It has been translated from the original French by Henry Andrews as part of the *Bat Tree Habitat Key* project.

This paper pre-dates the first edition of *Bat Tree Habitat Key* by eight years and the second edition by thirteen years. It is the single most important and useful account of tree-roosting ecology for five of our woodland bat species that has been produced to date, yet appears to have been entirely overlooked in the UK.

It is urged that it is given the widest possible distribution. However, despite translation, it must still be referenced as follows:

Pénicaud P. 2000. Chauves-souris arboricoles en Bretagne (France): typologie de 60 arbres-gîtes et éléments de l'écologie des espèces observées. *Le Rhinolophe* (2000) 14: 37-68

Note: The method of translation was primarily by processing individual paragraphs through Google Translate. The translated document was then reviewed by the author in order to ensure accuracy. However, there may nonetheless be some minor errors in the use of grammar and these are the fault of Henry Andrews alone.

Le Rhinolophe (2000) **14:** 37-68

Chauves-souris arboricoles en Bretagne (France): typologie de 60 arbres-gîtes et éléments de l'écologie des espèces observées

Tree-dwelling bats in Brittany (France): 60 roost trees and ecology of the species observed elements

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Abstract. Tree-dwelling bats in Brittany (France): typology of 60 tree roosts, and fragments of the ecology of the observed species. From 1992 to 1999, prospecting in woodlands in the North-west of Brittany has allowed the discovery of 60 natural roosts for tree-dwelling bats. Various kinds of occupied hollows have been found inside trees, but those created by the partial healing of narrow cracks, mainly resulting of storm and/or frost (especially in oaks), appear so particularly sought out by bats, that systematic inspection inside these kind of hollows (with ladders, a light and small mirrors), quickly turned out to be a really "productive" method, for discovering bats: (with) at least 58% of the suitable narrow crevices are used by bats (results needing an average of 2.2 visits per crevice). Five bat species have been recorded: brown long-eared bat *Plecotus auritus*; Natterer's bat *Myotis nattereri*; Daubenton's bat *Myotis daubentonii*; whiskered bat *Myotis mystacinus*; and pipistrelle *Pipistrellus* sp. The tree roosts can be occupied all through the year; reproduction and hibernation included. Besides, it has been noticed that tree-dwelling bats often move around, from one roosting site to another, probably following a similar pattern of movement every year. The observed numbers (bats inside trees, or flying off) go from 1 up to 26 individuals, and several nursery roosts were recorded. Some protective measures for suitable trees are now being taken in a few National Forests.

Keywords: typology of bat tree roosts, narrow crevices, 5 bat species, fragments of ecology, Brittany, preservation of suitable trees, France.

INTRODUCTION

As in other French regions, most of the research on bats in Brittany has been directed, so far, to 'traditional sites', such as underground hibernacula (old mines and slate quarries, bunkers, pipes etc.) and the built environment in breeding colonies (churches, castles, public and private buildings etc.) (Nicolas 1988).

Today we are making good progress in the knowledge of these types of roosts in the region, although we continue to discover interesting summer colonies (Boireau *pers. comm.*) and new underground cavities harbouring substantial numbers of hibernating bats, such as sea caves (Ros *pers. comm.*), and old slate quarries, for example in the

Aulne Valley (Nicolas *pers. comm.*) are still being discovered. These concern mainly three species: the greater and lesser horseshoe bat *Rhinolophus ferrumequinum* and *hipposideros*, and the greater mouse-eared bat *Myotis myotis*.

Not to mention the common pipistrelle *Pipistrellus pipistrellus* and serotine *Eptesicus serotinus*, which appear to be associated with human settlements; the summer and winter ecology of other species is less well known as a result, the numbers found hibernating in underground sites being low.

This is particularly acute in the case of Daubenton's bat: the cumulative winter counts in underground cavities will give ridiculously low numbers, but this species is commonly observed in the summer on all the lakes, ponds and rivers of the region. Furthermore, it uses only a few breeding roosts in the built environment.

Other types of roosts are virtually ignored, and that is why, at least in part, the knowledge of trees harbouring bats in the region was sought.

Potential tree-roosting species comprise Daubenton's bat, Natterer's bat, Bechstein's bat *Myotis bechsteinii*, whiskered bat, barbastelle *Barbastella barbastellus*, brown long-eared bat, possibly the serotine and common pipistrelle and very improbably the Nathusius' pipistrelle *Pipistrellus nathusii* and noctule *Nyctalus noctula* (as data on the latter two are very rare in the region).

Discovering occupied tree-roosts, we could better understand the ecology of these species, periods of occupation, and possibly complete inventories within the distribution atlas. A first assessment of nine tree-roosts was published in 1993 (Nicolas & Pénicaud). Since then, by searching for the same features, targeted surveys have led to more discoveries, and some early results were published in 1996, 1999 and 2000 (Pénicaud).

Outside the framework of this study, some tree-roosts were recently discovered in Brittany, in the department of Ille-et-Vilaine (35): Choquené (*pers. comm.*) recorded roosts in a beech *Fagus sylvatica* and oak *Quercus* sp. respectively comprising a Daubenton's bat sheltering in a long crack, and an unknown species discovered by the presence of a single dropping. In addition, a dozen serotine were observed flying from a woodpecker-hole (in oak) by Le Bris (*pers. comm.*), and two tree-roosts harbouring the same species were found by Farcy (*pers. comm.*): one in an oak whose access to the roost is hidden by a thick blanket of ivy *Hedera helix*, and another in a woodpecker hole in an old Scots pine *Pinus sylvestris*.

To my knowledge, no systematic surveys have been conducted elsewhere in France. Records of natural breeding tree-roosts are scattered and fragmentary, while in different regions, artificial bat-boxes have been deployed for inventory (presence/absence) studies and/or for conservation purposes to ensure the protection of tree-roosting bat species.

It was interesting to consider whether a better understanding of the roosts of tree-dwelling bats could result in better conservation measures than simply compensating for the loss of trees by the installation of roost-boxes, namely identifying and protecting the roost-trees themselves.

STUDY PERIOD AND AREA

Between May 1992 and June 1999, 60 roosts have been discovered in northern Finistere department (29) and west of Côtes d'Armor (22).

The landscape is characterised by woods and wooded slopes which have differing access depending upon agricultural activity; generally open near the coast (in vegetable growing areas) and more restricted in the interior (in livestock and cereal growing areas).

In the study area, wooded areas are divided into a multitude of small plots (often on the slopes of valleys), some most important private clumps and a national forest (see Fig. 1). Most wooded areas are below 200 m altitude. The crest of the Monts d'Arrée, culminating at 384 m (Roc Trevezel), is covered with moorland with heather *Calluna* sp., *Molinia* spp. and gorse *Ulex* sp., and a few parcels of conifers. The predominant woodland management is coppice. Oak is dominant with beech, sweet nchestnut *Castanea sativa*, birch *Betula* sp. or pine *Pinus* sp., and willow *Salix* sp. along streams and rivers. Apart from a few recent stands of poplars *Populus* sp. along the rivers, the high forests of beech and oak are only now present as remnant stands in private parks, the grounds of castles and small areas of state forests.

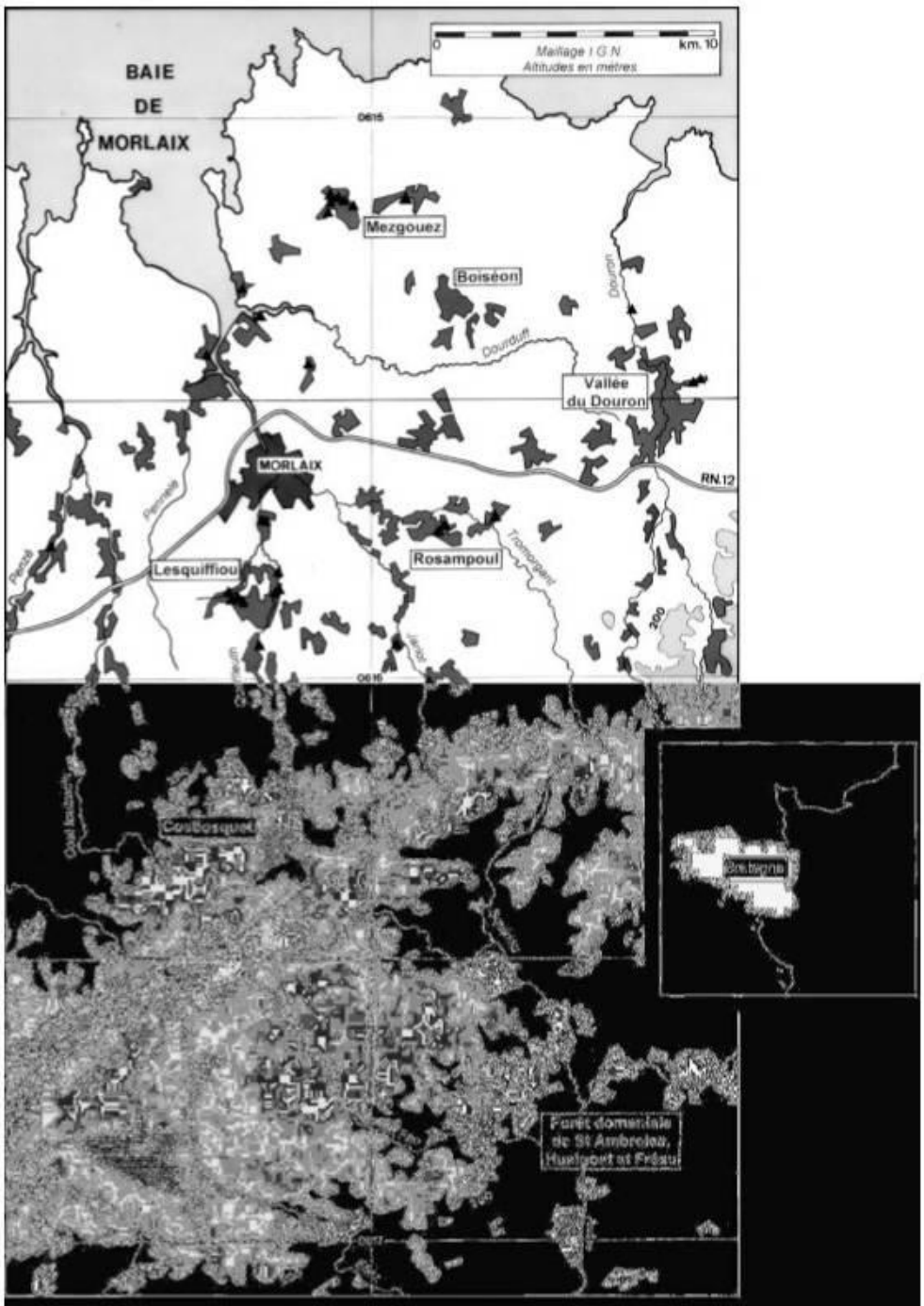

Fig. 1 : Situation et carte de la zone d'étude : principaux massifs forestiers et localisation des 60 arbres-gîtes à chauves-souris répertoriés

MATERIALS & METHODS

Finding tree-roosts is not easy, due to the cryptic behaviour of the various species and

their nocturnal habits. Such roosts are more often than not discovered by chance, sometimes due to naturalists hearing their social calls on warm days (Richardson 1985), or the mating "songs" of male noctules (Schwaab 1996).

One can also wait in the evening at the base of the tree that is thought to be favourable, and watch/listen for any flight visually or with an ultrasound detector. Using these methods, Schwaab has discovered occupied roosts of Natterer's bat, noctule and Leisler's bat *Nyctalus leisleri* in Romersberg Forest in Lorraine (1996).

Following bats that are carrying phosphorescent sticks can also be effective, as well as radio-tracking (Schofield *et al.* 1997). Other less intrusive and less expensive methods may also yield positive results, such as backtracking to follow hunting bats back to their tree-roosts, but this involves mobilising several people on several consecutive nights for each roost survey (Giosa *pers. comm*.).

Another technique is to search the woods in groups, in the early evening and especially just before sunrise, in summer, equipped with ultrasonic sensors. During the latter period, bats swarm (circle in the air) for a few minutes in close proximity to their shelter before taking refuge for the day, so indicating the location of their roost (Helmer, 1983). This method requires teams of ten people to identify and track animals, and has been developed and expanded, especially in the Netherlands, where it gives excellent results (Limpens 1993, Lustrat 1991). Latterly this method has also begun to be used France.

Finally, it should be noted that bats colonies are sometimes discovered during pruning (Arthur *pers. comm*.) and also, unfortunately, during the winter felling (Gaisler *et al.* 1979; Lustrat 1997 & 1998; Arthur, Giosa and Le Reste *pers. comm*.).

In this study, the method, already practiced by Richardson (1985) was to identify trees with all kinds of cavities during surveys in the plots.

During this process, the inspection of old woodpecker-holes gave disappointing results (dozens of unsuccessful inspections), and searches were very soon targeted towards the identification of cracked, split or twisted trees (although continuing to visit other cavities, including woodpecker-holes, but less consistently). Indeed, the occupation of this type of feature by bats proved significantly more frequent (Pénicaud 1996 & 1999).

Although searches were conducted throughout the year, depending on availability and without specific protocol, they were, however, more effective from December to April, due to better visibility in the undergrowth of deciduous forests during this period. Their intensity decreased significantly in the autumn.

During surveys, binoculars are essential to broaden the field of investigation progressing in the undergrowth. When present, it must take into account the position of the sun, not to be against the light (the identification of trees with cracks is not easy, especially as the most favourable are the narrowest). Some clues can still encourage their discovery: scars delineating cracks are smooth, contrasting with the roughness of the rest of the bark (especially oak), but this difference is not usually visible unless you look closely. However, the trunks are often slightly swollen at the height of the crack (by the spacing of the wood and the formation of scar beads), which may be visible from farther away. In trees that have stayed folded or bent, this thickening is even more pronounced. Furthermore, in areas where the trees are covered with moss, splits may be easily identified by the lack of moss in a clearly defined portion of the trunk or limb. This is often due to animals that grip bark regularly at a cavity they visit - perhaps bats.

At the end of the winter and spring, you can also find potential roost features by the singing of cavity-nesting birds in the immediate vicinity of their nest: songs of blue tits *Cyanistes caeruleus*, great tits *Parus major*, nuthatches *Sitta europaea*, great spotted woodpecker *Dendrocopos major* drumming etc.

Potential roost sites were not sought in the branches located at height: the cavities are certainly numerous, but their systematic inspection would have been impossible with the materials used here. In addition, it can be assumed that, given the predominant forest type in the region, their generally small diameter is less favourable to bats (dimensions of the internal space, insulation).

Once a "favourable" tree is spotted, and if the potential roost is accessible (distance from the vehicle, height in the tree, practicability of the land, access permission from the owner), a ladder is used for access, and internal inspection of the potential roosts is performed using an elliptical mirror (for optimum visual field at 45 °) which is articulated on a rod, and a dichroïc lamp, sufficiently powerful (12W) powered by a portable battery 12V. Four sizes of mirrors are used (width 1.5-4 cm) depending upon the interior (see Fig. 2). Although this simple equipment has allowed many discoveries, the big disadvantage is that it will not always allow full inspections of some features, which may have turns and sometimes separate internal spaces, and can be congested by large splinters of wood which hamper visibility.

Fig. 2 : Inspection d'une fissure étroite dans un chêne, avec échelle, lampe et miroir adapté (gîte **2**, côté sud-est).

Figure 2. Inspection of a narrow crack in an oak with a ladder, lamp and mirror (Roost No. 2).

Bats are typically found in the apex of the feature, except in hot weather, where they are sometimes visible at the entrance. In a few exceptional cases, they have been found at the bottom of the cracks. In several cases, their presence could be identified from the ground, using a spotlight (and possibly a pair of binoculars or a telescope), or due to a favourable angle, either because they were closer to the opening in the late afternoon by the time soft (see Table 2, roosts No. **10**, **11**, **14**, **16**, **22**, **25**, **41**, **45** and **52**)[1].

Only one roost was discovered through squeaks betraying the presence of bats sheltering within, in this case a colony of Daubenton's bats (**10**).

It goes without saying that the duration of observation of animals discovered in their roost is reduced to seconds - or even a few tens of seconds (the time of the determination

[1] All numbers in bold text refer to the numbers assigned to the occupied roosts in Table 2.

and counting) to limit the disturbance.

Although occupied roosts were found throughout the year, the majority were discovered from February to May (Fig. 3). This grouping is related to the period when the surveys are accentuated. The decrease in the number of discoveries from June to September is probably explained by the fact that, during this period, bats - at least females - congregate for breeding, these groupings are not necessarily located in trees. Hence a decrease in the number of occupied roosts during the summer.

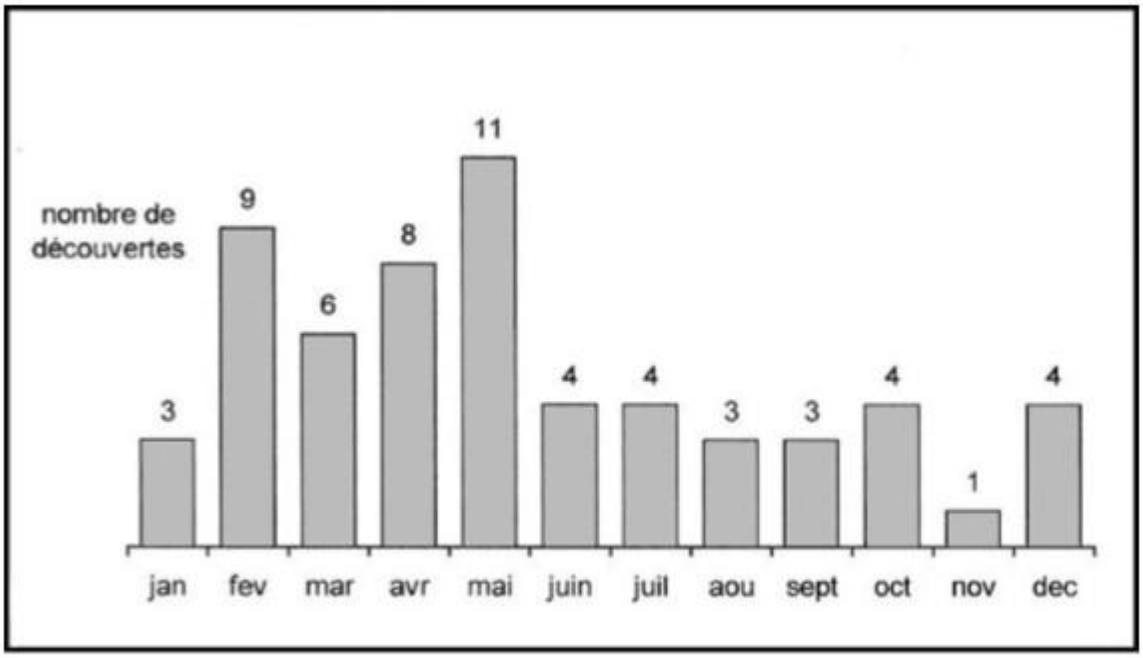

Fig. 3 : Répartition dans l'année des découvertes de gîtes occupés, toutes années confondues.

Figure 3. Monthly distribution of roost discoveries for all years combined.

The lack of records in November is related to a decrease in the intensity of research in the autumn.

The main objectives of this study is to propose a typology of trees occupied by bats and describe the species present, the roosts were, on the whole, little followed after discovery [i.e. the author made few repeat visits] (Fig. 4): the average number of subsequent visits was 4.3 per roost, and for 54 of them (90%), it was limited to a maximum of six. 15 (25%) were not revisited and another 15 were only revisited once more. For the vast majority of others, visits were spaced one or more months apart or distributed once a year at different times, their number also depends on how late in the study they were discovered.

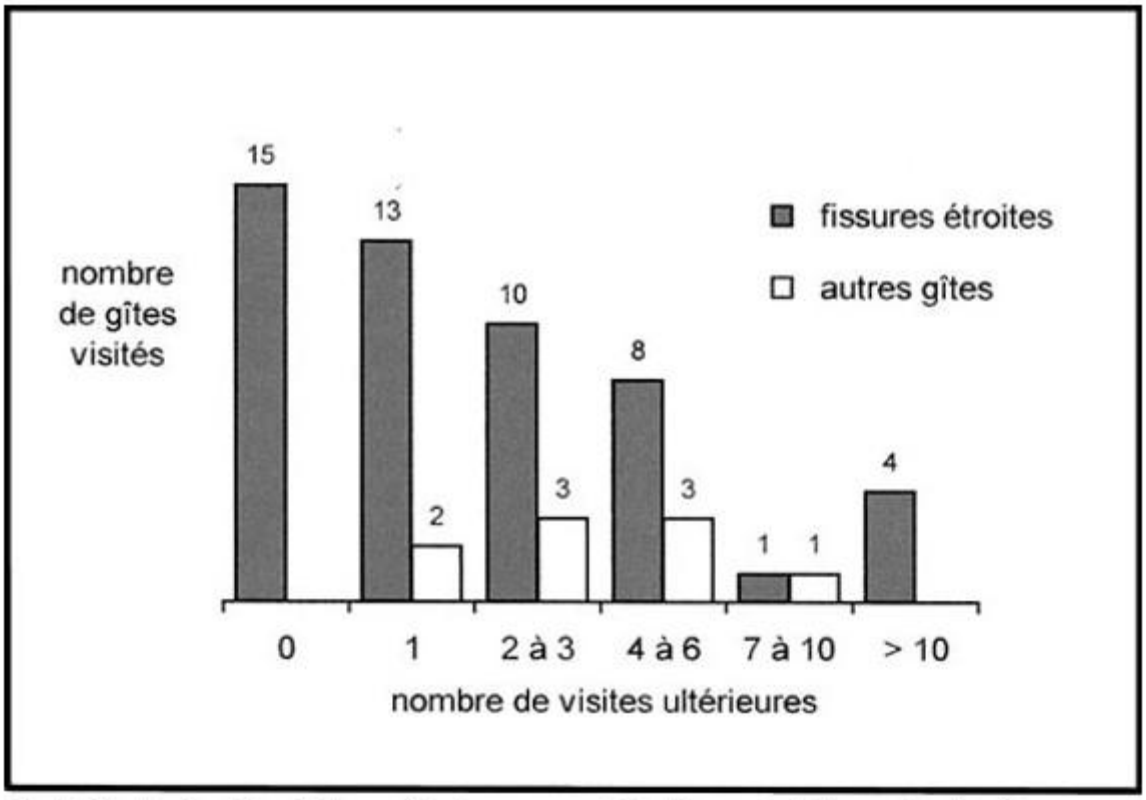

Fig. 4 : Nombre de visites ultérieures (fructueuses ou non) à la découverte de l'occupation des gîtes.

Figure 4. Number of subsequent visits (successful or not) to the discovery of the occupied roosts (*nombre de gîtes visités*: number of roost visits; *fissures étroites*: narrow cracks; *autres gîtes*: other PRF)[2].

However, some roosts have been subject to repeat inspections - although without specific protocol, particularly those in which the numbers observed were quite consistent, and where breeding has been proven (in the latter case, the visits have been relatively close during the rearing of young). Thus, four roosts were inspected over 10 times - the monitoring being scheduled for only two of them (over 50 visits in 7 years).

TYPES OF OCCUPIED TREES

Tree species

Various tree species can harbour tree-roosts. Table 1, which is not exhaustive, brings

[2] Interpreters note: in effort terms, 29% of roosts were identified on the first visit, 54% within two visits, 74% had been recorded by the fourth visit, 90% by the seventh visit but to get the lot it took over 10 visits.

together various examples of this diversity, 'X' represent bibliographic citations and personal data communications.

Table 1. Tree species cited in published literature as holding bat-roosts of individual bat species.

	Noctule commune	Noctule de Leisler	Noctule sp.	Murin de Daubenton	Murin de Natterer	Murin à moustaches	Murin de Bechstein	Oreillard sp.	Pipistrelle de Nathusius	Pipistrelle sp.	Sérotine commune	Barbastelle	Chauve-souris (*)
Feuillus													
Chêne spp.	XXXXX	XXX	-	XX	XXX	X	XX	X	-	XX	XXX	XX	XXX
Hêtre	XXXXX	-	-	XXXXXX	XXX	-	X	X	-	-	-	-	X
Platane	XXXXX	-	-	-	-	-	-	-	X	-	-	-	-
Frêne spp.	-	-	X	XXX	-	-	X	-	-	-	-	-	-
Robinier	X	-	-	X	X	X	-	-	-	-	-	-	-
Châtaignier	X	X	-	-	X	-	-	X	-	-	-	-	-
Tilleul spp.	-	-	-	X	-	-	X	X	-	-	-	-	-
Marronnier	X	-	-	-	X	-	-	X	-	-	-	-	-
Saule spp.	X	-	-	X	-	-	-	-	-	-	-	X	-
Lierre	-	-	-	-	-	-	-	-	-	(X)	-	-	XX
Poirier spp.	-	-	-	X	-	-	-	-	-	-	-	-	X
Bouleau spp.	-	-	-	X	X	-	-	-	-	-	-	-	-
Chêne rouge	-	-	-	X	-	-	-	X	-	-	-	-	-
Erable plane	-	X	-	-	-	-	-	-	-	-	-	-	-
Orme spp.	X	-	-	-	-	-	-	-	-	-	-	-	-
Résineux													
Pin sylvestre	X	-	-	-	-	-	-	X	-	-	X	X	-
Cèdre	-	-	-	-	-	-	-	-	-	-	-	-	X
Douglas	-	-	-	-	-	-	-	X	-	-	-	-	-
Séquoia spp.	-	-	-	-	-	-	-	-	-	-	-	-	X

French publications comprise Barataud *et al.* (1997), Lustrat (1997 & 1998), Noblet (1983 & 1987), Pottier (1992) Roue S.G. (1999) and Schwaab (1996). Personal communications comprise Arthur, Bardet, Choquené, Cosson, Farcy, Frontera & Roue S.Y. (quoted in Roue S.G. (1999), Giosa, Jourde, Le Bris, Le Reste, Schwaab and Sirugue (quoted in Roue S.G. 1999)[3]. Some other examples of data from publications from neighbouring countries: Great Britain: Richardson (1985), Schofield *et al.* (1997); Germany: Kiefer (1996), Schober & Grimmberger (1991) Wissing (1996), Ohlendorf, Steinhäuser (not yet published); Switzerland: Chapuisat *et al.* (1988), & Chapuisat &

3 These accounts are taken from this publication, and comprise data on the three main species found here, namely long-eared bats, Natterer's bat and Daubenton's bat.

Ruedi (1993); Netherlands: Limpens *et al.* (1997) (1), and, as cited in Mayle (1990) Smith (1985) (GB), Gaisler *et al.* (1979) (CZ), and Helmer (1983) (NL).

It is clear from these examples that the species most often cited in the literature are the oaks (spp.) and beech. Many papers do not detail the numbers of each tree species occupied, which would be likely to further increase the dominance of oak and beech: in the Netherlands, where surveys are the most comprehensive, of 180 roost-trees occupied by Daubenton's bats, 119 are oaks or beech, plus ten red oaks *Quercus rubra* (Limpens *et al.* 1997). The species of oak most often used by bats is the English oak *Quercus robur*.

Note that some roosts are located under the bark of trees, especially conifers (pine and redwood *Sequoia sempervirens*). In the case of ivy, there are small spaces between the thick trunks and those of the supporting stems.

In this study, of the 60 roost trees (see Table 2), there are 48 oaks *Quercus robur* and *Q. petraea*, six beech, two chestnut, one ash, one apple *Malus* sp., one black locust *Robinia pseudoacacia* and one Scots pine *Pinus sylvestris*. All trees are alive except the pine, which is dead and broken at low height.

Types of roosts

Given the favoured position of bats during their daytime rest, above the opening within cavities in stems or limbs of sufficient diameter, a narrow fissure (at least one centimetre wide), a woodpecker hole, a break, a knot-hole, a tear-out, "decay" due to parasitic fungi, and peeling bark may *a priori* constitute roost-features. But it is still necessary that the internal space is healthy and deep enough without being too narrow or too large. In addition, the passage of the animals should be possible without any contact with the flow of urine and droppings. We will see later that other criteria make certain types of cavities more attractive than others.

In French literature, most tree-roosts described (where the type is specified) are located in woodpecker-holes and hold primarily noctules and Leisler's bats. Relatively little data is available for other species that may roost in trees. To date, Leisler's bat is not recorded in Brittany and a small amount of noctule data is listed. Furthermore, cracks were not much explored in other regions of France and only a few roosts of this nature are known, yet it is these cracks that have proven the most welcoming for bat species discovered in the present study. They represent the vast majority of occupied roosts: 51 of 60.

Hairline cracks:

The wind, some frost cracks and sometimes lightning, are responsible for the formation of these cracks. It is certain that the outstanding power of the hurricane of 16th October 1987, multiplied these in Brittany (La Reste *pers. comm.*), But this particular type of cavity also exists in other parts of France. In fact, bats have been observed in many such features: in Lorraine, a long crack in an oak is home to a breeding colony of a hundred whiskered bats (Schwaab *pers. comm.*). In Auvergne, Giosa (*pers. comm.*) has identified two, which respectively house a group of 23 Leisler's bats and serotines. A beech in Picardy (Bardet, *pers. comm.*) and an oak in Seine et Marne (LUSTRAT, 1997), both hold noctules.

Recent storms of 26th and 27th December 1999, which severely damaged the northern forests and a large part of southern France, certainly will - paradoxically - allow the formation of new roosts in almost all French regions: a few years of healing and many trees cracked, split or twisted will seal[4] to form favourable shelters for bats. Some openings also gradually shrink over time (Fig. 5: in 1999, the access shown is still used by bats, and the other side of the tree has a less narrow fissure). In many cases, it was observed that almost closed access was maintained by active intervention, probably by cavity-nesting birds.

Other cracks tend to diverge further, probably due to the gradual penetration of the beads lignified in the interior, and repeated wind action upon still poorly grafted scars. Trees rarely break at the already healed cuts and this strength was verified in the weeks that followed the storms of December 1999: of the 33 favourable cracks already known (including 14 used by bats), none has suffered. In addition, 18 new favourable cracks - not previously damaged - have since been discovered, and an oak was even found with a trunk with a healed crack intact, and a new one, recently broken, about 2.50 meters above it.

During surveys, it has been noted that different species of trees do not "react" in the same way to trauma; for example, beech, when they do not outright break, contain very confined spaces but also very wet, oozing or rotting. Richardson (1985) notes that willow cracks, bordering rivers and lakes, are often home to Daubenton's bat. Here, these trees were poorly investigated, but some observed willows appeared too small and held only shallow cavities, or were instead split from one side, but with insufficient healing, the spaces created and then remaining gaping and little sheltered. However, this tree species and this type of environment probably deserve further attention.

[4] These are the healing beads [ribs of occlusion-wood] that seal the otherwise exposed internal areas of the roost feature, providing a tall, narrow inner upper fissure.

n°	Arbre	Type	H	D	Orient.	Milieu	Situation	Espèce(s)	Eff.	R?	Cohabitation
1	Chêne	Fiss T	3,5	50	NW-SE	Bois	Dans le bois	M N	26	R	Mes. ch., nn.
2	Chêne	Fiss T	3	45	SE-N	Bois	Talus chemin	O R	20	R	Mes. ch.bl.nn. (Mulot)
								M N	15	-	-
3	Chêne	Fiss T	2,5	20	SE	Bois	Talus chemin	M sp.	1	-	-
4	Chêne	Fiss T	4,5	25	NE	Bois	Talus dans bois	M N	1	-	-
5	Hêtre	Fente T	6	50	NW	Bois	Bord chemin	O sp.	1	-	-
6	Hêtre	Fente T	3	40	W	Parc	Bord chemin	M N	1	-	-
								O(R)	7	-	-
7	Pin †	Fiss T	1,6	50	SE	Bois	Talus dans bois	O(R)	4	-	-
8	Hêtre	Fente T	3,5	75	S	Parc	Lisière pâture	M D	13	-	(Sittelle)
9	Pomm.	T creus	1,8	30	SW	Bocage	Verger	CS sp.	2	-	-
10	Hêtre	Dbl TP T	5	45	NE	Parc	Allée de château	M D	11	R	-
11	Hêtre	Dbl TP B	7,5	25	N	Parc	Allée de château	M D	2	-	-
12	Chêne	Fiss T	2,5	25	SE-NW	Vallée boisée	Dans le bois	P sp.	1	-	-
13	Chêne	Fiss T	4,5	35	NW-SE	Vallée boisée	Dans le bois	O(R)	1	-	Mes. ch.
								M D	5	-	Mes. ch.
14	Chêne	Fiss T	7	40	S	Bois	Dans le bois	O(R)	10	R	Mes. sp.
15	Chêne	Fiss T	5,5	30	SE-(NW)	Bois	Dans le bois	O sp.	1	-	Mes. sp.
								M sp.	1	-	Mes. sp.
16	Chêne	Fiss T	4,5	20	W	Bois	Dans le bois	O(R)	11	-	Mes. bl.
								M N	1	-	-
17	Frêne	Ech cass T	3,5	30	W-E	Vallée/bocage	Bord de rivière	O(R)	1	-	-
18	Chêne	Fiss T	4,5	30	E-W	Vallée boisée	Dans le bois	O(R)	8	-	Mes. bl.
19	Chêne	Fiss T	5	18	E	Vallée boisée	Dans le bois	O(R)	5	-	Mes. bl., (Mulot)
20	Chêne	Fiss T	3,5	35	N-(S)	Grand bois	Dans le bois	M N	1	-	-
21	Chêne	Fiss T	3,7	25	NW-SE	Grand bois	Dans le bois	O(R)	1	-	-
22	Chêne	Fiss T	3,5	20	SE-(NW)	Petit bois	Dans le bois	M N	1	-	-
23	Chêne	Fiss T	4	20	Nb fiss	Vallée boisée	Dans le bois	P sp.	1	-	-
24	Chêne	Fiss T	5	20	E	Bois/bocage	Bord pte route	M N	1	-	-
25	Chêne	Fiss T	11	35	E-W	Vallée boisée	Bord rivière	CS sp.	1	-	-
26	Châtai.	Fiss T	3	25	S-(NW)	Vallée boisée	Dans le bois	O(R)	3	-	-
								M N	1	-	-
27	Chêne	Fiss T	4,5	20	E	Grand bois	Dans le bois	O(R)	2	-	-
28	Chêne	Fiss T+TP	6,5	25	N-SE	Grand bois	Talus dans bois	M sp.	1	-	Mes. bl.
29	Chêne	Fiss T+TP	4,5	20	SE	Grand bois	Dans le bois	O(R)	1	-	-
30	Chêne	Fiss T	3,5	25	E	Grand bois	Bord chemin	O(R)	1	-	-
31	Chêne	Fiss T	3	25	E	Grand bois	Dans le bois	O(R)	1	-	-
32	Chêne	Fiss T	4,5	35	N-S	Grand bois	Dans le bois	M N	2	-	-
33	Chêne	Fiss T	3,5	25	SW-(NE)	Grand bois	Dans le bois	M N	1	-	-
34	Chêne	Fiss T+TP	6	35	SE	Grand bois	Dans le bois	CS sp.	?	-	Mes. bl.
35	Chêne	Fiss T	4	23	E	Grand bois	Dans le bois	O(R)	8	-	-
								M N	1	-	-
36	Chêne	Fiss T	4,5	30	NE	Grand bois	Dans le bois	M N	1	-	Mes. sp.
								O(R)	1	-	-
37	Chêne	Fiss T	3	30	?	Grand bois	Dans le bois	O(R)	1	-	-
38	Chêne	Fiss T	2	30	N-S	Grand bois	Dans le bois	M N	3	-	-
39	Chêne	Fiss T	5,5	40	W-(E)	Grand bois	Talus dans bois	O(R)	5	-	nid sp.?
40	Chêne	Fiss T	4,5	30	SE	Grand bois	Dans le bois	O(R)	1	-	-
41	Chêne	Fiss T	2	30	N-S	Petit bois	Dans le bois	O(R)	1	-	-
42	Chêne	Fiss T	3,5	40	SE-NW	Bois	Dans le bois	P sp.	1	-	-
								O(R)	5	(R)	-
43	Chêne	Fiss T	3	20	SE-(NW)	Bois	Dans le bois	O(R)	1	-	-
44	Chêne	Fiss T	5	30	W	Petit bois	Dans le bois	M N	1	-	-
45	Hêtre	T creux	2	30	SW	Lande/bocage	Talus chemin	O sp.	1	-	-
46	Chêne	Fiss T+TP	6	30	N-(S)	Lande/lac	Talus chemin	MD+MM	5	-	-
47	Chêne	Insert Br/T	3,5	35	N	Petit bois	Dans le bois	M D	2	-	-
48	Chêne	Fiss B	5,5	30	W	Vallée boisée	Bord de rivière	M D	5	-	-
49	Chêne	Fiss T	6,5	30	SW	Forêt	Bord chemin	CS sp.	?	-	(Sittelle)
50	Chêne	Fiss T	2,3	20	E	Bois	Dans le bois	M N	1	-	-
51	Chêne	Fiss T	4,2	25	SW-(NW)	Vallée boisée	Dans le bois	M N	1	-	Mes. bl.
52	Chêne	Fiss T	8	30	N-(S)	Bois mixte	Dans le bois	M D	11	-	-
53	Châtai.	Fiss T	2,8	30	S-(N)	Bois	Dans le bois	O(R)	3	-	-
54	Chêne	Fiss T+TP	5	25	SE-(NW)	Vallée boisée	Dans le bois	M D	2	-	Mes. bl.
55	Chêne	Fiss T+TP	6	35	E-(S)	Vallée boisée	Dans le bois	M N	1	-	-
56	Chêne	Fiss T	4,5	18	NW	Boc prox bois	Talus chemin	M N	1	-	-
57	Robin.	Fiss T	4,5	32	SE-(N)	Vallée boisée	Bord chemin	P sp.	1	-	-
58	Chêne	Fiss T	4,8	30	SE-(NW)	Vallée boisée	Dans le bois	O(R)	7	-	-
59	Chêne	Fiss T	3,3	25	SE	Boc prox bois	Lisière pâture	M D	1	-	-
60	Chêne	Fiss T	3,4	19	N-(S)	Bois	Dans le bois	M D	1	-	-

Tableau 2 : Récapitulatif des gîtes à chauves-souris arboricoles occupés.
Type de gîte: Fiss = fissure(s) étroite(s), Fente = fente large, Ech cass = grosse écharde cassée, Insert Br = Insertion de branche tombée, TP = trou de pic (Dbl = double), T = tronc, B = branche. H = hauteur du plus haut de l'accès en mètres. D = diamètre du tronc ou de la branche en haut de l'accès, en centimètres. Orient. = orientation () = secondaire. Espèces: O(R) = Oreillard (roux), M N = Murin de Natterer, M D = Murin de Daubenton, M M = Murin à moustaches, P = Pipistrelle, CS sp. = chauve-souris indéterminée. Eff. = effectif maximum visible observé pour un gîte. R = reproduction. Cohabitation avec Mes. = Mésange, bleue (bl.), charbonnière (ch.), nonnette (nn.), indéterminée (sp.). () = cohabitation non simultanée (voir texte).

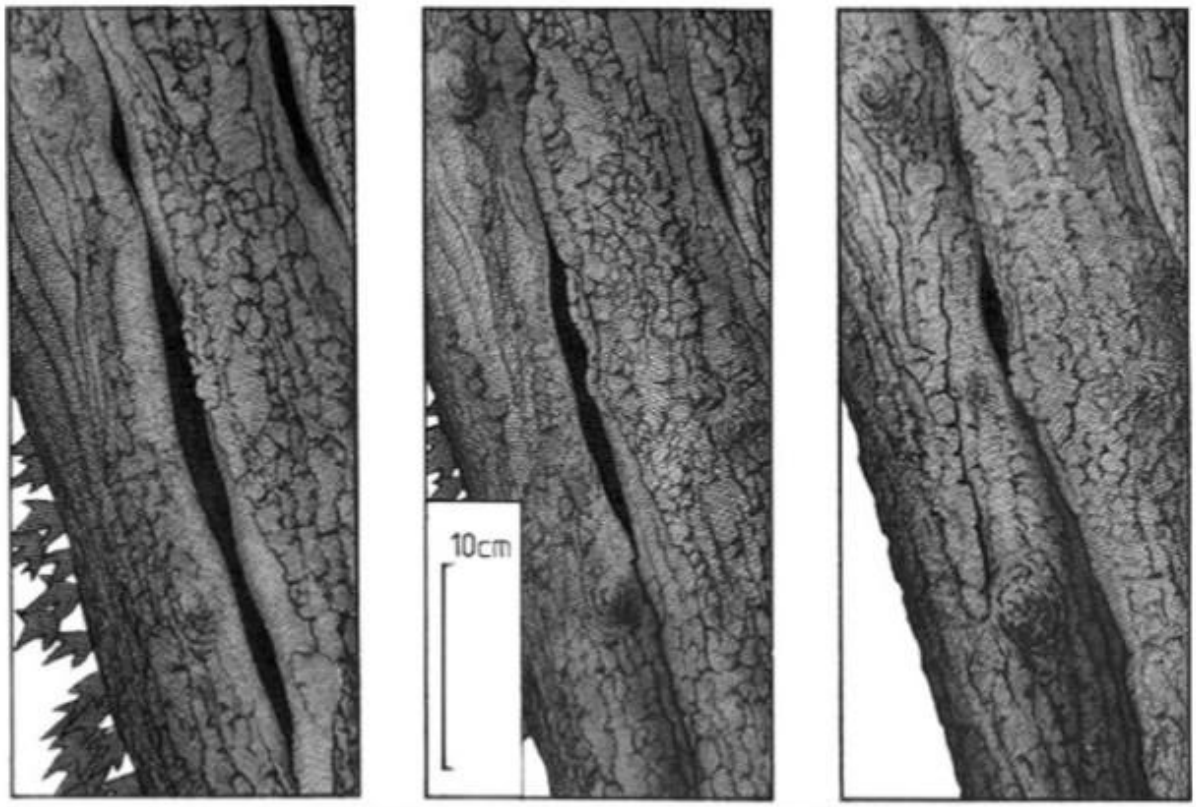

Fig. 5 : Rétrécissement progressif des fissures d'un chêne, en 7 ans (gîte **1**, côté nord-ouest, en 1993, 1996 et 1999).

Figure 5. Progressive shrinkage of a crack in an oak over seven years (Left to right - Roost 1 in 1993, 1996 and 1999).

In the case of chestnut trees, it is probably the combined action of wind and frost causing the detachment of the external parts of the trunk from the inner heartwood (see Fig. 6b). A more or less important part of the heart remains intact in general, so that, when there is an interior space, it is healthy, but its dimensions are often too narrow to allow bats to crawl through.

Under the action of the storm, the oak can bend and crack through the ray tissue. If the opening thus created is not too gaping at the start, the internal space is often of suitable dimensions (see Fig. 6a). Also it's dry and healthy. Furthermore, on the first meters of the trunk, oaks are usually devoid of branches that could interfere with the comings and goings of bats; this advantage in favour of oak is already noted by Gaisler *et al.* (1979) for noctules. Besides the fact that this tree species is dominant in the region, all these remarks explain that 47 of the 51 narrow cracks occupied are located in oaks (see Fig. 7) to only two in chestnut (**26** and **53** – Fig. 6b.), one in a dead Scots pine (**7**: small shallow crack – Fig. 8a.) and one in a black locust (**57**: internal structure similar to oak - Fig 8b).

50 are located in the trunk (**T**), and an individual roost is located on a main branch (**B**) (**48**).

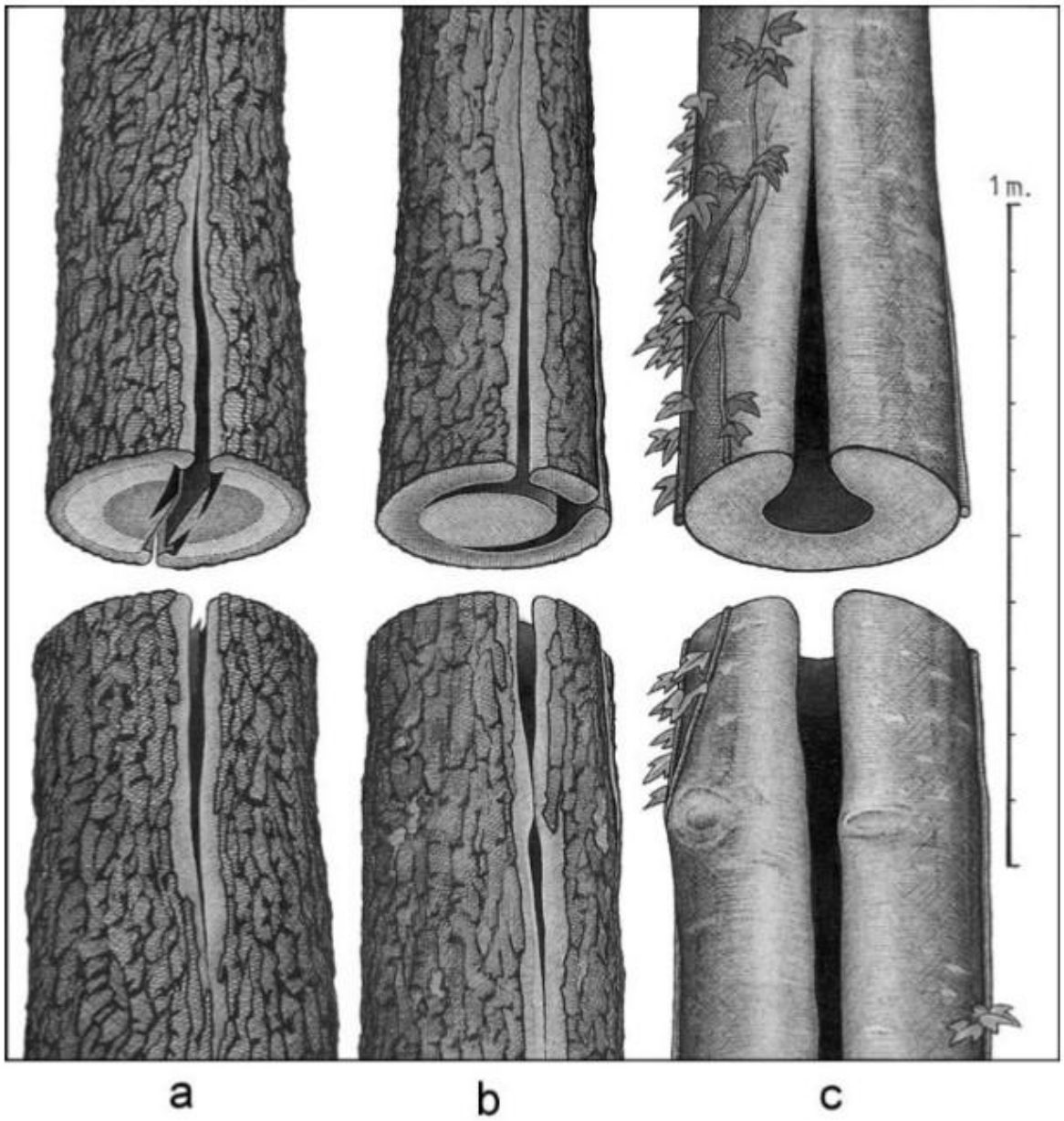

Fig. 6 : Aspect extérieur et coupe schématique montrant la structure interne de 3 gîtes :
a - fissure étroite typique dans un chêne (gîte **13**)
b - fissure étroite typique dans un châtaignier : "roulure" (gîte **53**)
c - fente large dans un hêtre (gîte 6).

Figure 6. External appearance and schematic section showing the internal structure of three roosts:

a) Typical narrow crack in an Oak (Roost 13);
b) Typical narrow crack in a ring-shake on sweet chestnut (Roost 53);
c) Wide slot in a beech (Roost 6).

In general, these roosts have the typical appearance shown in Figure 7 (a, b and c), but cracks may be very elongated or in twisted trunks which are bent or almost broken (Fig. 9a to d). Shelters often have two or more entrances on each side of the tree, when one of them is not already closed - or almost.

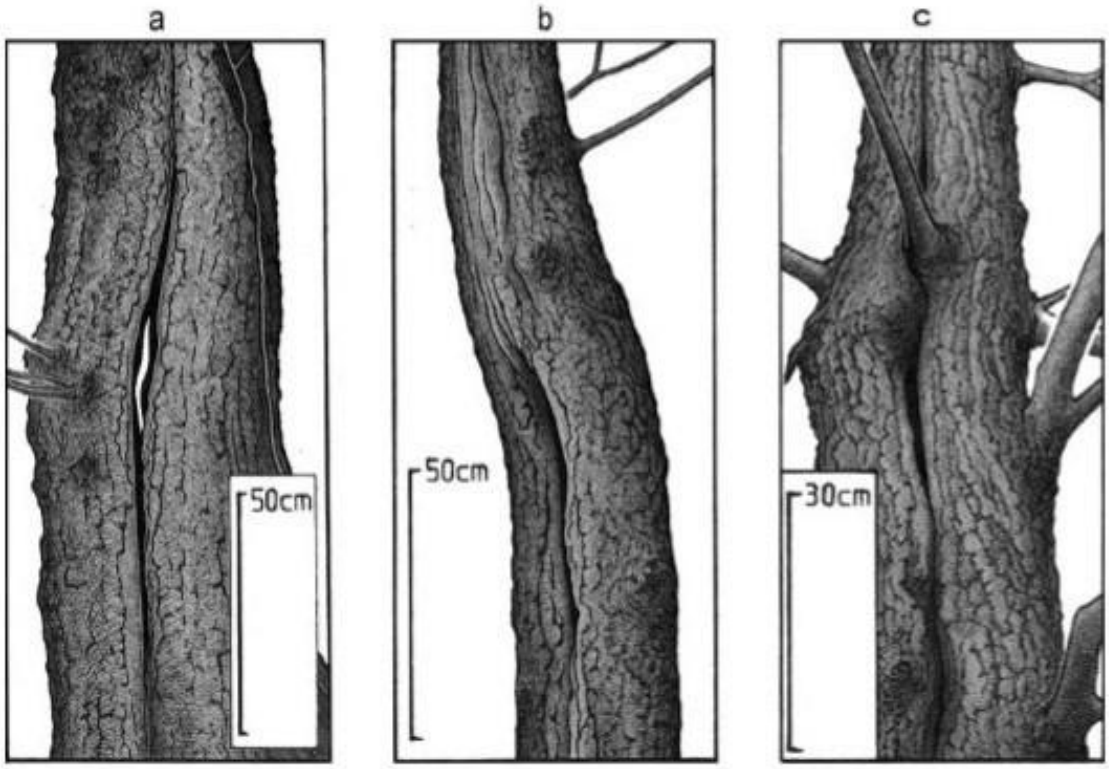

Fig. 7 : Fissures étroites typiques dans des chênes :
a - gîte **2**, côté nord
b - gîte **58**
c - gîte **16**.

Figure 7. Typical narrow cracks in oaks.

Finally, these cracks have the triple advantage of being a relatively constant temperature, in the heart of living trees, to allow the possible flow of guano separately from the crossing point of bats (always on top of the crack), and make the roost safe from predators whose size does not allow them to sneak inside. Trees with these favourable cracks are not common, and if a maximum of 18 was recorded in 30 ha, it is usually one (or a few) that were counted per plot surveyed - often none.

Interest in the exploration and inspection of trees to narrow cracks:

As mentioned above, it was towards this category of potential breeding sites that we oriented research. Of 109 cracks considered favourable (i.e. width between 1 and 3 cm,

length of at least 5 cm, interior apparently sufficient and healthy), 88 have been inspected with the proper equipment (ladder, lamp, mirrors): 80 oaks, five chestnuts, one black locust, one willow and one dead Scots pine. 51 of them were home to bats (58%).

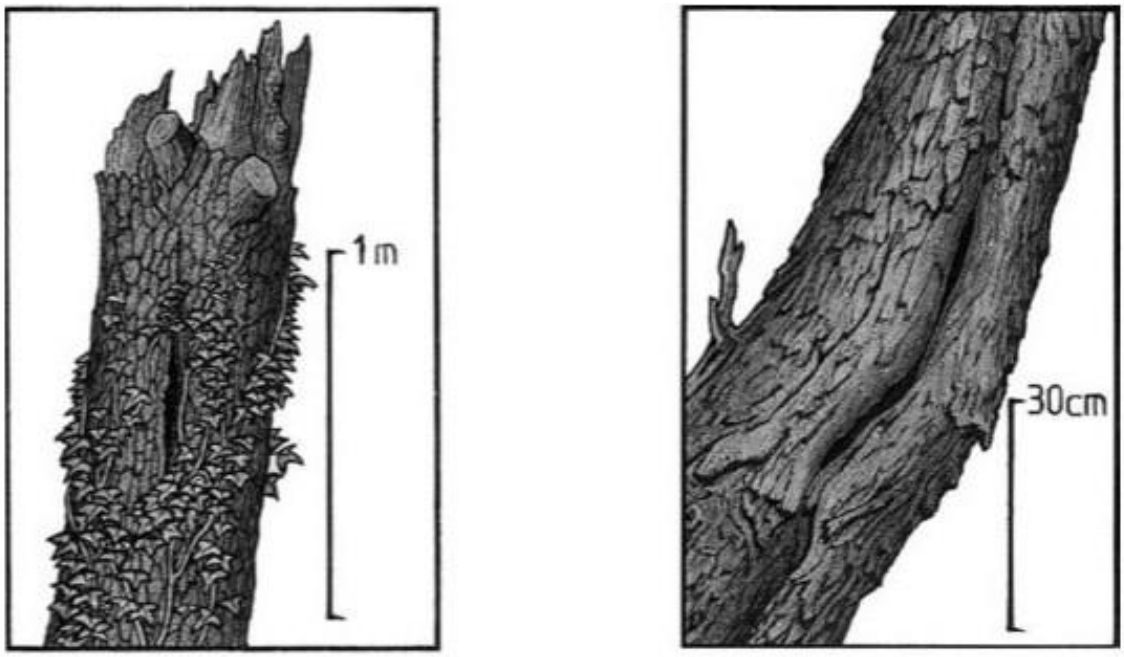

Fig. 8 : Fissures étroites dans d'autres essences d'arbres :
a - dans un pin mort (gîte **7**)
b - dans un robinier (gîte **57**).

Figure 8. Narrow cracks in other tree species:

a) In a dead pine;

b) In a black locust.

The average number of visits needed to discover their presence is 2.2[5]. One was enough in 26 cases (51% of occupied cracks), and 44 occupations were demonstrated in only 3 visits (86% of occupied cracks) (Fig. 10)[6]. In other words, 30% of cracks considered favourable (26 of 88) proved to be occupied on the first visit (average over the year, to modulate depending on the season - see above), which represents a "profitability" of very interesting exploration, taking into account the limitations imposed by the rudimentary

5 Those that where presence was confirmed from the ground are also counted as successful visits (**14**, **16**, **22**, **25**, **41** and **52**), and in two cases where only bat droppings were found in the bottom of the fissure (**34**, **49**).

6 Visits considered are spaced at least a month.

equipment used[7].

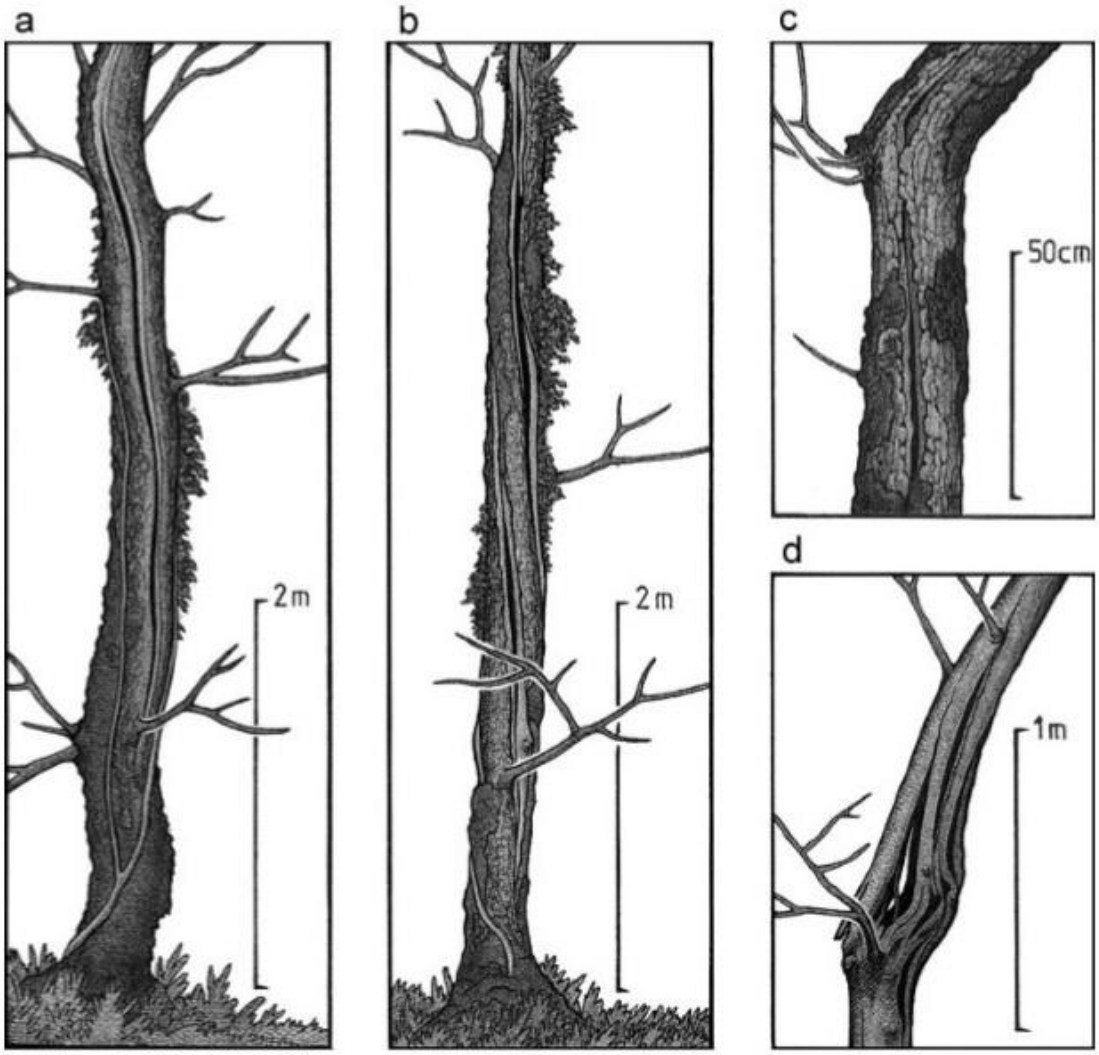

Fig. 9 : Fissures étroites atypiques dans des chênes :
a - fissure longue (gîte **36**) c - tronc coudé (gîte **43**)
b - tronc vrillé (gîte **32**) d - tronc presque cassé (gîte **23**).

Figure 9. Atypical narrow cracks in oaks:

a) Long crack;
b) Trunk twist;
c) Trunk elbow;
d) Almost broken trunk.

7 It is certain that more sophisticated equipment (i.e. an endoscope) would entail additional discoveries and improved efficiency surveys, particularly in cold weather, when bats dig as deeply as possible in the top of cracks.

The other 37 cracks defined as favourable, but where no bat was observed, were visited on average 2.6 times (Fig. 10). This value is slightly higher than that obtained for the occupied roosts, suggesting that all the narrow cracks are not used. Nevertheless it was discovered that by persevering with more visits, the proportion of "favourable" cracks becoming "confirmed roosts" continued to rise.

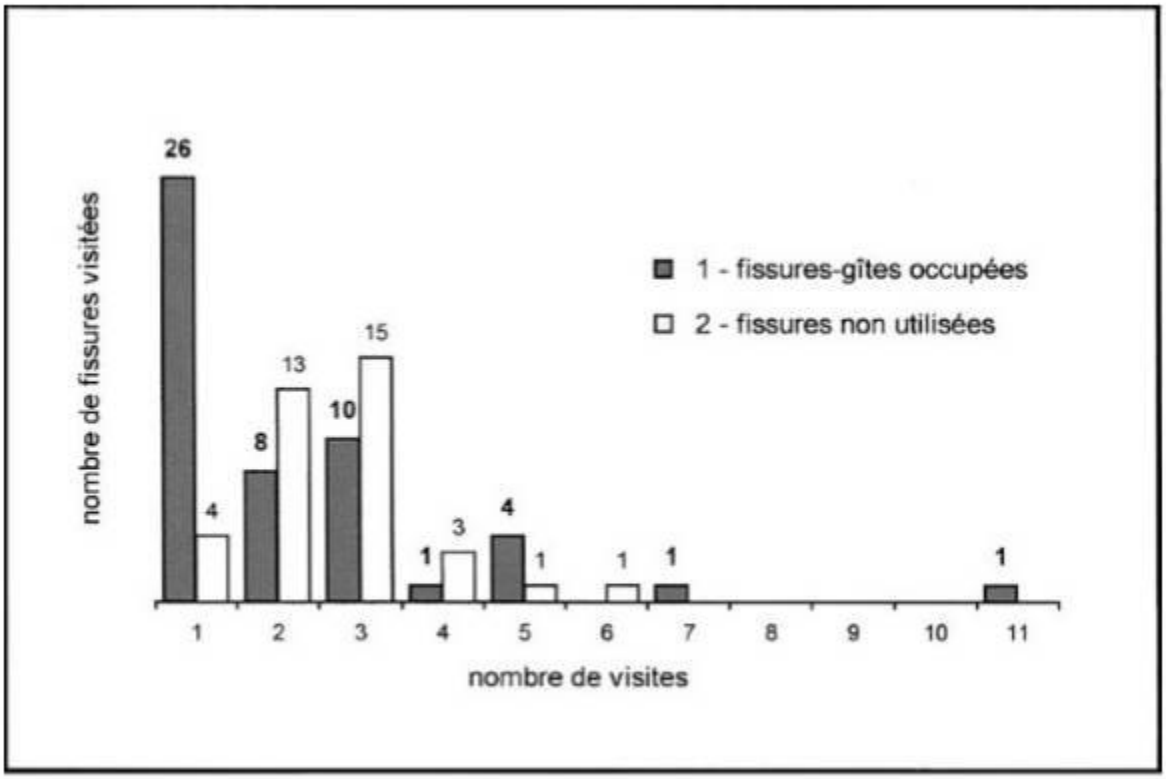

Fig. 10 : Nombre de visites dans des fissures étroites favorables
1 - nécessaires à la mise en évidence de l'occupation des gîtes
2 - n'ayant pas révélé la présence de chauves-souris

Figure 10. Number of visits to favourable narrow cracks
1 – Evidence of occupation by bats;
2 – No evidence of occupation by bats.
(1 – *fissures-gîtes occupées*: occupied crack roosts; 2 – *fissures non utilisées*: unoccupied cracks)

21 cracks considered favourable could not be inspected, among other reasons because of their excessive height. The average estimated height of those latest cracks is about 7.2 meters (Fig. 13).

The occupancy rate of the narrow fissures (58%) is important, compared to other types of

roost feature. In the Harz Mountains, Germany, Günther & Hellmann (1998) performed about 1,500 controls in 330 old nest-holes of great spotted woodpecker, and have observed an occupancy rate of 3.6% (two bat species). Comparing these results with those obtained in flat roost-boxes (more than half were occupied by five species, in two and a half months). They conclude that arboreal bats seem to prefer cavities whose internal dimensions are much smaller than the holes of the great spotted woodpecker. The findings of Günther & Hellmann (1998) point in the same direction as the observations described here.

In an oak wood in Belgium, Van der Wijden *et al.* (2000) also observed that the natural cavities where the access and interior space are narrow, appear to me more attractive to some bat species than the old woodpecker holes, particularly for Natterer's bats.

Other types of lodgings:

The 9 other occupied roosts are (see Fig. 6c and 11.) two double woodpecker-holes in beech (in a trunk - 10: Fig. 11a; and a main branch -. 11). In this case, the old nest cavities are joined under the effect of rotting and extend upwardly through a central hollow column (Fig. 12). Note that the discharge of urine and faeces can then be done through the bottom hole. For three other beeches (5, 6 and 8), the roosts are located in cavities accessible by wider slots and of varying lengths (30 cm to 2.50 m) (Fig. 6c, 11b and c) of undetermined origin (carved by decay after decay, frost cracks, or the loss of older branches (tear-outs)). One of them is partially closed by dried mud (Nuthatch's nest) (Fig. 11b). In the last beech occupied in the hollow trunk (killed in 1998), access could be through a large opening at the bottom of the stem and through small holes at height **(45:** Fig 11d). The interior of an occupied hollow apple (**9**) is also accessible by multiple openings of varying width, corresponding to old foundations of fallen branches [knot-holes] and clippings of various sizes [flush-cuts] (Fig. 11). Another insertion of a large fallen dead branch [tear-out], which has built up a small cavity in the trunk and shelters a Daubenton's bat roost is located in an oak (**47**. Fig 11f). Finally, the last roost in a ash is in the shelter of a big splinter which is pointed towards the ground (thick by about one third of the trunk), and partly healed in the top (**17**. Fig 11g). Again, the storm is most likely the cause of the break.

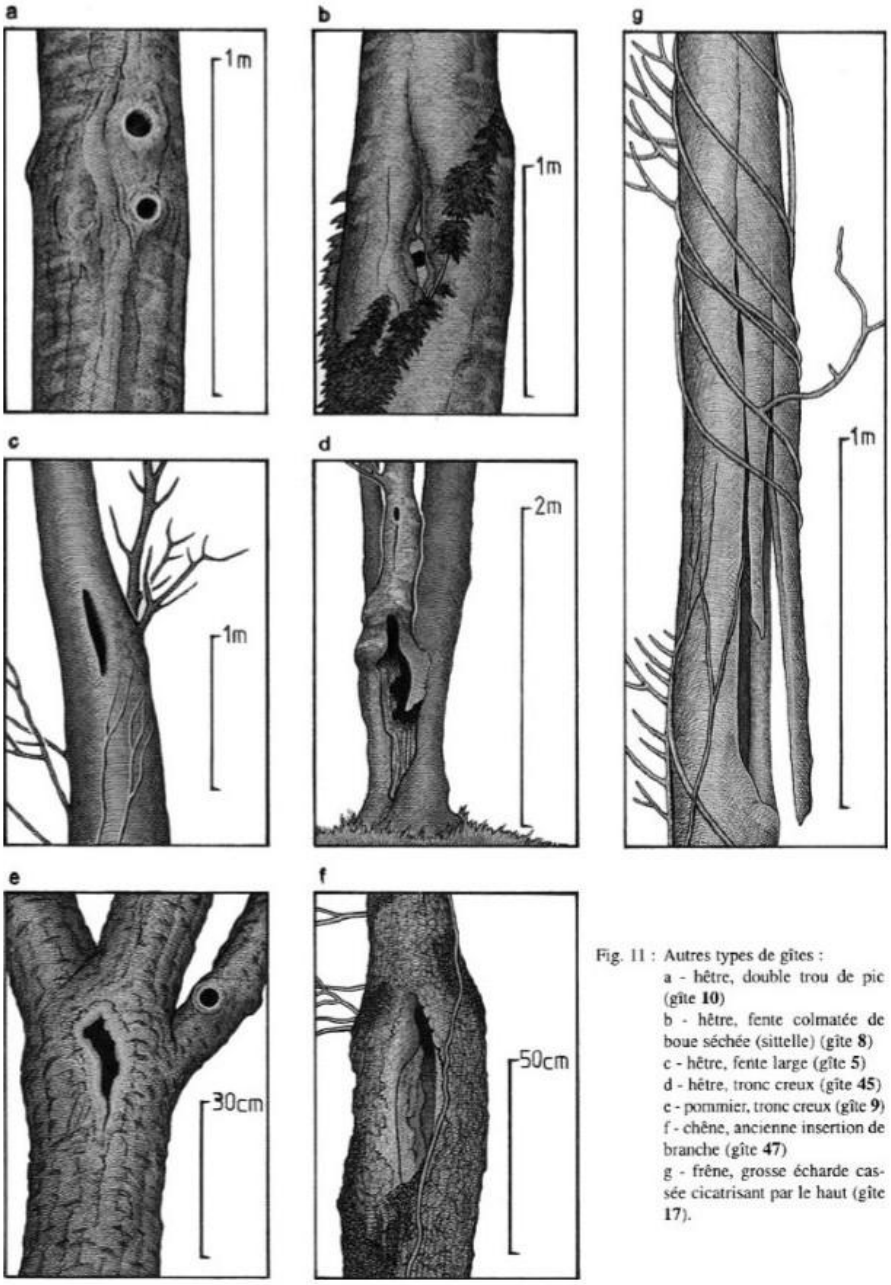

Fig. 11 : Autres types de gîtes :
a - hêtre, double trou de pic (gîte **10**)
b - hêtre, fente colmatée de boue séchée (sittelle) (gîte **8**)
c - hêtre, fente large (gîte **5**)
d - hêtre, tronc creux (gîte **45**)
e - pommier, tronc creux (gîte **9**)
f - chêne, ancienne insertion de branche (gîte **47**)
g - frêne, grosse écharde cassée cicatrisant par le haut (gîte **17**).

Figure 11. Other types of roosts:

a) Double woodpecker-hole on a beech (Roost 10);
b) Slot in a beech blocked up with mud by a nuthatch (Roost 8);
c) Wide slot in a beech (Roost 5);
d) Beech with hollow trunk (Roost 45);
e) Apple tree with hollow trunk (Roost 9);
f) Tear-out on oak (Roost 47);
g) Splintered ash healing from the top down (Roost 17).

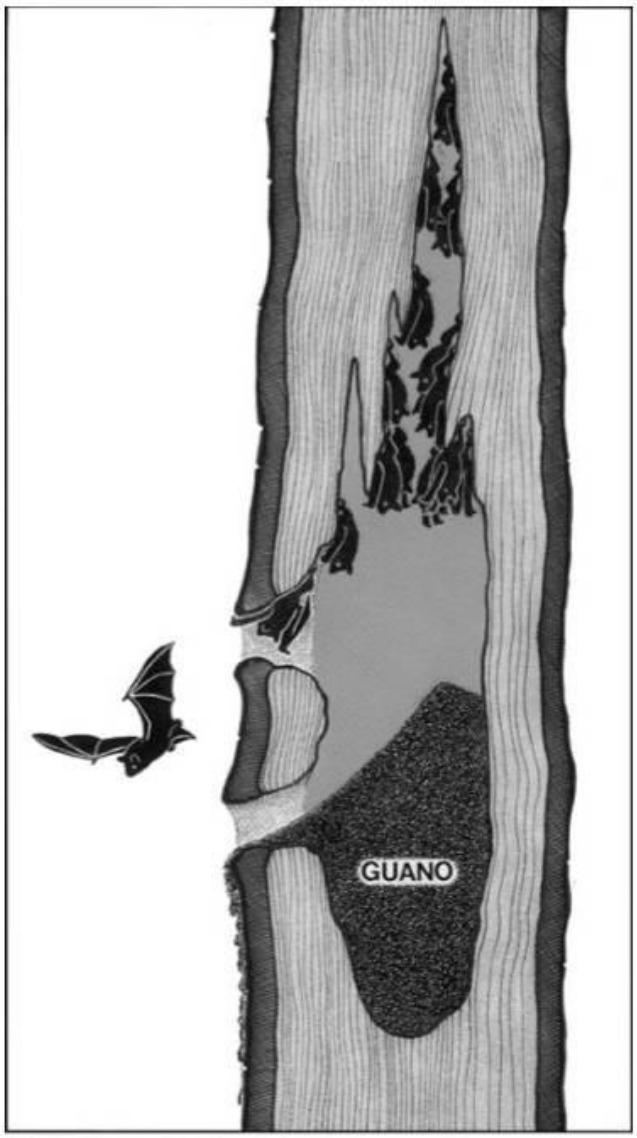

Fig. 12 : Coupe schématique longitudinale montrant la structure interne d'un gîte à double trou de pic.

Figure 12. Schematic longitudinal section showing the internal structure of a double woodpecker-hole roost.

Other data for roosts - Height:

The height of the roosts is measured (or estimated relative to the ladder used) from the highest point of access to the floor. In nine cases, the trees are located on a slope; the heights are then measured at the base of the tree. These range from 1.6 to 11 m (Fig. 13), for an average of 4.3 meters (all roosts), which is much lower than most of the heights of tree-roosts described elsewhere.

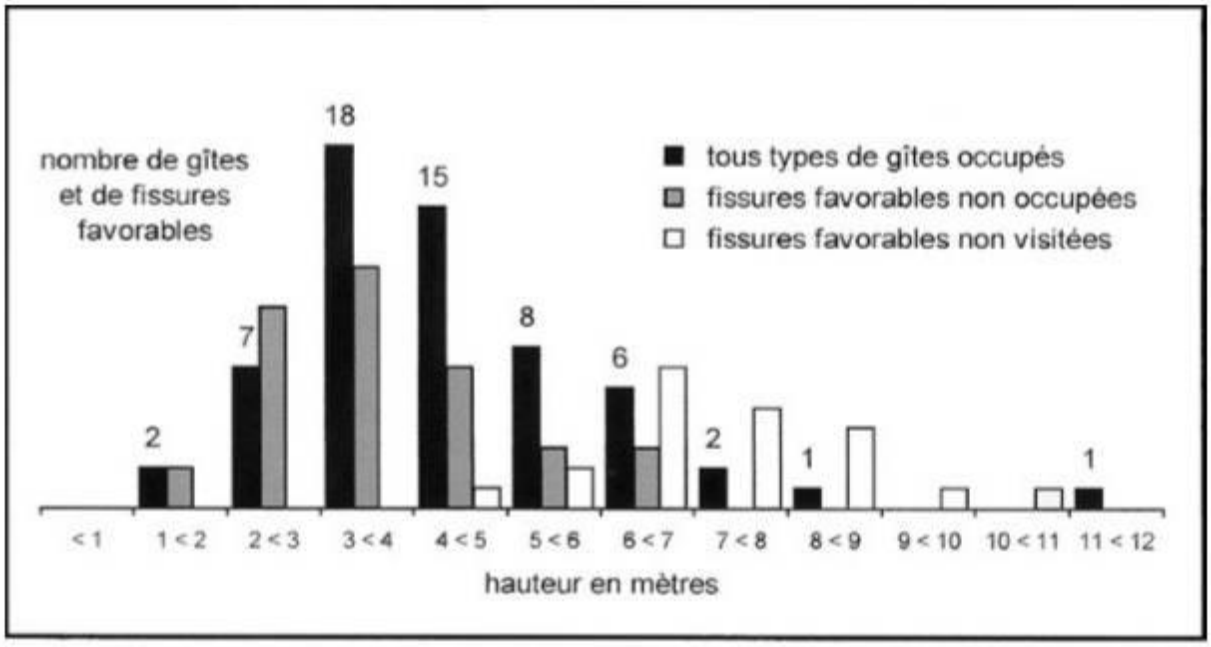

Fig. 13 : Hauteur des gîtes

Figure 13. Height of roosts.

There are two explanations for this relatively low value: first, the most representative forest stand of the study area is the coppice oak dominant where the soil (slate or granite) does not favour the development of large and regular stems even in older trees (Le Reste *pers. comm.*). The tall trees are therefore unusual. The second reason is due to the technical limitations of the method used. Indeed, one can see in Figure 13, that even if the high branches have not been explored, and the favourable cracks on stems that were not visited are significantly higher (mean of approximately 7.2 m.) than those that were, whether they are occupied by bats (average 4.4 m.) or not (average 3.6 m.).

There seems to be no particular preference for any particular height of roost from the five species of bats identified.

Tree diameter:

The occupied roosts-trees vary in size. The diameters of the trunks (or branches) measured at the roost height, range from 18 to 75 cm, with an average of 30.3 centimeters. Note that due to the slight bulge frequently observed in crack-type roosts, the measurements of the trunks may be overestimated compared to the rest of the tree.

Orientation of access:

In Figure 14, the number of orientations shown is greater than 60, because the openings are often double (multiple times), in particular for cracks. There is apparently no clear preference for the direction of access, contrary to what is usually reported in this case to the south or southeast. It must be said that most of the roosts previously described in the literature are in old woodpecker-holes, the average orientation of the holes rather decided by the behaviour of these birds. Assuming that the sample is representative, one can possibly consider here that besides a slight advantage for the south-east, two opposite orientations emerge more clearly, northwest and southeast. The dominant axis breaks (representing almost all roosts) could then be simply related to the direction (perpendicular) to the prevailing winds in the region (southwest).

Habitats:

54 of 60 tree-roosts are located in wooded areas of variable extent, hardwood dominant or mixes, but more often surrounded by a bocage. Many are in the slopes of the valleys nearby (Fig. 1). The remaining six are in the bocage near a wood (**56** and **59**), in an orchard not far from a river (**9**), at a river crossing between pasture (**17**) on an embankment along a path in the moors (**45**), the last in the same situation, but in the heart of moors and bogs, near a Lake (**46**).

Catching sessions using mist-nets and listening to ultrasound detectors show that softwood plantations can be used as hunting grounds by bats, because of the abundance of insects they harbour, but they have been hardly surveyed; perhaps wrongly, resin has been suggested to constitute an obstacle to the use of cavities.

The discoveries made outside woodland are in the minority, since it is in this environment that most surveys was conducted. This does not mean that the so-called ‘woodland bats’ are systematically targeting this habitat. This is illustrated elsewhere: their roosts can for example be found in manmade environments such as that of a Bechstein’s bat breeding colony occupying a cavity in a lime *Tilia* sp. in a village of Indre (Frontera & Roue S.Y., *pers. comm*., cited in Roue S.G. 1999).

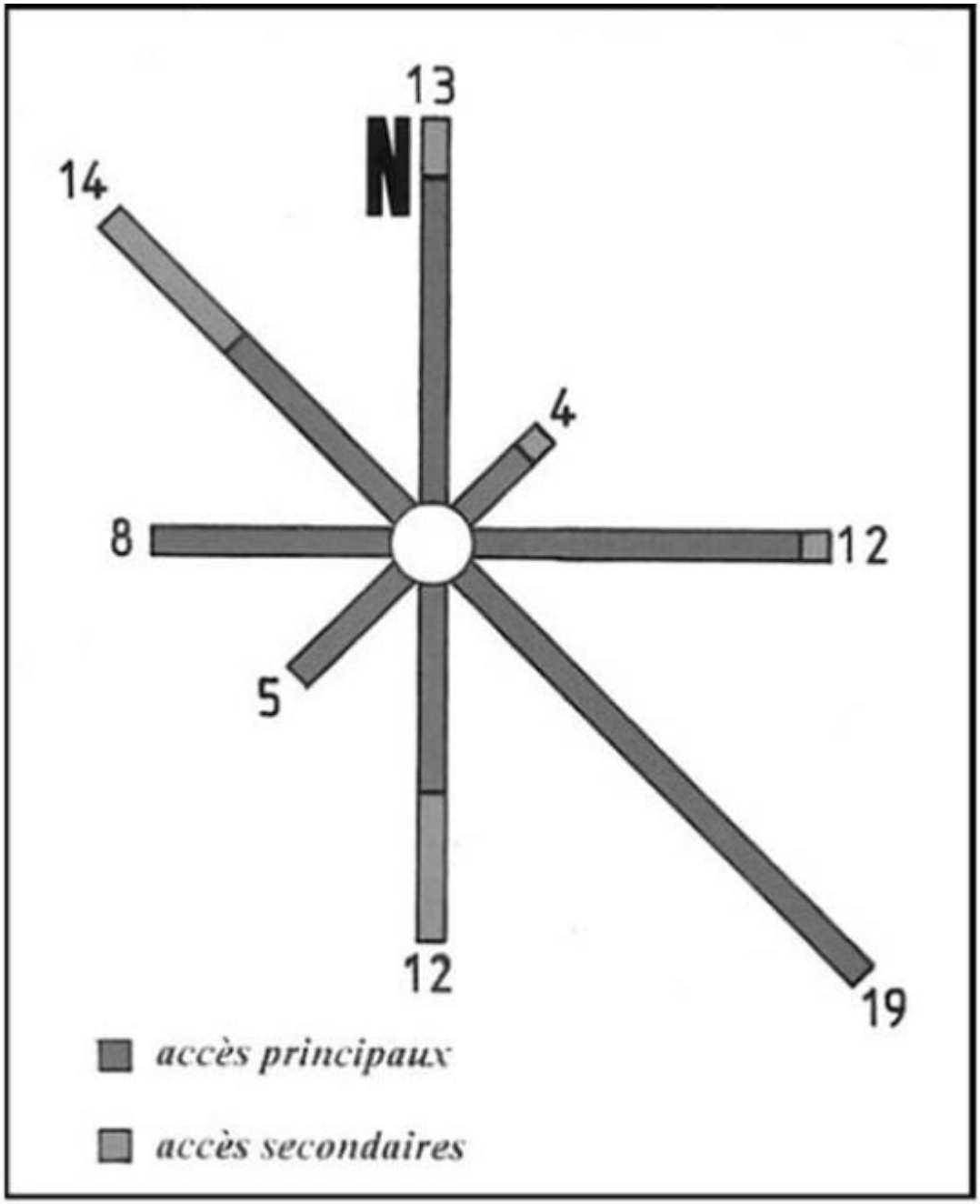

Fig. 14 : Orientations des accès, pour l'ensemble des gîtes

Figure 14. Orientation of access for all roosts.

Situation of roosts in the middle:

In the wooded area, only 13 out of the overall 54 roost-trees are located on the edge of land (road, river, and clearing edge) as is often described, at least for noctules (Gaisler *et.*

al 1979). Most are found within plots (41 cases), even in very dense undergrowth. But if long-eared bats, for example, can hunt with great agility in this environment (Barataud 1990), this suggests that bats are also actively seeking their roosts and therefore must have initially a precise knowledge of the type of roost they are looking for (at least the first time). In this case, narrow vertical cracks seem to be the most popular, at least for species described here. An anecdotal discovery illustrates this hypothesis: on 25th February 1999, a small crack was spotted in an oak, but a splinter prohibited access to any animal larger than the many woodlice present inside. The tree, located on an embankment along a path, is t about two hundred meters from the nearest wood. Just in case, the splinter was removed, and one Natterer's bat had colonised it by the 6th of May, barely more than two months later (**56**)!

Cracks associated with woodpecker-holes: (Fig. 15)

In a number of cases, woodpecker-holes are at the same height as the cracks in the bark ridge or on the side (**28**). Their dimensions (diameter of 4.5 cm, approximately) suggest that the great spotted woodpecker is the culprit, and their excavations has taken place following the cracking, if we judge by the appearance of their scarring (missing or later), or simply because we saw them appear after the discovery of the crack (29). The cracking is therefore not a consequence of embrittlement following their excavation.

The woodpeckers seem attracted to these portions of wood which are already hollow and probably softer to excavate. This subsequent addition to the cracks does not seem to be an obstacle to the occupation by bats, as the new hole is not usually located at the top of the scar (several observed cases), in which case the roost would not be protected from the weather, and so subsequently abandoned (**29**). Several cracks discovered with these conditions were therefore not considered favourable. In contrast, if the hole is not located at the top of the crack, it can also maintain or restore access for bats in a closed crack (**55**) and can also be a bonus for the naturalist, who enjoy a better view (**28** and **46**).

The question remains as to why great spotted woodpeckers attack these cracks (or even enlarge it, as shown in roost **29** - see Fig 15c.), where they do not dig to nest. If the cracked limbs provide them with sound boxes for their drumming, one wonders why the digging almost always reaches the interior. The search for food is certainly another motivation. Besides their attraction to insects and their larvae, the great spotted woodpecker is also known, on occasion, to have "*carnivorous tendencies*" and specialise in "*looting tits nests to eat eggs or young birds*" (Geroudet 1961). If the woodpeckers are interested in animals nesting in the bottom of these cracks – such as passerine birds (**34**), why would they not take those in the top (bats) too? However, although other birds are

listed as predators of bats (nocturnal and diurnal raptors, magpies *Pica pica*, starling *Sturnus vulgaris*, herring gull *Larus argentatus*) (Bekker & Mostert 1991), the great spotted woodpecker is not listed as such until now.

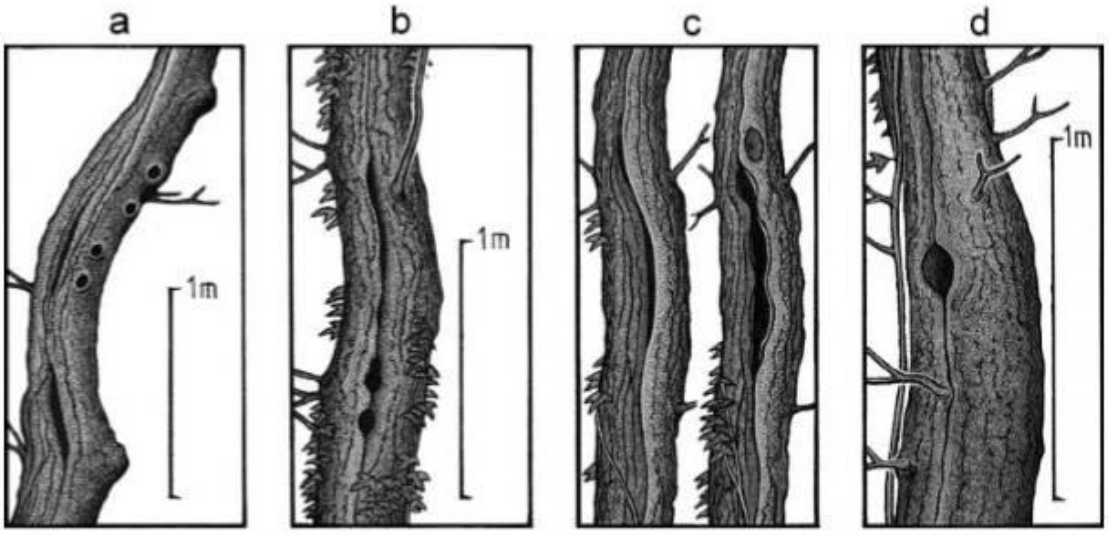

Fig. 15 : Gîtes situés dans des fissures de chênes, associés à des trous de pics :
a - gîte **28**
b - gîte **34**
c - gîte **29** (avant et après 1997)
d - gîte **55**.

Figure 15. Roosts in cracks on oaks associated with woodpeckers.

Ivy, branches and adjacent shrubs:

Most of the tree-roosts described herein are spared by ivy *Hedera helix*. At most they support a few leafy stems, which do not hide the roost entrance.

It is generally accepted that ivy is an obstacle to the flight and return of bats. However, during the felling of a large oak tree completely overgrown with ivy, several dozen bats flew from a hole in the trunk (La Reste *pers. comm.*); likewise, Farcy (*pers. comm.*) reports the case of serotines flying from an oak so covered in ivy that one cannot even describe the nature of their roost, about seven meters above. Furthermore, tight spaces sometimes present between large ivy stems and the tree trunk can provide roosting opportunities (Richardson 1985) and Cosson (*pers.comm.*) observed with near certainty a pipistrelle sp. flying from thick ivy covering the trunks of trees, in marshes of Vigueirat (Bouches-duRhône).

It is more logical to think that the development of ivy could instead be an additional protection after the discovery of the roost feature by bats without giving away their

whereabouts, but its presence is undoubtedly an obstacle to the subsequent discovery of the roost by naturalists.

In contrast, a dense network of branches or a thick bush (hawthorn, holly, blackthorn, wild pear) just in front of or against a cavity entry make normal flight and return impossible for bats.

Indicators of roost presence:

The blackish discharge (guano and urine) in a tree hole is commonly described as an indicator of the presence of bats. Certainly this is the case for large colonies, for example noctules, having no alternative evacuation.

In this study, the flows seen during surveys were not related to bats, but only due to seepage of a mixture of stagnant water and decaying wood in the trunks, especially beech, but also sometimes for oaks. Arthur (*pers. comm.*) made the same observation in the case of plane trees. This "*real fake index*" was also at the origin of numerous unsuccessful inspections of old woodpecker-holes at the beginning of the research. We even found that bats generally do not use this kind of cavity (wet and unhealthy) where the liquid stagnates flush with the bottom. However, cracks that are sufficiently tall internally can be occupied by bats and simultaneously have this flow at the bottom of the opening, but unrelated to the presence of the bats. In this case, we can assume it will not prevent the animals hiding in the top of the internal space.

In contrast, it was found that when the droppings filled the bottom of the roost (which is rarely the case, especially for cracks, which also extend downwards), they overflow just outside, and are not visible from the ground. Probably the overflow is dried quickly, or dispersed by wind and/or rain. Furthermore, in the absence of bats, the presence of guano in the bottom of the cavity is, in my opinion, the only valid indicator of present or past occupation by bats (one can easily estimate its freshness as the droppings are shiny or not), its absence does not necessarily mean the absence of bats. Thus, in a colony of twenty brown long-eared bats, visited several times in July 1997 (**2**), only some freshly fallen droppings were visible every time, on a clear background. Probably the guano fed daily some coprophagous invertebrate as this roost is very low (less than a meter from an adjacent bank) and slugs, caterpillars and woodlice were observed. Furthermore, spiders can entirely build their webs in the day, in an occupied roost, especially in winter, and only old thick sheets of webs, bleached, and dusty may lead to the conclusion of the absence of bats.

ELEMENTS OF THE ECOLOGY OF THE OBSERVED TREE BATS

Species present:

The five species found in the tree-roosts are:
1 – Brown long-eared bat *Plecotus auritus*
2 – Natterer's bat *Myotis nattereri*
3 – Daubenton's bat *Myotis daubentonii*
4 – Whiskered bat *Myotis mystacinus*
5 – Pipistrelle *Pipistrellus* sp.

Identification of brown long-eared bats (shown as **OR** in Table 2) was carried out formally only once during a session of net catches near roost **2**, by inspecting thumb, foot and dental measurements (C-M^3) according to the criteria defined by Menu & Popelard (1987). All other individuals appeared to be brown long-eared bats, except in two roosts, where an individual seemed darker than its neighbours (**18** and **58**). In Brittany, the distinction between the two species (brown and grey long-eared) seem possible in adult individuals, according to visual criteria : appearance of the face, shape of the tragus and coat colour. But since there is still doubt, they are marked "(brown) long eared bats" [O (R)].

In several other roosts, the determination of the observed bats could not be made accurately: incomplete view of the interior space (**3**, **15** and **28**), ground observation with binoculars and torch without any possible determination, given the height (**5** and **25**), guano alone (**34** and **49**), witness (**9** and **45**). In these cases, species are rated *Myotis* sp. (M sp.), Long eared bat sp. (O sp.), or bat sp. (CS sp.).

Furthermore, identification of the observed pipistrelles was not performed because it would need manipulation. Thus, they remain rated Pipistrelle sp. (P sp.) (**12**, **23**, **42** and **57**).

The barbastelle was not found. Although considered rare in the region, it is fairly evenly distributed, with several known breeding sites, including two near Morlaix. So it could be expected to discover in the trees, especially in winter.

The Bechstein's bat, despite being very associated with trees and woodland, was not found either (except, perhaps, in roost **28**), probably because of its rarity in the area, and because the two main forests in the study area were poorly investigated (it is observed and was captured in the forest Huelgoat). The absence of noctules is not surprising, since

the data concerning them are exceptional in Brittany, and distributed only in the east and south of the region.

Distribution of bat species by species of trees and types of deposits:

The content of Tables 3a and b shows that the different bat species recorded here generally choose the same shelters: the most popular tree is the oak, the dominant species in the region. It's also one that, because of its internal structure, can provide the bats the most suitable lodgings (see above). The narrow cracks are the most sought shelter in all species.

These preferences are clearly established for the brown long-eared bat and Natterer's bat represented here by significant samples. Daubenton's bat seems to use a little more diverse lodgings, but to state this with certainty would require more data.

Technical limits of the counts:

Except when it comes to counts of bats made during the twilight or night flight (**1**, **2**, **6**, **8**, **16**, **35** and **52**), the noted numbers represent only the bats that were visible inside the cavities. Most often, they are underestimated, if only because animals that hide in areas with often small size, so that only the lowest placed are clearly visible. The difference is also due to the limits of the method of observation (see materials and methods). Thus, for example, 21st April 1994, 5 brown long-eared are visible in roost No. **2** in the evening; but at night, 11 individuals exited, observed with a night-vision scope. In the same roost during the winter of 1994, the animals disappeared into the top of the crack when the weather was really cold, and approached the opening during periods of thaw.

On the other hand, we often noticed that active and awake individuals can back up into the top of a roost (especially in the case of cracks) to be no longer visible. Another example along the same direction: in May 1998, only 5 individuals were observed in roost No. 46, but the poor healing of the crack from the top let us hear the squeaks of many other bats that we could not see.

Finally, it is clear that the observations from the ground in the day only give partially effective results for the less accessible roosts. All these remarks imply that the reported counts are partially truncated and that their interpretation must take into account these approximations.

Tableau 3 : Nombre d'arbres-gîtes répertoriés...

a - ... selon les espèces qu'ils abritent et leur essence:

	Chêne	Hêtre	Châtaign.	Frêne	Pommier	Robinier	Pin mort
Oreillards	21	3	2	1	-	-	1
Murin de Natterer	17	1	1	-	-	-	-
Murin de Daubenton	8	3	-	-	-	-	-
Murin à moustaches	1	-	-	-	-	-	-
Murins sp.	3	-	-	-	-	-	-
Pipistrelles sp.	3	-	-	-	-	1	-
Chauves-souris sp.	3	-	-	-	1	-	-

b - ... selon les espèces qu'ils abritent et le type de gîte utilisé:

	Fissures étroites	Fentes larges	Trous de pics	Troncs creux	Echarde cassée	Insertion de branche
Oreillards	24	2	-	1	1	-
Murin de Natterer	18	1	-	-	-	-
Murin de Daubenton	7	1	2	-	-	1
Murin à moustaches	1	-	-	-	-	-
Murins sp.	3	-	-	-	-	-
Pipistrelles sp.	4	-	-	-	-	-
Chauves-souris sp.	3	-	-	1	-	-

c - ... selon les espèces qu'ils abritent et leurs effectifs maximaux observés:

	Effectifs maximaux observés													Nombre de gîtes par espèce
	1	2	3	4	5	7	8	10	11	13	15	20	26	
Oreillard roux, (roux) & sp.	15	1	1	1	3	2	2	1	1	-	-	1	-	28
Murin de Natterer	15	1	1	-	-	-	-	-	-	-	1	-	1	19
Murin de Daubenton	2	3	-	-	2	-	-	-	2	1	-	-	-	10
M. de Daubenton et M. à moustaches	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Murins sp.	3	-	-	-	-	-	-	-	-	-	-	-	-	3
Pipistrelles sp.	4	-	-	-	-	-	-	-	-	-	-	-	-	4
Chauves-souris sp.	1	1	-	-	-	-	-	-	-	-	-	-	-	2
TOUTES ESPECES	40	6	2	1	6	2	2	1	3	1	1	1	1	67

(N.B.: les 9 gîtes abritant 2 espèces de chauves-souris, non simultanément, sont comptabilisés séparément pour chaque espèce. De plus, dans a et b, la donnée de Murins à moustaches est notée à part. Les 2 gîtes où seul du guano a été trouvé, ne sont évidemment pas pris en compte en c. D'où des totaux ne correspondant pas aux 60 arbres-gîtes).

Results of the counts:

Despite these reservations, all counts (maximum numbers observed by roost) is presented in Table 3c.

Two species, the brown long-eared bat and Natterer's bat, occupy the majority of discovered roosts (respectively **25** [8] and **19**), which is an interesting first observation,

8 - The 3 long-eared bat *sp*. roosts are not taken into account.

given the relative scarcity of contact with these species in summer (net catches, trapping, observations, known colonies in the region) or in traditional hibernacula (underground cavities where the brown long-eared is documented very rarely). This suggests that these two species are relatively better represented in the region than previously thought. The majority of brown long-eared bat roosts held isolated individuals, but for some, the groups had relatively substantial numbers, including two breeding colonies (10 and 20 individuals observed). Almost all the Natterer's bats observed were isolated individuals except two roosts with 15 and 26 individuals (at least). Note that it was probably the same group observed at different times in two remote oaks of about 600 meters and reproducing only in one of them.

Conversely, the Daubenton's bat is frequently encountered in the summer, but is relatively less well represented in only 10 roosts. Now, if we refer to the Netherlands, where exhaustive surveys have been performed, almost all of the 189 roosts known for this species are in the trees, summer and winter (Limpens *et al*. 1997). It is probable that we did not explore sufficiently close to streams, ponds and wetlands (only four out of 10 roosts are located close to the water). For this reason, only two roosts are home to isolated individuals, but there were several small groups, including one male with 11 other bat animals.

A single tree roost held whiskered bats (at least two individuals), confirming the rarity of the species in the region. The pipistrelles (sp.) are represented only in four roosts, by individuals. The species has not been determined, but if it is common pipistrelle (which is likely, according to size), it is not surprising, considering the attachment of this species in the built environment, winter and summer.

Gender:

Except for the few females caught near roost **2** in 1994, no bats observed in the cavities were sexed, which adds an element of incompleteness to the results obtained, and approximation in their interpretation. One can only assume that the breeding groups make up only (or mainly) females.

Periods of occupation:

As noted above (see "Materials and Methods" and Fig. 4), the roosts were, overall, little followed with 50% of them only visited one or two times. In most of the rest, counts were made at different months in two or more years. There are counts over 12 months for two

roosts (**1** and **2**). In addition, it must be added here that the winter counts are even less reliable than those made from early April to late October, as during cold weather the bats retreat as deeply as possible into the cavities, and often become invisible to the primitive mirror and torch technique, particularly in the cracks.

Annual and actual cycle:

In Figure 16, despite prior comments, gathered monthly counts were made in all roosts. For those followed for several years, it is, for each month, the effective maximum observed which was retained (the "best" year). Changes in numbers observed during the year are shown for all the roosts, and for each species separately (the overall appearance histograms only reflects the fluctuations in the number of visits and discoveries in the year - Fig. 3).

It is noted from the outset that trees are used throughout the year, but with a difference between the spring/summer and autumn/winter seasons: from April to September, the largest groups are observed - in connection with reproduction, which does not exclude the existence of small groups and isolated individuals during this period. From October to March, there are only these last two categories. The roosts are also used by these species to hibernate, which poses the problem of winter felling work.

Some differences between the different species:

The brown long-eared bat, apart from maternity colonies, can remain in small groups throughout the year, including for hibernation. In summer, there are also probably all male groups. In contrast, Natterer's bats are observed to be in fairly large groups, before giving birth until well after weaning, or isolated, whether in summer or to hibernate.

For whiskered bats that were observed only once, for Daubenton's bats, but especially for pipistrelles sp., samples are obviously too weak to offer a valid interpretation. However, it should be noted that isolated Daubenton's bats have not often been observed (which does not necessarily appear on the corresponding histogram, which includes several roost data).

The pipistrelle sp. are absent from trees from June to September, probably in conjunction with reproduction in the built environment (whether common Pipistrelle or Kühl's pipistrelle *Pipistrellus kuhlii*) or departure to the north-east of Europe (for the less likely case of Nathusius' pipistrelle).

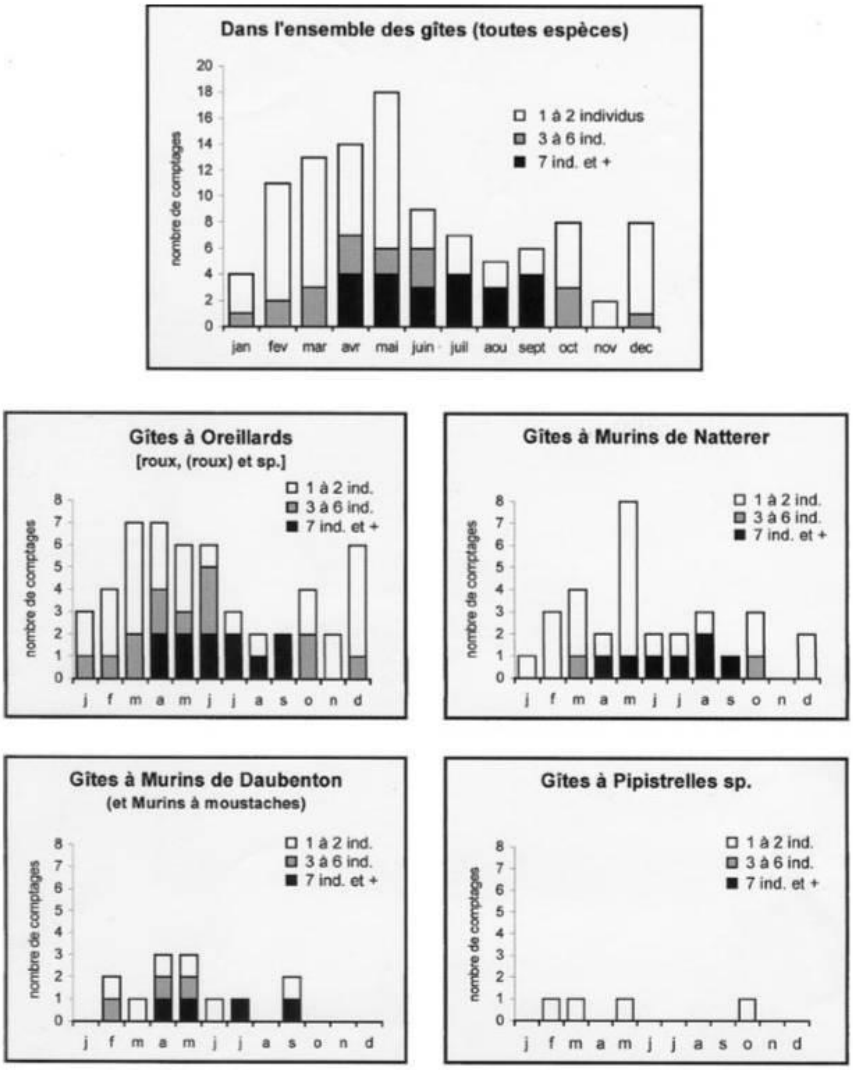

Fig. 16 : Répartition des comptages dans l'année : effectifs maximaux observés (pour les gîtes suivis, sont retenus ceux de la "meilleure" année).

Duration of occupations and movements:

It is generally accepted that bats change tree-roosts frequently. This is described for example for Daubenton's bat (Chapuisat *et al.* 1988; Helmer 1983) and Bechstein's bat (Schofield *et al.* 1997). Arthur (*pers. comm.)* noted that groups of noctules (mostly males) spend an average of 10 to 15 days in different cavities afforded by the plane trees of the "Green Gap" in Bourges.

Different behaviours depending on the season:

For hibernation, brown long-eared bats (in small groups or isolated) and Natterer's bats (isolated) spend all the winter season in the same roost. During this period, the former can be closer to the exit in mild weather and even go hunting (in February) when the temperature reaches 7 or 8°C at night, while returning to the same roost. This species is relatively insensitive to cold, and individuals were even repeatedly found in shallow cracks, a few inches from the outside in the snow. Conversely, the Natterer's bat absolutely will not move from November to March inclusive.

During the birth and weaning of young, maternity groups of brown long-eared (in June-July) and Natterer's bat (May-June) apparently do not change roost.

As for the non-breeding groups and isolated individuals, they regularly change roosts in summer. It is the same for all individuals (grouped or not) for the interim periods in the transitory roosts. The periods of occupation are so variable, ranging from a few days to three weeks or a month. Here they are difficult to measure precisely, but we observe that every year, the same roosts are used at the same time and by broadly constant numbers.

Thus, roost **2** is used mostly by brown long-eared, yet there are fifteen Natterer's bats which take over, every year in August. Roost **16** is occupied in April by 7-11 brown long-eared bats (in 1997, the year of its discovery, 1998 and 1999), then it is deserted but almost the same number is found in May in Roost **14**, which is distant by a few hundred meters. In roost **18**, although it is superficially very favourable, it took 11 visits to confirm its use by bats (eight brown long-eared in June 1998). In fact, the visits simply had not been made at the right time, since in June 1999 eight brown long-eared bats were again observed.

These examples, among others, show that in fact, it is as if the bat groups (for both species anyway) follow the same circuit each year; roost to roost (subject, of course, whether the same individuals). A similar behaviour is found in noctules, as close as weekly in the plane trees in Bourges city (Cher department, France) among others (Arthur, *pers. comm*). This need to regularly change roost requires having many favourable cavities in a relatively small area. This is probably why, as we have often found, it is in wooded areas that one has the best chance to discover occupied roosts.

Reproduction:

If adult individuals are difficult to see and count in the cavities, it is even truer for the

young of the year, especially when they are still small and lost in the mass of females (new-born and young several days could be observed only in one case). Moreover, especially in this situation, the duration of the inspection must be limited to the minimum. So we often supplemented visual counts by internal observations with evening emergence counts.

Reproduction has been proven with certainty in four roost-trees:

1 - Roost **1** (oak, cracks, discovered in May 1993, Fig. 5 and Fig 17b): This roost consists of two apparently distinct internal spaces and is used exclusively by Natterer's bats. Young were observed there in 1993, 1998 and 1999 (some reproduction). In 1996, breeding is likely: adults are present during the weaning period, which is not the case in 1997. In 1994 and 1995, the roost was not followed in time. The maximum number of bats simultaneously observed is 26 (17 adults and 9 young) beginning July 1999. Note that bats give birth in one of the spaces, while passerines (marsh tits in 1999, coal tits other years) raise their young in the other; but as soon as the chicks are gone, bats take over the former home of the birds. This suggests that the tits are winners in the choice of their shelter for nesting.

In the Natterer's bat, despite annual fluctuations, we see that the first births may be very early, compared to most other species. Newborn young were observed as early as June 1993, well-developed young in light grey coats, were present in 1999 at the same time. Emergence photographs at the roost could show that among the 17 individuals flying on the evening of July 1 of that year, there was one young (at least seven remaining inside with two adults); 6th July, in addition to 10 adults, there were six young. This fact had already been observed in late June 1988 in a small colony sheltering between the size of stones of an old mill in the region, in which there had been a young suckling, yet well developed and probably fit to fly. The early births in this species, is also observed by Arthur in the Cher department (*pers. comm.).*

2 - Roost **2** (oak, crack, discovered in May 1993, Fig. 2 and 7a): This roost, close to the previous one, for most of the year held (brown) long-eared bats, except in August, when it is occupied by Natterer's bats (most likely the group from roost 1) that take over each year. Reproduction is certain for 1997, when five or six already well developed young were observed in mid-July. The total numbers was observed to be 20 individuals. No reproduction was recorded in 1994 and 1996 and no visits were made to the roost in 1993 and 1995.

From early August 1997, and despite regular visits, no (brown) long-eared bats were observed in this roost for two years. This species hibernated in this roost each year, and

sometimes also used it as a transit shelter for small groups. It must be said that a small abandoned roost not far away, and where from 20 to 45 individuals of this species were observed (in a shed) every year in spring and autumn since 1990, has been renovated from the autumn of 1997. However, on 28th August 1999, two (brown) long-eared bats were again recorded.

3 - Roost **10** (beech, double woodpecker-hole, discovered in May 1992 Fig. 11a.): In this roost 11 Daubenton's bats were present in May 1992, monitoring was however not consistent. But in late July 1995, at least three adults and six well-developed young were observed there. One of them not yet able to fly. Reproduction is therefore certain, at least in that year.

4 - Roost **14** (oak, crack, discovered in May 1997, Fig. 17a.) In mid-July 1997 10 (brown) long-eared bats with two well-developed young were present. Reproduction is therefore certain. In 1998, an incomplete observation from the ground (this roost is high enough) allowed a count of at least 10 individuals in mid-June, but no young visible. That year, reproduction is only probable.

Note that the average diameter of these four roost trees is 45 cm, therefore greater than that of all the other roosts (30.3 cm).

In Roost **42** (oak, crack, discovered in June 1998, Fig. 17c), reproduction is not confirmed: one of five (brown) long-eared bats observed on 28th June 1998 showed the characters of a young of that year, although already well-developed. But the observation conditions were bad, and the date seemed early for this species. However, the large amount of guano observed by the opposite opening suggests that the number is much higher. Reproduction is a plausible hypothesis, but would need checking.

Coexistence between different species of bats:

Most roosts are single species, but the use of a single cavity with two species, at different times, is not uncommon (nine out of 60). However, the simultaneous coexistence of two species seems exceptional and was observed here only once: roost **46** (crack with woodpecker-holes in oak) housed in May 1998, at least five small *Myotis* comprising two whiskered bats, one Daubenton's bat and two other small *Myotis* not determined.

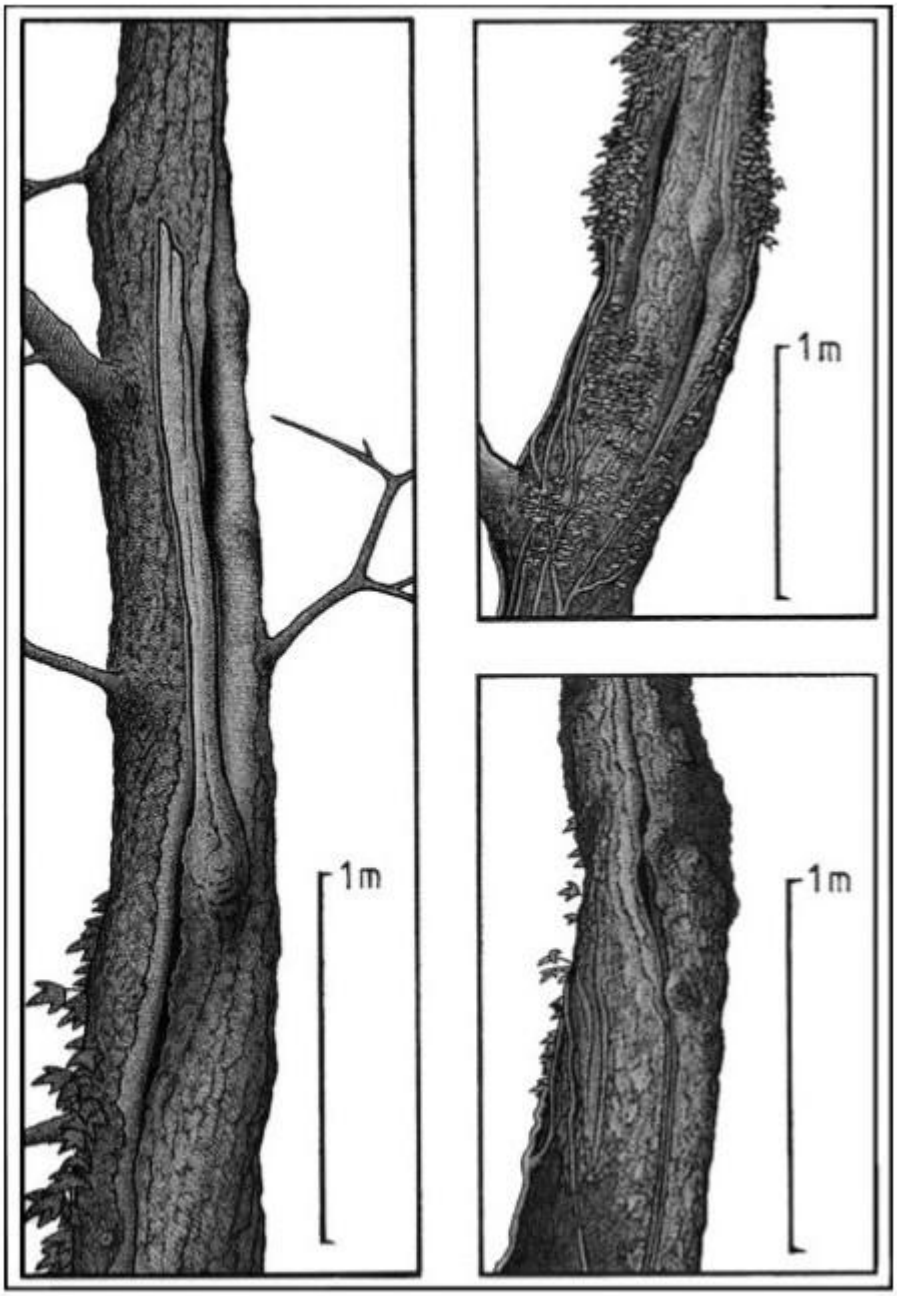

Fig. 17 : Gîtes de reproduction dans des fissures de chênes :
a - gîte **14**
b - gîte **1** (côté sud-est)
c - gîte **42**. Dans ce dernier gîte, la reproduction n'est pas certaine (voir texte)
[voir aussi Fig. 2 et 7a (chêne) ; et 11a (hêtre)]

Figure 17. Maternity roosts in cracks on oaks:

a) Roost 14;
b) Roost 1;
c) Roost 42.

In France, to my knowledge there have only been two cases of simultaneous coexistence of different species of bats tree in the same roost. One of Leisler's bats and a *Pipistrellus* sp. and another of Leisler's, common pipistrelle and Kuhl's pipistrelle, hibernating in two oaks in the Forest of Tronçais (Allier) (Giosa, *pers. comm.*). Mayle (1990) identifies two mentions of similar cases: between *Nyctalus* sp. and Daubenton's bats, it is reported by Smith in Great Britain (1985) and Gaisler *et al.* (1979) cite noctules and Daubenton's bats, and Leisler's bats in the same tree-roost. Another case of cohabitation between noctules and Daubenton's bats is described in Switzerland by Chapuisat & Ruedi (1993).

Use of roosts by other animals and cohabitation:

During inspections in the cavities, all kinds of animals were found: among the invertebrates include first pill bugs, but also slugs, spiders, beetles less often, Lepidoptera (adults and larvae) and rarely wasps or bees. Birds are present in their nests in the spring, but they are also observed in later visits, which surprised them in their night roosts: blue tits, coal *Periparus ater* and marsh tits *Poecile palustris*, nuthatch, starling, great spotted woodpecker and green woodpecker *Pica viridis*. Several times wood-mice *Apodemus sylvaticus* were found, and a dormouse *Muscardinus avellanarius* was found in two consecutive years in the same cavity.

The simultaneous use of cavities seems possible that with some species: if they are few in number, woodlice and slugs can coexist with the bats. Cohabitation with tits is often observed in the cracks. When features are sufficiently lengthened, it is not uncommon to see bats take the apex, and tits the base. In some cases, it was observed that separate internal spaces also allow this cohabitation (e.g. roost **1**, see Fig. 5 and 17b.).

In contrast, other animals encountered in cavities make it quite impossible: starlings can take possession of a roost, and even kill noctules (Richardson 1985) or serotine in the built environment (Arthur *pers. comm.*). Bees are also capable of killing noctules (Kiefer 1996).

Here wood-mice were discovered in several cracks not occupied by bats, but in also in two roost trees, in the absence of the bats. The use of a cavity by this "rodent" is absolutely incompatible with the tranquillity of bats, because it is well placed with the cat and the owl as a predator of bats (Bekker & Mostert 1991). This is probably the most dangerous for bat species found in this study because it is a skilled climber, and can easily squeeze through the narrow cracks.

PROTECTIVE MEASURES

In principle, bats, and all mammals protected by law, should also benefit from the preservation of their habitats (roosts and territories). When an accurate description of tree-roosts used by bats is known, it becomes possible to protect the trees themselves. This does not make the installation of artificial roost-boxes unnecessary, but both methods have limitations, the first likely to be incomplete, the second selective.

In the forest of Coat an Noz - Coat an Hay, in the Côtes d'Armor, several old silver-lead mines protected by grilles are home to eight bat species ("Arrêté de biotope" in project). In total and to date, 11 species have been recorded in this forest of 800 hectares, of which six are considered arboreal. The National Forestry Office (O. N. F.) has an environmental management plan with hardwoods (mostly oak, beech and chestnut) in "irregular stands with mixture of species". Based on the results of this study, all healthy trees thought to have the potential to be favourable for bats are systematically inventoried, mapped, marked (blue triangles) and preserved. The inventory and monitoring are carried out in partnership with the Breton Mammalogic Group (G. M. B.).

A framework convention G.M.B. - O.N.F. aimed, among others, to generalize the process of protection at regional level, was signed on 9th June 1998.

Meanwhile, other actions are currently being developed in the region, as two surveys carried out by "Bretagne Vivante"- SEPNB, to preserve the 'bat-friendly' trees: in forest of Rennes (Ille-et-Vilaine), in conjunction with the O.N.F. guards and as part of the *Natura 2000* program (Choquené *pers. comm.*); in Forest Lann ar Warem near Lannion (Côtes d'Armor) (Guerin *pers. comm.*). In this latter case, it is a property of the Conservatoire du littoral, managed by the O.N.F. and neighbouring municipalities. The integration of this type of protection is also planned, regionally, in other protective programs.

Elsewhere in France, similar actions are taking place (the list of examples below is not exhaustive, and for anyone I have missed please forgive me):

An agreement between the Conservatoire du Patrimoine Naturel of Champagne-Ardenne and the O.N.F. allows the maintenance of hollow trees and glades (Roue S.G. 1999).

At Rambouillet, the O.N.F. has sets up a protocol of study and protection of forest bats and their roosts on the forest and the "presidential" field (Tillon 1999).

In the forest of Haguenau (Alsace), over 800 hectares, the same process is underway at

the request of the O.N.C. As part of a "LIFE" project, the Study and Protection Group of mammals in Alsace must make an inventory of bats present in the Vosges mountains, in order, in particular, to provide safeguards for roost-trees (*Sané pers. comm.*).

In the P.A.C.A. region, Bats Provence Group inventories (current and planned) are conducted in different sites: in the forest of Mont Ventoux, in the context of *Natura 2000*; in the Massif de la Sainte Baume (state and communal forest), in partnership with Natural areas of Provence; in the Luberon, in conjunction with the Regional Natural Park; in the area of Vigueirat, south of the plain of the Crau, with the Conservatoire du Littoral (Cosson *pers. comm.*).

The protection of bat-friendly trees may also be considered in other situations: acquisitions, biotope protection prefectural, nature reserves and, in the eastern Pyrenees, all the trees of the forest of Massane (nature reserve) are protected, including the tree-roosts (Roue S.G. 1999 Roue S.Y. *pers. comm.*). These types of programs are certainly expected to multiply in the coming years. It would be desirable that they also be extended to private forests. In addition to protecting tree-roosts, they should also include a range of measures for pro-bat ecological forest management, recommended in several research reports, such as those of Piantanida (1994) Schwaab (1996) and Issartel (1999).

Finally, at national level, a convention is being developed[9] between the French Society for the Study and Protection of Mammals (SFEPM) and the O.N.F., aimed, inter alia, to safeguard the roosts of bats in trees and hunting grounds in national forests.

It is impossible to address the protection of roosts without mentioning the exceptional storms of 26th and 27th December 1999. It is estimated that in general 4% of French forests have been destroyed, or about 300 million trees (O.N.F. data). If the consequences on the Breton forests were relatively less important than elsewhere - despite equivalent wind speeds, it is probably in part to the fact that two-thirds of the area (west of a line Vannes - Saint Malo) have already suffered the same scale event in 1987, in which only the most resistant trees survived. In many other areas, the damage is immense - forests completely destroyed in some areas.

Mortality of tree and forest bats - little studied so far – is certainly considerable, although difficult to assess. During the fall of a tree-roost, we know that all the bats hiding inside do not necessarily die – although the risk is higher during hibernation. Nevertheless, countless tree-roosts had to be destroyed in the storms: in Charente maritime, for example, Jourde has found intact only four of 20 Leisler's bat roost-trees identified

9 - To date (June 2000).

earlier in hollow chestnuts (Jourde *pers. comm.).* These recent events make it more obvious that there is an urgent need to preserve, among the trees saved, not only those that have all kinds of favourable bat-friendly cavities, but also the trees that were cracked, split or twisted during these storms, which will provide bats lodgings after a few years of healing.

Furthermore, it was found that the native species stands, irregular forests and coppice, fared better than the old regular high forests and monoculture plantations of conifers. It is hoped that these lessons induce a more ecological reforestation policy on a large scale, such as irregular stands with species mix, also most favourable to biodiversity in forests.

CONCLUSION

The research method used in this study (systematic exploration of favourable cavities bats) demonstrated its effectiveness, to describe the characteristics of 60 roost-trees, used primarily by three bat species of an overall five identified. The narrow cracks, formed mainly in the wind and the subsequent healing of trunks or branches (mostly oak) are the most popular roosts for these species, at least in the area: the bats are present in at least 58% of these cracks, at one time or another during the year.

The results presented in this study suggest that other types of cavities are less attractive to bats, at least in the region. However, it should be considered that various features that originate in nature can accommodate tree bats. Old woodpecker-holes, for example, account for most of the described roost identified so far, especially for noctules and Leisler's bats, the serotine and the Daubenton's bat.

It is important to remember here, especially if one takes a view of the protective measures to be implemented, where all more or less favourable to bats cavities should be taken into account.

However, the high profitability of systematically searching for narrow cracks should encourage the bat surveyor to search and visit these particular features.

In other regions of France *"a priori"* less regularly subjected to high winds, we already knew - before the recent storms – of similar cracks greater or lesser in height[10], according to the type of afforestation and nature soil. It is certain that if the trees split during these storms are preserved, they will become much roost-trees in a few years.

10 - Which we probably should sometimes raise ladders to inspect, or climb the trees.

In this study, parts of trees (high branches) and environments (riparian, conifer stands etc.) have been little prospected, if at all. In addition, the basic material used has not always allowed full inspection of cavities. The results of the findings presented here are necessarily incomplete, in terms of number of species and numbers of individuals. The underrepresentation of Daubenton's bat is the most obvious example. It should therefore complete this systematic research by extending to these other sectors with better equipment.

Regarding other species observed, the relative frequency of (brown) long-eared bat and Natterer's bat roosts, previously little contacted using conventional survey methods (catches, surveys in buildings and underground cavities), demonstrates the method is effective for these two species.

In addition, it is clear that the tree-roosts may be occupied throughout the year, for maternity or transit, but also in winter. Winter felling, performed indiscriminately, may therefore not just entail the disappearance of roosts but also very often that of the bats themselves.

Finally, it was in order to protect the habitats of tree bats that this study was conducted. The results presented help to improve knowledge of the different types of features that may be their roosts. As it is already the case occasionally, these data should be used in a variety of programs for inventory and preservation of trees needed for the survival of bat colonies present.

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EXECUTIVE SUMMARY

From 1992 to 1999, prospecting in woodlands in the northwest of Brittany has allowed the discovery of 60 natural roosts for tree-dwelling bats. Various kinds of occupied hollows have been found inside trees, but those created by the partial healing of narrow cracks, mainly resulting of storm and/or frost (especially in oaks), appear so particularly sought out by bats, that systematic inspection inside this kind of hollows (with ladders, a light and small mirrors), quickly turned out to be a really "productive" method, as to the discovery of bats : (with) at least 58% of the suitable narrow crevices are used by bats (results needing an average of 2.2 visits per crevice). Five bat species have been recorded: brown long-eared bat *Plecotus auritus*; Natterer's bat *Myotis nattereri*; Daubenton's bat *Myotis daubentonii*; whiskered bat *Myotis mystacinus*; and pipistrelle *Pipistrellus* sp. The tree roosts can be occupied all through the year, reproduction and hibernation included. Besides, it has been noticed that tree-dwelling bats often move around, from one roosting site to another, probably following a similar pattern every year. The observed numbers (bats inside trees, or flying off) go from 1 up to 26 individuals, and several nursery roosts were recorded. Some protective measures for suitable trees are now being taken in a few National Forests.

BIBLIOGRAPHY (not limited)

Barataud M. 1990. Eléments sur le comportement alimentaire des Oreillards brun et gris Plecotus auritus (Linnaeus, 1758) et *Plecotus austriacus* (Fischer, 1829). *Le Rhinolophe* 7: 3-10

Barataud M, N. Chamarat N & Malafosse J 1997. Les chauves-souris en Limousin, biologie et répartition: bilan de 12 années d'étude. Coll. Découverte de la Nature en Limousin. F.L.E.P.N.A. et G.M.L., Limoges, 54 pp

Bekker J & Mostert K 1991. Predation on bats in the Netherlands; facts and assumptions. *Myotis* 29: 91-96

Chapuisat M, Delacretaz P, Reymond A, Ruedi M & Zuchuat O 1988. Biologie du Murin de Daubenton (*Myotis daubentonii*) en période de reproduction. *Le Rhinolophe* 5: 10-11

Chapuisat M & Ruedi M 1993. Les chauves-souris dans le canton de Vaud: statut et évolution des populations. *Le Rhinolophe* 10: 1-38

Gaisler J, Hanak V & Dungel J. 1979. A contribution to the population ecology of *Nyctalus noctula* (Mammalia: Chiroptera). *Acta Sc. Nat. Brno* 13 (1): 1-38

Geroudet P 1961: Les Passereaux et ordres apparentés. I: du coucou aux corvidés. Delachaux & Niestlé, Neuchatel, 238 pp

Günther E & Hellmann M 1998. Die Höhlen des Buntspechtes (Picoïdes major) von Fledermäusen nicht gefragt? *Nyctalus (N.F.)* 6 (5): 468-470.

Helmer W 1983. Tree-dwelling Daubenton's bat (*Myotis Daubentonii*) near Nijmegen. *Lutra* 26: 1-11

Issartel G 1999. Propositions de mesures pour une gestion sylvicole favorable aux chauves-souris forestières. D.I.R.E.N. Rhône-Alpes – C.O.R.A. Rapport d'étude. 9 pp

Kiefer A 1996. Grosse Abendsegler (*Nyctalus noctula*, Schreber 1774) durch Bienen (*Apis mellifera*) getötet. *Fauna Flora Rheinland-Pfalz* 21: 174.

Limpens H 1993. Bat-detectors in a detailed bat survey: a method. **In:** Kapteyn K (Ed.): Proceedings of the first European Bat Detector Workshop. Netherlands Bat Research Foundation, Amsterdam: 79-90

Limpens H, Mostert K & Bongers W 1997. Atlas van de Nederlandse vleermuizen. K. N. N. V. Uitgeverij, Utrecht, 260 pp

Lustrat P 1991. Compte-rendu du 1er séminaire européen de travail au bat detect, Gorssel (Hollande), 1-5 juillet 1991. **In:** Actes des 4èmes Rencontres nationales chauves-souris, 1991: 5457

Lustrat P 1997 Hivernage de la Noctule commune (*Nyctalus noctula*) en Seine et Marne. *Arvicola* 9 (2): 6

Lustrat P 1998. Les chauves-souris de la Forêt de Fontainebleau. *La Faune Sauvage, Bull. Assoc. des Amis de la Forêt de Fontainebleau* 1: 26-28

Mayle B 1990. A biological basis for bat conservation in British woodlands - a review. *Mammal Rev.* 20 (4): 159-195

Menu H & Popelard J 1987. Utilisation des caractères dentaires pour la détermination des Vespertilioninés de l'ouest européen. *Le Rhinolophe* 4: 1-88

Nicolas N 1988. Les chauves-souris de Bretagne. *Penn ar Bed* 125: 53-72

Nicolas N & Penicaud P 1993. Les chauves-souris en Bretagne: premier bilan. *Penn ar Bed* 150: 3844.

Noblet J 1987. Les chauves-souris. Atlas visuel Payot, Lausanne, 62 pp

Noblet J 1983. La Pipistrelle de Nathusius (*Pipistrellus nathusii*) dans les Alpes françaises. **In:** Actes du 7ème colloque francophone de mammalogie, Grenoble, 1983: 137-141

Penicaud P 1996. Protéger les chauves-souris en milieu naturel ou bâti. Groupe Mammalogique Breton, Sizun, 33 pp

Penicaud P 1999 (à paraître). Chauves-souris arboricoles en Bretagne: prospections, protection des gîtes. **In:** Actes du 22ème colloque francophone de mammalogie, Vannes, 1998

Penicaud P 2000 (à paraître). Les fissures étroites, des gîtes attractifs pour les chauves-souris arboricoles: résultats de 7 années de prospection en Bretagne. **In:** Actes des 8èmes Rencontres nationales chauvessouris S.F.E.P.M., Bourges, 1999

Piantanida A 1994. Gestion sylvicole pour la protection des chiroptères. Ministère de l'Environnement – Direction générale de l'O.N.F. Rapport d'étude. 56 pp

Pottier T 1992. Première colonie de reproduction de Noctule de Leisler (*Nyctalus leisleri*) en Seine Maritime (IGN 19-11), description et inventaire du site. *Le Petit Lérot* 41: 10-14

Richardson P 1985. Bats. Whittet Books, London, 128 pp

Roue S 1999. Etat des connaissances. In: C.P.E.P.E.S.C. Franche-Comté & S.F.E.P.M.: Plan de restauration des chiroptères. 34 pp

Schober W & Grimmberger W 1991. Guide des chauves-souris d'Europe: biologie, identification, protection. Delachaux & Niestlé, Neuchatel, 225 pp

Schofield H, Greenaway F & Morris C 1997. Preliminary studies on Bechstein's bat. *The Vincent Wildlife Trust*, Review of 1996: 71-74

Schwaab F 1996. Etude des populations de chiroptères de la forêt de Romersberg. Parc nat. reg. de Lorraine. Rapport d'étude. 91 pp

Smith B 1985. Co-habitation of two bat species in a single tree roost. *Newsletter of the Yorkshire Mammal Group* 5: 12-13

Tillon L 1999. Méthodologie d'étude des chauves-souris sur le massif forestier et le domaine présidentiel de Rambouillet. Première version. O.N.F., Division de Rambouillet. 10 pp

Van der Wijden B, Verkem S, Lust N & Verhagen R 2000 (à paraître). Importance du type de cavité et de la structure forestière pour la sélection de gîtes par les chauves-souris arboricoles. *In:* Actes des 8èmes Rencontres nationales chauvessouris S.F.E.P.M., Bourges, 1999

Wissing H 1996. Winterquartiere des Grossen Abendseglers (*Nyctalus noctula* Schreber, 1774) in der Pfalz (BDR, Rheinland-Pfalz). *Fauna Flora Rheinland-Pfalz* 21: 111-118