

## SPECIAL ISSUE – BATS

**Bat Rabies, Public Health and European Bat Conservation**P. A. Racey<sup>1</sup>, A. M. Hutson<sup>2</sup> and P. H. C. Lina<sup>3</sup><sup>1</sup> Centre for Conservation and Ecology, University of Exeter in Cornwall, Tremough, UK<sup>2</sup> Plumpton Green, East Sussex, UK<sup>3</sup> Netherlands Centre for Biodiversity 'Naturalis', Leiden, The Netherlands**Impacts**

- In the last 35 years, there have been only five cases of human rabies of bat origin in the 590 million people of greater Europe.
- Active and passive surveillance for European bat lyssaviruses (EBLVs), which cause rabies, involves virologists, public health officials, professional and amateur bat workers, who have cooperated for the protection of the public and the conservation of bats, with little polarization of views.
- European bat lyssaviruses are found in only a few of Europe's 52 bat species.

**Keywords:**

Bats; Europe; lyssaviruses; conservation; public health; zoonoses

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**Summary**

Most records of European bat lyssaviruses (EBLVs) are confined to three species – the serotine bat for EBLV1 (900 records) and Daubenton's bat and the pond bat for EBLV2 (25 records). High levels of seroprevalence, which may vary from year to year, are also recorded. All bat vectors of EBLVs are zoonotic, some exclusively so. Despite this, there have been only five cases of human rabies resulting from EBLV infection in the 590 million people of greater Europe during the last 35 years. These have triggered major programmes of surveillance in many European countries. The emphasis on active versus passive surveillance and the intensity with which they have been carried out has varied from country to country. Both involve cooperation between bat researchers, virologists and public health officials and the latter, in particular, engages amateur bat workers and members of the public. Bat NGOs throughout Europe have worked to persuade the public not to handle bats or to do so only with gloved hands and, in the case of bat workers, to receive pre-exposure immunization. They have also countered negative media coverage of bat rabies. Householders with bat roosts in their dwellings have in general been persuaded to retain their bats. Attempts have been made to persuade all European countries to establish comparable EBLV surveillance programmes. In the last 25 years, virologists, public health officials, bat biologists and conservationists, both amateur and professional have worked closely and collaboratively for the protection of the public and the conservation of bats, with little polarization of views.

**Introduction**

European bat lyssaviruses (EBLVs) are the only zoonotic viruses detected in bats in Europe. European bat lyssavirus 1 (EBLV1) has been recorded over 900 times, and

95% of those records are from the serotine bat, *Eptesicus serotinus* and its recently separated sibling species *Eptesicus isabellinus* from south-east Spain and North Africa. It often occurs at high levels of incidence in these species. It is also recorded from the greater mouse-eared bat, *Myotis*

*myotis*, and several other species around Europe. European bat lyssavirus 2 (EBLV2) has been found about 25 times in two bat species in Europe – Daubenton's bat, *M. daubentonii*, and the closely related pond bat, *M. dasycneme*. The distribution of these bat species is shown in Figs 1–4, and this reflects the potential distribution of their lyssaviruses. Although these maps were produced in 2005 in consultation with a wide range of European specialists, it should be noted that the distribution of *E. serotinus* in Fig. 3 includes *E. isabellinus*. They can be compared, however, with the known distribution of EBLV 1 and EBLV2 in the study described by Freuling et al. [this volume]. All four bat species make extensive use of artificial structures for roosting, that is, synanthropic. Serotines are the most synanthropic and roost in roof spaces, cavity walls and other parts of houses during summer and winter (Dietz et al., 2009). Greater mouse-eared bats roost in large roof spaces during summer in northern Europe (Dietz et al., 2009). Daubenton's bats roost mainly in tree holes close to rivers and other water bodies (Racey, 1998) but may also form maternity colonies in the roof spaces or cellars of buildings (Dietz et al., 2009). The pond bat is more synanthropic than Daubenton's and often roosts in churches and in the cavity walls of houses. Both species forage over rivers or other water bodies (Dietz et al., 2009). Both EBLVs have been identified in several other European bat species but none is thought to be a major vector. There is, however, increasing evidence that EBLVs are less pathogenic than other lyssaviruses in animals except man. Bats appear to develop lyssavirus infection that persist such that some wild-caught bats have antibodies to EBLV for up to 3 years and viral RNA has been detected in the saliva of apparently healthy bats (Serra-Cobo et al., 2002; Amengual et al., 2007; Vázquez-Morón et al., 2008).

Despite the potential for contact with bats, there have been only five reported cases of human rabies resulting from EBLV infection over the last 35 years among the 590 million people of greater Europe. This review examines the role of the research, conservation and public health communities in the evaluation and minimization of risk to the public from EBLV1 and EBLV2 and in mitigating the negative consequences for bats from the adverse publicity arising from their association with these viruses.

## History

The first recorded human case of bat rabies occurred in Hamburg in 1954 and was followed by a 30-year period with only twelve recorded cases (Hutson, 2004; King et al., 2004), until September 1985, when a Danish schoolteacher's attention was drawn to a grounded bat in



**Fig. 1.** The European distribution of Daubenton's bat, *Myotis daubentonii*. The closed circle denotes a single occurrence.



**Fig. 2.** The European distribution of the pond bat *Myotis dasycneme*. Closed circles denote single occurrences.

the playground (Grauballe et al., 1987). It bit her and she had the presence of mind to retain the bat, a serotine, which tested positive for EBLV1. The teacher was vaccinated. The previous month, an international bat conference was held in Aberdeen, Scotland and attended by a Swiss bat researcher. Six weeks later, he died from an unknown rabies-related virus, later identified as EBLV2



**Fig. 3.** The European distribution of the serotine bat, *Eptesicus serotinus*.



**Fig. 4.** The European distribution of the greater mouse-eared bat, *Myotis myotis*. The closed circle denotes a single occurrence.

(Lumio et al., 1986). He had been bitten by bats in Malaysia (4.5 years previously), Switzerland (1 year previously) and Finland, where he lived (51 days previously). These events triggered a programme of surveillance for EBLV 1 and EBLV2 in several European countries (Racey and Fooks, 2005).

During this time, driven by the 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats, legislation to protect bats was being enacted in

many of the European countries that had none (Stebbings, 1988). This increased the interest in bat conservation among amateur naturalists and resulted in the establishment of bat conservation NGOs and a general increase in public awareness about the conservation needs of bats (Racey, in press). So it was no longer acceptable to kill bats for disease surveillance, and in any event, the required information could be obtained by the analysis of blood and saliva samples from live bats and the brains of those found dead.

### Response of Individual European Countries

The examples of passive surveillance detailed later could not have taken place without extensive cooperation between virologists, public health officials, amateur and professional bat workers and members of the public. This has also involved active engagement by staff of bat conservation NGOs, which have access to the required networks. Although active surveillance can be undertaken by professional bat researchers working with virologists, it has often involved engagement with amateur bat workers.

#### Belgium

Small scale passive and active bat rabies surveillance has been carried out in Belgium (Van Gucht and le Roux, 2008). During 2004–2006, the brain tissue of 85 bats, 77% of which were the common pipistrelle *Pipistrellus pipistrellus*, was tested for rabies and all were negative. The other bat species involved were not recorded. In the 15 years before 2005, about 30 brains were tested and none was rabies-positive (Klein et al., 2007). In 2005, bats belonging to five *Myotis* species and one long-eared bat, *Plecotus* spp, were captured from six caves in Thierache and Haute Ardenne. Analysis of 24 serum samples from 40 of these bats revealed high titres of antibodies to EBLV1 in one of eight greater mouse-eared bats and one of eight long-eared bats and lower titres in one additional greater mouse-eared bat and in two Natterer's bats, *M. nattereri*. No neutralizing antibodies to EBLV2 were found (Klein et al., 2007). All those in close contact with bats are recommended to have pre-exposure immunization and revaccination when the annual anti-rabies titre test shows an antibody level lower than 5 IU (Van Gucht and le Roux, 2008). In 2010, a Belgian national was bitten by a serotine bat in Northern Spain. He had been immunized against rabies some years previously and received two boosters with classical rabies vaccine after being bitten and did not develop the disease. The case emphasizes the need for preventative rabies vaccination in those who come into contact with bats and the importance of post-exposure treatment (Van Gucht et al., in press).

### Czech Republic

In 2005, four children bitten by a common pipistrelle (*Pipistrellus pipistrellus*) infected with EBLV1, and two more, who had been in contact with the bat, were treated in Southern Moravia. This was the first confirmed case of bat rabies since 2002 and the fourth since 1994 (Helešić et al., 2007).

### Denmark

Following the 1985 incident involving the schoolteacher, and to counter the resulting negative media coverage about bats acting as vectors of rabies, a programme of public education was established, coordinated by Dr Hans Baagøe of The Natural History Museum in Copenhagen, working closely with veterinarians and public health officials. Householders whose dwellings harboured bats were successfully encouraged to retain their bats and to vaccinate their dogs and cats (Zoffmann et al., 1987; Baagøe, 1998). The public were warned not to handle bats or disturb bat colonies but to alert veterinarians about sick, dead or suspect bats. Only such bats with clinical signs of rabies were sent for virological examination (Grauballe et al., 1987). Between September 1985 and December 1987, a total of 1 057 bats of 13 species were analysed for rabies. Of 663 serotine bats, 160 were rabies-positive, whereas among the remaining species tested, only two Daubenton's bat and a single pond bat were positive (Grauballe et al., 1987; Baagøe, 2001a,b).

### Finland

The death of a bat worker from rabies in Helsinki in 1985, later confirmed to be EBLV2, resulted in an epidemiological study in 1986 which failed to find rabies in bats in Finland (Hagner et al., 1989). Despite subsequent rabies surveillance, the next recorded case, and the northernmost in Europe, was confirmed in Daubenton's bat in 2009. The isolates in both these cases were phylogenetically closely related (Jakava-Viljanen et al., 2010).

### France

Passive surveillance began in France in 1989 when the first positive case was found. From 1989 to 2004, 21 cases of EBLV1 were diagnosed, all in serotine bats, from 934 cadavers tested (Moutou et al., 2003; Picard-Meyer et al., 2006). Monthly overviews of bats tested throughout France and the number of positives are reported by AFSSA (Agence Française de Sécurité Sanitaire des Aliments) in the quarterly Bulletin Épidémiologique Mensuel de la Rage en France. A programme of active surveillance from

2004 to 2009 found neutralizing antibodies to rabies in six of the 17 species tested at the AFSSA Nancy Laboratory for Rabies and Wildlife, and in 19 of 177 individuals, mainly serotine and the greater mouse-eared bats, *Myotis myotis*. Neither infectious viral particles nor viral genomes were detected (Picard-Meyer et al., 2011). Members of the Société Française pour l'Étude et la Protection des Mammifères (SFPEM), who assisted in this programme, were required to be vaccinated to obtain a handling permit and their antibody titres were checked annually. This has encouraged more bat workers to request vaccinations. To wear gloves is not compulsory, however, even for bat workers who accept vaccinations (except National Park agents). Householders with bat colonies and members of the public are advised not to handle bats but to wear thick gloves should it become necessary to do so. The vaccination of cats in households with bats is sometimes recommended, because spillover of EBLV1 to cats occurred in 2003 and 2007 (Dacheux et al., 2009). So far as other wildlife is concerned, Cliquet et al. (2009) showed experimentally that the chances of spillover of EBLV from bats to foxes, *Vulpes vulpes*, is low, with a greater probability for EBLV1 than for EBLV2, but that foxes seem to be able to clear the virus before it reaches the brain and causes a lethal infection.

### Germany

In Germany, passive surveillance began in 1985. Among the 793 bats submitted between 1985 and 2005, 176 (22%) were EBLV1-positive (Müller and Freuling, 2006). Although the bat species concerned were not mentioned, in a later study, Müller et al. (2007) clarify that 50% of 187 rabies-positive bats were serotines, and the other 50% were not identified. Single Daubenton's bat and Nathusius' pipistrelle, *P. nathusii*, were also reported to be rabies-positive by Jüdes (1987) for the Federal German Republic. More recently, from 1998 to 2010, passive surveillance of more than 3000 bats from most of the German federal states revealed that 1.2% were rabies-positive (Freuling et al., 2011c). However, here, it also has to be assumed that the majority of the positive animals were serotines. Furthermore, EBLV2 was described in Daubenton's bat from the city of Magdeburg.

In 2010, a virus was isolated from a Natterer's bat found in November 2009 in the village of Bokeloh in Lower Saxony. It differed from other lyssaviruses and was named Bokeloh bat lyssavirus (BBLV) and may represent a newly discovered member of the lyssavirus genus (Freuling et al., 2011a,b).

Bat workers are recommended to have pre-exposure vaccination. To obtain more information on the epidemiology and pathogenesis of bat rabies, intensive cooperation

between bat workers, veterinary and public health authorities is also recommended (e.g. Müller and Freuling, 2006).

### Italy

As a part of a national rabies surveillance plan, 33 individuals of a dozen bat species were collected in the Aosta Valley, Piedmont and Liguria between 1994 and 1997. All were rabies-negative (Debernardi et al., 1999). In a second survey in Central Italy during 1996 and 1997, ten caves with many colonies of different bat species along with four woodland sites and two urban sites were monitored for dead or dying bats. A total of 43 specimens of 11 species were tested and all were rabies-negative (Frati et al., 1999). Nevertheless, Italian bat workers, who handle bats, are strongly recommended to wear at least light gloves and to have pre-exposure immunization (Russo, 2006).

### The Netherlands

A surveillance programme began in the Netherlands in 1984, when it became mandatory to submit bats which had direct bodily contact with humans or had been caught by domestic animals (cats and dogs), or were unable to fly, to the Central Laboratory for Animal Disease Control (now the Central Veterinary Institute) for virological testing. A total of 1 219 serotine bats had been tested by 2005, and 21% were positive for EBLV1. Five of 129 pond bats were positive for EBLV2, while none of 111 Daubenton's bats were positive (Van der Poel et al., 2005). More recently, Takumi et al. (2008) analysed the frequency of contact incidents of serotine bats with humans and with domestic cats and dogs. Of 17 serotines in bite contact with humans over a 6-year period, five tested positive for EBLV1. There were 49 recorded instances of contact between cats and serotines but only six of the bats were EBLV1-positive. There were only three recorded instances of contact between dogs and serotine bats, none of which tested positive. Mathematical modelling suggested that the incidence of bat rabies in humans in the Netherlands might be between one case a year and one every 700 years depending mainly on the number of infectious viral particles in bat saliva (Takumi et al., 2008). The identity of all bats tested for rabies in the Netherlands was verified by one of us (PHCL). All bat handlers are strongly recommended to have pre-exposure vaccinations (Bekker, 1987; Van Brederode, 1994). To wear gloves is not compulsory but is strongly recommended. Cats and dogs which are observed with a bat, or are suspected to have been in direct contact with bats, are vaccinated. Despite clear national guidelines for pre- and post-exposure vaccinations and for rabies antibody titre testing in bat workers, different opinions are often

expressed by Public Health Authorities and family doctors about these procedures. Clarification of these guidelines in relation to bat handlers is in preparation and will be widely welcomed throughout Europe.

### Poland

Rabies in a bat was first recorded in Poland in 1972 (Komorowski et al., 1974), and only four cases had been reported by 1998 (Smreczak et al., 2009a). Since then widespread passive surveillance has resulted in a significant increase in the number of bats sent for rabies testing to regional laboratories (Smreczak et al., 2009a). Reports of bat rabies range from four in 1999 to 14 in 2001 and 10 in 2004 (Sadkowska-Todys et al., 2005). In total, the number of cases confirmed by laboratory diagnosis had risen to 69 by the end of 2008 (Smreczak et al., 2009a). Most records are from the serotine bat, with a tendency to cluster across the north and north-east of the country. Nevertheless, the level of bat rabies in Poland should be kept in perspective. In 2008, for example, a total 23 448 samples from different animals were examined for the presence of the rabies antibodies. Twenty-nine rabies cases were diagnosed: five (17.2%) in domestic animals (three cattle, one dog and one cat), 21 (72.4%) in wildlife (19 foxes and two raccoon dogs), and only three (10.3%) were in bats (Smreczak et al., 2009b).

### Spain

From 1992 to 2000, over 1 000 blood samples and over 90 brains were obtained from 14 bat species in 37 localities in Spain. Antibodies to EBLV1 were detected in the greater mouse-eared bat, Schreiber's bent-winged bat, *Miniopterus schreibersii*, the European free-tailed bat, *Tadarida teniotis* and the greater horseshoe bat, *Rhinolophus ferrumequinum* in Aragon and the Balearic islands. At least one of these species, Schreiber's bent-winged bat, is migratory. In one colony, 60% seroprevalence was recorded initially, followed by a gradual decline. Most bat colonies were found in caves frequently visited by speleologists, tourists and bat enthusiasts. Following the virological investigation, grills were installed at entrances to restrict access by humans and allow bats free passage (Serra-Cobo et al., 2002).

In southern Spain, the serotine bat was reclassified in 2006 as *Eptesicus isabellinus*, a species previously recognized only from North Africa (Ibáñez et al., 2006). During 1998–2003, EBLV1 viral RNA was detected in 2.8% of 1 226 oropharyngeal swabs from 33 bats of eight colonies, and antibodies to EBLV1 were found in 9.3% of 549 plasma samples from 13 colonies (Vázquez-Morón et al., 2008).

The Spanish Ministry of Health, in collaboration with the Spanish Bat Conservation Society, has published advice for householders with bats and guidelines for bat workers and conservationists, emphasizing the need for anti-rabies vaccination for those at risk and for the use of gloves when handling bats. This advice is also available on the website of the Spanish Bat Conservation Society.

### Switzerland

Switzerland's National Bat Action included disease surveillance as one of its priorities (Moeschler, 1991). Only three of 837 brains taken from bats submitted to the Swiss Rabies Centre between 1976 and 2009 were found to be positive for EBLV. All three were from Daubenton's bats. Active surveillance revealed that one of 237 individuals (again a Daubenton's bat) had RNA corresponding to EBLV2 in oropharyngeal swabs. Three Daubenton's bats were also seropositive (Megali et al., 2010).

The discovery of a rabid bat is the subject of a press release, prepared jointly by the Swiss Coordination Centre for Study and Protection of bats, the Swiss Rabies Centre in Bern, the medical authorities of the canton concerned and the Swiss Coordination Centre for the Study and Protection of Bats which also maintains a Helpline for the public (with an automated back-up).

### UK

Since passive surveillance began in the UK in 1987, 11 500 bats found dead sick or badly injured by members of the public, amateur and professional bat workers have been sent by post to the Veterinary Laboratories Agency (now the Animal Health and Veterinary Laboratories Agency) for screening for antibodies using the fluorescent antibody virus neutralization and other tests. Ten were positive, all Daubenton's bats (Harris et al., 2006a,b; Horton et al., 2009). A prominent cause of death of these bats was cat bites (Harris et al., 2006b). From the outset, the identity of these bats was checked by one of us (AMH).

Rabies surveillance was also recommended by the UK National Bat Action Plan (Hutson, 1993), and during this time, the Bat Conservation Trust (BCT) did much to raise awareness about bats and rabies and the importance of vaccination and of treating all bats warily and with gloved hands. It also developed a contingency plan for when an EBLV-positive bat was identified in the UK.

Most of the ten bats recorded as positive for EBLV2 were behaving uncharacteristically in the care of rehabilitators. However, many other bats showing suspicious symptoms proved negative and several of the bats that proved positive had not been regarded as suspicious,

including one that had been in a freezer for a year. Of the ten positives, the first was found in 1996 in Newhaven, a port on the south coast *ca.*100 km from France. The area around this coastal port was generally unsuitable for Daubenton's bat, which had not been previously recorded in the area. Only one individual was recorded in a survey of all open water bodies within 8 km of the Newhaven location. This gave rise to the suggestion that the EBLV-positive bat may have had a wind-assisted passage from France or had been a passenger on a boat (Whitby et al., 1996, 2000).

Six years later, in 2002, a juvenile bat found in Lancashire, where it had been hand raised from infancy, proved positive. So island Britain, rabies free for 100 years, was no longer so. With the knowledge that the virus was established in the UK, the BCT, with 5 000 members, went to great lengths to advise all those handling bats to have pre-exposure vaccines and to ensure that such vaccines were widely and freely available. Not everybody heeded that advice, including an amateur bat worker who had been contracted in 2002 by the statutory conservation agency in Scotland, Scottish Natural Heritage, to survey bats in hibernacula. He found a Daubenton's bat in a culvert, which bit him and he died 21 weeks later of EBLV2 (Johnson et al., 2003; Nathwani et al., 2003). Scottish government ministers called for a cull of bats but were dissuaded by informed scientists and conservation managers and persuaded instead to invest in surveying blood samples and oropharyngeal swabs from live individuals of targeted bat species, mainly Daubenton's bats. The public and bat conservation community have been informed of the results, in advance of formal publication, by means of annual press releases. These revealed that seroprevalence of antibodies to EBLV2 in the 240 Daubenton's bats from which blood samples and oral swabs were taken each year decreased from 15% in 2005 to 2.5% in 2009. Significantly, no virus was isolated and only one of the *ca.* 1 000 oropharyngeal swabs collected over 5 years contained viral RNA which suggests that the Scottish bat worker who died of rabies in 2002 had been extremely unfortunate.

A similar project in England (2003–2006) targeted serotine and Daubenton's bats. Of the 273 serotine individuals tested, EBLV1-specific antibodies were found in a single bat. A mean prevalence of antibodies to EBLV2 of 2.2% was recorded in 363 Daubenton's bats (Harris et al., 2009).

In the UK, the relevant veterinary and public health departments hold regular liaison meetings to discuss new developments, practice and policy. The BCT informs members about risk and how to minimize it (e.g. Anon, 2003). Scottish Natural Heritage also contracted BCT to produce advice to bat workers, which, in an expanded

form, is now available on the BCT website as *Good Practice Guidelines on Bats and Rabies and advice to give to the public*. All parties share a common interest in keeping the general public aware of developments and general precautions, but remain ready to put any alarmist publicity into perspective (Racey and Fooks, 2005). The finding of another positive Daubenton's bat no longer arouses media interest and neither do the results of targeted surveys, although they have been disseminated by means of press releases.

The UK and the Netherlands have maintained a long-term approach to passive surveillance for EBLVs in their bats, with contrasting results. Thus, four of 112 Daubenton's bats tested in the UK between 1987 and 2004 were positive for EBLV2, while in the Netherlands, none of 111 individuals of the same species were positive (Van der Poel et al., 2005; Harris et al., 2006a,b). In contrast, none of 82 serotine bats tested in England was positive compared with over 20% of 1 200 tested in the Netherlands. The fact that serotine bats accounted for *ca.* 1.2% of UK submissions reflects the fact that it is much less common than in the Netherlands where it accounted for 25–30% of submissions. In the UK, Daubenton's bats are widespread and relatively abundant, while serotine bats are restricted to the south, although there is increasing evidence of major declines in the south-east, long regarded as the UK stronghold of this species.

### Ukraine

In the last 50 years, Ukrainian public health authorities have dealt with three human rabies fatalities, two of which were related to bat bites, in 1977 and 2002 (Botvinkin et al., 2005; Selnikova et al., 2006). The third case is reported in 1985 in an 11-year-old girl bitten by a bat during the day in her home in the Russian town of Belgorod. During a subsequent journey, the girl showed clinical symptoms and was admitted to hospital in Ukraine where she died from rabies (Botvinkin et al., 2005). These cases are regularly quoted but without information about the conservation status of bats and their vulnerability, which provokes a negative attitude towards them. Until now in Ukraine, no systematic bat rabies surveillance has been carried out and the current system of data collection does not provide a clear picture.

In view of this, the Ukrainian Centre for Bat Conservation initiated a project to improve bat conservation by circulating information through public health authorities about bats and the need for their protection and the development of collaboration between them and bat workers, both at the level of ministries and of individual specialists and to discuss a new strategy and implementation of modern methods of bat rabies surveillance. A

2-day workshop 'Bats and man: conservation and epidemiological aspects', was also held in Kiev in May 2009, with 44 participants (bat workers, biologists, physicians, veterinarians and virologists) from 22 cities of Ukraine. Those attending adopted a resolution about improving bat conservation practice and bat rabies surveillance. A brochure was issued subsequently with information about bat lyssaviruses, recommendations about retaining colonies in buildings, the outcome of the workshop and the EUROBATS guidelines for passive and active bat rabies surveillance (Godlevska et al., 2010.)

The workshop and production of the brochure were financially supported by the Ministère de l'Écologie, de l'Énergie, du Développement Durable et de l'Aménagement du Territoire (MEEDDAT), France; the Department for Environment, Food and Rural Affairs (DEFRA) UK, and the EUROBATS Secretariat, in the framework of the EUROBATS Projects Initiative (EPI).

### EUROBATS and the Kiev Conference

It is clear from the foregoing that surveillance programmes have varied in intensity and methodology in those European countries in which they have been undertaken. In an attempt to encourage a Europe-wide programme of surveillance, and further collaboration between the public health and bat conservation communities, EUROBATS organized a European bat rabies workshop in Vilnius in 2004. This was the first multidisciplinary meeting of veterinarians, public health officials, bat conservations and government representatives. See [http://www.eurobats.org/documents/Bat\\_Rabies\\_Workshop.htm](http://www.eurobats.org/documents/Bat_Rabies_Workshop.htm).

The workshop resulted in a series of recommendations and contributed towards a Resolution on Bats and Rabies in Europe which was adopted at the 5th Session of the Meeting of the Parties to the EUROBATS Agreement in Ljubljana in September 2006 (EUROBATS Resolution 5.2). Parties and range states were urged to establish national rabies surveillance programmes in collaboration with bat specialists, involving bats that had died or been killed for welfare reasons and/or by obtaining blood and saliva samples from live bats. The identities of submitted bats should be confirmed by competent authorities. The resolution also supported education efforts with respect to risks to human health and recommended that rabies vaccination should be compulsory or at least highly recommended for all those regularly handling bats. It also supported the retention of bat colonies in buildings where rabies-positive bats had been recorded.

The Vilnius meeting also stimulated the establishment of an EU-funded Med-Vet-Net programme which developed guidance on aspects of bats and rabies identified at the Vilnius meeting.

An international conference on rabies in Europe was held in Kiev, Ukraine, in 2005 (Dodet et al., 2006) and included a major session on bats that reviewed information on the current state of knowledge, with examples of EBLV surveillance and public protection being undertaken across Europe. Among the recommendations were those relating to bat rabies which recognized the importance of international cooperation, research and survey and recognizing the conservation status of bats.

In 2006, there were still many bat workers in Europe, professional as well as amateur, who handle bats from time to time and who had not received rabies vaccination, who did not consider the risk of exposure to bat rabies to be a high enough to be of significant concern, or who could not afford to be vaccinated (Dodet et al., 2006; Lina and Hutson, 2006).

Failure to heed recommendations to be vaccinated (as in the case of a Scottish bat worker who died), can have huge consequences, not only for the victim of the bite, but also for bat conservation. In the case mentioned, the contracting agency, Scottish Natural Heritage was served with two 'improvement notices' by the Health and Safety Executive. Vaccination is now compulsory for all those employed to work on bats in the UK, including students. It is further compulsory for all those licensed to handle bats, including volunteers, and for bat rehabilitators, with vaccine either provided *gratis* by the Department of Health or by the employer where one is identified. Elsewhere, in some European countries, to make vaccination compulsory for volunteers is more difficult but every effort should be made to do so and to discourage those who refuse from handling bats.

In a further attempt to improve and harmonize rabies surveillance, monitoring and reporting, Cliquet et al. (2010) reaffirmed that a national surveillance network should be established in all European countries and that bats found sick, showing clinical signs of rabies and/or abnormal behaviour, dead bats of all indigenous species, as well as bats involved in contact incidents, such as biting or scratching and bats caught by pets, should be tested for lyssavirus. This clearly involves extensive engagement between bat biologists, virologists, public health officials and members of the public.

### The Limits of Cooperation with Bat Conservationists

Although bat conservationists have cooperated fully in surveillance programmes, there are limits to what can be asked of them. That became apparent in 2006 when veterinary scientists, supported by the UK government department responsible, proposed to investigate the

mechanism by which rabies was transmitted among bat populations, by means of inoculation experiments on live Daubenton's bats caught in the UK and shipped to secure containment facilities in Germany. Daubenton's bat is one of the few European species for which there is evidence of a population increase (Kokurewicz, 1995; Haysom et al., 2010). Although the BCT maintained a neutral stance on this issue, the proposal resulted in widespread dissent and schism among members, some of whom felt that BCT should have vigorously opposed the experiment. Nevertheless, the investigation went ahead and important discoveries were made – that fatalities were inevitable only after intracerebral virus inoculation and not by buccal, subdermal and subcutaneous routes (Johnson et al., 2008), demonstrating that the virus has lower pathogenicity for bats and other animals (but not for humans) than the classical rabies virus (Müller et al., 2011). In a separate experiment, Johnson et al. (2006) found that some mice challenged by direct intranasal inoculation of EBLV2 developed rabies. Although aerosol challenge was ineffective, the possibility of aerosol transmission remains.

### The Media

Bats have always suffered from a poor media image which conservationists have worked hard to reverse but are not helped by their role as vectors of rabies. However, media coverage about bats and rabies (such as occurred after the initial UK isolation in Newhaven and later the human death in Scotland), while often negative and poorly informed, has a short half-life. Such coverage invariably results in an increased volume of calls to BCT's telephone Helpline, where well-briefed staff are able to allay the public's fears. Similar facilities exist in other European countries, such as Switzerland. The fact that in the last 25 years, virologists, public health officials, bat biologists and conservationists have worked closely and collaboratively for the protection of the public and the conservation of bats, with little polarization of views, has done much to diffuse media attention.

### Effects of Lyssaviruses on Bat Health

The interest in bat lyssaviruses is driven mainly by concerns for their effects on humans, and in South and Central America, on livestock. Their effects on bat populations themselves have seldom been documented. Several thousand Mexican free-tailed bats, *Tadarida brasiliensis*, died in Carlsbad Caverns, New Mexico in August 1955 and 1956, and the fact that half of the 20 bats sampled were rabies-positive, gave rise to the hypothesis that rabies was the overall cause of mortality. However,



inclement weather during migration was linked to deaths the following year (Constantine, 1970; Messenger et al., 2003). The only other mass mortality attributed to rabies was several hundred Dobson's fruit bat *Epomops dobsoni* in Southern Africa (Natal), 10–15% of which were confirmed to be infected with Lagos bat virus (serotype 2) (Brass, 1994).

The low recorded instance of mortality among European bats reflects the view, which continues to gain credibility, that lyssaviruses often result in an asymptomatic infection (Amengual et al., 2007; Vázquez-Morón et al., 2008). Nevertheless, there must be some fitness cost associated with such a disease.

## Conclusions

Great variability in the seroprevalence of antibodies to EBLVs is recorded among European countries and this may to some extent reflect variation in the intensity of rabies surveillance. Efforts to encourage surveillance in those countries without active programmes and to standardize the associated methodology, as detailed by Cliquet et al. (2010) should continue. All countries should ensure that all bat species tested for rabies are identified by a competent authority. The recent discovery of a new bat lyssavirus in Germany underlines the need for continued surveillance, and Freuling et al. (2009) have reviewed how much remains to be learned about bat rabies. Guidelines on pre- and post-exposure vaccination schedules, the need for titre testing and protective titre levels in particular should be reviewed and widely publicized. The fact that presently available vaccines do not protect against some newly identified lyssaviruses such as West Caucasian Bat Virus (Fooks, 2004) remains a matter of serious concern.

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