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„Population dynamic of western barbastelles
(*Barbastella barbastellus*) during summer“

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1. Zusammenfassung

Im Rahmen dieser Arbeit wurde die Populationsstruktur und –dynamik der Mopsfledermaus (*Barbastella barbastellus*) im Sommer untersucht. Dabei kam eine Kombination von Fang-/Wiederfangmethode, Sichtbeobachtungen und Radiotelemetrie zur Anwendung. Das Untersuchungsgebiet befand sich in einer Kulturlandschaft mit einem 30%igen Waldanteil in Zentraleuropa, Österreich. Die Daten wurden vorwiegend von März bis Oktober 2011 (10 Fang-/Wiederfangdurchgänge und 39 visuelle Kontrollen) und nur in Ersatzquartieren erhoben. Fang-/Wiederfangdaten aus den Jahren 2006 bis 2010 und 2012 wurden jedoch ebenfalls in die Auswertung integriert. Um zusätzliche unbekannte Quartiere ausfindig zu machen, wurde ein sexuell nicht aktives Weibchen telemetriert.

Die Studie zeigte, dass weibliche Mopsfledermaus-Gesellschaften dem Fission-Fusion Prinzip folgen. Dabei sind die Tiere in weitgehend geschlossenen Sozialsystemen organisiert, in Kolonien. Diese teilen sich häufig in kleinere Gruppen (Fission), sogenannten Subkolonien, und vereinigen sich wieder (Fusion). Die Zusammensetzung und Zahl der Subkolonien kann variieren. Pro Zählzeitpunkt wurde eine Aufspaltung in eine bis vier Subkolonien pro Kolonie beobachtet. Das Untersuchungsgebiet war zwischen mindestens vier Mopsfledermauskolonien aufgeteilt. Dabei betrug die maximale Distanz zwischen von einer Kolonie genutzten Quartieren 3 km. Benachbarte Kolonien grenzten aneinander an, waren aber räumlich eindeutig getrennt. Von 2006 bis 2012 wurden nur drei Weibchen registriert, welche die Kolonie wechselten (Cross-over) und fortan in einer benachbarten Kolonie beobachtet wurden. 2011 wurde im Untersuchungsgebiet eine neue Kolonie entdeckt.

Die beobachtete Größe einer Subkolonie reichte von einem bis 41 Individuen. Die Zusammensetzung einer Subkolonie war dabei nicht zufällig. Wiederkehrende Assoziationen zwischen den Individuen wurden beobachtet.

Für ein erfolgreiches Naturschutzmanagement ist es notwendig, genaue Kenntnis über die Struktur wildlebender Populationen zu haben. Besonders bei Fledermäusen, die in Fission-Fusion-Gesellschaften leben, muss für die Umsetzung von erfolgreichen Schutzmaßnahmen ihre besondere Populationsdynamik und Raumnutzung berücksichtigt werden.

Schlagwörter

Populationsstruktur, Populationsdynamik, *Barbastella barbastellus*, Fission-Fusion, Ersatzquartiere

2. Abstract

This study combines the methods of capture/recapture, visual controls and radio-telemetry in order to analyze the population structure and dynamic of female western barbastelles (*Barbastella barbastellus*) during summer. The work was carried out in a cultural landscape with approximately 30% woodland in central Europe, Austria. Data was mainly taken during the season of 2011 (10 capture/recapture controls and 39 visual controls) and only from artificial roosts. However, capture/recapture data from 2006 to 2010 and 2012 was integrated into the analysis too. In order to find additional roosts, a non-reproductive female was radio-tracked.

The study revealed the fission-fusion nature of the female barbastelle population. The bats roost in socially closed colonies that frequently split up into subcolonies (fission) and merge again (fusion). Neighbouring colonies border each other, but are still well separated. From 2006 to 2012 only three females crossed over from one colony to another and roosted in a neighbouring colony thenceforward. The study area was divided between at least four colonies with a maximum distance between occupied roosts of one colony of 3 km. Additionally a new colony was discovered within the study area in 2011.

The number of observed subcolonies in a colony varied from one to four. The size of observed subcolonies varied from one to 41 individuals. The individual composition of a subcolony is not random. Recurring associations of individuals were found, with some individuals roosting together more likely.

For conservation management it is inevitable to have a good knowledge about the structure and dynamics of populations. Especially bats living in fission-fusion societies need to be treated accordingly to their unique population dynamics. The barbastelle colonies' spatial distribution is very important for defining conservation areas.

Keywords

Population structure, population dynamics, *Barbastella barbastellus*, fission-fusion, artificial roosts

3. Introduction

Mammal societies can present themselves in complex social structures. Many social mammals are organized in more or less stable groups consisting of females with their offspring, males, juveniles, relatives or unrelated individuals of both sexes (Eisenberg, 1966). Multi-level groups can be structured with additional hierarchical character (Smith et al., 2007). Mammal populations can also be characterized by a dynamic dividing into subgroups and reuniting into socially closed units. So-called fission-fusion societies show temporary splits (fission), followed by merging again (fusion) on a frequent basis (Kerth & König, 1999). This allows flexible responses of group size to external conditions while at the same time retaining group stability (Lehmann & Boesch, 2004). Fission-fusion societies have been described in many mammal societies like primates (Sueur et al., 2010) and carnivores (Smith et al., 2007). Also cetaceans show fission-fusion characteristics (Connor et al., 2000). The process of splitting and merging of social groups is related to resource availability, predation pressure and social relationships (Robinson & Janson, 1987; Henzi et al., 1997).

Fission-fusion associations are also known within bats, for instance in a population of greater noctules (*Nyctalus lasiopterus*) inside a small city park (Popa-Lisseanu et al., 2008). Greater noctules formed smaller groups on a daily basis while the social cohesion of the larger group was preserved. Metheny et al. (2007) were able to demonstrate that kinship – contrary to other mammals – does not influence roosting associations within the big brown bat (*Eptesicus fuscus*). These forest dwelling bats too, show a fission-fusion roosting behaviour. Kerth and König (1999) have investigated fission, fusion and nonrandom associations in female Bechstein's bats (*Myotis bechsteinii*). Their extensive studies revealed that maternity colonies of the Bechstein's bat act as socially closed units forming several subgroups of variable size splitting up and reuniting. Genetic population analysis (based on mitochondrial DNA) proved that female Bechstein's bats show strong philopatric tendencies, even in the absence of dispersal barriers (Kerth et al., 2000). The observed population differentiation led Kerth et al. (2000) to the conclusion that theoretically only one female did successfully disperse to a foreign colony every five years.

The western barbastelle's (*Barbastella barbastellus*) social structure is still poorly understood due to the species' cryptic life-style. Long-term studies on this endangered bat are rare. Due to habitat loss and fragmentation, the western barbastelle is classified as 'Near Threatened' at a global scale (Hutson et al., 2012). By European law this mammal is protected under Annexes

II and IV of the Habitats Directive 92/43/EEC. Hence, this study provides the basic knowledge for prospective conservation management.

Western barbastelles show a comparable life-style to Bechstein's bats. Both forest-dwelling species hunt and forage in similar habitats (Steinhauser et al., 2002). The Bechstein's bat's fission-fusion behaviour (Kerth & König, 1999) therefore suggests that barbastelles might as well be organized in similar social structures.

Hence this study was based on the predictions that (1) colonies of barbastelles act as stable social units and (2) barbastelles follow a fission-fusion process where colonies split up and reunite on a frequent basis. Therefore, subcolonies change in number and size.

In detail the following predictions have been tested:

- The study area is split between several colonies that act as socially closed units consisting of females and their offspring.
- Colonies split up into subcolonies on a frequent basis.
- Cross-overs of females from one colony to another occur very rarely.
- The distance between occupied roosts within a colony is greater than the distance between roosts of different colonies.

4. Material and methods

4.1. Study species

The western barbastelle is a medium size bat (Fig. 1). Its fur, ears and short nose are dark brown, almost black, with its dorsal fur appearing frosted due to grey-white tips (Rydell & Bogdanowicz, 1997). The broad and short ears are joined across the forehead and reach up to 18 mm. Ears show five to six wrinkles and are never folded at rest (Dietz & v. Helversen, 2004).



Fig. 1: Western barbastelles (*Barbastella barbastellus*) in a bat box. (Selda Ganser)

The distribution in Europe extends from southern and central Europe northwards to Britain, Scandinavia and Latvia. The bat is missing or rare in the southernmost parts of Europe, being there confined to the mountains (Dietz & v. Helversen, 2004).

The barbastelle's prey ranges from large moths to small nematoceran flies, with moths representing the main part of their nutrition (Beck, 1995; Rydell et al., 1996). The animals forage in mature woodland, woodland edges and ecotones in agricultural landscapes. In summer they depend on a large number of roosts due to their frequent roost-switching behaviour (Hutson et al., 2012; Steinhauser et al., 2002). A study in southern Brandenburg, Germany, revealed that crevice-like roosts behind bark served as summer roosts for nursery

colonies as well as for single adult females or small groups of individuals including juveniles (Steinhauser et al., 2002). The observed nursery colony appeared to be organized as a rather loose social group (Steinhauser et al., 2002). Hillen et al. (2010) found roost-switching of single barbastelles every 2.0 days (± 1.8 STD). Russo et al. (2005) reported varying roost-switches of barbastelles depending on the reproductive status. They further reported that lactating females switched roosts less often due to higher energy costs.

Barbastelles in central Europe hibernate from November to March. Hibernation lasts 120 to 140 days, as estimated from changes in body mass (Lesiński, 1986; Urbańczyk, 1991).

Like most tree-roosting bats, the barbastelle suffers from loss of old mature woodland with ancient trees to roost in. Because of lacking of loose bark or wood crevices, reforested areas are seldom suitable for this species (Hutson et al., 2012). In central Europe, colonies roosting in crevices of buildings and other human-made structures are common (Steinhauser et al., 2002). Providing artificial roosts, like bat boxes, is a suitable conservation measure for this species when roost availability limits their populations.

4.2. Study area

The study area is located in the western part of the Mühlviertel, Upper Austria. Data was taken in two municipalities, Julbach and Peilstein. The study area consists mainly of agricultural areas (app. 64%) and woodland (app. 30%) (Fig. 2).



Fig. 2: View of the study area, comprising an extensive used cultural landscape. (Selda Ganser)

The Mühlviertel is divided into three climatic zones, below 600 meters a.s.l., between 600 and 800 meters a.s.l. and above 800 meters a.s.l. (Land Oö, 2011). Research was done within the intermediate zone where forest communities consist mainly of spruce (*Picea abies*), fir (*Abies alba*) and beech (*Fagus silvatica*) (Kilian et al., 1994). Anthropogenic monocultures of fir are still widespread over the area. However, during the last ten years they were partially replaced by native forest communities, after a large amount of fir had been destroyed by several strong storms.

The main part of agricultural use in the Mühlviertel aims to serve cattle farming. Therefore agricultural habitats mostly consist of meadows for producing hay (decreasing) and silage (increasing). A smaller part is used for pastures as natural areas for grazing and the extensive management of suckler cow herds, as the number of organic working farms is increasing. Arable land is used for producing concentrated feedingstuffs for the cattle. As the climate in this altitude is very rough, only selected types of corn can be grown and there is no large output of qualified corn for the food industry.

4.3. Artificial roosts

For this study data was taken only from bats in artificial roosts (Fig. 3). A total number of 84 bat boxes were put up at 24 locations within the study area (Fig. 4). The first artificial roosts were mounted in 2006 by the önj (Österreichische Naturschutzjugend), later to be continued by Naturschutzbund Mühlviertel-West. As a result, a relatively dense arrangement of potential roosts now covers the study area. Depending on the location, usually more than one bat box

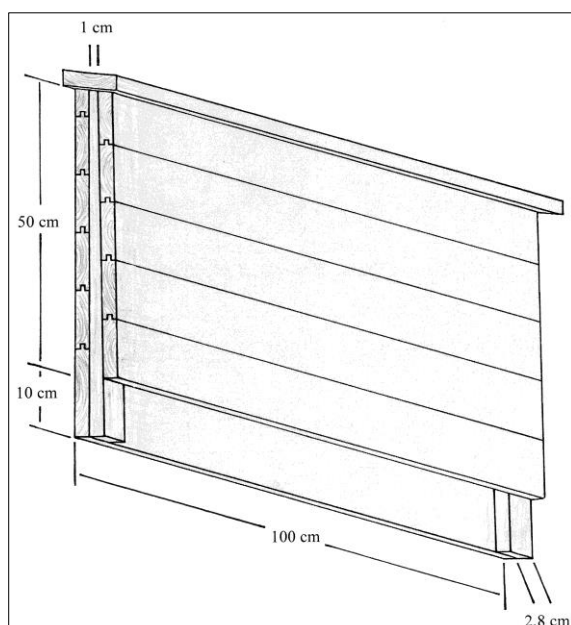


Fig. 3: Artificial roosts used by the barbastelles (*Barbastella barbastellus*) in the study area. (Christian Deschka, www.muehlviertelnatur.at)

was put up, preferably at barns or wooden walls of farmhouses (Fig. 5). Barbastelles prefer a type of bat boxes where the opening at the bottom is 2.8 cm wide and the cavity narrows to 1 cm on the top. The wooden surface of the boxes remains rough, so that the bat can hold on to it after landing and crawl up into the sheltered area.

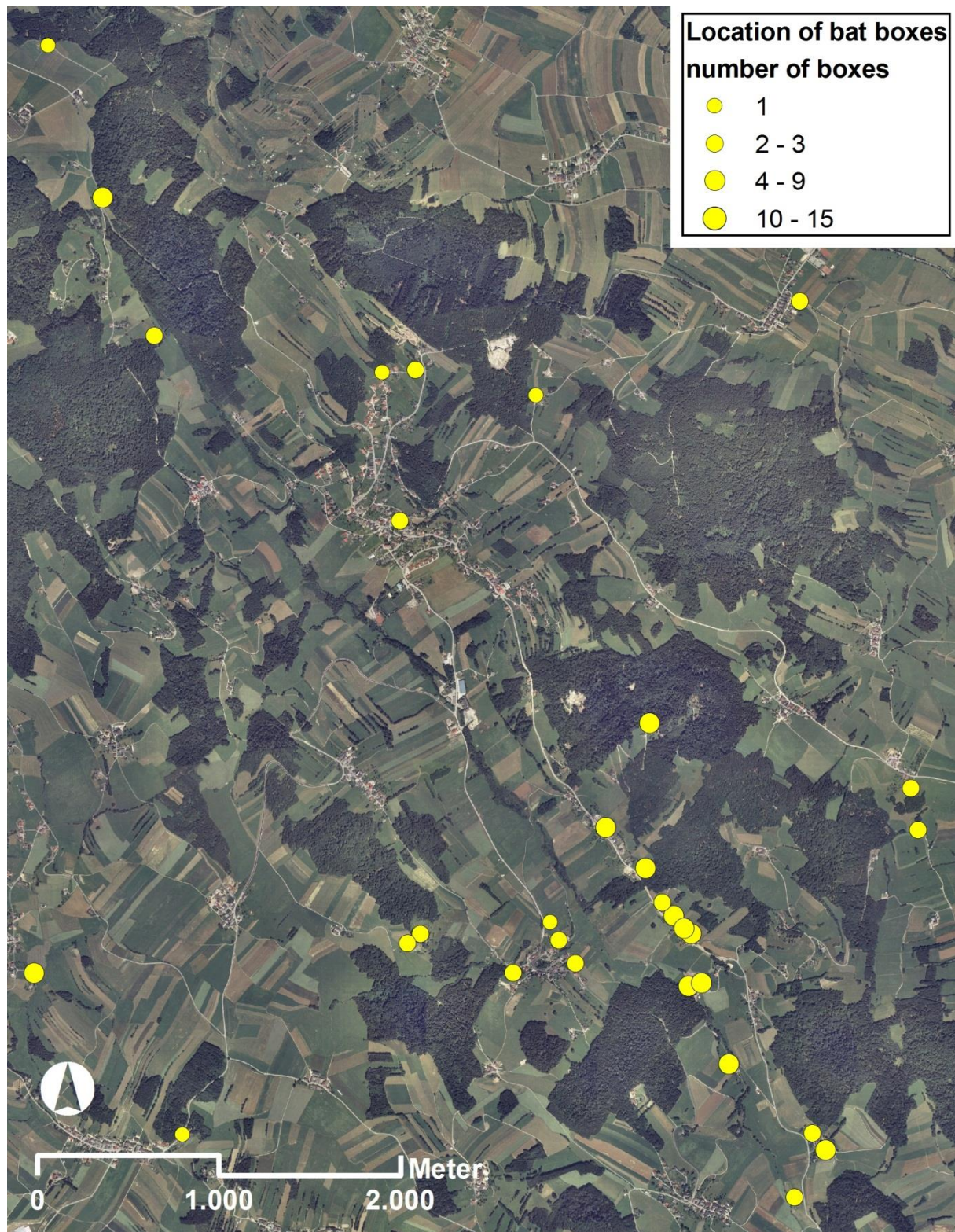


Fig. 4: Roost locations and number of bat boxes in the study area.



Fig. 5: Artificial roosts on a barn at a height of several meters beyond ground. (Christian Deschka)

4.4. Data collection

4.4.1. *Capture and recapture of bats*

All capture/recapture data that has been taken from 2006 onward was integrated into this study. However, the main focus was set on 2011 where most of the controls were carried out (Tab. 1).

All controls were performed during daytime. Occupied artificial roosts were climbed up to with the help of a ladder. The gap at the bottom was covered with a plastic bag for capturing the bats. With a flexible and rounded stick bats were herded carefully towards the flight gap and into the bag. The caught bats were held in calico bags before biometric data were taken. Mass was recorded to an accuracy of 0.1 g and forearm length to an accuracy of 0.1 mm. Animals were sexed and the reproductive condition of the females was assessed. Parous females were identified by hairless nipples, and palpably pregnant animals were recorded. The barbastelles were assigned to one of three age classes: juvenile, subadult and adult bats. Juveniles were distinguished from subadults by the inability of flight and a more greyish

coloration. Juveniles and subadults are additionally characterized by not fully ossified bones. Hence, the epiphyses were visible in the joints of the digits against a light background. In autumn the cartilage is replaced by bone and the joint becomes more rounded and knuckle-like (Dietz & v. Helversen, 2004).

Subsequently the bats were relocated to the artificial roost. The flight gap was closed with fabric while handling the animals in order to prevent the bats from flying away during daytime. The flight gap was opened again approximately 15 minutes after the last individual was put back into the roost.

The handling of the animals was carried out by myself under license (0022599/2011 ABA Nord 501/N113016) from the Nature Conservation Department of the government in Upper Austria.

Tab. 1: The number of capture/recapture controls and visual controls per year.

cap/recap capture/recapture

year	cap/recap controls	visual controls
2006	3	0
2007	3	0
2008	3	0
2009	3	0
2010	2	1
2011	10	39
2012	2	0

4.4.2. Marking of individual bats

The bats were marked with aluminium bat rings being individually numbered and registered at the Museum Bonn, Germany. When an individual was recaptured, the individual ring number was noted. Female bats were ringed on their left and male bats on their right forearm. Hence, also sex could be determined from the distance and without handling the bats. Starting in 2009, barbastelles were ringed with coloured bat rings. According to the place of their first capture a ring colour was chosen (Tab. 2). Therefore, the bats could also be assigned to a colony from the distance and without handling.

Tab. 2: Ring colours used for marking barbastelles (*Barbastella barbastellus*).

ring colour	notes
silver	years 2006-2008 and males
green	first capture: Vorderschlag
yellow	first capture: Vorderschlag
red	first capture: Niederkraml
violet	first capture: Sonnleitner
light blue	first capture: Bräuerau

4.4.3. Visual controls

In addition to the capture/recapture method, visual controls were carried out as a less invasive procedure. In 2011 visual controls were scheduled on a weekly basis in order to get more data on group composition and occupation of roosts. All artificial roosts within the study area were checked with ladder and torch. Number of individuals, sex and ring colour was recorded. Therefore the animals remained within the roost and influence of disturbance was strongly reduced.

4.4.4. Radio-telemetry

When consecutive visual controls didn't result in tracking any representatives of a colony, radio-telemetry was used to locate additional roosts. A non-reproductive female was tagged with a Holohil LB-2N transmitter (Holohil Systems LTd., Canada, www.holohil.com), weighing 0.42 g. After trimming the fur, the transmitter was glued on the back of the bat between the scapulae using surgical cement (SkinBond, Smith & Nephew United Inc., Largo, Florida, USA) (Fig. 6). Transmitters fell off when the fur had grown for some days or, at most, a few weeks. Every day the signal was checked with TRX-2000S, a PLL synthesized tracking receiver (Wildlife Materials Inc., Carbondale, Illinois).

In this study only one individual has been radio-tracked. The procedure of mounting the transmitter was carried out by Dr. Guido Reiter under license (0055325/2009 ABA Nord 501/N093052) from the Nature Conservation Department of the government in Upper Austria.



Fig. 6: Non-reproductive female barbastelle (*Barbastella barbastellus*) equipped with a transmitter.
(Christian Deschka)

4.5. Data analysis

All recorded data was transferred and stored in Excel-sheets (Microsoft Excel 2010, Version 14.0).

During controls, all bats in one roost were characterized as subcolony which could be represented by reproducing females with their offspring, single females and non-reproductive females in groups. Male barbastelles are found to roost solitary for most of the year (Steinhauser et al., 2002), therefore males were not included into the study, though also ringed and measured. However, juvenile and subadult males within maternity colonies were included in subcolonies, but single adult males were not counted as an independent subcolony.

As subcolonies are characterized by a frequent change in number and composition of individuals (Kerth & König, 1999), each control implied the possibility of subcolonies in varying number and size.

Based on previous findings, the presence of at least four colonies was proposed. These were named after the location of the first capture: “Vorderschlag”, “Niederkraml”, “Sonnleitner” and “Bräuerau”. Accordingly, all records were assigned to one of the colonies and individuals were marked with the ring colour of their first capture (Tab. 2). Subsequently, also subcolonies could be assigned to a colony, depending on the composition of the individuals.

The dispersion of a female to another colony was defined as cross-over. This means that the female was thenceforward recaptured roosting with individuals of a neighbouring colony.

Thus, date, roost location, number of subcolonies and composition of individuals (sex, age) was noted.

Additionally the GIS (geographical information system) ArcMap 9.3.1 was used to analyse spatial patterns, the area occupied by a colony (expressed as MCP, minimum convex polygon) and cross-overs between colonies.

5. Results

5.1. Capture and recapture data of individual barbastelles

From 2006 to 2012 in total 152 western barbastelles were captured and marked (Tab. 3). However, not all individuals were recaptured. From all 118 marked female barbastelles, 80 (68%) were recaptured at least once. In detail 35 of 51 females (69%) of the colony “Vorderschlag”, 15 of 19 females (79%) of the colony “Niederkraml”, 19 of 26 females (73%) of the colony “Sonnleitner”, 11 of 17 females (64.7%) of the colony “Scharinger” and 0 of 5 females (0%) of the colony “Bräuerau” were recaptured. From 34 marked male barbastelles 8 animals (24 %) were recaptured at least once. In total, 187 recapture events were registered (Tab. 4), these include repeatedly recaptured individuals. Only 38 female barbastelles (32%) were not recaptured at all, whereas many of the recaptured individuals were recaptured several times (Fig. 7).

Furthermore, juvenile and subadult individuals were additionally documented and analyzed (Tab. 5). The recapture rate of these individuals was very low. From 50 individuals only six were recaptured later on (12%).

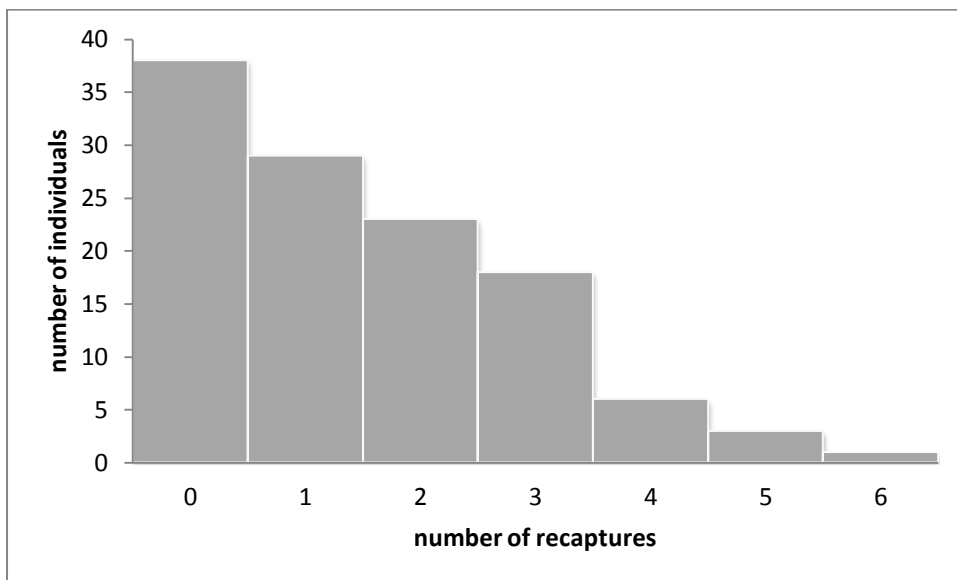


Fig. 7: Number of recaptures for all marked female individuals.

Tab. 3: Number of marked barbastelles (*Barbastella barbastellus*) per year, age and sex.

f female, *m* male, *sub* subadult, *juv* juvenile

year	f adult	f sub	f juv	m adult	m sub	m juv	marked f	marked m	all marked
2006	10	0	0	8	0	0	10	8	18
2007	8	3	0	3	2	0	11	5	16
2008	6	8	0	0	0	1	14	1	15
2009	18	7	0	2	6	0	25	8	33
2010	14	0	4	0	2	1	18	3	21
2011	29	5	6	4		5	40	9	49
2012	0	0	0	0	0	0	0	0	0
total	85	23	10	17	10	7	118	34	152

Tab. 4: Number of recapture events, including repeatedly recaptured barbastelles (*Barbastella barbastellus*).

f female, *m* male

year	recapture f	recapture m	all recaptured
2006	1	1	2
2007	7	2	9
2008	6	1	7
2009	9	0	9
2010	17	0	17
2011	102	8	110
2012	32	1	33
total	174	13	187

Tab. 5: Number of marked juvenile and subadult barbastelles (*Barbastella barbastellus*) that were later recaptured.

	female	male	all
Marked as juveniles/subadults	33	17	50
Recaptured as adults	5	1	6

5.2. Spatial distribution of roosts of barbastelles during summer

The results of this study support the existence of at least four colonies in the study area: “Vorderschlag”, “Niederkraml”, “Sonnleitner” and “Bräuerau” (Fig. 8). However, the five female adult barbastelles of the colony “Bräuerau”, marked in 2009, were never found later on.

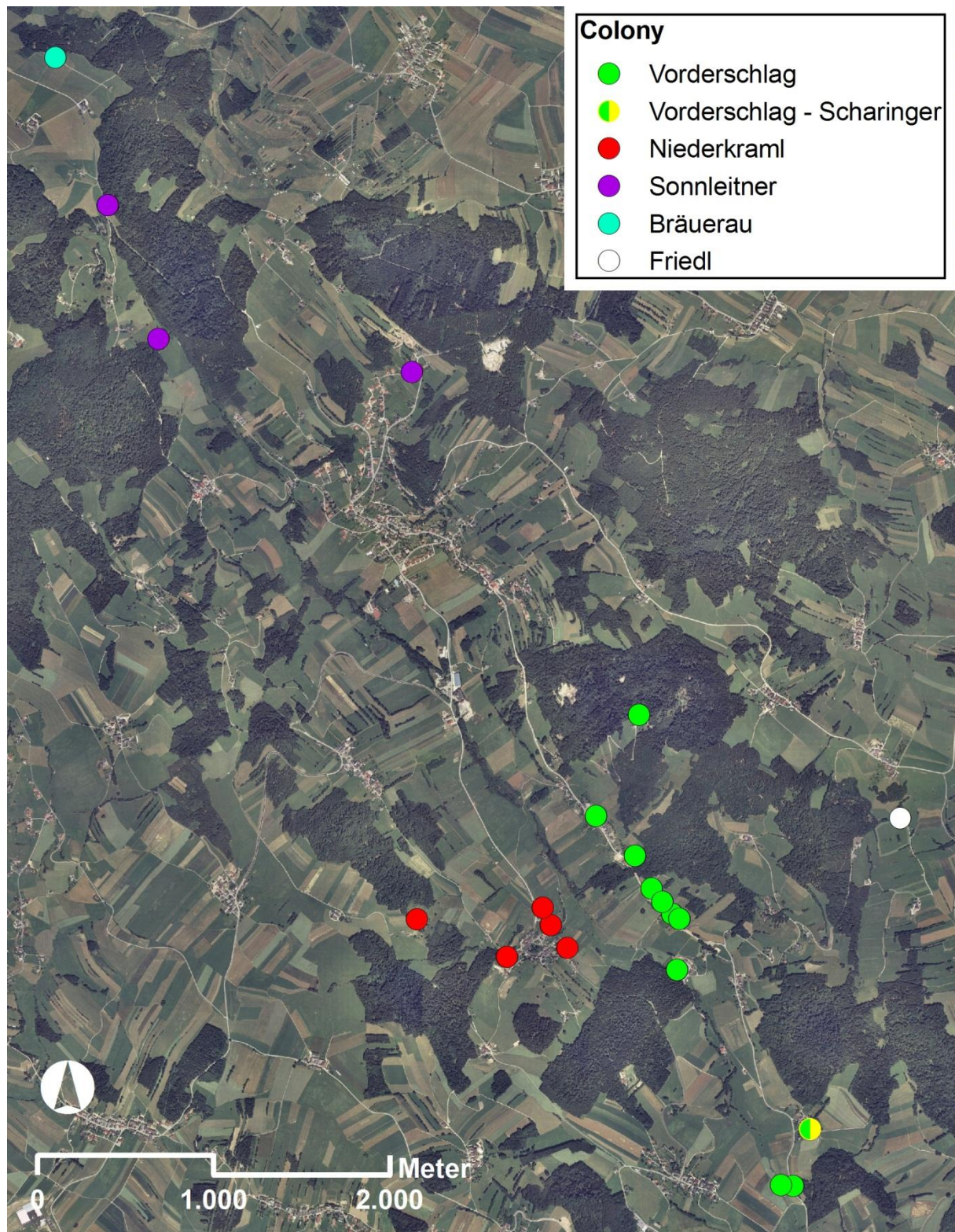


Fig. 8: Roosting locations of barbastelles (*Barbastella barbastellus*) in the study area. Only locations used by colonies are shown.

In 2011 a new colony established within the area of the colony “Vorderschlag”. This colony was named “Scharinger” after the location of the roost. The animals marked at this location in 2011 did not mix with animals of the colony “Vorderschlag”. Before 2011 the four artificial

roosts at the location Scharinger served as frequently visited roosts for the colony “Vorderschlag”. But the bats of the colony “Vorderschlag” didn’t use the roost location Scharinger after the colony “Scharinger” was found there. Therefore it is likely that the colony “Vorderschlag” was displaced by the colony “Scharinger” at this location. However, the bats of the colony “Scharinger” were not recaptured at every control in 2011 at the location Scharinger. Hence, it is obvious that there is at least one other unknown roost location used by this colony.

From 2006 to 2012 the colony “Vorderschlag” used eleven roost locations, the colony “Niederkrabl” used five roost locations and the colony “Sonnleitner” used three roost locations. In 2011 the colony “Scharinger” was found only at one roost location. Also the colony “Bräuerau” was recorded only at one roost location.

The colonies did not visit all potential locations every year (Tab. 6).

Tab. 6: Number of roost locations per colonies found per year.

year	"Vorderschlag"	"Niederkrabl"	"Sonnleitner"	"Scharinger"	"Bräuerau"
2006	7	0	2	0	0
2007	4	2	1	0	0
2008	4	1	1	0	0
2009	2	1	1	0	1
2010	4	2	0	0	0
2011	9	1	2	1	0
2012	3	1	0	0	0

The area of occupied roosts (MCP) is 0.9 km² for the colony “Vorderschlag”, 0.5 km² for the colony “Sonnleitner” and 0.1 km² for the colony “Niederkrabl”. The maximum distance between occupied roosts of the same colony is found in the colony “Vorderschlag” with 3 km. The maximum distance between occupied roosts of the colony “Sonnleitner” is 2 km and between occupied roosts of the colony “Niederkrabl” 0.9 km. The distance between occupied roosts within a colony is therefore greater than the distance between roosts of different colonies (Fig. 9). Hence, colonies mostly border other colonies, but are still well separated.

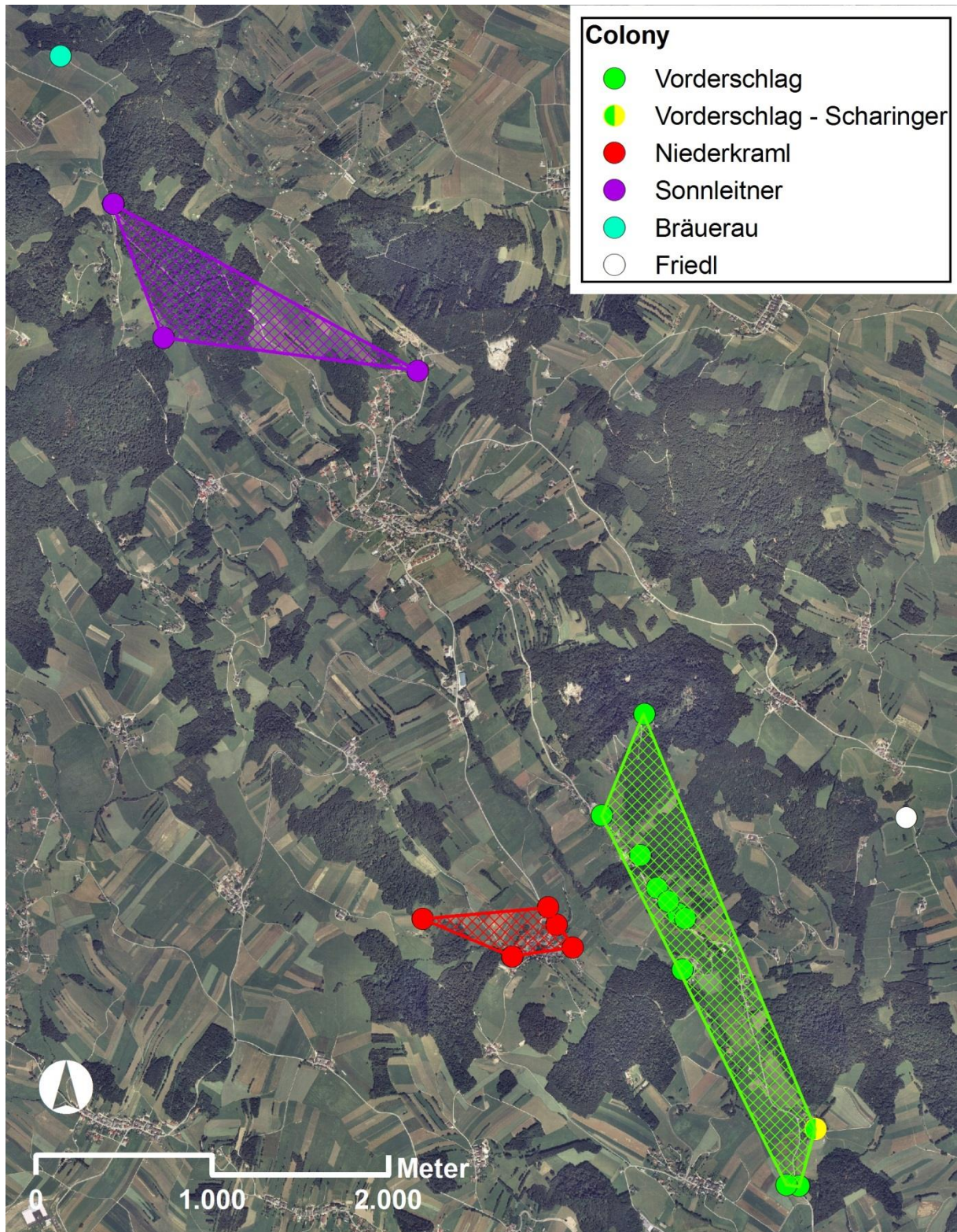


Fig. 9: Used area of the colonies “Vorderschlag”, “Sonnenleitner” and “Niederkraml” displayed as MCPs (Minimum convex polygon).

Because colonies were completely missing at some visits we can assume that for the studied colonies unknown roosts are existing. This is apparent for all colonies, but to a different degree. Most of the roosts of the colony “Vorderschlag” are known, whereas obviously only a

very small part of the roosts of the colony “Bräuerau” was identified so far. However, if taking into account unknown roosts, a schematic picture of the spatial distribution of the colonies could be drawn (Fig. 10).

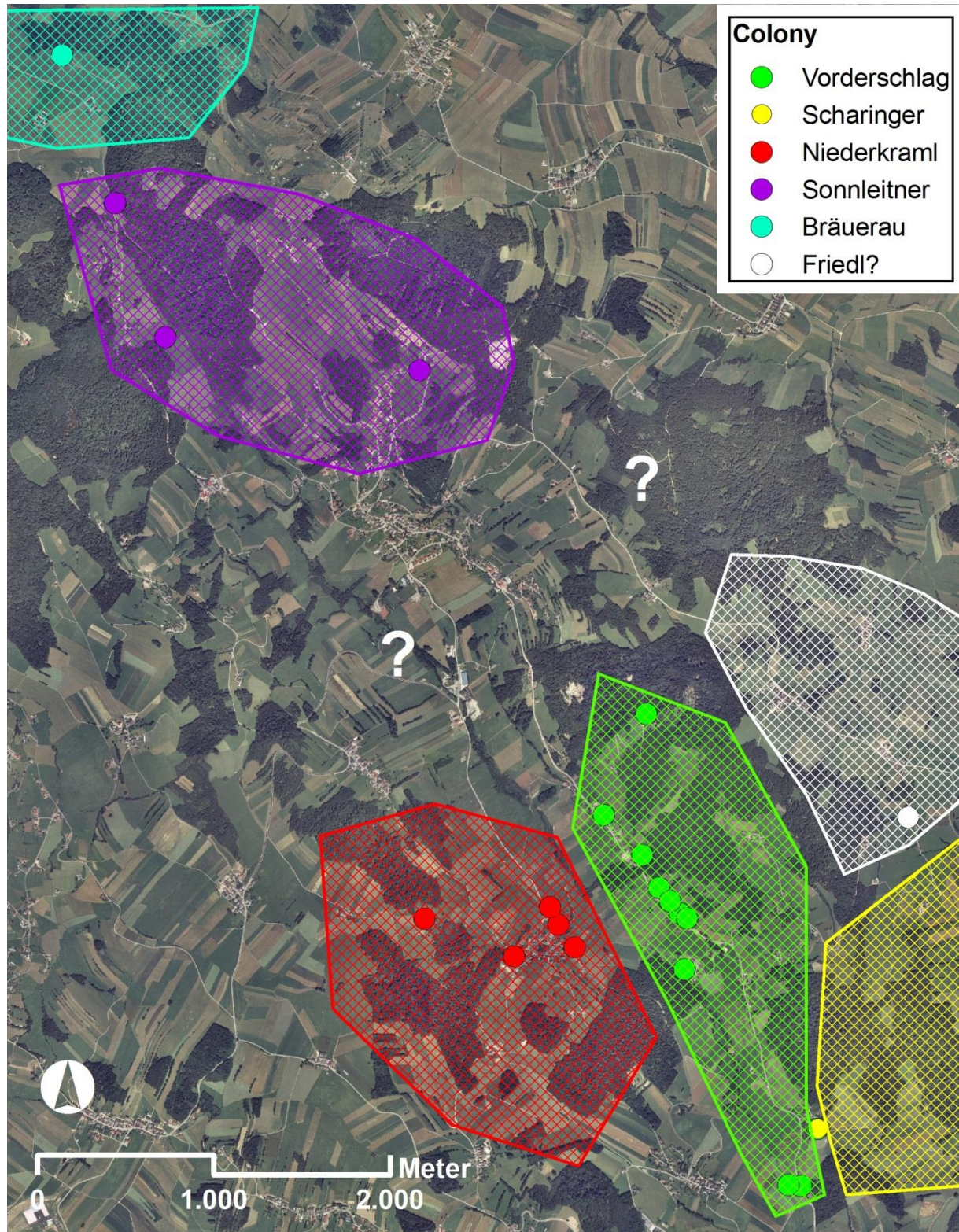


Fig. 10: Schematic spatial distribution of the different colonies of barbastelles (*Barbastella barbastellus*) in the study area.

The frequency of visits to the different locations used by the colony “Vorderschlag” was pooled for the years 2006 to 2012 (Fig. 11). The bats showed varying preferences for different locations, ranging from one to eight observations per roost (mean=4 $\pm$ 2.1 STD).

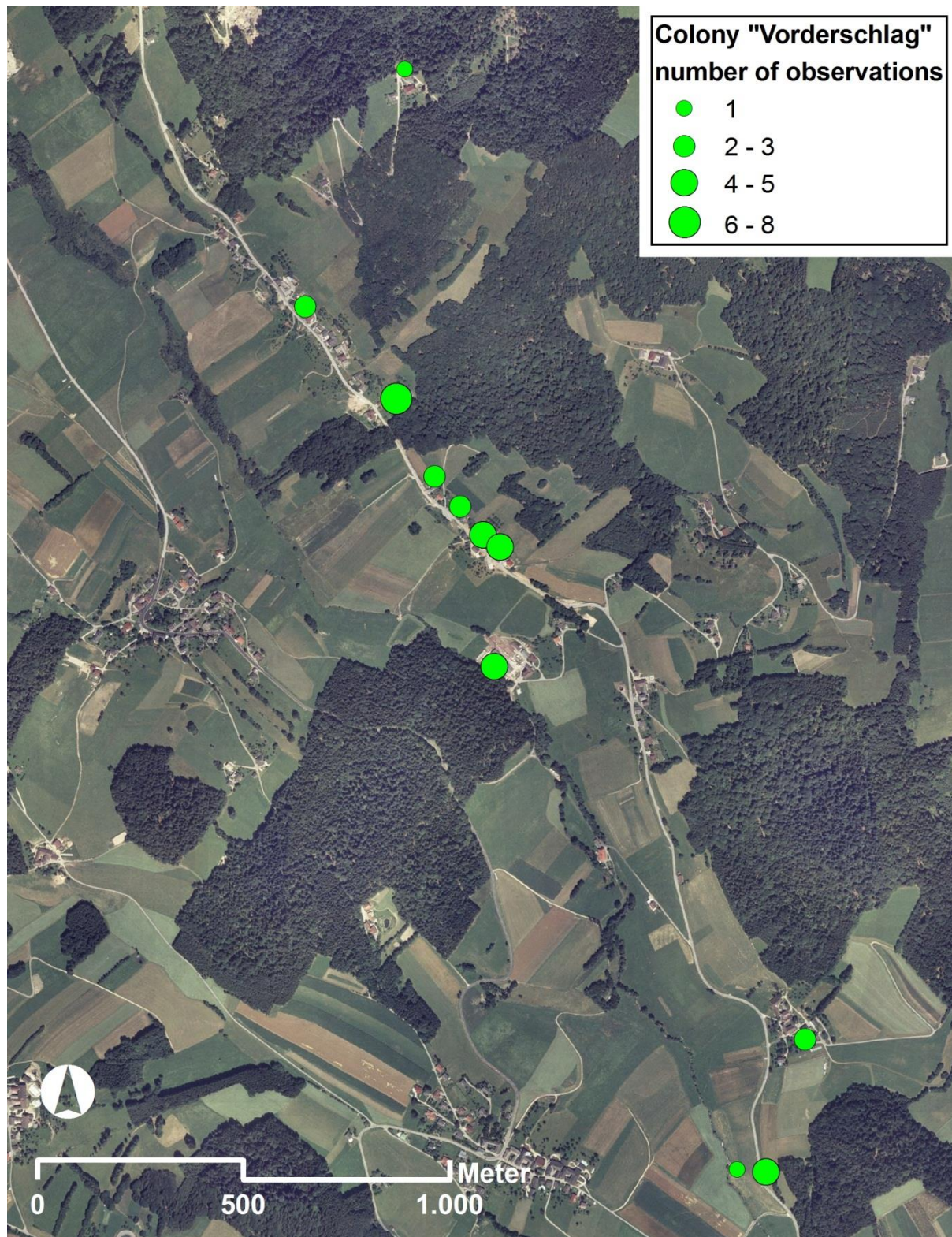


Fig. 11: Number of positive observations at different locations of the colony “Vorderschlag” from 2006 to 2012.

5.3. Size of colonies and subcolonies

No differences in the observed mean colony size were noticeable (ANOVA: $F = 1.0$, $p = 0.4$; Fig. 12; colony “Bräuerau” was excluded from the test due to insufficient data). The mean colony sizes ranged from ten bats in the colony “Niederkraml” (± 5.6 STD) to 18 bats in the colony “Scharinger” (± 1.2 STD).

The maximum colony sizes of the colony “Vorderschlag” ($\text{max}=37$) and the colony “Sonnleitner” ($\text{max}=41$) are nearly equal. These two colonies were most frequently observed in the season of 2011 where most research was done.

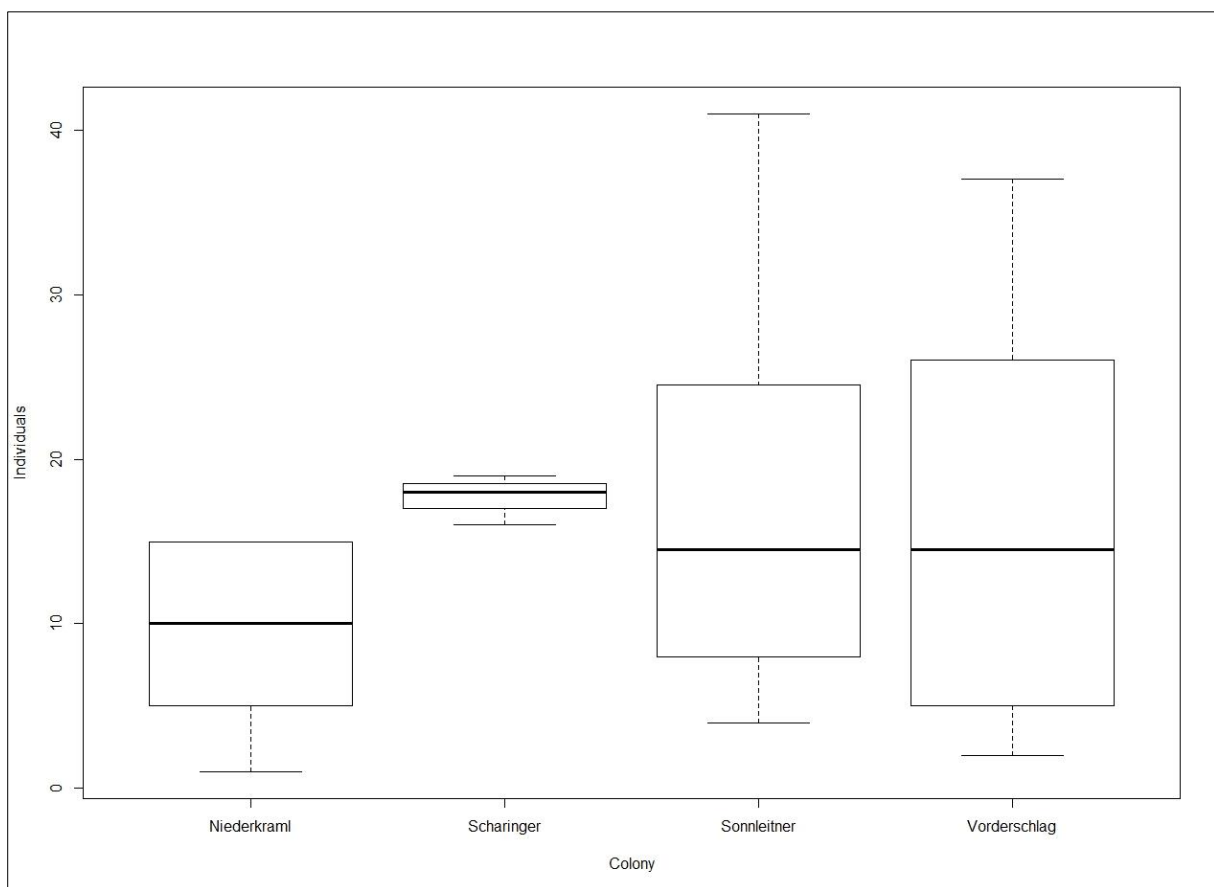


Fig. 12: Observed colony size of the different colonies: “Niederkraml” ($n=9$), “Scharinger” ($n=3$), “Sonnleitner” ($n=8$), “Vorderschlag” ($n=22$). ANOVA: $F = 1.0$, $p = 0.4$.

Comparing the two colonies with the most complete data sets (“Sonnleitner” and “Vorderschlag”), a significant difference in the size of the subcolonies was noticeable (Mann-Whitney: $U = 49.0$, $p = 0.52$). Thus, the subcolonies of the colony “Sonnleitner” were bigger compared to those of the colony “Vorderschlag” (Fig. 13).

The mean number of bats per subcolony for the colony “Vorderschlag” was seven individuals (± 8.1 STD). Thus, being more or less half the size of the median colony size found for the colony “Vorderschlag”.

A significant difference between the colonies “Sonnleitner” and “Vorderschlag” could be found also for the number of subcolonies (Mann-Whitney: $U = 44.0$, $p = 0.012$). The number of subcolonies for the colony “Vorderschlag” recorded per colony and day ranged from one to four, respectively the mean subcolony number was two individuals (± 0.9 STD). For the colony “Sonnleitner” only one subcolony per day was found.

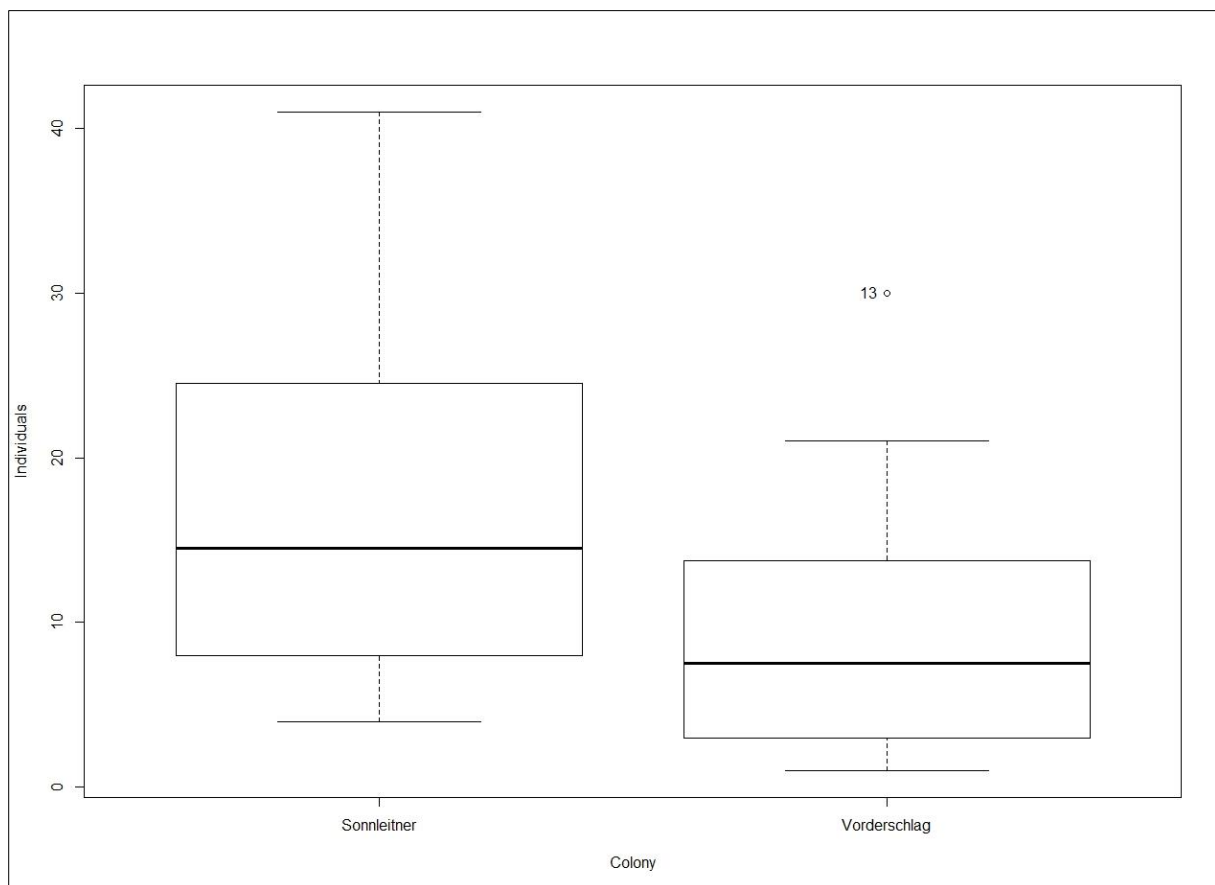


Fig. 13: Difference in the size of the subcolonies between the colonies “Sonnleitner” and “Vorderschlag”. Mann-Whitney: $U = 49.0$, $p = 0.52$.

5.4. Composition of subcolonies

The subcolonies showed a changing composition of individuals throughout the season and also in subsequent seasons. Hence, colonies with high fission-fusion dynamics are the consequence.

A selection of recaptured subcolonies of the colony “Vorderschlag” shows that the individuals with the ring numbers “H134551”, “H134553”, “H134558”, “H134675”, “H134681”, “H134687”, “H134689”, “H159566”, “H159575”, “H159577” and “H159579” are repeatedly recaptured, but in differently composed subcolonies of different size (Tab. 7).

The data also indicates that the associations are not completely random. Specific combinations of female individuals were found repeatedly roosting together. These combinations were composed of a female pair or even groups of up to twelve females. For example, the individuals with the ring numbers “H134553”, “H134681” and “H159577” were repeatedly found roosting together (Tab. 7). Groups often split up, but did occasionally join in bigger subcolonies with a recurring similar composition. The analyzed data also revealed that small groups of three to six individuals built temporary small subcolonies of non-random composition. Sometimes these subcolonies were repeatedly recorded with the exact same composition, sometimes additional individuals had joined. Constant combinations of individuals were not only observed during one season, but in subsequent seasons.

Usually individuals did merge in maternity colonies of greater size to give birth to their offspring. Simultaneously small subcolonies of up to six non-reproductive barbastelles were observed, that did alternately also roost with the maternity subcolony during that period. Some bats did prefer to roost alone. Solitary animals were from time to time recorded joining in pairs or small groups. Some individuals did roost with a subcolony for several seasons, just to abandon it for unknown reasons and join another subcolony one day. The female barbastelle with the ring number “H134596” was recaptured nearly every year from 2006 to 2011 (Tab. 8). Given to that longevity, it was recaptured in subcolonies with varying composition.

Tab. 7: An example for subcolony composition of the colony “Vorderschlag”. Repeatedly recaptured individuals are highlighted in colours.

f female, *m* male, *juv* juvenile, *cap* capture, *recap* recapture

colony name	date	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	03.06.2011	Egermühle	4	H134596	silber	f	adult	capture
				H159594	yellow	f	adult	capture
		Binder	6	H134689	green	f	adult	recapture
				H159566	yellow	f	adult	capture
				H159570	yellow	f	adult	capture
				H159575	yellow	f	adult	capture
Vorderschlag	30.07.2011	Binder a	2	H134687	green	f	adult	recapture
				H134558	green	f	adult	recapture
		Binder b	25	H134551	silber	f	juv	capture
				H134552	silber	m	juv	capture
				H134553	silber	f	juv	capture
				H134675	green	f	adult	recapture
				H134681	green	f	adult	recapture
				H134689	green	f	adult	recapture
				H159577	yellow	f	adult	recapture
				H159767	silber	f	adult	capture
Vorderschlag	16.06.2012	Naderhirn a	9	H134551	silber	f	adult	recapture
				H134553	silber	f	adult	recapture
				H134561	green	f	adult	recapture
				H134681	green	f	adult	recapture
				H134690	green	f	adult	recapture
				H159577	yellow	f	adult	recapture
				H159579	yellow	f	adult	recapture
				H159673	violet	f	adult	recapture
		Naderhirn b	7	H134558	green	f	adult	recapture
				H134599	silber	f	adult	recapture
				H134675	green	f	adult	recapture
				H134683	green	f	adult	recapture
				H134687	green	f	adult	recapture
				H159552	yellow	f	adult	recapture
				H159575	yellow	f	adult	recapture
Vorderschlag	20.07.2012	Egermühle	8	H134505	silber	f	adult	recapture
				H134593	silber	f	adult	recapture
				H159564	yellow	f	adult	recapture
				H159766	silber	f	adult	recapture
		Binder	29	H134553	silber	f	adult	recapture
				H134681	green	f	adult	recapture
				H134687	green	f	adult	recapture
				H159566	yellow	f	adult	recapture
				H159577	yellow	f	adult	recapture
				H159579	yellow	f	adult	recapture

Tab. 8: Recaptures of the individual with the ring number “H134596” from 2006 to 2011.

f female, *m* male, *sub* subadult, *cap* capture, *recap* recapture

colony name	date	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	27.05.2006	Naderhirn	3	H134596	silver	f	adult	capture
				H134597	silver	f	adult	capture
				H134598	silver	f	adult	capture
Vorderschlag	09.07.2006	Deschka	3	H134587	silver	m	adult	capture
				H134588	silver	m	adult	capture
				H134596	silver	f	adult	recap
Vorderschlag	02.09.2007	Höfler nord	30	H134590	silver	f	adult	recapture
				H134591	silver	f	adult	recapture
				H134592	silver	f	adult	recapture
				H134596	silver	f	adult	recapture
				H134598	silver	f	adult	recapture
				H134600	silver	f	adult	recapture
				H156258	silver	f	sub	capture
				H156264	silver	f	sub	capture
				H156265	silver	m	sub	capture
				H156266	silver	f	adult	capture
				H156267	silver	f	sub	capture
				H156270	silver	m	sub	capture
				H156272	silver	f	adult	capture
				H156273	silver	f	adult	capture
Vorderschlag	05.07.2008	Oppel	9	H134596	silver	f	adult	recapture
				H156273	silver	f	adult	recapture
Vorderschlag	01.09.2008	Winkler	21	H134593	silver	f	adult	recapture
				H134596	silver	f	adult	recapture
				H156254	silver	f	sub	capture
				H156257	silver	f	sub	capture
				H156299	silver	f	sub	capture
Vorderschlag	08.08.2009	Scharinger	14	H156300	silver	f	adult	capture
				H134593	silver	f		recapture
				H134596	silver	f	adult	recapture
				H156272	silver	f	adult	recapture
Vorderschlag	03.06.2011	Egermühle	4	H159593	yellow	m	sub	capture
				H134596	silver	f	adult	recapture
				H159594	yellow	f	adult	capture

5.5. Cross-overs of individuals between colonies during summer

As predicted, cross-overs of female barbastelles did occur very rarely. From 2006 to 2012 only three female barbastelles (2.5% of all marked females) made a successful change to another colony (Fig. 14). Two animals changed colony as adult individuals, one barbastelle was first captured as a juvenile and subsequently recaptured as an adult in another colony one year later (Tab. 9). The female juvenile individual was marked in a maternity colony in 2011. One year later it was recaptured in a subcolony of a neighbouring colony that consisted of four individuals with their offspring.

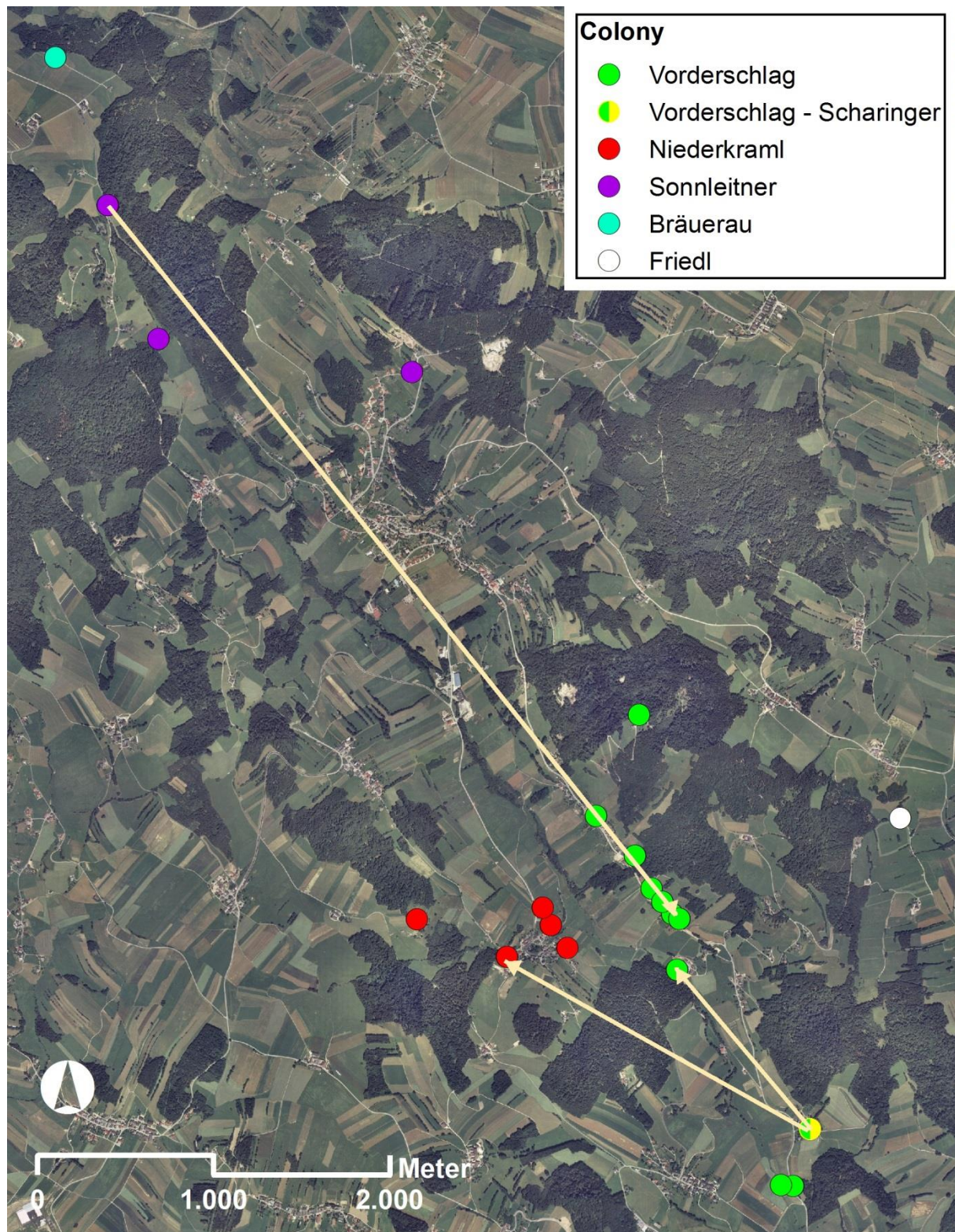


Fig. 14: Cross-overs of individual female barbastelles (*Barbastella barbastellus*) between colonies.

Tab. 9: Cross-overs of adult and juvenile female barbastelles (*Barbastella barbastellus*).

individual		capture	recapture	recapture	recapture
H134597, female, adult	date	27.05.2006	02.09.2007	13.06.2009	07.08.2011
	roost location	Scharinger	Ganser	Ganser	Ganser
	colony	"Vorderschlag"	"Niederkruml"	"Niederkruml"	"Niederkruml"
H159673, female, adult	date	03.06.2011	30.07.2011	16.06.2012	
	roost location	Haininger	Sonnleitner	Naderhirn	
	colony	"Sonnleitner"	"Sonnleitner"	"Vorderschlag"	
H159564, female	date	juvenile 30.07.2011	subadult 12.08.2011	adult 20.07.2012	
	roost location	Scharinger	Scharinger	Egermühle	
	colony	"Scharinger"	"Scharinger"	"Vorderschlag"	

5.6. Phenology of barbastelles in the study area

The first individual was registered in the study area on March 31st 2011 (Tab. 10). Birth took place during the second half of June and the first half of July. About one month later the juveniles were fledging. The start of the mating season could be roughly estimated to end of July due to recurring recaptures of one male-female couple. Another male roosting with three different females was recaptured at the end of October and possibly indicates the end of mating season (Tab. 11). Due to absence of confirmative data on other couples, time of mating season is classified as hypothetical. The bats begin to leave their summer roosts mid of September. The last four animals in 2011 were recaptured on October 31st: One single female was visually confirmed on this day, roosting alone at the location Scharinger. The subcolony of two adult females (H134505 and H134506) and one adult male (H159764), as stated previously, was recaptured in the colony "Vorderschlag".

Tab. 10: Phenological data of barbastelles (*Barbastella barbastellus*) in the year 2011.

green confirmed, **blue** proposed

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
arrival in summer roost												
birth												
fledging of juveniles												
mating season												
leaving summer roost												

Tab. 11: The male with the ring number “H159764” roosting with three different females. The potential mating partners are also highlighted in colours.

f female, *m* male, *cap* capture, *recap* recapture

colony name	date	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	02.09.2011	Winkler	2	H134505	silver	f	adult	recapture
				H159766	silver	f	adult	recapture
		Winkler	3	H134506	silver	f	adult	recapture
				H134508	silver	f	adult	recapture
				H159594	yellow	f	adult	recapture
Vorderschlag	18.10.2011	Höfler nord	2	H159764	silver	m	adult	recapture
				H159766	silver	f	adult	recapture
Vorderschlag	25.10.2011	Höfler nord	1	H134505	silver	f	adult	recapture
		Höfler nord	1	H134506	silver	f	adult	recapture
Vorderschlag	31.10.2011	Höfler nord	3	H134505	silver	f	adult	recapture
				H134506	silver	f	adult	recapture
				H159764	silver	m	adult	recapture

6. Discussion

6.1. Social structure of barbastelles during summer

6.1.1. Fission-fusion

The results of this study strongly indicate the structure of a fission-fusion society in western barbastelles. Animals in a colony do split up in subcolonies and merge again. The bats of the colonies in the study area demonstrated a frequent splitting into subcolonies that varied in number and size. Hence, barbastelles and Bechstein's bats do not only show similarities in their habitat use, both also demonstrate a fission-fusion structure in their populations. The reasons that cause that dynamic social structure are still subject of investigations. The roosting pattern of members of a Bechstein's bat maternity colony supports the hypothesis that two factors influence the species' social organization: Environmental factors like variable climatic conditions, predation and/or parasite pressure can cause fission and fusion of subgroups, and cooperation among reproductive females generates individual associations (Kerth & König, 1999). The big brown bat (*Eptesicus fuscus*), a forest-dwelling bat of the New World, shows a fission-fusion roosting pattern too. The bats remained loyal to small roosting areas of a forest within and between years and often switched trees (Willis & Brigham, 2004). The authors suggest that in this fission-fusion scenario, switching between roosts, within a local area, could serve to increase the numbers of individuals with which bats maintain associations. In experimental field studies in Bechstein's bat populations, Kerth et al. (2006) investigated the influence of fission-fusion behaviour on group decisions. Conflicting information about roost suitability was followed by an increased fission in the colony. Therefore Kerth et al. (2006) suggested that a fission-fusion society offers the opportunity for individuals to avoid majority decisions that are not in their favour.

Fission-fusion societies are not restricted to bats, but are widespread among mammals. Similar social structures in other mammal species have been researched to a greater extent. Wolf et al. (2007) studied the social system of the Galápagos sea lion (*Zalophus wollebaeki*) which is organized in at least three levels. As factors for splitting into the third level, "cliques", individual preferences, genetic relatedness or a combination of both were suggested. Ramos-Fernández et al. (2006) further pointed out the influence of the heterogeneity and complexity of the environment in which social animals live. Hence a simple foraging model as an ecological factor could lead to a complex fission-fusion society.

Also societies of the African elephant (*Loxodonta africana*) represent fission-fusion systems characterized by high flexibility and the potential for multiple scales of organization (Couzin, 2006). Social groups can divide into small parties or fuse with other groups to form aggregations of hundreds of animals. New studies by Wittemeyer et al. (2005) and Archie et al. (2005) on association structures in wild African elephant populations have elucidated important roles of both ecological processes and relatedness in complex multi-level societies (Couzin, 2006). Genetic relatedness did predict group fission as well as temporary group fusion between social groups of female elephants (Archie et al., 2005). In barbastelles, only individual preferences were observed so far. The influence of genetic relatedness would need further research. In contrast to many other mammals, barbastelles seem to be organized in only two levels: colonies and subcolonies. Nonetheless, ecological factors and a complex environment are likely to play a major role in the barbastelles' social structure too. Detailed studies about the barbastelles' environment would be necessary to understand the correlations between ecological processes and the bats' social organization.

Additionally, the observations in this study indicate a non-random composition of the subcolonies of the bats. Also in populations of female Bechstein's bats, individuals of different age, size, reproductive status and relatedness were found to maintain long-term social relationships (Kerth et al., 2011). However, large datasets are needed to reveal the full details of the social structure. Our amount of datasets on barbastelles is still incomplete and therefore only general first observations could be made.

6.1.2. Cross-overs

From 2006 to 2012 only three female barbastelles changed the colony and were observed roosting within another colony in the subsequent seasons. The majority of marked female barbastelles stayed within their colony. No analogies in timing or patterns of the cross-overs could be found. What they had in common was that only one event of crossing over occurred. No recurring cross-overs were registered so far. Although data may be incomplete, the rate of cross-overs is definitely very low. Colonies of barbastelles seem to be well separated, despite bordering each other.

In a study of female Bechstein's bats no immigration occurred over five years in four colonies living in close proximity, despite considerable fluctuations in population size were registered (Kerth et al., 2002). In subsequent confrontation tests by Kerth et al. (2002), females of a maternity colony even showed the ability of detecting foreign females and preventing them

from intruding into an occupied roost. It is likely that female barbastelles are capable of doing the same.

Recaptures of individuals that were marked as juveniles or subadults occurred very rarely. That could either indicate a high dispersal of these young adults or a low survival rate of juveniles and subadults.

6.1.3. Colony and subcolony size

Interspecific colony sizes of bats roosting in cavities show obvious variation. Moreover, different observations suggest a correlation between colony size and social structure of a particular bat species (Kunz & Lumsden, 2003). Some species do form very small colonies of fewer than ten individuals. So does the Jamaican fruit bat (*Artibeus jamaicensis*) that shows a harem formation (Morrison, 1979), and also the spectral bat (*Vampyrum spectrum*), among which monogamous pairs were found (Vehrencamp et al., 1977). It seems likely that in fission-fusion societies an optimal colony size is maintained as well. Kerth & König (1999) describe Bechstein's bats' maternity colonies with an average of 20 to 40 adult females, consisting of reproductive and non-reproductive females. In the studied barbastelles, the maximal observed colony size was 41 individuals. In other mammal fission-fusion societies a correlation of demographic variables (community size and composition) and fission-fusion parameters could be demonstrated (Lehmann & Boesch, 2004). The study revealed that small communities are more cohesive and have a less flexible fission-fusion system.

In this study subcolonies show variation in number and size. If we consider the results on group decision making of Kerth et al. (2006), conflicting information about communal roost selection led to an increased fission in one colony. A larger amount of potential roosts could therefore lead to increased conflicts about where to roost and subsequently fission would also increase. Hence, a correlation between the number of potential roosts within an area and the number of subcolonies could be assumed. The results of my study show that the colony "Vorderschlag" splits in one to four subcolonies per day, by using in total eleven roost locations, whereas in the colony "Sonnleitner" only one subcolony per day was found, using in total three roost locations. Hence, the larger number of potential roost locations within the area of the colony "Vorderschlag" could have led to increased fission and a higher number of subcolonies. Of course it is still unclear to what extent the barbastelles in the study area do use yet unknown roosts in trees or buildings.

Concerning the varying subcolony size, I presume that individual preferences as well as the number of available roosts play a major role in subcolony composition. In the colony “Sonnleitner” bigger subcolonies were observed than in the colony “Vorderschlag”.

Studies of other bat species revealed that variation does also appear in roost size within one colony. Roverud & Chappell (1991) found that maternity subcolonies of the lesser bulldog bat (*Noctilio albiventris*) generally count more individuals than do non-reproductive female subcolonies. Due to less energy loss for reproductive females and their offspring they show clustering behaviour. In my study, only few non-reproductive barbastelle subcolonies could be observed. The equally low number of individuals (maximum six) suggests that the data is in accordance with the results of Roverud & Chappell (1991). Furthermore, adult males were mostly found roosting solitary. Also males of the eastern forest bat (*Vespadelus pumilus*) are found more often roosting alone in cavities in comparison to their female conspecifics (Law & Anderson, 2000).

6.2. Spatial distribution of roosts of barbastelles during summer

6.2.1. Area used by colonies

The study area is divided into varying parts between at least three colonies. The occupied minimum areas range from 0.1 to 0.9 km². These results correspond to a study of radio-tracked barbastelles in southern Brandenburg. The colony occupied 32 natural roosts in an area of 0.6 km² (Steinhauser et al., 2002). Also a new colony was found in the season of 2011. The animals were captured and recaptured only at one roost site, a former roost site of a neighbouring colony. Most likely, the colony called “Scharinger” uses additional natural roosts that are still unknown. Further recaptures within the new colony will be necessary to clarify if the colony continues to exist as an autonomous colony.

Although no research on foraging areas was done so far, that of course would be an interesting aspect for further research. Examples of Bechsteins’ bats show that the colonies not only defend their roosts but also their foraging areas (Dietz & Pir, 2009). However, because of much greater foraging areas I would not expect that to be the case for barbastelles. The energetic costs for defending such big areas are likely to be too high.

6.2.2. Hypothetical use of the landscape for roosting

The study revealed that some colonies directly border each other, e.g. “Vorderschlag” and “Scharinger”. Therefore it is likely that other colonies do the same. Presumably, the colonies split the study area amongst them and discrete borderlines can be drawn. One can speculate if some kind of puffer zone between the colonies exists. Due to the appearance of the study area, some obvious natural barriers could serve as colony borders. A brook flows between the colony “Niederkraml” and the colony “Vorderschlag” that most probably separates their roosting areas. Also the role of the densely populated village Julbach still needs to be fully clarified. Julbach may mark a border between the colony “Sonnleitner” and the colony “Vorderschlag”. But there may also be unknown roosts in anthropogenic or natural structures within the village to some extent.

6.2.3. Use of roosts

Due to the study design I observed only animals in artificial roosts. For including so far unknown roosts, extensive radio-telemetry would be inevitable. It is still unclear how many barbastelles within the study area do use both artificial and natural roosts. The recorded data suggests that for the animals of the colony “Vorderschlag”, natural roosts are of little importance. For the neighbouring colonies more recapture data is needed to confirm that hypothesis. Russo (2003) demonstrated the importance of dead trees for barbastelles in a national park in the central Italian Apennine. He radio-tracked a population of barbastelles in their summer roosts, which were roost trees without exception. Due to a frequent roost-switch, the barbastelles needed a large number of dead trees. Russo (2003) explains the behaviour of a frequent roost-switch as valuable to avoid predation, search for a more favourable microclimate, disrupt parasite cycles or respond to social needs. In a subsequent study, Russo et al. (2010) even highlighted the importance of harvested forests for the conservation of barbastelles. In the past, intensively managed forests were often seen as of low priority to preserve forest bats. But the study revealed the conservation potential of harvested forests, as long as some unmanaged patches and at least a small number of dead trees were retained in logged areas. Barbastelles roosting in managed forests show high flexibility by using live trees and rock crevices as roosts (Russo et al., 2010).

Also anthropogenic structures may be used to a greater extent than recorded. Roosts behind wood panellings on houses and barns are known to be used by barbastelles, but difficult to

find. Documented roosts behind wooden window shutters (Dolch et al., 1997; Issel et al., 1977) are of minor importance in the study area as window shutters are untypical for houses in the area.

A study on the influence of roost temperature on female Bechstein's bats' day roost selection by Kerth et al. (2001) revealed that roost selection was based directly on temperature. Females significantly preferred cold roosts before parturition, whereas post-partum, they significantly favoured warm roosts (Kerth et al., 2001). The barbastelles also showed variation in the frequency of use of different roosts. Additionally did the subcolonies alternate between different roosts within one roost location. That could imply that the barbastelles' roost selection does correspond with temperature conditions too. However, microclimatic conditions in this study were not recorded.

6.3. Phenology of barbastelles during summer

The phenological analysis was based on the data of the summer season 2011 only. The weather and temperature conditions of the season do significantly influence the phenological outcome. The data of one particular season may therefore not be representative for all populations of barbastelles.

The arrival of the animals in their summer roosts from beginning of April to beginning of May was later than expected. Provided oral information about previous years revealed that the barbastelles may even arrive at the end of February or in March. This would correspond approximately to the results of Lesiński (1986) and Urbańczyk (1991) who dated hibernation in central Europe from November to March. The time of birth could be narrowed to the second half of June and the first half of July. The exact dating of mating season needs further research. During the season of 2011 only few male-female pairs could be observed, one at the end of July and the others at the end of October. Studies on the barbastelle's mating behaviour are still rare. Abeljentsev et al. (1956) stated that in the Ukraine mating was observed during late summer and early autumn, and sometimes also in winter. Urbańczyk (1991) did not confirm winter mating for barbastelles at Nietoperek in Poland. Finally, leaving of the summer roosts could be exactly observed. The barbastelles started to leave their roosts mid of September; the last four animals were recaptured on October 31st. Until now it is still unknown where the barbastelles hibernate.

6.4. Conclusions and implications for conservation and management

For optimizing the data collection for further analyzing population structures in barbastelles it is necessary to implement new methods that are less invasive. I operated in intervals of one week to carry out visual controls. Animals did react with movement to the torch light after a few seconds. Controls therefore had to be very quick to keep disturbance at a low level. Recapture events were carried out with minimum time intervals of four weeks. The subcolonies might have vanished for the following visual controls as a reaction to the invasive method of handling the animals. Varying time periods were observed until the animals could be tracked again after handling. Of course we cannot differentiate between regular roost switching and disturbance. Nevertheless, it is inevitable to find new methods of tracking the barbastelles if uninterrupted data is requested. The methods I primarily used (capture/recapture and visual control) are adequate to reveal the basic structure and dynamics of populations. But if we want to get detailed information about quantified associations between the individuals, continuous data is necessary. Kerth & König (1999) used subcutaneously implanted microchips (transponders) in adult female Bechstein's bats. A unique code can be identified with a mobile reading device without handling the animals. A possible disadvantage might be that when the bats show clustering behaviour, the reader cannot identify animals that sit in the rear part of the roost. For further analyzing, a pairwise sharing index could be used to quantify the individuals' roosting preferences. Also the distribution of further roosts in trees and buildings in the study area would require further research by extensive radio-tracking.

According to Meschede & Heller (2002), the western barbastelle seems to be depending on a permanent high resource of moths that provides their feeding basis. Barbastelles seem to be less capable of forage on alternative food resources than other forest-dwelling bats. Hence, the preferential foraging habitat might act as a limitation factor and food shortage must be regarded as a threat to the bats (Meschede & Heller, 2002). The analysis of the food resources in the study area may also reveal further information about the spatial distribution of the colonies.

The fission-fusion structure of barbastelle populations is of great interest for prospective conservation management. Bats roosting in subcolonies need management that keeps track of the complete colony which may be scattered across a large area. It is necessary to know the entire range of a colony before defining a restricted conservation area. Supplementary studies on the western barbastelles' roosting and habitat requirements (Russo et al., 2004; Hillen et

al., 2010; Hillen et al., 2011) do also represent an important contribution to their conservation. Further research should investigate if barbastes use additional natural roosts in trees behind bark. Forest management would therefore needed to be included in the conservation management.

The knowledge about the dynamics in wild barbastele populations is important for taking appropriate and effective conservation measures in the future.

7. References

- ABELJENTSEV, V. I., PYIDOPLYICHKO, I. G. & POPOV, B. M. (1956): Fauna Ukrayini. *pp 1-448*. SSavtsyi. Vidavnistvo Akademiyi Nauk Ukrayins'koyi RSR, Kiev.
- ARCHIE, E. A., MOSS, C. J. & ALBERTS, S. C. (2005): The ties that bind: genetic relatedness predicts the fission and fusion of social groups in wild African elephants. *Proc. R. Soc. Lond. B.* 273:513-522.
- BECK, A. (1995): Fecal analysis of European bat species. *Myotis* 33-34:109-119.
- CONNOR, R. C., WELLS, R. S., MANN, J. & READ, A. J. (2000): The bottlenose dolphin: social relationships in a fission-fusion society. In: *Cetacean societies* (MANN, J., CONNOR, R. C., TYACK, P. L. & WHITEHEAD, H., eds.) *pp 91-126*. University of Chicago Press, Chicago.
- COUZIN, I. D. (2006): Behavioral Ecology: Social Organization in Fission-Fusion Societies. *Curr. Biol.* 16:R169-R171.
- DIETZ, C. & v. HELVERSEN, O. (2004): Illustrated identification key to the bats of Europe. *Electronic Publication. Version 1.0. released 15.12.2004*. Tuebingen & Erlangen.
- DIETZ, C. & PIR, J. P. (2009): Distribution and habitat selection of *Myotis bechsteinii* in Luxembourg: implications for forest management and conservation. *Folia Zool.* 58(3): 327-340.
- DOLCH, D., THIELE, K., TEUBNER, J & TEUBNER, J. (1997): Beobachtungen an einer Wochenstube der Mopsfledermaus, *Barbastella barbastellus* (Schreber, 1771). *Nyctalus* 6:211-213.
- EISENBERG, J. F. (1966): The social organizations of mammals. In: *Handbuch der Zoologie – Eine Naturgeschichte der Stämme des Tierreichs, Band 8*. (HELMCKE, J. G., v. LENGERKEN, H., STARCK, D. & WERMUTH, H., eds.) 10 (7) *pp 1-92*. Walter de Gruyter & Co, Berlin.
- HENZI, S. P., LYCETT, J. E. & PIPER, S. E. (1997): Fission and troop size in a mountain baboon population. *Anim. Behav.* 53:525-535.
- HILLEN, J., KIEFER, A. & VEITH, M. (2010): Interannual fidelity to roosting habitat and flight paths by females western barbastelle bats. *Acta Chiropterologica* 12(1):187-195.
- HILLEN, J., KASTER, T., PAHLE, J., KIEFER, A., ELLE, O., GRIEBELER E. M. & VEITH, M. (2011): Sex-specific habitat selection in an edge habitat specialist, the western barbastelle bat. *Ann. Zool. Fennici* 48:180-190.

- HUTSON, A. M., AULAGNIER, S. & SPITZENBERGER, F. (2012): *Barbastella barbastellus*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucn.org>. Downloaded on 22 August 2012.
- ISSEL, B., ISSEL, W. & MASTALLER, M. (1977): Zur Verbreitung und Lebensweise der Fledermäuse in Bayern. *Myotis* 15:19-97.
- KERTH, G. & KÖNIG, B. (1999): Fission, Fusion and nonrandom associations in female Bechstein's bats (*Myotis bechsteinii*). *Behaviour* 136:1187-1202.
- KERTH, G., MAYER, F. & KÖNIG, B. (2000): Mitochondrial DNA (mtDNA) reveals that female Bechstein's bats live in closed societies. *Mol. Ecol.* 9:793-800.
- KERTH, G., WEISSMANN, K. & KÖNIG, B. (2001): Day roost selection in female Bechstein's bats (*Myotis bechsteinii*): a field experiment to determine the influence of roost temperature. *Oecologia* 126:1-9.
- KERTH, G., SAFI, K. & KÖNIG, B. (2002): Mean colony relatedness is a poor predictor of colony structure and female philopatry in the communally breeding Bechstein's bat (*Myotis bechsteinii*). *Behav. Ecol. Sociobiol.* 52:203-210.
- KERTH, G., EBERT, C. & SCHMIDTKE, C. (2006): Group decision making in fission fusion societies: evidence from two-field experiments in Bechstein's bats. *Proc. R. Soc. B* 273:2785-2790.
- KERTH, G., PERONY, N., & SCHWEITZER, F. (2011): Bats are able to maintain long term social relationships despite high fission-fusion dynamics of their groups. *Proc. R. Soc. B*, published online 9 February 2011.
- KILIAN, W., MÜLLER, F. & STARLINGER, F. (1994): Die forstlichen Wuchsgebiete Österreichs. Eine Naturraumgliederung nach waldökologischen Gesichtspunkten. pp 53-55. Forstliche Bundesversuchsanstalt. Wien.
- KUNZ, T. H. & LUMSDEN, L. F. (2003): Ecology of Cavity and Foliage Roosting Bats. In: Bat ecology (KUNZ, T. H. & FENTON, M. B., eds.) pp 3-89. The University of Chicago Press, Ltd., London.
- LAND Oö (2011): Baumartenwahl im Mühlviertel (Amt der Oö. Landesregierung, eds.). Linz.
- LAW, B. S. & ANDERSON, J. (2000): Roost preferences and foraging ranges of the eastern forest bat, *Vespadelus pumilus* under two disturbance histories in northern New South Wales. *Austral Ecol.* 24:352-367.

- LEHMANN, J. & BOESCH, C. (2004): To fission or to fusion: effects of community size on wild chimpanzee (*Pan troglodytes verus*) social organization. *Behav. Ecol. Sociobiol.* 56:207-216.
- LESIŃSKY, G. (1986): Ecology of bats hibernating underground in central Poland. *Acta Theriol.* 31:507-521.
- MESCHEDE, A. & HELLER, K. G. (2002): Ökologie und Schutz von Fledermäusen in Wäldern. Schriftenreihe Landschaftspflege Naturschutz Heft 66:81-98. Bundesamt für Naturschutz. Bonn.
- METHENY, J. D., KALCOUNIS-RUEPELL, M. C., WILLIS, C. K. R., KOLAR, K. A. & BRIGHAM, R. M. (2007): Genetic relationships between roost-mates in a fission-fusion society of tree-roosting big brown bats (*Eptesicus fuscus*). *Behav. Ecol. Sociobiol.* 62:1043-1051.
- MORRISON, D. W. (1979): Apparent male defense of tree hollows in the fruit bat, *Artibeus jamaicensis*. *J. Mammal.* 60:11-15.
- POPA-LISSEANU, A. G., BONTADINA, F., MORA, O. & IBÁÑEZ, C. (2008): Highly structured fission-fusion societies in an aerial-hawking, carnivorous bat. *Anim. Behav.* 75:471-482.
- RAMOS-FERNÁNDEZ, G., BOYER, D. & GÓMEZ, V. P. (2006): A complex social structure with fission-fusion properties can emerge from a simple foraging model. *Behav. Ecol. Sociobiol.* 60:536-549.
- ROBINSON, J. G. & JANSON, C. H. (1987): Capuchins, squirrel monkeys, and atelines: Socioecological convergence with old world primates. In: Primate societies (SMUTS, B. B., CHENEY, D. L., SEYFARTH, R. M. & STRUHSAKER, T. T., eds.) pp 69-82. University of Chicago Press, Chicago.
- ROVERUD, R. C. & CHAPPELL, M. A. (1991): Energetic and thermoregulatory aspects of clustering behavior in the Neotropical bat *Noctilio albicentris*. *Physiol. Zool.* 64:1527-1541.
- RUSSO, D. (2003): Dead trees mean life to Italian barbastelle bats. *Ecologia Mediterranea* 29:258-260.
- RUSSO, D., CISTRONE, L., JONES, G. & MAZZOLENI, S. (2004): Roost selection by barbastelle bats (*Barbastella barbastellus*, Chiroptera: Vespertilionidae) in beech woodlands of central Italy: consequences for conservation. *Biol. Conserv.* 117:73-81.
- RUSSO, D., CISTRONE, L. & JONES, G. (2005): Spatial and temporal patterns of roost use by tree-dwelling barbastelle bats *Barbastella barbastellus*. *Ecography* 28:769-776.

- RUSSO, D., CISTRONE, L., GARONNA, A. P. & JONES, G. (2010): Reconsidering the importance of harvested forests for the conservation of tree-dwelling bats. *Biodivers. Conserv.* 19:2501-2515.
- RYDELL, J., NATUSCHKE, G., THEILER, A. & ZINGG, P. E. (1996): The diet of the barbastelle bat *Barbastella barbastellus*. *Ecography* 19:62-66.
- RYDELL, J. & BOGDANOWICZ, W. (1997): *Barbastella barbastellus*. *Mammalian Species published by the American Society of Mammalogists* 557:1-8.
- SMITH, J. E., MEMENIS, S. K. & HOLEKAMP, K. E. (2007): Rank-related partner choice in the fission-fusion society of the spotted hyena (*Crocuta crocuta*). *Behav. Ecol. Sociobiol.* 61:753-765.
- STEINHAUSER, D., BURGER, F., HOFFMEISTER, U., MAETZ, G., TEIGE, T., STEINHAUSER, P. & WOLZ, I. (2002): Untersuchungen zur Ökologie der Mopsfledermaus, *Barbastella barbastellus* (Schreber 1774), und der Bechsteinfledermaus, *Myotis bechsteinii* (Kuhl 1817) im Süden des Landes Brandenburg. In: Ökologie, Wanderungen und Genetik von Fledermäusen in Wäldern. Untersuchungen als Grundlage für den Fledermausschutz (MESCHÉDE, A., HELLER, K. G. & BOYE, P., eds.) Schriftenreihe Landschaftspflege Naturschutz Heft 71:81-98. Bundesamt für Naturschutz. Bonn.
- SUEUR, C., PETIT, O. & DENEUBOURG, J. L. (2010): Short-term fission processes in macaques: a social networking approach. *J. Exp. Biol.* 213:1338-1346.
- URBAŃCZYK, Z. (1991): Hibernation of *Myotis daubentoni* and *Barbastella barbastellus* in Nietoperek Bat Reserve. *Myotis* 29: 115-120.
- VEHRENCAMP, S. L., STILES, F. G. & BRADBURY, J. W. (1977): Observation on the foraging behavior and avian prey of the Neotropical carnivorous bat, *Vampyrus spectrum*. *J. Mammal.* 58:469-478.
- WILLIS, C. K. R. & BRIGHAM, R. M. (2004): Roost switching, roost sharing and social cohesion: forest-dwelling big brown bats, *Eptesicus fuscus*, conform to the fission fusion model. *Anim. Behav.* 68:495-505.
- WITTEMEYER, G., DOUGLAS-HAMILTON, I. & GETZ, W. M. (2005): The socioecology of elephants: analysis of the processes creating multitiered social structures. *Anim. Behav.* 69:1357-1371.
- WOLF, J. B. W., MAWDSLEY, D., TRILLMICH, F. & JAMES, R. (2007): Social structure in a colonial mammal: unraveling hidden structural layers and their foundations by network analysis. *Anim. Behav.* 74:1293-1302.

8. Appendix

Annex I: Questionnaire with biometric data for each individual and detailed information on the roost location. (KFFÖ, 2009 © Reiter, Hüttmeir & Jerabek)

Ort / Objekt					
FundortNr.	ELänge	☐ ± 10m	☐ ± 100m	☐ eintragen	☐ ergänzen
ÖK-Blatt	NBreite	☐ ± 50m	☐ > 100m	Bezirk	Bundesland
Politische Gemeinde	Ortsteil	Objekt		Höhe	Monitoring-Programm
					☐ nein ☐ ja
Besitzer		Quartierbetreuer ☐ nein ☐ ja ↓ (Name, Adresse)			
Artnachweis					
Datum	Beobachter	Monitoring-Erhebung ☐ nein ☐ ja			
Art A	Anzahl adult	Art B	Anzahl adult	☐ exakte Zählung	
	Anzahl juvenil		Anzahl juvenil	☐ gute Schätzung	
	Tote adult		Tote adult	☐ schlechte Schätzung	
lfd.Nr.	Tote juvenil	lfd.Nr.	Tote juvenil	☐ mind., evt. mehr	
Nachweistyp					
☐ Einzelfunde	☐ Fraßplatz	Quartierfund ↓↓		☐ Paarungen beobachtet	
☐ Verkehrsoffer	☐ Ø verwendb. Angaben	☐ Winterquartier		☐ Paarungen wahrscheinlich	
☐ Beutegreiferopfer	☐ Negativnachweis	☐ Zwischenquartier		☐ Paarungen möglich	
☐ Sichtnachweis	☐ Kotfund ↓↓	☐ Sommerquartier ⇔⇔⇔		Tagesquartier:	
☐ Detektornachweis	☐ frisch ☐ vereinzelt	↓		☐ Einzelquartier	
☐ Netzfang	☐ nur alt ☐ wenig	☐ Night roost		☐ Männchenquartier	
☐ Sonst. Nachweise	☐ keiner ☐ viel			☐ Mögliche Wochenstube	
	☐ sehr viel			☐ Wochenstubenquartier	
Aktuelles Quartier ☐ ja ☐ nein ☐ wahrscheinlich ☐ unbekannt			Kontrolle ☐ vollständig ☐ nur teilw. (siehe Notizen)		
Angaben zum Hangplatz / Quartier					
Detail	„Hochbauten“		Nistkästen		
☐ Freihängend	☐ Fensterladen		☐ Turm		☐ Vogelnistkasten
☐ Anliegend	☐ Rollladenkasten		☐ Innenraum		☐ Flachkästen
☐ In Spalten	☐ Schilder		☐ Dach, außen		☐ Rundkästen
☐ Im Boden	☐ Holzstoß		☐ Zwischendach		☐ sonstige
☐ sonstiges	☐ Wandverschalung		☐ Dachboden		
	☐ Firstbrett		☐ Balkon		
	☐ Mauerwerk, außen		☐ sonstige		
Notizen			Beutegreifer ☐ nein		
			☐ indirekt ↓ ☐ direkt		
			☐ aktuell ☐ Art:		
			☐ nur alt		
Angaben zu Einzelindividuen - Bestimmung nach DIETZ & v.HELVERSEN 2007					
Beobachter (beob./leg.)			Bestimmung durch (det.)		
Art	lfd.Nr.	Geschlecht	Alter	Lebend	Körperlicher Zustand
		☐ Männlich	☐ Juvenil	☐ Ja ⇔⇔	☐ Normal
		☐ Weiblich	☐ Subadult	☐ Nein	☐ Verletzt
		☐ Unbekannt	☐ Adult		☐ Geschwächt
			☐ Senil		
Gewicht (g)	Weiteres Schicksal		Reproduktiver Status		
	☐ Keine Manipulation		☐ Keine Zeichen		
	☐ Sofort freigelassen		☐ Non breeding		
Unterarm (mm)	☐ Sofort gestorben		☐ Trächtig		
	☐ Gepflegt, freigelassen		☐ Laktierend		
	☐ Gepflegt, gestorben		☐ Post Laktierend		
5.Finger (mm)	☐ Euthanasiert				
	☐ Unbekannt				
	Daumen (mm)		Ohrlänge (mm)	Penis verdickt ☐ ja ☐ nein	
Bestimmungsmerkmale (Größe, Tragus, Zähne, etc.)			Notizen (Parasiten, Verletzungen, etc.)		
Genetische Analyse	☐ Haut ☐ Haare		RingNr.:	☐ Neuberingung ☐ Wiederfund	
	☐ Kot ☐				

Objekttyp und Umgebung des Fundortes				
„Hochbauten“				
Repräsentationsb. ☐ Kirche ☐ Kapelle ☐ Kloster ☐ Schloß ☐ Burg ☐ Ruine ☐ Sonstige	Öffentl. Gebäude ☐ Amt/Verwaltung ☐ Pfarrhof ☐ Schule ☐ Verkehrsgebäude ☐ Versorgungsgeb. ☐ Techn. Bauten ☐ Sonstige	Wohngebäude ☐ Einfamilienhaus ☐ Mehrfamilienhaus ☐ Wohnbl. < 5 Etag. ☐ Wohnbl. > 5 Etag. ☐ Bauernhaus ☐ Sonstige	Nebengebäude ☐ Scheune ☐ Garage ☐ Stall ☐ Gartenhaus ☐ Geräteschuppen ☐ Holzschuppen ☐ Sonstige	Hütten ☐ Jagdhütte ☐ Wochenendhaus ☐ Almhütte ☐ Heustadel ☐ Seilbahnhütte ☐ Hochstand ☐ Sonstige
Gewerbliche Anlag. ☐ Kleinbetrieb ☐ Mittelbetrieb ☐ Großbetrieb ☐ Hotel/Gaststätte				
Ein-/Ausflugöffnung ☐ nichts Sichtbar ☐ < 10 cm ☐ 10 – 25 cm ☐ > 25 cm	Alter ☐ vor 1900 ☐ 1900 bis 2. Wk. ☐ nach 2. Wk. ☐ Rohbau	Dachbedeckung ☐ Zinkblech ☐ Kupferblech ☐ Alublech ☐ Holzschindel	☐ Eternitschindel ☐ Welleternit ☐ Ziegel ☐ Naturstein ☐ Sonstiges	Zwischendach ☐ ja ☐ nein ☐ unbekannt Beleuchtung ☐ nein ☐ weiß ☐ orange
Nistkastenquartier				
Haupttyp ☐ Vogelnistkästen ☐ Flachkästen ☐ Rundkästen ☐ Sonstige	Nebentypen ☐ Vogelnistkästen ☐ Flachkästen ☐ Rundkästen ☐ Sonstige	Anzahl Gesamt ☐ < 10 ☐ 51-100 ☐ 11-30 ☐ 101-200 ☐ 31-50 ☐ > 200		Material ☐ Holz ☐ Holzbeton ☐ Sonstiges
Baumquartier				
Quartiertyp ☐ Spechthöhle ☐ Fäulnishöhle ☐ Unter Borke	Baumart	Brusthöhendurchmesser	Höhe des Quartiers	Ø Quartieröffnung
„Tiefbauten“				
☐ Kellerreihe ☐ Kellergruppe ☐ Kellersystem ☐ Einzelkeller > 30m ☐ Einzelkeller 10-30m ☐ Einzelkeller < 10m	☐ hist. Wehranlage oberirdisch ☐ hist. Wehranlage unterirdisch ☐ Wehranlage Wk. oberirdisch ☐ Wehranlage Wk. unterirdisch ☐ Tunnel ☐ Wasserdurchlässe	☐ Bergwerk ☐ Stollen ☐ Höhle, begehbar ☐ Höhle, nicht begehbar ☐ Halbhöhle ☐ sonstiges	Spaltenreichtum ☐ Keine/wenige Spalten ☐ Vereinzelte Spalten ☐ Viele Spalten ☐ Extrem viele Spalten	
Vorherrsch. Material ☐ Gestein: sandig, kieselig ☐ Gestein: locker, erdig ☐ Mauer: Ziegel, Hohlblock ☐ Gestein: glatt und hart ☐ Gestein: kalkig ☐ Gestein: schieferig ☐ Mauer: Beton, Putz				
Umgebung des Fundortes				
Dörfliches Umfeld ☐ Dorfkern, bäuerlich ☐ Dorfkern, bürgerlich ☐ Dorfrand, bäuerlich ☐ Dorfrand, Wohnsiedlung ☐ Dorfrand, gewerblich	Städtisches Umfeld ☐ Stadtkern, Altstadt ☐ Stadtkern, Neustadt ☐ Wohngebiet, locker ☐ Wohngebiet, verdichtet ☐ Gewerbe-/Industriegebiet ☐ Industriebrache	Landwirtschaftl. Umfeld ☐ Mähwiesen ☐ Weiden ☐ Ackerland ☐ Almgebiet	Gehölzelemente ☐ Allee ☐ Feldgehölz ☐ Hecken ☐ Baumgruppen ☐ Streuobstwiesen ☐ Parks	
Flächige Sonderstandorte ☐ Steinbruch ☐ Verkehrsanlage ☐ Deponie ☐ Freizeitanlage		Umfeld ohne Nutzung ☐ Trockenes Ödland ☐ Feuchtes Ödland		Sonstiges
Forstliches Umfeld ☐ Nadelwald ☐ Auwald ☐ Laubwald ☐ Mischwald, nadelholzreich ☐ Mischwald, laubholzreich ☐ Stangenholz	Gewässer ☐ Teich ☐ Fischzuchanlage ☐ See ☐ Stausee ☐ Bach ☐ Fluß		⇒ ⇒ ⇒ Subtyp ☐ Zentrum (Waldinneres, Freie Wasserfläche) ☐ Rand (Waldrand, Ufer) ☐ Lichtung (Insel) ☐ Weg (Waldweg, Steg) ☐ Sonstiges	
Notizen, Bemerkungen, Erläuterungen				

Datum

Ort

Blatt Nr. /

Angaben zu Einzelindividuen – Bestimmung nach Dietz & v. Helversen 2004

Beobachter (beob./leg.)			Bestimmung durch (det.)		
Art	Ifd.Nr.	Geschlecht ☐ Männlich ☐ Weiblich ☐ Unbekannt	Alter ☐ Juvenil ☐ Subadult ☐ Adult ☐ Senil	Lebend ☐ Ja ⇔⇔ ☐ Nein	Körperlicher Zustand ☐ Normal ☐ Verletzt ☐ Geschwächt
Gewicht (g)	Weiteres Schicksal ☐ Keine Manipulation ☐ Sofort freigelassen ☐ Sofort gestorben ☐ Gepflegt, freigelassen ☐ Gepflegt, gestorben ☐ Eingeschlüpfert ☐ Unbekannt		Reproduktiver Status		
Unterarm (mm)			Weibchen ☐ Keine Zeichen ☐ Non breeding ☐ Trächtig ☐ Laktierend ☐ Post Laktierend	Männchen ☐ Hoden nicht entwickelt ☐ Hoden mittelgroß ☐ Hoden groß ☐ Nebenhoden leer ☐ Nebenhoden leicht gefüllt ☐ Nebenhoden prall gefüllt	
5.Finger (mm)	Daumen (mm)		Ohrlänge (mm)	Penis verdickt ☐ ja ☐ nein	
Bestimmungsmerkmale (Größe, Tragus, Zähne, etc.)			Notizen (Parasiten, Verletzungen, etc.)		
Genet. Probe	☐ Haut ☐ Haare ☐ Kot ☐		RingNr.	☐ Neuberingung ☐ Wiederfund	
Fanghöhe (m)	Fangzeit		Fangstandort		

Angaben zu Einzelindividuen – Bestimmung nach Dietz & v. Helversen 2004

Beobachter (beob./leg.)			Bestimmung durch (det.)		
Art	Ifd.Nr.	Geschlecht ☐ Männlich ☐ Weiblich ☐ Unbekannt	Alter ☐ Juvenil ☐ Subadult ☐ Adult ☐ Senil	Lebend ☐ Ja ⇔⇔ ☐ Nein	Körperlicher Zustand ☐ Normal ☐ Verletzt ☐ Geschwächt
Gewicht (g)	Weiteres Schicksal ☐ Keine Manipulation ☐ Sofort freigelassen ☐ Sofort gestorben ☐ Gepflegt, freigelassen ☐ Gepflegt, gestorben ☐ Eingeschlüpfert ☐ Unbekannt		Reproduktiver Status		
Unterarm (mm)			Weibchen ☐ Keine Zeichen ☐ Non breeding ☐ Trächtig ☐ Laktierend ☐ Post Laktierend	Männchen ☐ Hoden nicht entwickelt ☐ Hoden mittelgroß ☐ Hoden groß ☐ Nebenhoden leer ☐ Nebenhoden leicht gefüllt ☐ Nebenhoden prall gefüllt	
5.Finger (mm)	Daumen (mm)		Ohrlänge (mm)	Penis verdickt ☐ ja ☐ nein	
Bestimmungsmerkmale (Größe, Tragus, Zähne, etc.)			Notizen (Parasiten, Verletzungen, etc.)		
Genet. Probe	☐ Haut ☐ Haare ☐ Kot ☐		RingNr.	☐ Neuberingung ☐ Wiederfund	
Fanghöhe (m)	Fangzeit		Fangstandort		

Annex II: Subcolonies from 2006 to 2012.

Single male barbastes or mixed pairs were not counted as independent subcolonies, therefore no subcolony-number was assigned to them. Due to integrity of data collection, all individuals are listed.

2006: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	27.05.2006	4	1	Binder	1	H134599	silver	f	adult	capture
			2	Deschka	1	H134600	silver	f	adult	capture
			3	Naderhirm	3	H134596	silver	f	adult	capture
						H134597	silver	f	adult	capture
						H134598	silver	f	adult	capture
				Höfler nord	1	H134595	silver	m	adult	capture
			4	Scharinger	7	H134590	silver	f	adult	capture
						H134591	silver	f	adult	capture
						H134592	silver	f	adult	capture
						H134593	silver	f	adult	capture
Vorderschlag	09.07.2006	1		Oppel	1	H134583	silver	m	adult	capture
				Öller	1	H134586	silver	m	adult	capture
			1	Deschka	3	H134587	silver	m	adult	capture
						H134588	silver	m	adult	capture
						H134596	silver	f	adult	recap
Sonnleitner	09.07.2006			Sonnleitner	1	H134584	silver	m	adult	capture
				Haininger	1	H134585	silver	m	adult	capture
Vorderschlag	09.09.2006	4	1	Binder	7			3 f / 2 m	2 ad / 3 sub	
			2	Öller	8			6 f / 2 m	5 ad / 3 sub	
			3	Scharinger	10			2 f		recap
				Höfler nord	1			m		recap
			4	Oppel	1			f	adult	

2007: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	02.05.2007			Binder	1	H134588	silver	m	adult	recapture
				Höfler süd	1	H134595	silver	m	adult	recapture
Bräuerau	02.05.2007			Bräuerau	1	H134567	silver	m		capture
Vorderschlag	17.07.2007	1	1	Winkler	2	H156340	silver	f	adult	capture
						H156346	silver	f	adult	capture
Sonnleitner	17.07.2007	1	1	Sonnleitner	4	H156020	silver	f	adult	capture
						H156325	silver	f	adult	capture
Niederkrabl	17.07.2007	1	1	Ganser	1	H156337	silver	f	adult	capture
Vorderschlag	02.09.2007	1	1	Höfler nord	30	H134590	silver	f	adult	recapture
						H134591	silver	f	adult	recapture
						H134592	silver	f	adult	recapture
						H134596	silver	f	adult	recapture
						H134598	silver	f	adult	recapture
						H134600	silver	f	adult	recapture
						H156258	silver	f	sub	capture
						H156264	silver	f	sub	capture
						H156265	silver	m	sub	capture
						H156266	silver	f	adult	capture
						H156267	silver	f	sub	capture
						H156270	silver	m	sub	capture
						H156272	silver	f	adult	capture
						H156273	silver	f	adult	capture
Niederkrabl	02.09.2007	1	1	Grübl	13	H134597	silver	f	adult	recapture

2008: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult, *juv* juvenile

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	23.05.2008	1	1	Höfler süd	2	H134594	silver	f	adult	recapture
Vorderschlag	05.07.2008	2	1	Oppel	9	H134596	silver	f	adult	recapture
			2	Binder	min. 10	H156273	silver	f	adult	recapture
Friedl	05.07.2008	1	1	Friedl	min. 10					
Sonnleitner	05.07.2008	1	1	Sonnleitner	min. 10					
Niederkraml	05.07.2008	1	1	Ganser	min. 10					
Vorderschlag	01.09.2008	1	1	Winkler	21	H134593	silver	f	adult	recapture
						H134596	silver	f	adult	recapture
						H156254	silver	f	sub	capture
						H156257	silver	f	sub	capture
						H156299	silver	f	sub	capture
						H156300	silver	f	adult	capture
Niederkraml	01.09.2008	1	1	Maurer	15	H134504	silver	f	adult	capture
						H134511	silver	f	sub	capture
						H134514	silver	f	sub	capture
						H134515	silver	f	sub	capture
Sonnleitner	01.09.2008	1	1	Sonnleitner	14	H134516	silver	f	adult	capture
						H134517	silver	f	sub	capture
						H134518	silver	m	juv	capture
						H134519	silver	f	sub	capture
						H156020	silver	f	adult	recapture

2009: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Niederkraml	13.06.2009	1	1	Ganser	15	H134511	silver	f	adult	recapture
						H134597	silver	f	adult	recapture
						H134604	red	f	adult	capture
						H134614	red	f	adult	capture
						H134617	red	f	adult	capture
						H134619	red	f	adult	capture
						H134633	red	f	adult	capture
						H134641	red	f	adult	capture
Bräuerau	13.06.2009	1	1	Bräuerau	5	H134647	red	f	adult	capture
						H156367	light blue	f	adult	capture
						H156373	light blue	f	adult	capture
						H156376	light blue	f	adult	capture
						H156377	light blue	f	adult	capture
Vorderschlag	08.08.2009	1	1	Öller	1	H156379	light blue	f	adult	capture
						H159792	silver	m	adult	capture
						H134593	silver	f	adult	recapture
						H134596	silver	f	adult	recapture
						H156272	silver	f	adult	recapture
Sonnleitner	08.08.2009	1	1	Sonnleitner	28	H159593	yellow	m	sub	capture
						H134516	silver	f	adult	recapture
						H134517	silver	f	adult	recapture
						H134519	silver	f	adult	recapture
						H156020	silver	f	adult	recapture
						H159651	violet	f	adult	capture
						H159652	violet	f	adult	capture
						H159653	violet	f	adult	capture
						H159656	violet	f	adult	capture
						H159657	violet	m	sub	capture
						H159658	violet	m	sub	capture
						H159659	violet	f	sub	capture
						H159660	violet	f	sub	capture
						H159661	violet	f	sub	capture
						H159662	violet	f	sub	capture
						H159663	violet	m	sub	capture
						H159664	violet	f	sub	capture
						H159666	violet	m	sub	capture
						H159667	violet	f	sub	capture
						H159668	violet	f	sub	capture
						H159688	silver	m	sub	capture
						H159689	violet	f	sub	capture
						H159690	violet	f	sub	capture

2010: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult, *juv* juvenile

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	06.06.2010	2	1	Egermühle	10					
			2	Naderhirn	25					
Niederkraml	06.06.2010	1	1	Ganser	15					
Vorderschlag	12.06.2010	1	1	Deschka	8	H134599	silver	f	adult	recapture
						H134675	green	f	adult	capture
						H134681	green	f	adult	capture
						H134689	green	f	adult	capture
						H134690	green	f	adult	capture
						H156343	green	f	adult	capture
Niederkraml	12.06.2010	1	1	Ganser 20	5	H159777	silver	f	adult	capture
						H159776	silver	f	adult	capture
						H159775	silver	f	adult	capture
						H159773	silver	f	adult	capture
Vorderschlag	07.08.2010	3	1	Binder	26	H134558	green	f	juv	capture
						H134560	green	f	adult	capture
						H134599	silver	f	adult	recapture
						H134663	green	f	adult	capture
						H134673	green	f	adult	capture
						H134683	green	f	adult	capture
						H134687	green	f	adult	capture
						H134690	green	f	adult	recapture
						H156343	green	f	adult	recapture
			2	Egermühle	9	H134554	silver	m	sub	capture
						H134555	silver	m	sub	capture
						H134593	silver	f	adult	recapture
						H156272	silver	f	adult	recapture
			3	Naderhirn	1	H134689	green	f	adult	recapture
Niederkraml	07.08.2010	1	1	Sommer Klaus	15	H134511	silver	f	adult	recapture
						H134514	silver	f	adult	recapture
						H134597	silver	f	adult	recapture
						H134614	red	f	adult	recapture
						H134619	red	f	adult	recapture
						H134628	red	f	juv	capture
						H134633	red	f	adult	recapture
						H134642	red	f	juv	capture
						H134648	red	f	juv	capture
						H134650	red	m	juv	capture
						H156337	silver	f	adult	recapture
						H159773	silver	f	adult	recapture
						H159775	silver	f	adult	recapture
						H159776	silver	f	adult	recapture

2011: Number and size of subcolonies.

m male, *f* female, *cap* capture, *recap* recapture, *sub* subadult, *juv* juvenile

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	03.06.2011	2	1	Egermühle	4	H134596	silver	f	adult	recapture
						H159594	yellow	f	adult	capture
		2		Binder	6	H134689	green	f	adult	recapture
						H159566	yellow	f	adult	capture
						H159570	yellow	f	adult	capture
						H159575	yellow	f	adult	capture
Sonnleitner	03.06.2011	1	1	Haininger	15	H134687	green	f	adult	recapture
						H134516	silver	f	adult	recapture
						H134519	silver	f	adult	recapture
						H156320	silver	f	adult	recapture
						H159651	violet	f	adult	recapture
						H159661	violet	f	adult	recapture
						H159665	violet	f	adult	recapture
						H159668	violet	f	adult	recapture
						H159671	violet	f	adult	capture
						H159672	violet	f	adult	capture
						H159673	violet	f	adult	capture
						H159674	violet	f	adult	capture
Vorderschlag	01.07.2011	2		Höfler süd	1	H159764	silver	m	adult	capture
				Naderhirn	1	H159765	silver	m	adult	capture
			1	Oppel	1	H134558	green	f	adult	recapture
			2	Bergheindl	14	H134561	green	f	adult	recapture
						H134599	silver	f	adult	recapture
						H134675	green	f	adult	recapture
						H134681	green	f	adult	recapture
						H134683	green	f	adult	recapture
						H134689	green	f	adult	recapture
						H134690	green	f	adult	recapture
						H159552	yellow	f	adult	capture
						H159566	yellow	f	adult	recapture
						H159570	yellow	f	adult	recapture
						H159575	yellow	f	adult	recapture
						H159577	yellow	f	adult	capture
						H159579	yellow	f	adult	capture
						H159587	yellow	f	adult	capture
Scharinger	01.07.2011	1	1	Scharinger	16	H159553	yellow	f	adult	capture
						H159558	yellow	f	adult	capture
						H159561	yellow	f	adult	capture
						H159573	yellow	f	adult	capture
						H159580	yellow	f	adult	capture
						H159583	yellow	f	adult	capture
						H159584	yellow	f	adult	capture
						H159585	yellow	f	adult	capture
						H159588	yellow	f	adult	capture
						H159589	yellow	f	adult	capture
Niederkruml	01.07.2011			Mitgutsch	1	H159763	silver	m	adult	capture
Vorderschlag	30.07.2011	2		Höfler süd	1	H159764	silver	m	adult	recapture
				Winkler	1	H134509	silver	m	adult	capture
			1	Binder	2	H134558	green	f	adult	recapture
			2	Binder	25	H134551	silver	f	juv	capture
						H134552	silver	m	juv	capture
						H134553	silver	f	juv	capture
						H134675	green	f	adult	recapture
						H134681	green	f	adult	recapture
						H134689	green	f	adult	recapture
						H159577	yellow	f	adult	recapture
						H159767	silver	f	adult	capture
Scharinger	30.07.2011	1	1	Scharinger	19	H134510	silver	m	juv	capture
						H159551	yellow	f	juv	capture
						H159553	yellow	f	adult	recapture
						H159558	yellow	f	adult	recapture

						H159559	silver	m	juv	capture
						H159561	yellow	f	adult	recapture
						H159564	yellow	f	juv	capture
						H159565	yellow	f	adult	capture
						H159572	yellow	f	juv	capture
						H159574	yellow	f	juv	capture
						H159576	silver	m	juv	capture
						H159580	yellow	f	adult	recapture
						H159583	yellow	f	adult	recapture
						H159586	silver	m	juv	capture
						H159589	yellow	f	adult	recapture
						H159590	yellow	f	adult	recapture
Sonnleitner	30.07.2011	1	1	Sonnleitner	6	H159671	violet	f	adult	recapture
						H159673	violet	f	adult	recapture
						H159685	violet	f	adult	capture
						H159686	violet	f	adult	capture
						H159693	violet	f	adult	capture
						H159699	violet	f	adult	capture
Sonnleitner	04.08.2011	1	1	Reitberger	41	H134516	silver	f	adult	recapture
						H134517	silver	f	adult	recapture
						H159651	violet	f	adult	recapture
						H159653	violet	f	adult	recapture
						H159659	violet	f	adult	recapture
						H159661	violet	f	adult	recapture
						H159662	violet	f	adult	recapture
						H159664	violet	f	adult	recapture
						H159665	violet	f	adult	recapture
						H159668	violet	f	adult	recapture
						H159674	violet	f	adult	recapture
						H159686	violet	f	adult	recapture
						H159689	violet	f	adult	recapture
						H159690	violet	f	adult	recapture
						H159693	violet	f	adult	recapture
Vorderschlag	05.08.2011	1	1	Öller	20	H134561	green	f	adult	recapture
						H134599	silver	f	adult	recapture
						H134675	green	f	adult	recapture
						H134681	green	f	adult	recapture
						H134683	green	f	adult	recapture
						H134687	green	f	adult	recapture
						H134689	green	f	adult	recapture
						H159552	yellow	f	adult	recapture
						H159575	yellow	f	adult	recapture
						H159577	yellow	f	adult	recapture
						H159579	yellow	f	adult	recapture
						H159587	yellow	f	adult	recapture
						H159767	silver	f	adult	recapture
Sonnleitner	05.08.2011	1	1	Sonnleitner	21	H134516	silver	f	adult	recapture
						H134517	silver	f	adult	recapture
						H134519	silver	f	adult	recapture
						H159320	silver	f	adult	recapture
						H159651	violet	f	adult	recapture
						H159653	violet	f	adult	recapture
						H159656		f	adult	recapture
						H159659	violet	f	adult	recapture
						H159661	violet	f	adult	recapture
						H159662	violet	f	adult	recapture
						H159665	violet	f	adult	recapture
						H159668	violet	f	adult	recapture
						H159671	violet	f	adult	recapture
						H159672	violet	f	adult	recapture
						H159686	violet	f	adult	recapture
						H159689	violet	f	adult	recapture
						H159690	violet	f	adult	recapture
						H159693	violet	f	adult	recapture
Vorderschlag	12.08.2011	1	1	Egermühle	7	H134505	silver	f	sub	capture
						H134506	silver	f	sub	capture
						H134508	silver	f	sub	capture

						H159766	silver	f	sub	capture
				Höfler nord	1	H159764	silver	m	adult	recapture
Scharinger	12.08.2011	1	1	Scharinger	18	H134507	silver	f	sub	capture
						H134510	silver	m	sub	recapture
						H159558	yellow	f	adult	recapture
						H159559	yellowish	m	sub	recapture
						H159561	yellow	f	adult	recapture
						H159564	yellow	f	sub	recapture
						H159572	yellow	f	sub	recapture
						H159573	yellow	f	adult	recapture
						H159574	yellow	f	sub	recapture
						H159576	yellowish	m	sub	recapture
						H159583	yellow	f	adult	recapture
						H159586	yellowish	m	sub	recapture
						H159589	yellow	f	adult	recapture
						H159590	yellow	f	adult	recapture
Vorderschlag	02.09.2011	2	1	finkler	2	H134505	silver	f	adult	recapture
						H159766	silver	f	adult	recapture
			2	finkler	3	H134506	silver	f	adult	recapture
						H134508	silver	f	adult	recapture
						H159594	yellow	f	adult	recapture
Vorderschlag	18.10.2011	1	1	Höfler nord	2	H159764	silver	m	adult	recapture
						H159766	silver	f	adult	recapture
Vorderschlag	25.10.2011	2	1	Höfler nord	1	H134505	silver	f	adult	recapture
			2	Höfler nord	1	H134506	silver	f	adult	recapture
Vorderschlag	31.10.2011	1	1	Höfler nord	3	H134505	silver	f	adult	recapture
						H134506	silver	f	adult	recapture
						H159764	silver	m	adult	recapture

2012: Number and size of subcolonies. *m* male, *f* female, *cap* capture, *recap* recapture

colony name	date	total number	number	roost position	animals total	ring number	ring colour	sex	age	cap/recap
Vorderschlag	16.06.2012	2		Egermühle	1	H159576	silber	m	adult	recapture
			1	Naderhirn a	9	H134551	silber	f	adult	recapture
						H134553	silber	f	adult	recapture
						H134561	green	f	adult	recapture
						H134681	green	f	adult	recapture
						H134690	green	f	adult	recapture
						H159577	yellow	f	adult	recapture
						H159579	yellow	f	adult	recapture
						H159673	violet	f	adult	recapture
			2	Naderhirn b	7	H134558	green	f	adult	recapture
						H134599	silber	f	adult	recapture
						H134675	green	f	adult	recapture
						H134683	green	f	adult	recapture
						H134687	green	f	adult	recapture
						H159552	yellow	f	adult	recapture
						H159575	yellow	f	adult	recapture
Niederkraml	16.06.2012	1	1	Maurer	10	H134511	silber	f	adult	recapture
						H134514	silber	f	adult	recapture
						H134628	red	f	adult	recapture
						H134633	red	f	adult	recapture
						H156337	silber	f	adult	recapture
						H159773	silber	f	adult	recapture
						H159775	silber	f	adult	recapture
Vorderschlag	20.07.2012	2	1	Egermühle	8	H134505	silber	f	adult	recapture
						H134593	silber	f	adult	recapture
						H159564	yellow	f	adult	recapture
						H159766	silber	f	adult	recapture
			2	Binder	29	H134553	silber	f	adult	recapture
						H134681	green	f	adult	recapture
						H134687	green	f	adult	recapture
						H159566	yellow	f	adult	recapture
						H159577	yellow	f	adult	recapture
						H159579	yellow	f	adult	recapture

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Curriculum vitae

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Education:

1992-1996 Volksschule Peilstein/Mühlkreis
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2004-2013 Biology/Zoology studies at the University of Vienna
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Congresses:

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Jul-Aug 2001 Veterinary Doneus & Tews, Rohrbach
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Jul 2005 Seal Rehabilitation and Research Centre, Pieterburen/Netherlands
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