THE LESSER HORSESHOE BAT *RHINOLOPHUS HIPPOSIDEROS* IN SWITZERLAND: PRESENT STATUS AND RESEARCH RECOMMENDATIONS

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ABSTRACT

Once the lesser horseshoe bat *Rhinolophus hipposideros* (Bechstein, 1800) was known to be widespread and common in Switzerland. In the past 50 years their overall population has undergone a severe decline, as in most countries of Central Europe. With the aim to build a conservation research concept, we collected information about the current status of the remaining regionals populations in Switzerland and made an evaluation of the causes of their decline. Then we developed a research program based on the most important research recommendations.

The evaluation of the present status of the populations in Switzerland in 2000 reveals 39 nursery colonies with about 1700 adult individuals, distributed over eight Cantons, mainly in the alpine area. 95% of the animals are found in four clusters of colonies, which could represent separate populations. 55% of the colonies have shown an increase in numbers, 27% have remained stable and 18% have decreased over the last 10 years.

Following an evaluation of possible factors and an enquiry with bat experts, the most threatening factors are thought to be pesticides, changes in the structure of habitats and food shortage. Therefore we propose the following research topics with high priority: resource exploitation, pesticide contamination and the development and implementation of refined methods for monitoring populations. Moreover, depending on the results of the first research phase, studies about population dynamics, roost conditions, climate, populations genetics and the colonisation potential of these animals could be included in a second phase. Further we propose to carry out regional public enquiries to find more roosts in private houses and to build action plans to implement protection schemes.

INTRODUCTION

Since the 1950s or 1960s lesser horseshoe bats *Rhinolophus hipposideros* (Bechstein, 1800) have undergone a severe decline in most of western and Central Europe (review in STEBBINGS, 1988, OHLENDORF, 1997a). The same dramatic development was recorded in Switzerland, where lesser horseshoe bats were once widespread and common. Today only some isolated populations remain in the alps (STUTZ & HAFFNER, 1984). The exact reason(s) for this decline is/(are) not known. Moreover, it is not clear whether the remnant colonies are still confronted with the problems that led to their decline or whether the situation has changed in the meantime. Therefore, no focused conservation scheme could be developed up to now; and it is not surprising that roost protection has always been given the priority. There is definitely a need for a broader knowledge of the problems faced by the species so as to propose effective conservation measures that may be implemented, first, to foster the recovery of small populations and, second, to promote the progressive recolonisation of once inhabited but today abandoned areas.

We present here an evaluation of the causes of the decline of these bats in Switzerland, give an overview of the recent distribution of colonies of the lesser horseshoe bat and, as conclusion, we suggest a conservation research program which includes the major research recommendations.

This concept for an applied research program was requested by the Scientific Board of the Swiss Bat Coordination Centre with the intension to define a conservation plan for this threatened species based on scientific results.

We hope that the implementation of the conservation measures which will be drawn from the proposed investigations will enable the responsible authorities to act efficiently for the conservation of this highly endangered bat species.

METHODS

Status in Europe

We summarize the information gathered at the International Workshop on Rhinolophids, held at 1995 in Nebra, Germany (OHLENDORF, 1997a). The status for Austria, Germany, Italy and Great Britain was updated by contacting experts working with the species in the respective countries.

Status in Switzerland

Regarding the current situation and most recent trends in Switzerland, we obtained good data from an enquiry addressed to all Swiss regional bat coordinators (RFE/CR) and to experts. On the enquiry form, we requested information on all known colonies (with the maximum number of adult animals counted between 1990 and 2000) and also asked whether the colony had decreased, was stable or had increased during the 90s. We also requested additional data on monitoring to see whether precise population trends could be documented.

Potential causes of the decline

We performed an analysis of the potential causes of decline of *R. hipposideros*. For this purpose, we used three sources. Firstly, referring to the literature, we listed all the potential causes suggested by various authors. Secondly, two of us made our own list of potential factors, those which seemed the most relevant ones to us and, thirdly, we asked all Swiss regional coordinators, during the enquiry described above, to make their own appraisal of possible factors. The estimation was made on an interval scale, ranging from 0 (irrelevant factor) to 5 (very relevant factor). The scores from the experts were averaged and the factors listed in decreasing order of rank.

Research recommendations

To establish priorities for research, we took into account the following constraints, either set by the framework of the mandate or by ourselves:

- The research program should be realistic and provide a description of research topics, priorities, possible study areas and time schedule.
- Poor knowledge in some fields ranked as relevant for conservation (see above) must dictate research priorities.
- *A posteriori*, comparative research has to be envisaged, particularly as experimental work is hardly feasible with this highly endangered species.
- Comparative analyses should take advantage of the various geographical situations available in Switzerland, and of the various demographic situations: extinct vs. extant populations of lesser horseshoes, increasing vs. decreasing colonies, etc.
- Research (retrospective) will be carried out in priority in areas where population trends have been sufficiently documented in the long-term or at colonies with the best chance of population increase (prospective).
- The proposed research program includes control procedures.

Database of literature

To generate a comprehensive list of literature we collated information from the following sources:

Database from Réseau Chauves-souris Valais, December 1999

“Centre de coordination ouest pour l’étude et la protection des chauves-souris” (CCO) database, December 1999
“Koordinationsstelle Ost für Fledermausschutz” (KOF) database, June 1997
NISC – Wildlife Worldwide, Mars 1997
Database from Guido Reiter, Austria, August 1998
Database from Fabio Bontadina, December 1999

ESTIMATION OF THE STATUS OF THE SPECIES AND ITS DEMOGRAPHIC TRENDS

Europe

We present here a brief review of some data about the present status and recent demographic tendencies of *R. hipposideros* in Central Europe. For a more detailed overview, consult STEBBINGS (1988), KULZER (1995) and OHLENDORF (1997a). *Rhinolopus hipposideros* has become a rare species in Central Europe. This is particularly true for the Netherlands and Benelux countries where the species is almost extinct at present (Fig. 1, FAIRON, 1997). A strong decrease in, and a fragmentation of, populations is reported from Northern- and North-East France. The remaining populations are estimated to number 1700 animals (DUBIE & SCHWAAB, 1997). In the rest of France, some 10 – 11'000 individuals were censused in 1995 (ROUÉ, 1997). In the east and south-east of Germany, some 600 lesser horseshoe bats are counted in winter roost, and half of this number is found in summer roosts (M. Biedermann, 1997, *pers. com.*, H. Geiger, *pers. com.*, OHLENDORF, 1997b, A. Zahn, *pers. com.*). Austria still reports some strong populations, especially in Carinthia and Styria. In total several thousand individuals are reported (SPITZENBERGER, 1997, G. Reiter, *pers. com.*). Both have found, populations with steep downward trends and also roosts with population recoveries. In the South of Poland, less than 500 animals are known and the populations are estimated to total about twice this number of individuals (Kokurewicz, *pers. com.*). In the Czech Republic the total population comprises some 3800 animals (Gaisler, *pers. com.*). A discountious distribution is documented with some trends of recent population recoveries (GAISLER, 1997). Countries in Eastern Europe still harbour large lesser horseshoe bat populations, although some signs of decreasing numbers are reported there, too. In many countries of southern Europe, little information exists about the current status and the demographic tendencies of this species. In general they seem to be common, but there are also many reports of lost colonies.

[Figure 1]

[Figure 2]

Switzerland

There are numerous data attesting to population crashes in Switzerland in the 50s–70s (see the example in Fig. 2). However, according to our enquiry, at least eight Swiss cantons still harbour the species at present (1999). These are the cantons of Bern (BE), Grisons (GR), Fribourg (FR), Neuchâtel (NE), Obwalden (OW), St. Gallen (SG), Solothurn (SO) and Valais (VS). Fig. 3 shows the distribution of 39 known nursery colonies active from 1990 to 1999, whereas Table 1 presents a list of these nursery colonies during the past 10 years, with the hightest number of adult animals counted and recent demographic trends. The total number of adult lesser horseshoe bats counted in all roosts is about 1400 animals. We estimate the actual population size to be about 2000 adult animals, some 1.5 times as many animals as the number counted in the nursery roosts.

Although many caves have been controlled during winter time in Switzerland, only few winter roosts (with mostly single lesser horseshoe bats) have been found. Because small caves and crevices are available in large numbers in the alpine area, the census of bats in winter roosts cannot be used to estimate population size in this area.

32 out of 39 colonies seem to be aggregated as clusters of colonies which could represent separate populations (marked with circles in Fig. 4). More than 95% of the animals are found within these four main populations. All but one of the larger colonies are situated within these clusters (Fig. 5).

As regards population trends within those 39 nurseries, 31% showed a recent increase in number, 15% appeared stable, whereas 10% were decreasing; it should be noted, however, that 44% (n = 17) of all nursery sites did not yield data precise enough to estimate population tendencies (Table 2). When considering only the sites with sufficient data to document exact trends (n = 22), we found that 55% of them exhibited an overall population increase, 27% seemed stable, whereas 18% only exhibited a marked decrease. These results suggest that some populations might well be undergoing a positive development, as exemplified by a maternity roost in Obwalden (Fig. 6).

[Figure 3] / [Table 1]

[Figure 4] / [Figure 5]

[Table 2] / [Figure 6]

POTENTIAL CAUSES OF THE DECLINE AND EVALUATION OF THEIR RELEVANCE

The evaluations by bat experts matched each other, demonstrating concording views about the possible origins of decline. A list of the most relevant factors, according to the questionnaire sent out, is given in Table 3. Comments to the eight possible factors are given in the next paragraph. In Table 4 suggestions for priorities in conservation research are listed, ranked according to the number of times it was mentioned by the Swiss regional coordinators.

[Table 3]

[Table 4]

We present now the comments of two of us (FB & RA) about possible causes of decline, separating the factors in two main classes: abiotic and biotic factors, although both clearly interact and may correlate.

The signification of the symbols (in bracket) is as follows:

• *a priori* not a relevant factor

•• factor that might play / have played some role but further evaluation is required

••• factor ranked as a major potential cause of decline.

The sections 'Comment' presents a justification of our classification into one of these three categories.

Abiotic factors

Pesticides (•••)

The extensive use of pesticides began during the period of World War II, particularly in agriculture. Many animal species began to decrease soon after, as exemplified by raptors (*Falco peregrinus*, *Accipiter nisus*, etc.) that were heavily contaminated by organochlorined pesticides (DDT, etc.). Horseshoe bats may have faced the same problem. Yet, those raptors have now largely recovered in Europe, including Switzerland, whereas there has not been such a dramatic increase in horseshoe bat populations. It should be pointed out that a slower population recovery in bats may be due to their lower reproductive rate. The effects of pesticides may be the contamination of the food chain (abiotic) and/or a decreasing food availability (biotic, discussed in next section).

Comment: The hypothesis that pesticides may be responsible for the decline of the lesser horseshoe bat is appealing as it typically represents a global effect. Recent investigations have shown that some pesticides act as hormones and can then potentially interfere with reproductive ability. If pesticides are the main factor of decline, we would expect to observe population recoveries unless pesticides especially harmful to horseshoes are still in use. A research project exists in this field in Switzerland, but conclusive results are not yet available. The main problem is that even if one finds a correlative evidence of a relationship between environment contamination and bat population status, the causality is not demonstrated. Also, this would raise the question whether the incriminated pesticides still persist in the environment and therefore constitute a permanent source of contamination.

Changes in the physical structure of habitats (•••)

Lesser horseshoe bats exploit cultivated landscapes such as farmland or woodland (BONTADINA *et al.*, 1999), two types of habitats which have faced dramatic modifications since World War II. Traditional insect-rich meadowland and pastureland have been changed into crops, whereas forest patches, hedgerows and single trees have been systematically eradicated. This has resulted in a loss of overall habitat diversity and connection, whilst rendering the overall landscape more homogeneous. Moreover, cattle and small domestic animals were banned from Swiss forests early this century, which certainly implied further losses in vegetation patchiness and vertical structure within woodlands. A direct influence of this is of course a global drop in the available insect prey biomass (see biotic factors).

Comment: Habitat changes are ranked among the probable major factors of decline. However, as many areas still harbour highly structured landscapes but no lesser horseshoe bats any more, habitat destruction may explain the extinction of local populations, but certainly not the whole phenomenon of the decline of lesser horseshoes across most of Western Europe. Regarding the changes in woodlands, they may have been largely underestimated. Major changes in farming practices could have had a large scale impact on lesser horseshoe bats.

Loss of roosts and roost deterioration (••)

Lesser horseshoes in Switzerland used to roost in large lofts (attics, mostly during the summer) and in underground cavities (mostly outside the summer). The renovation of buildings and a decrease in mining activity may have reduced the number or quality of roosts available to bats (e.g. through the insulation of roofs, which deteriorates thermic conditions).

Comment: Lost of roosts and roost alteration could have played a role locally, but they would hardly be able to explain the widespread decrease of the species in western Europe.

Climate changes (••)

Fluctuations in climate may cause alterations in distribution and population sizes; a climatic optimum actually took place in the late 40s and early 50s, i.e. just before lesser horseshoes began to decline.

Comment: The decrease of *R. hipposideros* took place almost simultaneously in much of western Europe. This supports the hypothesis of a global effect. If global warming starts to affect earth, we should soon expect a population recovery. If climate is the main factor, there are no special measures to implement for species conservation. However, the fact that *R. hipposideros* was an abundant species in Switzerland early this century, when the climate was not significantly warmer than today, contradicts the scenario of a great thermic dependence as a single acting factor.

Biotic factors

Food shortage (•••)

The availability of insect prey to bats has certainly decreased significantly in the past decades in most of western Europe. This is thought to be mainly due to habitat transformation (farmland into human settlements), the use of pesticides (dramatic drop in insect prey biomass; for contamination see abiotis factors), changes in agriculture (meadows into crops, pastures into arable land) and sylviculture (deciduous into coniferous trees), among others. As a result, many relevant habitats no longer exist or do not provide enough insect biomass. This may have affected lesser horseshoes.

Comment: As food is usually the most important condition for species existence and reproduction, this hypothesis should be given a high priority. However, little is known about insect availability in the past. It is noteworthy that lesser horseshoe bats have gone extinct in areas where changes in food supply have certainly been slight and this factor cannot explain the complete disappearance of some populations.

Competition against other species (••)

Recent investigations have suggested that some bat populations have probably dramatically increased in the past decades, presumably as a consequence of foraging upon insects attracted by street lamps. This is possibly the case of pipistrelle bats, whose diet appears similar to that of lesser horseshoes. As European bat communities appear saturated (due to most ecological niches being already occupied), it is difficult to imagine that one species could substantially increase in number without affecting the demography of others using convergent resources (see ARLETTAZ *et al.*, 2000).

Comment: This hypothesis would benefit from a deeper evaluation. However, it remains to be shown how it can account for the recent positive populations trends observed in several lesser horseshoe bat populations? The only possibility would be that white lamps particularly attractive for some bats have progressively been replaced by orange bulbs, which do not offer such favorable foraging conditions… but this seems contradicted by observations.

Genetic inbreeding (•)

A lack of exchanges between colonies and populations could cause some genetic inbreeding.

Comment: Genetic bottlenecks could play some detrimental role within local populations close to extinction, but they would certainly not be able to eventually cause the extinction of a population, which was still panmictic in the 1950s.

Diseases (•)

Pathogens suddenly introduced into a population, particularly when they are of alien origin, may provoke rapid extinctions through sudden, massive mortality.

Comment: Diseases usually decimate populations quickly, whereas the decline of *R. hipposideros* has been progressive. Moreover, pathogens tend to affect all populations similarly, but several populations have remained almost unaltered to date.

Predation, including human disturbance (•)

Predation and human disturbance may well explain some population crashes at a local scale but certainly not the wider global population decline of *R. hipposideros*.

RESEARCH RECOMMENDATIONS

Referring to our list of potential causes of population decline (Table 3), and considering the convergent views of regional bat experts for the evaluation of the factors possibly involved, we propose the following research topics (Table 5):

- Resource exploitation, subdivided in two sections: use of space, and trophic & foraging ecology
- Contamination by pesticides
- Population dynamics
- Roost conditions
- Climate change
- Population genetics
- Colonisation potential

A PROPOSAL FOR A CONSERVATION RESEARCH PROGRAM IN SWITZERLAND

The main goals of the proposed research are the following: 1) To understand the causes of regression of *R. hipposideros*, as far as possible [One constraint is, that an experimental approach is hardly applicable on that threatened and rare species, therefore we shall mostly rely on a comparative approach], 2) to find out the key factors which may currently be responsible for the survival of the remnant colonies and 3) to propose an efficient conservation scheme for this endangered species in Switzerland, which would include both, the protection of remnant colonies and their management, so as to elicit an increase in population size, and a progressive recolonisation of lost distribution.

The research program has been divided into two chronological phases (phase I and II, Table 5), the first one being subdivided into two priorities (phase I.1, phase I.2). The first two topics (resources exploitation and pesticides) are the most relevant and therefore, both are included in phase I as priority actions. The development of refined monitoring methods for long-term population dynamics surveys must also be placed in phase I.1, as much of the work depends on accurate monitoring. Altogether, this first phase is planned over three years. It is our oppinion, that planning of the second phase will have to be submitted for reevaluation, once the first phase has been completed.
Since most of the research methods involved (e.g. electronic techniques, manipulations of the animals, statistical analysis, etc.) require scientific skills in the field of bat research, most work will have to be carried out by reputable bat biologists. However, some projects would offer opportunities for students to familiarise themselves with bat fieldwork.

We propose that every project is considered separately, from an organizational viewpoint, with an attributed team and supervisors. The latter will be responsible for planning the research, coordinating the activities, and contributing to data analysis and publication. The following sections highlights the research topics, planned methods and approximate time schedules, in greater detail.

Resource exploitation

Use of space (revealed by radiotracking) - phase I

- Habitat selection (i.e. habitat use vs. availability) in different regions
- Use of microhabitat: preferred vs. avoided vegetation structure
- Home range use in relation to landscape structure and connectivity
- Roost use and availability in relation to landscape structure and connectivity

Trophic and foraging ecology - phase I

- Diet vs. insect prey biomass availability according to habitat and region

Use of space - phase II

- General habitat profile and comparative landscape evolution (possibly including comparisons with foreign populations)

Description of work (phase I)

The study of resource exploitation in phase I is aimed at comparing different regions and various population dynamics.

As regards radiotracking, we propose to tag six lesser horseshoe bats in each of the four main populations. Data on habitat use and spatial behaviour of two animals should be collected in spring, summer and autumn at given locations. In order to widen the database to enable the comparison of resource exploitation in healthy vs. remnant populations, further data from relict colonies should be collected. One – two animals will be radiotracked at 4-6 sites, if possible.

Individual bats will be captured with mistnests outside the roosts across their traditional flight lines in order to minimize disturbance at colony roosts. We shall use the lightest and smallest radio-tags available on the market and avoid marking heavily pregnant females. In any case, the weight of tags should not exceed 10% of body mass (BONTADINA *et al.*, 1999; a pilot study conducted on 12 lesser horseshoe bats).

In the intensively studied regions, food availability will be assessed by insect trapping within foraging grounds of the species, using various sampling methods (light traps, sticky traps, etc.). Diet will be studied by means of faecal analysis. Diet selection will be investigated by comparing diet composition with insect availability.

Time schedule

We are planning to collect the data above during the spring, summer and autumn of 2001/02. Winters will be devoted to data compilation and analyses.

Pesticide contamination

There is already an ongoing extensive research project on that subject at the moment. The idea is to see whether pesticide contamination correlates with the decline of lesser horseshoe bat populations. Results have been presented at the Bat Conference 1999 and are expected to be reported in full form in the next time. Any further project on pesticides will depend on the results of that study.

Population dynamics

Marking and methodological tests - phase I

- Development of refined monitoring methods enabling the estimation of sex ratios, and the proportion of yearlings and other age classes within populations
- Development of a safe method enabling young bats to be marked.

Population dynamics and modelling - phase II

- Collection of data on life history traits and fitness parameters
- Prospective and predictive modelling of population dynamics

Description of work (phase I)

Various techniques will be evaluated with the aim of minimising sampling effort (and thus colony disturbance) whilst getting reliable basic population data: maximum number of adults and youngs in a nursery roost, sex ratios, mean or median date of birth, growth of young and, possibly, the reproductive success of mothers.
It is proposed that as a control experiment, a yearling cohort should be ring-marked in one nursery colony, whereas a similar cohort will be captured, but not ringed, in another

colony (control). The behaviour of the young bats before and after ringing will then be monitored using IR video cameras at both sites, and their behaviour compared.

Time schedule

This module, one year in duration, should be started in the first year. The results will serve to establish a standard protocol for monitoring all nursery roosts in the country.

Roost conditions

There is a an ongoing research project at the moment aiming to compare roost structure and climatic conditions in different attics occupied by lesser horseshoes in the Grisons. Results could be presented at the next Bat Conference, following which any new project on roost conditions will be formulated.

Overall climatic effects

- Long-term evaluation of possible climatic changes in different areas of Switzerland.

Description of work (phase I)

Various Swiss regions showing different demographic trends of *R. hipposideros* will be compared from a climatic perspective: Valais, Grisons, Berner Oberland as regards the alpine arc, but also areas of the Swiss Plateau and Jura mountains. Seasonal subgroups should be analysed, looking for statistical trends in precipitation and temperature. The extant data collected by the Swiss Meterological Institute (SMA) since 1930(50) will be available for use.

Time schedule

This is part of the second stage of phase I according to the ranking of research topics. Data are delivered as spreadsheets by the SMA; analysis could be performed by a student, for instance in geography, but supervision will be necessary and must be funded.

Population genetics

Any project on that topic will be reconsidered once the first phase is completed.

Colonization potential / release experiments

The need for such a research as well as the methods will be considered when the first phase is completed.

ACCOMPAGNYING MEASURES

We list here some non research activities which will have to be developed in parallel with, and complement to, the research activities. They are usually carried out either by the Coordination centres or the local bat workers (RFE/CR).

Public campaign

- Nationwide public campaign to locate new horsehoe bat roosts
- Regional enquiries and/or calls complementary to the nationwide action

Description of work (phase I)

Successful public calls and enquiries in Obwalden and the Berner Oberland have shown that such actions are well worth the additional effort. Horseshoe bats in particular are very suitable as an enquiry target through the mass medias as they are easily recognizable due to their unique morphology. We propose that our two Coordination centres (KOF & CCO) launch the national public campaign. Under the supervision of the centres, the RFE/CR could take over the operations in the various regions, relaying information in the regional/local medias. Along with the aim of finding new roosts, the campaign would also be used to provide information on the thread to lesser horseshoe bats and on the planned conservation project. The strategy should be discussed together with the Centres and the RFE/CR. An internet site as well as a target-group approach must be envisaged.

Time schedule

It would be advantageous to carry out the enquiry as soon as possible, so that the following research project could benefit from the results.

Monitoring program

In order to facilitate the collection of long-term data on population dynamics, the protocols for population monitoring have to be standardized. The following should be considered:

- Establishment of a minimum monitoring scheme (number of bats present, number of adults vs. young, etc.)
- Focus on the future demographic evolution of nursery colonies
- As far as possible, collection of parameters relating to life history traits and fitness
- Use of this refined monitoring as a tool for control of implementation actions

Description of work

Data collection on population dynamics should, from the outset, considering the need for long-term population surveys and modelling. We propose to establish a working group (in which RFE/CR will be included) with the task to elaborate a common, standardized monitoring scheme. Also, a monitoring centre should collect the data, analyse it on a nationwide level, provide overviews and, finally, send the results back to the local responsibles. The monitoring scheme should be, as far as possible, Euro-compatible. Permanent contact and exchange with people in charge of the population dynamics project will be required so as to optimize the improvements in survey methods and efficiency.

Time schedule

A minimum monitoring scheme should be implemented and co-ordinated from the start of the whole project. Fine surveys are expected to be performed every second year.

ACTION PLAN

The action plan itself consists of the implementation of all conservation recommendations drawn from the research results. The implementation of the action plan is primarily the responsibility of the RFE/CR. But, according to conservation needs, this may require the enrolment of additional personal and additional funding. Appropriate implementation may also require some clarification of the legal basis for the conservation measures proposed.

Description of work (phase I)

The conclusions from the various research projects should be put into action as soon as they become available.

Time schedule

In order to be able to carry out crucial conservation actions and / or to save time in implementing recommended actions, we must keep the option of carrying out management measures open, even if research work is ongoing.

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STUTZ, H. P. & M. HAFFNER. 1984. Arealverlust und Bestandesrückgang der Kleinen Hufeisennase (*Rhinolophus hipposideros*) (Bechstein, 1800) (Mammalia: Chiroptera) in der Schweiz. *Jber. Natf. Ges. Graubünden* 101: 169–178.

Literature list

On the following web site we provide a list of about 700 references (status at Nov. 2000) on lesser horseshoe bats: http://www.dplanet.ch/users/fabio.bontadina/112/lit.html. The list may be downloaded, too.

[Figure 1]

File: Rh_fig1.tif (668 kB)
suggested original size: one column, 75 x 78.5mm

Fig. 1: Distribution of the lesser horseshoe bat in Europe. The recent distribution is shaded. The dotted line depicts the northern border of the distribution of the species before World War II (after Ohlendorf 1997b).

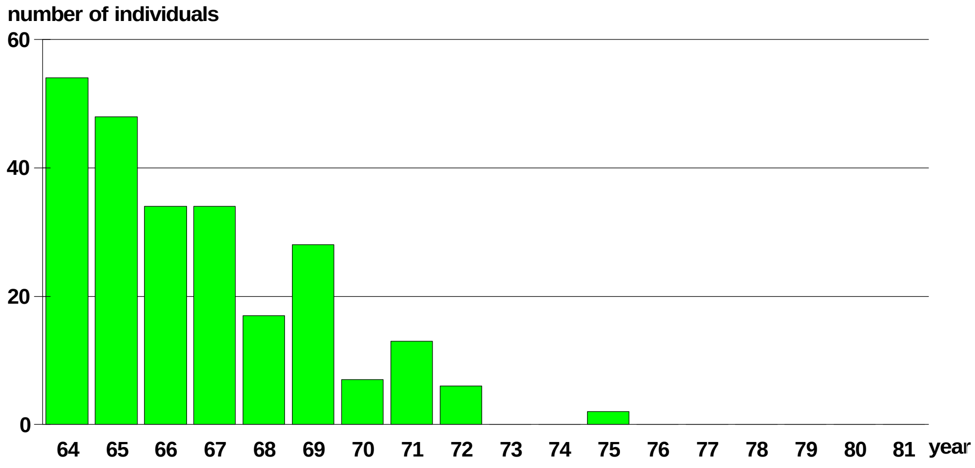

Fig. 2: An example of population decrease at one winter roost in Switzerland (number of individuals, after Arlettaz *et al.* 1998).

[Figure 3]

File: Rh_fig3.eps (109 kB)
suggested original size: two columns, 162 x 109 mm

Fig. 3: Distribution of 39 known nursery roosts of *Rhinolophus hipposideros* in Switzerland in 1990-2000.

[Figure 4]

File: Rh_fig4.eps (135 kB)
suggested original size: two columns, 162 x 109 mm

Fig. 4: Distribution of the 39 nursery colonies known in Switzerland in the year 2000. The four clusters of colonies sheltering the largest populations are depicted by circles. The numbers show the maximum number of adult animals counted (number of colonies in brackets).

[Figure 5]

File: Rh_fig5.eps (110 kB)
suggested original size: two columns, 162 x 109 mm

Fig. 5: 22 out of 39 nursery colonies of *Rhinolophus hipposidero*s shelter more than 20 individuals each (marked with star). The largest nursery colonies are situated in the core distribution areas (see Fig. 5).

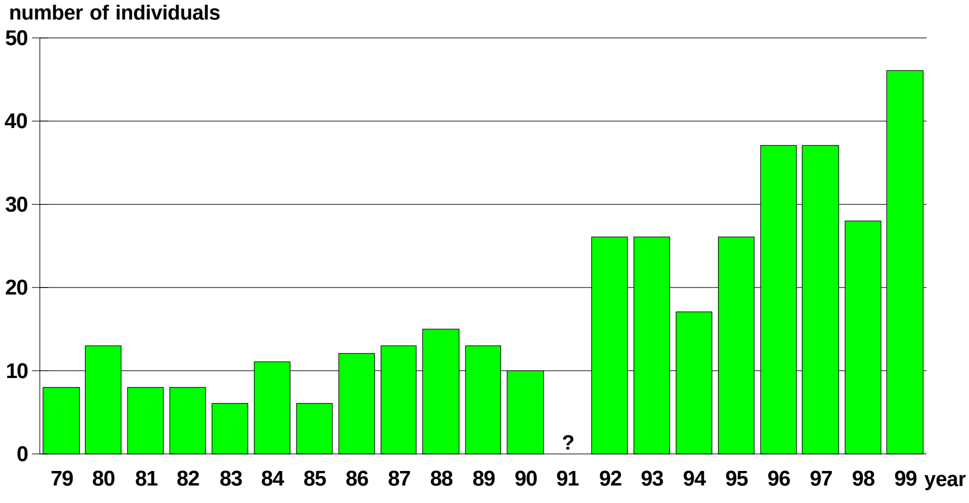

Fig. 6: Example of a recently increasing population: maximum number of individuals censused since 1979 at one maternity roost in Obwalden (data from Alex Theiler).

Table 1: List of the 39 nursery roosts of *Rhinolophus hipposideros* known in Switzerland from 1990 to 2000. The last four roosts of the Canton BE could not be confirmed as nursery roosts in the most recent years.

Canton	**Community**	**max. adults**	**max. juveniles**	**prop. juv. / ad.**	**year of count**	**trend**
SG	Flums	8		0%	1995	down
SO	Kleinlützel	1		0%	1997	
FR	Estavayer-le-lac	4	3	75%	1999	(stable)
NE	St-Sulpice	2			1990	down
GR	Camuns	20	8	40%	1999	stable
GR	Castiel	43	11	26%	1999	up
GR	Cumbel	11	8	73%	2000	down
GR	Uors-Peiden	120	64	44%	2000	
GR	Uors-Peiden	53	15	28%	1999	stable
GR	Uors-Peiden	150	66	44%	2000	up
GR	Surcasti	166	59	36%	2000	up
GR	St. Martin	245	50	20%	2000	up
GR	Tomils/Tumegl	8			1999	stable
GR	Valendas	24	17	71%	2000	up
GR	Valendas	52	23	44%	2000	up
GR	Waltensburg	121	25	21%	1999	
BE	Blumenstein	75	36	48 %	2000	up
BE	Erlenbach	62	7	11 %	2000	up
BE	Brienzwiler	42	5	12 %	2000	
BE	Daerstetten	19			1998	
BE	Diemtigen	16	10	63 %	2000	
BE	Brienz	11			1999	
BE	Burgistein	40	30	75 %	2000	
BE	Daerstetten	35	11	31 %	2000	
BE	Toffen	30	15	50 %	2000	up
BE	Amsoldingen	25	20	80 %	2000	up
BE	Wimmis	60	20	33 %	2000	
BE	Erlenbach ?	3			1995	
BE	Kandergrund ?	1			1999	
BE	Meiringen ?	12			1999	stable
BE	Wimmis ?	1			1998	down
OW	Giswil	20	16		1999	stable
OW	Giswil	23	6		1999	
OW	Giswil	31			1998	
OW	Giswil	54	33	61%	2000	
OW	Sarnen	30			1997	
OW	St. Niklausen	3	1		1997	
OW	Sachseln	46			1999	up
VS	Le Châble	9			2000	up
total	**39 nursery colonies**	**1676**	**559**			

Table 2: Population trends in 39 nursery colonies in 1990-2000

Population trend	Number of colonies total N (%)	Number of sites with data (%)
Up	12 (31%)	12 (55%)
Stable	6 (15%)	6 (27%)
Down	4 (10%)	4 (18%)
Missing data	17 (44%)	
Total	39 (100%)	22 (100%)

Table 3. Potential causes of regression of the lesser horseshoe bats in Switzerland. Replies from an enquiry submitted to 12 regional bat experts; factors were scored according an interval scale ranging from 0 (irrelevant factor) to 5 (very relevant factor). Averaged scores were listed in decreasing order.

	Average rank
A. Abiotic factors	
Pesticides	4.0
Changes in the physical structure of habitats	3.1
Loss of roosts and roost deterioration	1.2
Climate changes	0.4
B. Biotic factors	
Food shortage	3.4
Competition against other species	0.8
Genetic inbreeding	0.4
Diseases	0.2
Predation, including human disturbance	0.0

Table 4. Suggestions for priorities in conservation research proposed by 11 regional bat experts; the proposed topics are ranked with respect to the number of mentions.

	number of counts
Habitat use	8
Diet	4
Roost availability/function	4
Identification of potential foraging habitats	3
Comparative landscape evolution	3
Pesticide analysis of faeces/tissues	3
Pesticide analysis of potential prey	3
Connection of roosts	2
Comparison with foreign colony (optimum)	2
Spatial use around nurseries	2
Protection and improvement of foraging areas	2
Landscape analysis around nurseries	2
Structure and microclimate of roosts	2
Changes in climate	1
Finding of new colonies	1
Monitoring colonies	1
Genetic variability within and between colonies	1
Conservation of existing colonies	1
Recolonialisation of roosts	1
Reproduction success/body mass and condition/mortality	1
Legal situation for protection of sites	1

Table 5: Overview of the proposed projects.