

Hibernating bats in Flemish marlland: an overview of the period 1989-2020

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Abstract: Twenty six different marl quarries in Flanders are checked annually for hibernating bats, 18 in the Meuse basin and eight in the Scheldt basin. Most of the quarries were created in the second half of the 16th Century through the extraction of marl as a building material and as a raw material for fertilizing agricultural lands. After the Second World War, mushrooms were grown in both large and small tunnel systems. In 1958, virtually all underground mushroom cultivation ceased. This article provides an overview of the bat counts by the Nature Point Bat Working Group, carried out since 1989, between the last week of December and the end of February. Over the years, a few more quarries have been included bringing the total up to 26 sites, which are counted completely every year. The numbers for 2015 are not included in the data because the count in the Lacroix quarry, the largest of the quarries, which accounts for a substantial proportion of the total bats counted did not take place in that year. In 1989 the two species of whiskered bats, *Myotis mystacinus* and *M. brandtii* (no distinction is made between the two in the counts) were the second most counted species with 158 individuals counted. By 2020 this number had risen to 1,622, making the whiskered bat the most commonly observed bat in the Flemish marl quarries. In 1989, Daubenton's bat (*M. daubentonii*) was the most commonly observed species with 269 individuals. The numbers continued to rise until 2002 to a peak of 949 animals with a low of 340 animals observed in 2013. Initially, Natterer's bat (*M. nattereri*) was still a rarity, but by 2020 there were 1191 hibernating animals. Geoffroy's bat (*M. emarginatus*) is the species that has increased the most. Since 1989, their numbers have increased exponentially. The number of pond bats (*M. dasycneme*) initially increased moderately, to 154 in 2013 and there are now about 100 animals every year. The numbers of brown long-eared bats vary between 30 and 55 animals, which is barely 1% of the total number of bats counted in the Flemish marl quarries. Similarly, Bechstein's bat (*M. bechsteinii*) was a very rare sight during the counts; in 2015-2016 the number increased to 16 animals. Greater mouse-eared bat (*M. myotis*), and common pipistrelle (*Pipistrellus pipistrellus*) were seldom seen, while a serotine (*Eptesicus serotinus*) is very exceptionally observed in the marl quarries. The proportion of 'unidentified bats' was significant in 1989, but has declined steadily thereafter. The Lacroix, Verbiestberg and De Keel quarries have the most bats. The strong increase of counted hibernating bats is possibly due to an increase in the population as a result of efforts made to close the quarries. Better illumination, increased capacity to identify the bats and better knowledge of the cave systems have also all played a role in more hibernating bats being counted and identified.

Keywords: whiskered bats (*Myotis mystacinus*, *M. brandtii*), Daubenton's bat (*M. daubentonii*), Natterer's bat (*M. nattereri*), Geoffroy's bat (*M. emarginatus*), brown long-eared bat (*Plecotus auritus*), pond bat (*M. dasycneme*), Bechstein's bat (*M. bechsteinii*), greater mouse-eared bat (*M. myotis*), Flemish marlland.

Introduction

Twenty six different marl (limestone) quarries

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in Flanders, are checked annually for hibernating bats. In the Meuse basin there are 18 quarries connected to the large complex of marl that is linked to the Walloon and Dutch tunnel systems. These quarries are all situated in the municipality of Riemst. In the Scheldt

basin, the Henisdael quarries are located in Vechmaal, in the Heers sub-municipality (figure 1). The eight systems lie in a semicircular valley basin, which allows migration between the quarries due to the small distance between the different entrances.

Most of the quarries were created in the second half of the 16th Century by the extraction of marl, initially extracted as a building material and as a raw material for fertilizing agricultural lands and later as a raw material for cement production (Walschot 2010). After the Second World War, mushrooms were grown in both large and small tunnel systems. After the serious collapse of the Roosburg quarry in 1958, almost all underground mushroom cultivation stopped because of the risk of collapse (Medaerts 1998), although the cultivation continued in a few quarries until the beginning of 2000 and continues to this day in the Avergat quarry in Kanne.

A total overview of the bat counts is available from 1989. Before then only a few of the quarries were counted (Fairon & Lefevre 1991). Over the years, a few more quarries were added, and since 2007, 26 quarries are fully counted every year. The counts are carried out by the Natuurpunt Bat Working Group, starting from the last week of December and ending at the end of February. More than 50 volunteers annually map the hibernating bats. Each animal is noted on a detailed map. The data is managed by the Natuurpunt Bat Working Group and published in annual reports (Palmans, various years). From 2021, INBO (the Institute for Nature and Forest Research) has taken over managing the data in collaboration with Natuurpunt (Natuur. Studie) to make them available to European monitoring networks.

Species

The four most commonly observed species during the censuses from 1989 to 2020 are the whiskered bat, Daubenton's bat, Natterer's bat and Geoffroy's bat. The proportion of 'other'

(pond bat, brown long-eared bat, Bechstein's bat, greater mouse-eared bat and common pipistrelle) and 'unidentified bats' was significant in 1989, but the number of 'unidentified bats' has steadily decreased over the years, largely due to better identification (see figures 2 and 4j).

Over the years, more quarries have been included in the count (figure 3a, b and c) also contributing to the increase in bats counted: the development in numbers therefore does not reflect the real increase in population. The relevance of the different quarries for all bats over the different time periods is illustrated in figures 3a, b and c., which give these totals for the periods 1989-2020, 2001-2020 and 2011-2020 respectively, showing the relative importance of each quarry in terms of the total number of bats counted. This was done by comparing the quotient of the total number of bats and the number of years to the number of years counted.

The individual species are discussed separately below. Figures 4a to 4j show the counted numbers for these species, although they are not strictly comparable year-on-year values. Data from 2015 are not included in any of these analyses as the count in the Lacroix quarry (with an average share of 30% of total bat numbers) did not take place then. The loss of some counts in other quarries in some years is of a much lesser influence.

Three species are counted each year that are listed in Appendix 2 of the Habitats Directive: Geoffroy's bat, pond bat and Bechstein's bat.

Whiskered bats (*Myotis mystacinus/brandtii*)

During the winter counts, no distinction is made between the two species of whiskered bats, *Myotis mystacinus* and *M. brandtii*, as the two are difficult to distinguish without handling. Only in case of a 100% certain determination, are they distinguished – overall the two species are listed under one denominator.

In 1989 this species was the second most



Figure 1. Location of (a) the marl quarries in the Meuse basin and (b) the Henisdael quarries in the Scheldt basin. 1: Coolen; 2: Collas; 3: Drie Dagen; 4: Flessenberg; 5: Juge; 6: De Keel; 7: Koegat; 8: Lacroix; 9: Lindestraat; 10a: Mathuus; 10b: Opcanne IV; 11: Pitjesberg; 12: Verbiestberg; 13: Jagenua's Huiske; 14: Pauly; 15-1: Henisdael 1; 15-2: Henisdael 2 - Champignonkuil; 15-3: Henisdael 3 - Walenkuil; 15-4/5: Henisdael 4 en 5; 15-6: Henisdael 6 - Hussenkuil; 15-7: Henisdael 7 - Waterkuil; 15-8: Henisdael 8; BE: Belgium; NL: the Netherlands.

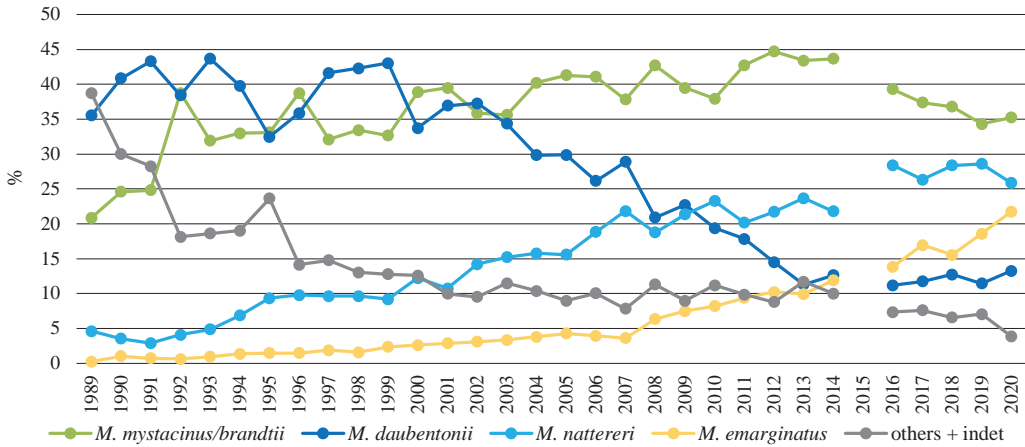


Figure 2. Percentage distribution of the counted numbers of the four most common bat species and the other and unidentified species in the period 1989-2020.

prevalent species. With 158 animals in 1989, the number continued to increase to 1622 in 2020. This makes the whiskered bat the most commonly observed bat in the Flemish marl quarries. The increase is steady, although in some years a temporary, slight, decline can be observed, despite an increase in the number of quarries counted (figure 4a).

Daubenton's bat (*M. daubentonii*)

In 1989 this was the most commonly observed species with 269 animals. The number continued to increase until 2002 to a peak of 949 animals, but from then on the number has steadily decreased. Daubenton's bat was the most counted species until 2000, when it was dislodged by the whiskered bat. In 2013, the species bottomed out with only 340 animals observed. A slight recovery is currently visible and more than 600 animals were counted in the most recent survey (figure 4b). Despite the recovery, it now ranks fourth in percentage in terms of the number of bats observed.

Natterer's bat (*M. nattereri*)

At the end of the 1980s, Natterer's bat was still

a rarity in the Flemish marl quarries. However, this species has a strong preference for hidden niches and crevices in the walls and ceilings and it is likely that, due to poor quality lighting, animals hiding deeper in crevices may have been overlooked.

With today's stronger LED lamps and higher-quality binoculars, it is possible to look much deeper into crevices. Yet these technological improvements probably explain only part of the spectacular increase of this species. With 1191 hibernating animals in 2019-2020, Natterer's bat is firmly in second place in terms of the number of animals observed. The increase is very constant and almost predictable (figure 4c).

Geoffroy's bat (*M. emarginatus*)

Geoffroy's bat has increased more than any other species. In 1989-1990 it was a rarity. Up to 1994, the counters used to gather under individuals after the counting session to admire them with their binoculars. The species was first observed in the Lacroix quarry where two animals were hanging in section 30. Since then, the number of animals in this quarry has increased to 561.

With 1002 animals observed in 2020, Geof-

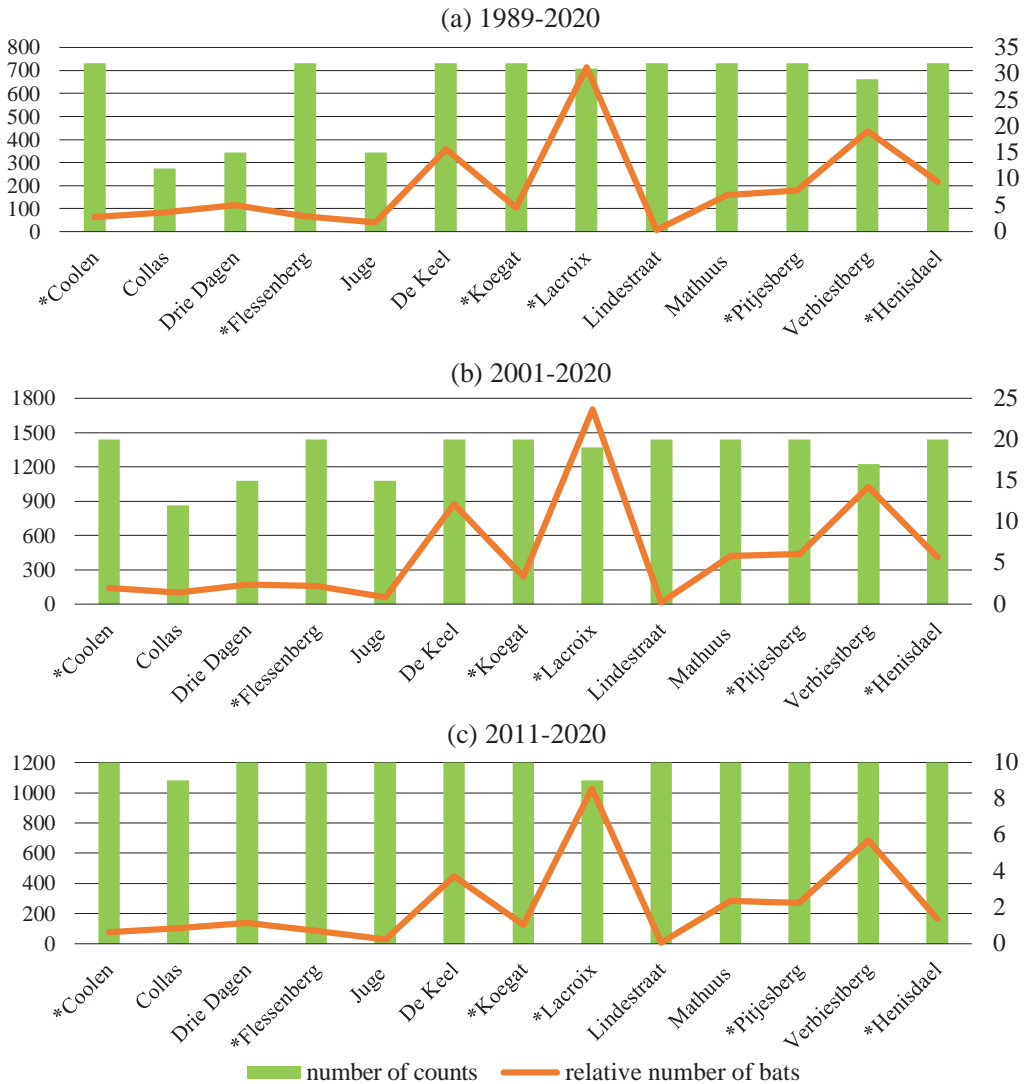


Figure 3. The relative contribution of each quarry to the total of bats counted. Left y-axis: average number of bats per year; right y-axis: number of counts in the periods 1989-2020 (a), 2001-2020 (b) and 2011-2020 (c).

* quarries in which bat counts were made before 1989

froy's bat ranks third in terms of number of hibernators. The increase in the number of animals is spectacular, as well as its appearance in quarries where it did not initially occur (or was not spotted). The species clearly has a preference for larger complexes; where the increase in its numbers is exponential (figure 4d).

Pond bat (*M. dasycneme*)

The number of hibernating pond bats varies greatly. Just over 20 animals were found at the beginning of the counts. The number increased moderately every year, until 154 animals were counted in 2013. Since then, the number has decreased again and about 100

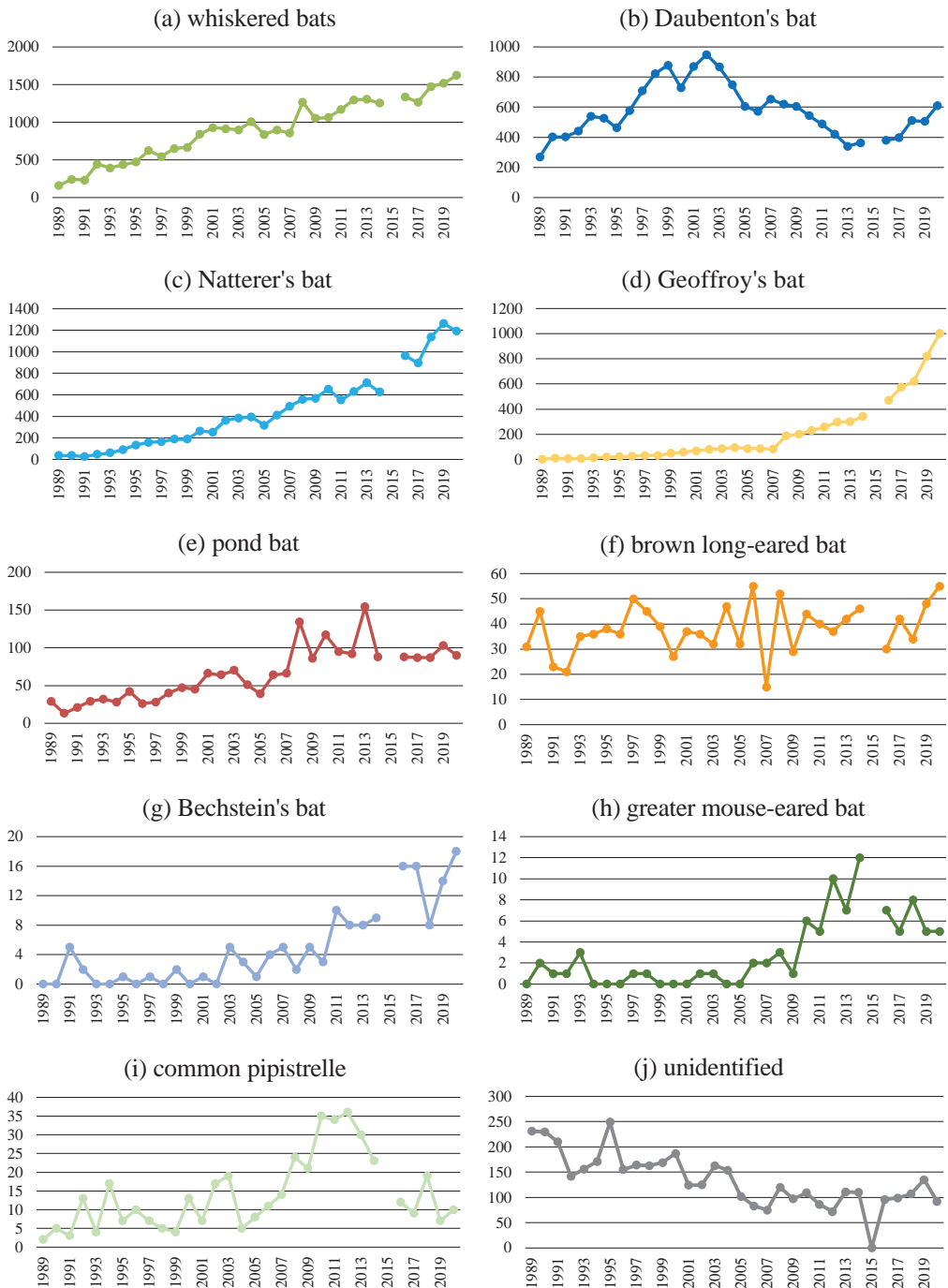


Figure 4. Development of the number of bats per species in Flemish marl quarries in the period 1989-2020.

animals are now found annually (figure 4e).

Brown long-eared bat (*Plecotus auritus*)

More brown long-eared bats are found during cold winters than during milder winters. Over the study period, the numbers varied between 30 and 55 animals (figure 4f). This is barely 1% of the total number of bats found in the Flemish marl quarries.

Bechstein's bat (*M. bechsteinii*)

In the late 1980s, Bechstein's bat was a very rare sight during the censuses. The numbers initially remained very low, with a maximum of five animals, until in 2015-2016 the number suddenly increased to 16 animals. Since then, the number has remained this high (figure 4g). There is now a good chance of encountering Bechstein's bat in the large quarries such as Lacroix, De Keel and Verbiest, A few animals are also observed every year in the quarries of Vechmaal.

Greater mouse-eared bat (*M. myotis*)

This species is mostly encountered in De Keel quarry and rarely in any other quarry. It is relatively rare: in 2014 just ten animals were counted (figure 4h). Like pond bats, the animals are creatures of habit and seem to be conservative in choosing the same hanging spot almost every year to hibernate.

Common pipistrelle (*Pipistrellus pipistrellus*)

The number of common pipistrelles found is very variable. In some years only a few animals are found, in other years it is difficult to count the number of animals exactly because a cluster of several animals has retreated into

a very narrow gap. The highest number of common pipistrelles counted was 36 animals in 2012. Normally, the number fluctuates around ten animals (figure 4i).

Serotine (*Eptesicus serotinus*)

Very occasionally a serotine is observed in the marl quarries.

Unidentified bats

Sometimes bats hang in places that make it impossible to identify them at species level. In the first years, the share of unidentified specimens was well above 20% of the total. Due to the use of better light and a more thorough knowledge of the counters, this figure has decreased every year. Currently, approximately just 2% of the hibernating animals cannot be identified (figure 4j).

The relative importance of the quarries

The duration of the research into hibernating bats in quarries in the Flemish marl land varies between the individual quarries. The first census took place in Hensisdael quarry in 1942, some quarries were first counted in the 1970s, and many other quarries started to be counted in 1989. In a small number of quarries the counts started in 2006 and 2007 and in the last quarry, Pauly (see figure 1), in 2020. The causes of these differences are various and are explained in more detail in the quarry section (below). The quarries in which bat counts were made before 1989 are marked with an asterisk (*) in figures 3 and 5-18. The relevance of the different quarries for all bats over the different time periods, is illustrated with three figures (3a, b and c). These three figures, for the periods 1989-2020, 2001-2020 and 2011-2020 respectively, give the number of years counted

and the relative importance of each quarry for the total number of bats counted. This was done by comparing the quotient of the total number of bats and the number of years to that number of years counted.

The quarries with the largest bat populations in this area are Lacroix, Verbiestberg and De Keel (figure 3). Missing data in 2015 for Lacroix and from 2005-2007 for Verbiestberg can be recognized in figures 4a-e (and also in figure 19) as marked dips.

Overview of the quarries

Coolen, Val-Meer

This small quarry (area 2 ha) is completely enclosed in a land consolidation. The quarry lies like an island in vast fields with almost no linear or natural connections and some remains of lynchets (small terraces on a hillside, their steep often covered with shrubs) in the fields. The quarry is located less than 2 km from the village of Val-Meer. Some species that follow linear landscape elements still find their way to this quarry, probably using a concrete allotment road with a few trees and the remains of the lynchets.

Fewer than 100 bats hibernate in the tunnel system each year (figure 5). Yet almost all the species that are also found in the larger complexes can be found here. With seven different species, this is a species-rich quarry.

Collas, Zussen

In 2009, the Flemish Community (ANB – Agency for Nature and Forests) bought the land around the Lacroix and Collas Quarries (Lacroixbosjes) thus acquiring the access to the quarry. This marked the definitive end of mushroom cultivation in the quarry by the Peeters family.

Collas is connected to the Lacroix quarry by a tunnel, allowing for underground migra-

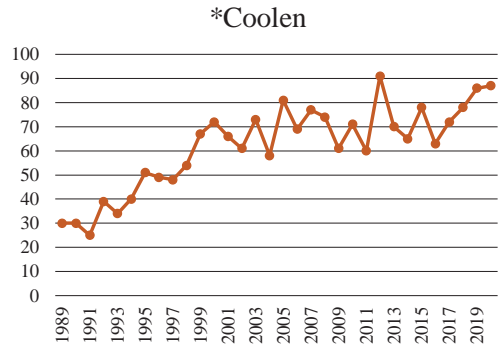


Figure 5. Development of the total number of bats found in the Coolen quarry, Val-Meer.

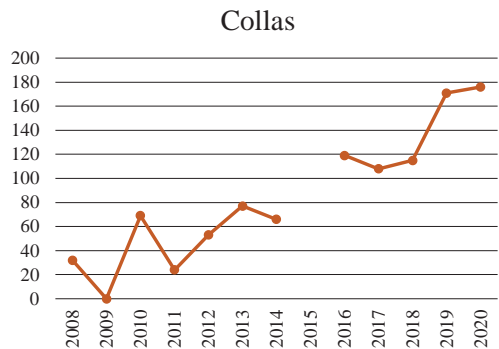


Figure 6. Development of the total number of bats found in the Collas quarry, Zussen.

tion between these two systems. Before 2009, incidental bats were observed in the corridors of Collas, but there was no structured counting. In 2016, the main entrance to the quarry was closed – after the mushroom cultivation ended in 2011 – to prevent illegal cavers from accessing the underlying tunnel system. That was the start of a complete absence for the hibernating animals in both Collas and Lacroix. The numbers of bats increased gradually, with over 170 individuals in 2020 (figure 6).

The corridor system has three levels, making the airflow very complex. Due to the vastness and because there are very few animals here, the upper and lower systems are not counted. Ancient inscriptions made by early bat counters such as ‘klhf chamber’ (kleine hoefijzerneus – lesser horseshoe bat chamber) indicate the value of the quarry

before the mushroom cultivation. It is an important quarry for the hibernation of Bechstein's bat and the pond bat. The complex has several 'pockets' – dead-end areas – where the temperature is slightly higher, which have a less dynamic airflow than the rest of the quarry.

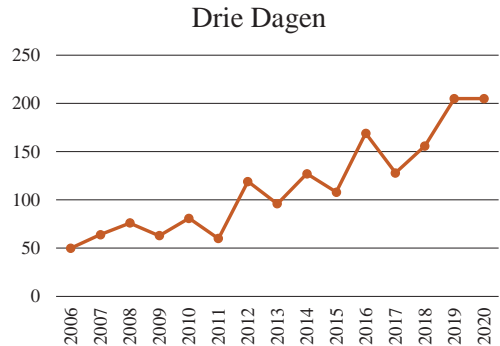
Drie Dagen, Zichen

This quarry, together with Flessenberg, Koegat, Jageneau's Huiske and Verbiestberg, forms the Roosburg complex. Collapses separated the galaxies from each other, so they are now considered separate quarries.

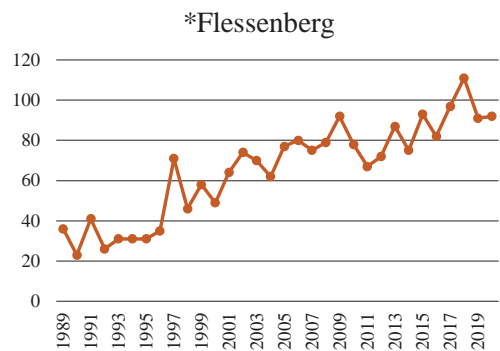
Mushrooms were cultivated in Drie Dagen until the end of the 1980s. After the cessation of cultivation, the front part of the quarry was used as a storage place for agricultural vehicles and potatoes. In 2013, a fire caused considerable damage. A thick layer of soot adhered to walls and ceilings, preventing the bats from entering the most important part of the quarry. Very few bats are found in this area, with a little over 200 counted in 2019 and 2020 (figure 7). The whiskered bat represents more than half of the hibernating animals.

Flessenberg, Zichen

This small complex, barely one hectare in size, was closed off from the Verbiest quarry after the collapse of 1958. The pillars are quite unstable and show multiple cracks. Until 2016 the quarry was used by a compost processing company (Coenjaerts) for the storage of materials. A gate was installed in 2016, to keep unauthorized persons out and provide a safe haven for the bats. From around 30 bats counted in the early 1990s, the number has steadily increased to over 90 individuals (see figure 8). Due to the presence of many fissures and cracks, Natterer's bat is the most counted species here.



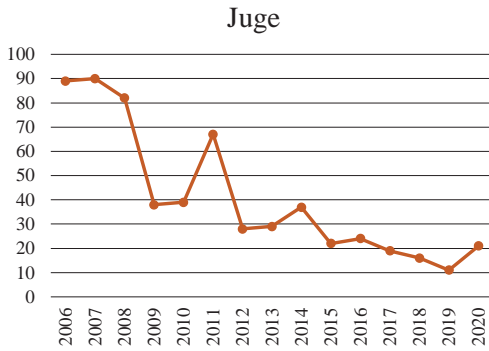
Figuur 7. Development of the total number of bats found in the Drie Dagen quarry, Zichen.



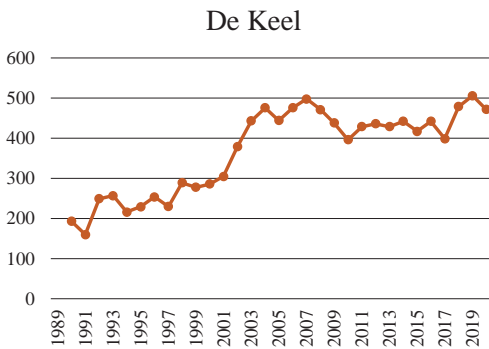
Figuur 8. Development of the total number of bats found in the Flessenberg quarry, Zichen.

Juge , Zussen

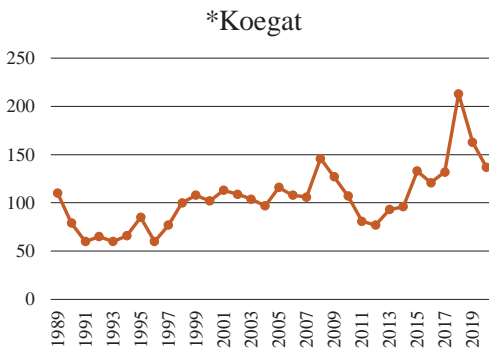
Before 2005 this small quarry was only sporadically visited by the members of the 'Hulp-groep Mergelgroeven' (Marl Quarries Relief Group) to check its stability. Reports of Bechstein's bat led the quarry to be included in the counts from 2005. With 90 animals in 2006 – four of which were Bechstein's bats – expectations were high for the future, but the total number of bats has gradually decreased (figure 9) and the numbers of Bechstein's bats steadily decreased and the species has now disappeared completely. However, the number of hibernating Geoffroy's bats increases every year. The reasons for these changes are unclear and there are no data on temperature and air dynamics.



Figuur 9. Development of the total number of bats found in the Juge quarry, Zussen.



Figuur 10. Development of the total number of bats found in the De Keel quarry, Kanne.



Figuur 11. Development of the total number of bats found in the Koegat quarry, Zichen.

De Keel, Kanne

De Keel is the third largest quarry in Flanders, covering almost 4 hectares. The corridors are quite high and due to the wide variety of mining

methods used in the past, the range of niches, slots, crevices and cavities is very varied. This makes counting in this complex a challenge, as the ability of counters to determine species is critical. Each counting group takes care of at least one section every year, passing its knowledge on to the newcomers.

In 2006 the main entrance to the quarry, more than seven metres high was completely gated off in order to inhibit frequent disturbances from mountain and cross-country cyclists and illegal parties. The gate allows access to counters and a flow of air throughout the complex (Walschot 2010). Since then, the total numbers of bats has consistently exceeded 400 individuals, with peaks of up to 500 (figure 10).

The quarry is important for Geoffroy's bats and Natterer's bat. A varying number of greater mouse-eared bats are counted every year. The pond bat has been in decline in recent years.

Koegat , Zichen

This system has four different sections, each of which has a completely different microclimate. The entrance to Koegat was closed off in 2017, for unwanted visitors, with holes at the top of the closing wall in order to maintain the air dynamics. While this intervention has protected this hibernaculum the number of bats has fallen slightly in recent years (figure 11).

Lacroix, Zussen

Lacroix was the first quarry to be fenced off. The management of the quarry was in the hands of the (then) nature association, Belgische Natuur- en Vogel-Reservaten (BNVR), which later merged with De Wielewaal and became Natuurpunt. Yet the fencing only had a partial effect: cave hikers and 'revelers' gained access to the corridors via other entrances, often disrupting the bats' winter rest. In 1986, two entrances were fitted with solid gates. Cavers could only enter the quarry

on request and this resulted in a sharp decline in cave tourism. It was still possible to enter the quarry illegally via the Collas quarry, until its permanent closure in 2016.

The Grote Berg, which is the name of the entire system, consists of more than 20 reclamations that have formed one gigantic system over the years (Jennekens 2016). Access to the entire complex can only be gained via Lacroixberg.

This, the largest system of Riemst municipality – more than 20 hectares – also contains the most hibernating bats. With almost 1500 animals, it contains more than a third of the total number of animals in all the quarries (figure 12). However, the complex, which is divided into more than 40 sections, has not been fully counted. The lower sections are not, or hardly, used by hibernating bats. The effort of counting does not justify the result here. In the 27 sections that are counted, the animals are not indicated individually on a map, because a detailed map of this system is not yet available.

No count was performed in 2015, due to a collapse in one of the underlying sections. The high number of Geoffroy's bats in this complex is striking. With 561 animals in 2020, this is almost 40% of the number of hibernators in this quarry.

Lindestraat, Zichen

A party hall has been set up in this quarry. A door without an entrance opening for bats prevents unauthorised access to the quarry. The few animals that hibernate here stay in the reception hall of the quarry. Occasionally, some animals are found in the deeper part of the quarry that enter through the only air shaft. The maximum total number of bats in any year is 14 (figure 13).

Mathuus and Opcanne IV, Kanne

Originally the Mathhuus quarry had only one

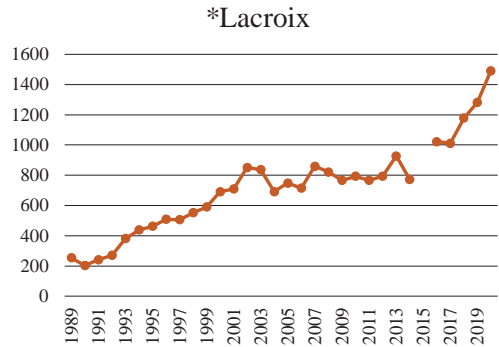


Figure 12. Development of the total number of bats found in the Lacroix quarry, Zussen.

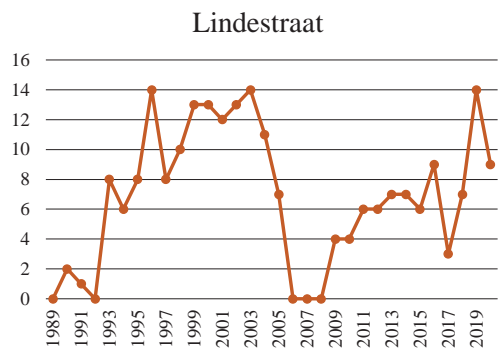


Figure 13. Development of the total number of bats found in the Lindestraat quarry, Zichen.

entrance. In the early 1960s, the widening of the Albert Canal led to a third of the Mathuus quarry being excavated and gave the quarry no fewer than 14 entrances. The air dynamics are therefore very complex (Walschot 2010). Opcanne IV was originally part of this complex, but has now become a separate system, closed to bats from Mathuus.

One of the extraction techniques used here was 'shooting' the marl. Boreholes were made in which charges of explosives were placed. A large proportion of the bats hibernate in the remnants of these boreholes and finding them is quite difficult and requires the counters to have a thorough knowledge of the site and good illumination and binoculars to correctly identify the animals.

After the closure of De Keel in 2006, the problem of disruption by party goers moved

to Mathuus. Every year dozens of bags with beer cans and tea lights were collected, and occasionally even a kitchen cabinet or portable toilet. Since 2016, there has been stricter control by the Municipality of Riemst.

Despite this, more than 300 animals reside in this system each winter (figure 14), nearly half of which are whiskered bats. Occasionally a single greater mouse-eared bat is encountered. In recent years, the number of Geoffroy's bats has increased very gradually.

Pitjesberg, Zichen

This quarry is a fusion of several small systems. A large system – De Kuil – is only accessible via a narrow passage, which was dug out after a mud wash-in. De Kuil only has one open air shaft, so the number of bats in this section is modest. The total surface of the quarry is approximately 5 ha, which makes it one of the larger quarries of Riemst. More than 400 bats have been counted in recent years (figure 15).

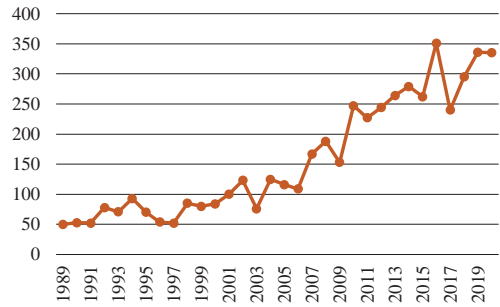
Pitjesberg has two main entrances, one of which has a gate. The other entrance consists of four holes, which makes the air dynamics complex, with low temperatures. This explains why many Natterer's bats hibernate here (almost half of the total number of bats in this complex).

Pauly, Zussen

The Pauly quarry is actually part of the De Grote Berg complex. A collapse in 1962, well before the research period, completely closed off this section from the rest of the system. The air shafts were closed for safety and to facilitate agricultural use. In 2018, one of the shafts was reopened and provided with a safe descent. The shaft is closed with a grid, so that bats can fly down between the bars.

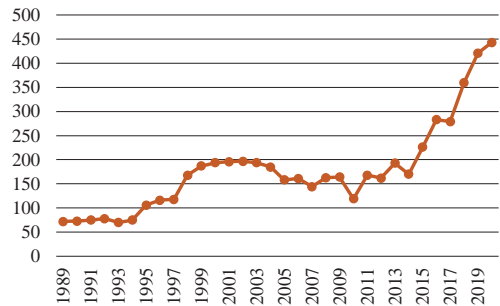
In 2020, the quarry was checked for hibernating bats for the first time. Not a single ani-

Mathuus and Opcanne IV



Figuur 14. Development of the total number of bats found in the Mathuus and Opcanne IV quarries, Kanne.

*Pitjesberg



Figuur 15. Development of the total number of bats found in the Pitjesberg quarry, Zichen.

mal was found. Nevertheless, this is a unique research object. As the quarry has been completely closed off for over 60 years, it will be interesting to see whether and how this system will be discovered by bats and whether a population will develop.

Verbiestberg, Zichen

The second largest quarry in the municipality of Riemst has only two accesses: one via a spiral staircase and the other via a tunnel that starts at ground level. The spiral staircase was made safer in 2019 by completely replacing the handrails. The door of the 'house' above the stairs has been replaced by a heavy steel gate with a small letterbox type entrance. This has not

made much difference to the potential for bats to enter as the old gate also only had a narrow strip at the top. The tunnel underwent a significant change in 2012 when a fence made of reinforced steel closed off the entire large opening of the tunnel. Before that a pair of chains was the only obstacle to entering the quarry. The municipality of Riemst has made several structural changes around the entrance, installing a sewage pipe closed off by a steel gate with horizontal bars. This has drastically changed the air dynamics in the tunnel, making it more difficult for cold air to enter and reducing the size of the entrance opening for the bats. Nevertheless, this intervention has had little impact on the number of bats that hibernate in the quarry and since 2016 their number has increased significantly. Due to the large number of air shafts, the climate in the quarry is very variable, with cold and warm sections.

Mushroom cultivation continued in the quarry until the early 1980s. At the end of the 1980s, only 55 animals were found in the system, which covers more than 8 hectares. As with Grote Berg, Verbiestberg is an amalgamation of several small reclamations. Following the great collapse of 1958, Verbiestberg was closed off from the neighbouring systems Koe-gat, Flessenberg and Drie Dagen. In 2019, 955 hibernating animals were counted (figure 16).

The whiskered bat is the most commonly encountered species, accounting for almost 40% of the bats in the complex. Natterer's bat follows with 25% and the numbers of Geoffroy's bat, are rising rapidly and account 20% of the total. The number of bats as a whole has increased spectacularly from 2016; particularly whiskered bats, Natterer's bats and Geoffroy's bats. There was no counting in the quarry between 2005 and 2007, because the owner did not give permission; as a result, the totals for the years 2005, 2006 and 2007 are missing.

The quarries of Henisdael, Vechmaal

Southeast of Tongeren, there are seven

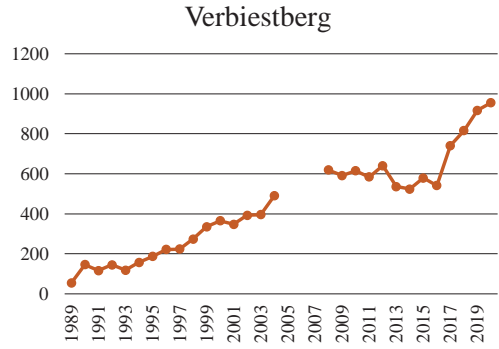


Figure 16. Development of the total number of bats found in the Verbiestberg quarry, Zichen.

smaller and one large quarries in a cirque, the entrances of which are only a few tens of metres apart. Yet these separate systems each have their own microclimate. As bats are assumed to move easily from one system to another, figure 1 shows the overall picture of all the systems. The quarries are located in the middle of an agricultural enclave, where a hollow road without vegetation is the only accompanying landscape element.

The largest system of corridors (Henisdael 1) was fenced off at the end of the 1980s. However, this construction was not resistant to vandalism, so disturbance continued for some time. In 2012, a new fence was installed that proved to be stronger. The second largest quarry (Henisdael 7 - Waterkuil) was closed in 2014 with a genuinely artistic pair of gates (figure 17). The shutdown of the other systems is in the pipeline.

All of Henisdael's complexes are relatively cold with only a limited number of rooms having higher temperatures. As a result, the majority of the hibernating animals are species preferring colder conditions in their hibernacula.

Whiskered bat accounts for half the numbers counted. The brown long-eared bat, which usually accounts for only a few percent of bats in other quarries, accounts for 10% of the hibernating population here. Geoffroy's bats were first observed here in 2012. At that time there were still two animals, but by 2020



Figure 17. Closure of the Waterkuil, one of the largest quarries of Henisdael.

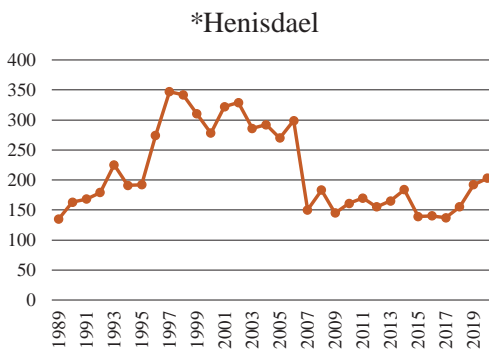


Figure 18. Development of the total number of bats found in the Henisdael quarries, Vechmaal.

this had risen to 16 individuals.

There was a sudden drop in the number of bats in 2007, probably caused by the felling of poplars close to the entrance, in the autumn of 2006. During the swarming period, the falling trees caused vibrations, which were probably felt in the quarries and several lumps of marl appeared to have come loose. A gradual increase in the number of animals has only been noticed since 2017 (figure 18).

Discussion

In 1989, only 622 hibernating bats were observed in the 18 accessible quarries. In 2020, 26 quarries were counted and the number had risen to 4493 (figure 19). This strong increase is possibly due to an increase in the

population, probably partly as a result of the efforts made to close the quarries. Progress in illumination and the training and experience of counters has probably also played a role. At the end of the 1980s, the strongest lamps were equipped with 'Krypton Light', whereas current LED lamps have a light output that is many times higher. With stronger light and with better binoculars, animals hidden in the ceiling or higher crevices are easier to find and identify. The knowledge of the counters has also greatly improved year on year, both in terms of the characteristics of the animals and in knowledge of the bats' use of the quarries. Bats often hibernate in the same (hidden) places. Checking those places increases the chance of finding hibernating bats. That is why it is important that counters get a 'fixed section' in the quarry and pass their knowledge on to the next generation of counters.

The end of mushroom cultivation did not immediately mean a major increase in the numbers of hibernating bats. Cultivation involved daily visits to the systems, plastic sheeting closed corridors and the regular use of fungicides. These factors all inhibited bats using these quarries for hibernation. In particular, the effects of strong insecticides, such as DDT, were felt until the mid 1980s.

In Riemst, the first quarries were counted in the early 1970s. René Gilson and Jacques Ferron took the lead in mapping the hibernating bat populations with some local experts at the quarries. The counting data appeared in the publications of the Royal Belgian Institute of Natural Sciences (RBINS) (Fairon & Lefevre 1991). In the beginning, the research was mainly led by Walloonian researchers. At the end of the 1980s, the counts were coordinated by a Flemish working group with the support of Dutch volunteers. The current working group consists of approximately 50 Flemish and Dutch volunteers, who receive regular support from British, French, German or Luxembourg researchers.

The Riemst quarries are much larger than the Henisdael quarries, so the overview of

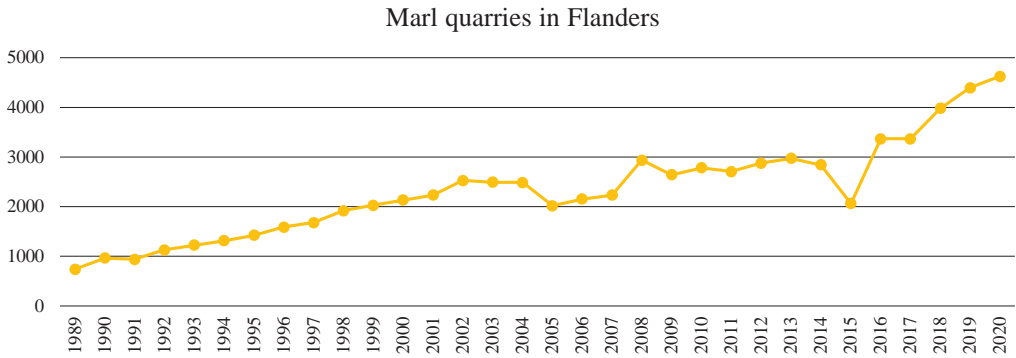


Figure 19. Total number of bats counted in the quarries of the Flemish marlland 1989-2020.

these complexes clearly differs. Counting was first done in Vechmaal in 1942. The most commonly counted species in those early years were the lesser horseshoe bat (*Rhinolophus hipposideros*), greater horseshoe bat (*Rh. ferrumequinum*) and barbastelle (*Barbastella barbastellus*). Yet the figures from 1942 to 1985 are only partial. One cannot compare the quality of the light with that of today. With the limited light of carbide lamps and then weak flashlights, only specimens that hung from the ceiling or against a tight wall could be seen. Bats hiding in crevices were almost certainly not included in the sightings. The counters were probably not as well trained as they are now. Intensive mushroom cultivation in the quarries and the excessive use of insecticides, led to a decrease in the number of bats in Henisdael. From 1960 the cultivation of mushrooms stopped in Henisdael and the largest quarry was closed in 1989. But by then, the critical species, such as the lesser and greater horseshoe bats and the barbastelles, had already completely disappeared.

The proportions between the different species of bats that hibernate in the Flemish marl quarries have changed radically since 1990. The whiskered bat is the currently most commonly observed species, while the Geoffroy's bat is the species that has increased the most. All the other species also have increased in number.

It is difficult to make comparisons with the

Dutch or the Walloon quarries as there is currently no cooperation in terms of the different working groups exchanging data between, despite several volunteers actively participating in the censuses in the different regions. The picture presented in this overview will hopefully contribute to further cooperation.

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