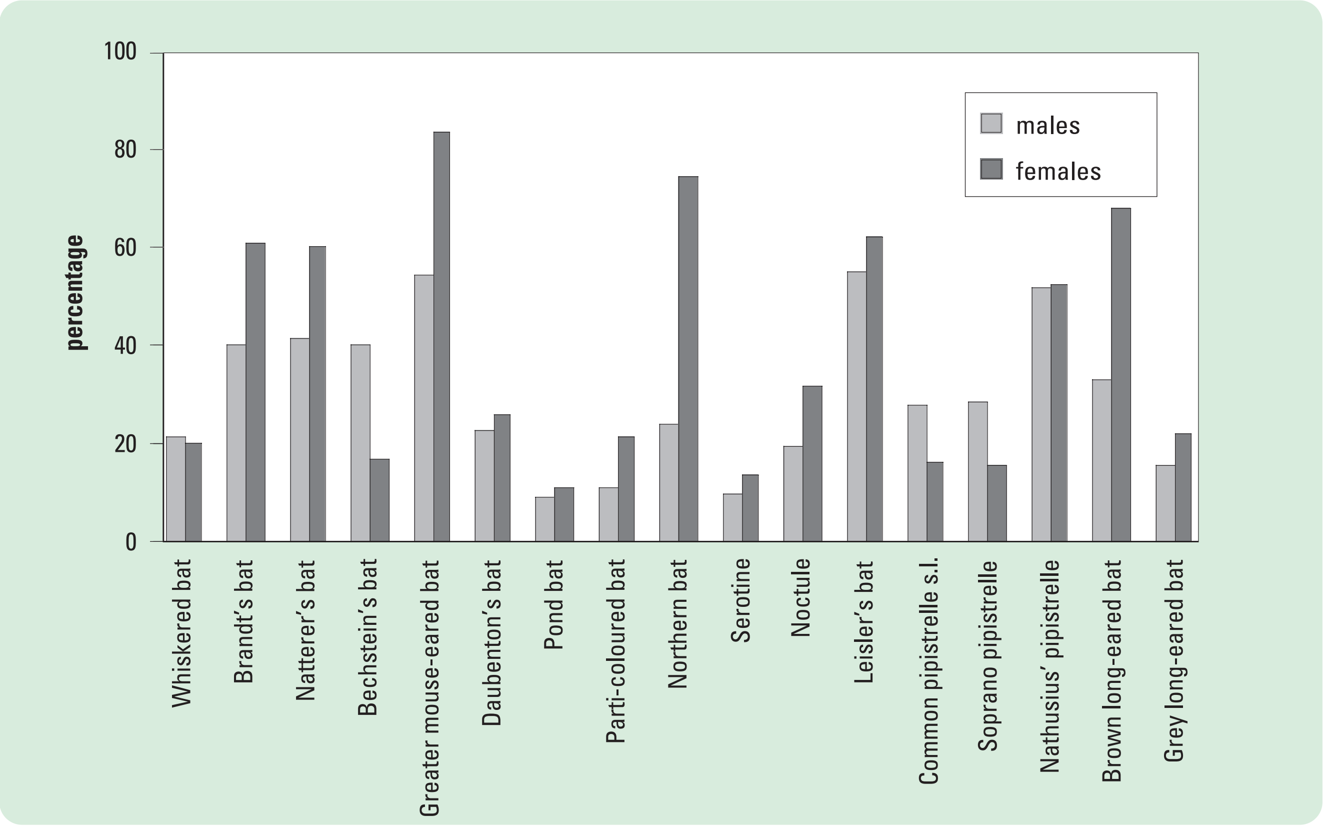

Fig. 9: Proportion of refound male and female bats in East Germany

3.2 Translocation and site fidelity of marked bats

3.2.1 Introduction and overview of results

The ability to fly enables bats to change their position rapidly and to a lesser or greater distance. Due to their predominantly nocturnal way of life knowledge was very limited. Only through the introduction of bat marking by means of lower arm clips did it become possible to win insights into the spatial movements of these species (e.g. Eisentraut 1934, Meise 1951, Roer 1960). With the development of efficient miniaturized transmitters at the end of the 1980s telemetry enabled very detailed studies. However, when investigations, which depend on a large sample size and durable marking or which serve the collection of spacious local changes, the classical marking method is almost without alternative until today.

For the understanding of the spatial behaviour of bats it is of interest to know at what distance the marking location refinds are done. For those species that were marked and recorded within the responsibility of the bat marking centre Dresden the following data for ♂♂ and ♀♀ were obtained (Fig. 10).

In principle the exact location of all refinds is known. Therefore the total number of the species-related refinds (Tab. 4) is identical with the respective sample size in Fig. 10.

All species have a high percentage (62–98 %, on the average 89.3 % ♂♂ and 86.7 % ♀♀) of refinds < 1 km distance from the marking location.* The main cause for this phenomenon is the relative high roost site fidelity of all species. On the other hand a much higher chance exists to refind animals at the marking place than at any of the other possible locations. Finally it has to be considered that local roost site fidelity can only be interpreted regarding the respective type of roosts (summer roosts, winter roosts, mating roosts etc.) and that the proportion of non-migrating animals is only interpretable in relation to the seasonal migration between appropriate roosts, so that these data are not discussed further here.

In contrast information on location changes are relatively rare (Fig. 10). 4,544 refinds with a distance of more than 10 km to the marking location represent only 6.9 % of the refinds (6.8 % for males, 6.9 % for females). Remote finds with more than 100 km distance represent 1.3 % of the refinds and for all species with an amount of large data represent less than 0.6 % of the marked animals. An exception is the Greater mouse-eared bat, which exhibits altogether a relatively high refind rate of 1.8 %.

The longest species specific migration routes for animals marked within the range of the bat marking centre Dresden are arranged in Tab. 6 and compared with literature data of other European marking centres.

When bat species are distinguished on the basis of the extent of the distance of their migration distances according to Roer (1971), Gaisler & Hanak (1969) and Gaisler et al. (2003) in three groups, then according to the refind data of the bat marking centre Dresden the following groupings are possible (Fig. 10)

a) Migrating species (Long distance migrants)

For this group typically the majority of migrations are over a distance of 100 to 1,000 km with/or maximum migration distances of > 500 km. This group consists of species such as Nathusius' pipstrelle, Leisler's bat and Noctule (comp. Fig. 10 and Tab. 6).

b) Species with the ability to migrate (Regional migrants)

For this group typically the majority of migrations are over a distance of 10 to 100 km with maximum migration distances of 100 to 500 km. This group consists of

- Daubenton's bat, Greater mouse-eared bat, and Brandt's bat with evenly distributed refinds of 10 to 100 km distance and a relative high number of refinds > 100 km,
- Natterer's bat, Common pipistrelle s. l., Serotine, and Whiskered bat with decreasing number of refinds between 10 and 100 km and only a few refinds > 100 km.

Only as a result of some refinds >100 km, supported by additional references (comp. Tab. 6), are Northern bat, Pond bat, and Parti-coloured bat listed under b). A further refinement of the assignment is not possible at the moment because of a lack of data. For the Common pipistrelle s. l. refind data of up to 775 km are available (B. Ohlendorf) (Tab. 6), but the final species determination (Common pipistrelle or Soprano pipistrelle) is unclear.

c) Generally not a migrating species (Sedentasy species)

For this group typically the majority of migrations are over a distance of 1 to 10 km with maximum migration distances of <100 km. This is supported further by Gaisler & Hanak (1969) and Gaisler et al. (2003) for the Czech Republic and Slovakia (comp. Tab. 6). Assigned to this group are Bechstein's bat and Barbastelle. For Bechstein's bat the maximum migration distance is clearly less than 100 km. Similar results are also available for Bavaria (Rudolph et al. 2004). For the Barbastelle data are available for migration distances of up to 100 km and even >100 km (Gaisler & Hanak 1969, Hoehl 1960, Kepka 1960). For both species the main proportion of refinds is in the range of 10 – 100 km, when only ♂♂ are considered. These distances may not

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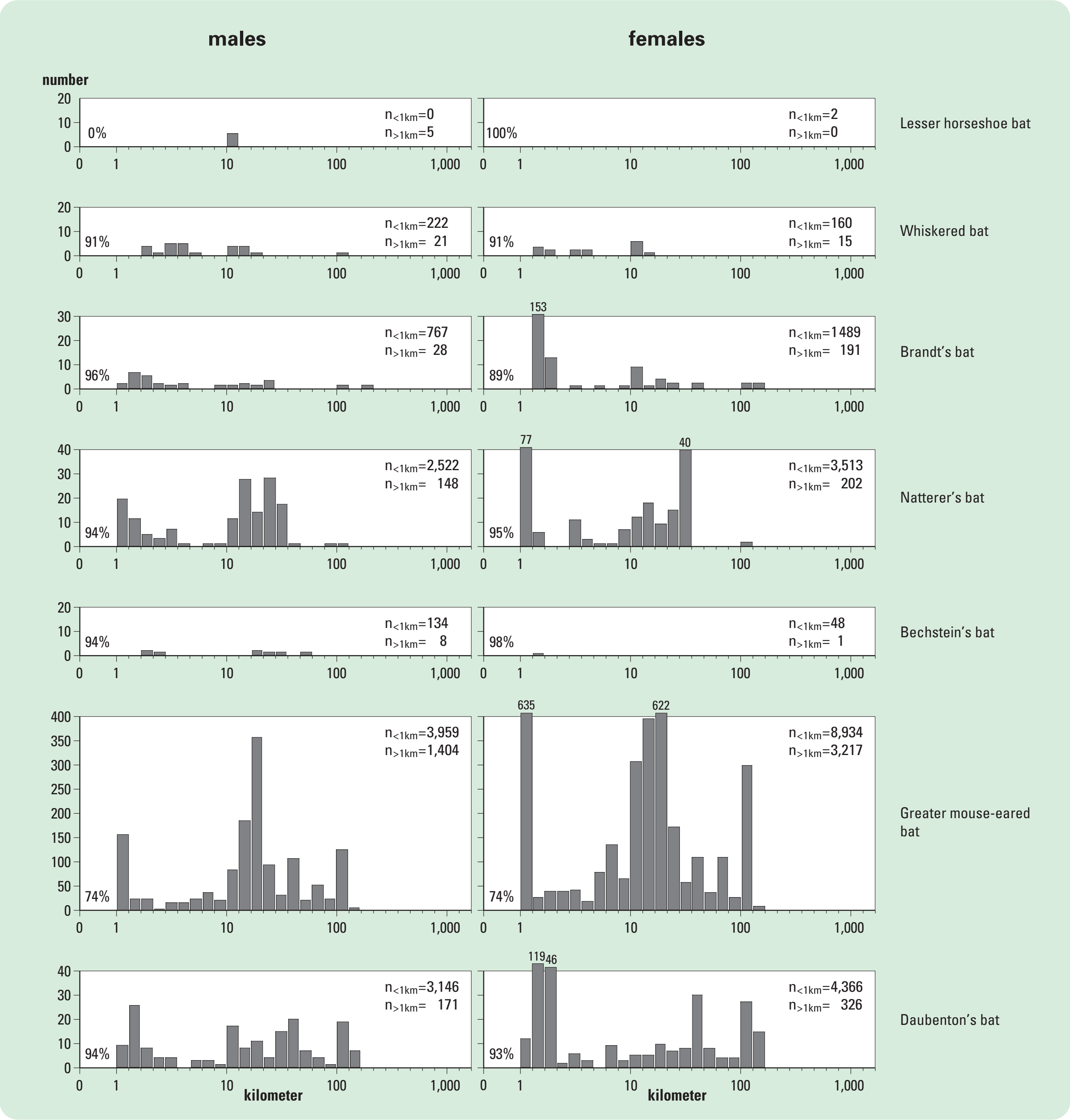
* The Lesser horseshoe bat was thereby excluded from the analyses due to the limited data available.

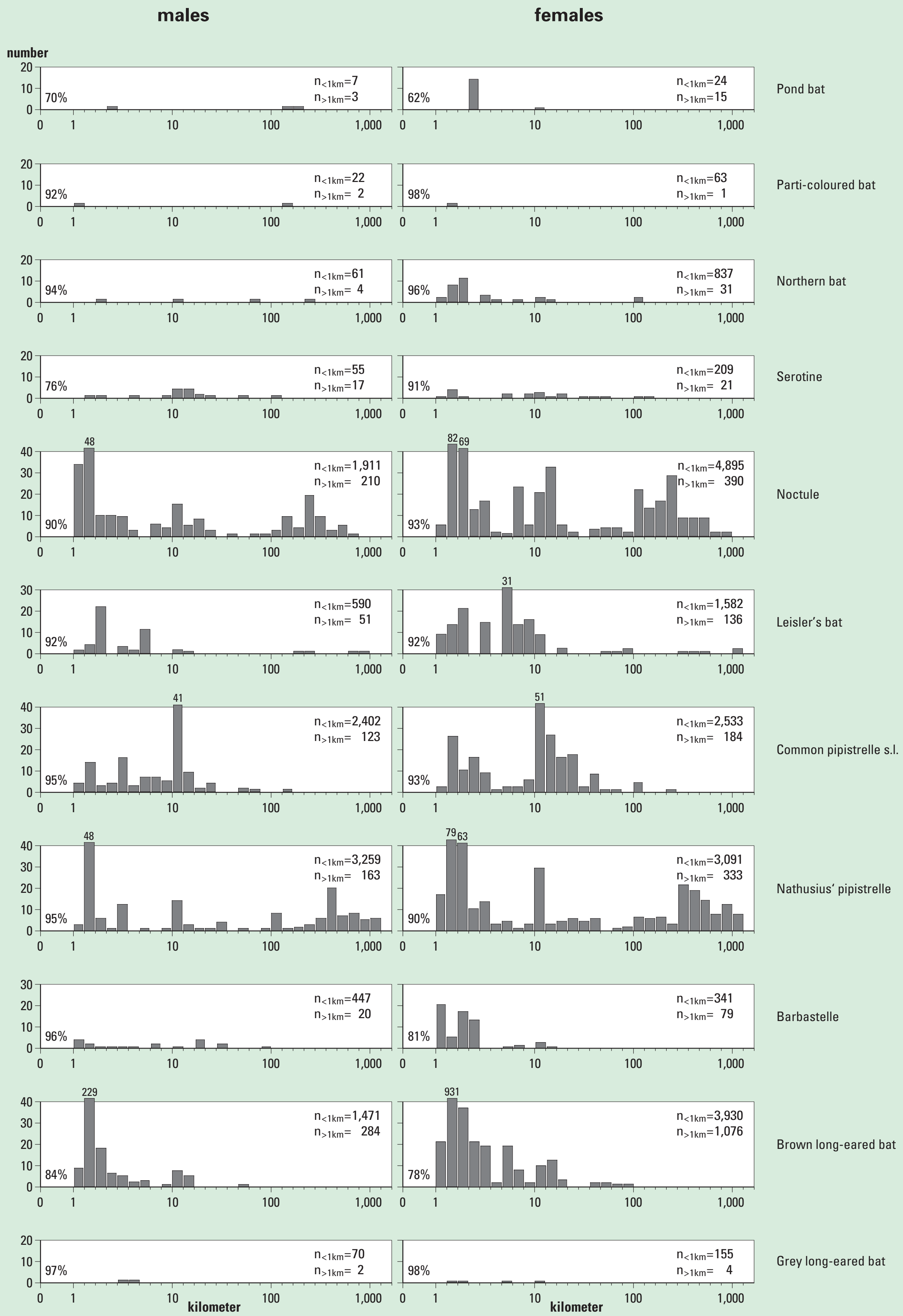
prove typical for these species as it is only for the ♂♂ that a sufficient number of data over longer time periods exist. So eventually these two species may be assigned in the future to the second group. In the light of other ecological information this is more likely for the Barbastelle than for Bechstein's bat.

The Lesser horseshoe bat is also definitely a part of this group, but hardly any data are available for the area for which bat marking centre Dresden is responsible.

Furthermore, for all species for which the database allows such a comparison no big differences between males and females in respect to the migration distances between ♀♀ and ♂♂ were found (Fig. 10). As a result of a more detailed differentiation of the data between animals marked in adult or juvenile stage this may not be true for all species but this will be discussed later.

Fig. 10: Proportion of refinds at the marking location (< 1 km = %) and the distribution of the refinds in distances > 1 km, differentiated for ♂♂ and ♀♀.




males
females
number
kilometer
kilometer
0
1
10
100
1,000
Pond bat
70%
$n_{<1km}$=7
$n_{>1km}$=3
62%
$n_{<1km}$=24
$n_{>1km}$=15
Parti-coloured bat
92%
$n_{<1km}$=22
$n_{>1km}$= 2
98%
$n_{<1km}$=63
$n_{>1km}$= 1
Northern bat
94%
$n_{<1km}$=61
$n_{>1km}$= 4
96%
$n_{<1km}$=837
$n_{>1km}$= 31
Serotine
76%
$n_{<1km}$=55
$n_{>1km}$=17
91%
$n_{<1km}$=209
$n_{>1km}$= 21
Noctule
48
90%
$n_{<1km}$=1,911
$n_{>1km}$= 210
82
69
93%
$n_{<1km}$=4,895
$n_{>1km}$= 390
Leisler's bat
92%
$n_{<1km}$=590
$n_{>1km}$= 51
31
92%
$n_{<1km}$=1,582
$n_{>1km}$= 136
Common pipistrelle s.l.
41
95%
$n_{<1km}$=2,402
$n_{>1km}$= 123
51
93%
$n_{<1km}$=2,533
$n_{>1km}$= 184
Nathusius' pipistrelle
48
95%
$n_{<1km}$=3,259
$n_{>1km}$= 163
79
63
90%
$n_{<1km}$=3,091
$n_{>1km}$= 333
Barbastelle
96%
$n_{<1km}$=447
$n_{>1km}$= 20
81%
$n_{<1km}$=341
$n_{>1km}$= 79
Brown long-eared bat
229
84%
$n_{<1km}$=1,471
$n_{>1km}$= 284
931
78%
$n_{<1km}$=3,930
$n_{>1km}$=1,076
Grey long-eared bat
97%
$n_{<1km}$=70
$n_{>1km}$= 2
98%
$n_{<1km}$=155
$n_{>1km}$= 4

Tab. 6: Longest migration distances of bats marked in East Germany and comparison with literature references from other European marking centres

bat species	♂ ♀ **?**	**bat marking centre Dresden**		**other European marking centres**	
		max. distance in km	**source**	**max. distance in km**	**source**
Lesser horseshoe bat	♂	12	data base	145	Harmata (1968)
	♀	0	data base	112	Gaisler et al. (2003)
Whiskered bat	♂	127	data base	165[1]	Gaisler et al. (2003)
	♀	74	data base	38	Gaisler et al. (2003)
Brandt's bat	♂	308	data base	230	Kraus & Gauckler (1972)
	♀	228	data base		
Natterer's bat	♂	109	Ohlendorf (2002b)	102	Masing et al. (1999)
	♀	157	Ohlendorf (2002b)		
Bechstein's bat	♂	73	data base		
	♀	37	data base	27	Schlapp (1990)
Greater mouse-eared bat	♂	328	data base	325	Rudolph et al. (2004)
	♀	304	data base	390	Paz et al (1986)
	?	379	data base	368	Rudolph et al. (2004)
Daubenton's bat	♂	304	data base	100	Gaisler et al. (2003)
	♀	261	data base	185	Kallasch & Lehnert (1995)
Pond bat	♂	302	data base	317	Sluiter et al. (1971)
	♀	177	Ohlendorf (2004)	332	Feldmann (1969), Sluiter et al. (1971)
Parti-coloured bat	♂	483	data base	1,440	Masing (1989a)
	♀	382	data base	360	Panjutin (1968), Strelkov (1971)
Northern bat	♂	450*	Treß (1994)		
	♀	150	data base	250	Gaisler et al. (2003)
Serotine	♂	144	Schmidt & Mainer (1999)		
	♀	201	data base	330	Havekost (1960)
Noctule	♂	801*	Oldenburg & Hackethal (1986)	1,500	Kameneva & Panjutin (1960)
	♀	950	Heise & Blohm (2004)	1,600	Bureš & Beron (1960), korr. Strelkov (1969)
Leisler's bat	♂	1,275	data base	977	Néri & Aulagnier (1996)
	♀	1,568	Ohlendorf et al.(2001)		
Common pipistrelle s.l.	♂	775	data base	54	Gaisler et al. (2003)
	♀	442*	Wilhelm (1971b)	411[2]	Sachteleben (1991), Gaisler et al. (2003)
Nathusius' pipistrelle	♂	1,455	Treß et al. (2004)	1,905	Petersons (1990)
	♀		Schmidt (2004)	1,620	Petersons (1990)
Barbastelle	♂	100	data base	135	Gaisler & Hanák (1969)
	♀	21	data base	290	Kepka (1960)
	?			145	Hoehl (1960)
Brown long-eared bat	♂	71	data base	88	Gaisler et al. (2003)
	♀	90	data base	77	Gaisler et al. (2003)
Grey long-eared bat	♂	6	data base	62	Gaisler & Hanák (1969)
	♀	15	data base	58	Gaisler & Hanák (1969)

* calculated flight distance corrected

[1] Data of Feldmann (1979) with 240 km and Fairon (1967) with 112 km (♂/♀) are from the time when *M. mystacinus* and *M. brandtii* were not distinguished and may therefore refer to both species

[2] Data of migrating populations in the European part of Russia are not added (e. g. 1,160 km (♀) Bureš & Beron (1962), Popov (1941))

3.2.2 *Necessity and possibilities for a further differentiation of results*

3.2.2.1 Data basis

Due to the different possibilities of quality record the amount of data that is available for analysis differ considerably, partly because of the distribution of the marking and record results from different types of roosts and seasons for males and females of different species (Fig. 11). For Nathusius' pipistrelle, Leisler's bat, Particoloured bat, Pond bat, Serotine, Noctule, Northern bat and Brown long-eared bat data are predominantly present from the summer season. On the other hand, most data available for Daubenton's bat and Grey long-eared bat, but also for Natterer's bat, Barbastelle and Bechstein's bat are from the winter season. In respect to genders, the proportion of adult marked ♀♀ is higher in the summer than those of adult marked ♂♂; mainly because adult ♀♀ are ringed more often in the nursery roosts as they are visited for this purpose by the markers. For animals marked as juveniles this difference exists equally for records of marked animals in the following summers. These species, sex and age disparities affect of course the results as presented in Fig. 10.

3.2.2.2 Type of change of site

Depending upon the type of the location change the following categories can be differentiated:

- seasonal migrations between summer and winter roosts
- migrations to swarm, mating or intermediate roosts
- dispersal migrations of juvenile animals
- summer and winter roost shifting (eventually also mating and intermediate roost shifting) of adult animals
- daily nocturnal flights between appropriate roosts and hunting areas

The different species can only be categorized accurately concerning their spatial behaviour by appropriate separation between genuine migration and new settlements as a result of roost change and roost fidelity as well as daily and yearly activity areas.

3.2.2.3 Possibilities for further differentiation of the results

Information about daily nocturnal flights between roosts and hunting areas can be derived only exceptio-

Fig. 11: Distribution of marking and recaptures on different seasonal roost types depending on bat species and sex (continuation p. 28)

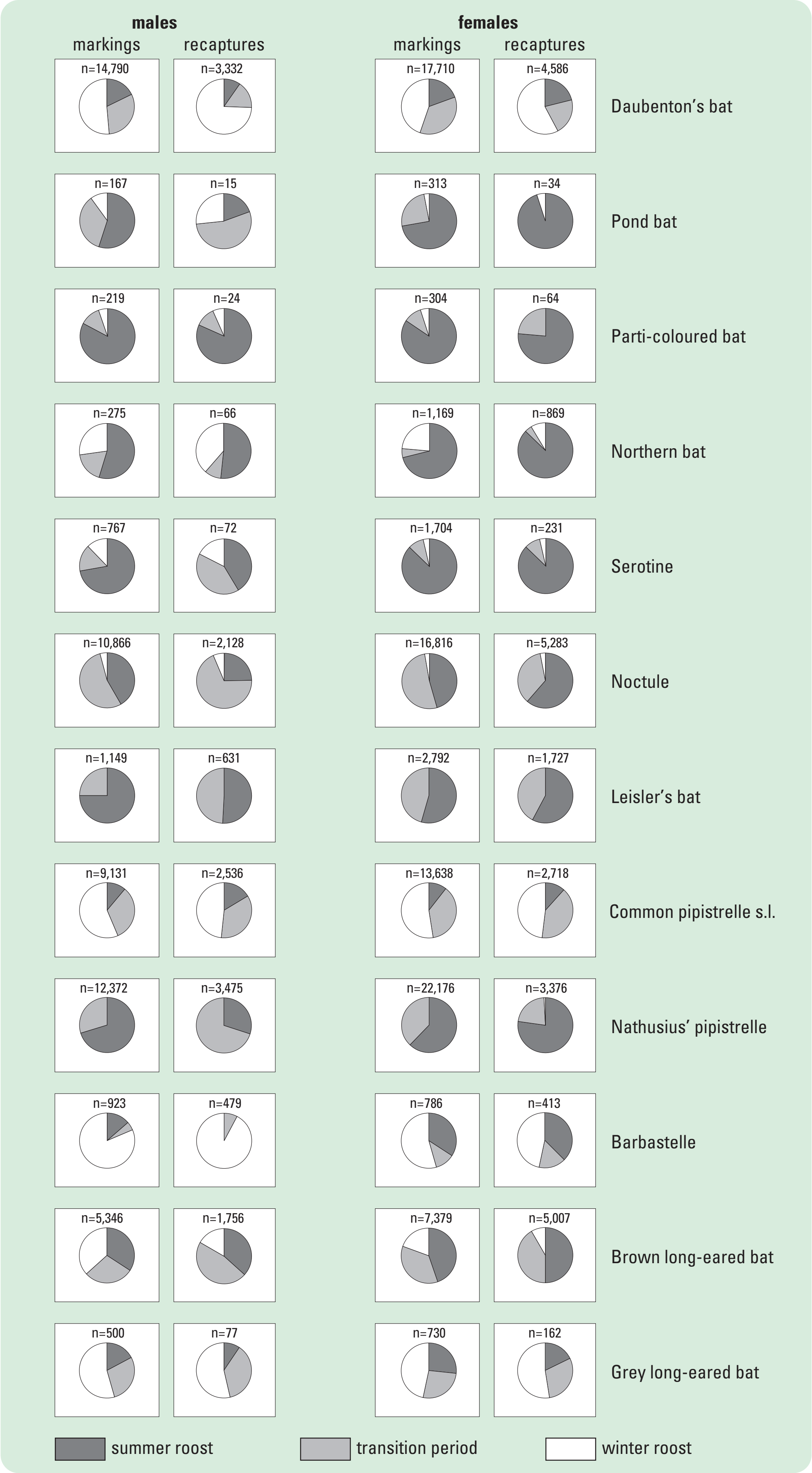


Fig. 11:
Distribution of marking and recapture on different seasonal roost types depending on bat species and sex (continuation from p. 27)

nally from available refind information, since they would need specially designed studies and probably only telemetry would be able to deliver results with justifiable expenditure. Also migrations to swarm, mating or to intermediate roosts and exploratory flights and dispersal migrations require a special experimental design or an individual case investigation, in order to be able to distinguish it sufficiently from normal seasonal migration between winter and summer roosts.

The bulk of the available marking and refind results refers to typical winter and summer roosts (and/or nursery roosts). For the evaluation and attempted general analysis of roost site changes aimed here, the following must be differentiated:

- seasonal migrations between summer and winter roosts (su–wi)
- changes between summer roosts (su–su) as well as winter roosts (wi–wi)

Within one season the same individual may be recaptured at the same place several times and may also be recaptured at different places. In the case of the above mentioned data analysis a recaptured animal is only counted once in a season and in the case of several locations only the most distant one is counted. Therefore the addition of recaptured su–wi, su–su and wi–wi (Fig. 12–28) is somewhat less than the total number of recaptures.

The winter season is defined roughly from 01.10. to 31.03., the summer season from 01.04. to 30.09. This procedure has the advantage that all refind data can be considered. On the other hand this leads to some imprecise calculations:

- for seasonal migration: if bats are still in the winter roosts after 31.03. or are still in the summer roosts after 30.09. then these animals are classified as non-migrating. As a result the proportion of non-migrating animals is too high.
- regarding roost site fidelity: bats that have not arrived in the summer accommodation after 31.03. or have left before 30.09. are counted as having changed roosts. The proportion of roost changes is therefore too high and the distance range due to migration may be over-estimated.

This problem can be tackled by specifying the summer and winter roost periods for different species (e.g. for Greater mouse-eared bat 20.05. to 31.07. and 15.11. to 10.03., for all species see Fig. 12–28). However this procedure has the disadvantage that many data that are relevant for the migration behaviour will remain unconsidered. By the combination of both procedures (see Fig. 12–28) and using differentiated interpretation the mutual disadvantages can be moderated. In some cases of doubt individual evaluations are necessary. A data analysis according to the status of the location of the roost (nursery roost, winter roost, mating roost, intermediate roost on the migration route etc.) is in principle also conceivable. For many finds appropriate status data are still missing and in some cases there are also difficulties in providing them. However in the future they should be supplied more frequently in a standardized form, although for encounters outside the area of responsibility this is not easy to fulfil.

Results for the local changes of the individual species of bats are summarized in general maps as well as in appropriate diagrams in respect to the local changes (all) (Fig. 12–28). Here the data for seasonal migration between summer and winter roosts (su–wi) as well as to roost site fidelity and/or to roost changes in the summer (su–su) and winter (wi–wi) are also presented. Refinds are represented on the maps with regard to the main summer and/or winter season, as are the refinds at the same place shown on these maps. Some general evaluations in addition are presented in chapter 3.2.2.4 and a species specific total summary is given in chapter 3.2.3. Chapter 3.2.2.5 attempts to derive statements in respect to the settlement behaviour and seasonal migration of juvenile marked bats compared with adult bats.

3.2.2.4 Some general evaluations of the refind results differentiated after seasonal migration and roost shifting

3.2.2.4.1 Seasonal migration between summer and winter shifting

The basis for appropriate evaluations is generally the temporary and if necessary also spatially differentiated marking and record of marked animals in appropriate roosts. The distance determined in each case must therefore not be identical to the migration distance, since a first settlement to another place may have taken place (see chapter 3.2.2.4.2). In particular the place of the first settlement of ♂♂ of certain species (e.g. Noctule – see chapters 3.2.2.4.2 and 3.2.2.5) may have substantial influence on the determined "migration distance". Different authors (e.g. Gaisler et al. 2003, Treß et al. 2004) propose therefore that the refind in the season immediately following the marking or recapture has a special importance. However dispersal emigration may already have happened.

A direct proof for seasonal migration routes is possible by refinds in the winter and summer routes (as a proof for migration in both directions), but this is seen only rarely due purely to statistical reasons. Appropriate proofs for migration distances > 1 km are available for 9 species of bats in the area of responsibility of the bat marking centre Dresden (Tab. 7).

Tab. 7: Number of proven pendulum flights between summer and winter roost (distance >1 km)

bat species	sex	number of flights/animal								number of animals	max. distance in km
		2	3	4	5	6	7	8	9		
Brown long-eared bat	♀	4								4	15
	♂	1								1	8
Barbastelle	♀	2								2	8
Natterer's bat	♀	6	1							7	54
	♂	1								1	49
Northern bat	♀	1								1	12
Whiskered bat	♂	1								1	3
Greater mouse-eared bat	♀	288	77	65	20	17	6	4	1	478	304
	♂	8	2		1					11	86
Daubenton's bat	♂	1								1	2
Noctule	♀	3								3	474
Nathusius' pipistrelle	♀	2								2	979

In principle the results confirm (su–wi diagrams in Fig. 12–28) the grouping of bat species according to their local change behaviour (see chapter 3.2.1). However some new criteria are added.

In respect of the direction of migration, species can be distinguished into the following groups (Fig. 12–28):

a) **Species with directed migration over longer distance (to climatically preferable regions)**
Leisler's bat, Nathusius' pipistrelle, Noctule, (Pond bat, Parti-coloured bat)

b) **Species with non-directed migration over a long distance**
Greater mouse-eared bat, Daubenton's bat, Brandt's bat, Northern bat, Natterer's bat, Serotine, Whiskered bat, Common pipistrelle s. l., Barbastelle, Bechstein's bat, Brown long-eared bat, Grey long-eared bat, (Lesser horseshoe bat)

Pond bat, Parti-coloured bat and Lesser horseshoe bat are placed in parenthesis as only few data are available on the ecology of the species that are not from the studies described here.

In respect of the percentage of non-migrating species the following distinctions can be made:

a) **Species without or with only a few non-migrating animals**
Leisler's bat, Nathusius pipistrelle, Noctule, (Pond bat, Parti-coloured bat, Whiskered bat, Brandt's bat, Northern bat, Bechstein's bat)

b) **Species with a low to intermediate percentage (10–40 % of refinds) of non-migrating animals**
Daubenton's bat, Greater mouse-eared bat, Natterer's bat, (Serotine, Barbastelle)

c) **Species with intermediate to high percentage of non migrating-animals**
Brown long-eared bat, (Common pipistrelle s. l., Grey long-eared bat)

Several restrictions need to be made to this classification:

1. If non-migrating animals are determined, they are usually over-represented, because they can be found in a higher proportion than migrating animals (see chapter 3.2.1). The determined proportions are therefore only suitable for relative comparisons.

2. If species need very different roost types for summer and winter, the proof for non-migrating animals is more difficult, compared to when this is not the case. The allocation of the species to a), b) and c) therefore has to be critically analysed.

3. In cases with only limited data available or when only a few roosts are under continuous all-year round observations, a high or low percentage of non-migrating animals is possible by chance. Therefore all species in parenthesis have to be critically evaluated in respect of their placement into a certain group.

A very descriptive example for 3. is the Common pipistrelle s. l., (for which there is much refind data, but only from two large winter roosts – Demmin and Rüdersdorf). Altogether the proportion of non-migrating animals amounts to 83 % here, 90 % (n = 188) when only the catchments area of Demmin is considered but only 11 % (n = 18) when Demmin is not considered or 39 % (n = 126) when only the season summer-winter (su–wi) is considered. Therefore is has to be assumed that in addition to roost dependent differences (in the sense of 3. methodical causes (in the sense of 1.) are also involved. To what extent additional species population dependent differences contribute, must unfortunately remain open at the current stage.

Once all division criteria are summarized, then, despite all uncertainties, the following class distribution seems appropriate, from which the further presentation of results in chapter 3.2.3 is organized.

a) Species with directed migration over longer distances (in climatically preferred areas) and hardly any non-migrating animals
Leisler's bat, Nathusius' pipistrelle, Noctule, Particoloured bat, (Pond bat)

b) Species with a wider home range, without directed movements and with hardly any non-migrating animals
- 1st group: Daubenton's bat, Greater mouse-eared bat, (Brandt's bat, Northern bat)
- 2nd group: Natterer's bat, (Serotine, Whiskered bat, Common pipistrelle s. l.)

c) Species with relative small home range, without directed migration and a high percentage of non-migrating animals
Grey long-eared bat, Brown long-eared bat, (Barbastelle, Bechstein's bat, Lesser horseshoe bat)

Species shown in parenthesis are those which on the basis of current data have a degree of uncertainty with respect to certain criteria.

3.2.2.4.2 Shifting of summer roosts or winter roosts

The proportion of site-fidelity individuals is about 90 % both for summer roosts and for winter roosts (with the exception of summer roosts of Pond bat and European barbastelle which are 63 % and 83 % respectively) (Fig. 12–28). Similar to the seasonal migration this percentage is a result of over-representation due to higher probability of refinds close to the marking location. In addition, comparison between species cannot be made as a result of the different amount of data available. The distance of resettlements (for juvenile marked animals this can also be a first settlement) corresponds for many species to those for the seasonal migration. Migration distances can be shorter (e.g. Natterer's bat, Whiskered bat, Northern bat, Barbastelle) or longer (e.g. Brown long-eared bat, Common pipistrelle s. l.), whereby the situation regarding different data also has to be considered.

It is also remarkable that for species with directed migration the distances for long distance resettlements and first settlements can be in the same order of magnitude (Noctule, Nathusius' pipistrelle). For the Noctule this refers primarily to ♂♂, which in this species frequently settle south of the place of birth, probably on the migration route of the ♀♀ (Strelkov 1969). This behaviour can also be observed in ♀♀ (as proved by bat marking centre Dresden for Nathusius' pipistrelle), where it may represent animals which have remained behind or have expanded towards the W or SW.

For species which usually only migrate small distances between summer and winter roosts it seems likely that accommodation changes and first settlements can exceed this distance range. In particular, the data relating to the Brown long-eared bat may be seen as a proof for this.

Summer and winter roosts can also be changed within the same season, as a special accommodation is frequently used as nursery roosts (e.g. with Leisler's bat, Noctule, Nathusius' pipistrelle, Barbastelle, Greater mouse-eared bat). In addition, accommodation changes can take place due to disturbance and other severe threats (e.g. Nathusius' pipistrelle, Greater mouse-eared bat).

For species tolerant to low temperatures, like the Barbastelle, it is well known that they show a more marked migration into underground roosts only during prolonged periods of frost (e.g. Dolch et al. 1997). Here it is obvious that such species can change the roosts several times within one winter season. To a certain extent such roost changes are probably part of the normal behaviour for all species. In the data available single roost changes within one winter term, i.e. hibernation in two different winter roosts in one winter, are proven for Greater mouse-eared bat (17 x), Daubenton's bat (3 x), Common pipistrelle s. l. (2 x), Brown long-eared bat (2 x) and Natterer's bat (1x). The longest distances travelled were 118 km for the Greater mouse-eared bat, 37 km for Daubenton's bat, 9 km for Brown pipistrelle s. l., 5 km for Brown long-eared bat and 4 km for Natterer's bat. A Greater mouse-eared bat-♀ changed its winter roosts three times (Haensel 2004c).

3.2.2.5 *Settlement behaviour and seasonal migration of juvenile marked animals compared with adults*

Adult individuals are predominantly less site-faithful than juveniles in all bat species (s. Tab. 8). The place of the first settlement of juvenile bats in summer is much less important for population mixing than for many other species of vertebrates (e.g. most bird species).The site fidelity of ♂♂ is generally less than those of ♀♀ with respect to summer roosts, and so they may play a greater role in population mixing. However again this applies only with substantial restrictions, as the location of the mating areas must not be identical with those of the summer roosts for ♂♂, and also ♀♀ must not inevitably visit the nearest mating roost.

However, there are some exemptions from the general statements on settlement behaviour and site fidelity (Tab. 8). Juvenile ♂♂ of Noctule, Leisler's bat, Common pipistrelle s. l. and Nathusius' pipistrelle are generally less site-faithful than adult ♂♂. These species are migrating over long distances (Noctule, Leisler's bat, Nathusius' pipistrelle), and a settlement of ♂♂ at a greater distance from the birth place (nursery roost) is not unusual (see below and chapter 3.2.3). For the Common pipistrelle s. l. it has to be remembered that the data refer to two species, of which the Soprano pipistrelle is possibly migrating over long distances in the area of bat marking centre Dresden (see e.g. v. Helversen & Holderied 2003). Generally for Leisler's bat and Common pipistrelle s. l. the database is too small, and this also applies to the Northern bat and Serotine which have fewer site-faithful juvenile ♀♀ than adult ♀♀. In addition the site fidelity for ♀♀ of the Common pipistrelle s. l. is generally lower than those of the ♂♂.

The site fidelity in the winter roost in ♂♂ is generally higher than in ♀♀, and only with Barbastelle and Daubenton's bat is the relationship slightly in favour of ♀♀. For juvenile animals sufficient data are only available for the Greater mouse-eared bat, from which a comparable relation between ♂♂ and ♀♀ can be seen, and especially for juvenile ♀♀ there is clearly less site fidelity than for adult ♀♀.

Juvenile animals of species with long migrations (Noctule, Nathusius' pipistrelle) tend to move earlier than adults from the summer roosts (Tab. 9). A similar tendency can be observed for Daubenton's bat, which has possibly an intermediate position to the species with long migrations. The migration distances between summer and winter roosts can be somewhat longer for marked juvenile animals than for adult animals and tend to become shorter again with increasing age. This is especially true for ♀♀ of the Greater mouse-eared bat (Tab. 9). These data show a similar picture to the published results of Haensel (1974) and Oldenburg & Hackethal (1989a), which show that ♀♀ with increasing age tend to stay in winter roosts that are closer to the nursery roosts. This is additionally supported by the fact that there is less site fidelity of marked ♀♀ juvenile Greater mouse-eared bats in the winter roosts (see Tab. 8). Oldenburg & Hackethal (1989a) try to explain this behaviour through a population mixing strategy of juvenile animals. This explanation seems, however, to be illogical, since the appropriate effect is not found later when the animals are at their optimum reproductive age. It may merely be some migration behaviour of animals which are not yet sexually mature and an optimizing process with increasing age. For the Noctule and to a lesser extent for Nathusius' pipistrelle the higher migration distances in juvenile animals has another reason. For the Noctule the non-moving animals are only ♂♂ (Tab. 9) and this phenomenon has only occurred in recent years (Heise & Blohm 2004). Obviously with changes in climate the ♂♂ tend to stay throughout the year in our areas more readily than ♀♀. For all other aspects, the overview in Tab. 9 reflects the different settlement and movement behaviour of ♀♀ and ♂♂ of this species. Juvenile ♀♀ Noctule tend to returne close to their birth place and are long distance migrating animals. Juvenile ♂♂ tend to settle at a greater distance (to the north) from the nursery roosts (Heise & Blohm 2004, Strelkov 1969) and many remain in the southern winter roost or on the migration route and do not migrate or show a lesser tendency to migrate (Gebhard & Bogdanowicz 2004, Strelkov 1969). Thus the relatively low fidelity to the place of birth appears to be correct for juvenile ♂♂ (Tab. 8) and the distances between place of birth and winter roosts (Tab. 9) are for juvenile Noctule-♂♂ predominantly single migration distances, which are not repeated after the first settlement. This is proven by the results in the summer marked adult ♂♂, both in respect to the first settlement from the northern nursery roosts and first settlements at the place of birth.

For Nathusius' pipistrelle and Leisler's bat there are similar conditions for ♀♀ and ♂♂ concerning settlement and moving behaviour to those described for the Noctule (Strelkov 1969). For both species in our region this is implied by the low fidelity of juvenile ♂♂ to the place of birth. In addition there are shorter migration distances shown for adult ♂♂ than for juvenile ♂♂ Nathusius' pipistrelles (Tab. 9), which can be explained in the same way as for the Noctule with the difference that the behaviour is less pronounced. To date no sedentary settlement of ♂♂ was observed, but nevertheless adult ♂♂ do clearly stay longer in autumn than juvenile ♂♂. There are no such data available for Leisler's bat.

Tab. 8: Local shiftings of juvenile marked animals of selected species in the summer (su–su) and in the winter (wi–wi) compared with adults of selected categories

species	**sex**	**summer roost**						**winter roost**					
		number of recaptures		**share >1 km %**		**share >3 km %**		**number of recaptures**		**share >1 km %**		**share >3 km %**	
		ad.	**juv.**	**ad.**	**juv.**	**ad.**	**juv.**	**ad.**	**juv.**	**ad.**	**juv.**	**ad.**	**juv.**
Barbastelle	♂	1	2					303	6.4	2.3	1.6	2.0	1.6
	♀	104	36	23.1	0	12.5	0	138	25	2.1	0	1.4	0
Northern bat	♂	0	1					15	0	0		0	
	♀	551	85	2.0	2.4	1.1	1.2	40	2	12.5	0	7.5	0
Serotine	♂	22	3	13.6		13.6		7	4				
	♀	154	46	1.9	4.3	1.9	4.3	2	0				
Brandt's bat	♂	19	5	21.1		10.5		446	8	0.7		0.7	
	♀	588	120	8.8	5.8	1.5	0	51	0	2.0			
Daubenton's bat	♂	149	33	6.7	6.1	5.4	0	2,256	9	1.4			
	♀	535	101	9.2	1.0	3.0	1.0	2,330	8	1.2			
Greater mouse-eared bat	♂	27	121	25.9	14.9	14.8	11.6	1,706	1,276	6.2	6.5	5.7	6.3
	♀	2,021	3,336	5.7	3.5	4.2	2.5	1,653	1,164	7.6	12.5	7.2	12.3
Natterer's bat	♂	33	74	12.1	2.7	3.0	2.7	1,807	30	1.5	0	0.7	0
	♀	547	558	0.4	0	0	0	831	24	1.7	0	1.2	0
Leisler's bat	♂	35	21	8.6	9.5	3.1	9.5	0	0				
	♀	229	356	7.0	4.8	6.6	4.8	0	0				
Noctule	♂	16	40	18.8	20.0	6.3	12.5	1	0				
	♀	1,078	1,448	5.8	2.4	3.0	2.1	0	0				
Brown long-eared bat	♂	171	314	4.7	13.3	1.2	1.0	223	11	2.2	0	0.9	0
	♀	1,196	804	7.4	10.9	1.1	0.6	290	11	8.9	9.1	3.4	9.1
Nathusius' pipistrelle	♂	268	100	4.9	9.0	0.7	8.0	1	0				
	♀	711	998	7.2	6.8	4.9	3.7	6	2				
Common pipistrelle s.l.	♂	46	27	0	3.7	0	3.7	409	172	0.2	0	0.2	0
	♀	107	49	5.6	4.1	4.7	4.1	512	33	1.2	0	0	0

* no share (%) for translocations >1 km resp. >3 km is given for n ≤ 10

Tab. 9: *Local changes of juvenile marked animals of selected species from summer to winter compared with adult animals*

distance in km	first year (juv.) / first 6 months after marking (ad.)																				winter roost 2 ff.			
	July				August				September				Oct./Nov.				winter roost 1							
	juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Brown long-eared bat (marked juv.: ♂♂ 1,571, ♀♀ 1,501; ad.: ♂♂ 900, ♀♀ 2,977)																								
–1	8	4	18	49	70	68	16	40	91	81	22	70	23	31	14	10	10	3	3	8	5	9	5	11
–3	4	2	5	11	17	11	5	3	12	21	3	14	21	26	2	2	1	2				1	1	1
–10				3				2	3	4			2				3	3		6	2		6	2
–30								1					1						1		1	2		3
–100														1			1			1				1
–300																								
sum:	**12**	**6**	**23**	**63**	**87**	**79**	**21**	**46**	**106**	**106**	**25**	**84**	**47**	**58**	**16**	**12**	**15**	**8**	**4**	**15**	**8**	**12**	**12**	**18**
Natterer's bat (marked juv.: ♂♂ 864, ♀♀ 872; ad.: ♂♂ 226, ♀♀ 857)																								
–1	6	12	2	14	70	78	5	25	29	47	2	17	15	29									3	1
–3																								
–10											1						1	1				1		1
–30																	2	2			7	2	1	1
–100					2		2		5	2	2	1	2	3			1	1		2		3	1	2
–300																								
sum:	**6**	**12**	**2**	**14**	**72**	**78**	**7**	**25**	**34**	**49**	**5**	**18**	**17**	**32**	**0**	**0**	**4**	**4**	**0**	**2**	**7**	**6**	**5**	**5**
Daubenton's bat (marked juv.: ♂♂ 987, ♀♀ 879; ad.: ♂♂ 1,558, ♀♀ 2,664)																								
–1	31	47	23	80	53	49	20	74		5	5	11												
–3								3											1					
–10	1		1	1				3			1	1												
–30																								
–100						2						1					1				1		1	3
–300						1			1								1	1		1				9
–1,000																								
sum:	**32**	**47**	**24**	**81**	**53**	**52**	**20**	**80**	**1**	**5**	**6**	**13**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**1**	**1**	**0**	**1**	**12**

distance in km	first year (juv.) / first 6 months after marking (ad.)																				winter roost 2 ff.			
	July				August				September				Oct./Nov.				winter roost 1							
	juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.		juv.		ad.	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Greater mouse-eared (marked juv.: ♂♂ 4,646, ♀♀ 4,739; ad.: ♂♂ 510, ♀♀ 4,731)																								
–1					5	5	6	8			5	3		1	1		61	68	3	34	124	150	5	126
–3						1							1				51	79	5	37	84	223	7	62
–10					2	1	3		1		3		1			1	21	13	2	7	36	73	1	24
–30						2				1		2	1	1	1		35	35	6	36	94	79	8	101
–100						1		1	5	2	1	5	6	3	1	2	131	95	5	45	249	186	14	83
–300									1	1	1	1			1	2	17	23	7	21	52	78	16	45
–1,000																		1			1			
>1,000																								
sum:					**7**	**10**	**9**	**9**	**7**	**4**	**10**	**11**	**9**	**5**	**4**	**5**	**316**	**314**	**28**	**180**	**640**	**789**	**51**	**441**
Noctule (marked juv.: ♂♂ 5,741, ♀♀ 6,155; ad.: ♂♂ 1,064, ♀♀ 5,809)																								
–1	345	347	70	198	446	521	28	102	6	2	7	2	5	2	11	4	3		1		10		2	
–3			1		3	3			2		2				1									
–10	1	1		2	12	9		3	1						1									
–30		4		1	4	3		1					1					1						
–100				1	4	3					1						1							
–300				1	1	1				1		1	1	1			1			2		2		1
–1,000					2	1			7	5			4	3		2	6	8		5	2	4		5
>1,000																								
sum:	**346**	**352**	**71**	**203**	**472**	**541**	**28**	**106**	**16**	**8**	**10**	**3**	**11**	**6**	**13**	**6**	**11**	**9**	**1**	**7**	**12**	**6**	**2**	**6**
Nathusius’ pipistrelle (marked juv.: ♂♂ 7,177, ♀♀ 8,824; ad.: ♂♂ 1,748, ♀♀ 5,774)																								
–1	192	246	27	98	179	259	102	86	16	4	88	9			1									
–3			1	1		1	6				3				1									
–10	2	2		1		1		4		1														
–30		5		1		1					1	2												
–100			1	1		2					2										1			
–300												1										1	1	1
–1,000					1	3			4	2		1		2			3	6		1	3	3		2
>1,000										2							2			1	3	1		1
sum:	**194**	**253**	**29**	**102**	**180**	**267**	**128**	**90**	**20**	**9**	**94**	**13**	**0**	**2**	**2**	**0**	**5**	**6**	**0**	**2**	**7**	**5**	**1**	**4**

3.2.3 Migrations and roost changes of different species

3.2.3.1 Species with directed migration over long distances (to climatically preferable areas) and no or hardly any non-migrating animals

Available results suggest the classification of **Leisler's bat** (*Nyctalus leiseri*) in Eastern Europe as a typical migrating species and in the west and in the center of Europe as a facultative migrating species (Bogdanowicz & Ruprecht 2004). For East Germany the refind data available show an exclusively seasonal southwestern migration over long distances (Aellen 1984, Driechciarz & Driechciarz 2004, Fischer 1999, Schorcht 1989), which are in the same distance ranges for Nathusius' pipistrelle for adequate winter roosts (see Fig. 12 and 13). Local changes of up to 1,568 km (Ohlendorf et al. 2000, 2001) are the longest migration distance of any bat marked within the area of bat marking centre Dresden and with the only refind coming from Spain. In contrast to Nathusius' pipistrelle there are no refinds available for the passage to and from winter roosts, which corresponds to summer occurrences in Eastern Europe. So far no definitely proven winter occurrences are known from the bat marking centre Dresden reference area.

A shifting of the summer accommodation of up to a maximum of 14 km (♀♀) and 24 km (♂♂) were found, with the majority of distances up to 10 km. In the latter range it is difficult to differentiate between species-typical roost site change (e.g. in the nursery time) and genuine resettlement. Also from the data for first settlement of juvenile ♀♀ and ♂♂ so far no serious differences were found (Schorcht 1989). However, juvenile ♂♂ are altogether less faithful to roost site than juvenile ♀♀ as well as adult ♀♀ and ♂♂ (see Tab. 8).

In contrast to the Noctule up to now no large distances for the first settlement in the migration direction were found for juvenile ♂♂. Altogether the time range and data available are still too small to be able to make final statements.

Nathusius' pipistrelle (*Pipistrellus nathusii*) moves in the winter over large parts of central and Eastern Europe (Vierhaus 2004). In East Germany the species has summer occurrences as a transient and up to now only a very small proportion stays over the winter.

According to the results from the marking and record of marked animals in the scope of the responsibility of the bat marking centre Dresden, all summer occurrences are from migrating animals, whose winter roosts are up to 1,299 km (♀♀) and 1,455 km (♂♂) from the location of marking in a SW direction (in particular Switzerland, Southern France), in part also in the W (Schleswig-Holstein, the Netherlands, Belgium, northern France, Atlantic coast) and in a few cases also in the S (Czech Republic, South Germany, Austria, upper Italy, Slovenia) (Haensel 2001, Heise 1982, Kuthe & Ibisch 1994, Ohlendorf et al. 2002, Oldenburg & Hackethal 1989b, Schmidt 1984, 1985, 1989c, 1994a, 2000a, 2004, Stratmann 1973, Treß et al. 2004). There is no evidence of non-migrating animals from the summer occurrences (see su-wi-diagram in Fig. 13). The only relevant refind in the Demminer church was most likely a mistake with the Common pipistrelle. Transients originate from the NE [Poland, region Kaliningrad, Lithuania, Latvia, Estonia (e.g. Schmidt 2004, Petersons 1990), Fig. 13].

The few animals that stayed over the winter (e.g. Gerber 1956, Haensel 1997, Hochrein 1999b, Ohlendorf et al. 2002, Wilhelm 2002) probably also come mainly from the NE and this is proven for one animal from Latvia.

Regarding the proportion of site faithful animals in summer roosts, Nathusius' pipistrelle does not differ from the Leisler's bat (see diagrams su–su in Fig. 12 and 13). The majority of the local shiftings are in the range of 1–4 km, and 1–10 km for Leisler's bat, which may be coincidental (e.g. by different investigation conditions). Remarkably, however, there are records of first settlements > 600 km SWW from the marking location, which in contrast to the Noctule also concerns (two) ♀♀. This may concern either refinds of animals that were "omitted" due to non-clarified reasons or genuine emigration. Support for the latter comes from the fact that Nathusius' pipistrelle is at present showing at least a partial expansion towards the west and/or southwest.

Compared with the Noctule, mating roosts of Nathusius' pipistrelle are found more often in the regions where regular nursery roosts are found (e.g. Schmidt 1994). In addition, they can be located towards the south or southwest. In agreement with that, there are fewer refind data that give evidence for a different settlement behaviour of juvenile ♀♀ and ♂♂ compared with the Noctule: so far only one proven first settlement of a juvenile marked ♂♂ at a distance > 800 km SW of the marking location, shows that low roost site fidelity of young ringed ♂♂ to their place of birth is less pronounced (see also chapter 3.2.2.5).

For winter roosts so far no roost changes are proven. There are only a few available refinds (Fig. 13, diagram wi–wi) which do not permit an evaluation

The **Noctule** (*Nyctalus noctula*) does not accomplish long migrations, such as Leisler's bat and Nathusius' pipistrelle. Settlement and migration behaviour of ♀♀ and ♂♂ is at least partly different (Gebhard & Bogdanowicz 2004, Strelkov 1999 and others). In East Germany the

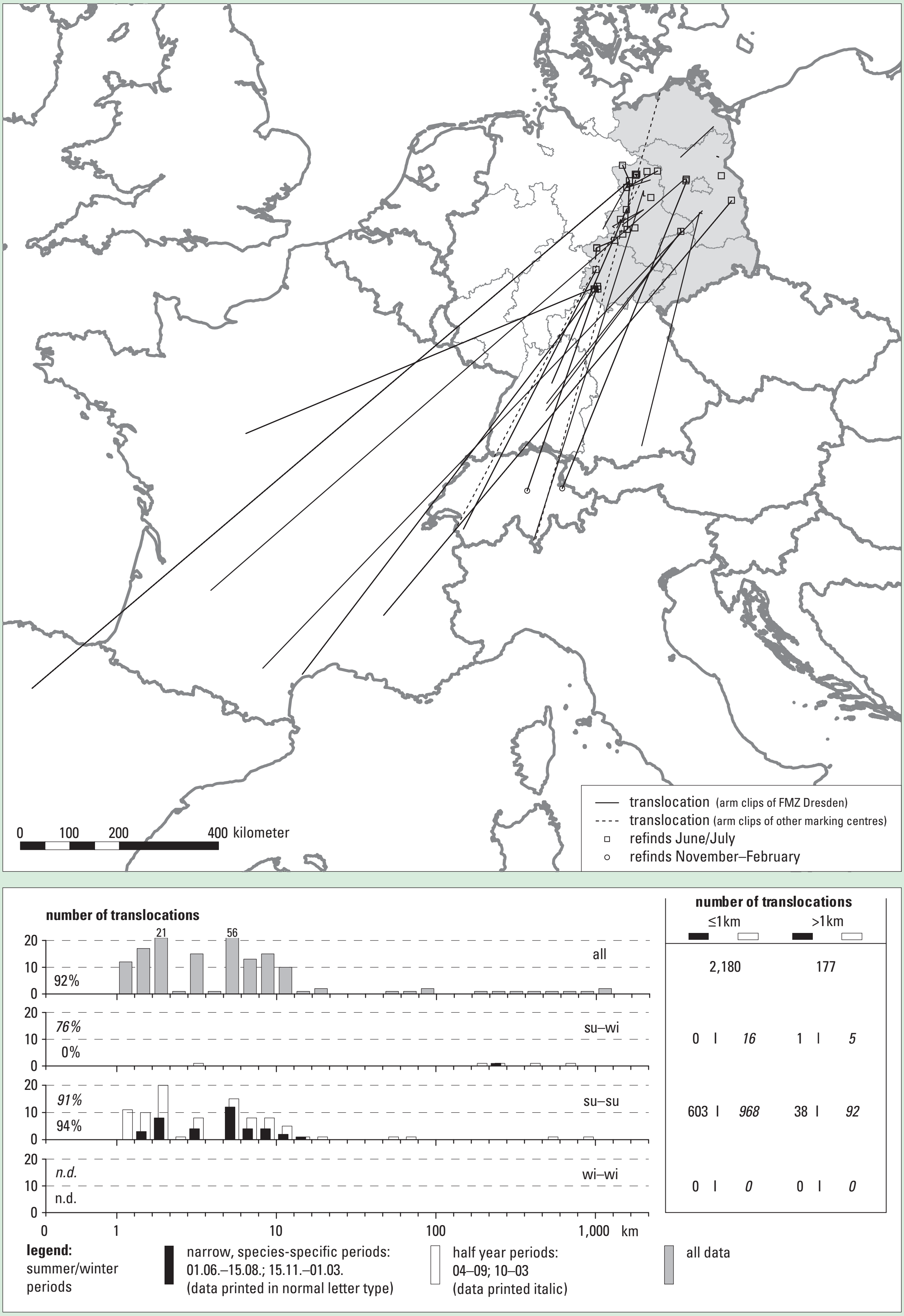


Fig. 12: Translocations of Leisler's bat (Nyctalus leisleri)

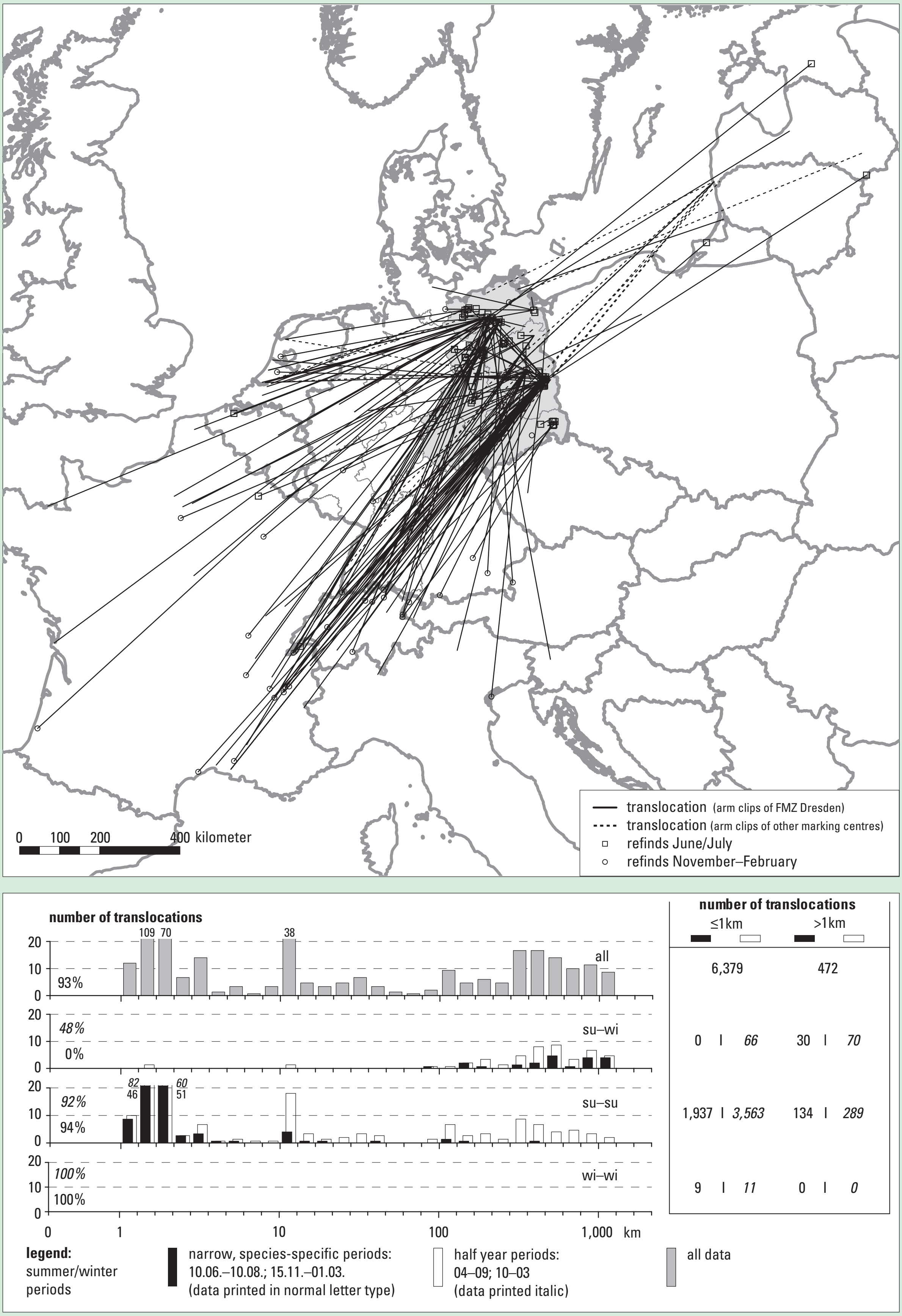
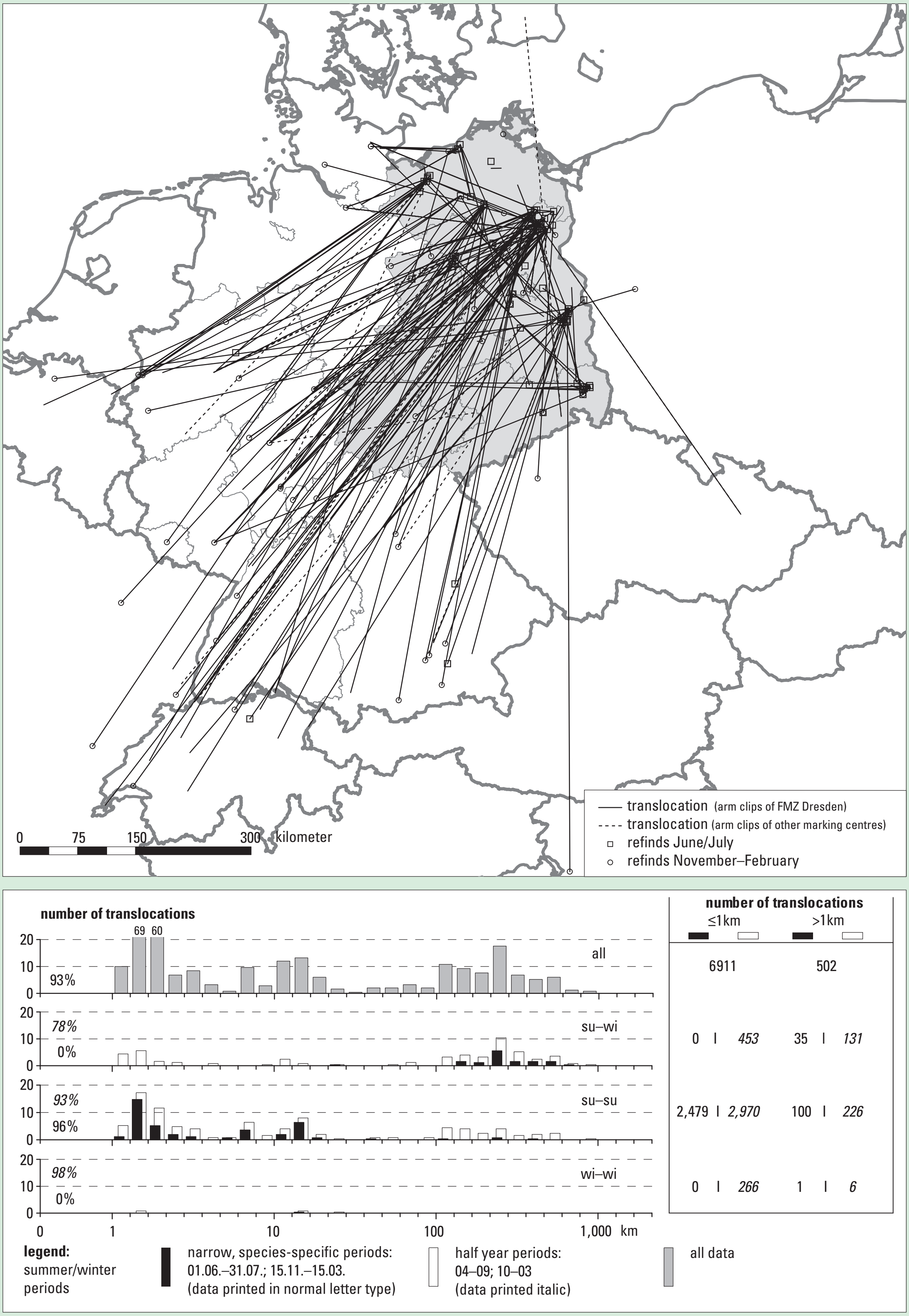


Fig. 13: Translocations of Nathusius' pipistrelle (Pipistrellus nathusii)



number of translocations	≤1km ■	≤1km □	>1km ■	>1km □
all	6911		502	
su–wi	0	*453*	35	*131*
su–su	2,479	*2,970*	100	*226*
wi–wi	0	*266*	1	*6*

Fig. 14: Translocations of Noctule (Nyctalus noctula)

Noctule has summer occurrences, is a migrating visitor and can stay over the winter. In recent years also, individual animals and smaller groups (of predominantly ♂♂) have become increasingly faithful to their roost site almost throughout the year (U. Hermanns, R. Labes, Heise & Blohm 2004).

From marking and record of marked animals for the summer occurrences in East Germany within the dataset of the bat marking center Dresden, migration distances to the winter roosts of (0) 28–950 km, with the majority between 200–800 km, can be found, with ♀♀ migrating up to 950 km (Heise & Blohm 2004) and ♂♂ up to 801 km (Oldenburg & Hackethal 1986). The main migration direction is SW, furthermore W and NW, and rarely S, SE and E.

The main wintering areas are West and South-West Germany as well as Switzerland, adjacent regions of France, Belgium, Schleswig-Holstein, and exceptionally Poland, Czech Republic and Slovenia (Heise 1992, Heise & Blohm 2004, Heise & Schmidt 1979, Oldenburg & Hackethal 1986, Schmidt 2000a, Fig. 14). In recent times a tendency to larger variability in migration direction and reduction of migration distances up to a complete halt in migration is observable. This could be explained by a decrease in hibernation risk due to temperature increases (e.g. Heise & Blohm 2004).

In the reference time period (1964–2001), migrating visitors and overwintering animals originate, as shown by ring finds, almost exclusively from East Germany. Only one ring found in Saxon Switzerland has Sweden (Wilhelm 1989) as country of origin. During markings in the winter roosts in the the Dresdner Frauenkirche in the 1930s Meise (1951) obtained numerous refinds from Poland, and even one refind from Litvia. Further refinds from more recent times, confirm the interrelations of Central European winter roosts with Poland and the Baltic (Gebhard & Bogdanowicz 2004). Corresponding data could be achieved for East Germany by an intensification of marking and record activities in mating and winter roosts in the Dresden area and the Lusatia and respectively in Poland.

Regarding roost site fidelity of the Noctule in the summer, the proportion of the settlement of juvenile animals at the place of birth show clear differences between juvenile ♂♂ and juvenile ♀♀, adult ♀♀ and ♂♂ (see chapter 3.2.2.5). In contrast, in the summer time in its stricter sense, only juvenile ♂♂ (three) were found at a distance of 473–620 km SW of the marking location (in South Germany and Switzerland), with one find of a juvenile ♀♀ only 170 km NW from the marking location. This supports the statement of Strelkov (1969 and 1999) that many ♂♂ do not settle at their place of birth, but rather spend the summer at the southern edge or beyond the reproduction area or stay in the southern wintering area (Gebhard 1983–84, Stutz & Haffner 1985–86). Heise & Blohm (2004) concur with this opinion. In agreement the mating areas are concentrated in the southern area of our reference territory (e.g. Heddergott 1994, Hochrein 1999a) and/or in South Germany and in Switzerland (Gebhard & Bogdanowicz 2004).

Regarding roost site fidelity in the winter and/or appropriate local shiftings the available data still do not permit an evaluation.

The status of the **Parti-coloured bat** (*Vespertilio murinus*) is unclear for many places. Well documented nursery roosts as well as courtship and winter roosts are in Denmark and Sweden. Baagøe (2001b) assumes therefore that the species does not predominantly migrate there. In Central Europe and in the alpine region there are mainly single observations, summering ♂♂-colonies as well as courtship sightings and winter verifications. These may be mainly migrating visitors and winter visitors predominantly out of east and north European origins, far from the nursery roosts, as this was proven for summering ♂♂ in Kazakhstan (Strelkov 1980). Finally the remote findings made in NE Europe may also be dispersing animals wandering far, which can lead eventually to the emergence of new local populations (Baagøe 2001b).

In agreement with this situation the Parti-coloured bat was at first only a rarely marked species without appropriate refinds in East Germany. With the discovery of the nursery roost in Graal Müritz at the end of the 1980s the situation changed. However, appropriate markings at first resulted only in some refinds at the place of marking or in the local proximity. It was not before the discovery of a further nursery roost in Eichwalde, close to Berlin, and the intensified marking and record activity of U. Hoffmeister that genuine progress was made (Fig. 15).

As a result, the Parti-coloured bats of the summer occurrences from the Berlin area can be at least provisionally characterized as migrating animals with two preferred directions, NW (area Hamburg) and S (East Bavaria). Both directions are proven with in each case 2 refinds in November/December, with 1 ♀ and ♂ each (altogether thus 2 ♀♀ und 2 ♂♂) and maximum distances of 293 and 483 km (Hoffmeister in prep.).

Whether there are animals in the Berlin area or in the recorded nursery roost colony, which carry out no migrations or move only over short distances remains to be answered. So far appropriate finds fall only into the transition period from winter to summer roost. It is interesting in this connection to read the statements of Zöphel & Wilhelm (1999c) for Saxony that most animals are found from August/September to March with a balanced sex ratio. However, the majority of animals found during the summer

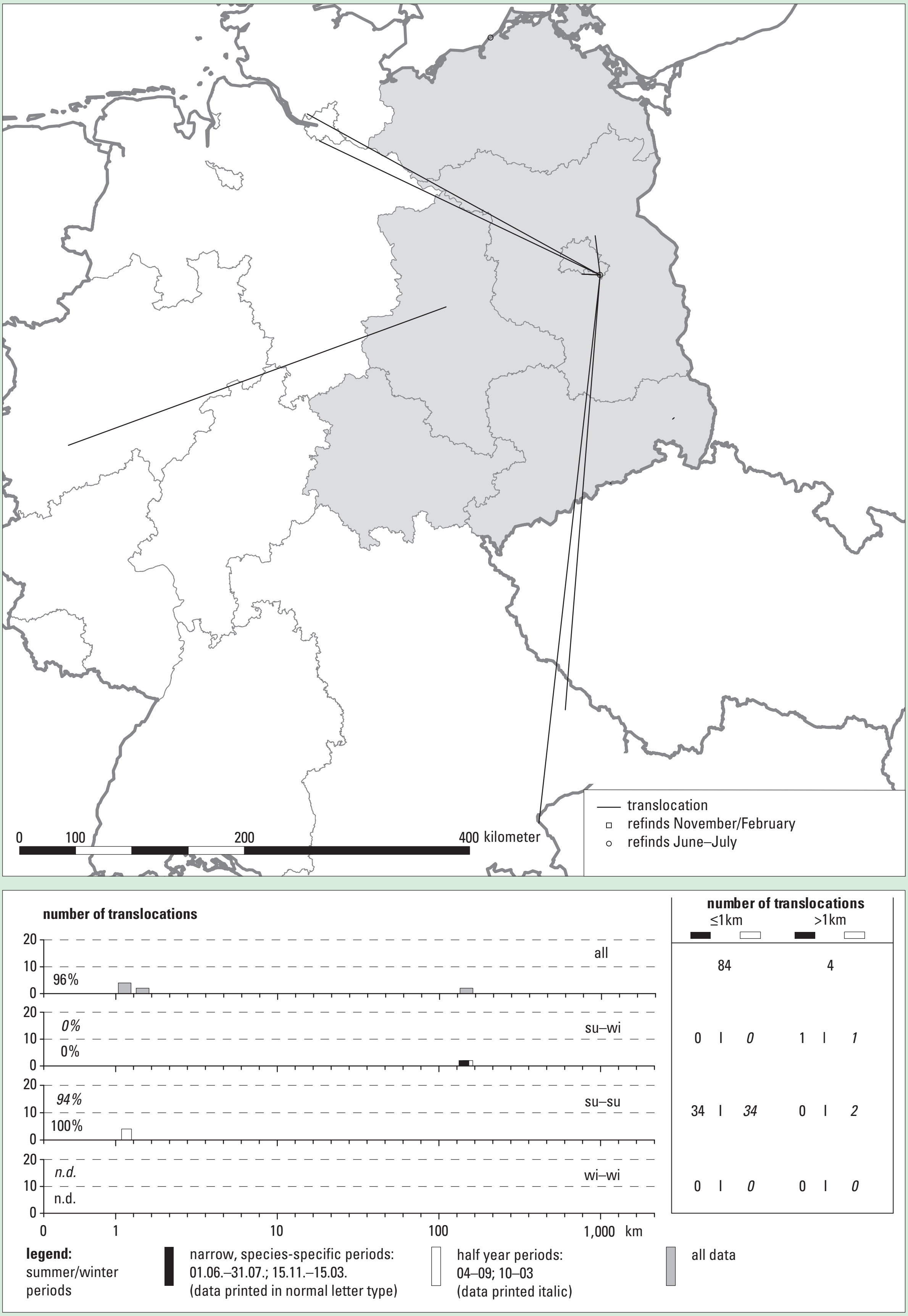
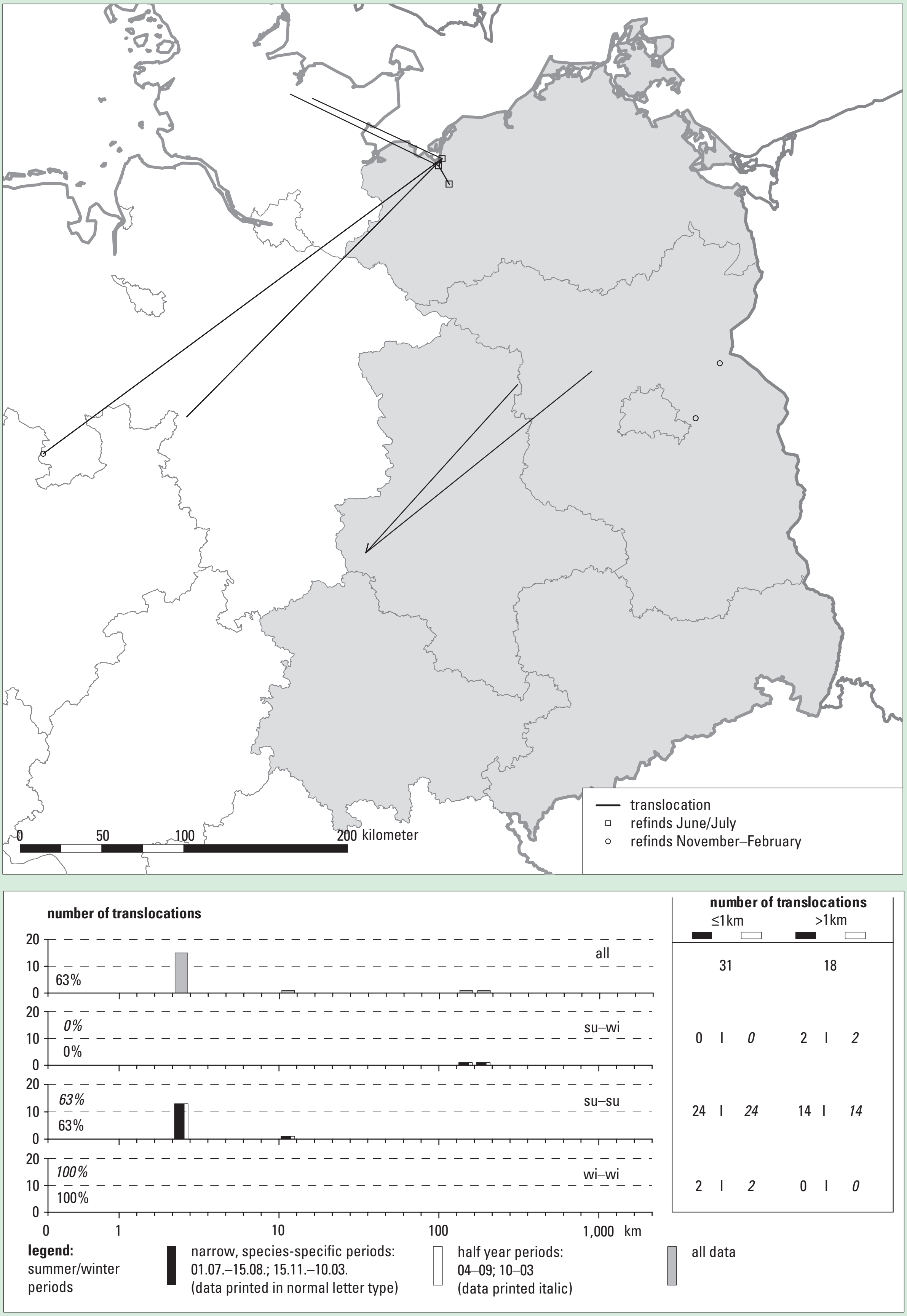


Fig. 15: Translocations of Parti-coloured bat (Vespertilio murinus)



	number of translocations ≤1km ■	number of translocations ≤1km □	number of translocations >1km ■	number of translocations >1km □
all	31		18	
su–wi	0	*0*	2	*2*
su–su	24	*24*	14	*14*
wi–wi	2	*2*	0	*0*

Fig. 16: Translocations of Pond bat (Myotis dasycneme)

are ♂♂, and for some years during June/July in the Ore Mountains a colony of ♂♂ (up to 72 animals) has been found. Also in September/October in several places the typical courtship sounds of ♂♂ can be heard. Saxony is therefore a migration and wintering area, which is also suggested by the southerly migration route of the animals from Berlin, as well as the summer residence for ♂♂, whose origin however is still completely open. For colonies of ♂♂ in the Vogtland (S. Fischer) and Thuringia (Treß & Treß 1988) the same applies.

In the summer roosts many animals are site faithful (see Fig. 15 diagram su–su). How high the proportion actually is, must remain unanswered at present, because with only a few well-known roosts hardly any accommodation interrelations can be determined. For the winter season there is a local change (adult ♂) over 351 km (Magdeburg–Cologne) (Driechciarz & Driechciarz 2004), which could be evidence for the migration of individual animals over a larger distance. Furthermore no results to roost site fidelity in the winter are present.

Nursery roosts of the **Pond bat** (*Myotis dasycneme*) might concentrate themself in Europe particularly as (isolated?) occurrences in the water-rich landscapes of the Netherlands, Northern Germany, Denmark, South Sweden, north of Poland up to the Baltic (Roer 2001). Autumn and winter finds in areas further south probably mark the migration and winter stays, but appropriate interrelations are, apart from the Netherlands, almost unexplored so far.

In East Germany in the 1960/70s initially only some animals were marked in the winter roosts and from this a few refinds at the marking location were obtained (in particular J. Haensel). After 1990 nursery roosts were proven first in Wismar (R. Labes) and later also in the Brandenburg (D. Dolch et al.) and more intensive marking and record programs began. The first relevant results (Fig. 16) document four seasonal migrations in a southwest direction of 139–302 km (Ohlendorf 2004, D. Dolch, R. Labes), from the low country to the central mountain threshold (cave systems for hibernation). Conditions resemble, apart from a somewhat different main migrating direction, those observed by Roer (2001) who described conditions for the summer occurrences in the Netherlands. So far no non-migrating animals have been determined, which corresponds with the results from the Netherlands (Sluiter et al. 1971).

Remarkable for the summer occurrence in Wismar is the relatively high proportion of local changes up to 13 km (Fig. 16 – diagram su–su) as well as first settlements and resettlements of one marked juvenile ♀ and ♂ over a distance of 88 and 101 km in a northwest direction (R. Labes, M. Göttsche, F. Gloza). Whether it is possible to derive species specific behaviours from these early conclusions requires further investigation, but these are very much desired.

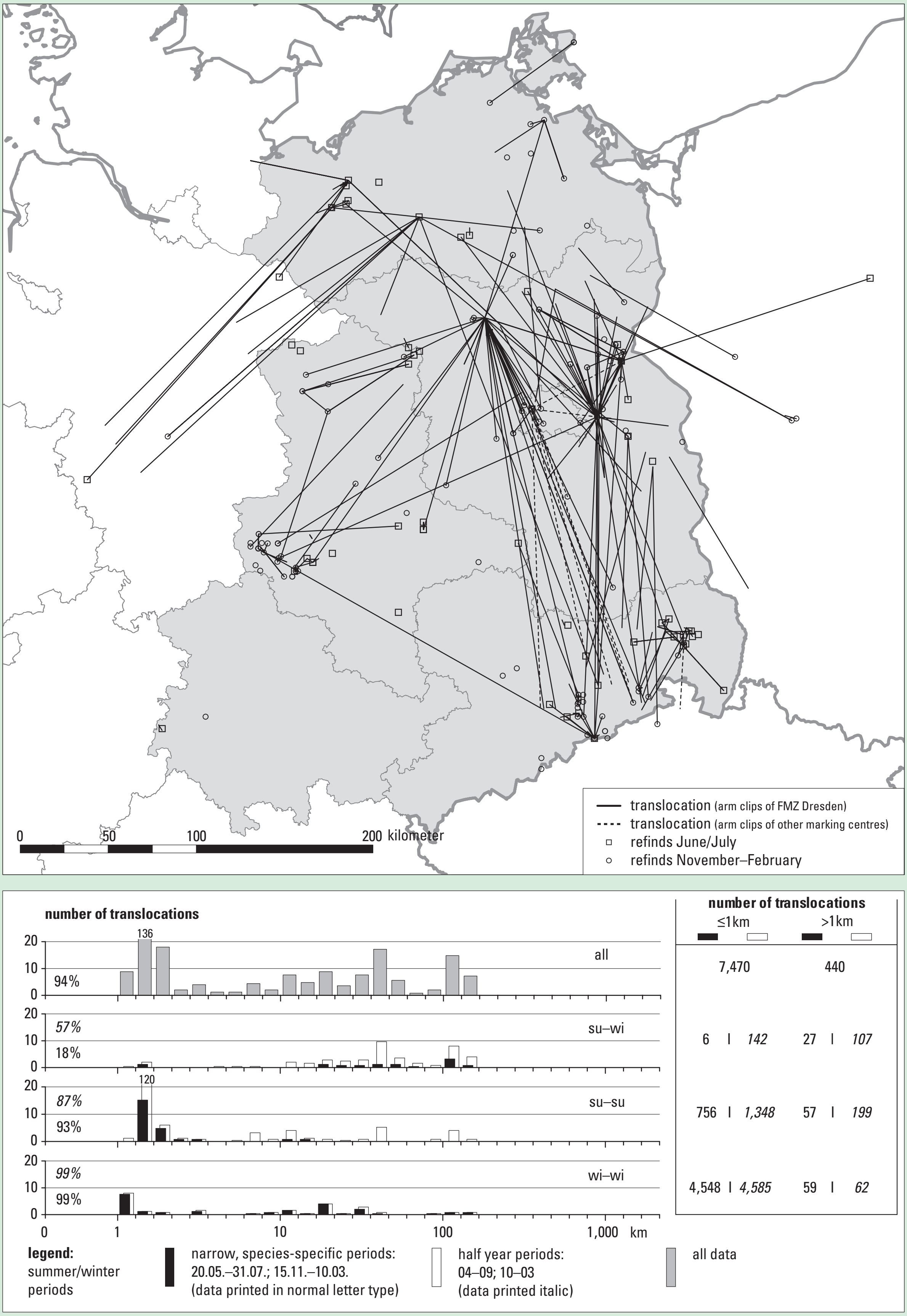
Since the direction of the seasonal migration obviously depends on the location of suitable natural or artificial cave systems and not on a more favourable winter climate and that the absence of non-migrating animals seems to be connected with the very different requirements to summer and winter accommodation, the Pond bat should be placed under chapter 3.2.3.2.

3.2.3.2 Species with wider home ranges, without directed migration and with a small to medium proportion of non-migrating animals

Daubenton's bat (*Myotis daubentonii*) is a widespread species in Europe (Roer & Schober 2001b), with seasonal migrations of usually less than 100 km up to a maximum of 260 km. In East Germany the tendency seems to be more strongly pronounced to migrations over larger distances (e.g. Dolch 1995, Haensel 1973a und b, 1978a, Kallasch & Lehnert 1995, Treß et al. 2004, Zöphel & Schober 1999) as observed in other places in Central Europe (e.g. Egsbaek et al. 1971, Gaisler et al. 2003, Geiger & Rudolph 2004).

According to the refind data of the bat marking centre Dresden a substantial proportion of the animals perform local migrations >100 km, and in the period 1964–2004 a total of 81 (= 13.4 %) of the refinds had a local migration >1 km. The largest distances for such local changes are to date 304 km (♂♂) and 261 km (♀♀). The main migration direction between summer and winter roosts is from SW to SE with an emphasis on S (Fig. 17). This preference can be explained by the dominance of the summer roosts and the examined summer roosts in water-rich north German lowlands and the occurrence of appropriate winter accommodation further south and in particular in the mountainous areas. It is not only the nearest attractive (winter) roosts e.g. the Spandau Citadel or the lime-burning plant Rüdersdorf that are sought out, but also areas much further south, e.g. the east of the Ore Mountains and Saxon Switzerland (Fig. 17). It is remarkable that the refind results show that there are much less accommodation interrelations between the two large (winter) roosts in the city of Berlin area than between these and the much far distant eastern parts of the Ore Mountains and Saxon Switzerland, which means that here also is a preferential north-south orientation. Nevertheless it must be pointed out that marking and recording in the Spandau Citadel took place particularly in the swarm phase (Kallasch & Lehnert 1995), which has only a very limited connection to the actual winter accommodation (e.g. Haensel 2004b).

Treß et al. (2004) assume that there are determined traditions in such reproductive communities, which mean that the animals do not necessarily visit the nearest suitable winter accommodation but totally (or predominantly) only



number of translocations

	≤1km ■	≤1km □	>1km ■	>1km □
all	7,470		440	
su–wi	6	*142*	27	*107*
su–su	756	*1,348*	57	*199*
wi–wi	4,548	*4,585*	59	*62*

Fig. 17: Translocations of Daubenton’s bat (Myotis daubentonii)

specific ones. It is interesting in this connection that there are no or almost no seasonal migrations within the distance range up to 30 km (Fig. 17 – diagram su–wi), although appropriate winter roosts are present and are used by Daubenton's bats of unknown origin (Treß et al. 2004). It is possible that Daubenton's bats in the transient area of the low country to the mountain country are more strongly inclined to migration, to trans-regional visiting of winter roosts, with a special preference to such roosts in mountainous areas. This also fits with the congregation of wintering Daubenton's bats at the northern edge of the low mountain range (Roer & Schober 2001b) and could explain the mostly short migration distances from appropriate summer occurrences from the Upper Lusatia heath- and pond-area (Fig. 17). Altogether the existing gaps in knowledge, in particular for summer roosts and in general for the western Ore Mountains and Thuringia, still have to be considered.

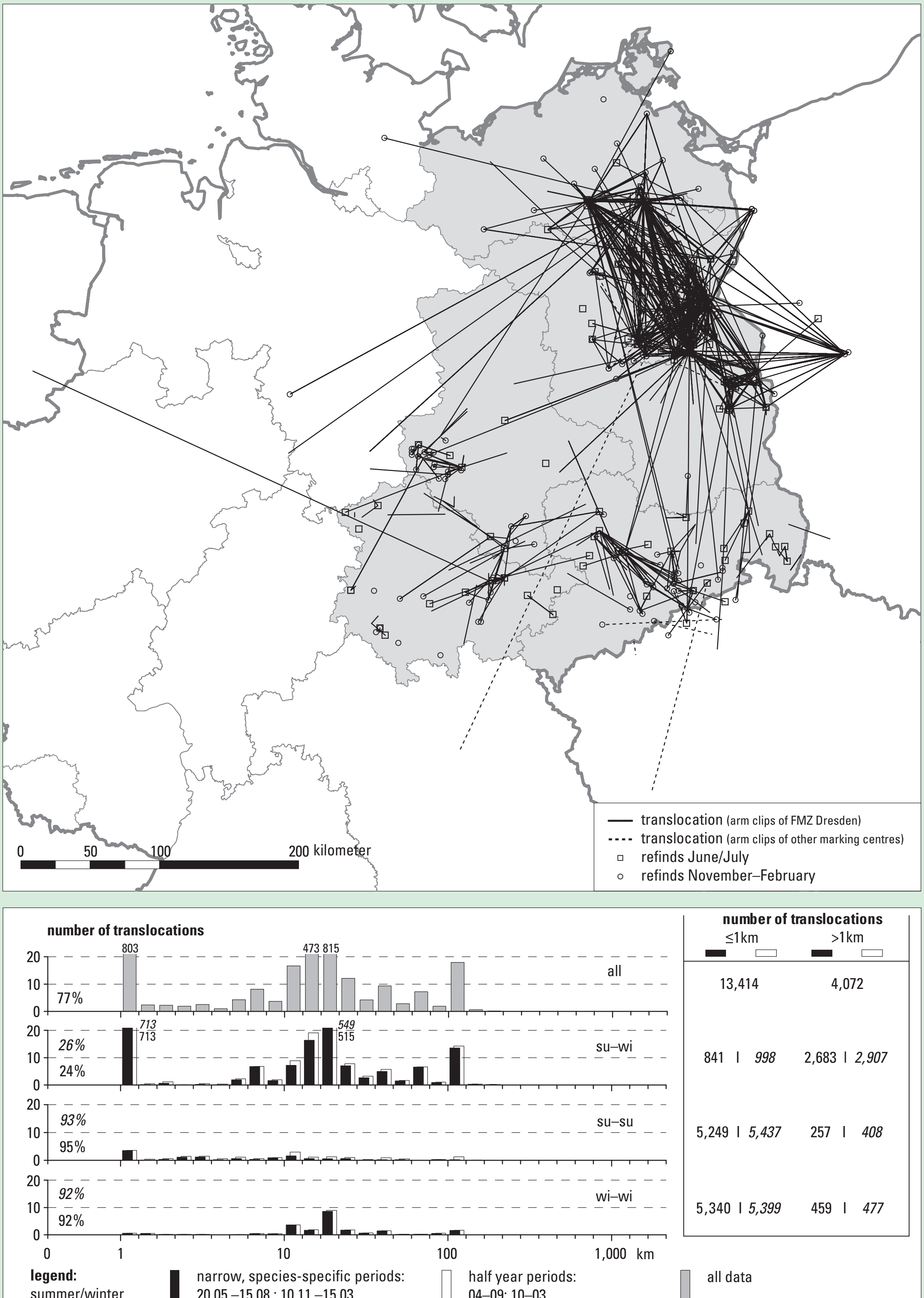
The above mentioned maximum distances for movements may reflect seasonal migration between summer and winter roosts, in particular with the ♂ and with additional results for ♂♂, but also a lagging behind in the range of the winter roost (see below). If one refers the results of the seasonal migration to species specific confined time periods, then the results are a maximum of 202 km for ♂♂ and 257 km for ♀♀. Non-migrating animals or animals with a migration distance of up to 3 km are exclusively adult ♂♂ that stayed during the summer at or within the range of the winter roost. For Daubenton's bats the question therefore arises as to what extent ♂♂ and ♀♀ have a different settlement behaviour and roost site fidelity and it seems that winter roosts and their surrounding areas are also generally used in the summer. This should held in mind for research programs.

Regarding summer accommodation shiftings within the narrower species specific time frame, distances of 166 km for ♂♂ and 30 km for ♀♀ have so far been determined. Since, however, only a few nursery roosts have so far been examined, this value, at least for ♀♀, is not yet representative. On the other hand there is extensive data available for winter roosts in the narrower species specific time frame of distances of 182 km (♂♂) and 229 km (♀♀). Therefore the considerable fidelity to roost site of the animals in winter roosts (Egsbaek et al. 1971, Haensel 1973b, 1978a) can be confirmed, but this applies to many species (see Tab. 8) and is due to methodical reasons concerning the %-portion being over-represented (see chapter 3.2.2.4.2).

The **Greater mouse-eared bat** (*Myotis myotis*) is essentially a European species, with its main distribution in central and south Europe (Schober & Grimmberger 1998). In Central Europe it is the bat species, which is in the centre of many investigations since the beginning of bat marking (e.g. Eisentraut 1934a and b, 1960b) and has been the subject of the most extensive relevant studies and evaluations. From these data Güttinger et al. (2001) report distances for seasonal migrations from a few tens to approximately 100 km and cite a maximum of 269 km (Stratmann 1980) and 279 km (Rackow 1998). For South Germany there are reports of distances of 325 km (Rudolph et al. 2004b), between the Czech Republic and Slovakia 355 km (Gaisler et al. 2003) and for Spain 390 km (Paz et al. 1986).

In the area of bat marking centre Dresden the Greater mouse-eared bat is no longer the most frequently marked species, but in the period of 1964–2000 it was still the species with the most refinds (17,490 = 27 % of all refinds – see Tab. 4 – Grimmberger & Labes 1995, Haensel 1974, 1980a, 1987, 1992a, Heise 1989b, Oldenburg & Hackethal 1989a, Schmidt 1995a, Schober & Liebscher 1998, Zöphel & Schober 1999 among others). The above mentioned range for seasonal migration in Central Europe can be extended again. Local migrations over 379 km (data base) and 368 km (Rudolph et al. 2004, Haensel 2004a) were found. However according to the time window these cannot be clearly assigned as seasonal migrations between summer and winter roosts and the sex of the animals was also not determined. For the species specific period, however, distances of 304 km for ♀♀ and 328 km for ♂♂ km were found. As with the Daubenton's bat, there is generally in addition still another substantial proportion of animals, which performs local migrations >100 km, that represents a total of 465 (= 9.6 %) of the refinds with local migration >1 km for the period 1964–2004. Thus this proportion is considerably larger, although observed relatively less than for Daubenton's bat. The Greater mouse-eared bat also has a higher proportion of non-migrating animals, which is distributed evenly over ♀♀ and ♂♂ as well as adults and juveniles, and is partly based on the same use of both summer roost (nursery roost) and winter roost (e.g. Haensel 2003c). In addition in the lowlands in the NE of our reference territory, interrelations between the well-known, larger nursery roosts as well as with the winter accommodation are very intensive and well investigated (Fig. 18), with a significant number within the distance range of 10–50 km, compared to Daubenton's bat. In comparison to Daubenton's bat there is proportionately much less local migration to the mountain country.

Changes between summer roosts are relatively evenly distributed over a large distance range (Fig. 18 – diagram su–su) and for ♀♀ were up to 197 km and for ♂♂ up to 262 km determined in the species specific closer time window. Generally ♀♀ seem to be more faithful to roost site than ♂♂ (96 % to 83 % refinds <1 km distance of the marking location). Corresponding maximum distances for local shiftings between winter roosts are up to 227 km for ♀♀ and up to 128 km for ♂♂. In this species possibly ♀♀ are somewhat less faithful to roost sites than the ♂♂ (90 % to 94 %). As for the seasonal migration, a large number of such local



	number of translocations ≤1km	number of translocations >1km
all	13,414	4,072
su–wi	841 I *998*	2,683 I *2,907*
su–su	5,249 I *5,437*	257 I *408*
wi–wi	5,340 I *5,399*	459 I *477*

legend: summer/winter periods

- ■ narrow, species-specific periods: 20.05.–15.08.; 10.11.–15.03. (data printed in normal letter type)
- □ half year periods: 04–09; 10–03 (data printed italic)
- ▨ all data

Fig. 18: Translocations of Greater mouse-eared bat (Myotis myotis)

changes from 10–50 km can be recognised. Appropriate roosts seem to be connected, which is proven within one winter by such roost changes (see chapter 3.2.2.4.2 and e.g. Haensel 2004). At least according to our data, the Greater mouse-eared bat is less faithful to roost site than Daubenton's bat with regard to winter accommodation.

The distribution of the **Brandt's bat** (*Myotis brandtii*) is incompletely known, and this also applies to its migrations (Tupinier 2001). From Bavaria local migrations of up to 230 km are reported (Kraus & Gauckler 1972). A record flight of 700 km is mentioned by Hanák for Czechoslovakia, but according to Gaisler et al. (2003) this has to be considered as non-valid.

From the refinds of the bat marking centre Dresden local migrations are performed mainly from 10–50 km (diagram in Fig. 19). The high proportion of migrations from 1–4 km may also lie well within the normal accommodation group of a nursery roost, as with other species. Local migrations >100 km have been registered eight times so far (e.g. Heise 1999a, Ohlendorf 1990, Zöphel & Wilhelm 1999b), among them maximum values of 308 km (♂♂) and 228 km (♀♀).

Finds, which prove seasonal migration between summer and winter roosts, are rare, since most nursery roosts and winter roosts are still relatively isolated in this connection (see Fig. 19, in particular diagram su–wi). Therefore the determined maximum distances of 175 km for ♂♂ and 69 km for ♀♀ also only provisional values. This also possibly applies to 0 % non-migrating animals, for which at least for ♂♂ it has to be further investigated whether there are similar observations as for Daubenton´s bat.

Local changes between summer roosts are more frequently found (Fig. 19 – diagram su–su) and were found to be at a maximum of 71 km for ♀♀ and 308 km for ♂♂ in the species specific narrow time window. Also the proportion of ♀♀ which are faithful to roost site is higher with more refinds (92 %) at the marking location than for ♂♂ (83 %). Regarding the winter roosts again a high site fidelity can be found for both ♂♂ and ♀♀. In the species specific narrow time window only local changes of up to 12 km took place. However the small knowledge of alternative winter roosts and the small data proportion of approximately 10 % for ♀♀ have to be considered again.

The **Northern bat** (*Eptesicus nilssonii*) is distributed in North, Central and East Europe and in Central Europe and accours above all in the mountainous areas (Schober & Grimmberger 1998). The species is regarded as site faithful (Gerell & Rydell 2001). The furthest refinds known were 115 km (Kraus & Gauckler 1965–66) and 250 km (Gaisler et al. 2003).

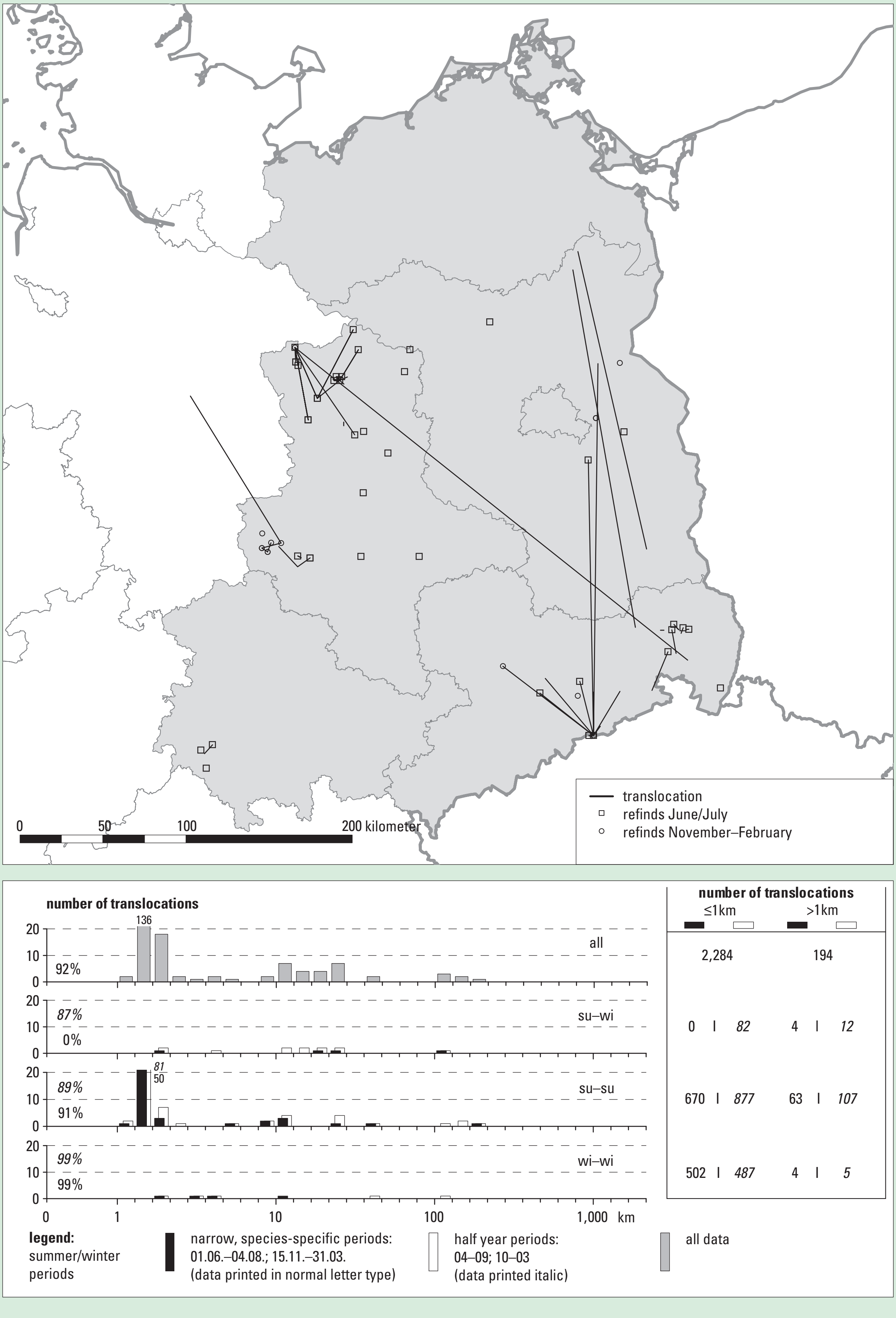
For East Germany twelve refinds are available for a distance >10 km, of which 5 were >100 km. The determined maximum was 450 km (♂♂) and 150 km (♀♀). The few remote finds and circumstances permit an allocation in seasonal migration or resettlement only with much caution. However it has to be assumed that both takes place within these distance ranges. In particular the very few refinds in winter roosts make an evaluation more difficult and lead to the assumption that most animals stay elsewhere during the winter, e.g. in wall linings and roofs of houses (Rydell 1993). In this connection also, the 0 % non-migrating animals (Fig. 20, diagram su–wi) are only a provisional result, particularly since on isolated islands of Scandinavia the winter roosts are also visited in the summer and in the autumn during the night (Ahlen 1981).

Natterer's bat (*Myotis nattereri*) is distributed almost all over Europe with the exception of the higher north (Schober & Grimmberger 1998). Maximum seasonal migration distances are between 62 km (Topál 2001, Bels 1952) and 90 km (Roer 1960). In addition a migration distance of 102 km is reported (Masing et al. 1999).

According to the refind data of the bat marking centre Dresden, Natterer's bat tends to less migration than the aforementioned species (Fig. 21). However in the meantime 10 proofs of local migrations >100 km are available (e.g. Haensel 2004b, Ohlendorf 2002b) with a maximum of 327 km (♀♀) and 266 km (♂♂). The peak values are all refinds made after 2000, and do not include species specific narrow time window for seasonal migration (su–wi), so that these may at least partly concern first settlements and resettlements in connection with the increasing population of Natterer's bat.

In the species specific narrow time window for seasonal migration (su–wi) a maximum distance of 195 km for ♀♀ and 48 km for ♂♂ is proven. The proportion of non-migrating animals is 18 % for ♀♀ and 48 % for ♂♂ and in this species is also sex specific. Whether it reflects only an extended stay in the summer roosts (e.g. Dolch 2003) or in so-called collecting roosts (O. Ohlendorf 2002b), or a stay during the summer in the winter roosts is still to be examined. On the specifics of the swarming phases and swarming accommodation (e.g. Haensel 2004b) it is only referred to at this stage in relation to other species, as in the available summarizing presentation no conclusive data allocation is possible (see chapter 3.2.2.3).

Local changes of the summer accommodation were in the species specific narrow time window for seasonal migration only proven very rarely for ♀♀ up to 135 km and for ♂♂ to 70 km. The same applied to changes in winter roosts of 31 km for ♀♀ and 109 km for ♂♂. Regarding the proportion of animals faithful to sites there were in both cases no substantial differences between ♀♀ and ♂♂.



	number of translocations ≤1km		number of translocations >1km	
	■	□	■	□
all	2,284		194	
su–wi	0	*82*	4	*12*
su–su	670	*877*	63	*107*
wi–wi	502	*487*	4	*5*

Fig. 19: Translocations of Brandt's bat (Myotis brandtii)

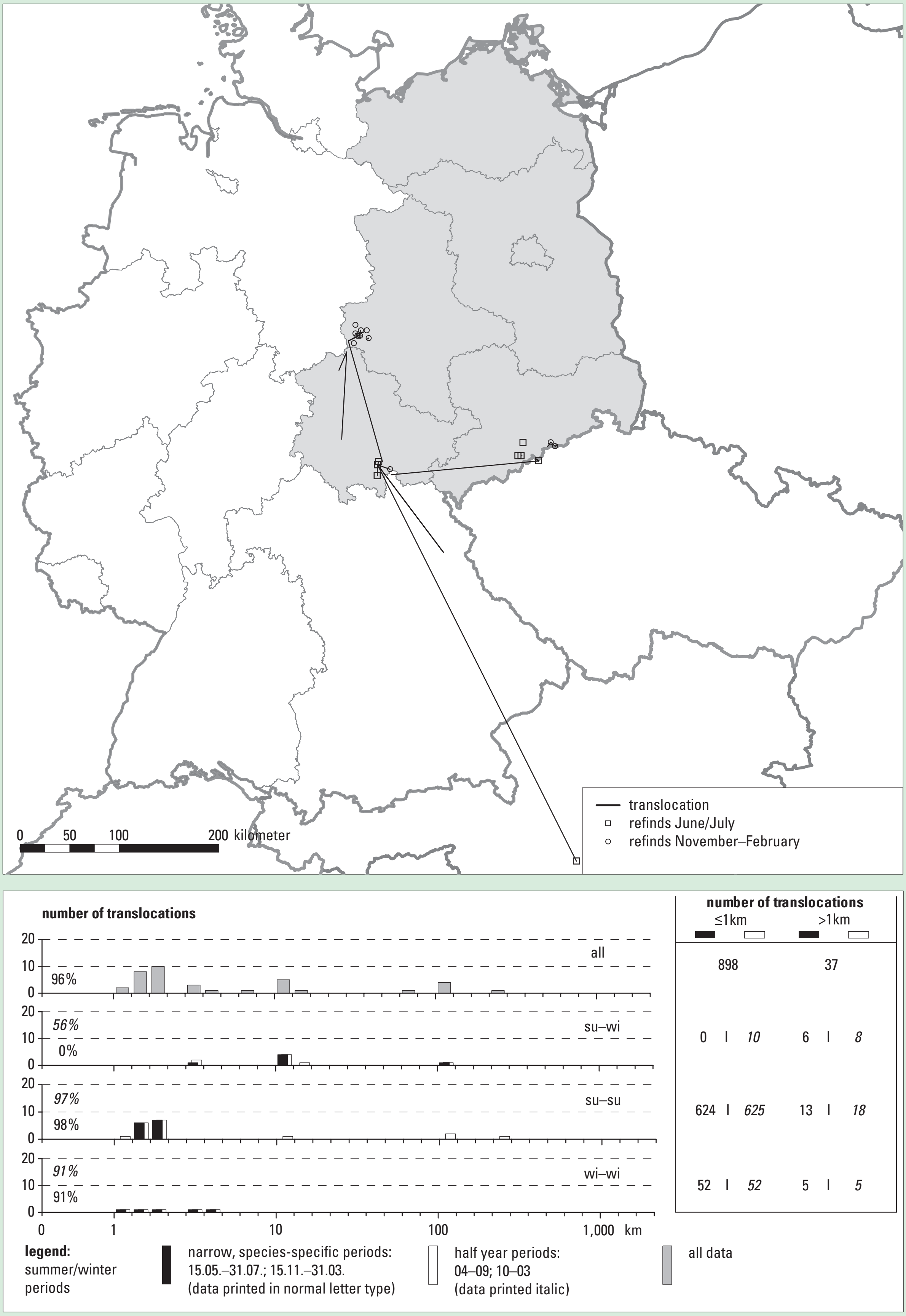


Fig. 20: Translocations of Northern bat (Eptesicus nilssonii)

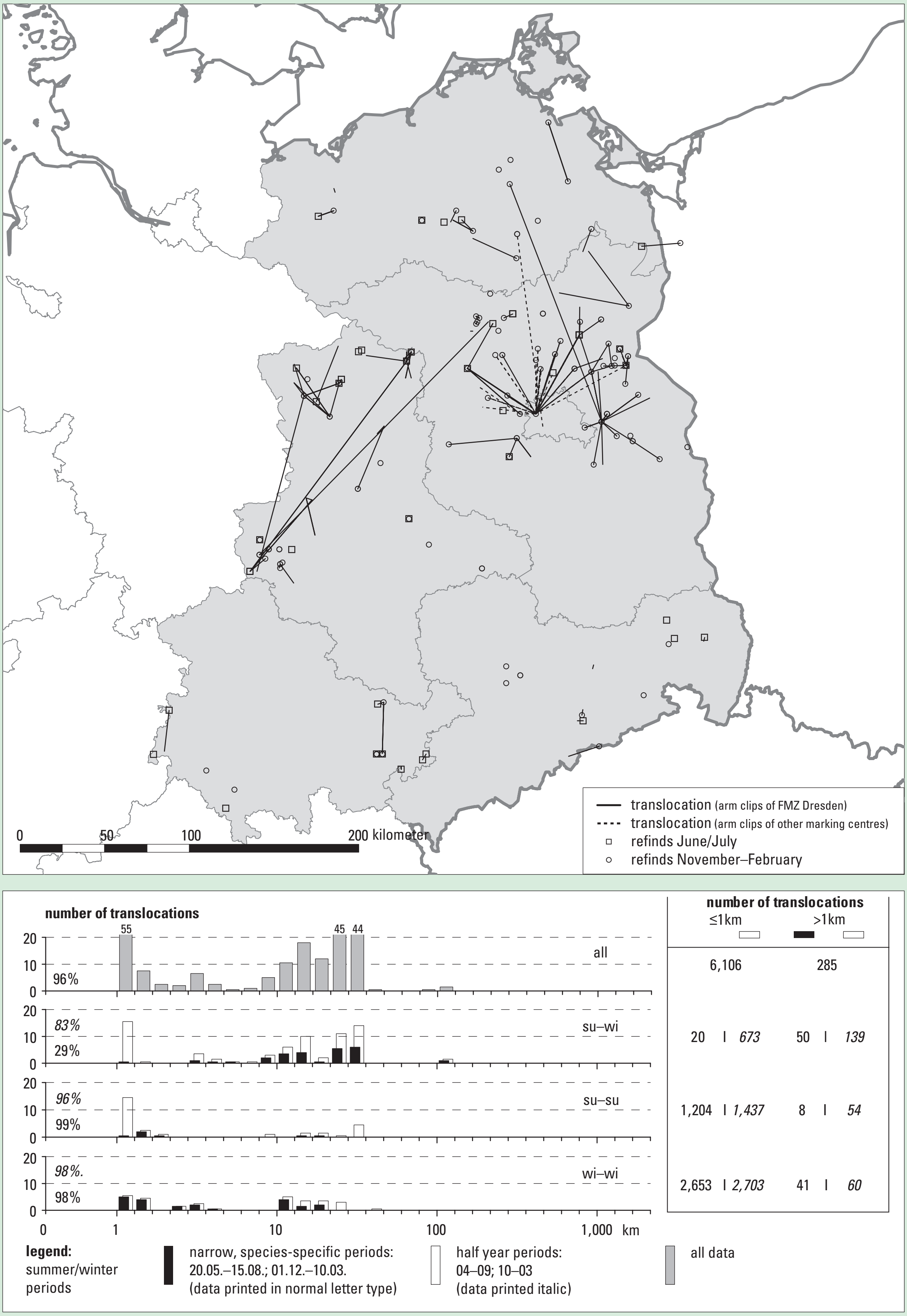


Fig. 21: Translocations of Natterer's bat (Myotis nattereri)

Serotine *(Eptesicus serotinus)* is a species particularly distributed in Central, West and South Europe, and they are concentrated in Central Europe in the lowlands. They only migrate exceptionally over distances >40–50 km between summer and winter accommodation (Baagøe 2001a), with a maximum of 330 km (Havekost 1960).

Refind results of the bat marking centre Dresden essentially confirm results obtained in the past. Seasonal migration between summer and winter roosts have, however, in particular when including at results from the Czech Republic (Gaisler et al. 2003), a somewhat further "normal span" (up to 80 km). 201 km (♀♀) and 92 km (♂♂) is the maximum distance observed in the species specific narrow time window. Data on non-migrating animals so far represent only adult ♀♀ and ♂♂, but the few data are not yet sufficient for relevant generalizations. In addition their proportion may increase clearly with sufficient investigation of the winter roosts (see e.g. Lubeley 2003).

Summer roost migrations are particularly in the distance range between 9 and 30 km with a maximum of 107 km (♀♀) and 142 km (♂♂). The few markings and refinds in winter roosts give evidence for site fidelity. One exception to this was one animal which was marked in Usti nad Labem and was found in Zwönitz/Ore Mountains and which had therefore carried out a migration of 89 km (Gaisler et al 2003). However in this case uncertainties do exist about the ring reading and it probably relates to a Greater mouse-eared bat (V. Hanák, written comm.).

Altogether the level of knowledge over local changes for Serotine is inadequate in respect to the spreading and frequency of this species and should therefore be improved by directed studies.

The **Whiskered bat** *(Myotis mystacinus)* is common all over Europe, except the high north and the southwest (south Spain, Portugal). For the Netherlands migrations of 57 km were determined (Lebrun 1971), for Bavaria 110 km (Cordes 2004), for Belgium 112 km (Fairon 1967) and for Czechia 165 km (Gaisler et al. 2003). The 240 km migration (Feldmann 1979) as cited by Tupinier & Aellen (2001) may also refer to Brandt's bat, since at the time of the ringing both species were not yet separated.

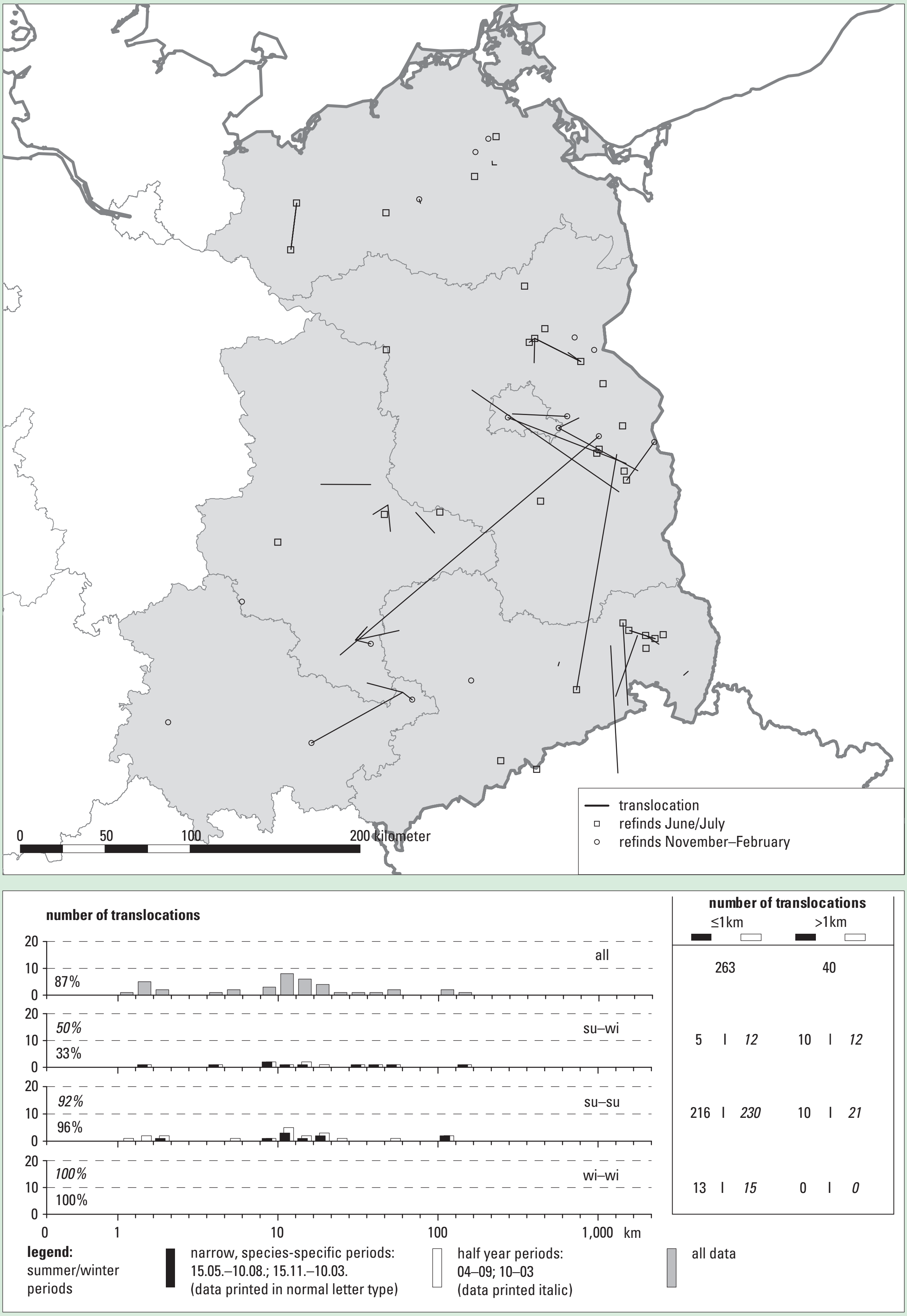
In the dataset of bat marking centre Dresden four finds >100 km are present, all concerning ♂♂, with a maximum of 127 km. For ♀♀ a maximum distance of 74 km was determined. For seasonal migrations between summer and winter roosts in the species specific narrow time window a maximum of 127 km for ♂♂ and 21 km for ♀♀ was found, for shiftings between summer roosts resp. first settlements 5 km for ♂♂ and 2 km for ♀♀, and for shiftings between winter roosts 109 km for ♂♂ and 0 km for ♀♀.

In many cases the data are not yet representative, as marking and refinding were mostly performed for ♂♂ in winter roosts. Increased marking and records in summer roosts started to take place only a few years ago particularly in Saxony-Anhalt (see Fig. 23), for which the results in many cases are still awaited. Altogether the spatial connection of the sites currently under record is not sufficient in order to obtain conclusive results. This applies in particular also to 0 % records of non-migrating animals. In order to gain more knowledge regarding the summer stay of the ♂♂ in particular, the winter roosts and the further surrounding areas should be also recorded in the summer.

The **Common pipistrelle s.l.** (*Pipistrellus pipistrellus* s.l.) has its main distribution in Europe, with the exception of the higher north (Taake & Vierhaus 2004). Concerning local changes and migrations so far no uniform picture can be drawn. In Eastern Europe it seems to accomplish regular migrations over larger distances (Strelkov 1969), while in Central Europe and Great Britain most animals are site-bound and seasonal migrations are carried out only to a small extent. Exceptionally distances of up to 400 km can be travelled (Avery 1991, Grimmberger & Bork 1979, Haensel 1992c, Hurka 1988, Sachteleben 1991, Thompson 1992 – all references in Taake & Vierhaus 2004).

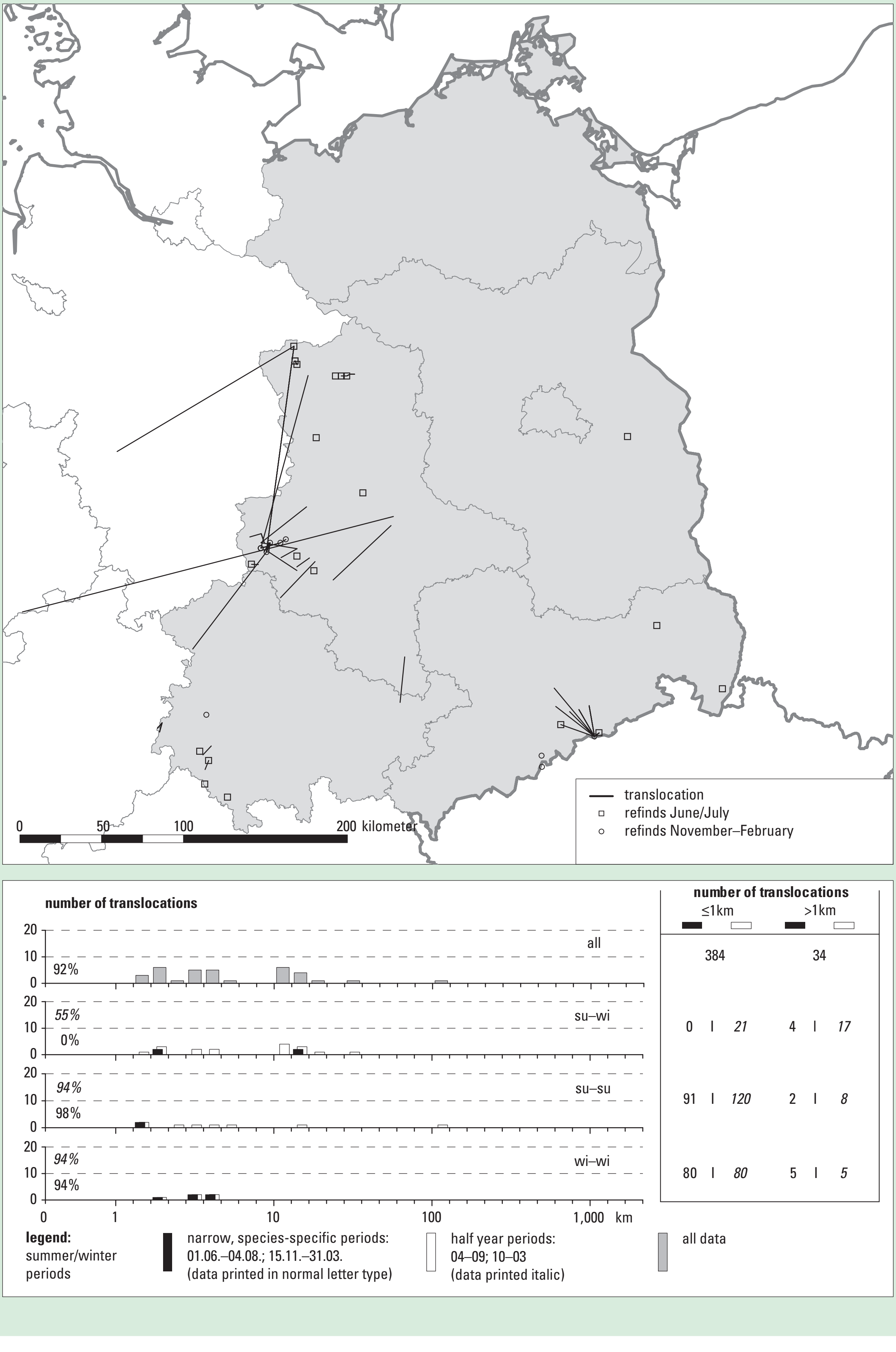
The picture that is at least non-uniform for Central Europe is again reflected in the refinds of the bat marking centre Dresden (see Fig. 24 as well as Grimmberger & Bork 1978, 1979, Haensel 1971a, 1973a, 1979b, 1992c, Ohlendorf & Nicolai 1996, Wilhelm 1971b). Here on the one hand 9 remote finds >100 km are available, of which at least five can be attributed clearly to the Common pipistrelle s.l. and for a further six this is probable. The remaining can be false markings and misreadings. On the other hand, the large numbers of findings in the district surrounding the two large winter roosts in Demmin and Rüdersdorf as well as an accordingly high proportion of non-migrating animals are important. However, as since so far marking and record activity was essentially concentrated on two activity centres, the picture may also be substantially shifted in favour of the close distance findings, as was already discussed in connection with the proportion of non-migrating animals in chapter 3.2.2.4.1. Finally it has to be noted that the refinds concern two species that have only been separated for a few years (*P. pipistrellus* and *P. pygmaeus*) and that may exhibit different behaviour in respect to location changes (see e.g. v. Helversen & Holderied 2003) and the proportion between the two species remains unknown.

The maximum distance between marking and rediscovery site can be up to 442 km for ♀♀ and 775 km for ♂♂. In the species specific narrow time window for seasonal migration (su–wi) the migration distance is 47 km for ♀♀ and 241 km for ♂♂, and in the appropriate time window for



	number of translocations ≤1km		number of translocations >1km	
all	263		40	
su–wi	5	*12*	10	*12*
su–su	216	*230*	10	*21*
wi–wi	13	*15*	0	*0*

Fig. 22: Translocations of Serotine (Eptesicus serotinus)



	number of translocations ≤1km		number of translocations >1km	
	■	□	■	□
all	384		34	
su–wi	0	*21*	4	*17*
su–su	91	*120*	2	*8*
wi–wi	80	*80*	5	*5*

Fig. 23: Translocations of Whiskered bat (Myotis mystacinus)

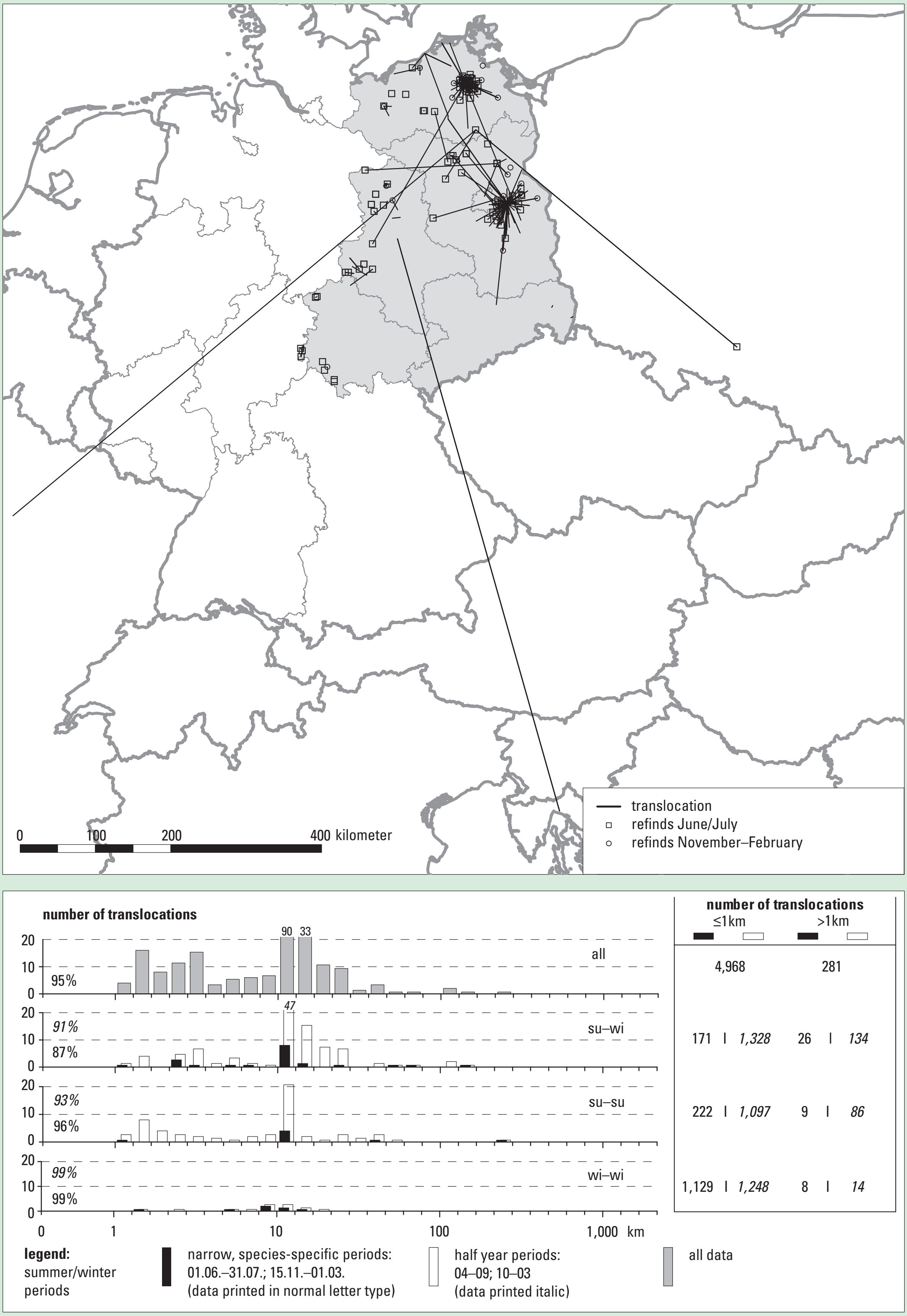


Fig. 24: Translocations of Common pipistrelle s. l. (Pipistrellus pipistrellus s. l.)

local shiftings in the summer (su–su) 442 km for ♀♀ and 15 km for ♂♂ and for location shiftings in the winter (wi–wi) 32 km for ♀♀ und 10 km for ♂♂.

As there is a very strong dispersion of the individual values, like those relatively few data in the species specific narrow time window for seasonal migration (Fig. 24 – diagrams) on the one hand as well as the separation between Common pipistrelle and Soprano pipistrelle on the other hand, it will be necessary to reconstruct the appropriate marking programmes for both species. In addition it will also be necessary to examine the two large winter roosts recorded so far on appropriate proportions of the Soprano pipistrelle. The organization and the distribution of bat marking in East Germany by many people should enable us soon to realize a start in this process.

3.2.3.3 Species with smaller home ranges, without directed migration and a high proportion of non-migrating animals

The **Barbastelle** *(Barbastella barbastellus)* is found most frequently in central and Eastern Europe (Schober 2004). The species is evaluated predominantly as very faithful to roost site, with migration distance ranges within 50 km, but some migrations of up to 118 km (Rudolph 2004), 152 km (Gaisler et al. 2004) and a maximum of 290 km (Kepka 1960) have been reported.

From refind data of the bat marking centre Dresden (Fig. 25) so far no major new results have been obtained. Migrations of up to 100 km (♂♂) and 21 km (♀♀) were determined, with seasonal migration (su–wi) in the narrower species specific time frame of 55 km (♂♂) and 15 km (♀♀), and summer accommodation changes in the narrower species specific time frame of up to 10 km ♀♀. For ♂♂ no data are present. The distances for winter roost shiftings are up to 37 km (♂♂) and 21 km (♀♀). Altogether the database is still too small and too unbalanced for detailed analysis. In particular, evidence is missing for ♂♂ in the summer and also an adequate number of refinds for interrelations between summer and winter roosts. Therefore also the proportion of non-migrating animals is very uncertain and the data refers exclusively to ♀♀. Increased marking in the summer roost as well as the deliberate search for corresponding winter roosts should bring us closer to a solution.

The distribution of **Bechstein's bat** *(Myotis bechsteinii)* is so far only very incompletely known (Baagøe 2001c), but the species is concentrated in central and more southern Europe. From the current level of knowledge, it would appear that the species is relatively faithful to roost site. So far migrations of 32 km (Rudolph et al. 2004a) and 39 km (Haensel 1991) have been reported.

In the area of bat marking centre Dresden to date, nine cases of a migration > 30 km have been recorded, and the maximum is 73 km (♂♂) and 37 km (♀♀). Refinds originate almost exclusively from winter roosts (see Fig. 26 – diagrams), as only recently, and particularly in Thuringia, have summer roosts been taken under record. In that respect the 0 % of non-migrating animals in the data set is only of restricted value. Particularly the rare occurrence of Bechstein's bat in well-known winter roosts suggests that there are a substantial proportion (and in particular ♀♀) at other sites, probably tree caves (in summer-areas). An intensive treatment of the species in the summer and winter habitat suggests that there will be appropriate progress in research results (see e.g. also Schlapp 1990 and Kerth 1998).

The **Lesser horseshoe bat** *(Rhinolophus hipposideros)* is a common species in Europe especially in the south, and southwest (Mediterranean), but it has a few island-like occurrences in Saxony, Thuringia and Saxony-Anhalt in East Germany (Roer & Schober 2001a). Extensive markings in the 1930s to 1960s showed migrations, which were mainly in a distance range to 20 km, and this led to the classification of the species as sedentary (Roer 1971). Known maximum distances are 112 km (Gaisler et al. 2003) and 145 km (Harmata 1968).

In East Germany the Lesser horseshoe bat was not marked, so no appropriate data are available. Only by a unique case of marking in connection with a necessary resettlement project was a migration of 8 km determined. The situation of the nursery roosts and winter roosts, which at least in Saxony are very strongly concentrated spatially (see Zöphel & Wilhelm 1999a), supports the classification of the Lesser horseshoe bat in East Germany as well as a sedentary species. However for Thuringia such a simplified interpretation would be daring (see e.g. Biedermann 1994). Whether the marking of the Lesser horseshoe bat in relation to strictly directed scientific study (i.e. more relevant to nature protection) should be undertaken in East Germany, still requires further examination by experts.

The **Brown long-eared bat** *(Plecotus auritus)* inhabits nearly the entire Palaearctic region (Horáček & Đulić 2004). As a typical species of forests it is present only in the mountainous areas in southern Europe and has its northern limit of distribution at approximately 64 ° latitude, probably as a result of the climate (Schober & Grimmberger 1998). The Brown long-eared bat ranks among the species with the smallest number and the shortest proven distance ranges for migrations. The known maximum distances so far are 66 km (Masing 1989b) and 88 km (Gaisler et al. 2003).

These comments on location changes and migration behavior also apply in principle to East Germany (e.g. Dolch 1995, Heise & Schmidt 1988, v. Riesen & Dolch 2003). Only a few refinds were in the distance range > 30 km and maximum migration distances of 90 km (♀♀) and 71 km (♂♂) were determined (Fig. 27 – diagrams).

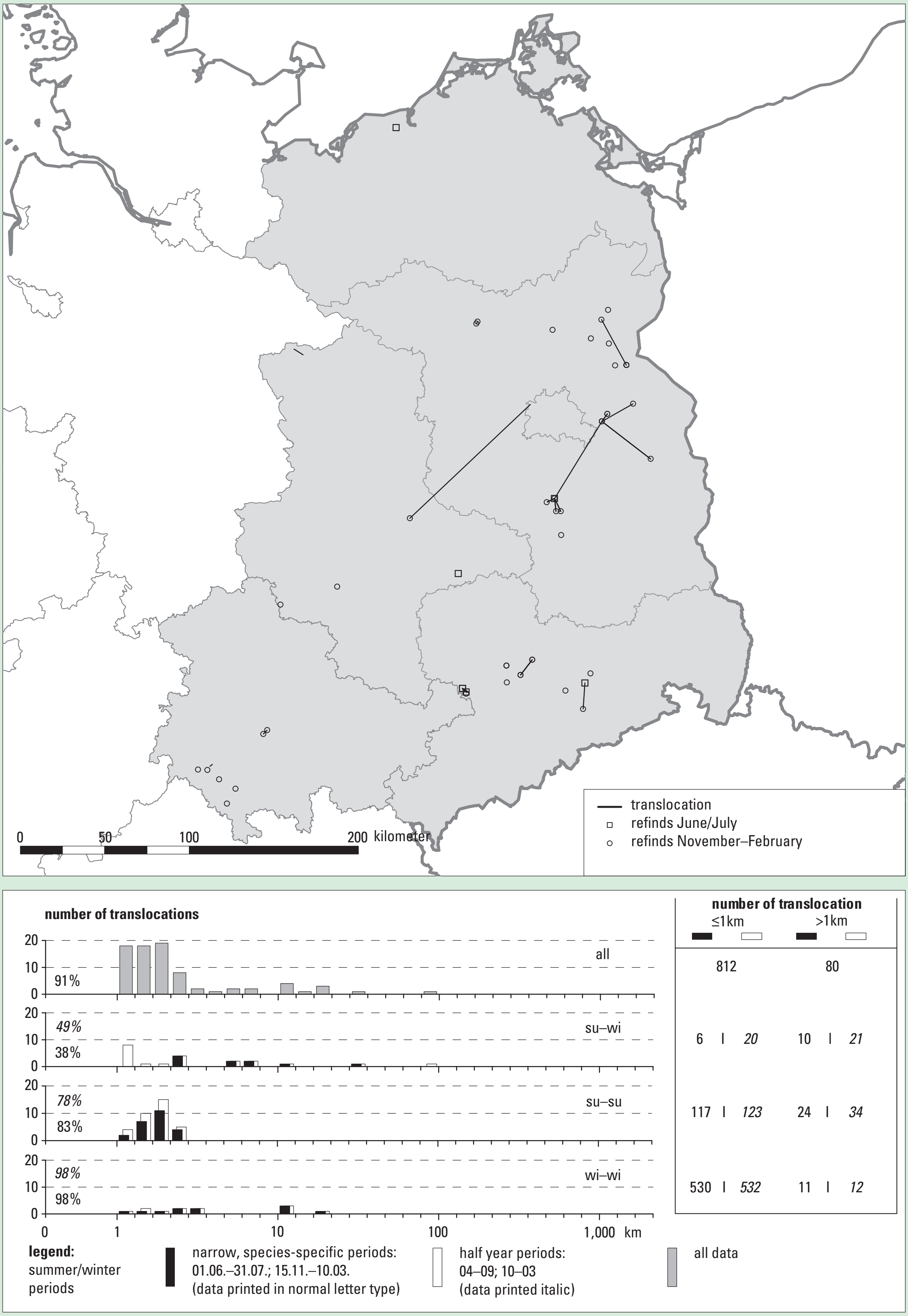


Fig. 25: Translocations of Barbastelle (Barbastella barbastellus)

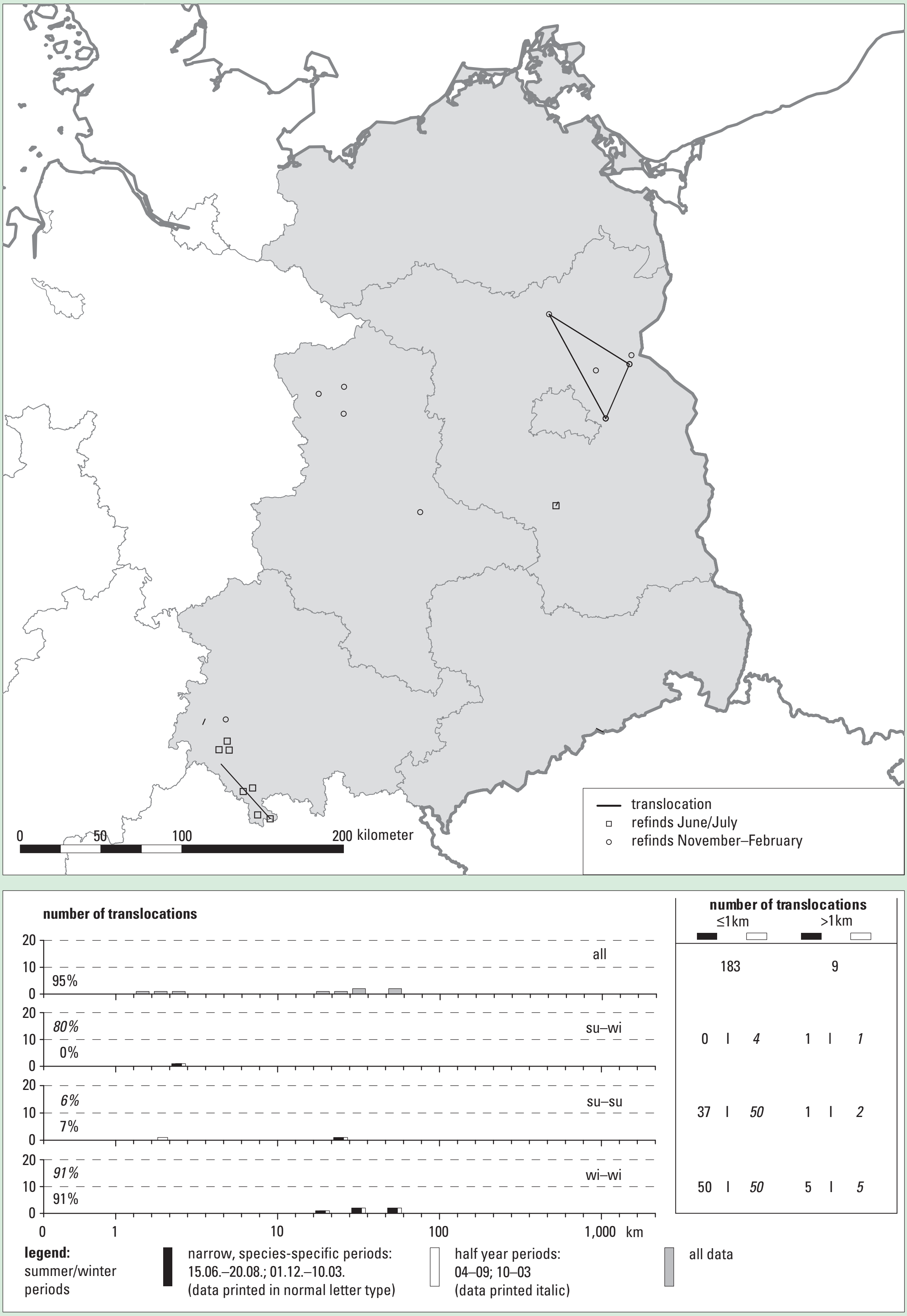
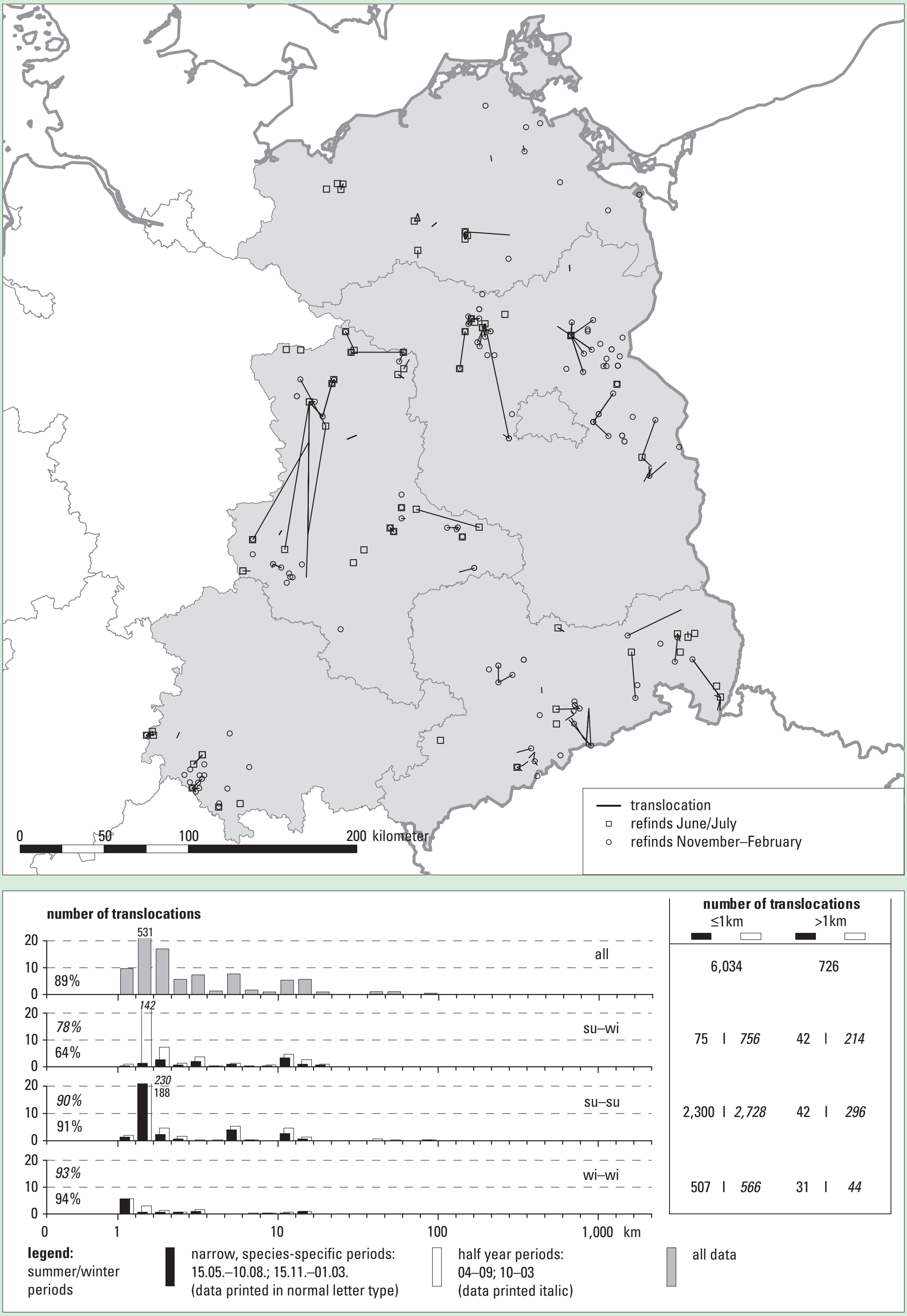


Fig. 26: Translocations of Bechstein's bat (Myotis bechsteinii)



number of translocations

≤1km ■	≤1km □	>1km ■	>1km □
6,034		726	
75	*756*	42	*214*
2,300	*2,728*	42	*296*
507	*566*	31	*44*

Fig. 27: Translocations of Brown long-eared bat (Plecotus auritus)

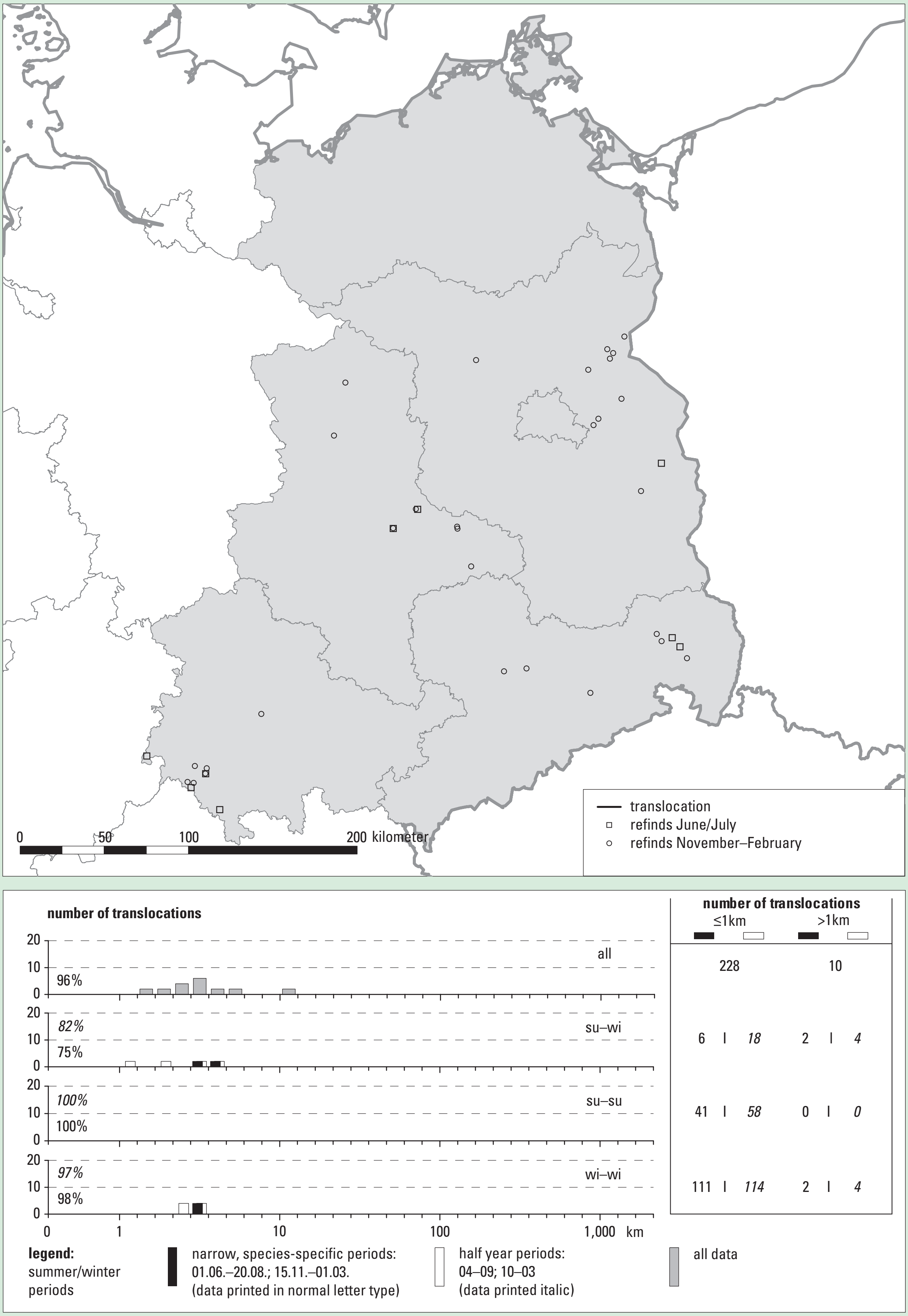


Fig. 28: Translocations of Grey long-eared bat (Plecotus austriacus)

Seasonal migrations in the narrower species specific time frame were up to 71 km (♂♂) and 29 km (♀♀). However ♂♂ seem to move considerably less than ♀♀ (74 % compared to 57 % of refinds of non-migrating animals) and adults less than juveniles (69 % compared to 52 %). Changes of the summer roosts and first settlements away from the place of birth are somewhat more frequently determined than winter accommodation changes. Migration distances in the narrower species specific time frame for summer roost changes of 90 km for ♀♀ and 7 km for ♂♂ and for winter accommodation changes of 21 km for ♀♀ and 3 km for ♂♂ were determined. The winter roost site fidelity is thereby again greater for ♂♂ (98 % of the refinds) than for ♀♀ (91 %).

The **Grey long-eared bat** *(Plecotus austriacus)* is in the main a european species which likes a warm climate, and its northern limit of distribution runs through Central Europe (approx. 53 ° latitude) (Schober & Grimmberger 1998).

From refinds of the bat marking centre Dresden a still smaller distance range for migration (maximum 15 km) and a still higher portion of non-migrating animals (75 % of the refinds) can be derived than for the Brown long-eared bat. However only relatively few suitable refind data are available (see Fig. 28). According to Gaisler et al. (2003) in the Czech Republic and in Slovakia migrations with a maximum of 61 km were determined. The proportion of the finds within a distance range > 20 km was greater for the Grey long-eared bat than for the Brown long-eared bat.

3.2.4 Summary and conclusions on site fidelity and migration of marked bats

For Nathusius' pipistrelle, Noctule, Daubenton's bat, Greater mouse-eared bat, Natterer's bat and Brown long-eared bat we have a good level of knowledge on seasonal migration and site fidelity. Future relevant investigations will contribute particularly to further understanding of the spatial and temporal dynamics.

With Brandt's bat, Whiskered bat, Northern bat, Serotine, Bechstein's bat, Common pipistrelle, Soprano pipistrelle, Barbastelle, and Lesser horseshoe bat it is important to improve the database to include appropriate data.

In particular there is little knowledge with regard to the settlement behaviour of ♂♂ of all species in the summer. In this connection it is especially desirable to investigate summer, mating and winter roosts and their surrounding areas throughout the year.

Attempts to combine the classical marking method for certain questions with telemetry should be increased e.g. for the principle investigation of typical summer and winter roosts for selected species, for collection and evaluation of data on the feeding grounds, the interrelations of nursery roosts and winter accommodation with swarm and mating roosts as well as the actual movements patterns.

3.3 Refind results as a contribution for the evaluation of species specific survival rates and age structures

3.3.1 Introduction

The 187,452 markings performed and 66,056 refinds made within the reporting period (1964–2000) in the scope of responsibility of the bat marking centre Dresden (see Tab. 4) are not only an important basis for the documentation of settlement behaviour and roost site fidelity but also provide proof of seasonal migrations. The marking and record of marked animals gives at the same time much additional information concerning the development, the life histories, and life achievements of the individuals, of the group, the age group, and the population. Age distribution of populations or roosting groups and survival rates of cohorts can be determinated. Pre-reproductive, reproductive and post-reproductive life phases can be divided and the population dynamics can be determined by reproductive and mortality rate as well as migration into and out of a population.

In this chapter in addition to the space aspects above, the time relation is added and leads to spatial-temporal considerations. Each single refind contributes to this goal. However it has to be noted that the relationship of the refind data of the ringers to refind data of other persons is about 11 : 1 and that the refind data of the ringers therefore secures the sample size for most of the individual species (see below). This chapter therefore could not be written, without almost all bat markers making their own refind data continuously available (annually) through programmes, that are methodically coordinated with the marking centre.

It is particularly necessary to emphasize the help here of:

- *Barbastelle*
  D. Dolch, R. Geißler, J. Haensel
- *Northern bat*
  FFG Meinigen, M. Wilhelm, G. Zapf
- *Serotine*
  J. Haensel, G. Natuschke
- *Bechstein's bat*
  FFG Meiningen, J. Haensel
- *Brandt's bat*
  U. Dingeldey, E. Leuthold, B. Ohlendorf, F. Rüssel, M. Wilhelm
- *Pond bat*
  R. Labes
- *Daubenton's bat*
  S. Dankhoff, D. Dolch, J. Haensel, R. Labes, G. Natuschke, B. Ohlendorf, C. Treß, J. Treß, M. Wilhelm
- *Greater mouse-eared bat*
  C. Gottschalk, J. Haensel, G. Heise, G. Natuschke, W. Oldenburg, W. Schober, M. Wilhelm
- *Whiskered bat*
  U. Dingeldey, FFG Meiningen, G. Natuschke, B. Ohlendorf, F. Rüssel, M. Wilhelm
- *Natterer's bat*
  D. Dolch, J. Haensel, D. Heidecke, R. Labes, E. Leuthold, B. Ohlendorf, C. Treß
- *Leisler's bat*
  A. Clausen, D. Dolch, M. Heddergott, FFG Meiningen, B. Ohlendorf, W. Schorcht
- *Noctule*
  G. Heise, C. Kuthe, R. Labes, W. Oldenburg, C. Treß
- *Nathusius' pipistrelle*
  D. Dolch, C. Kuthe, R. Labes, W. Oldenburg, C. Treß
- *Common pipistrelle s. l.*
  H. Bork, D. Dolch, J. Haensel, B. Ohlendorf, C. Treß
- *Brown long-eared bat*
  D. Dolch, J. Haensel, D. Heidecke, G. Natuschke, C. Treß
- *Grey long-eared bat*
  J. Haensel, D. Heidecke, FFG Meiningen, B. Ohlendorf
- *Parti-coloured bat*
  E. Grimmberger, U. Hoffmeister

In general, once more time has passed since the beginning of the appropriate marking programmes, more data has been accumulated, and more appropriate evaluations can be obtained. From refinds in the first three years after marking within the range of the bat marking centre Dresden GRIMMBERGER & BORK (1978) tried already to take conclusions on the survival rate for the Common pipistrelle on the basis of extensive markings- and refind data from the north of the GDR (church of Demmin). SCHMIDT (1984) strives to represent appropriate conditions including all age groups for Nathusius' pipistrelle (age distribution, survival rate, life expectancy). A similar approach is followed by HEISE (1985) for the Noctule who tries at the same time to adjust the results with the reproductive rate. After this an active discussion developed in which the bat marking centre Dresden was also involved, in particular on methodical views on different topics (STEFFENS & HIEBSCH 1989, STEFFENS et al. 1989). Further published reports followed including HEIDECKE & BERGMANN (1989), HEISE (1989), SCHMIDT (1994b), HEISE & BLOHM (2003) or concerning this particular topic (e.g. GÖTTSCHE et al. 2002, HAENSEL 2003, v. RIESEN & DOLCH 2003).

Unfortunately some methodical problems and misunderstandings also arose, which have to be clarified respectively on the basis of examples from the results. In all cases, in which such examples from above cited references are selected, this always takes place in order to clarify circumstances and never with the intention of diminishing the value of appropriate work which is altogether very deserving. On the contrary, bat marking centre Dresden sees itself here as responsible, since it failed to describe appropriate methodical aspects at that time in more detail. After 1989, due to personnel capacity, bat marking centre Dresden was not able to continue the methodological discussion and to support this with examples from results. This obvious deficit will be followed up in the following chapters, as more extensive methodical remarks and descriptive examples are presented in front of results.

3.3.2 Species specific survival rates for bats

3.3.2.1 Methodological background

In conjunction with the determination of the survival and mortality rates respectively, the life expectancy and temporal succession of age groups (of a birth year, a cohort) is investigated. A fictitious example of an appropriate mortality table is used to discuss this method (Tab. 10). The appropriate methodical basis is as cited by SCHWERDTFEGER (1968), ODUM (1983), WISSEL (1990) and others.

The crucial information from Tab. 10 is the number of animals alive i.e. the survivors of an age class (a birth year group), which itself can be deduced from direct observation (counting) of animals alive with a known age (e.g. juvenile marked animals) and/or from the animals found dead. Depending on the type of organism a more or less typical total lifetime ($x_0 \dots x_n$) results and within this total lifetime a specific curve, which can vary spatially and temporally, e.g. as a function of adjustment mechanisms. In particular this can be described by the survival rate (l_x), the mortality rate (q_x, q_y) and the life expectancy (e_a, e_b, e_c).

The **survival rate** (l_x) expresses which proportion of the output organism number lives at the beginning of the respective age group (AC = *age class*):

$$l_x = \frac{L_x}{L_0} \qquad \text{example:} \quad AC_0 \quad l_0 = \frac{310}{310} = 1$$

$$AC_5 \quad l_5 = \frac{25}{310} = 0.081$$

The survival rate can also be understood as an age specific annual value. In this case it expresses the proportion of the survivors from one age group to the next.

$$l_y{}^* = \frac{L_{x-1}}{L_x} \qquad \text{example:} \quad AC_{0/1} \quad l_y = \frac{173}{310} = 0.558$$

$$AC_{5/6} \quad l_y = \frac{15}{25} = 0.600$$

This **age specific survival rate** (l_y) is the counterpart to the age specific mortality rate (q_y):

$$q_y = 1 - l_y,\ l_y = 1 - q_y$$

The age specific survival rate (l_y) is not very common in scientific literature. However it is often used in practice as "survival rate" (e.g. SCHMIDT 1994b), since it represents the direct ratio (from the age specific mortality rate) between the individual age groups. We explicit point to the difference to the survival rate (see data in Tab. 10)

The **mortality rate** has generally (and contrary to l_x) an annual reference in scientific literature. Usually the symbol q_x is used. We want to distinguish between age specific annual mortality rate q_y ($_y$ because of the reference to age group intervals – see*) and a mortality rate of the "normal population" starting from the respective age group q_x which is described later.

The **age specific mortality rate** (q_y) expresses the proportion of dead animals from one age group to the next.

$$q_y = 1 - \frac{L_{x-1}}{L_x} \qquad \text{example:} \quad AC_{0/1} \quad q_y = 1 - \frac{173}{310} = 0.442$$

$$AC_{5/6} \quad q_y = 1 - \frac{15}{25} = 0.400$$

The age specific mortality rate is for organisms – as also in our fictitious example – higher in younger animals, because of the selection of less strong individuals, lacking life experience. It then reduces by the omission of these parameters and becomes higher again towards the end of the lifetime due to aging (reductions in physical strength) and amounts finally to 100 % (age of death of the last survivor). At least for longer living mammals (see e.g. ODUM 1983, Fig. 7.5, p. 273 – survival curves for black-tailed deer (*Odocoileus hemionus*)) an increased number of deaths among young animals, followed by a short stabilization can be followed again by a phase with a higher number of deaths before stabilization occurs as described above. The results for the Greater mouse-eared bat agree strongly with this pattern (see Tab. 13–15 and Fig. 37). This can possibly be interpreted as: increased deaths among young animals – stabilization toward the end of the pre-reproductive phase – increased number of deaths with entrance into the reproductive phase – stabilization in the process of the reproductive phase – increased age dependent number of deaths.

The **mortality rate of the "normal population"** is a step from temporal successive mortality of a birth year to the spatial subsequent mortality of a population.

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* With the index y all parameters are described that deal with intervall between AC_x and AC_{x+1} .

Tab. 10: Fictitious example of a mortality table and resulting parameters

x	L_x	$\sum L_x$	l_x	$\sum l_x$	L_{ym}	$\sum L_{ym}$	l_y	T_x	t_x	T_y	q_y	q_x	e_{ax}	e_{bx}	e_{cx}
0	310	740	1.000	2.387				0	0.000			0.419	2.39	1.89	1.39
					241.5	585	0.558			137	0.442				
1	173	430	0.558	1.387				137	0.442			0.402	2.49	1.99	1.49
					137	343.5	0.584			72	0.416				
2	101	257	0.326	0.829				209	0.674			0.393	2.54	2.04	1.54
					82	206.5	0.624			38	0.376				
3	63	156	0.203	0.503				247	0.797			0.404	2.48	1.98	1.48
					51.5	124.5	0.635			23	0.365				
4	40	93	0.129	0.300				270	0.871			0.430	2.33	1.83	1.33
					32.5	73	0.625			15	0.375				
5	25	53	0.081	0.171				285	0.919			0.472	2.12	1.62	1.12
					20	40.5	0.600			10	0.400				
6	15	28	0.048	0.090				295	0.952			0.536	1.87	1.37	0.87
					11.5	20.5	0.533			7	0.467				
7	8	13	0.026	0.042				302	0.974			0.615	1.63	1.13	0.63
					6	9	0.500			4	0.500				
8	4	5	0.013	0.016				306	0.987			0.800	1.25	0.75	0.25
					2.5	3	0.250			3	0.750				
9	1	1	0.003	0.003				309	0.997			1.000	1.00	0.50	0.00
					0.5	0.5	0.000			1	1.000				
10	0	0	0.000	0.000				310	1.000						

x = age classes from year 0 to year 10
L_x = living i.e. surviving in the corresponding age class
$\sum L_x$ = sum of the living i.e. surviving at the beginning of the corresponding age class until the end of the age class
l_x = animals alive i.e. survivors
$\sum l_x$ = analog $\sum L_x$
L_{ym} = mean number of animals alive i.e. survivors in the interval of two age classes
$\sum L_{ym}$ = sum of the mean number of animals alive i.e. survivors in all intervals following the corresponding interval
l_y = age specific survival rate between two age classes
T_x = Number of dead animals
t_x = percentage of dead animals
T_y = dead animals in the interval of two age classes
q_y = age specific annual mortality rate
q_x = annual mortality rate of the "normal population" from the respective age class onwards (mortality expectancy of the age class)
e_{ax}, e_{bx}, e_{cx} = life expectancy of a certain age class according to three different calculation methods

A condition for the transmission of the temporal successive mortality of a mortality table into the spatial succession is the normal population. By this, a stable population is understood (reproductive rate = mortality rate, immigration = emigration), which corresponds to the survival rates and determined mortality rates in the respective mortality table. In this case the successive dying process of the individual age groups during the lifetime in the mortality table takes place side by side during a year. At the same time each age group will become one year older and the youngest age group must be replaced by an appropriate new generation. Hence it follows that under these constant conditions the sum of dead animals in the course of a year equals the existing first age class at the beginning of the year ($T_{10} = 310 = L_0$ in our table), which must then be replaced by a corresponding number through reproduction (reproductive rate = mortality rate). Accordingly the mortality rate for the normal population is:

$$q_x = \frac{L_x}{\Sigma L_x} \qquad \text{example:} \quad \text{from } AC_0 \quad q_{x0} = \frac{310}{740} = 0.419$$

$$\text{from } AC_5 \quad q_{x5} = \frac{25}{53} = 0.472$$

In reality, in real populations, these assumed (constantly stable) conditions are of course not present. The consequences will be shown later several times.

The **life expectancy** (e_x) can be calculated differently, according to whether it refers to the beginning (e_{ax}), the center (e_{bx}) or the end (e_{cx}) of the time interval of the respective age group.

$$e_{ax} = \frac{\Sigma L_x}{L_x} \qquad \text{example:} \quad AC_0 \quad e_{a0} = \frac{740}{310} = 2.39$$

$$AC_5 \quad e_{a5} = \frac{25}{53} = 2.12$$

$$e_{bx} = \frac{\Sigma L_{ym}}{L_x} \qquad \text{example:} \quad AC_0 \quad e_{b0} = \frac{585}{310} = 1.89$$

$$AC_5 \quad e_{b5} = \frac{73}{25} = 1.62$$

$$e_{cx} = \frac{\Sigma L_x - L_x}{L_x} \qquad \text{example:} \quad AC_0 \quad e_{c0} = \frac{740-310}{310} = 1.39$$

$$AC_5 \quad e_{c5} = \frac{53-25}{25} = 1.12$$

Therefore $e_{ax} = e_{bx} + 0.5 = e_{cx} + 1$. For our discussion at this point e_{bx} is closest to reality, because this computation assumes that half of the individuals dying from one age group to the next age group no longer live around the middle of this time interval. However because it is simpler to deal with e_{ax} is calculated in the following chapters and used in appropriate formulae, because the life expectancy e_{ax} stands in direct relation to the annual mortality rate of the normal population q_x, as it is the reciprocal value.

$$e_{ax} = \frac{1}{q_x} \qquad \text{example:} \quad AC_0 \quad e_{a0} = \frac{1}{0.419} = 2.39$$

$$AC_5 \quad e_{a5} = \frac{1}{0.472} = 2.12$$

q_x can therefore be understood as (annual) **mortality expectation rate** of the respective age group in the dying state. Therefore it is corresponding to:

$$e_{bx} = \frac{1}{q_x} - 0.5 \quad \text{and}$$

$$e_{cx} = \frac{1}{q_x} - 1.$$

In principle the different calculation variants, even if somewhat differently described, are already explained by Schwerdtfeger (1968), who refers particularly to Davis (1960).

Schwerdtfeger (1968) refers also to a calculation made by Burkitt (1926)

$e = \frac{2-q}{2q}$, which because of the relation

$$e = \frac{2-q}{2q} = \frac{2}{2q} - \frac{q}{2q} = \frac{1}{q} - \frac{1}{2}$$

corresponds to our formula for e_{bx}. It has to be noted that this applies for a continuous annual mortality rate. A continuous annual mortality rate, if one refers to the succession of the age groups, does not exist. The mortality rate can be continuous over certain sections of the lifetime, but at least at the end it always amounts to 100 %. The above mentioned relationship is very important for the consideration of populations, for their annual mortality rate, and in this sense it is more or less independent of different mortality rates of the individual age groups.

On the basis of the normal population (mortality rate = reproductive rate) the new generation rate necessary for the preservation of a constant population can be determined (n) and it is possible by using a well known reproductive rate to calculate the life expectancy necessary for the preservation of a constant population status. The Central European bat species living usually become sexually mature in the first or second year and give birth to one or two pups. In the case of ♀♀ reaching sexual maturity in the first year the following relationship applies:

$$(l_0 \cdot e_{a0} - l_0)\, n = 2l_0$$

$$n = \frac{2l_0}{l_0 \cdot e_{a0} - l_0} \qquad e_{a0} = \frac{2l_0}{l_0 n} + 1$$

Because of $l_0 = 1$ (see. Tab. 10) this results in:

$$n = \frac{2}{e_{a0} - 1} \qquad e_{a0} = \frac{2}{n} + 1$$

The formula

$$n = \frac{l_0}{l_0 \cdot e_{a0} - l_0}$$

expresses in a strict sense how many offspring the surviving ♀♀ ($L_0 \cdot e_{a0} - L_0$) have to bring up in order to replace the number of ♀♀-individuals dying within a normal population over the course of a year (with a sex relationship of juveniles $1:1 = 2L_0$). Accordingly the following relationship also applies

$$n = \frac{2q_{x0}}{1 - q_{x0}}$$

Examples as taken from Tab. 10 (here as mortality table for ♀♀):

$$n = \frac{2}{e_{a0} - 1} = \frac{2}{2.39 - 1} = 1.44$$

$$n = \frac{2q_{x0}}{1 - q_{x0}} = \frac{2 \cdot 0.419}{1 - 0.419} = 1.44$$

$$e_{a0} = \frac{2}{n} + 1 = \frac{2}{1.44} + 1 = 2.39$$

The new generation rates of 0.5/1.0/1.5/2.0 for juvenile/adult ♀ calculated life expectancies for the normal population (e_{an0}) are assumed to be 5.0/3.0/2.3 and 2 years. Such calculations are, for example, suitable in order to compare results obtained by different calculation methods and that are afflicted with appropriate uncertainties (see e.g. section 3.3.6), but also to determine and forecast the trend for populations when reliable data are available (see e.g. sections 3.3.7 and 3.3.8).

For ♀♀ reaching sexual maturity in the second year the following relationship is valid:

$$(l_0 \cdot e_{a0} - l_0 - l_1)\ n = 2l_0$$

Because $l_0 = 1$ this results in

$$(e_{a0} - 1 - l_1)\ n = 2$$

l_1 can be replaced by

$$l_1 = \frac{e_{a0} - 1}{e_{a1}}$$

Now, however, e_{a1} must be determined. In other words, we would have to determine the mortality rate or survival rate from AC_0 to AC_1 and determine the life expectancy from AC_1. The only possibility would be to set for $e_{a0} = e_{a1}$ and $q_{x0} = q_{x1}$, which however, as shown in Tab. 10, is not completely correct, but should be sufficient for our more calculations and intentions.

Accordingly we find:

$$n = \frac{2qx}{(1-q_x)^2} \qquad e_{a0} = \frac{2+2n}{2n} + \sqrt{\left(\frac{2+2n}{2n}\right)^2 - 1}$$

Examples according to Tab. 10 (here as life table for ♀♀):

$$n = \frac{2 \cdot 0.419}{(1-0.419)^2} = 2.48$$

$$e_{a0} = \frac{6.96}{4.96} + \sqrt{\left(\frac{6.96}{4.96}\right)^2 - 1} = 2.39$$

The exact values according to Tab. 10 would be:

$$n = \frac{2}{\sum\limits_{x \geq 2} l_x} = \frac{2}{0.829} = 2.41$$

$$e_{a0}\ \frac{2}{n} + 1 + l_1 = \frac{2}{2.41} + 1 + 0.558 = 2.39$$

From these calculations it can be concluded that with sexual maturity in the second year for the normal population as shown in Tab. 10 a reproductive rate of approximately 2.4 juveniles/adult ♀ would be necessary. As our native bats give birth to maximum of 2 juveniles/adult ♀, the mortality table as given in Tab. 2 can only belong to a species that reproduces in the first year and that usually produces more > 1 juvenile/♀.

With an assumed new reproductive rate of 0.5/1.0/1.5 and 2 juvenile/adult ♀ life expectancy values (e_{an0}) of 5.83/3.73/3.00/2.62 are calculated according to the above mentioned formulae.

3.3.2.2 *Remarks on some of the published results of the area of bat marking centre Dresden*

In Steffens et al. (1989) the missing methodical explanations have to be added afterwards as follows:

The life expectancy corresponds to the calculation for

$$e_{ax} = \frac{\Sigma L_x}{L_x} = \frac{1}{q_x}$$

The annual mortality of the normal population was used as mortality rate:

$$q_x = \frac{L_x}{\Sigma L_x}$$

The necessary reproductive rate was calculated from:

$$n = \frac{2}{\sum\limits_{x \geq 2} l_x} \quad \text{for the Greated mouse-eared bat,}$$

$$n = \frac{2}{\sum\limits_{x \geq 1} l_x} = \frac{2}{e_{a0} - 1} \quad \text{for the Common pipistrelle.}$$

The average age relates to the age structure of the normal population.

The relation of all calculations is for

- mortality data evaluation AC_0 resp. from AC_0,
- for refind data of live animals in the winter roost $AC_{0.5}$ resp. from $AC_{0.5}$,
- for refind data of live animals in the summer roost AC_1 resp. from AC_1.

In addition Schmidt (1994b) published survival and/or mortality rates in connection with his investigations on Nathusius' pipistrelle within the range of the bat marking centre Dresden. First the age specific survival rates ($1 - q_y$) are determined in the usual way (Tables 12, 13, 14, 16 in Schmidt 1994b), but not including the entire lifetime (eventually omitting the higher age groups). Results are then averaged (simple arithmetic means), in part with further restrictions concerning the age groups included thereby receiving the average and/or total survival rates. In addition to the fact that simple arithmetic means do not sufficiently represent the survival rates of the individual-richer younger age groups, an average of (age specific) survival rates has always to be judged critically especially in respect to the purpose for which such calculations are made. This also applies in particular in connection with the approach to determine the mortality rate (M) using the average age (x) following Winkel & Frantzen (1991)

$$M = \frac{100}{\bar{x}}\ .$$

This relationship exists only, if a constant mortality is assumed over the entire lifetime. In this case $\bar{x} = e_a$, $q_y = q_x$, each age group has the same life expectancy and the lifetime goes (purely mathematically) approximately towards infinity. Odum (1983) adds to this on p. 272: "Probably no population of the real world has a constant age specific survival rate during the entire lifespan". It is surely appropriate to assume age specific constant mortality rates for certain models and calculations, at least for certain periods of life. However, it is misleading to generalize using this special case with the average age as a design basis for calculation of the mortality rate. For species for which the number of deaths is above average in early life phases and below average in later life (concave process of the number of deaths), mortality rates which are too low arise from the above mentioned formula. For those species with mortality rates which are below average over the main lifetime and above average towards the end of life (convex process of the number of deaths) mortality rates which are too high result. Apart from the youth phase most of our native bat species seem to exhibit a rather convex process of death rate (see e.g. Fig. 37), as with many long-lived species of mammal and in particular humans. Therefore the relations are amplified (because of the descriptive character extreme) example with the following input values (Fig. 29).

x	0	1	2	3	4	5	6	7	8	9	10	11	12	13
l_x	100	80	79	78	76	73	69	64	57	44	25	10	1	0

Applying the weighed arithmetic means of the mortality rate the same life expectancy of the AC_0 results as in reality, but the shape of the survival curve is completely different and a considerable proportion of survivors extend far beyond actual lifetime. With calculations of the mortality rate from the average age ($1/\bar{x}$) one gets a similar unreal shape of the survival curve. At the same time the life expectancy of the AC_0 is only 56 % (4.27/7.58 years) of the actual value.

Beyond that, the average age of a real population (or a group of animals) is therefore not suitable for the determination of the mortality and survival rate, because it depends not only on the mortality rate but also on the reproductive rate. If the reproductive rate is > than the mortality rate, then the population (group of animals) is increasing, and this results in a lower average age (and a higher mortality rate if calculated on this basis). If the reproductive rate is < than the mortality rate, then the population (or group of animals) decreases, and this results in a higher average age (and a lower mortality rate if calculated on this basis). Thus real conditions cannot be reflected with mortality rates that are determined in such a way. If one interprets the age distribution in Tab. 12 of Schmidt (1994b) according to the normal population (see section 3.3.2.1, p. 63), then an average age of 2.93 years results and if we correct for the number of ringed animals as given in Tab. 10 (according to section 3.3.5.2, p. 70), then an average age of 3.09 results. Both results are then independent from the new generation rate. However they are not identical, because of the different time (space) relation. As expected they are clearly above the real average age of 2.67 years, indicated by Schmidt (1994b), because in this population the reproductive rate is > mortality rate (see below).

The different problems mentioned above can be solved relatively simply, if one turns from the age specific annual mortality rate (q_y) of the cohort (year of birth group, age group) to the annual mortality rate of the (normal) population. According to the explanations in chapter 3.3.2.1, p. 63 for

$$q_x = \frac{L_x}{\Sigma L_x}$$

this would result in Tab. 12 of Schmidt (1994b) in a mortality rate (of the population):

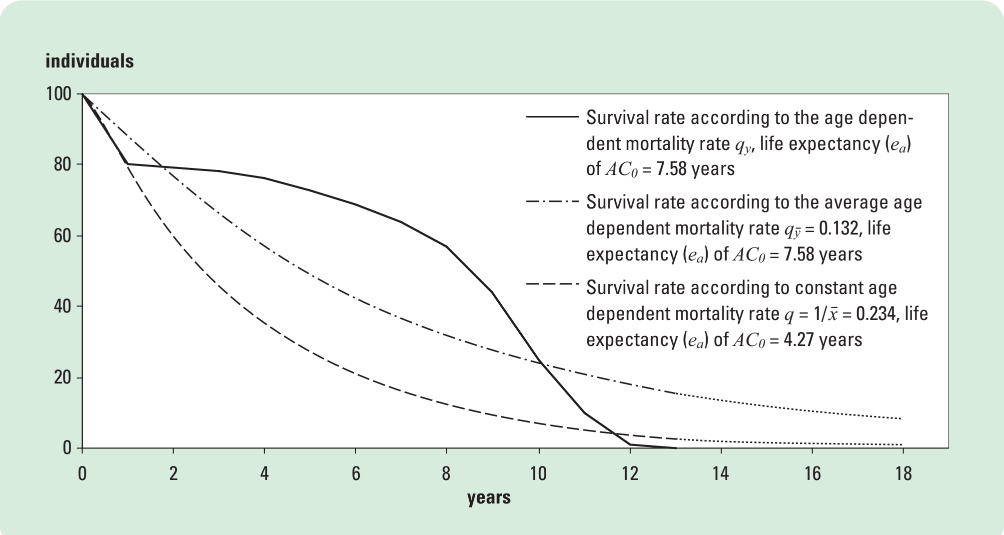

Fig. 29: Consequences of the formation of average values from age-dependent mortality rates and their calculation after the average age with the predominantly convex process of the actual mortality rate

from AC_0 $q_x = \frac{96}{286} = 0.336$ and 33.6 % = survival rate of 66.4 %,

from AC_1 $q_x = \frac{54}{190} = 0.284$ and 28.4 % = survival rate of 71.6 %.

For the other overviews (Tab. 13–16 in Schmidt 1994b) a similar procedure should apply. The values deviate not substantially from Schmidt (1994b. They are, however, clearer in respect to the interpretation (annual mortality rate as the sum of the single mortality events in all age groups with age specific mortality rates in the course of a year, related to the entire population and/or group of animals). In addition, in other cases, e.g. with a more convex process of the mortality rate (e.g. Greater mouse-eared bat – see Fig. 37), larger differences arise and these result in different population increase and decrease rates already becoming evident at relatively small differences between reproductive and mortality rate (see below). In addition Schmidt (1994b) gives a life expectancy of 1.95 years without any information on the mode of calculation. From Tab.12 results according to $e_{ax} = \frac{\Sigma L_x}{L_x}$ for $AC_0 : e_{a0} = 2.98$ and for $AC_1 : e_{a1} = 3.52$ years.

Later (p. 136) Schmidt (1994b) makes a connection between the reproductive rate and mortality rate, by adding the mortality rate of adult ♀♀ and ♂♂ and dividing this by the survival rate of juveniles up to sexual maturity. There are parallels to our formula in section 3.3.2.1, p. 64 for sexual maturity in the first year.

$$n = \frac{2q_x}{1 - q_x}$$

but still it contains several important misunderstandings:

1. It is not meaningful to add the mortality rate of ♀♀ and ♂♂ in the calculation. Here only the limiting mortality rate can be used (for species with strict monogamous pairings those of the sex with the higher mortality rate should be used and for species with harems those of the females should be used). In the calculation the multiplication factor 2 appears, because with a birth relationship of 1:1 between ♀♀ and ♂♂ double the number of pups must be born to those which die from the limiting gender. In the case where the birth relationship is not 1:1, a correction factor for the calculation of $\gtrsim 1$.

2. In the denominator the survival rate of the ♀♀, appears, but not the age specific survival rate $(1 - q_y)$ between AC_0 and AC_1 (as with Schmidt), but the survival rate of the entire ♀♀-population $1 - q_x$. This is because it is the rate starting from age 1 of the living individuals, which must adjust (double) the rate of the dead animals (q_x) by reproduction. The age specific survival rate of juveniles has to be considered only for sexuallymature animals in year 2:
$$n = \frac{2q_{x0}}{(1 - q_{x0})(1 - q_{x1})}$$
(see chapter 3.3.2.1, p. 65). In this way the study of Latzel & Scherner (1985) can be understood as cited by Schmidt.

According to Schmidt (1994b) this results in a necessary growth rate of:

$$\frac{0.31 + 0.426}{0.563} = 1.31 \text{ juv./ad. } ♀$$

Nach unserer Berechnung von:

$$\frac{0.336 \cdot 2}{0.664} = 1.01 \text{ juv./ad. } ♀$$

The basis for both calculations was Tab. 12. For the consideration of a population this has to result in our example (normal population, sexually mature in the first year) for the young of AC_{1-8} of Tab. 12 in 2 AC_0 (AC_0 = number of ringed animals as in Tab. 12).

In the case of the calculation of Schmidt this results in:

$$190 \cdot 1.31 = 249 > 192$$

In our case:

$$190 \cdot 1.01 = 192 = 192$$

As such, only the formula $n = \frac{2q_x}{1 - q_x}$ leads to a result that fits the observation.

The difference between the necessary reproductive rate (1.01 juvenile/adult ♀) and the actual reproductive rate (1.81 juvenile/adult ♀) however is still even larger than the calculated values of Schmidt (1994b). That is on the one hand a crucial basis for the positive development of Nathusius' pipistrelle [see e.g. Schmidt (2000a)], but on the other hand it requires additional discussion (see chapters 3.3.7.6 and 3.3.8).

In addition to Schmidt (1994b) Heidecke & Bergmann (1989), Heise (1985 and 1989), and Treß et al. (1989) publish data on survival and mortality rates. Heidecke & Bergmann (1989) and Treß et al. (1989) assume constant age dependent mortality rates. For the very general considerations made in both reports this is acceptable (in the case of Treß et al. for the comparison of the order of magnitude of mortality and birth rate of the Northern bat, in the case of Heidecke & Bergmann for the estimation of the missing proportion of Natterer's bats in the winter accommodation). Heise (1985) in his investigations on the Noctule determined an average mortality rate on the basis of the proportion of the AC_2 of the ♀♀ group with an age of ≥ 2 years and supplements (AC_1) and discusses (AC_{5-7}) on this basis the complete age structure. Later the mortality rate of the population (resp. the ♀♀ group) is derived from the reproductive rate and the proportion of last year's ♀♀ in the total population (resp. ♀♀ group) in the subsequent year (Heise 1989). This assumes that immigration and emigration are in balance and that the population is stable. This procedure is suitable for rough calculations but following sufficiently long and very detailed investigations (e.g. Heise & Blohm 2003) one would wish that the topic is taken up again and the statements are further differentiated.

3.3.3 Research into species specific age distributions in bat populations and roost communities in the area of bat marking centre Dresden

At first sight, the age distribution of populations resp. roost communities of the different species usually has much similarity to appropriate mortality tables and survival curves. It appears to us as a concurrent process (spatially and temporally) that resembles what happens within the cohort (of one birth year) over the entire lifetime. From this, misunderstandings over the determination of survival and mortality rates and life expectancy very easily develop, as described several times in the previous chapter. While the age distribution in the field population or group of animals is determined by mortality and reproductive rate, settlement and immigration and emigration, the age distribution in the mortality table reflects only the dying process. Finally, the mortality tables and calculations performed on their basis serve the determination of mortality rates, which are apart from reproductive rates the most important parameters for the dynamics of populations, and these cannot be derived directly from the age structure of populations or groups of animals. Apart from the specific views of a normal population (see chapter 3.3.2.1 p. 63) as a model for further discussion, all attempts to derive survival and/or mortality rates directly from age structures have to be considered with caution (see chapter 3.3.2.2).

In the area of responsibility of the bat marking centre Dresden the most detailed and coherent investigation into the age structure of nursery roost communities of the Noctule in the Melzow forest (Uckermark) was published by Heise & Blohm (2003). For over one decade all juvenile and adult bats present in bat boxes were ringed once the young began to fly following weaning and rings of animals which were already marked were recorded. In this way, both animals marked as juveniles (in which case an accurate age was known) and marked adult animals were considered for the determination of the age structure. The AC_0 is derived directly from the reproductive rate, whereby the determination of the actual relationship of juveniles to adults is very dependent on the correct record dates (see Heise et al. 2003). The AC_1 and the following age classes result, in the case of juvenile marked animals, from the refind rates. For adult marked animals however, this applies only from AC_2, AC_1 corresponds to the number of marked animals. Thus the AC_1 is over-represented (see Fig. 3), not all marked animals still living are caught again, but only a certain, but never complete, proportion (the remaining may be in tree caves or in unknown or not accessible roosts). Therefore the (minimum-)average age of adult marked animals is lower (2.1 years) than that of juvenile marked animals (2.2 years). Beyond that the age group distribution in adult marked animals is very similar to that of juvenile marked animals (starting from AC_2 in Fig. 30), from which Heise & Blohm (2003) conclude that the minimum age usually corresponds to the real age. The similar age group distribution is however no proof of this, since the mortality rate for the Noctule as a relatively short-lived bat species has only a weak convex shape (approximates a con-stant age-dependent mortality rate) and also exhibits only little age-dependent differences. The over-representation of the first age group does not result from the fact that it represents animals that are at least over 1 year old (Heise & Blohm), but rather because of the above mentioned methodical background. One can remove the problem, if the age distribution is only referred to juvenile marked animals, particularly as in the presented case (Heise & Blohm 2003) extensive data are available (see Fig. 31).

Due to the detailed and very accurate data it is also worth examining for the Noctule, to what extent the real age structure (the average age) is affected by differences between mortality and reproductive rates and associated increase or decrease of marked animals. If Tab. 2 in Heise & Blohm (2003) is evaluated according to procedures described in chapters 3.3.2.1, 3.3.2.2 and chapter 3.3.5.2, then for ♀♀ of known age for the marking years 1990–1996 (only these are documented in Tab. 2 of Heise & Blohm in a sufficient long period) an average age of 2.52 years results and for the recapture classes 1996–2002 an average age of 2.42 years results. Resulting from these, the reproductive rate for Heise & Blohm (2003) is also higher than the mortality rate. With AC values corrected after the model of the normal population (mortality rate = reproductive rate) we can now also calculate the annual mortality rate of the population $q_x = \dfrac{L_x}{\Sigma L_x} = 0.34$ (marking years 1990–1996) and 0.36 (recapture years 1997–2002). As demonstrated for Nathusius' pipistrelle in the previous chapter this results in a necessary growth rate (n), at this stage following Heise & Blohm (2003) only related to juvenile ♀♀, of

$$n = \frac{q_x}{1 - q_x} = \frac{0.34}{0.66} = 0.51 \quad \text{respectively} \quad \frac{0.36}{0.64} = 0.56.$$

This clearly lies again below the actual reproductive rate of 0.71 juvenile ♀♀/adult ♀♀. However the difference is not as large (absolutely and relative) as with Nathusius' pipistrelle, and the population growth is more moderate (G. Heise oral comm.) and only increases steeply in the

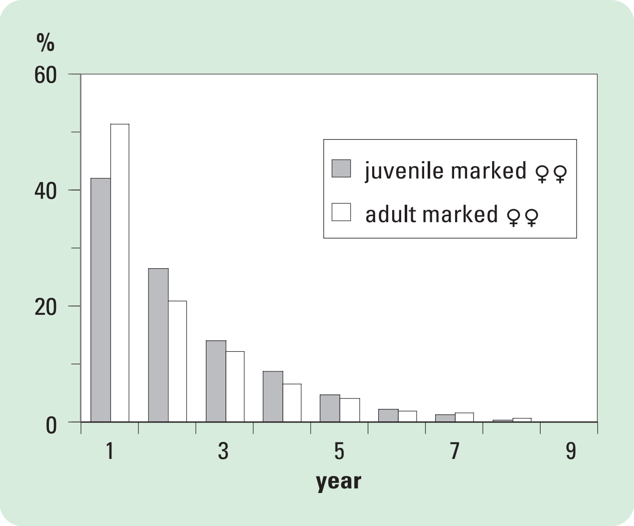

Fig. 30: Age structure of nursery roosts of the Noctule in the Melzow forest (Uckermark) 1990–2002 corresponding to Table 2 of Heise & Blohm (2003) – differentiated according to adult ♀♀ of known age and those that were marked once adult (at least 1 year old)

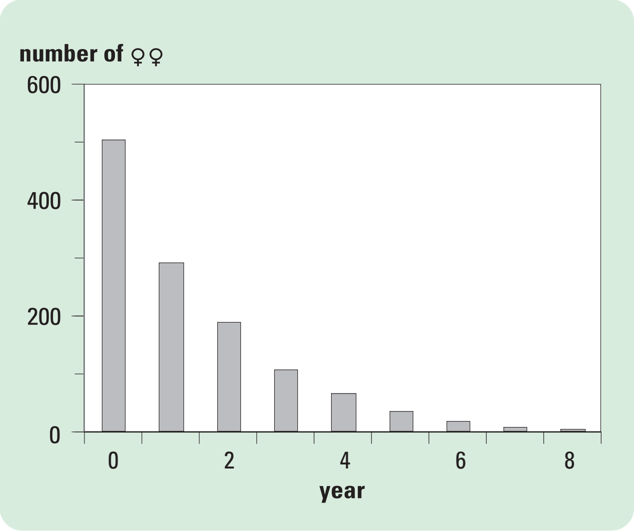

Fig. 31: Age structure of nursery roosts of the Noctule in the Melzow forest (Uckermark) 1996–2002 corresponding to Fig. 8 of Heise & Blohm (2003) – reduced to adult ♀♀ of known age and their female offspring

last years (Schmidt 2000a). For the Noctule this topic also requires still further reviews (see chapters 3.3.7.5 and 3.3.8).

Apart from the investigations on Nathusius' pipistrelle of Schmidt (1994b) concerning age distribution of nursery roost inhabitants already quoted in the previous chapter, for Greater mouse-eared bats we have to refer particularly to Göttsche et al. (2002), Haensel (2003), and Oldenburg & Hackethal (1989a). Haensel calculates for two intact populations an average age of 4.1 and 3.8 years, while it amounted for a dying population to 7.0 years.

Concerning the mortality rate however opposite tendencies are possible (high mortality rate = low average age, low mortality rate = high average age – see e.g. Steffens et al. 1989, Tab. 3). Also the settlement behaviour of young ♀♀ can influence the average age (e.g. Tab 4 as well as Fig. 11 and 12 in Steffens et al.). Both will be considered by an additional comparison with the average age of the normal population in the respective time frame.

On the basis of data available in the bat marked centre Dresden, for the period of 1995–2000, (for juvenile marked ♀♀ in the summer roost) and refinds in the summer roost this) amounts to 4.8 years ($n = 1{,}509$), and for the period of 1964–1977 to 4.6 years ($n = 416$). This supports the statement of Haensel for the average age of 7.0 years = dying colony = mortality rate > reproductive rate (see Haensel 2003, Tab. 3). For the average age of 4.1 resp. 3.8 years we state: mortality rate < reproductive rate = increasing colony (see Haensel 2003, Tab. 4) and corresponds to the general trend for the Greater-mouse-eared bat (see chap. 3.3.7.1).

Nevertheless it must be pointed out that generalized statements, derived from all examined nursery roosts (average age, normal population), must not necessarily fit with specific conditions in Berlin/Brandenburg (average age of normal population for Brandenburg or the specific location). In addition the average age for Greater mouse-eared bat ♀♀ in nursery roosts is not identical with the total average age of ♀♀ because of their settlement behavior (see chapter 5.4/5.6), which, for example, is also true for the settlement behavior of ♂♂ Nathusius' pipistrelles in mating roosts (see Schmidt 1994b) and may also apply to other situations. Finally it has always to be examined, to what extent the results are affected by immigration and emigration and by continuity and intensity of the markings and records of the entire reference area. In the examples presented the factors mentioned seem to have a subordinated importance, as the results are conclusive in several respects (determined reproductive rates, determined mortality rates, well-known population trends).

The collection of the age distribution of populations or groups of animals in appropriate bat roosts requires primarily subject-related investigations, in order to be able to correspond sufficiently to the usually specific conditions and to individual events during the documentation and evaluation of the results. The following presentations of results from the view of the bat marking centre (chapters 3.3.6 and 3.3.7) concentrate therefore particularly on general statements on the level of mortality tables and normal populations. Nevertheless we would like to request the individuals or groups involved in marking to perform similar evaluations for the results of their work and very extensive investigations over many years according to the above quoted methodical references and additions. Bat marking centre is very ready to support as well as to contribute to a relevant exchange of experiences. We would also encourage that results of studies with specific goals which have already been published (e.g. Haensel 2003, Fig. 2–5, v. Riesen & Dolch 2003, Fig. 6), are likewise evaluated in this sense and are re-analysed at a relatively low expenditure both for the determination of survival rates and the age distribution of populations and nursery roost communities.

3.3.4 Growth rate of bat populations and roost communities

The growth rate of a population can be calculated from the number of animals at time point 0 (N_0) multiplied by the exponential function e^r at the corresponding time point (t) (Odum 1983).

$$N_t = N_0 \cdot e^{rt}.$$

Thus e is the general growth constant (2.718…) and r the growth rate. The growth rate can be calculated after Odum (1983) and Wissel (1990) by the subtraction of the mean mortality rate (d) from the birth rate (b)

$$r = b - d.$$

In only a few cases do we have sufficiently robust and independently determined data for regenerating and mortality rates of bat species, to allow such computations. According to our knowledge this is primarily possible for Greater mouse-eared bat, Nathusius' pipistrelle and Noctule and this will be performed with further restrictions in chapter 3.3.8.

3.3.5 Results preparation, evaluation and differentiation for the analyses of survival rates of native bat species

3.3.5.1 Preface

The use of bat refinds for the preparation of mortality tables is connected with a whole set of conditions. The marking must be durable and must not affect the survival of the animals, which is essentially possible with today's methodical standards. Beyond that, the proportion of recaptured animals must in principle be similar for all age groups and exhibit above all no age-dependent tendency. This depends on many further conditions, including continuous work and appropriate data preparation and differentiation, and these will be discussed in greater detail later in the report.

3.3.5.2 Reference periods

A condition for conclusive survival curves and the determining parameters is a complete generation interval with appropriate data. Depending upon the life strategy of the native species of bats this results in minimum periods of 10 (15) to 20 (30) years. As the last years of life refer only for single animals a further reduction to 8–16 years is possible. From this we can conclude that if we set 2000 as the year of reference, an evaluation back to the birth and marking year 1992 would be possible for more short-lived species and to 1984 for long-living species.

For our fast-living modern time with a strong need of actual data that is naturally not sufficient. Therefore apart from the evaluation according to marking years an evaluation in respect to the refinding years can be performed (Steffens et al. 1989). The basis, as already quoted, is the reorientation from a temporal to a spatial subsequent consideration of mortality. Similarly as for the normal population (reproductive rate = mortality rate) the same start conditions (AC_0) must also here be given for all age groups. Since, however, this is not ensured by annual marking numbers, the respective refinds must always be expressed as a fraction of the marking number (e.g. in percent). A secondary condition is that for each year a minimum number of markings takes place, so that the influence of coincidental refinds is not too large (e.g. if in one year only one animal was marked and refound coincidentally after five years, then this refind would show a disproportionately high bias). According to this methodological approach and a lifetime of 8–16 years, from our commencement of markings in 1964, evaluations for the years 1974–2000 and 1982–2000 can be accomplished. The general context is presented once more in Tab. 11.

Fundamentally it has to be stated therefore that we do not set the space-time relation aside by our view but rather modify it. The evaluation related to marking years always represents living conditions which are historically further in the past concerning the recent age groups and concerning the higher age groups, which are however historically prepared. The refind-class referred evaluation represents more current conditions, which are nevertheless historically shaped concerning the older age groups. However since the younger age groups have a larger weight for the determination of life expectancy, their time relation is also more important. The connection between both views has always to be considered, particularly for time series with strong overlaps.

Tab. 11: *Survival rate for Greater mouse-eared bat ♀♀ related to marking year and recapture year in the winter roost (juvenile* animals marked in the winter roost)*

marking year	mark	recapture year																																									
		1.5		**2.5**		**3.5**		**4.5**		**5.5**		**6.5**		**7.5**		**8.5**		**9.5**		**10.5**		**11.5**		**12.5**		**13.5**		**14.5**		**15.5**		**16.5**		**17.5**		**18.5**		**19.5**		**20.5**		**21.5**	
	n	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1965	15	4		4		1		2		2		2		2		1		2		1		1		1		1		1		1													
1966	42	8		4		4				4		7		2		4																											
1967	89	23		18		4		13		10		4		2						1																							
1968	87	11		4		6		8		3		2				1																										1	1.1
1969	51	1		7		5		5		4										1						1	2.0																
1970	25	8		7		3		4		2		1		3		2																											
1971	54	25		12		11		5		1		6		4		3		3		2	3.7	2	3.7									1	1.9										
1972	34	13		10										1				1	2.9											1	2.9												
1973	39	6		3		1		2		2		1		2		3	7.7	2	5.1	1	2.6																						
1974	15	7		1		4		2		3		5		2	13.3	2	13.3			1	6.7	1	6.7			1	6.7	1	6.7														
1975	8	1		1								2	25.0	1	12.5			1	12.5																								
1976	6	2		1																																							
1977	17	7		4		2		1	5.9	3	17.6	2	11.8	1	5.9	2	11.8	1	5.9	1	5.9																						
1978	14	3		2		3	21.4	1	7.1	1	7.1	2	14.3	1	7.1	2	14.3	1	7.1	1	7.1																						
1979	16	2		3	18.8	4	25.0	1	6.3	3	18.8	2	12.5	1	6.3	1	6.3	2	12.5																								
1980	23	8	34.8	4	17.4			2	8.7			1	4.3																														
1981	45	10	22.2	6	13.3	5	11.1	6	13.3	5	11.1	4	8.9	3	6.7	1	2.2	2	4.4	2	4.4	1	2.2	2	4.4	1	2.2			1	2.2												
1982	47	13	27.7	8	17.0	7	14.9	7	14.9	4	8.5	5	10.6	1	2.1	3	6.4	4	8.5	4	8.5	2	4.3	2	4.3	1	2.1	1	2.1														
1983	35	5	143	4	11.4	4	11.4	2	5.7	4	11.4	5	14.3	1	2.9	2	5.7	2	5.7	1	2.9	1	2.9			2	5.7																
1984	28	11	39.3	6	21.4	10	35.7	6	21.4	3	10.7	4	14.3	3	10.7	1	3.6	1	3.6	3	10.7	2	7.1	1	3.6	2	7.1	1	3.6	1	3.6												
1985	21		52.4		47.6		19.0		9.5		28.6		23.8		14.3		19.0		14.3		9.5		9.5																				
1986	26		15.4		23.1		15.4		3.8		7.7		3.8				3.8		3.8																								
1987	127		10.2		9.4		4.7		5.5		3.9		3.9		3.1		1.6		5.5		7.1		6.3		3.9		0.8																
1988	43		23.3		11.6		18.6		7.0		16.3		9.3		7.0		4.7		2.3		2.3		2.3		2.3																		
1989	23		21.7		17.4		17.4		8.7		21.7		8.7		17.4																												
1990	33		21.2		12.1		6.1		9.1		12.1		6.1						3.0																								
1991	71		43.7		22.5		18.3		8.5		8.5		9.9		8.5		2.8		4.2																								
1992	37		18.4		13.2		10.5		13.2		7.9		5.3				5.3																										
1993	32		40.6		21.9		15.6		12.5		12.5		6.3		3.1																												
1994	40		32.5		25.0		17.5		15.0		7.5		7.5																														
1995	47		25.5		23.4		14.9		8.5		8.5																																
1996	35		8.6		2.9		2.9		2.9																																		
1997	38		26.3		10.5		5.3																																				
1998	26		7.7		15.4																																						
1999	28		14.3																																								
2000	24																																										
mark. year.	Σ	168		109		74		67		54		55		30		28		23		19		10		6		9		4		4		1		-		-		-		-		1	
1965–1984	%	25.4		16.5		11.2		10.1		8.2		8.3		4.5		4.2		3.5		2.9		1.5		0.9		1.4		0.6		0.6		0.2										0.2	
$e_{a1,5} = 662:168 = 3.94$ $n = 662$																																											
recapture year	Σ		500.1		355.3		285.7		187.5		220.4		200.6		121.0		108.5		101.3		71.4		45.0		18.5		26.6		12.4		8.7		1.9		-		-		-		-		1.1
1981–2000	%		22.1		15.7		12.6		8.3		9.7		8.9		5.3		4.8		4.5		3.2		2.0		0.8		1.2		0.5		0.4		0.08										0.05
$e_{a1,5} = 2266:500.1 = 4.53$ $n = 792$																																											

* juvenile animal in the sense of being in the 1st year

3.3.5.3 Time intervals and roost relationships

Bat markings and the record of marked animals are not distributed spatially or temporally purely by coincidence. The markings concentrate on certain accommodation types and roosts as well as record periods. Thus on the one hand high marking and refind rates can be obtained, on the other hand the associated species specifics must also be considered. For long-living organisms time is divided into yearly intervals in connection with the determination of survival rates, age structures etc. The calendar year is therefore not suitable for bats, since, in particular, refinds are done intermittently as a function of the yearly rhythm of the animals, e.g. specific features in connection with the stay in summer and/or winter roosts cannot be separated and records within the same wintering season can fall into two different years.

According to the main marking and refind activities a period from 01.04.–30.09. (summer season) and 01.10.–31.03. (winter season) is determined, with a temporal distance (interval) of one year in each case. Using this approach most data can be allocated. For special evaluations however, still stronger temporal restrictions may be necessary (such as solely on nursery roosts, hibernation time, mating time, intermediate accommodation period etc., see e.g. chap. 3.2.2.3) or intended record dates. The same is true for the calculation of the proportion of non-reproducing and reproducing ♀♀ (see e.g. Treß et al. 1989) and for an accurate determination of reproduction rate (see e.g. Heise et al. 2003).

For one specific individual several refinds as a function of the marking and supervisory routine, within short time phases (hours, days, weeks) were obtained. For the evaluations within this chapter however, usually only one recapture in each case of the appropriate time period (winter roost, summer roost, intermediate roost, mating roost) is relevant in the respective year. Keeping this in mind the data available for evaluation decrease from 65,139 to 47,346 live animal refinds (see Tab. 4 and 12).

Long term balanced distribution of the markings and refinds (with sufficient representation of the different

Tab. 12: Overview of recaptures 1965–2000 of marked animals in the area of bat marking centre Dresden after reduction of animals with multiple refinds per time interval.

species	recaptures								
	total			marked as juveniles			marked as adults		
	♀	♂	sum	♀	♂	sum	♀	♂	sum
B.BAR	309	375	684	72	67	139	237	308	545
E.NIL	669	17	686	84	2	86	585	15	600
E.SER	201	35	236	46	5	51	155	30	185
M.BEC	37	73	110	2	14	16	35	59	94
M.BRA	996	540	1,536	138	14	152	858	526	1,384
M.DAS	19	4	23	13	3	16	6	1	7
M.DAU	3,558	2,783	6,341	242	121	363	3,316	2,662	5,978
M.MYO	11,061	4,496	15,557	5,889	2,417	8,306	5,172	2,079	7,251
M.MYS	103	117	220	5	6	11	98	111	209
M.NAT	2,723	2,323	5,046	823	230	1053	1,900	2,093	3,993
N.LEI	919	95	1,014	463	35	498	456	60	516
N.NOC	3,190	727	3,917	1,639	204	1,843	1,551	523	2,074
P.ARI	3,215	1,101	4,316	1,117	503	1,620	2,098	598	2,696
P.AST	88	34	122	12	3	15	76	31	107
P.NAT	2,119	1,676	3,795	1,128	250	1378	991	1,426	2,417
P.PIP	1,977	1,730	3,707	486	722	1208	1,491	1,008	2,499
V.MUR	29	7	36	21	5	26	8	2	10
sum	**31,213**	**16,133**	**47,346**	**12,180**	**4,601**	**16,781**	**19,033**	**11,532**	**30,565**

age groups), can be expected to provide the first useful results in the sense of the goal of this chapter with refinds > 100 individuals. Sufficient data is given for 14 species of bat, in descending order: Greater mouse-eared bat, Daubenton's bat, Natterer's bat, Brown long-eared bat, Noctule, Nathusius' pipistrelle, Common pipistrelle s.l., Brandt's bat, Leisler's bat, Northern bat, Barbastelle, Whiskered bat, Serotine and Grey long-eared bat (Tab. 12). For Bechstein's bat that applies only in certain conditions (see chap. 3.3.6 and Fig. 36). For the Pond bat, Soprano pipistrelle, Parti-coloured bat and Lesser horseshoe bat no evaluations concerning survival rates or age structures on the basis of the data of the bat marking centre Dresden are possible.

3.3.5.4 Live refinds, dead refinds, final refinds

The bulk of the available data (approx. 92 %) are **recaptures** (live refinds). In each case it is almost these data exclusively which are available for an evaluation. Nevertheless live refinds have a substantial disadvantage. At marking event all animals are 100 % incorporated in the data set. How-ever in the case of the refinds in spite of all attempts no appropriate results for the animals that are still alive can be obtained. A part of the animals extracts itself for different reasons from the proof, possibly because the bats could not be found (e.g. at present not visible or in the accommodation), are in a not well known or accessible neighbouring roost, are not reproducing this year, etc. With sufficiently extensive data material, one can prove statistically that this proportion (assuming continuous ongoing studies) remains the same in subsequent years apart from migration. This is no longer applies at the end of the lifetime because there is little evidence and this therefore has very little relevance to the total result (q_y, e_x of AC_0 and/or AC_1). This has to be considered for all statements on age distribution of roost communities and/or survival rates of marked animals, which neglect the above mentioned source of error (e.g. Grimmberger & Bork 1978, Schmidt 1994b, Heise & Blohm 2003). Attemped explanation like „... Die sehr geringe Überlebensrate im 1. Jahr scheint einen hohen Anteil noch nicht einjähriger Tiere nahezulegen ..." Taake & Vierhaus 2004, p. 793) can be aroided like in case for Grimmberger & Bork (1979). The fact is that the first age group is over-represented in relation to the following age groups. As a conclusion corresponding evaluations of live refinds cannot be accomplished with conclusive resultsa before the first recapture series following the marking.

In a few cases (e.g. Schmidt 1994b – Tab. 12) the mortality rate from AC_0 to AC_1 it can be assumed that also in the AC_1 one achieved almost a 100 % recapture. In the current case this happened probably because of the complete lack of roost alternatives in middleold pine forests as well as the unusually high survival rate of animals born in 1982. Already appropriate evaluations for adults (Tab. 13) as well as juveniles of the second period no confirm this. In particular it is risky to rate the obviously deviating results for the nursery roost at Kirschweg (Tab. 14) as emigration. In this richly structured habitat naturally rich in tree hollows, an individual exchange with inhabitants of such naturaly shelters and thus a reduced recovering rate of marked animals would have to be discussed at least beginning from the first age group.

In the case that the reproductive rate and the population development of adults in nursery roost communities is sufficiently documented, the mortality rate can be indirectly determined as a substitute from AC_0 to AC_1. Thereby applying the relationship

$$\frac{N_0 n(1-q_{y0/1})}{2} + N_0\,(1\text{-}q_{x1}) = N_1$$

From which $q_{y0/1}$ can be derived:

$$q_{y0/1} = 1 - \frac{[N_1 - N_0\,(1-q_{x1})]2}{N_0 n}$$

N_1 is the population in the subsequent year and all other symbols can be found in chapter 3.3.2 and 3.3.4.

On the basis of our fictitious example in Table 10 (AC_0 is a little known size not considered here) the following computations result for different assumed reproductive rates and population trends:

reproductive rate 1.4 juv./ad. ♀	**reproductive rate 1.8 juv./ad. ♀**
declining population ($N_0 = 100$, $N_1 = 90$)	
$q_{y0/1} = 1 - \frac{(90-59.8)2}{140} = 0.569$	$q_{y0/1} = 1 - \frac{(90-59.8)2}{180} = 0.664$
stable population ($N_0 = N_1 = 100$)	
$q_{y0/1} = 1 - \frac{(100-59.8)2}{140} = 0.426$	$q_{y0/1} = 1 - \frac{(100-59.8)2}{180} = 0.553$

reproductive rate 1.4 juv./ad. ♀	**reproductive rate 1.8 juv./ad. ♀**
increasing population ($N_0 = 100$, $N_1 = 110$)	
$q_{y0/1} = 1 - \frac{(110-59.8)2}{140} = 0.283$	$q_{y0/1} = 1 - \frac{(110-59.8)2}{180} = 0.442$

All these variants are in principle conceivable under appropriate conditions. Only $q_{y0/1}$ from 0.283 appears unrealistic, as a death rate of young animals lower than the mortality of adults ($q_{y0/1} < q_{x1}$) is rarely observed in mammals. Here instead it has to be assumed that an eventual population increase took place via immigration, which in connection with continuous marking should easily be proven (increasing portion of unmarked animals or animals marked by others).

When the $q_{y0/1}$-values of Table 10 are considered, then a reproductive rate of 1.4 juvenile/adult ♀ would give evidence for a stable population ($q_{y0/1}$ of the Table = 0.442, the appropriate value = 0.426 as calculated above). A reproductive rate of 1.8 juvenile/adult ♀ would give evidence for an average annual population increase of 10 % (value of 0.442, calculated above is identical to the value in the Table). Similarly, the q_{x1}-values can be indirectly determined with appropriate models. However these values are usually among the parameters most easily determined by the marking.

Altogether the only goal for such calculations is to make the orders of magnitude (of unknown or insufficiently assignable) parameters visible. Determination limits and/or errors of the other parameters are transferred and can eventually add up or disclose themselves. In principle, settlement behaviour (see 3.3.5.6) and in particular emigrations (see 3.3.5.7) can affect the results substantially. However when applying critical evaluations such model computations can contribute considerably to the plausibility check of results and are therefore urgently recommended (if necessary also with technical support of the bat marking centre Dresden). In the following overview of results they play only a subordinated role, since the necessary population data are not available to bat marking centre Dresden.

During an appropriate evaluation of the **dead refinds** ("band recovery") this problem does not exist, since the sum of the dead refinds of a marking year (or several) forms the output over the entire lifetime. If we consider all discovery sites we then have the age group which in each case is a result of subtraction of the annual dead refinds. The following overview is given to illustrate this (Tab. 10, chapter 3.3.2.1):

year	**no of dead animals found annualy**	**dead animals total**	**age class**	**living/ survivors**
(y)	(T_y)	(T_x)	(x)	(L_x)
			0	310
1	137	137		
			1	173
2	72	209		
			2	101
3	38	247		
			3	63
4	23	270		
			4	40
5	15	285		
			5	25
6	10	295		
			6	15
7	7	302		
			7	8
8	4	306		
			8	4
9	3	309		
			9	1
10	1	310		
			10	0

The AC_0 represented thereby the middle refind rate of all dead animals and is free from the above mentioned problems between AC_0 and the following age groups with refinds of living animals. However a general problem here is that the refind rate for dead animals is very low, so that only for a few species are representative evaluations possible and/or the results can only be considered for an evaluation. Though STEFFENS et al. (1989) indicated an advantage in the coincidence distribution, we now state a bias because often an above average proportion of the dead refinds also originate from the roosts regularly recordled by bat markers.

Very often for the determination of survival rates on the basis of recaptures the animals are also taken into account which were not found in the appropriate year, but which re-appeared at least once in later years

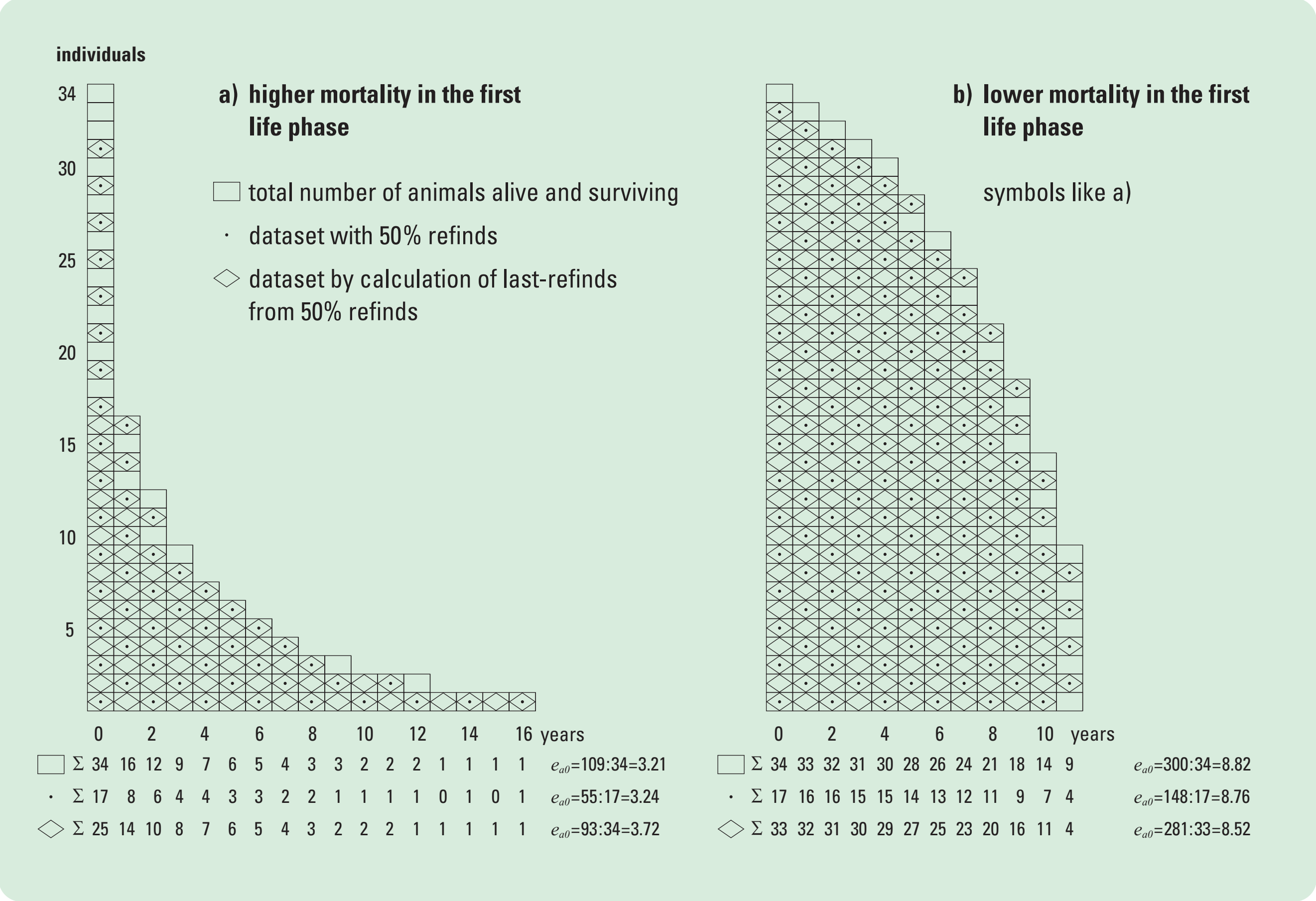

Fig. 32: Survival rates and life expectancy depending on different data collection and evaluations

(e.g. Grimmberger & Bork 1978). The procedure is called **last refind evaluation.** In the mathematical sense it functions similarly to the above mentioned evaluation of dead refind evaluation. The reason its application is plausible is because the particular animal obviously was still alive in all preceding years. In addition, one can increase thereby the degree of proof and in particular with species with reduced settlement in the first years of life (juvenile ♀♀ in nursery roosts, juvenile ♂♂ in mating roosts) a resulting improvement is obtained. The last refind evaluation also has some disadvantages in the statistical sense. Multiple live refinds can be obtained for the same animal in contrast to dead refinds. Long-living animals thereby have a higher chance of being found again, which leads to the fact that with a higher number of deaths in the first life phase (which in the case of our species is probably the normal case) too high values of life expectancy are determined and in the case of a lower number of deaths in this phase low life expectancies are calculated. The connection is schematically simplified in Fig. 32.

Similar calculation examples for the Greater mouse-eared bat ♀♀, marked as juveniles and recorded in the winter roost support the results for a) in Fig. 32:

Evaluation of all live refinds		Evaluation last refind	
1964–1977	$e_{a0.5}$ = 3.63	1964–1977	$e_{a0.5}$ = 4.30
1978–1984	$e_{a0.5}$ = 4.83	1978–1984	$e_{a0.5}$ = 5.10

Beyond that the differences between the age groups level out, as because of the above mentioned reasons animals proven to be alive during the recent year (those that constitute the difference in the following age group) have a smaller chance of detection in the respective age group than animals that still grow older (see values in each case for 1964–1977 and 1978–1984 as well as Fig. 37, p. 83). Therefore it might be more appropriate, depending on the data situation, to accept certain method dependent irregularities in the age group succession (such as that a following age group is somewhat higher in individual numbers than a preceding – logically this is impossible and for the last refind year avoidable), then to “dress up“ the results and lose the total statement. In addition for last refind evaluations the latter is not applicable for the view referring to refind years, because it concerns only partially genuine last refinds for the incomplete time series of the recent age group.

At least the problem of under-represented age groups in connection with the eventual settlement behaviour of juvenile ♀♀ and ♂♂ can be better approached in another way.

For all age groups the proven presence of the animals which were still alive in the age groups is determined. This proven presence is higher in the first age group with complete settlement in relation to the following and can therefore be used for their correction. By this approach both the long living individuals and the disappearing animals are treated equally. The difference between the two different procedures will be described and schematized again (Fig. 33). Thereby it is confirmed that the determined survival rates and the life expectancy can deviate substantially from the reality (e_{a0} 3.21 to 5.56). As a result of the consideration of last refind data a certain approximation is obtained (e_{a0} 3.21 to 4.72), but only the above mentioned correction of the under-represented first age groups with the proven presence of animals still alive in the following age class leads to satisfactory data (e_{a0} 3.21 to 3.29). Appropriate example calculations for Greater mouse-eared bat ♀♀ marked as juveniles recorded in the summer roost support the results for the approach mentioned above (see also Fig. 34).

	1964–1977 e_{al}	**1978–1984** e_{al}
all live refinds	5.91	6.69
evaluation of last finding data	4.79	5.37
live refinds AC_1 and AC_2 corrected with proven presence AC_3	4.19	4.94

This procedure can generally be applied to the examination of result differences related to heterogeneity of the data (apart from markings and refind statistics for the individual species of bats and accommodation). Nevertheless only with a sufficiently large amount of data, thus only in the younger age groups, will this lead to statistically secure results. Since these age groups have the highest influence on life expectancy this is not a serious problem. For other methods for the data adjustment see also chapter 3.3.7.1.2. Beyond that a calculation of the described relations by appropriate computer programs should be aimed at and existing programs have to be tested and adequately adapted.

3.3.5.5 Age at marking and sex of marked animals

The **marking age** has substantial influence on the efficiency of the refind evaluations. Animals marked as juveniles will most probably permit the most complete statements in respect to survival rates. With restrictions this also still applies to animals from the first year. Adults (usually of unknown age) cause some problems. Gene-

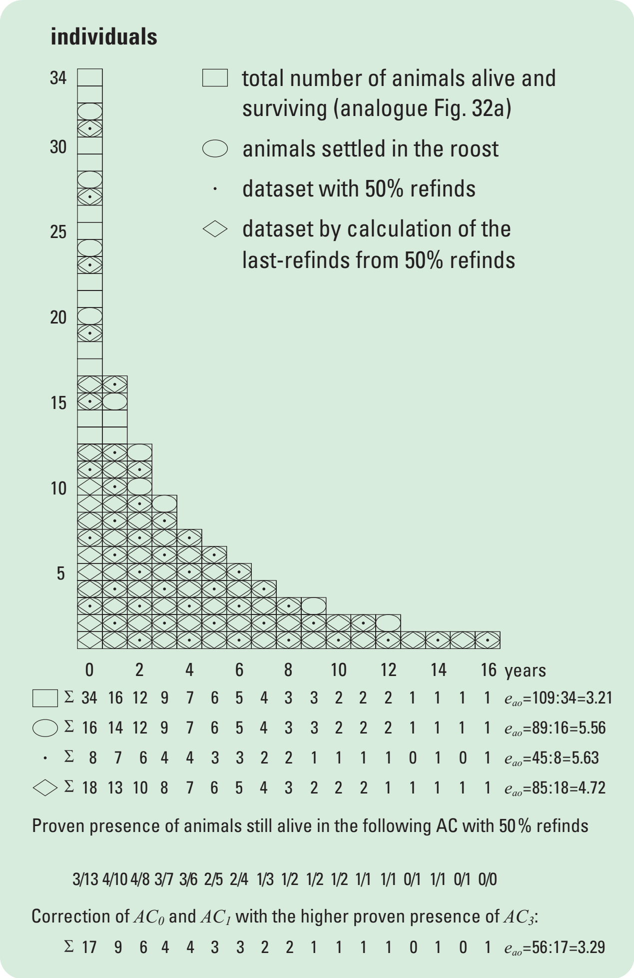

Fig. 33: Survival rates and life expectancy depending on different settlement behaviour

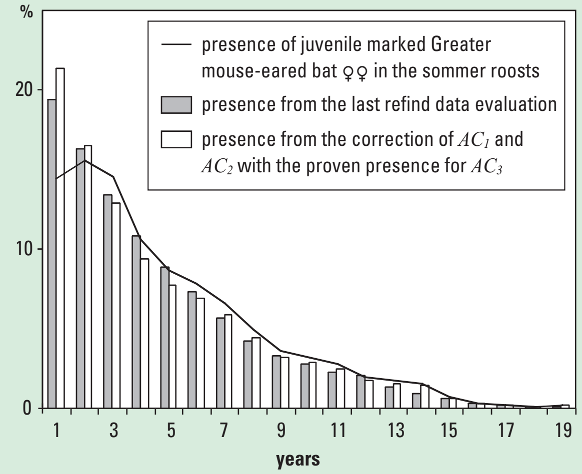

Fig. 34: Proven presence of juvenile marked Greater mouse-eared bat ♀♀ in the summer roosts for the period 1964–84 and presence from the last refind data evaluation and correction of AC_1 and AC_2 with the proven presence for AC_3

rally it can be assumed that they exhibit an age mixture at the marking time reflecting the survival rates of animals marked as juveniles. In the case of new settlements or of immigration (and not marked animals of a community recorded for a long period more or less continuously) this may also be animals born in the previous year in the sense of a first settlement (see e.g. Heise & Blohm 2003). However, somehow the high magnitude of birth place fidelity of juvenile ♀♀ contradicts this (see chapter 3.2.2.5 and Tab. 9), so that probably also in this situation an age group mixture can be assumed. No further discussion is possible in most cases. At first sight, survival rates derived from juveniles and adults exhibit often amazingly small differences. However, the mortality rates for adult marked animals in the first survival years are less differentiated and gradually approach those of juvenile marked animals. This is caused by the fact that in the first years the juvenile/adult mixture adjusts the age-dependent mortality rates to some extent, whereas later on the disparities in age becomes ever smaller. If the age group mixture for adult marked animals corresponds to the survival curve of juvenile marked animals, then for the mortality rates of both groups the relationship q_{x+1} (juv.) = q_y (ad.) exists as shown in chapter 3.3.2.1 (see also Tab. 10).

Sex-specific evaluations are necessary, because sexes are present in different proportions depending upon the type of accommodation (e.g. in nursery roosts there are predominantly adult ♀♀) and differing settlement behaviour and site fidelity, and so eventually they may exhibit different survival rates. Most important are the ♀♀ as even slight changes in their survival rates are related directly via the birth rates to the population development, while the number of necessary ♂♂ can have a larger variation.

Only in the rarest cases is the ideal dataset, ♀♀ marked as juveniles, available to a sufficient extent and in the appropriate consistency, so that eventually compromises must be made (see chapters 3.3.6 and 3.3.7).

3.3.5.6 Settlement at roosts

The settlement behavior may differ depending upon the species of bat and type of roost. Various studies (see e.g. Treß et al. 1989, Haensel 1980b, Oldenburg & Hackethal 1989a, Steffens et al. 1989) have shown that only a proportion of the first year ♀♀ (and some two and three-year old ones) are present in the nursery roost, at least toward the end of the nursery roost at the time of standard records. This is especially true for bat species in which the ♀♀ only reproduce in the second year [and to some extent those with a low percentage of reproduction in the first year and partly also those which are still low in the second and third year]. Thus the first age group (also partly the second and third age group, e.g. Steffens et al. 1989 – Fig. 3) is under-represented and if life tables are based on this it will result in mortality rates which are too low for the first and second age group (eventually also first to fourth age groups), and this will require separate interpretation (see e.g. Steffens et al. 1989, pp. 345 ff.). The problem can probably be moderated substantially for some species by additional records at the beginning of the nursery roost period (see e.g. Treß et al. 1989 for the Northern bat – something similar is assumed by specialists also to be the case for the Greater mouse-eared bat). Further solutions (last refind evaluation, correction for proven degree of animals found in the following age groups) were already considered in chapter 3.3.5.4.

3.3.5.7 Site fidelity and roost interrelations

A further problem related to the evaluation of recapture data results from the fact that the site fidelity is never 100 %. The dynamics of the population are caused by reproductive and mortality rate as well as immigration and emigration. If one wants to determine a factor from refind data, in our example the survival rate (mortality rate, life expectancy), the remaining parameters must be kept constant or their actual value or trend must be known. When age groups in the life tables are discussed the reproductive rate is not considered (and in the normal population reproductive rate = mortality rate). In the same way the immigration is not considered as the immigrating animals, as far as they are unmarked, are not part of our sample (marked animals of an appropriate ringing year); if they are marked, the allocation is possible without problems. A subject which is almost unanswered is the question of emigrating marked animals, whose proportion might be larger, at least related to the marking place than the immigration of marked animals. This is due to the fact that the proportion of marked animals (in a homogeneous roost) decreases rapidly with increasing distance. This problem can only be tackled with difficulty. A possibility would be to assume that emigration is identical to immigration for a stable population (Heise 1989). In this case it would be possible to add non-marked adult animals found with the record animals to the following age-classes as equivalent to the emigrants. If one assumes for example that this portion would be on average 10 % in the period of interest, this would reduce the age-specific mortality rate in each case by 0.1. From this the following conditions would result for our fictious example from Tab. 10:

x	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
L_x *old*	310	173	101	63	40	25	15	8	4	1		$q_{x0} = 0.419,\ e_a = 2.38$
L_x *new*	310	204	139	101	74	54	38	24	14	5	1	$q_{x0} = 0.322,\ e_a = 3.11$

The absolute difference in q_x- and e_{ax}-values depends therefore on the specific life span, apart from the emigration rate.

The calculation of any parameter from non-marked animals has to be judged critically. Only in a few cases will it be possible to mark all animals at a certain roost. In addition to the workload of marking in theory all animals, a proportion of the animals will not be available for access, because at the time of the marking they may be at an (unknown) alternative roost. This proportion can be substantially reduced however with systematic work over many years (see e.g. Heise & Blohm 2003). Schmidt (1994b) expresses doubts, assuming that in time of growth of a population the number of immigrants is greater than the number of animals leaving, while with further growth of the colony due to birth rate > mortality rate the population surplus causes increasing emigration because of “capacity reasons”. Schmidt therefore sets the proportion of juvenile marked animals (Nathusius' pipistrelle ♀♀), that settles at the place of birth in relation to the average survival rate from the time of the increase in population and tries to determine from this the proportion of the emigrants (Schmidt 1994b, Tab. 21, p. 138). The same result is obtained by simply setting the refind rate at the place of birth in the first settlement phase in relation to the refind rate in the second settlement phase and calculating the difference (e.g. on the basis of Tab. 21, 1st and 2nd column in Schmidt 1994b). However, in this way the proportion of emigrants is not obtained, but rather it is shown that its proportion is higher in the second phase than in the first, because it has clearly been demonstrated that in the first phase emigration also occurs (Tab. 22, p. 139 in Schmidt (1994b). Nevertheless the relative statement for the proportion of emigrants applies only if, in the reference time area, the mortality rate and the proven degree of marked animals did not change, as in such a situation we would have a circular argument.

The influence of emigration thus remains a difficult topic and requires further consideration and investigation. In addition, it can be limited in certain cases from the beginning as refind evaluation of marked animals in nursery roosts and in winter accommodation can be less problematic. Only a relatively small proportion of mark-ed animals from nursery roost(s) are found in winter accommodation at a greater distance from the nursery roost(s) in which marking occurs, because these distribute themselves at several winter roosts. As far as these winter roosts communicate with each other, both immigrating and emigrating animals can be mark-ed in comparable order of magnitude. In this case the problem of the emigration of marked animals is no longer relevant or strongly diminished. Except for the Greater mouse-eared bat, our data base is still insufficient in order to make such nursery roosts and winter roost interrelations usable. However, donor (marking location) and receiver (refind location) relations between homogeneous (e.g. nursery roosts) and different (e.g. nursery roosts – winter roosts) accommodations are objects for further interesting explanations, not only concerning local changes, but also regarding the “internal” system of the population. Such evaluations must usually remain restricted to regional evaluations. In this connection and with reference to site fidelity however, these evaluations are relevant to the strange “survival rate” of juvenile marked Greater mouse-eared bat ♀♀ in the winter roosts and recaptured in the summer roost (Fig. 35). Apart from the settlement behaviour of juvenile ♀♀ in the summer roosts (see chapter 3.3.5.4), this also results from the fact that in the winter accommodation only those ♀♀ born in this year can be marked which were not already marked in the nursery roost.

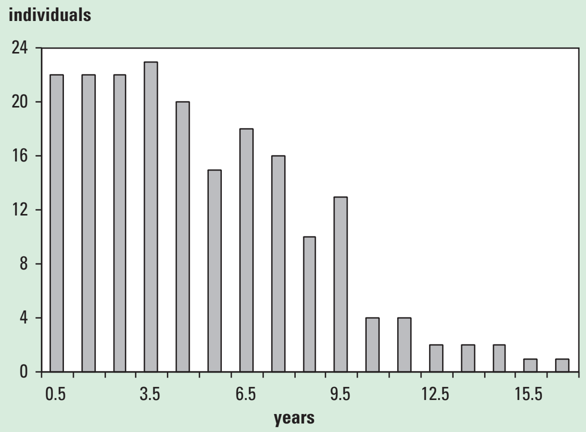

Fig. 35: Frequency of refinds in summer roosts for juvenile marked Greater mouse-eared bats ♀♀ dependent on age for the years 1965–84

An appropriate proportion originates from non-recorded nursery roosts and therefore cannot be regained in recorded nursery roosts. Later a small percentage is found, which, if new accommodations were not taken into record, can only be explained by assuming shift from unrecorded into recorded summer roosts. Comparing the age distribution from Fig. 35 with the refind rates for juvenile marked ♀♀ in the summer accommodation (Fig. 34), then another approach for the determination of the proportion of genuine immigration and emigration is available. On this basis changes in the proportion of marked animals not previously refound can also generally be evaluated in well documented, nursery roosts and winter roosts which communicate with each other. With such investigations and appropriate mathematical relations (models) we will have to employ ourselves more strongly in the future in order to explain and evaluate the condition and dynamics of bat roost communities.

3.3.6 Overview of results

According to Tab. 10 and the given methodical explanations, as well as considering the specific conditions for bat refinds, the survival curves for 15 bat species are determined (Fig. 36). At the same time the values for life expectancy (e_{ax}) are indicated and the life expectancy of the normal population (e_{an}) is compared on the basis of the reproductive rate. The data situation required to proceed differentiated the following:

- Only for Greater mouse-eared bat was the most preferable situation (juveniles marked in the summer roosts; recapture data for winter roost, evaluation separated by sex) given.

- For Brown long-eared bat, Leisler's bat, Nathusius' pipistrelle, Noctule and Common pipistrelle s. l. it was possible to restrict the evaluation to animals of an exact age (juvenile marked).

- For Natterer's bat and Daubenton's bat data were only available in sufficient numbers for adult marked animals (usually ♀♀ and ♂♂) in winter roosts. For Brandt's bat only adult ♂♂ in winter roosts were sufficiently represented.

- All other species could only be evaluated by using all data independent from the age at marking or type of roost.

- For Serotine, Northern bat and Leisler's bat because of settlement behavior and for Bechstein's bat because of the low number of refind data it was neccessary to use the last refind data and adapt the refind data.

Nevertheless this overview shows a first and predominantly meaningful rank of species depending on specific life span and specific life phases with appropriate reproduction and mortality rates. Species related single results and explanations, and foreseeable trends resulting from the evaluable results of the past approximately 35 years will be discussed separately. To the overview presented here some fundamental remarks have to be added:

Row 1 of Fig. 36 shows data for Brandt's bat, Serotine and Greater mouse-eared bat. Current knowledge suggests that these species predominantly give birth in the second year. The remarkably high life expectancy of adult marked Brandt's bat ♂♂ in the winter roost ($e_{a\,1.5m}$ = 6.4 years) is far higher than the life expectancy of the normal population (e_{an} = 3.7–4.8), although in the main recorded winter roost no general population increase can be registered (see Zöphel & Schober 1999). However, the life expectancy of ♂♂ has only limited influence on the population development and for ♀♀ values are much lower (see chapter 3.3.7.8.1).

For juvenile marked Greater mouse-eared bat ♀♀ which are recorded in the winter roosts, $e_{a0.5} > e_{an}$ is realistic due to the positive population trend since the end of the 1970s, which is when most of the data collection began. This is particularly the case since the refind evaluation in winter roosts includes a certain portion of the youth mortality in the winter roost (starting from age 0.5). This can be even higher in the second half of the year after juveniles become independent when results of the mortality evaluation are considered as compared with the first half of the year (possibly because of special physiological demands toward the end of the winter hibernation).

In row 2 and 3 of Fig. 36 species can be found that usually already begin to give birth to predominantly one (up to two) young in the first year. The allocation and the sequence of the individual species however are not yet final. For the Northern bat the data are unbalanced due to collection difficulties, and the first refind age group seems to be under-represented. The last refind data could not fully adjust for this. It is possible that the species should be located further down, and there is a further suggestion for this from partly two juveniles (Treß et al. 1989). However, with correction of the first refind AC by means of collection degree reconciliation invariably high e_{a2m} values (4.1) are reached and there are also refinds of up to 22 years of age. However, it has to be considered that the data documentation starts in 1978 for the Northern bat, thus at a time of general population increase with generally higher e_a values.

The Brown long-eared bat should be placed according to e_{an} together with Greater mouse-eared bat. The actual determined values for life expectancy (e_{a1}) are, however, lower and even lower than those of the Northern bat. In addition e_{an} = 3.7 is derived only from the reproduction results of one area although they were very accurately determined (v. Riesen & Dolch 2003)*. Nevertheless e_{an} can be lower or higher at other locations. Altogether it is however estimated that the Brown long-eared bat is probably in the correct place, which is supported by the values of the maximum age. This is more open for Leisler's bat. In the case of correction of the first refind AC by correction with proven presence for next AC a value for e_{a1} = 3.3 still results. Considering the reproductive rate of 1.1 juvenile/adult ♀ (Schorcht 1998) as well as the maximum age determined so far, the species had to be located further down. However, the higher age groups are judged by the survival curve to be not yet completely represented.

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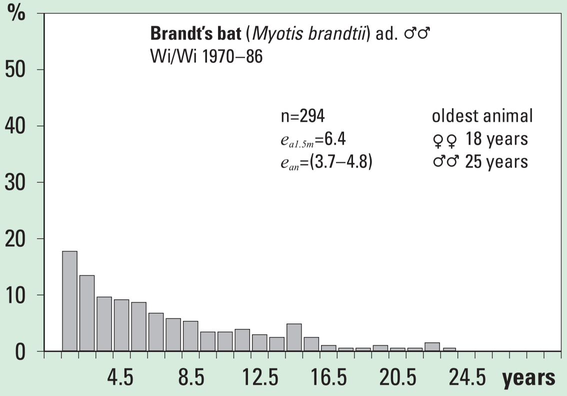
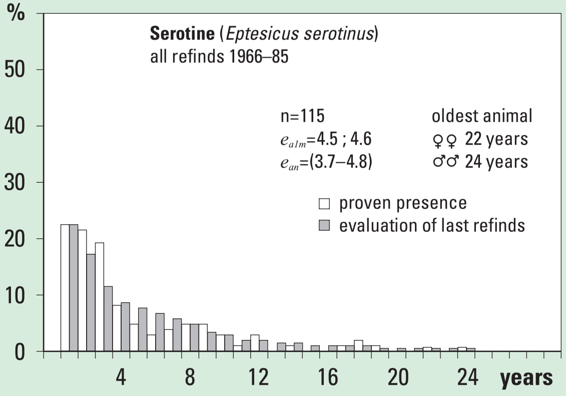
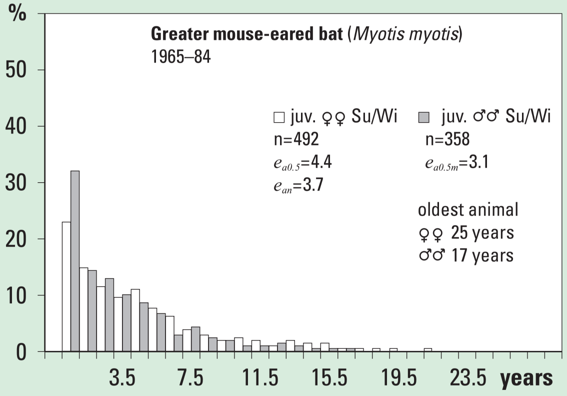
* Already at this stage in addition to the excellent studies of HAENSEL (2003), HEISE & BLOHM (2003) and V. RIESEN & DOLCH (2003), SCHMIDT (1994b) and SCHORCHT (1998) there is a high need of additional results for other areas and species for the assessment of population status of the different species.



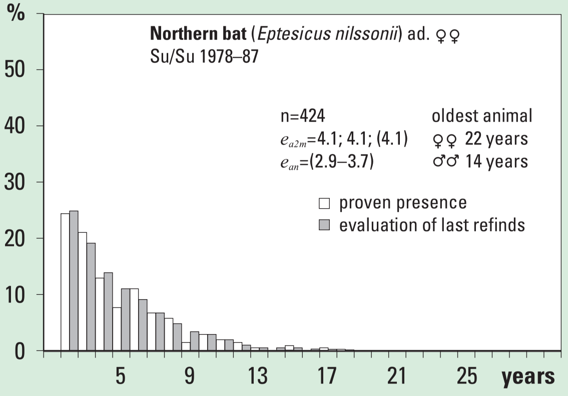
Brandt's bat (*Myotis brandtii*) ad. ♂♂
Wi/Wi 1970–86
n=294
$e_{a1.5m}$=6.4
e_{an}=(3.7–4.8)
oldest animal
♀♀ 18 years
♂♂ 25 years
%
50
40
30
20
10
0
4.5
8.5
12.5
16.5
20.5
24.5
years



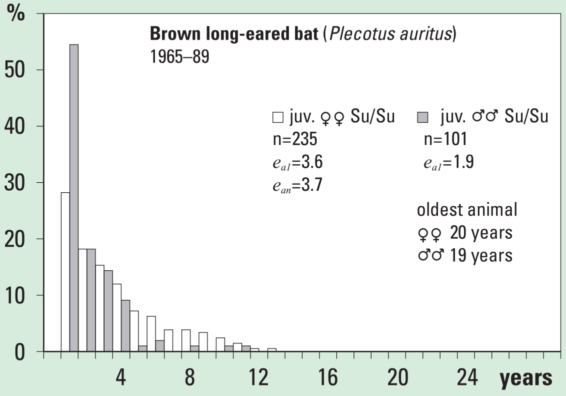
Serotine (*Eptesicus serotinus*)
all refinds 1966–85
n=115
e_{a1m}=4.5 ; 4.6
e_{an}=(3.7–4.8)
oldest animal
♀♀ 22 years
♂♂ 24 years
☐ proven presence
▨ evaluation of last refinds
%
50
40
30
20
10
0
4
8
12
16
20
24
years



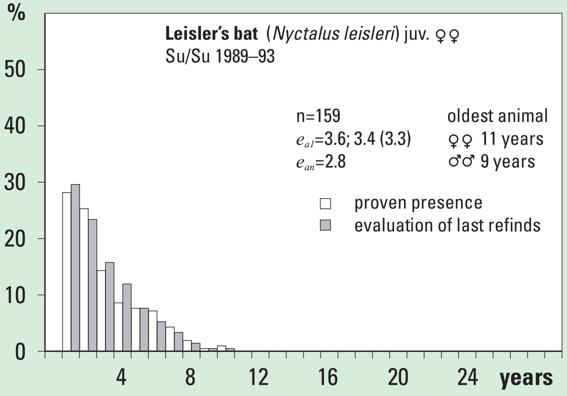
Greater mouse-eared bat (*Myotis myotis*)
1965–84
☐ juv. ♀♀ Su/Wi
n=492
$e_{a0.5}$=4.4
e_{an}=3.7
▨ juv. ♂♂ Su/Wi
n=358
$e_{a0.5m}$=3.1
oldest animal
♀♀ 25 years
♂♂ 17 years
%
50
40
30
20
10
0
3.5
7.5
11.5
15.5
19.5
23.5
years



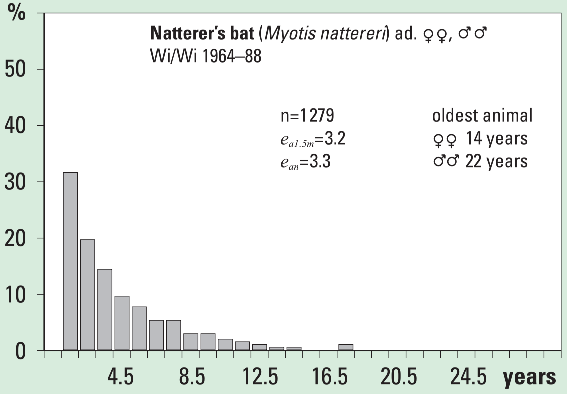
Northern bat (*Eptesicus nilssonii*) ad. ♀♀
Su/Su 1978–87
n=424
e_{a2m}=4.1; 4.1; (4.1)
e_{an}=(2.9–3.7)
oldest animal
♀♀ 22 years
♂♂ 14 years
☐ proven presence
▨ evaluation of last refinds
%
50
40
30
20
10
0
5
9
13
17
21
25
years



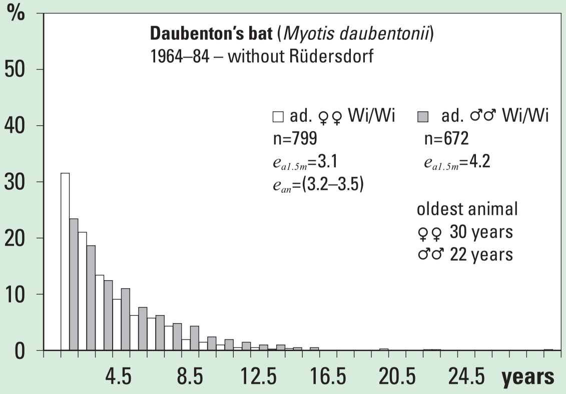
Brown long-eared bat (*Plecotus auritus*)
1965–89
☐ juv. ♀♀ Su/Su
n=235
e_{a1}=3.6
e_{an}=3.7
▨ juv. ♂♂ Su/Su
n=101
e_{a1}=1.9
oldest animal
♀♀ 20 years
♂♂ 19 years
%
50
40
30
20
10
0
4
8
12
16
20
24
years



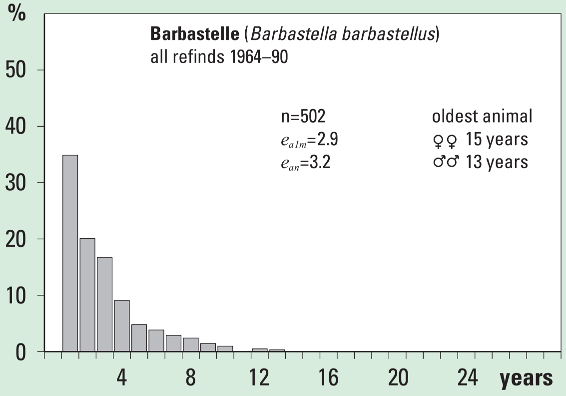
Leisler's bat (*Nyctalus leisleri*) juv. ♀♀
Su/Su 1989–93
n=159
e_{a1}=3.6; 3.4 (3.3)
e_{an}=2.8
oldest animal
♀♀ 11 years
♂♂ 9 years
☐ proven presence
▨ evaluation of last refinds
%
50
40
30
20
10
0
4
8
12
16
20
24
years



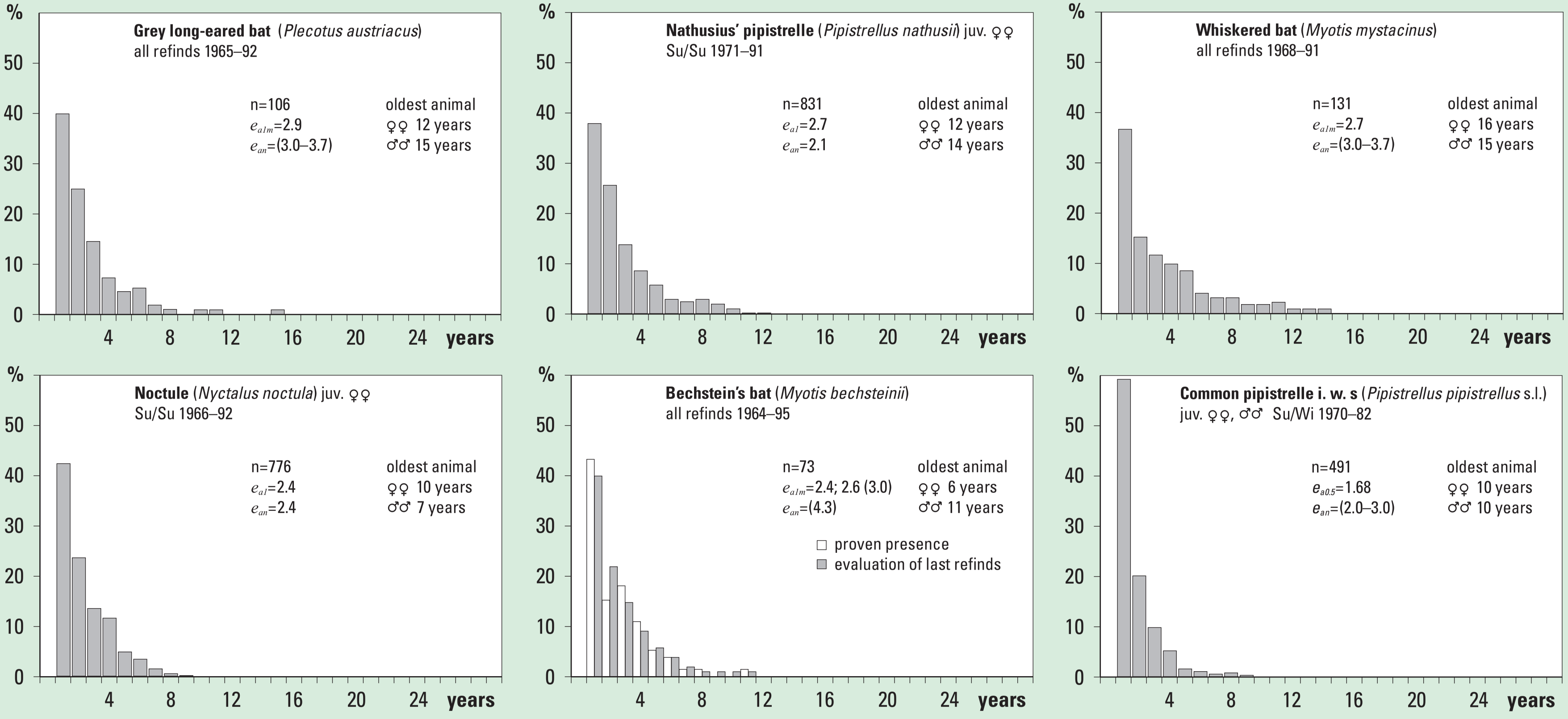
Natterer's bat (*Myotis nattereri*) ad. ♀♀, ♂♂
Wi/Wi 1964–88
n=1279
$e_{a1.5m}$=3.2
e_{an}=3.3
oldest animal
♀♀ 14 years
♂♂ 22 years
%
50
40
30
20
10
0
4.5
8.5
12.5
16.5
20.5
24.5
years



Daubenton's bat (*Myotis daubentonii*)
1964–84 – without Rüdersdorf
☐ ad. ♀♀ Wi/Wi
n=799
$e_{a1.5m}$=3.1
e_{an}=(3.2–3.5)
▨ ad. ♂♂ Wi/Wi
n=672
$e_{a1.5m}$=4.2
oldest animal
♀♀ 30 years
♂♂ 22 years
%
50
40
30
20
10
0
4.5
8.5
12.5
16.5
20.5
24.5
years



Barbastelle (*Barbastella barbastellus*)
all refinds 1964–90
n=502
e_{a1m}=2.9
e_{an}=3.2
oldest animal
♀♀ 15 years
♂♂ 13 years
%
50
40
30
20
10
0
4
8
12
16
20
24
years



Legend

Wi/Wi	recorded and marked in the winter roost
Su/Su	recorded and marked in the summer roost
Su/Wi	marked in the summer roost and recorded in the winter roost
$e_{a0.5/1}$ $e_{a1m/1.5m/2m}$	life expectancy according to calculation method a (chapter 3.3.2.2) for the age 0.5, 1 years respectively minimum age 1m, 1.5m, 2m ages. 1st value= real refind value, 2nd value = last refind data evaluation, value in parenthesis = with adaption of refind data (chap. 3.3.5.4)
e_{an}	Life expectancy according to calculation method a (chap. 3.2.2.2), for the normal population on the basis of the growth rate for age 0 (juvenile at the age of independency). Values without parenthesis = special values for the year of first reproduction of ♀♀ and number of juvenile/adult ♀ in the area of bat marking centre Dresden. Values in parenthesis = literature data used

Fig. 36: *Survival curves of bat species and corresponding ranking of species depending on life expectancy based on marking year evaluations of recapture data of bat marking centre Dresden for the whole life period and additional features for the species*

Natterer's bat, Daubenton's bat and Barbastelle appear again to be as well located. For all three species (for Daubenton's bat only for ♀♀) e_{a1m} resp. $e_{a1.5m} < e_{an}$, which formally would be a hint to population decrease. Both indices are, however, as already mentioned several times, not as accurately determinable and the basic conditions, to which they are connected, are not directly comparable. In particular for Natterer's bat and Daubenton's bat a certain proportion of shift to other roosts also has to be assumed predominantly because of the fact that marking and record is taking place in the same accommodation. As this might follow a square function (e^{xt}) over time, this factor is, apart from the data quantity, also contributing to the curve shape that is close to a function $1/e^{xt}$ for Natterer's bat and Daubenton's bat. Beyond that a large quantity of data can also show very rare extreme values for survival curves, like the incidence of the refind in the winter roost of a marked and recorded Daubenton's bat ♀♀ after 29 years (minimum age 30 years) (J. Haensel, U. Dingeldey).

Row 4 also still has a transitional character, but at the beginning we find with Nathusius' pipistrelle a species that clearly belongs to the 3rd group (sexually mature in the 1st year and more or less regularly gives birth to 2 young). Their classification at this position has several reasons. On the one hand, the species clearly seems to profit from currently increased favourable environmental conditions with above average life expectancy and above average reprodutive rate (see chapters 3.3.2.2 and 3.3.7.6) and thus $e_{a1} > e_{an}$ and there is a population increase (see e.g. Schmidt 2000a). On the other hand, the classification of Whiskered bat needs discussion. For this species the data available are not sufficient. A further increase in data for the survival curves will possibly lead to a classification before Nathusius' pipistrelle. There are already indications for this even with a much smaller database and there are single refinds in the 15th/16th year of age. However, in particular the birth rate of the *Myotis*-species (1 young/adult ♀) and thus the relationship of the e_{a1m} values to those e_{an} suggest such a change of the sequence. However at present no special data for e_{an} are available.

Row 5 is actually reserved for the species with sexual maturity in the 1st year and more or less regular birth of 2 young. In addition to Noctule and Common pipistrelle s.l., Nathusius' pipistrelle is part of this group, as previously mentioned. However, Bechstein's bat is obviously in the wrong place, and a value of e_{a1m} of 2.4 (actual proofs) and 2.6 (last refinds) cannot mislead. Only a correction of the results from first to fourth refind AC with the proven presence for AC_4 leads to $e_{a1m} = 3.0$ values, which approximate those of *Myotis* species. Altogether the amount of available data is still much too small for Bechstein's bat, which also applies to the data on maximum age. A maximum age of 21 years (Henze 1979) is worth mentioning as well as a reproductive rate of 0.61 (0.29–0.78) juvenile/adult ♀ ($n = 122$) (Kerth 1998), which is still below that of the Greater mouse-eared bat. Both results originate from South Germany and do not have to apply to our area. However it becomes evident at which orders of magnitude the results can still change for Bechstein's bat.

In the last position the Common pipistrelle s.l. can be found. The values for life expectancy ($e_{a0.5} = 1.68$) are by far the lowest and can be attributed on the one hand to the acquisition period (the unfavourable 1970s) and on the other hand to collection problems (see chapter 3.3.7.7.4). In principle the species probably stands in the correct place.

For some species, as shown for Greater mouse-eared bat, Brown long-eared bat and Daubenton's bat (Fig. 36), more or less clearly deviating survival curves between ♀♀ and ♂♂ are obtained. The causes for this can be different. For the Greater mouse-eared bat the assumption can be made that it actually concerns different survival rates, as on the one hand there are methodical advantages of the summer/winter evaluation, and on the other hand, because this difference was probably connected with certain environmental conditions and increasingly starts to disappear (see chapter 3.3.7.1). For the Brown long-eared bat it is probably primarily a problem of refinding. Juvenile ♂♂ have in the beginning a stronger connection to their birth district and the appropriate nursery roost, which later however more or less dissolves and so leads to less refinds (see also v. Riesen & Dolch 2003). Contrary to this Grimmberger & Bork (1979) as well as Steffens et al. (1989) could show a smaller site fidelity for ♀♀ as the reason for apparently lower survival rates of Common pipistrelle s.l. ♀♀ and this can also be seen in Tab. 8 and Fig. 10. However for similar roosts, comparisons with Greater mouse-eared bat and Daubenton's bat show that this does not apply and this should lead to opposite results for the Greater mouse-eared bat (higher site fidelity of juvenile ♂♂ in the winter roost – see Tab.8).

3.3.7 Species specific results

The following presentations are substantially shaped by the available data. The sequence of the species follows the amount of available data (see chapter 3.3.5.2 and Tab. 12).

3.3.7.1 Greater mouse-eared bat (*Myotis myotis*)

3.3.7.1.1 Status of available data

With 15,557 recaptures for these chapters the Greater mouse-eared bat is the best documented bat species in the data set of bat marking centre Dresden. Daubenton's bat follows clearly at some distance (6,341 live refinds). In particular the high proportion of juvenile marked animals within the recaptures (8,306) has to be emphasized, and the difference to the next species (Noctule – 1,843 recaptures) is even bigger (see Tab. 12). Also concerning the dead refinds (245) the Greater mouse-eared bat is in the first place. The difference to the next species (Common pipistrelle s. l. – 223 dead refinds) is only small, but with juvenile marked animals again the difference is more clear (133 to 71). Furthermore, it is outstanding that for the Greater mouse-eared bat for the entire period complete data sets (e.g. J. Haensel since 1966, W. Oldenburg since 1975, G. Heise since 1979, W. Schober since 1984) are present. Therefore the most comprehensive evaluations are possible on the basis of the data for the Greater mouse-eared bat. Only for this species does the particularly favorable registering of juveniles marked in the summer roost, and the recording of marked animals in the winter roosts, provide sufficient data which permits the determination of survival rates (see chapter 3.3.5.7). Therefore for the explanation of methodical aspects in chapter 3.3.5 the examples often used data from the Greater mouse-eared bat. For the same reason in the following presentations more space is also dedicated to this species.

3.3.7.1.2 Life tables and survival curves

In Tab. 13–15 life tables for juvenile marked Greater mouse-eared bat ♀♀ and ♂♂, in the winter roost are presented for selected periods and evaluation methods according to chapter 3.3.2.1 (Tab. 10 – in part shortened). From this and in connection with Fig. 37 the following general conclusions can be derived:

1. In connection with chapter 3.3.5.4 the statement made there that the last refind evaluation emphasizes too strongly the age group specific differences (the age-dependent mortality rate) is supported (see Tab. 13 and 14 as well as in particular Fig. 37a).

2. If constant age-dependent mortality rates are calculated (second part of the life Tab. 13–15), e.g. by graphic reconciliation of appropriate curve sections in Fig. 37, then the following succession applies for all three examples:
   - high number of deaths of age group 0.5 to age group 1.5
   - smaller number of deaths for the next 2–3 age group intervals
   - higher number of deaths for further 4–5 age group intervals

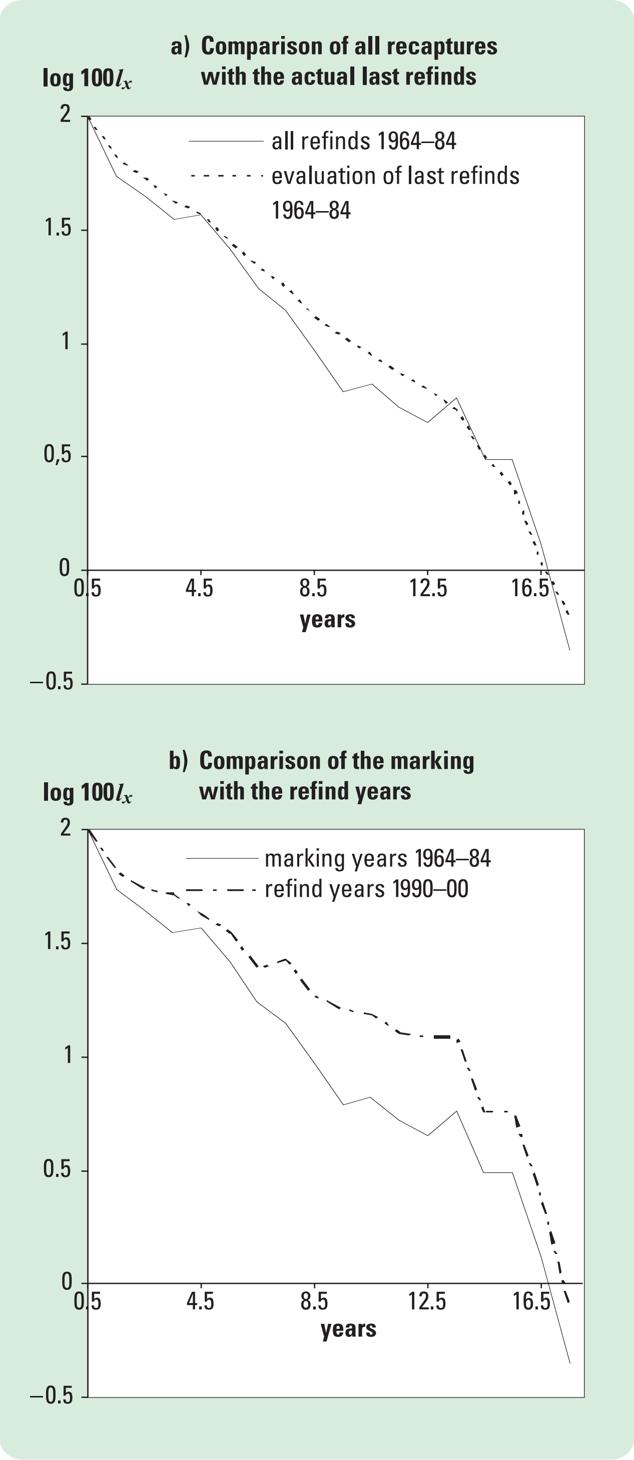


Fig. 37: Survival curves of juvenile marked Greater mouse-eared bat ♀♀ and ♂♂, recaptures in winter roosts (survivors in logarithmic scale)

- smaller number of deaths for the next 4–5 age group interval
- high number of deaths up to the end of the lifetime, with possibly a repeated flattening for a few exceptional features (Tab. 13–15 $AC_{17.5-21.5}$). However there are too few data available and therefore this is omitted in Fig. 37.

This agrees, as already mentioned in chapter 3.3.2.1, amazingly well with appropriate data of Taber & Dasmann (1957) for the Black-tailed deer (*Odocoileus hemionus*) (quoted in Odum 1983), so that a certain ability for generalizations can be assumed for long-lived mammals and thus also for other species of bat.

Tab. 13: Life table for juvenile marked Greater mouse-eared bat ♀♀ and ♂♂, recaptures in winter roosts (from an age of 0.5 years, marking years 1964–1984, all recaptures

age	real values					adjusted values for pooled age classes			
age (x)	**number of recaptures** (L_x)	**percentage ♀♀**	**age specific mortality *rate*** (q_y)	**mortality expectation rate** (q_x)	**life expectancy** (e_{ax})	**age specific mortality rate** (q_y)	**mortality expectation rate** (q_x)	**life expectancy** (e_{ax})	**number of animals** (L_x)
0.5	226	0.50		26.6	3.76		25.8	3.88	226
			45.6			45.6			
1.5	123	0.59		19.7	5.07		18.9	5.29	123
			17.9			11.9			
2.5	101	0.54		20.2	4.96		20.5	4.88	108
			20.8			11.9			
3.5	80	0.56		20.0	5.00		22.7	4.41	95
			(–5.0)*			11.9			
4.5	84	0.63		26.2	3.81		25.9	3.86	84
			29.8			29.9			
5.5	59	0.61		25.0	4.00		24.6	4.07	59
			33.9			29.9			
6.5	39	0.74		22.0	4.54		22.6	4.42	41
			17.9			29.9			
7.5	32	0.53		23.2	4.31		20.7	4.84	29
			34.4			29.9			
8.5	21	0.62		19.8	5.05		18.0	5.57	20
			33.3			29.9			
9.5	14	0.57		16.5	6.07		15.3	6.52	14
			(–7.1)*			2.3			
10.5	15	0.73		21.1	4.73		18.1	5.52	14
			20.8			2.3			
11.5	12	0.75		21.4	4.67		22.1	4.52	14
			16.7			2.3			
12.5	10	0.50		22.7	4.40		26.4	3.79	13
			(–30.0)*			2.3			
13.5	13	0.69		38.2	2.62		35.8	2.79	13
			46.2			26.7			
14.5	7	0.86		33.3	3.00		42.9	2.33	10
			0.0			26.7			
15.5	7	0.86		50.0	2.00		52.6	1.90	7
			57.1			62.2			
16.5	3	0.67		42.9	2.33		47.6	2.10	3
			66.7			62.2			
17.5	1	1.00		25.0	4.00		30.3	3.30	1
			0.0			20.6			
18.5	1	1.00		33.3	3.00		34.7	2.88	0.8
			0.0			20.6			
19.5	1	1.00		50.0	2.00		40.0	2.50	0.6
			100.0			20.6			
20.5	0						55.6	1.80	0.5
			(–100.0)*			20.6			
21.5	1	1.00		100.0	1.00		100.0	1.00	0.4
			100.0			100.0			
22.5	0								0

* Values in parenthesis are due to big variations within the observation period or low number of values at the end of the life time which are unrealistic

3. The survival curves for the reference time areas 1964–1984 and 1990–2000 differ clearly (Tab. 13 and 15 in connection with Fig. 37b). The reason for this is a low mortality rate in half of the lifetime and thus altogether a higher life expectancy for the period 1990–2000. For the lower course of the curve the results adapt themselves, as due to methodical reasons they are based on identical data (see chapter 3.3.5.2).

4. In Tab. 13 and 14 the ♀♀ proportion in the $AC_{0.5}$ first amounts to 50 % and then increases, probably because ♂♂ have a smaller life expectancy. In Tab.15 the ♀♀ proportion for instance remains constant until

Tab. 14: Life table for juvenile marked Greater mouse-eared bat ♀♀ and ♂♂, recaptures in winter roosts (from an age of 0.5 years), marking years 1964–1984, using the last refind method

age	**real values**					**adjusted values for pooled age classes**			
	number of recaptures*	**percentage ♀♀**	**age specific mortality *rate***	**mortality expectation rate**	**life expec-tancy**	**age specific mortality rate**	**mortality expectation rate**	**life expectancy**	**number of animals**
(x)	(L_x)		(q_y)	(q_x)	(e_{ax})	(q_y)	(q_x)	(e_{ax})	(L_x)
0.5	471	0.52	33.5	23.3	4.29	33.5	23.1	4.32	471
1.5	313	0.54	18.5	20.2	4.96	17.3	20.0	5.00	313
2.5	255	0.55	20.8	20.6	4.85	17.3	20.7	4.83	259
3.5	202	0.58	12.4	20.5	4.87	17.3	21.6	4.64	214
4.5	177	0.59	25.4	22.7	4.41	23.1	22.7	4.40	177
5.5	132	0.61	21.2	21.8	4.58	23.1	22.6	4.42	136
6.5	104	0.63	20.2	22.0	4.54	23.1	22.6	4.43	105
7.5	83	0.61	25.3	22.6	4.43	23.1	22,5	4.44	81
8.5	62	0.66	17.7	21.7	4.60	17.3	22.2	4.50	62
9.5	51	0.69	17.6	22.9	4.37	17.3	23.5	4.25	51
10.5	42	0.74	16.7	24.4	4.10	17.3	25.3	3.95	42
11.5	35	0.74	14.3	27.0	3.71	17.3	28.2	3.54	35
12.5	30	0.77	20.0	31.5	3.17	17.3	32.6	3.07	29
13.5	24	0.83	37.5	36.9	2.71	40.5	40.0	2.50	24
14.5	15	0.87	26.7	36.6	2.73	40.5	38.9	2.57	14
15.5	11	0.82	54.5	42.4	2.36	40.5	36.4	2.75	8
16.5	5	0.80	40.0	33.3	3.00	40.5	35.7	2.80	5
17.5	3	1.00	0.0	30.0	3.33	24.0	33.3	3.00	3
18.5	3	1.00	33.3	42.9	2.33	24.0	33.0	3.00	2
19.5	2	1.00	50.0	50.0	2.00	24.0	50.0	2.00	2
20.5	1	1.00	0.0	50.0	2.00	24.0	50.0	2.00	1
21.5	1	1.00	100.00	100.00	1.00	100.0	100.0	1.00	1
22.5	0								0

* calculated from the last refinds

$AC_{7.5}$, as in this situation the life expectancy for ♂♂ obviously became identical to those for ♀♀. The differences in the following age groups are shaped again by increasingly identical data (see 3.) apart from irregularities in the $AC_{12.5}$ and $AC_{13.5}$ caused by the methodology.

Additional information to trends and reasons are part of the following chapters.

Tab. 15: Life table for juvenile marked Greater mouse-eared bat ♀♀ and ♂♂, recaptures in winter roosts (from an age of 0.5 years), marking years 1964–1984, all recaptures

age	**real values**					**adjusted values for pooled age classes**			
age (x)	**number of recaptures*** (L_x)	**percentage ♀♀**	**age specific mortality *rate*** (q_y)	**mortality expectation rate** (q_x)	**life expec-tancy** (e_{ax})	**age specific mortality rate** (q_y)	**mortality expectation rate** (q_x)	**life expectancy** (e_{ax})	**number of animals** (L_x)
0.5	123	0.50	33.3	19.7	5.08	33.3	19.3	5.18	123
1.5	82	0.50	18.3	16.3	6.12	11.0	15.9	6.27	82
2.5	67	0.55	3.0	15.9	6.29	11.0	16.9	5.92	73
3.5	65	0.45	20.0	18.4	5.43	18.8	18.1	5.53	65
4.5	52	0.48	15.4	18.1	5.53	18.8	18.0	5.55	53
5.5	44	0.45	31.8	18.7	5.36	18.8	17.8	5.61	43
6.5	30	0.57	(–10.0)**	15.6	6.40	18.8	17.6	5.67	35
7.5	33	0.45	30.3	20.4	49.1	18.8	17.2	5.83	28
8.5	23	0.61	13.0	17.8	5.61	8.2	17.0	5.88	23
9.5	20	0.50	5.0	18.9	5.30	8.2	18.7	5.34	21
10.5	19	0.68	15.8	22.1	4.53	8.2	20.8	4.81	19
11.5	16	0.63	6.3	23.7	4.19	8.2	24.9	4.02	18
12.5	15	0.33	0.0	29.4	3.40	8.2	29.5	3.39	16
13.5	15	0.47	53.3	41.7	2.40	31.7	39.2	2.25	15
14.5	7	0.57	0.0	33.3	3.00	31.7	42.9	2.33	10
15.5	7	0.86	57.1	50.5	2.00	62.2	52.6	1.90	7
16.5	3	0.67	66.7	42.9	2.33	62.2	47.6	2.10	3
17.5	1	1.00	0.0	15.0	4.00	20.6	30.3	3.30	1
18.5	1	1.00	0.0	33.3	3.00	20.6	34.7	2.88	0.8
19.5	1	1.00	100.0	50.0	2.00	20.6	40.0	2.50	0.6
20.5	0		(–100.0)**			20.6	55.6	1.80	0.5
21.5	1	1.00	100.0	100.00	1.00	100.0	100.0	1.00	0.4
22.5	0								0.0

* results are biased for the marking intensity (sum of refinds), number of refinds clearly higher (age 0.5 = 316, age 0.5 – 21.5 = 1,080)

** Values in parenthesis are due to big variations within the observation period or low number of values at the end of the life time which are unrealistic

3.3.7.1.3 Trends of population parameters and populations

The **life expectancy** of Greater mouse-eared bat roost communities was evaluated depending on age at marking, sex and reference period (Tab. 16) and the following statements can be made:

a) In the case of juvenile marked animals a clearly higher life expectancy both for ♀♀ and ♂♂ was found for the reference time period 1977–2000 than 1965–1976. Considering the fact that the results for the period 1977–2000 in the higher age groups are still affected by conditions in the years 1965–1977 (see chapter 3.3.5.1), somewhat higher values can still be expected for this period.

Tab. 16: Life expectancy of Greater mouse-eared bat communities depending on sex, age at marking and reference period

females, recaptures juveniles marked, record in winter roost			**males, recaptures** juveniles marked, record in winter roost		
period	$e_{a0.5}$	n	period	$e_{a0.5}$	n
1965–1976	3.15	123	1965–1976	1.96	90
1977–1984	4.97	358	1977–1984	4.14	261
1985–1991	4.97	305	1985–1991	3.91	251
1992–2000	5.01	510	1992–2000	4.51	471
1st year animals, marked in winter roost, record in winter roost			1st year animals, marked in winter roost, record in winter roost		
period	$e_{a1.5}$	n	period	$e_{a1.5}$	n
1965–1976	3.56	388	1965–1976	3.51	347
1977–1984	4.64	274	1977–1984	3.51	284
1985–1991	4.64	273	1985–1991	3.37	341
1992–2000	4.50	418	1992–2000	4.66	478
adults, marked in winter roost, record in winter roost			adults, marked in winter roost, record in winter roost		
period	$e_{a2.5m}$	n	period	$e_{a2.5m}$	n
1965–1976	3.54	917	1965–1976	3.09	819
1977–1984	3.56	313	1977–1984	3.08	369
1985–1991	3.26	379	1985–1991	4.08	304
1992–2000	3.68	258	1992–2000	4.35	433
female, dead refinds juveniles (and 1st year) marked			**male, dead refinds** juveniles (and 1st year) marked		
period	e_{a0}	n	period	e_{a0}	n
1964–1976	3.42	24	1964–1976	2.00	31
1977–1986	3.90	19	1977–1986	2.94	15
1987–2000	4.21	17	1987–2000	4.32	18
adult marked			adult marked		
period	e_{a1m}	n	period	e_{a1m}	n
1964–1976	4.57	37	1964–1976	3.50	26
1977–1986	4.42	19	1977–1986	4.33	6
1987–2000	5.45	18	1987–2000	5.13	8

b) The statements in a) are supported by data of juvenile animals of both sexes by results from mortality data evaluations, although the number of data is in the lower range.

c) For animals marked in the first year of life in the winter roost and recorded at the age of 1.5 years for the first time, the development of life expectancy is still positive, although not as clear as for juvenile marked animals from $AC_{0.5}$.

d) For adult ♀♀ marked in the winter roost no differences in respect to life expectancy except the usual fluctuations can be observed for animals that are 2.5 year old at the first record. The corresponding ♂♂ only have a higher life expectancy for the period 1985–2000.

e) From the evaluation of marked animals of both sexes found dead for whom evaluations starting at an age of 1 year are possible (see chapter 5.4), this tendency is supported by how far the few data (especially for ♂♂) allow such an evaluation.

Some general conclusions from this are:

1. From the above mentioned data for the Greater mouse-eared bat, an increase in life expectancy within the reference time periods in the area of responsibility of bat marking centre Dresden has occurred and this confirms the relevant first statements in Steffens et al. (1989) on a currently much larger database.

2. Such conditions are more prominent for younger animals and can be missing completely for older animals. The explanation for this phenomenon is multilayered. On the one hand, under more favourable life circumstances vital young animals can resist environmental effects better and possibly environmental effects are no longer so extreme. In both cases the young animals have a greater chance of survival. On the other hand, (older) animals which survived a hard selection, will be better suited for future conditions, and if appropriate harsh conditions have not occurred before less fit animals will disappear in later years. To that extent it is not unusual under natural conditions that a change in life expectancy becomes apparent, particularly in the younger age groups, and that in older age classes, at least in part, a stagnation is possible or it can be moving in opposite directions.

3. The life expectancy of Greater mouse-eared bat ♂♂ was in the beginning much shorter than those of ♀♀, but then it increased rapidly so that today it is at the same level as those of ♀♀. All data show this trend and it can therefore be considered as real (Tab. 16). This fact is also very interesting as the older age groups of our marking and record age classes are identical and represent predominantly the same historical situation. If this tendency continues then the life expectancy of Greater mouse-eared bat ♂♂ might increase even further once the younger marking age classes reach their full lifetime and eventually approximate the maximum age of the ♀♀.

4. Furthermore, it is remarkable that, apart from 1965–1976, for young animals in the 1st year, that were marked in the winter roost, in the $AC_{1.5}$ a lower life expectancy than for the $AC_{0.5}$ of juveniles (marked in the summer roost) was usually calculated. It should generally be higher because $AC_{0.5}$ also contained a high number of young deaths (Tab. 13–15, compare in each case $e_{a0.5}$ with $e_{a1.5}$). In agreement with chapter 3.3.5.7 this is indirect evidence towards the migration problem, because if marking and record takes place in the same roost, it is a further component for the quantification of the migration rate of marked animals.

5. Even lower than for juveniles is the life expectancy of adult animals marked in the same roost type. Besides the migration problem already discussed under 4, it could play a role here as starting from the age of 2.5 the life expectancy falls considerably (see Tab. 5 and 7). In addition to the mixture of age classes of adults there are animals that are more or less close to their physical end of life.

Investigations in central Bohemia in 1966–1975 result in $e_{a0} = 3.37$ years for the life expectancy (calculated using values as given in Table 28 by Horáček 1985) in similar low values as for the corresponding years of our own investigations. Horáček determined a mortality rate of 0.48 for juveniles in the first year. For the remaining lifetime a value of 0.22 can be derived from Table 28. For the period 1965–1976 for ♀♀ $AC_{0.5}/AC_{1.5}$ a figure of 0.59 and for the remaining lifetime of 0.19 is derived in our calculations. From 1977–2000 the mortality ratio of $AC_{0.5}$ to $AC_{1.5}$ is only 21–30 % (on average 27 %) and for remaining lifetime 18–20 % (on average 19 %). Thereby the results determined for East Germany are confirmed and also in the reference time period, namely that the mortality rate of juveniles is the main variable element (see above 2) and the suitability of the $AC_{0.5}$ (juv. marked, 1st refind in winter roosts) as equivalent parameter for the statistically problematic AC_0 for the recapture data of live animals (see chapter 3.3.5.4).

Concerning the **reproductive rate** and its development we again have a good database for the Greater mouse-eared bat, particularly due to the publications of Haensel (1980b, 2003), Göttsche et al. (2002), Oldenburg & Hacke-

THAL (1989a) as well as reports by W. SCHOBER. In principle, Greater mouse-eared bat ♀♀ give birth to 1 young. The crucial question is therefore at what age they start to breed and to what extent they participate in the reproduction. According to GÖTTSCHE et al. (2002) out of 70 adult ♀♀ 60 (85.7 %) had youngs in Eberswalde in 1994, and according to SCHOBER this value was 85 % in the area of Leipzig in the 1980s and 1990s. In both cases the reproductive rate of the nursery roost is 0.86 and 0.85 juveniles/adult ♀. Despite this high agreement in values, one cannot use this to make direct conclusions on the reproductive rate of the population, because both the reproductive rate and the settlement behavior of the Greater mouse-eared bat ♀♀ is age dependent. According to HAENSEL (2003), for the period of 1970–2000 the participation in reproduction of AC_1 was 39.6 % that of AC_2 was 88.7 %, that of AC_3 was 93.1% and that of the remaining age groups was on average 95 %. In addition, HAENSEL made the interesting statement that if you look at ♀♀ born last year, at first only in a few years, then more frequently and beginning in 1986 they annually have pups in different proportions (HAENSEL 1980, HAENSEL 2003 – Fig. 2, p. 460). From this the following proportions of animals born last year which are found in nursery roosts can be roughly estimated:

1970–1976	close to 10 %
1977–1985	more than 20 %
1986–2000	more than 45 %

The age group dependent settlement of Greater mouse-eared bat ♀♀ in nursery roosts can be estimated according to the method represented in chapter 3.3.5.4 (correction of the AC_1 and AC_2 with the proven degree of longer living animals in the AC_3) for the total time area in the AC_1 with 65 % and in the AC_2 with 85 %. Also the settlement degree of younger ♀♀ in nursery roosts changed over the course of time. For the AC_1 (1965–1977) it amounted to 55 %, for the period 1978–1985 to about 60 % and for the period 1986–2000 already to more than 70 %. No similar estimations are made for the AC_2, since the relevant data sets are too small. From this the following reproducing age group proportions result considering the settlement behaviour for the total time period:

AC_1	39.6 x 0.65 = 25.75 = ca. 25 %
AC_2	88.7 x 0.85 = 75.40 = ca. 75 %

For the remaining age groups the numbers communicated by HAENSEL (2003) remain unchanged. For the AC_1 the results can be differentiated further after periods as follows.

1970–1976	10 x 0.55 = 5.50 = ca. 5 %
1977–1985	20 x 0.60 = 12.00 = ca. 12 %
1986–2000	45 x 0.70 = 31.50 = ca. 32 %

Finally, in order to determine how high the proportion of reproducing Greater mouse-eared bat ♀♀ actually is, the determined values would have to be brought in connection with the proportion of the age class of the average real population for the total time period resp. the pooled time periods. For the sake of simplicity a population model of e_{a1} = 4.90 is used here. This procedure is possible as the most substantial time/ space-dependent differences in the life expectancy of Greater mouse-eared bat ♀♀ occurs between AC_0 and AC_1 (see Tab. 16), but our discussion here only concerns the animals starting from AC_1. In addition, for the purpose pursued here it would also only be pretended accuracy to use reference time/space and age group specific mortality rates for the $AC_1 – AC_4$. In the case of e_{a1} = 4.90 the following rounded age group portions result:

AC_1	=	20 %
AC_2	=	16 %
AC_3	=	13 %
$AC_{4\text{-}n}$	=	51 %

Correspondingly the reproductive rate (the proportion of reproducing ♀♀) is:

1970–2000	0.78
1970–1976	0.74
1977–1985	0.75
1986–2000	0.79

From this, according to chapter 3.3.2.1 and applying the formula

$$e_{a0} = \frac{2}{n} + 1$$

the life expectancy can be determined, which is necessary for a given reproductive rate (n), in order to keep the population in a stable condition (reproductive rate = mortality rate). Similar to Fig. 36 this life expectancy is designated as e_{an0}. According to the above given data this is for the total time period e_{an0} = 3.56. For the three reference time periods the appropriate results are given in Tab. 17 and compared with the data that were determined from recaptures of juvenile marked Greater mouse-eared bat ♀♀ for only slightly deviating period $e_{a0.5}$ values.

Tab. 17: Necessary life expectancy for a stable population according to the reproductive rate (e_{an0}) in comparison with the real life expectancy from live refinds of juvenile marked Greater mouse-eared bat ♀♀ for three reference periods

reference period	e_{an0}	$e_{a0.5}$
1970 – 1976	3.70	
1965 – 1976		3.15
1977 – 1985	3.67	
1977 – 1984		4.97
1986 – 2000	3.53	
1985 – 2000		4.99

From this it can be concluded that in the period before 1977 the actual life expectancy lies below the necessary reproductive rate and that therefore the population must have been in decline. After 1976 the necessary life expectancy according to reproductive rate lies above the actual life expectancy and therefore the population will increase. Also this development already started to become visible some time ago (see Steffens et al. 1989), but now this is much better supported by appropriate population analyses (e.g. Haensel 2003, Schmidt 2000a, Schober & Liebscher 1999, Treß et al. 1994, Zöphel & Schober 1999) and it applies to many regions in Central Europe (e.g. Benk & Heckenroth 1991, Gaisler et al. 1980–81, Roer 1993, Weinreich et al. 1992).

In this relation it is interesting that Schmidt (2001b) determined a (temporary?) decrease after 1996 and 1997 for the nursery roost at Niewisch as well as at the winter roost in the brewery cellar at Frankfurt. If we calculate the life expectancy of the $AC_{0.5}$ juvenile marked Greater mouse-eared bats on the basis of refinds in the winter roosts separately for the period 1996–2000, then the life expectancy is slightly under the values of 1992–2000 (with values for ♀♀ of 3.90 compared to 5.1 and for ♂♂ 4.32 compared to 4.51 as shown in Tab. 16). The decrease documented by Schmidt (2001b) therefore is no regional characteristic, but might represent a supra-regional feature, which may be connected to lower survival of juveniles starting from age 0.5 (the phase before we cannot measure due to methodical reasons). At the same time a slight decrease is documented by Řehák & Gaisler (1999) for a winter roost in north-eastern parts of the Czech Republic, where the above mentioned general population trend is shown with an impressive example.

In summary considering appropriate results from chapter 3.3.8 it is concluded that the results presented for the Greater mouse-eared bat are very close to reality. They can therefore:

1. be the basis for models to be developed and developed further for population prognosis
2. supply important criteria for the conservation status and the conservation prognosis in the sense of:
    - positive conservation status, positive conservation prognosis

reproductive rate	≥	mortality rate
life expectancy of the normal population according to reproductive rate (e_{an0})	≤	life expectancy according to life table (e_{a0})
average age of the normal population ($\bar{x}_n$)	≥	average age of the real population ($\bar{x}$)

- negative conservation status, negative conservation prognosis

reproductive rate	<	mortality rate
life expectancy of the normal population according to reproductive rate (e_{an0})	>	life expectancy according to life table (e_{a0})
average age of the normal population ($\bar{x}_n$)	<	average age of the real population ($\bar{x}$)

Beyond that they show a positive conservation condition (among other things also in connection with chapter 3.3.3) and a positive conservation prognosis for the Greater mouse-eared bat concerning the population parameters.

3.3.7.1.4 Reasons for the observed trends

Decrease and increase are for the Greater mouse-eared bat probably related to the general use of chlorinated hydrocarbons and the treatment of roof framings with wood preservatives (see e.g. Haensel 2003, Schmidt 2001a) as well as the specific bat protection programmes. The strong decline of the Greater mouse-eared bat occurred parallel to an enormous growth in the use of DDT preparations in the 1950s and 1960s, and the trend change in the 1970s occurred at the same time as prohibitions and restrictions for such biocides (Steffens et al. 1989, Straube 1996, and so on). Active bat protection meant that appropriate summer and winter roosts were protected and secured against negative effects.

Another positive factor for Greater mouse-eared bat populations is the increasingly dry, warm weather of the past 10–20 years that obviously also favoured the raising of pups and the development of the young. The relationship between reproductive development and climate is discussed by Speakman & Racy (1987) and Weishaar (1992). The increasing proportion of 1st year Greater mouse-eared bat ♀♀ participating in reproduction may also be interpreted in this sense, as a correlation of the results of Haensel (2003) with appropriate weather data shows. The average temperature from May to April (except December until February) of the preceding year rose in the reference time area from 11.6 °C to 12.4 °C (Tab. 18). Although the values show some variation in detail, reproduction in the 1st year never took place at temperatures under an average value of 11.3 and always took place at temperatures over 12.2 °C.

It is possible that for other species the climatic change is also responsible for recently detected high reproduction proportions in the 1st year (e.g. v. Riesen & Dolch 2003), although some of these "new" facts possibly already existed in former times but were more hidden.

Tab. 18: Average temperatures over 5 years before birth period (Station Cottbus)

Period	**1966 to 1970**	**1971 to 1975**	**1976 to 1980**	**1981 to 1985**	**1986 to 1990**	**1991 to 1995**	**1996 to 2000**
mean temperature from May to April (without December –February) before birth period	11.62	11.57	11.75	12.01	12.05	12.35	12.43

The determined stagnation of Greater mouse-eared bat populations is connected with the use of insecticides in Poland in 1994 to fight forest parasites (Schmidt 2001b). Haensel (2003) warns of the consequences of the large amount of renovation of old buildings as well as the development of attics. Further developments must therefore be pursued conscientiously.

3.3.7.1.5 Conclusions for bat marking and population monitoring

Bat marking and record of marked animals of the Greater mouse-eared bat are an example for other species concerning extent and continuity. The emphasis of further work must therefore be to secure the continuation of the past programs. In particular this concerns:

- as complete as possible marking of juveniles and likewise very comprehensive record in nursery roosts and particularly in the pertinent winter roosts for the nursery roosts Waren, Burg Stargard (both Mecklenburg-Western Pomerania), Bad Freienwalde, Eberswalde (both Brandenburg) and the viaduct Steina (Saxony) – including the determination of reproduction rate and year of 1st reproduction

- the development of an adequate and durable record system (nursery roost – winter roost) for one nursery roost each in Saxony-Anhalt and Thuringia as well as in the Eastern Ore Mountains (Saxony).

Beyond that in the appropriate nursery roosts adults may be marked and recorded in the winter roosts, and above all 1st year animals in the winter roosts. Further tasks of marking are to be examined as required, but they do not belong to the standard program.

3.3.7.2 *Daubenton's bat (Myotis daubentonii)*

3.3.7.2.1 Status of available data

With 6,341 recaptures Daubenton's bat is the second and with 97 dead finds it is in third place of the refind data of the bat marking centre Dresden data which can be evaluated for this chapter. However the data structure is relatively unfavourable. The proportion of juvenile marked animals amounts to only scarcely 6 % (363) of the recaptures and only since 1987 (in particular through appropriate marking programs of C. Treß, J. Treß, R. Labes) has it achieved a considerable magnitude. Dead finds of juvenile marked animals (5 ♀♀, 7 ♂♂) are not relevant for any evaluation. Only for adult ♀♀ and adult ♂♂, marked and recorded in winter roosts, are sufficient data present for the entire period, in particular from J. Haensel, and also from F. Rüssel, M. Wilhelm, D. Dolch, E. Grimmberger. Therefore the following evaluations must concentrate on these data, supplemented by dead finds of adult marked animals.

3.3.7.2.2 Survival curves

For adult ♀♀ and ♂♂ marked and recorded in the winter roost no further evaluations than those in Fig. 36 are performed, because for animals of unknown age the interpretation of the results has too many unknown factors (see chapter 3.3.5.5). For juvenile marked ♀♀ and ♂♂ the period from 1987–2000 is still too short, in order to overview the entire lifetime of animals with a sufficiently large data set. However the intermediate data collected up to 2004/2005 could make such an evaluation possible. In any case we would like to suggest this at least for first evaluations of the above mentioned marking programs parallel to the analysis of the age distribution of appropriate nursery roost communities (see chapter 3.3.2.1, 3.3.2.2 and 3.3.3).

3.3.7.2.3 Trends of population parameters and populations

For Daubenton's bat the following values differentiated for reference periods and sexes for **life expectancy** can be calculated:

■ **♀♀ adult, marked in winter roosts, recorded in winter roosts**		
Period	$e_{a1.5m}$	n
1964–1976	2.75	978
1977–1989	2.67	511
1990–2000	3.47	994
■ **♀♀ adult marked, dead refinds**		
Period	$e_{a1.0m}$	n
1964–1976	3.68	19
1977–2000	4.22	16

■ ♂♂ adult, marked in winter roosts, recorded in winter roosts

Period	$e_{a1.5m}$	n
1964–1976	3.26	796
1977–1989	3.43	506
1990–2000	4.73	1 101

■ ♂♂ adult marked, dead refinds

Period	$e_{a1.0m}$	n
1964–1976	4.33	18
1977–2000	5.01	32

From this a positive trend (increase in life expectancy) both for ♀♀ and for ♂♂ can be recognized, which becomes more clearly visible for ♂♂ for whom this is shown by live refinds already beginning in 1977, whereas this occurs for ♀♀ only after 1990. However the results are affected by special conditions in the limestone mine at Rüdersdorf. Here the marking and recording possibilities were substantially limited in the 1970s because of progressive mining, restrictions of admission and misalignment of the roosting sites (see Fig. 38). This leads in the sense of chapter 3.3.5.7 to an apparently lower life expectancy during this period. If one calculates the appropriate values without Rüdersdorf, then the following conditions result:

■ ♀♀ adult, marked in winter roosts, recorded in winter roosts

Period	$e_{a1.5m}$	n
1964–1976	3.46	530
1977–1989	3.38	490
1990–2000	3.42	916

■ ♀♀ adult marked, dead refinds

Period	$e_{a1.0m}$	n
1964–1977	3.78	18
1978–2000	4.22	16

■ ♂♂ adult, marked in winter roosts, recorded in winter roosts

Period	$e_{a1.5m}$	n
1964–1976	4.70	357
1977–1989	4.23	485
1990–2000	4.59	975

■ ♂♂ adult marked, dead refinds

Period	$e_{a1.0m}$	n
1964–1977	4.33	15
1978–1986	5.12	30

Now for the live recorded animals in the period of 1964–1989 clearly higher values for life expectancy are determined. No trends are recognized. For dead refinds the former statement remains valid, because Rüdersdorf, contributes only few data to it.

For the **reproductive rate** for Daubenton's bat no special investigations are present. According to Schober & Grimmberger (1998) the animals become sexually mature in the 1st year and ♀♀ usually have one pup. Accordingly 0.8–0.9 juveniles/♀ can be expected, which is confirmed by Fischer & Kissner (1994) as well as the markings and refind statistics of bat marking centre Dresden. The following spans for life expectancy of a stable population would then have to be expected:

$$e_{an0} = \frac{2}{n} + 1 = 3.5\text{–}3.2$$

These values that were determined using refind evaluations and reproductive rate values, lead to different conclusions relating to ♀♀ as they are crucial for the reproductive rate-mortality balance (see chapter 3.3.2.2, p. 65). When all data (including Rüdersdorf) are taken as the basis a population decrease and a following increase would result from recapture data for the period 1964–1984, and a progressive increase results if the dead refinds are taken as the basis. If one excludes the Rüdersdorfer data, then conditions are constant and a long-term increase can be assumed.

A further factor of uncertainty is introduced as the life expectancy could be derived only from adult marked animals, which possibly, as determined for the Greater mouse-eared bat (see chapter 3.3.7.1.3), do not react as sensitively as juvenile marked animals. In a similar way the life expectancy calculated from dead refinds of adult marked animals could be too high in comparison to the total lifetime (juvenile marked animals, higher mortality of young animals). For adults marked and recorded live in winter roosts slightly too low values have to be expected, or perhaps there may even be the opposite tendencies from unobserved mortality of juveniles and migration, particularly since the latter for Daubenton's bat in winter roosts does not seem to have the same importance as for the Greater mouse-eared bat (see Fig. 17 and Fig. 18, diagram winter–winter). Bearing this in mind a slightly positive population trend for the reference time area can be assumed.

From direct observations a positive population development since the middle of the 1980s is out of discussion for our reference area (Fig. 38, Hochrein 1999c, Mehm 1994 and others) as it can also be observed trans-nationally (Bufka et al. 2001, Georg 1994, Kokurewicz 1994–95, Řehák & Gaisler 1999, Rieger 1996, Weinreich 1992). Also a long term positive population trend (since 1945/1950) has been reported several times (e.g. Haensel 1973, Kokurewicz 1994–95, Weinreich 1992) and agrees in prin-

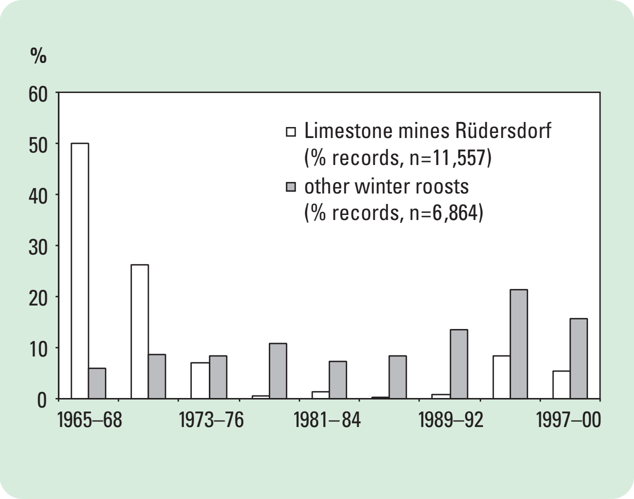


Fig. 38: Population trends of Daubenton's bat recorded for many years in winter roosts based on the data of bat marking centre Dresden

ciple with our results from life expectancy and reproductive rate and the marking statistics, if one excludes Rüdersdorf starting from the 1970s.

Altogether regarding the determined population parameters a positive conservation prognosis for Daubenton's bat is also given. However the data set that serves as a basis for bat marking centre Dresden is not as robust as for the Greater mouse-eared bat. In addition as can be seen from the example of the limestone mine at Rüdersdorf several spatially separated investigations (if possible at least 3–5) should always be performed for condition and trend determinations of appropriate populations (or roost communities) in order to be able to exclude regional characteristics and to recognize such regional features as are necessary for generalizing statements.

3.3.7.2.4 Reasons for the observed trends

For long-term positive population development, an improved food source due to the eutrophication of waters and the construction of dams is seen as a major cause (e.g. Kokurewicz 1994–95, Rieger 1996). At least for the development in recent time (since the 1970s) it can also be assumed for Daubenton's bat that the recovery has several causes, with biocide use, trends of climatic elements (see Tab. 18) and bat protection in a central role. In contrast to the Greater mouse-eared bat, no direct threat from the use of wood preservatives is given. Indirect effects through the food chain are however equally relevant. Higher temperature in the active annual life phase (March/April until September/October) is here probably not to be interpreted as the need for heat but rather in the sense of better food availability. Also the abandonment of unprofitable land in areas of minimal exploitation (e.g. wet- and relict forests) as well as more extensive fish farming can at least have regionally positive effects. Regarding bat protection above all the protection and constant recording of the condition in winter roosts is worth mentioning.

3.3.7.2.5 Conclusions for bat marking and population monitoring

Bat marking and recording of marked animals for Daubenton's bat are so far only satisfactory for adults in the winter roost. For ♀♀ which are juvenile marked and recorded in the nursery roost the data sets are still too small. For ♀♀ and ♂♂ which are juvenile marked and recorded in the winter roost an appropriate database is so far missing. In particular the following is therefore necessary:

- The marking of juveniles in nursery roosts of C. Treß (Wooster Teerofen) and R. Labes (Ventschow) as well as net catches in the summer/autumn by D. Dolch should be continued and if possible connected with the determination of the reproductive rate.
- Winter roosts in the area of recorded nursery roosts should be explored and recorded every year for the presence of marked animals and there should be close co-operation with the corresponding investigation in the Spandau Citadel.
- To build up and continue one adequate summer roost and winter roost recording program on a long-term basis in Saxony (Oberlausitzer Heide- and Teichlandschaft) and in Saxony-Anhalt (for example Elbe-Havel-Winkel, Havelberg).
- To continue the marking and recording in winter roosts East of Berlin (J. Haensel), Sanssouci, Zippelsförde (D. Dolch) and in Rehefeld in the Eastern Ore Mountains (M. Wilhelm), at least until the above mentioned alternatives provide better monitoring results.

3.3.7.3 Natterer's bat (Myotis nattereri)

3.3.7.3.1 Status of available data

For Natterer's bat the state of data sets is similar to that for Daubenton's bat. The ratio of recaptures of juvenile marked animals (1,053) to adult marked animals (3,993) is more favourable, but the regular marking of juveniles did not start before about 1990, and the data acquisition is still too incomplete, so that appropriate evaluations must wait. Also dead finds (a total of 47 – see Tab. 12) are from their number close to any evaluation limit and permit no trend statements. Thus the following evaluations must concentrate again on adult ♀♀ and ♂♂, marked and recorded in the winter roost, for which the longterme investigations of J. Haensel, D. Heidecke and D. Dolch are particularly representative.

3.3.7.3.2 Survival curves

Due to the same reasons as for Daubenton's bat (see above) no evaluations in addition to those in Tab. 38 are performed.

3.3.7.3.3 Trends of population parameters and populations

The **life expectancy** of Natterer's bat shows the following features separated for time periods and sexes:

🟩 **♀♀ adults, marked in winter roost, recorded in winter roost**

period	$e_{a1.5m}$	n
1964–1976	2.95	165
1977–1984	3.12	178
1985–1994	3.33	345
1995–2000	3.44	236

🟩 **♂♂ adults, marked in winter roost, recorded in winter roost**

period	$e_{a1.5m}$	n
1964–1976	2.78	189
1977–1985	3.27	379
1985–1994	3.42	825
1995–2000	3.50	758

From this a positive trend in life expectancy can be recognized, which is somewhat clearer for ♂♂ than for ♀♀ and which is probably more clearly related to the total lifetime (AC_0), than can be shown here.

For the onset of sexual maturation and the **reproductive rate**, results of Dolch (2003), Weidner (1998), Heise (1991) and R. Labes are available. According to this Natterer's bat ♀♀ already breed in their first year (Heise 1991, Schober & Grimmberger 1998). For the period of 1993–2000 Dolch (2003) determined a reproductive rate of 0.70–0.98, which is on average 0.88 juveniles/adult ♀ (n = 193). Exactly the same result is given by R. Labes for the period 1990–2000, when an average of 35 (87.5 %) out of 40 ♀♀ was involved in reproduction.

From this we find: $e_{an0} = \dfrac{2}{n} + 1 = 3.27$

Having consulted the more detailed results for the Greater mouse-eared bat (chapter 3.3.7.1.3, Tab. 16), we can assume that the above mentioned $e_{a1.5m}$ values are somewhat too low, which is also supported by the $e_{a1.0m}$ values from dead refinds for Natterer's bat determined over the complete time period (♀♀ 3.81, $n = 16$; ♂♂ 3.70, n = 20). From these results for ♀♀ for the period 1964–1984, there is no change or a slight decrease followed by an increase in the population. However, one further factor of uncertainty still has to be considered. The reproduction results for Natterer's bat originate from bat boxes, which are optimized to various extents and therefore possibly lead to higher values than under natural conditions. In this case the prognosis would be too optimistic [see also appropriate notes for Noctule, Nathusius's pipistrelle (chapter 3.3.7.5 and 3.3.7.6)].

These results and assumptions can again be compared with population trends which have actually been determined. Marking and recapture statistics of winter roosts recorded over many years (Fig. 39) support the decrease and stable level of the population up to the middle of the 1970s as well as the following population increase. The latter is also confirmed by appropriate observation from winter roosts in Thuringia (Weidner 1994) as well as from nursery roosts in bat boxes since 1990 (e.g. Dolch 2003). Furthermore it is interesting to note that for Natterer's bat there is certain stagnation in the population data toward the end of the observation period (Fig. 39) as well as an increasing predominance of ♂♂. The latter is further supported by an appropriate trend of the $e_{a1.5m}$ values. Nevertheless, for both facts it is necessary to consider the incomplete collection of the age of adult marked animals, which makes a final discussion more difficult.

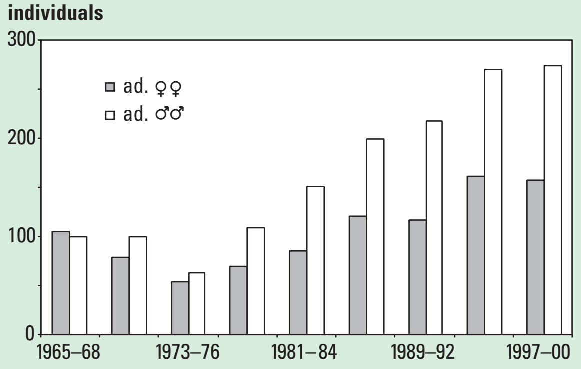


Fig. 39: Trends for Natterer's bat populations in long-term recorded winter roosts according to marking and refind data of bat marking centre Dresden

The statements regarding population trends are supported by trans-national data. In winter roosts in the Netherlands, Natterer's bat populations reached the lowest level after a continuous population decrease in the 1970s and started to increase in the 1980s (Weinreich 1992). In Hesse in mine galleries there is likewise a decrease in the beginning of the 1970s followed by stagnation and a slight increase toward the end of the 1980s (Georg 1994).

Altogether for Natterer's bat a positive conservation prognosis is given according to the determined population parameters, which is more obvious from the data situation in the bat marking centre Dresden than for Daubenton's bat, but it is not as strong as for the Greater mouse-eared bat.

3.3.7.3.4 Reasons for the observed trends

Most probably identical reasons as for Daubenton's bat are responsible for the observed population trends. The special situation for areas with bat boxes is discussed in chapter 3.3.7.5 and 3.3.7.6.

3.3.7.3.5 Conclusions for bat marking and population monitoring

As for Daubenton's bat the marking and recording of marked animals is only done adequately for adults in winter roosts. For ♀♀ juveniles marked and recorded in the nursery roost as well as for ♀♀ and ♂♂ juveniles marked and recorded in the winter roosts, the data sets are still too small and also still too intermittent. In particular it is necessary to carry out the following:

- The marking of juveniles in nursery roosts of C. Treß (Wooster Teerofen), D. Dolch (Friesacker Zootzen), R. Labes (Grambower Moor) and J. Haensel (Schorfheide) should be continued and if possible connected with the determination of the reproductive rate.
- Winter roosts in the area of recorded nursery roosts should be explored and recorded every year for the presence of marked animals and there should be close co-operation with the corresponding investigation in the Spandau Citadel.
- To build up and continue one adequate summer roost and winter roost recording program on a long-term basis in East Thuringia (H. Weidner), in Harz (B. Ohlendorf) and in the Altmark (E. Leuthold),
- To continue the marking and recording of adults in winter roosts East of Berlin (J. Haensel), Sanssouci and Zippelsförde (D. Dolch) and Zerbst (T. Hofmann, previously D. Heidecke) at least until the above mentioned alternatives provide better monitoring results.

In addition adult animals can be marked in the recorded nursery roosts as is done with the Greater mouse-eared bat. Further marking studies and objects should be evaluated on a case-by-case basis but are not part of any standard monitoring scheme.

3.3.7.4 Brown long-eared bat (Plecotus auritus)

3.3.7.4.1 Status of available data

For the Brown long-eared bat the data set is evaluable for the total number of recaptures (4,316) and also for the relationship of juvenile to adult marked animals with recaptures (1,620 : 2,696) showing relatively favourable conditions. However, sufficiently extensive and continuous refinds of juvenile marked animals are here also only available after 1985 and appropriate interrelations to the winter roosts can still not be evaluated. Over the entire reference time period the data situation is best for adult ♀♀ marked and recorded in the summer roosts. For adult ♀♀ and ♂♂ marked and recorded in the winter roosts the data set is almost not evaluable, and for dead refinds of juveniles and adult marked animals (30 and 45 individuals) the date set is generally too low.

3.3.7.4.2 Survival curves

Survival curves with a logarithmic scale of the survivors are given for two reference time periods (Fig. 40) similar to the Greater mouse-eared bat (Fig. 37). From this a predominantly convex shape of the mortality rate (which corresponds to the shape of the curve when logarithmic scales are applied) also results in the case of the Brown long-eared bat, and this confirms the relevant statement in chapter 3.3.2.2 (p. 66). Beyond that again, as described for the Greater mouse-eared bat (3.3.7.1.2, point 2, p. 83) and likewise the black-tailed deer (*Odocoileus hemionus*) (Taber & Dasmann 1957) the phases of age-dependent survival become visible for the reference period 1965–1989. This is not so clear for the period 1995–2000. Despite the considerably larger amount of data no abstracted shape of the curve becomes visible from annual specifics. In addition it must be noted that starting from AC_1 (for the Greater mouse-eared bat nevertheless starting from $AC_{0.5}$) the mortality rate at a young age is not sufficiently documented.

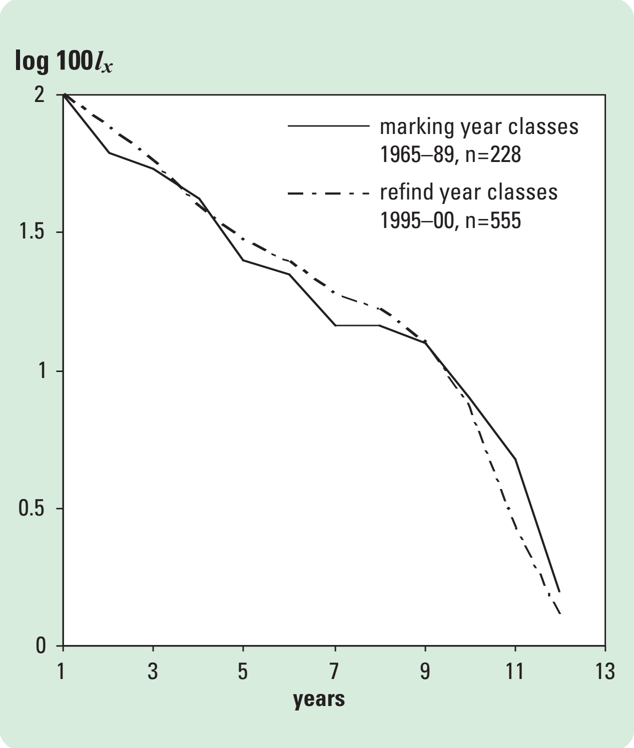


Fig. 40: Survival rates of juvenile marked ♀♀ of the Brown long-eared bat, recaptures in summer roosts (survivors in logarithmic scale)

3.3.7.4.3 Trends of population parameters and populations

From the **lengths of life** expectancy of roost communities of the Brown long-eared bat (Tab. 19) presented as a function of sex, age and type of roost the following conclusions can be derived:

1. In the 1960/1970s, ♀♀ exhibited in principle lower values of life expectancy than in the following reference time periods. There is however no lasting positive trend, as for the reference time period 1992–2000, at least as far as this can be regarded separately, clearly lower values for life expectancy again result.

2. For ♂♂ no conclusive trends can be derived on the basis of the calculated values for the life expectancy.

Regarding the onset of sexual maturation and the **reproductive rate** in particular, data from v. Riesen & Dolch (2003) are available. According to this from the age of one year old ♀♀ on average 53.7 % (n = 95) and for those ♀♀ at least two years old 83.4 % (n = 205) reproduce. 46.9 % of the juveniles are ♀♀. The ratio of one year: several year old ♀♀ corresponds assuming a life expectancy of:

2.67 (years 1965–1984) 37.5/62.5 % = total of 72.3% reprod. ♀♀,	e_{an0} = 3.95
4.73 (years 1985–1991) 21.1/78.9 % = total of 77.3 % reprod. ♀♀,	e_{an0} = 3.76
3.53 (years 1992–2000) 28.3/71.7 % = total of 75.0 % reprod. ♀♀,	e_{an0} = 3.84

Assuming an average life expectancy of the normal population on the basis of the reproductive rate of e_{an0} = 3.80 then (considering the few values for juvenile marked ♀♀ and the high life expectancy of adult ♀♀ marked and refound in the summer roost during the period 1977–1984) it can be assumed that there were population decreases at least up to the middle of the 1970s, a population increase for the 1980s and another population decrease for the 1990s. This differentiation is methodically justified, but for 1965–1986 however appropriate measurements are missing and in addition the results of v. Riesen & Dolch (2003) may not apply for the entire reference territory of the bat marking centre Dresden.

Tab. 19: Life expectancy of roost communities of the Brown long-eared bat in relation to sex, age at marking, and reference period for live refinds

Females juvenile marked, record in summer roost			**Males** juvenile marked, record in summer roost		
period	$e_{a1.0}$	n	period	$e_{a1.0}$	n
1965–1984	2.67	72	1965–1984	2.05	43
1985–1991	4.73	232	1985–1991	1.57	44
1992–2000	3.53	723	1992–2000	1.89	263
adult marked, record in summer roost			adult marked, record in summer roost		
period	$e_{a2.0m}$	n	period	$e_{a2.0m}$	n
1965–1976	2.80	126	1965–1976	2.70	27
1977–1984	4.15	365	1977–1984	2.27	50
1985–1991	3.31	371	1985–1991	2.43	51
1992–2000	2.94	799	1992–2000	2.35	121
adult marked, record in winter roost			adult marked, record in winter roost		
period	$e_{a1.5m}$	n	period	$e_{a1.5m}$	n
1965–1984	2.59	119	1965–1984	2.13	85
1985–2000	2.92	214	1985–2000	2.33	174

In principle, the results correspond well with actually determined **population trends**. From the marking and refind statistics of winter roosts recorded for many years, it is possible to see a population decrease to the middle of the 1970s, followed by a steep rise and then population fluctuations with still perhaps a slight positive trend (Fig. 13). Fischer (1994) reports a positive population trend for Thuringia, although this statement is based on the 1960/1970s as compared with the 1970/1980s. Schmidt (2000a) determined an irregular fluctuation in population densities for bat populations in Brandenburg, whereby Fig. 41 on p. 268 in Schmidt (2000a) gives evidence for an increase at the end of the 1970s followed by population fluctuations with a slight positive trend. Beyond that he reports strong population losses in wintering cellars between 1979 and 1998, which however cannot generally be confirmed with the data available here.

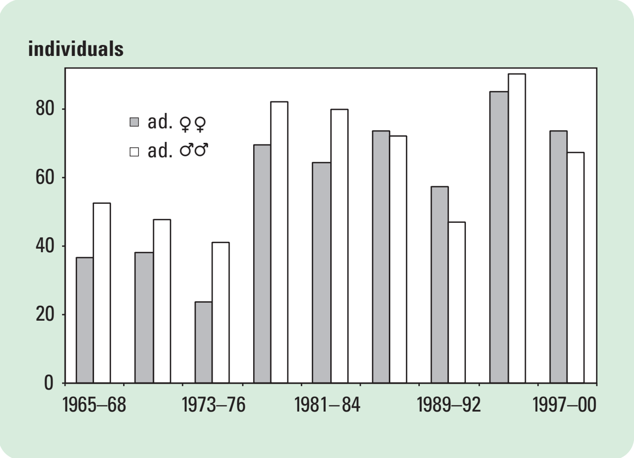


Fig. 41: Trends for Brown long-eared bat in long-term monitored winter roosts based on the marking and refind statistics of bat marking centre Dresden

Furthermore it is remarkable in Fig. 41 that the proportion of ♂♂ compared with ♀♀ decreases. This is well supported by the life expectancy values (Tab. 19). Generally the population trend for ♂♂ is through the net increase of juveniles determined by the trend of the life expectancy for ♀♀. As the life expectancy (e_{al}) of ♀♀ increases but not in ♂♂, the ♂♂ proportion must decline if no other factors are involved. Also trans-regional Common long-eared bat populations show strongly variable population sizes (e.g. Gaisler et al. 1980–81, Veith 1996, Weinreich 1992) with an all time low in the middle of the 1970s (Weinreich 1992) and low values from the end of the 1960s to the middle of the 1980s (Georg 1994).

Altogether for the Brown long-eared bat a stronger population status can be stated for the 1980/1990s compared with the 1960/1970s on the basis of appropriate population parameters although further prognosis is however uncertain.

3.3.7.4.4 Reasons for the observed trends

The general trend of a population decrease until the middle of the 1970s, followed by a steep increase and since then no change could, within the specified cause complex, probably be related to the use of biocides as well as more recent problems for the species such as renovation, development and intensified use of cellars and attics (see e.g. Schmidt 2000a) as well as competition with other species in bat boxes (e.g. Heise & Schmidt 1988, v. Riesen & Dolch 2003).

3.3.7.4.5 Conclusions for bat marking and population monitoring

Systematic markings of juvenile ♀♀ and ♂♂ and appropriate refind reports start in the middle of the 1980s (C. Treß, D. Dolch, FFG Meiningen) and continue in the beginning (J. Haensel) or middle of the 1990s (B. Ohlendorf). They should be continued indefinitely, should be related to reproductive rate and if possible be combined with appropriate records from winter roosts lying in the catchments area. For Saxony the start of an adequate marking and supervisory routine has to be evaluated.

In addition adults should be marked and recorded in the appropriate nursery roosts. Further tasks and objects of marking programs are to be examined as required, but however do not belong to the standard program.

3.3.7.5 Noctule (Nyctalus noctula)

3.3.7.5.1 Status of available data

For the Noctule the data set is relatively good with 5,046 recaptures, of which 1,843 juvenile marked animals (the largest relevant data set after Brown long-eared bat). This applies, however, only to ♀♀ marked and recorded in the summer roost. For them there are incomplete data from 1965–1984 followed by very extensive and complete marking and refind reports, in particular from G. Heise, and also C. Treß, R. Labes and others. Therefore the following evaluations concentrate on recapture data for ♀♀ in the summer roosts. For other roost types and the combination of summer roost marking and winter and intermediate roost records the available data set is not sufficient. This also applies to recaptures of ♂♂ as well as generally for finds of dead animals.

3.3.7.5.2 Survival curves

Fig. 42 shows appropriate curves for two reference time periods. From this it can be seen that the convex character of the curves and the phases of age-dependent survival as described for the Brown long-eared bat are only weakly pronounced but still recognizable. This can

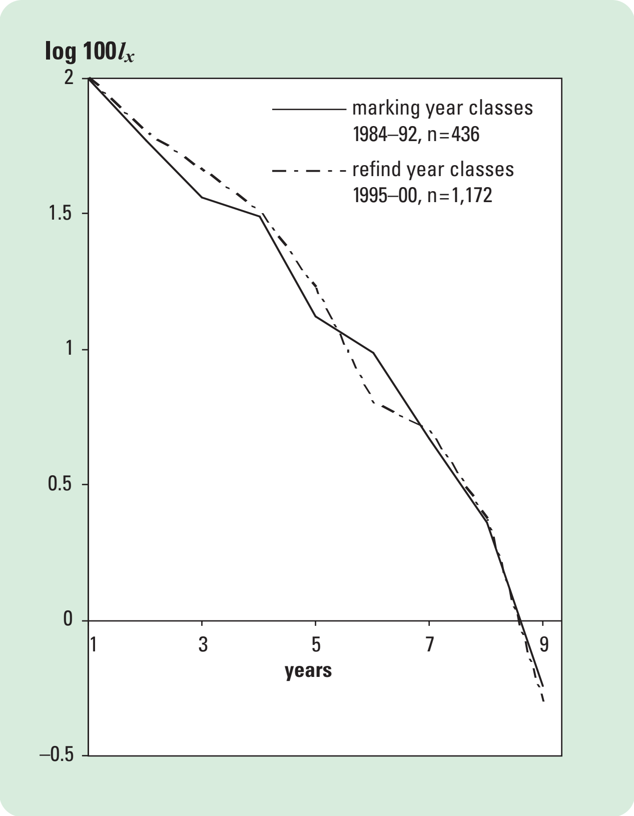


Fig. 42: Survival rates of juvenile marked ♀♀ of the Noctule, live refinds in summer roosts (survivors in logarithmic scale)

be explained by the relatively short lifetime of the Noctule. In addition it has to be noted that the mortality rate of animals up to age 1 is not available due to methodical reasons.

3.3.7.5.3 Trends of population parameters and populations

For Noctule ♀♀ the following values for **life expectancy** differentiated for reference periods can be obtained:

■ **♀♀ juveniles marked and recorded in summer roosts**		
period	$e_{a1.0}$	n
1970–1983	2.20	22
1984–1992	2.52	463
1993–2000	2.68	1,332
■ **♀♀ adults marked and recorded in summer roosts**		
period	$e_{a2.0m}$	n
1965–1983	2.19	103
1984–1992	2.33	315
1993–2000	2.33	992

From this a positive trend for life expectancy in the 1980/ 1990s compared with the 1960/1970s for both juveniles and adult marked Noctule ♀♀ can be concluded. This trend is more visible for juveniles and increases further in the 1990s, but has low support from the data set for the period 1979–1983.

For the **reproductive rate** detailed investigations of Heise (1989), Heise & Blohm (2003) and Heise et al. (in preparation) are available. According to this, the reproductive rate for the period 1986 to 2001 is 1.26 to 1.82, with on average 1.48 juveniles/adult ♀ ($n=1{,}914$). From this, due to a small surplus of ♂♂, 0.73 juvenile ♀♀/adult ♀ results, this corresponds to a life expectancy of 2.37 years of the normal population derived from the reproductive rate. This means that for the 1960/1970s a decrease can be expected followed by a slight and then stronger increase. In principle, this is confirmed by Schmidt (2000a) for 1973 to 1998 (Fig. 6 in Schmidt), by G. Heise from the marking statistics since 1979 and by Heise et al. (2003) since 1986.

In summary the determined population parameters for the Noctule result in a positive population status and a positive conservation prognosis, which is, apart from the results presented here, also derived from appropriate investigations into the age structure (Heise & Blohm 2003) in connection with chapter 3.3.3 (average age normal population > average age real population).

3.3.7.5.4 Reasons for the observed trends

Again for the Noctule the prohibition and decrease of the use of certain biocides (chlorinated hydrocarbons) is seen as a substantial factor for the change of population trends. In addition the medium-term climatic development may contribute. A higher proportion of dry, warm summers contribute positively to the reproduction results according to Heise (1989) and Heise et al. (2003). Furthermore, more vital young animals can cause a decrease in juvenile mortality. Mild winters lead to a shortening of the migration distances (e.g. Heise & Blohm 2004) and to a reduction of the risk during migration, which likewise contributes to the performance success of a species. Finally, improved bat boxes are also available and these will not only improve settlement in pine forests and other areas which have few tree holes, but also improve reproduction success. Tree holes are often more unfavourable as a result of humidity (water pots), pathogens, parasites etc. (special investigations are unfortunately not available). Therefore reproduction success and population trends in areas with bat boxes may be overestimated, although the results are generally speaking still valid.

3.3.7.5.5 Conclusions for bat marking and population monitoring

Bat marking and recording of marked animals was strongly intensified for the Noctule in appropriate nursery roosts of the Uckermark by the enthusiastic work of G. Heise and his co-workers in the 1990s. The data pool available from this region dominates the entire evaluation. For an appropriate supra-regional standard program it is therefore necessary

- to continue the studies of C. Treß (Wooster Teerofen), W. Oldenburg (Müritzarea) and R. Labes (near Ventschow)
- to provide continuous recapture data from own research to the long-term investigations of A. Schmidt (Eastern Brandenburg)
- the investigations of G. Heise (Uckermark) should concentrate in the future on long-term research on standardized areas
- corresponding marking and recording programs should be started in areas adjacent to the Baltic Sea, in Saxony-Anhalt (e.g. Havelberg) and Saxony (e.g. Upper Lusatia) on a long-term scale.

Beyond that substantial progress in knowledge can be expected through wide investigations and continuous recording of intermediate roosts and winter roosts. This will particularly be the case if they are in direct interaction with the above mentioned nursery roosts in which marked animals can be proven and the first available results can be developed to appropriate time series (district Stahnsdorf/C. Kuthe).

3.3.7.6 Nathusius' pipistrelle (Pipistrellus nathusii)

3.3.7.6.1 Status of available data

The situation for Nathusius' bat is similar to that for the Noctule, both regarding the proportion of juvenile marked animals of the recaptures, and regarding the evaluable roost types. The data situation however permits additional evaluations for juvenile marked ♂♂ (due to the mating roosts existing in the observation areas) and at least for the total time period indications of appropriate orders of magnitude for life expectancy from dead refind evaluations.

For Nathusius' bat the data acquisition did not start before 1970, apart from a few exceptions (B. Stratmann, A. Schmidt). There are continuous data sets only from the end of the 1970s/beginning of the 1980s. Since that time, research on this species has been continually performed up to the present by A. Schmidt. Only very few of his own refinds were made available by him but for certain questions appropriate publications can be used (e.g. Schmidt 1994a,b).

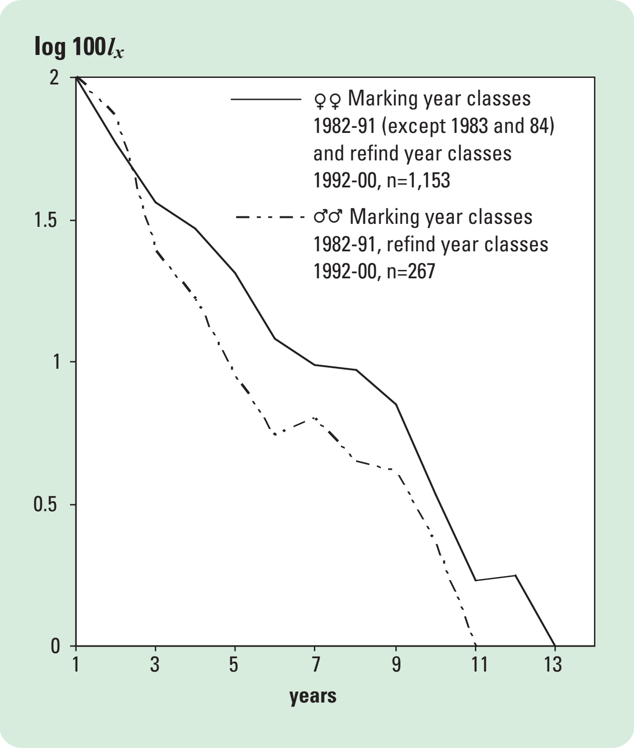


Fig. 43: Survival rate of juvenile marked ♀♀ and ♂♂ of Nathusius' bat, recaptures from 01.04. until 30.09. (survivors on logarithmic scale)

Since 1980 appropriate data sets of W. Oldenburg (Müritzarea) and since 1986 very well documented continuous data sets of C. Treß and co-workers (Wooster Teerofen) have become available. With incomplete data sets G. Heise (1974–1985), J. Haensel (since 1977), R. Labes (since 1993) contributed to the total result. To these materials the following evaluations essentially refer.

3.3.7.6.2 Survival curves

Fig. 43 shows summer records for the period 1982–2000 of juvenile marked live animals, separated by sex. For the ♀♀ the marking years 1983 and 1984 were excluded, as these were too incomplete due to intermittent collection. In principle, the survival curve for juvenile marked ♀♀ again shows the phases already described for the Greater mouse-eared bat, although the convex shape of the curve can hardly be recognized. The latter applies even more clearly to ♂♂, for which it can be assumed that the AC_1 is under-represented and thus the mortality rate from AC_1 to AC_2 is calculated too low, because only some of the juvenile ♂♂ have already settled in appropriate mating roosts after the first year (see e.g. Schmidt 1994b).

Tab. 20: Life expectancy of Nathusius' bat

Females – recaptures juvenile marked, recorded in summer roost			**Males** – recaptures juvenile marked, recorded in summer roost		
period	$e_{a1.0}$	n	period	$e_{a1.0}$	n
1978–1991	2.88	647	1978–1991	2.29	152
1992–2000	3.21	649	1992–2000	2.63	124
adult marked, recorded in summer roost			adult marked, recorded in summer roost		
period	$e_{a2.0m}$	n	period	$e_{a2.0m}$	n
1976–1991	2.43	588	1977–1991	2.57	627
1992–2000	3.10	465	1992–2000	2.39	892
Females – dead refinds juvenile marked, complete period			**Males** – dead refinds juvenile marked, complete period		
	e_{a0}	n		e_{a0}	n
	2.78	15		2.36	19
adult marked, complete period			adult marked, complete period		
	$e_{a1.0m}$	n		$e_{a1.0m}$	n
	2.23	18		2.00	9

3.3.7.6.3 Trends of population parameters and populations

For ♀♀ marked and recorded in the summer roosts, the determined values for life expectancy (Tab. 20) show a positive tendency for the 1990s compared with the 1980s, both for juvenile and adult marked animals. For the ♂♂ this applies only for juvenile marked animals, but in this case the results would have to be corrected however with the recapture probability (see chapter 3.3.5.4.5). This is because in mating roosts one year old ♂♂ when compared with older ♂♂ can usually only be proven to be at a below average proportion (see chapter 3.3.7.6.2 and Fig. 43).

Generally Nathusius' pipistrelle ♀♀ already have two pups in the 1st year (e.g. Schober & Grimmberger 1998). Hackethal & Oldenburg (1984) found that for 40 lactating ♀♀ had 70 pups (1.75 juveniles/adult ♀). Schmidt (1994 – Tab. 19) determined for the period of 1980–1990 1.69–1.96* juvenile/adult ♀. A total of 414 adult ♀♀ had 760 juveniles, which results in 1.84 juveniles/adult ♀. Of the juveniles 48.9 % are ♀♀ = 0.90 juvenile ♀♀/adult ♀ according to Schmidt (1994, Tab. 17). On the basis of the latter a life expectancy (e_{an0}) for the normal population (mortality rate = reproduction rate) of 2.10 years or of 2.20–2.04 for the above mentioned variation results. Therefore for the reference time period a population increase has to be expected from the marking and refind data and this is confirmed e.g. by Schmidt (1994a,b; 2000).

Altogether therefore, a positive population status can also be determined for the Nathusius' bat and a favourable conservation prognosis can be given. This is also confirmed by appropriate investigations into the age structure (Schmidt 1994b) in connection with chapter 3.3.2.2 of this work (average age of the normal populations). Beyond that the large difference between the current mortality and reproductive rate (see also chapter 3.3.8) suggests the further increase and spreading of the population.

3.3.7.6.4 Reasons for the observed trends

Whether also for Nathusius' bat a population decrease occurred in the 1960/1970s, cannot be proven with the available data. The positive population development is also documented for the 1980/1990s, for which in principle the same complex of causes can be assumed as for the Noctule. The more Eastern European continentally spread species may also have responded to the climatic development in recent times, with more dry and warm summers. Above all it is remarkable to see the populations in areas with bat boxes, in which reproductive rates are reached, that are clearly higher than those of the Noctule and in addition have a higher life expectancy (see previous chapter with 3.3.7.5.3). Therefore it is appropriate to assume that Nathusius' bat profited in particular from bat box availability, which made it possible to conquer whole regions (e.g. old central pine forests of Brandenburg) and allowed the species with this population surplus to found new populations in another place or at least try to do so. Nathusius' bat is possibly like the pied flycatcher (*Ficedula hypoleuca*) of bats, which was also rare in many regions or was even missing, and for which similar features and developments in connection with the establishment of nestbox facilities in the 1930–1960s were observed.

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* values regarding to data of Table 19 of Schmidt slightly recalculated

3.3.7.6.5 Conclusions for bat marking and population monitoring

The marking and recording of marked animals for Nathusius' bat concentrate on nursery roosts and mating places in Brandenburg and Mecklenburg-Western Pomerania. In the interest of a more detailed documentation of appropriate population parameters it is necessary:

- to continue the investigations of C. Treß (Wooster Teerofen), R. Labes (Ventschow), W. Oldenburg (Müritzarea), J. Haensel (northern Königs Wusterhausen), B. Ohlendorf (northern Saxony-Anhalt), E. Leuthold (Altmark) and to combine this with a continuous collection of data on population recruitment
- to provide a continuous set of own refind data for the long-term investigation in East Brandenburg of A. Schmidt
- to eventually perform research into population parameters especially the reproductive rate in natural tree holes
- explore mating and intermediate roosts that communicate with the nursery roosts studied, record marked animals here and build up time rows of data sets.

3.3.7.7 Common pipistrelle s. l. (Pipistrellus pipistrellus s.l.)

3.3.7.7.1 Status of available data

In respect of the extent of the available recaptures including the relevant proportion of adult and juvenile marked Common pipistrelle s. l., the species is to be compared with Nathusius' bat. Regarding the available dead refinds the species is in second place after the Greater mouse-eared bat. A large disadvantage for the Common pipistrelle s. l. however is the heterogeneous data set. Frequent change of accommodation and location as well as a lack of marking and recording programs of marked animals on a long-term basis, make concrete statements concerning life expectancy (mortality rates, survival rates) and their trends more difficult. Similarly, no specific investigations are present for the reproductive rate within the range of the bat marking centre Dresden. In addition, it is only a short time since a distinction was made between Common pipistrelle and Soprano pipistrelle. It is possible that they may also differ concerning appropriate population characteristic values, and their proportions are unknown in the old data.

3.3.7.7.2 Survival curves

The data do not allow any presentation other than Fig. 36.

3.3.7.7.3 Trends of population parameters and populations

On the basis of the available data from recaptures the following values for the **life expectancy** of Common pipistrelle s. l. can be calculated differentiated by reference time periods and sex.

Females

juvenile marked, recorded in summer roost

period	$e_{a1.0}$	n
1972–1978	(1.48–1.72)	108
1979–1994	2.46	32
1999–2000	3.10	45

adult marked, recorded in summer roost

period	$e_{a2.0m}$	n
1970–1978	(1.73–1.94)	218
1979–1994	2.64	111
1995–2000	2.96	153

adult marked, recorded in winter roost

period	$e_{a1.5m}$	n
1965–1969	(1.61–2.40)	48
1970–1978	(1.57–1.71)	246
1979–1994	2.79	291
1995–2000	2.48	139

Males

juvenile marked, recorded in summer roost

period	$e_{a1.0}$	n
1972–1978	(1.34–1.43)	173
1979–1994	1.89	17
1998–2000	2.33	20

adult marked, recorded in summer roost

period	$e_{a2.0m}$	n
1970–1978	(1.76–1.95)	128
1979–1994	2.67	56
1995–2000	2.80	112

adult marked, recorded in winter roost

period	$e_{a1.5m}$	n
1965–1969	(1.93–2.00)	54
1970–1978	(1.94–2.15)	299
1979–1994	2.81	90
1995–2000	2.04	70

For the 1960/1970s a relatively low life expectancy has to be assumed, which is clearly higher in the 1980/1990s. However, from 1965–1969 only in the case of adult marked ♀♀ recorded in the summer and/or winter roosts the data set is sufficient. In addition, the period with the lowest values (1965–1978) is marked by incomplete data sets, so that the statement is very uncertain, despite consulting last refind data and correction with presence data of higher age classes. Also appropriate dead refind data of juvenile and adult marked animals confirm for ♀♀ that there are too low values and a negative tendency, whereas for ♂♂ values correspond more to the reality, but do not exhibit a trend:

Females

period	e_{a0-1m}	n
1970–1978	1.81	73
1979–2000	1.57	28

Males

period	e_{a0-1m}	n
1970–1978	2.49	69
1979–2000	2.43	14

The Common pipistrelle ♀♀ usually reproduce in the 1st year and two young are born (Schober & Grimmberger 1998). The **reproductive rate** of 1.8–1.5 juveniles/adult ♀, which corresponds to a life expectancy of the normal population (mortality rate = reproductive rate) of 2.11–2.33 years. For the 1960/1970s population decreases are assumed followed later by a population increase. The marking and refind statistics, and also relevant documentation of occurrence in Thuringia (Treß et al. 1994) do not exclude this, but give more evidence for stable populations (Treß 1994) and substantial fluctuations in the refinds. Conclusive trend statements are therefore not possible. For the 1980/1990s the available data point to a rather stable to positive general population trend, which would correspond also to the overall estimate (Taake & Vierhaus 2004).

3.3.7.7.4 Reasons for the observed trends

The problems during the evaluation of Common pipistrelle s.l. data already concerned Steffens et al. (1989). Schmidt (1994b) refers to this when he writes on p. 133: “... a population of the Common pipistrelle s.l. of 1,000 ♀♀ with a survival rate of approximately 35 % (Steffens et al. 1989) would become extinct after approximately 15 years. That opposes completely field observations, and the applied methodology, refind evaluation of all roosts, markers and seasons are useless...“. This report suggested first, that Steffens et al. (1989) start from a survival rate which is too low. Nevertheless, this must be contradicted, because the fact of a very high annual mortality rate represented there (according to the data situation) apparently serves primarily to describe the problem: “... Since the latter (rapid population decrease) however did not occur at least to some extent, it must be stated that the *Pipistrellus pipistrellus* data reflects real conditions insufficiently...“ (Steffens et al. 1989, S. 350). Moreover it diverts from the core of the problem, by describing the applied methodology as useless, as this was intended to achieve usable results by selection of the data by roost types and seasons. During the evaluation of juvenile marked ♀♀ and ♂♂ Tab. 5–8, Fig. 13–18 in Steffens et al. 1989) the data almost exclusively refer to the investigations of H. Bork in the Demmin church, so that this problem cannot have been caused by the number of markers. Also the inclusion of further data (see chapter 3.3.7.7.3) do not lead to any progress – at least for the period of 1970–1978, during which the evaluations of Steffens et al. were made. The above mentioned therefore rather divert from the actual problem, namely the generally insufficient database for the Common pipistrelle s.l. According to Steffens et al. (1989) this has two causes:

1. higher age classes are under-represented due to discontinuous data collection.

2. higher age classes are under-representated due to fluctuations.

These statements were sufficiently supported with facts in Steffens et al. (1989) and are still valid. Principally annual mortality rates (q_x) > 50 % are not unusual in times of drastic population decreases or population fluctuations, as in the 1960/1970s for species like the Common pipistrelle s.l. (reproduction in the 1st year, 2 pups). However these values are, as already shown several times in previous chapters, appropriate for temporal and spatial dynamics, so that therefore a species must not necessarily become extinct.

From 1980–1997 hardly any juvenile Common pipistrelle s.l. were marked and adults were marked in too few numbers in the summer roosts and too intermittently marked and recorded in the winter roosts. Beyond that, appropriate investigations are made more difficult for the Common pipistrelle s.l. by the fact that roosts are frequently hard to detect and there may be changes of roosts resp. changes of the roosting places.

3.3.7.7.5 Conclusions for bat marking and population monitoring

For the Common pipistrelle s.l. there is an urgent need to develop co-ordinated programs for the marking and recording of marked animals in 3 to 4 reference territories of the bat marking centre Dresden with homogeneous occurrences (e.g. U. Hermanns for Rostock, D. Dolch for Krangensbrück, J. Haensel region Berlin, A. Hochrein Upper Lusatia, B. Ohlendorf Colbitz-Letzlinger Heide) and to perform these on a continuous long-term basis. These studies should concentrate on well recordable and appropriate well-known nursery roosts or such that have to be explored and are connected with winter roosts. The emphasis should therefore be on the marking of juvenile animals and their recording in the summer and winter roost, and at the same time facts corresponding to the reproductive rate have to be documented. Beyond that, in particular in winter roosts east of Berlin (J. Haensel), adult ♀♀ and ♂♂ should be continuously marked and comprehensively checked for marked animals. In addition, it may be necessary to determine the proportion of *P. pygmaeus*, and the conclusions of this could result in the evaluation of the older data.

3.3.7.8 Other species

3.3.7.8.1 Brandt's bat *(Myotis brandtii)*

With 1,536 recapture, in spite of the fact that they are almost exclusively of adult marked animals (1,384) and in particular ♂♂ (858), the data situation is still relatively favorable. For the entire observation period, only refind data of winter roosts are available (in particular F. Rüssel, M. Wilhelm and U. Dingeldey), for which the following values for life expectancy can be calculated:

🟩 **adult marked** ♀♀

period	$e_{a1.5m}$	n
1969–1979	2.50	10
1980–2000	3.45	44

🟩 **adult marked** ♂♂

period	$e_{a1.5m}$	n
1966–1970	3.00	30
1971–1976	6.00	114
1977–1984	6.50	143
1985–1994	5.91	198
1995–2000	4.23	69

From this, for the 1960/1970s for adult ♂♂ a relatively low **life expectancy** with higher values later can be assumed, and towards the end of the observation period (1995–2000) values are again declining. The results correspond quite well with Fig. 28 in Zöphel & Schober (1999) in that ♂♂ dominate Brandt's bat in the marking and refind statistics for this roost. However it has to be noted that population trends of ♂♂ are with regard to the reproductive rate also substantially dependent on that of the ♀♀, and in the above mentioned winter roost, from which the markings originate, the annual collection degree varies substantially due to conditions in the roost. For adult ♀♀ an increase in life expectancy in the 1980/1990s has to be assumed, but due to the few available data this is however very uncertain.

The statements given here also fit into the trans-national situation, where in the long term a similar variation in population size, probably with a general increase in winter roosts can be determined (Řehák & Gaisler 1999, Weinreich 1992) respectively to the increase in the 1980s (Georg 1994).

For the **reproductive rate** the bat marking centre Dresden does not have any data from special investigations from their scope of responsibility, so that a relevant alignment to the above mentioned values (in addition to the data in chapter 3.3.6 and Fig. 36) is not possible.

For **bat marking** and recording of marked animals the following main points are necessary:

1. Continous research at winter roosts in the Eastern Ore Mountains and separate documentation of results for adults and animals marked in the 1st year. Eventually there should be net catch during emergence and return from the winter roosts on the basis of a standardized sample method.

2. Continuation and long-term security of the marking program that started in 1996/1997 in Saxony-Anhalt (B. Ohlendorf, E. Leuthold) and the start of corresponding research (D. Dolch Friesacker Zootzen, G. Heise Damerow forest and others, K.-P. Welsch Schwarzbach) with special attention to obtaining a continuous recording percentage and document reproductive rates.

3. If possible a selection of 2–3 nursery roost communities in other regions for corresponding marking and recording programs should be made.

4. Monitoring of winter roosts in the catchments area of the studied nursery roosts and continuous recording of the populations by the presence of marked animals.

3.3.7.8.2 Leisler's bat *(Nyctalus leisleri)*

With 1,014 recaptures, predominantly ♀♀ (919) and among them approximately 50 % (463) juveniles, the data situation is likewise still favorable. However the systematic marking and report of refinds does not start before the end of the 1980s (in particular FFG Meiningen, D. Dolch), after appropriate nursery roost communities in areas with bat box had been established and experience in the middle of the 1990s showed an upswing (A. Claussen, B. Ohlendorf, M. Heddergott, E. Leuthold, K. Thiele). Trend statements for life expectancy are not possible therefore, however due to the investigations of Schorcht (1998) appropriate comparative statements to the reproductive and mortality rate and thus to the population trend and its causes can be made. For juvenile marked ♀♀ in the period of 1989–2000 (marking year and refind-class evaluation) and considering the settlement behaviour (non-reproducing ♀♀ in the first year of life stay only partly in the nursery roost community, see Schorcht 1998, p. 74) a **life expectancy** on the basis of a correction with presence data of higher age-classes (see chapter 3.3.5.4) $e_{a1.0}$ of 3.28 years results. Possibly this value is still somewhat too low, as the data set (marking year 1983–1993, refind classes 1996–2000) is not yet complete (see chapter 3.3.6 and Fig. 36). Schorcht (1998) determined for Leisler's bat from 1989–1997 a **reproductive rate** of 1.12 juveniles/adult ♀ (n = 340), with a sex ratio of juvenile ♀♀ to ♂♂ of 182 : 166, from which 0.59 juvenile ♀♀/ adult ♀ result. The presence degree of ♀♀ in the 1st year of life is according to the methodology represented in chapter 3.3.5.3 and according to past determinations approximately 10 % below that of the 2nd age group. This proportion of non-reproducing ♀♀ should accordingly still be considered. With a life expectancy of 3.28 years the AC_1 has a proportion of 30 %, i.e., the reproductive rate would have to be reduced again by 3 %, which however has hardly any effect. With a reproductive rate of 0.57 juvenile ♀♀/ adult ♀ a e_{an} a value of 2.75 results for the normal population (mortality rate = reproductive rate). Therefore for Leisler's bat, if the mortality rate in the 1st year (which is difficult to determine) is within the normal range, which investigations appear to support (Schorcht 1998, p. 78 ff.), a population increase can be assumed ($e_{a1.0} > e_{an}$ = mortality rate < reproductive rate). This is true at least for the parts of the population which reproduce in bat boxes. Schorcht (1994) relates the more frequent observations of Leisler's bat with the better observation possibilities due to bat boxes. Also the rapid upswing in the marking statistics and the enlargement of the nursery roost communities from 1989–1996 (Schorcht 1998) could be explained with resettlement from natural into artificial accommodation. The relationship from reproductive to mortality rate however makes it clear that all these processes also have something to do with the increased amount and development of appropriate habitats. From data of Schorcht (1998) a determined average age of the juvenile marked Leisler's bat ♀♀ in the year 1997 of 2.96 years and an average age of the normal population of 3.43 years can be calculated, from which again a population increase can be concluded (average age real population < average age normal population).

Therefore altogether a favourable conservation prognosis is very probable for communities of Leisler's bat reproducing in bat boxes. It is not yet possible to assess far this will have noticeable positive effects on the entire population of the species. With regard to the causes of the favourable relationship of reproductive and mortality rate concerning the reproductive rate one refers in particular to the problem of bat boxes that has already been discussed (e.g. chapter 3.3.7.6.4)

For **bat marking** and recording of marked animals of Leisler's bat the following main points are necessary:

1. Continuation of marking and recording programs of the above mentioned marking groups and single markers together with continuous documentation of reproductive rates.

2. Start of new programs in the area of Rostock (U. Hermanns) and in West-Saxony (F. Meisel, W. Mainer).

3. Systematic research into mating habitats and other intermediate areas as a contribution to continous recording of marked animals.

3.3.7.8.3 Northern bat *(Eptesicus nilssonii)*

With 686 recaptures, above all adult ♀♀ (585), the data situation is still relatively favorable. Marking and refind results originate particularly from nursery roosts communities in the Eastern Ore Mountains (G. Zapf and H. Tippmann) and in south Thuringia (FFG Meiningen). They cover the period in the first mentioned area since 1978 and in the latter since 1983. From this for adult ♀♀ the following **life expectancy** values ($e_{a2.0m}$) can be calculated:

1978–1982	3.93	n = 232
1983–1987	4.34	n = 191
1988–2000	5.77	n = 240

These results show a clearly positive trend, which however must be considered with some caution, as due to the difficulty in detecting the species and also because of partial intermittent studies, the data are very heterogeneous.

Only a few concrete data are available for the **reproductive rate** (e.g. Treß et al. 1989). The reported values and the fact that approximately 38 % of ♀♀ (usually in the 1st year) do not participate in reproduction, reproductive rates are of approximately 0.75–1.06, and thus life expectancy of the normal population (e_{an}) is in the order of magnitude of 2.9–3.7 years. This is clearly under the life expectancy as determined above, but this was calculated only on the basis of adult ♀♀, i.e. it does not include the usually higher mortality rate among juveniles. Nevertheless from these data (bearing in mind the determined ratio of the life expectancy between adult and juvenile animals for other long-living species, such as Greater mouse-eared bat) an increase in population size can be assumed. This is also suggested by Treß et al. (1989) and by the markings statistics, in particular in winter roosts, and similar results were also determined by Řehák & Gaisler (1999) for winter roosts in the Jeseniky-mountains. Altogether the determined population parameters give a favourable conservation prognosis for the Northern bat.

For **bat marking** and recording of marked animals the following main points are necessary:

1. Intensified research programs in nursery roosts in Southern Thuringia and in the Ore Mountains with the goal of obtaining a more continuous data set and to document reproduction data.

2. Start of an analogue marking and recording program for nursery roosts in the Harz.

3. Investigation of winter roosts in mountainous ranges. Starting and development of data sets for comparisons with results from nursery roosts.

3.3.7.8.4 Barbastelle *(Barbastella barbastellus)*

A total of 684 records are available for evaluation (Tab. 12) and comparison with the Northern bat, but data are more widely distributed between juveniles and adults, ♀♀ and ♂♂ respectively over different roost types. Marking and refind data are available since 1964, especially from J. Haensel and R. Geißler, and from nursery roosts (juveniles and adults) since 1986, especially from D. Dolch. From this the following **life expectancy** ($e_{a1.0m}$) for ♀♀ and ♂♂ can be derived:

Females		
1964–1976	1.83	n = 53
1977–1993	3.26	n = 150
1994–2000	4.28	n = 140

Males		
1964–1976	3.09	n = 136
1977–1993	2.84	n = 173
1994–2000	(4.48	n = 95)

This shows that for ♀♀ a clearly positive trend can be recognized. This appears both for juvenile and for adult marked animals, and applies for summer and winter roosts, although for the period of 1964–1976 only relative few data are available to support this. For ♂♂ no clear trend can be recognized, particularly as the data for the period from 1994 to 2000 are very unbalanced and therefore have only limited suitability for refind class referred evaluations.

Concerning the **reproductive rate**, results from Dolch et al. (1997) as well as of Dolch (in litt.) are available, which indicate that ♀♀ usually already begin to reproduce in the 1st year, only occasionally give birth to 2 pups, and 92.6 % (n = 149) are involved in reproduction. From this a life expectancy of the normal population (mortality rate = reproductive rate) of 3.16 years results on the basis of the reproductive rate. For the Barbastelle a population decrease in the 1960/ 1970s followed by a subsequent increase can be found. This population decrease with a low in the 1970s is supported by the marking statistics. In Thuringia the population starts to increase in the 1980s (Treß et al. 1994; Weidner & Geiger 2003). Schober & Meisel (1999) report on stable populations and there is altogether a positive conservation prognosis on the basis of population parameters.

For **bat marking** and recording of marked animals the emphasis should be put on:

1. Continuation of the research program of D. Dolch (Horstmühle),

2. To build up and continue marking and recording programs for 3–4 nursery roosts (e. g. U. Hermanns – area of Rostock, U. Hoffmeister – Alt-Zauche and others, B. Ohlendorf – Southern Harz and foothills, F. Meisel – area of Leipzig, J. Fischer – Behrungen) including a continuous documentation of the reproductive rate.

3. Continuation of marking in winter roosts of R. Geißler in Northwest Saxony and J. Haensel in Rüdersdorf and surrounding area, for comparison with data from nursery roosts.

3.3.7.8.5 Serotine *(Eptesicus serotinus)*, Whiskered bat *(Myotis mystacinus)*, Grey long-eared bat *(Plecotus austriacus)*, Bechstein's bat *(Myotis bechsteinii)*

The data situation available at bat marking centre Dresden does not permit any statements for these species that go further than those given in chapter 3.3.6/Fig. 36, both regarding life expectancy and their trends and reproductive rates. Therefore for these species generally, more attention should be paid to bat marking programs and new marking programs are particularly desired. In detail the following should be the priorities of marking programs:

Serotine

- Continuation of marking and recording of roost communities Groß Schönebeck by J. Haensel . Build-up and continuation of 3–5 comparable projects for this widely distributed bat species including documentation of reproductive rates in more provinces.
- Exploration of winter roosts and a general intensified marking and recording in winter roosts of Serotine, especially in the surrounding of nursery roost communities.

Whiskered bat

- Continuation of marking and recording in winter roosts in the Eastern Ore Mountains (M. Wilhelm et al.) and the Harz (B. Ohlendorf et al.).
- Intensification and continuation of marking programs in nursery roosts in Thuringia (FFG Meiningen) and Saxony-Anhalt (B. Ohlendorf, E. Leuthold) including data collection for reproductive rates. Commencement of comparable programs in other provinces.

Grey long-eared bat

- Intensification of marking and recording in nursery roosts at the Rhön (FFG Meiningen) as the only nursery roost with long-term data collection, and eventual start/ restart of comparable, programs in Saxony-Anhalt and Saxony, including documentation of reproductive rates.
- Continuation and eventual intensification of marking and recording in winter roosts in the area of Berlin (J. Haensel) and start/restart of such programs at further promising locations.

Bechstein's bat

- Intensification and continuation of marking programs in bat roost areas in Thuringia (FFG Meiningen) and Saxony-Anhalt (B. Ohlendorf). Start of comparable programs at other suitable locations (e. g. Rochauer Heide – U. Hoffmeister, Ziegelrodaer Forst – B. Lehmann), including documentation of reproductive rates.
- Continuation and eventual intensification of marking and recording in winter roosts in NE-Brandenburg (J. Haensel) and in the Altmark (B. Ohlendorf et al.). Exploration of further suitable winter roosts.

3.3.7.8.6 Parti-coloured bat *(Vespertilio murinus)*, Pond bat *(Myotis dasycneme)*, Soprano pipistrelle *(Pipistrellus pygmaeus)*, Lesser horseshoe bat *(Rhinolophus hipposideros)*

For these species so far no statements on survival rates, life span, life expectancy etc. are possible on the basis of the data from the bat marking centre Dresden. However, from current investigations in nursery roost communities of the Pond bat (R. Labes) as well as the Parti-coloured bat (U. Hoffmeister) appropriate results can be expected in the foreseeable future. For both species appropriate marking and recording programs should be started (e.g. Pond bat D. Dolch, Parti-coloured bat U. Hoffmeister), as soon as further nursery roost communities and winter roosts become available. For the Soprano pipistrelle, which has only recently been separated from the Common pipistrelle, initial marking programs (e.g. J. Teubner, D. Dolch) are just starting. It is desirable that such investigations are carried out at 4–5 nursery roosts which are homogeneous for Soprano bats in the catchment areas of the bat marking centre Dresden (e.g. U. Hermanns – area Rostock, G. Heise – Uckermark, B. Ohlendorf et al. – Elbe/Altmark, T. Frank – Moritzburg). In addition comparable research should start for sufficient Common pipistrelle roosts (see chapter 3.3.7.7.5) in order to be able to define both species ecologically from each other.

For the Lesser horseshoe bat, apart from a few markings in connection with a necessary resettlement and some refinds related to this single event, no markings were made in the catchment areas of the bat marking centre Dresden because of species protection. New, or the re-commencement of appropriate projects should be examined technically on a mid-term time frame.

3.3.8 *Calculation examples for population development of selected bat species*

Population trends can be calculated directly from the ratio of reproductive to mortality rate. In the following this exercise is performed for Greater mouse-eared bat, Noctule, and Nathusius' pipistrelle, for which we have an adequate database for both the reproductive and mortality rate.

According to chapter 3.3.4 the following formula applies:

$$N_t = N_0 \cdot e^{rt}, \text{ with } r = b - d.$$

Here d corresponds to the mortality rate of the population q_x. The reproductive rate (juveniles/adult ♀) refers, however, only to adult ♀♀ (in our case AC_1 to AC_n). It must therefore still be supplemented by the disappearing AC_0 (in case it takes several years until sexual maturation and the additional age groups) and reduced for the ♀♀ proportion in order to obtain the same population relation for d and q_x. This can easily be performed here, as in the population the survival rate of the AC_0 (l_0) can be deduced as follows (see chapter 3.3.2.1, Tab. 10):

$$l_0 = \sum_{x=0}^{n} l_x - \sum_{x=1}^{n} l_x = e_{x0} - (e_{x0} - 1)$$

Therefore the reproductive rate (the proportion of reproducing ♀♀ of the age classes AC_1 to AC_n) has to be multiplied with the following factors:

$$\frac{\sum_{x=1}^{n} l_x}{\sum_{x=0}^{n} l_x} = \frac{e_{x0} - 1}{e_{x0}}$$

The following growth rates (b) and population growth rates (r) result:

- For the Greater mouse-eared bat

1965 to 1976 $\quad b = \frac{0.74}{2} \cdot \frac{3.15 - 1}{3.15} = 0.25 \qquad r = 0.25 - \frac{1}{3.15} = -0.07$

1977 to 1985 $\quad b = \frac{0.75}{2} \cdot \frac{4.97 - 1}{4.97} = 0.30 \qquad r = 0.30 - \frac{1}{4.97} = 0.10$

1986 to 2000 $\quad b = \frac{0.80}{2} \cdot \frac{5.00 - 1}{5.00} = 0.32 \qquad r = 0.32 - \frac{1}{5.00} = 0.12$

- For the Noctule

1970 to 1983 $\quad b = 0.73 \cdot \frac{2.20 - 1}{2.20} = 0.40 \qquad r = 0.40 - \frac{1}{2.20} = -0.05$

1984 to 1992 $\quad b = 0.73 \cdot \frac{2.52 - 1}{2.52} = 0.44 \qquad r = 0.44 - \frac{1}{2.52} = 0.04$

1993 to 2000 $\quad b = 0.73 \cdot \frac{2.68 - 1}{2.68} = 0.46 \qquad r = 0.46 - \frac{1}{2.68} = 0.09$

- For Nathusius' pipistrelle

1978 bis 1991 $\quad b = 0.90 \cdot \frac{2.88 - 1}{2.88} = 0.59 \qquad r = 0.59 - \frac{1}{2.88} = 0.24$

1992 bis 2000 $\quad b = 0.90 \cdot \frac{3.21 - 1}{3.21} = 0.62 \qquad r = 0.62 - \frac{1}{3.21} = 0.31$

From this we can derive the development of fictitious populations with the same start and lowest population level over species specific time periods (Fig. 44).

These results cannot reflect the dynamics inherent in individual communities, as they are abstracted from the local features and are levelled out by generalizations for certain time periods or short term incidents. Accordingly the turning points of the curves (Greater mouse-eared bat, Noctule) are fixed by the time periods used, but in reality there is a longer transient area. By considering all of this and in comparison with appropriate population investigations, these results are, however, a substantial basis for the quantitative estimation of the spatial spreading of the actual population development.

For the **Greater mouse-eared bat** (Fig. 44) it has to be stated first that, while considering the above mentioned restrictions, trends and change of trends agree with appropriate regional and trans-national data sets (for sources see 3.3.7.1.3). At the nursery roosts in Freienwalde (Haensel 2003) and Niewisch (Schmidt 2001b) populations have increased from the end of the 1970s to the end of the 1990s by a factor of 5–10 times, in the viaduct at Steina (Zöphel & Schober 1999) from 1986 to 1999 by a factor of 2–3 and according to our calculations even by a factor of 5–15. From this one could assume that our calculations are too high. However, it has to be noted that roost communities cannot grow for an unlimited period, but that in the phase of population growth emigration and foundation of new communities occur (see e.g. Göttsche et al. 2002). Since these factors are only known to a limited extent, our computations lead in combination (if necessary also after calibration) with appropriate population investigations to an altogether more comprehensive estimate of the actual order of magnitude of the population development. However it cannot be excluded that our results refer particularly to optimal roost and/or living conditions (that have also survived the critical phases). Under other (suboptimal) conditions it is possible that reproductive rate and life expectancy are lower, which could lead altogether to conditions that are lower than our calculations, or lead to such conditions in the foreseeable future. At the present general trend nothing would probably change, and to pursue the future development is an interesting task from a population ecological point of view.

For the **Noctule** there is a general lack of data and the curve shape for the 1970s is only supported by data of Schmidt (2000c, Fig. 6, p. 267) (Fig. 44). It will therefore not be discussed further. In more recent years (1993–2000) according to our calculations the population size has trebled. According to Schmidt (2000c) populations grew by five times in the same period in East Brandenburg and from 1986–2002 four times in the Melzow forest (Heise et al. (2003). From this, one could conclude that our calculations are too low. This possibly reflects only regional differences in the reproductive and mortality rate. A. Schmidt (pers. comm.) determined e.g. 1.71 juveniles/adult ♀ (n = 34), whereas we used only 1.48 (see chapter 3.3.7.5.3). From Heise & Blohm (2003) a life expectancy ($e_{a1.0}$) of 2.92 (marking years 1990–1996) and of 2.79 (refind years 1997–2002) can be determined in the Melzow forest. We used 2.52 for the entire data from 1984–1992 and 2.68 for the years 1993–2000. If we had used the values for life expectancy as determined by Heise & Blohm (2003), then the population increase in the Melzow forest would have been five to eight-fold from 1986–2001, which is well conceivable. Such an increase in the appropriate population data is probably, as described for the Greater mouse-eared bat, no longer apparent in the data set due to migration (colony re-establishment etc.). An indication for this is the (apparently?) smaller life expectancy from 1997–2002 compared with 1990–1996 in the Melzow forest, which in addition is a further example of the problem of marking and recording in the same roost site (see chapter 3.3.5.7). Altogether it can be concluded from the calculations and comparisons with results for the Noctule that whenever possible data from several trans-national and long-term studies should be available, in order to obtain reliable results.

The most impressing development was calculated for **Nathusius' bat** (Fig. 44). For this species the population grew in 22 years (1978–2000) on the basis of available data on life expectancy and reproductive rate (see chapter 3.3.7.6.3) by approximately 370 times. This development is also confirmed by Schmidt (2000c, Fig. 8, p. 268), where populations in nursery roost areas rose first (1980–1986) by approximately 5–6 times, and were then

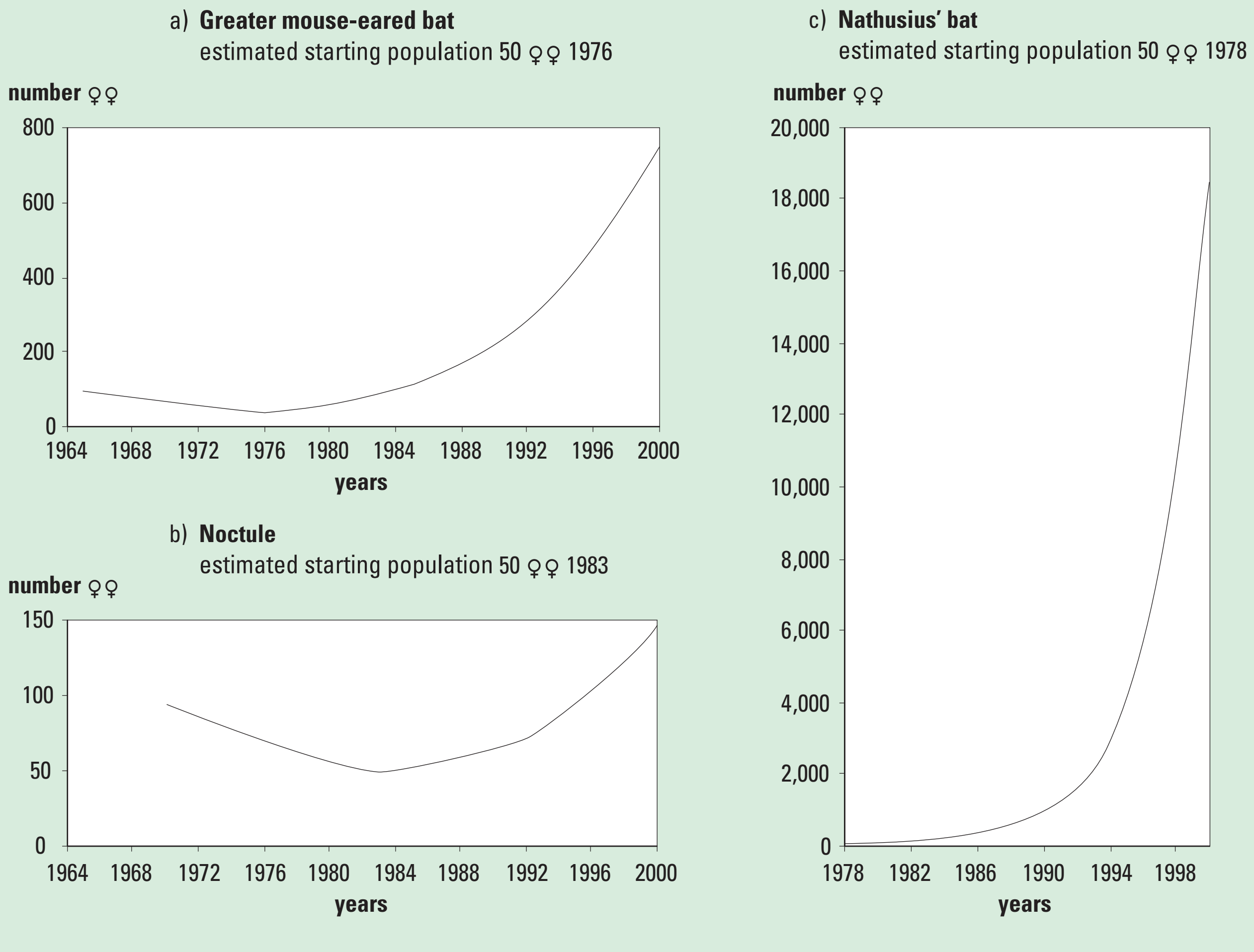

Fig. 44: Calculated population development for Greater mouse-eared bat, Noctule and Nathusius' bat on the basis of species specific periods and growth rates .

subject to stronger fluctuations (until 1998) and finally annually by about 15–20 times the starting population. For the period of 1980–1986 our calculations result in a population growth of 4 times. The lower values have presumably the same causes like for Noctule (s. 3.3.2.2 life expectancy AC_1 3.25 years after Schmidt; 2.88 resp. 3.21 years by own calculations).

Later on the results of Schmidt (2003) are in agreement with Schmidt (1994b) and affected by increasing emigration, which is also indirectly supported by recent finds of new summer roosts (e.g. Iffert 1994) and population spreading tendencies in Europe (e.g. Vierhaus 2004). Nevertheless our calculations represent not the real population development, but only the developmental potential in areas with bat boxes. Apart from regional differences that again have to be considered, it also has to be assumed (in agreement with chapter 3.3.7.6.4) that emigrating animals do not all meet equivalent conditions as in the bat box areas, by which both reproduction success and life expectancy can be limited. In addition, the reproductive rate may also have been reduced in well-occupied districts, for which so far no information is available.

The results of Schmidt (2000c) and our calculations show the variation in the development. The publication of additional regional results (e.g. of the Wooster Teerofen and from the Müritz-area) as well as the still ongoing research of Schmidt (1994) is therefore much desired. In addition, comparative investigations under undisturbed conditions (in particular natural tree holes) are recommended.

Furthermore it is remarkable that for the Noctule and Nathusius' bat calculated results fit very well with population developments despite the level of juvenile mortality (computation of the life expectancy can for methodical reasons only start from AC_1). On the one hand this can be explained with an approximation of juvenile mortality to those of the adult animals in times of positive population developments (see e.g. chapter 3.3.7.1.3); on the other hand the mortality rates of adults are probably too high due to the problem of emigration (see chapter 3.3.5.7), which will overall result in a certain compensation. Particularly in the situation with changes between positive and negative population trends the calculations possibly will react more delayed starting from AC_1, because the juvenile mortality rate as the more strongly variable element is not sufficiently considered (see chapter 3.3.7.1.3).

3.3.9 Summary and conclusions from survival rates and other population parameters

On the basis of appropriate methodical defaults (chapter 3.3.2–3.3.5) and the data situation in the bat marking centre Dresden the following summary of the results for the different bat species can be given:

- For Greater mouse-eared bat, Noctule and Nathusius' pipistrelle plausible survival curves can be calculated, corresponding parameters can be differentiated in respect to time periods and by comparison with population growth population trends can be estimated and calculated.
- For Daubenton's bat, Natterer's bat, Leisler's bat, Northern bat, Barbastelle, Brown long-eared bat, Common pipistrelle s. l. and Brandt's bat the same is true as for the above mentioned species although the conclusions on survival rate and reproductive rate are not based on a similar robust data set, so that population trends can only be estimated and discussed using additional information.
- For Serotine, Whiskered bat, Grey long-eared bat and Bechstein's bat initial survival curves can be given without the possibility of additional interpretations.
- For Parti-coloured bat, Pond bat, Common pipistrelle (sensu stricto), Soprano pipistrelle and Lesser horseshoe bat up to now no conclusions on survival rates are possible.

Generally the following recommendations for bat marking programs can be drawn:

1. Continuation of the long-term programs of marking juveniles and recording of marked animals in nursery roosts (and where possible in alternative roosts) including determination of reproductive rate and year of the first reproduction of ♀♀ for Greater mouse-eared bat, Noctule and Nathusius pipistrelle and improvement of the spatial distribution.
2. Intensification of programs to obtain long-term data sets for Daubenton's bat, Natterer's bat, Common long-eared bat, Leisler's bat and Barbastelle and eventually successive replacement of marking in winter roosts that are still currently necessary.
3. Intensification of programs for Northern bat, Brandt's bat and Whiskered bat with the aim of continuous marking and recording in nursery roosts and winter roosts, and collection of data for determination of reproductive rates.
4. Commencement of comparable programs and obtaining additional and increasing data sets for Soprano

pipistrelle, Common pipistrelle (sensu stricto), Bechstein's bat, Parti-coloured bat, Pond bat, Grey long-eared bat, (Lesser horseshoe bat).

Beyond that, the available investigations should serve as preliminary studies for the development and/or adjustment of appropriate mathematical models, in order to improve the use of our refind data for the estimation of survival rates considering the many measured variables.

4 Bat marking and bat protection

Bat marking is firstly a scientific method, which can serve bat protection, but always involves at least some disturbance of the animals that are marked and recorded. From the beginning bat protection had highest priority in East Germany in relation to bat marking. Selection procedures and qualification tests for bat markers are fully devoted to these principles. The ideal was that the efforts connected with preventive measures resulted in questions, that could be solved using marking, e.g.:

- Which roosts and alternative roosts are connected within a bat community and therefore have to be protected as a complex?
- Which seasonal migrations are performed by the different species, so that sufficient protection can be given to both summer and winter roosts including the intermediate roosts?
- How are summer roosts connected to hunting areas?

This publication and the many references quoted herein give a good example for all these efforts. In addition, some the above-mentioned questions could only be solved in part with the classical marking method. Modern techniques, e.g. telemetry, now also offer important additional methods.

On the other hand, in connection with the extensive bat marking experience has been gained on the distribution and ecology of the species and acute threats are recognized. Observations on the social behaviour of the species, general and specific requirements of nursery roosts and winter roosts, roosting places etc. are indispensable for roost protection. Bat markers have therefore been substantially involved in the development and installation of bat boxes. Bat markers and the marking centre were engaged and took a leading role in practical roost protection and for support of some bat roosts. The fact that many nursery roosts in buildings, winter roosts in cellars and mine galleries were defined as protected bat roosts and that entrance openings were locked bat-friendly, were and are also positive results of bat markers in personal co-operation with conservationists.

Finally with appropriate systematic roost recording, connected with marking and recording and determination of adult/juvenile ratios, not only information on population trends but also on age distribution of animal communities can be obtained. Furthermore, information is gained on the relationship of mortality and reproductive rate and by this also the necessary results for the conservation condition of various species, the causes and consequences. Thus the specific degree of threat and required action becomes much more reliable and above all becomes apparent with regard to future needs. Also in this sense the present publication would like to inform and inspire.

As already mentioned, bat marking and recording of marked animals may, cause injury and thus may also pose a threat. The appropriate lower arm clips can lead to inflammation and injury of the wing membrane (e.g. GRIMMBERGER & BORK 1978), particularly when using bird rings, or clip ring material which is too soft or clips which have been insufficiently deburred (e.g. HEISE 1982). In addition even after gradual improvement of the clip – quality and optimization of its form and size as well as careful marking, damage cannot completely be excluded.

The catching and marking of the animals clearly involve disturbance, and this can be substantial particularly in nursery roosts and winter roosts, and may lead for the former to a change of the roost and in the latter to waking up and loss of energy. Appropriate marking and recording should therefore be accomplished outside of the roost or in the phase of the dissolution of the nursery roosts and at the beginning or at the end of the winter hibernation. The drastic decrease of bat communities in winter roosts was also partly attributed to disturbance in connection with marking and recording (e.g. JENSEN & BAAGØE 1984, VEITH 1996) and led to the situation where relevant activities in such roosts were forbidden or strongly limited. Today we know that such a connection did not exist. Nevertheless also today the demand of RICHTER (1970), EISENTRAUT (1972) and HIEBSCH (1972) still has to be followed so that in the case of doubt the priority has to be given to bat protection and marking should only take place for a clear scientific goal, which cannot be solved in a different manner.

The main aspect of bat conservation always asks for a careful and scientific based evaluation as to whether:

- The respective marking program will result in a reasonable knowledge increase especially for important conservation-related questions.

- The necessary conditions can be expected for a successful program including all aspects until data evaluation can be given and results, as mentioned above.

- There are no alternative methods without disturbance available.

- The place and time point of marking and recording are optimized in the sense of minimizing all disturbance and activity is restricted to the amount necessary for the corresponding research question.

The approval of bat marking on the basis of reviewed and evaluated marking programs in addition to regular bat marker workshops and education courses form a good framework for this.

5 References

5.1 References on bat marking in East Germany

(Cited references are marked with a *; further cited references see chapter 5.2)

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