Swarming of *Myotis Myotis* in an old slate of Morbihan in Brittany. France.

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Abstract : The results presented here stem from a larger program on the study of the Great Mouse-eared bat (*Myotis myotis*) throughout its life cycle. This program is based on the individual marking of all members of five nurseries in Morbihan. During the swarming seasons 2011, 2012 and 2013, bats were mistnettted during 93 nights (about 30 per season). The results show that members of the five nurseries are found during swarming in an old slate. We recorded a female-biased sex ratio and an age-ratio in favor of juveniles. Substantial interannual variation in the number of *Myotis myotis* captured was recorded and may reflect a low survival rate of juveniles. This fall in numbers is consistent with high levels of mortality for the 2012 cohort in the same year in some nurseries and in the largest hibernacula in Brittany. This suggests that captures in swarming sites could help to evaluate the survival rate of juveniles at least for species for which juveniles are visiting swarming sites.

Résumé : Les résultats présentés ici constituent une phase d'un programme plus vaste portant sur l'étude du Grand murin (*Myotis myotis*) tout au long de son cycle biologique. Ce programme est basé sur le marquage individuel de l'ensemble des membres de cinq nurseries dans le Morbihan. Au cours des saisons de regroupements automnaux 2011, 2012 et 2013, 93 soirées de captures ont réalisées soit environ 30 par saison. Les résultats prouvent que les membres des cinq nurseries se retrouvent lors du swarming dans une ancienne ardoisière. Nous avons enregistré un sexe ratio en faveur des femelles et un âge ratio principalement en faveur des juvéniles. Une importante variation interannuelle du nombre de *Myotis myotis* capturés a été enregistrée en 2012 et pourrait être le reflet d'un faible taux de survie des juvéniles en particuliers. Cette chute des effectifs est concordante avec une forte mortalité enregistrée pour cette cohorte la même année dans certaines nurseries et des effectifs en

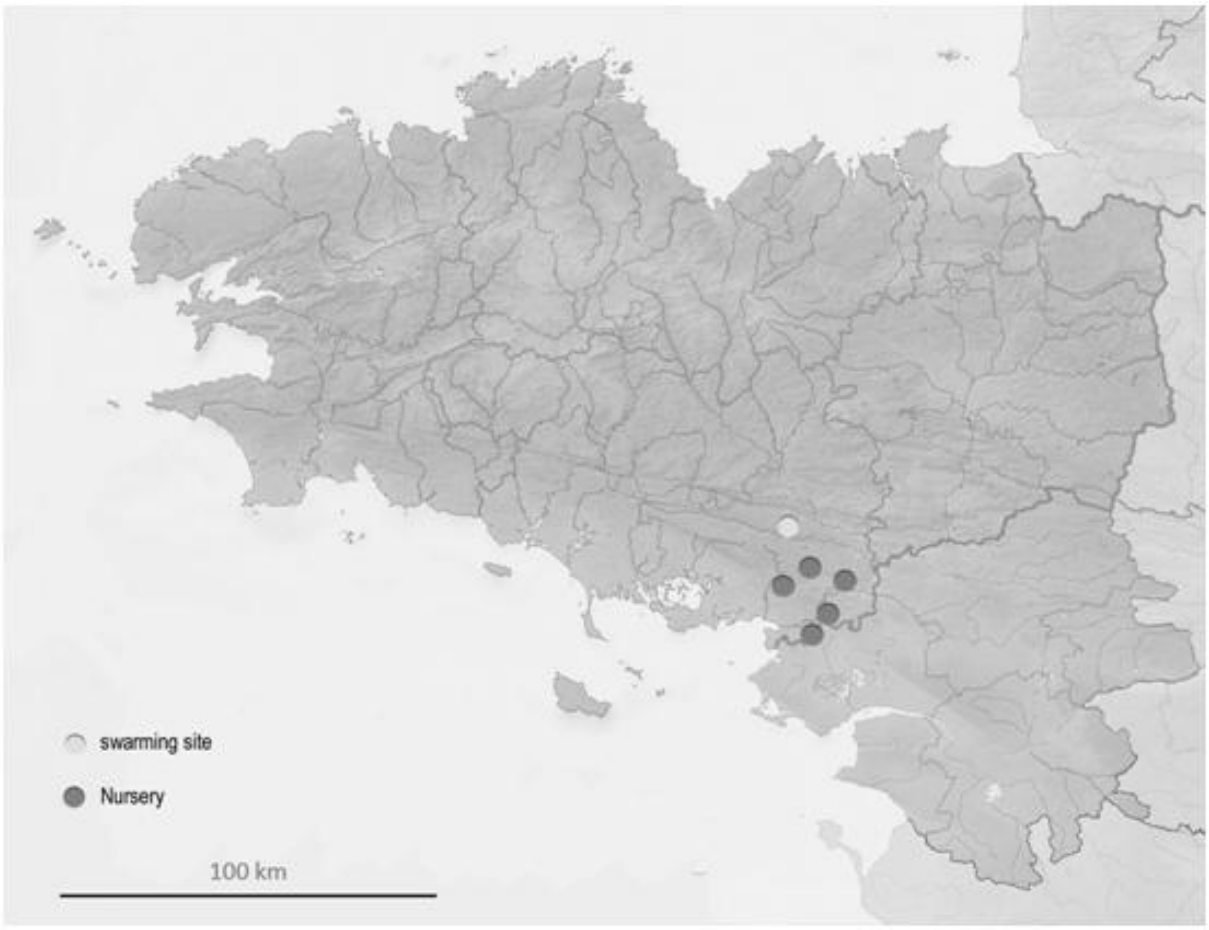
chute libre dans les plus importants gîtes d'hibernation. Il est donc possible de supposer que le swarming pourrait contribuer à évaluer le taux de survie des juvéniles, du moins pour les espèces où ceux-ci gagnent des sites de regroupement automnaux.

Keys words : Sex ratio, Age ratio, Pit-tag, Interannual variations.

Introduction

Swarming has been described in North America (Thomas et al. 1979) and more recently in Europe through studies conducted in Great Britain (e.g. Parsons et al. 2003). Swarming comes from « swarm » used to characterize this phase of the life-cycle of bats during which they converge in autumn to underground sites in order to mate. For some authors, the presence of bats in autumn in underground sites can be motivated by mating opportunities but also as an insurance to find suitable hibernacula (Nagel et al. 2005). Even if swarming sites can offer ideal characteristics for hibernation, significant differences between the numbers of bats visiting such sites in autumn and winter populations have been documented : the numbers of bats and species which are swarming in autumn are higher than those observed in winter (eg. Rivers et al., 2005).There is evidence that this mating strategy concerns a large number of species, but not all species. It was also demonstrated the importance of these sites for the maintenance of gene flow between populations (e.g. Kerth et al. 2003, Veith et al. 2004, Rivers et al. 2005) giving them a major role in the conservation of species for which some are also unaffected by protective measures. In Brittany, the Bretagne Vivante Association identified the first sites in 2003 (Farcy et al. 2010), including this former slate which is unexploited since the end of the 19th century. Abandoned, the site was gradually colonized by bats. In the late 1980s, chiropterologists of Bretagne Vivante have shown interest in this complex slate for hibernating bats. In 2000, one of the galleries of this complex gained a protection status through an agreement between Bretagne Vivante and the owner, and a gate was installed to protect its entrance. Finally in 2011, the slate was included in the Natura 2000 site FR5300058 "Valley of the Arz". The results presented here were obtained as part of a larger study on the Greater Mouse-eared bat (*Myotis myotis*) funded by a Contrat Nature established by the Regional Council of Brittany with additional funds coming from ERDF and the DREAL of Loire Atlantique under the Action Plan for the Conservation of Bats. This study is based on a capture-tagging-recapture method. Since 2010, we marked individuals from five nurseries with pit-tags. The individuals are captured in one night for each colony when the juveniles are able to fly and to go outside the nursery.

Figure 1 : Localization of the five pit-tagged ‘nursery and the swarming site.



Material and method

Pit tag

Since 2010, we have set up a large program based on tagging via transponders in five nurseries in Morbihan (Brittany). We used injectable Trovan ID 100. All *Myotis myotis* captured were examined with a pocket reader Trovan LID 572 which has a circular antenna ANTC100.

In 2010, 196 *Myotis myotis* have been marked, 444 additional individuals in 2011, 335 in 2012, and 289 in 2013, for a total of 1264 individuals.

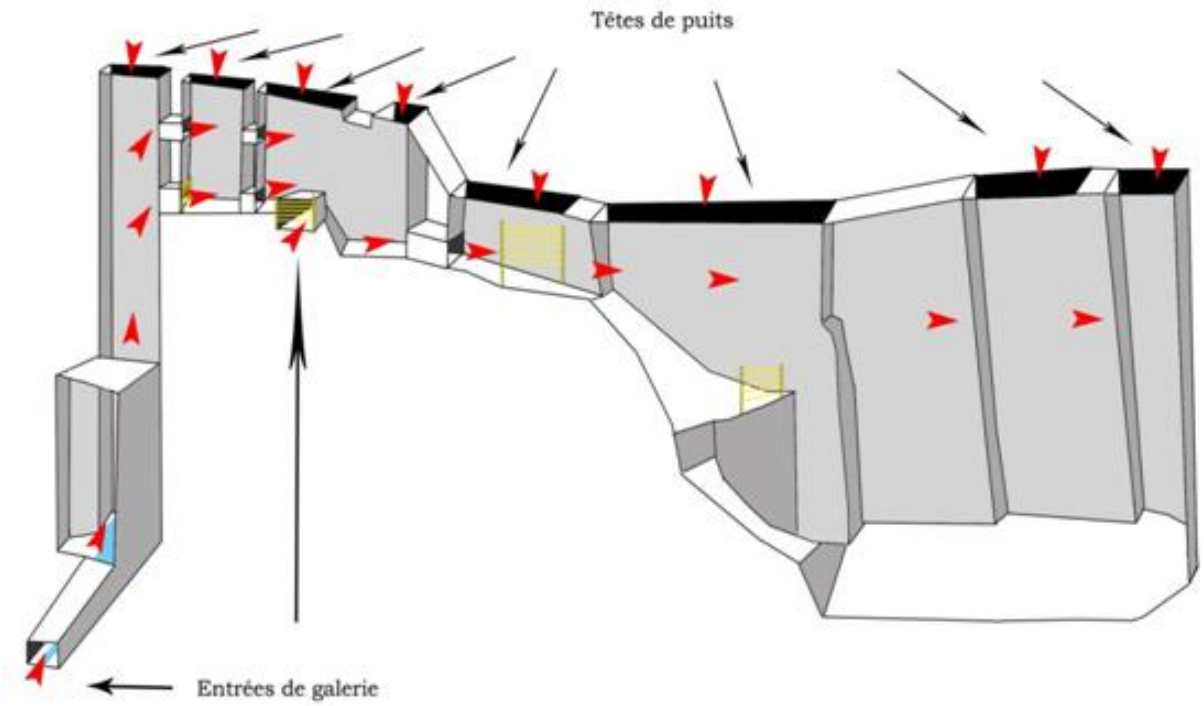
Study site

The study site is located in the southeast of Morbihan (Brittany). Followed for nearly 25 years, the slate features large numbers and a wide range of species of bats in winter which ranks it among the most important hibernacula of Brittany. However, in terms of its topography, large wells, deep cracks, debris on the ground or mounted in walls, the reported numbers of bats in winter are probably

underestimated.

The study slate consists of six distinct cavities unconnected but close to each other. Our study was performed on one of these cavities, which had also been evaluated for its interest for swarming in 2003. It consists of several well connected mine shafts (cf. Figure 2).

Figure 2 : Sectional view of the cavity studied. The nets are drawn in yellow. Red arrows indicate the movement of bats in the cavity.



Period and capture mode

This study was conducted between 26 August 2011 and 14 October 2011 inclusive, between the 27 August 2012 and the 12 October 2012 inclusive and between the 27 August 2013 and the 14 October 2013 inclusive. We captured five consecutive nights a week (32 nights in 2011, 31 in 2012 and 31 in 2013). Catches began between 20pm and 20.30pm depending on season. The nets were placed in front of the access used by bats to enter into the site but also even inside the cavity. A maximum of five nets were set up, four or five more generally, before sunrise and until 3am or 4am (see Figure 1). In 2011, 2012, and 2013, we captured five days per week from the end of August until 14 October. All *Myotis myotis* captured were sexed, aged and their reproductive status clarified. *Myotis myotis* which were not pit-tagged, were released on site after being marked by cutting hair. Note that catches are

only a sample of individuals who visited the site. In fact, due to the presence of wellhead, bats can access the cavity without going through the entrances where the nets were installed. The temperatures used here are extracted from a database available at http:/.

Reproductive status of males and females

The male sexual status was determined by observation of swelling of the gonads and epididymis and the status of females was determined by observation of the breasts (Table 1).

Table 1 : Criterions use to determinate the reproductive status.

	Observation	Code	Reproductive status
Male	Undeveloped gonads	G0	non reproductive status
	Not visible epididymis	E0	non reproductive status
	Visible gonads	G1	reproductive potential
	Visible epididymis	E1	reproductive potential
	Gonads enlarged	G2	reproductive
	Epididymis enlarged	E2	reproductive
Female	Breasts and released from hair	AL	breastfeeding
	Undrawn breasts and more or less clear	PL	post-lactating
	Other	NL	nulliparous

Results

32 nights catches were made in 2011, 31 in 2012, and 31 in 2013. In 2011, 2481 bats were captured, 707 in 2012, and 2240 in 2013. A significant change in the number of bats captured was recorded in 2012 compared to 2011 and 2013. This change affected all species. *Myotis myotis* was after *Myotis daubentoni* the predominant specie captured. It represented 28.7% of the mist-netted bats in 2011, 25% in 2012, and 18% in 2013.

Average temperatures and number of individuals

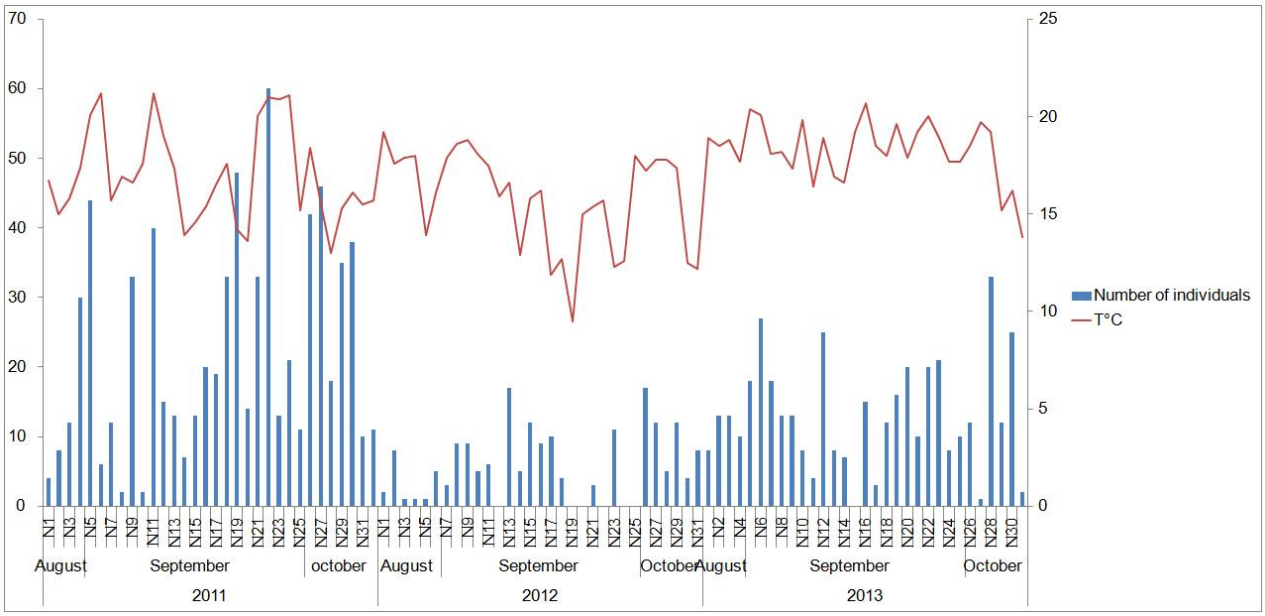
There was a slight variation between the average temperatures recorded in 2011, 2012 and 2013. In 2011, the average mean temperature was 16.9°C (SD: 2.33). It was 15.6°C in 2012 (SD: 2.53), and 17.7°C in 2013 (SD: 2.79).

In 2011, we captured 713 Great mouse-eared bats, against 175 in 2012, and 405 in 2013. In 2011, the maximum number of individuals captured during one night was 60. It was 17 in 2012 and 33 in 2013. We caught more than 33 bats per night all along eleven night catches in 2011. In 2012, there were only four evenings during which we captured more than 10 bats each night, and in 2013, we could

catch more than 20 bats/night during five nights.

Numbers of capture do not seem to be correlated with the temperature (cf. Figure 3).

Figure 3 : Number of *Myotis myotis* mist-netted per night and daily average temperatures in 2011, 2012 and 2013.

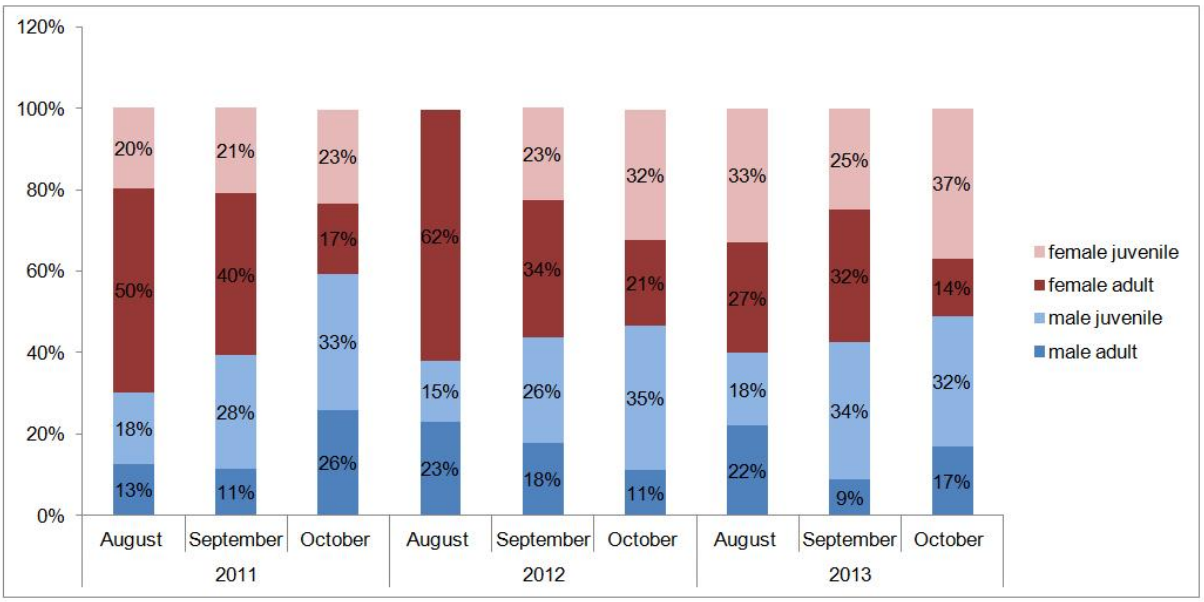


Age group and Sex ratio

In 2011 and 2013, juveniles accounted for 51% and 59.2% of *Myotis myotis* captured in the slate and 49.8% in 2012. The age of the juvenile class, determined by the presence of the chin spot, which is the only criterion for discriminating adults from youth at this period, may be overstated because of the persistence of this chin spot in some adults (Farcy et Touzalin, 2011). For the cohort of males, juveniles accounted for 63.8% of individuals captured in 2011, 60.5% in 2012 and 71% in 2013. In juvenile males, we found 57.5% of them sexually active in 2011, 30.4% in 2012 and 50.7% in 2013. In adult males, we found 87% of them sexually active in 2011, 86.6% in 2012 and 96% in 2013.

Whatever the year, the sex ratio was dominated by females which accounted for between 55% and 56.5% of *Myotis myotis* captured. The sex ratio tended to be balanced at the end of the swarming season (cf. Figure 4).

Figure 4 : Monthly age group and sex ratio of Myotis myotis mist-netted in 2011, 2012 and 2013



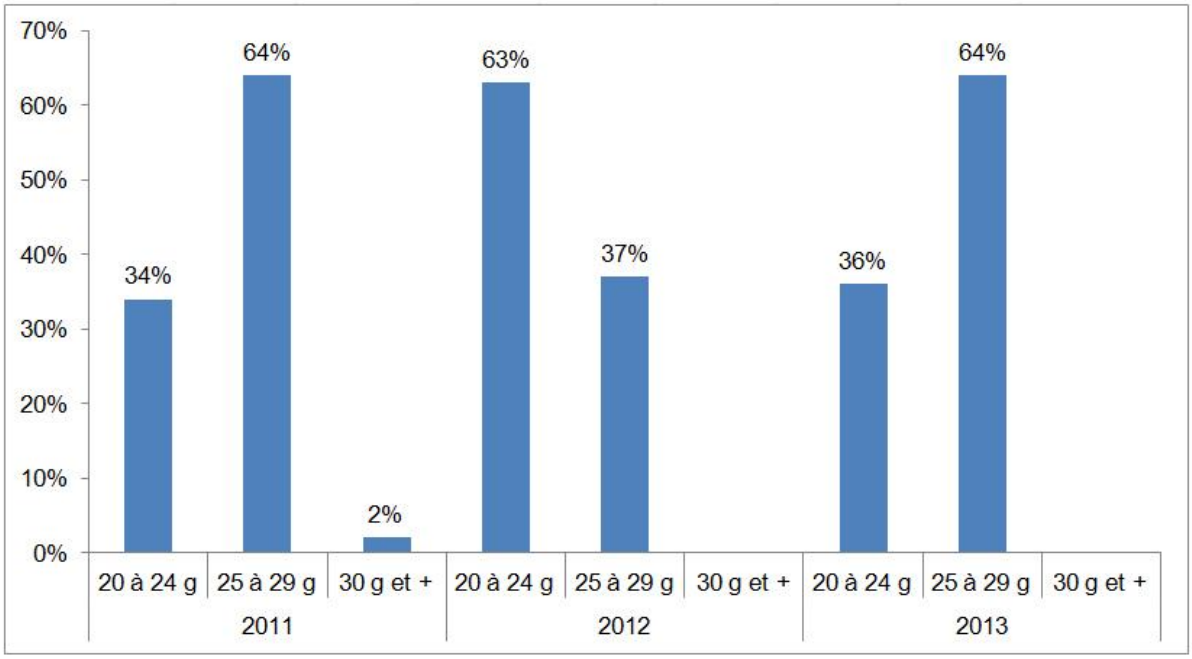
Pittagged Myotis myotis

During the swarming season in 2011, 115 marked individuals were captured, 43 in 2012, and 94 in 2013. It represented in 2011 17.9% of the individuals marked (n=640) since 2010, 4.4% of the individuals marked (n=945) in 2012, and 7.4% of the individuals marked (n=1264) in 2013. These percentages might be underestimates because of the mortality of a non evaluated part of the pit-tagged *Myotis myotis*, especially for the juvenile males. Members of the five marked nurseries were retested in our study site. This swarming site is remote to nurseries from 8km for the nearest and 25.5km for the farthest.

Weight

We recorded a significant difference between the weights recorded in 2012 and those recorded in 2011 and 2013. Juveniles had an average weight of 25.4 grams (sd : 1.65) in 2011, 25.4 grams (sd :1.61) in 2013, and 23.6 grams (sd :1.81) in 2012. Thus, 63% of juveniles in 2012 weighed less than or equal to 25 grams (weight which can be considerate as the average weight for this cohort at this period), while in 2011 and 2013, the majority of this cohort exceeded 25 grams (see Figure 5). For adults, the average weight recorded was 28 grams (sd : 2.48) in 2011, 27.1 grams (sd : 1.47) in 2012 and 28.6 grams (sd : 2.49) in 2013. None of them had reached 30 grams in 2012, while 17-20% of them in 2011 and 2013 had reached or exceeded this weight.

Figure 5 : Statement of the juvenils 'weight of Myotis myotis mist-netted in 2011, 2012 and 2013



Fidelity

The sample considered is composed of 89 individuals For these individuals, we have evidence of life in summer 2013**.** No matter the year of marking or the age of the individuals, there is a very low rate of recapture. Thus 93.2% of *Myotis myotis* were observed only one year at the swarming site (cf. Table 2).

Table 2 : Number of individuals rechecked during the three seasons of swarming (Cohorts 2010-2011-2012).

	Female						**Male**					
	Adults			**Juvenils**			**Adults**			**Juvenils**		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
One season of swarming	10	28	7	7	14	3		1			6	7
Swarming 2011-2012	2							1				
Swarming 2011-2013	1											
Swarming 2012-2013					1							1

Presence during hibernation of individuals controlled during the swarming season.

Of the 115 individuals captured in 2011, 10.4% were retested at least once the next winter. For the 41 individuals tested in 2012, only 2.4% of them were observed the following winter. Of the 94 individuals captured in 2013, 4.3% were found the following winter. Finally, the 250 individuals captured between 2011 and 2013 during the swarming seasons, 8.4% were controlled in subsequent winters.

Discussion

Few data are in general available on swarming and it's worth for the autumn dispersal of *Myotis myotis*. For *Myotis myotis*, the mating strategy identified turns to a displacement of females which are joining the males in their roost, which are scattered around the nurseries. To our knowledge, only the study by Nagel et al (2005) (not available exhaustively) aimed at elucidating the autumnal activity of *Myotis myotis* in one hibernation site.

Interannual variation

To our knowledge, published data on swarming did not demonstrate, as we have seen, a large-scale interannual variation. However, Vintalis and Suba (2010) recorded such a variation that they attribute hypothetically 1) to a seasonal variation as it has been described by several authors (e.g. Parsons et al., 2003b) ,and 2) or as a sign of the functional change of bat activity (end of intensive mating ?). We attribute this significant variation observed in 2012 to a low survival rate of juveniles for the following reasons. In 2012 in Brittany, juvenile mortality was recorded in some nurseries (up to 81 % mortality for this age class). Moreover, in 2012 in some nurseries, the number of juveniles produced was lower than in 2011 (up to - 32%). The weight recorded both in the nurseries and in this swarming site in 2011, 2012 and 2013, showed also that the year 2012 was outside the norm. Thus unlike the years 2011 and 2013, 63% of juveniles captured in 2012 in the swarming site showed a weight less than or equal to 24 grams. In nurseries in July 2012, between 77 % and 96 % of juveniles weighed less than 20 grams, against 6 to 68% in June 2011. Drastic declines of winter' numbers were recorded during the winter of 2012-13, up to 71%. These falls have mainly affected the hibernacula where more than 50 individuals are usually counted and where juveniles are present. It is therefore possible that changes in numbers recorded between different seasons of swarming and hibernation is correlated with a higher mortality of juvenile, but it remains a working hypothesis. This change in winter can't be attributed to the observation pressure or a temperature effect. These biases are avoided by a standard protocol. This protocol is based on counting the beginning of months between December and February. During an episode of prolonged (15 days gel) gel another counting is performed.

Sex ratio

The sex ratio in *Myotis myotis* differs from that recorded for most species considered as swarming

species in Europe (eg: Rivers et al, 2005). Nevertheless, Pocora et al (2012) found a sex ratio equilibrated for *Myotis mystacinus* and a sex ratio biased towards females for *Myotis myotis* in Roumania. In their study, *Myotis myotis* and *Myotis blythi* were the dominant species (46.4% for *Myotis myotis* and 32.2% for *Myotis blythi*). In our study, we find too that the sex ratio is dominated by females (between 55% and 56.5% of the *Myotis myotis* captured). There is also a greater representation of males as the autumn progresses. An opposite result for females has been observed in *Myotis nattereri* which numbers progress too at the end of september (Glover et Altringham, 2008).

Fidelity and hibernation at the swarming site

Insofar many authors agree that the species which are visiting many underground sites, come there in order to mate, but also to check the status of these sites for hibernation and also for females to show to their youth suitable site for hibernation. This suggests that these sites should be visited year after year by the same individuals (eg. Vintulis and Suba. 2010, Nagel et al. 2005). However, our results for the time, not argue for any of these assumptions. Thus with 9.3% of individuals were captured only once in three years during the swarming and 11% of individuals captured in the fall were controlled the following winter. However, given the configuration of this site in particular, it is more than likely that part of the individuals (not estimated) is not detectable in winter (deep and inaccessibles fissures). Vintulis and Suba (2010) found 37% of the swarming *Myotis myotis* in the site during the following winter. The fidelity remains to be proved. To prove or disprove the fidelity of individuals to this site swarming, we should be able to avoid the bias that is the capture (net avoidance by individuals) and install automatic transponder readers. In order to prove that the site is used as a mating place, it will connect young from colonies with females and adult males using the site. To do this some biopsies should be performed on males in order to link them with the juveniles and the mothers which come out the marked nurseries.

Conclusion

Thanks to individual marking, this study confirms for *Myotis myotis* the existence of a significant mixing of populations in an underground site in autumn. However, there is still no evidence for this specie that the swarming participates in any way as a mating strategy and only one study combining genetic and marking will enable to progress on the topic.

Acknowledgements

Thanks of the major of Pluherlin which allowed us to get into the slate during this three past years. Thanks to the volunteers of Bretagne Vivante for their participation of the capture during sometimes cold night especially in October. Thanks to Eric Petit and Yann Gager for theirs advices and theirs corrections

Bibliographie

Farcy. O, Jamault. R, Le Bris. Y, Le Mouël. A et Le houédec. A. (2010). Première évaluation de l'intérêt de huit sites souterrains pour le regroupement automnal des chauves-souris en Bretagne. Bretagne Vivante : 17 pages

Farcy. O et Touzalin. F. (2011). Bilan 2011 Contrat Nature Etude de la dynamique des populations du Grand murin (Myotis myotis) en Bretagne et Pays de Loire. 22 pages.

Fenton. T.D.W and Barclay. M.B. (1979). Social behaviour of the Little Brown Bat, *Myotis lucifugus*. Mating behaviour. Behavorial Ecology and Sociobiology 6, 129-136.

Glovers, A and Altrigham, J. (2008). Cave selection and use by swarming bat species. Biological Conservation 141 : 1493 – 1504.

Kerth. G, Kiefer. A, Trappmann. C and Weishaar. M, (2003). High gene diversity at swarming sites suggest hot spots for gene flow in the endangered Bechstein's bat. Conservation Genetics 00: 1-9

Nagel, A., Nagel, R., Wunsch, E., Schmid, M. et Schmit, W. (2005). Swarming behaviour in Myotis myotis-Phenology and relation between different types of roost in the Swabian Alp (SW Germany). Abstracts of the X Europ. Bat research symp. (Galway, Ireland, 21–26 August 2005).

Parsons. K.N, Jones. G, Davidson-Watts. I and Greenaway. F, (2003). Swarming of bats at underground sites in Britain-implications for conservation. Biological Conservation 111, 63-70.

Parsons, K. N., Jones, G. and Greenaway, F. (2003b). Swarming activity of temperate zone micro-chiropteran bats: effects of season, time of night and weather conditions. J. Zool., 261. 257-264.

Pocora.I, Pocora.V, and Baltag.E.S. (2012). Swarming activity of bats at the entrance of Liliecilor cave from Rarau mountains. Analele Științifice ale Universității Alexandru Ioan Cuza" din Iași, s. Biologie animală, Tom LVIII, 201

Rivers, N. M., Butlin, R. K. and Altringham, J. D. (2005). Genetic population structure of Natterer's bats

explained by mating at swarming sites and philopatry. Mol. Ecol., 14, 4299-4312.

Veith. M, Beer. N, Kiefer. A, Johannesen. J, and Seitz. A.; 2004. The role of swarming sites for maintaining gene flow in the brown long-eared bat (*Plecotus auritus*). Heredity (2004), 1-8

Vintulis. V and Suba. J (2010). Autumn swarming of the pond bat Myotis dasycneme at hibernation sites in Latvia. Estonian Journal of Ecology, 2010, 59 , 1, 70-80.