Bath Urban Surveys: Dusk Bat Surveys for horseshoe bats around south-western Bath. Assessments Summer 2008 & Spring 2009

Final Report

prepared

by

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for

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REMIT

Bath & NE Somerset Council is required by Government through the Regional Spatial Strategy to identify (a) location(s) somewhere to the south-west of Bath to build an urban extension to the city providing some 1,500 to 2,000 dwellings. The development has the potential to adversely affect the SAC in this region. The SAC designation was initially made to safeguard Greater horseshoe bats, but Lesser horseshoe bats were added later.

In June 2008 Bat Pro Ltd. was commissioned by Bath and North East Somerset Council to:

- Review the historical data for horseshoe bats in the Bath and Bradford on Avon SAC, and especially the areas of south-west Bath where the development may be located.

- Carry out monthly dusk surveys for bats within six locations to the south and west of Bath. The surveys were to be primarily for horseshoe bats, but would also identify other species.

- Write a report of the survey findings and assess the importance of each location to horseshoe bat populations

- Recommend key steps that should be taken to safeguard and promote the long-term security of horseshoe bat populations in and around Bath

Surveys were to be designed to re-assess the use made by horseshoe bats of certain foraging areas identified by the Billington radio-tracking study carried out in the summer of 2000. In addition the recent surveys were to identify the presence of other bat species (vesper bats) that were foraging at the various sampling stations. Surveys were to be monthly from June to September in 2008. Following the recommendations made in the 2008 Report, two further monthly surveys were conducted in April and May 2009 to complete a whole 'summer' foraging cycle.

These surveys were required to inform the planning authority of the current importance of various locations to the horseshoe bats that roost in the Combe Down Mines. Their roosts form part of the Bath and Bradford on Avon SAC. This designation was initially made because of the presence of significant populations of greater and lesser horseshoe bats. Both of these bat species are listed as endangered. Horseshoe bat foraging areas close to a SAC enjoy a high level of protection from activities that may harm their use.

Greater horseshoe bats are known to forage along tall hedgerows and woodland edge over long grass from May to July/August, and cattle or sheep-grazed pastures for a significant part of the remaining summer months, and again in April. Lesser horseshoe foraging behaviour is less well known, but is thought to be quite similar. Although detecting horseshoe bats and quantifying their use of different locations was a priority, it was also important to assess locations for foraging use by vespertilionid bats, since they are also protected species.

An interim report was required in early August, and a final report of the 2008 surveys was required at the end of the surveys. A final report of all surveys was required in June 2009.

Karen Renshaw, Council Ecologist, provided current maps of the site and arranged site access permission.

HISTORICAL REVIEW OF HORSESHOE BAT POPULATIONS

POPULATIONS WITHIN THE WHOLE SAC

The Bath and Bradford on Avon SAC contains a number of disused oolitic limestone mines that are used as hibernacula. At least two also contain maternity roosts through the summer. The mines are located in, or near Bradford on Avon, Box, Winsley, Lympley Stoke, Mells, Bathampton and Combe Down. There are six maternity colonies of Greater horseshoe bats at Bradford on Avon, Box, Iford, Mells, Byfield and Camerton. Summer roosts are either in large old buildings or underground sites, and colonies vary in size from about 20 to over 300 adults. Altogether a total adult population of about 1,200 Greater horseshoe bats is currently present in the SAC, or about 19% of the UK total.

The quality and proximity of their foraging habitats are probably the main factors influencing specific maternity colony size in a region. The Iford and Mells colonies have grown strongly during the improved climatic conditions since 1987; the Combe Down colony failed to recover until after the CDSM Project works started in 2000, and the Camerton colony has remained as a minor population for the past two decades.

Little is known about Lesser horseshoe maternity sites, but a significant maternity colony was discovered roosting in the disused office block at Mount Pleasant Quarry in 2005. Subsequently some of these bats started to breed underground after the Grey Gables incubator chamber was available to bats.

DATA

The longest winter population data set consists of hibernation counts of both horseshoe bat species at Combe Down, carried out annually in January by Roger Ransome and his team. Counts and captures of GH bats for his ecological research project started in 1961 at Byfield Mine, and continue at present at six Combe Down Mines. In 1961, over 120 Greater horseshoe bats were hibernating in Byfield Mine alone. By 2000, the numbers had fallen to the mid 20s. In contrast the number of Lesser horseshoe bats showed strong rises after the mid 1980s as climate improved (Bat Pro Ltd Report to BNES Council, 2001).

Following ventilation improvements implemented by the Combe Down Stone Mines Project (CDSMP) at Byfield, and installation of an underground incubation chamber, Greater horseshoe numbers at the Combe Down mines rose from the mid 20's to nearly 100 by the winter of 2006/7. In September 2007, all bats were excluded under licence from Byfield, so that stabilisation works could proceed without harming them. In January 2009, totals of 65 Greater horseshoe and 95 Lesser horseshoe bats were counted during visits to the other mines (Shaft Complex; St Winifreds & Horsecombe Mines).

In the summer of 2000, exit counts at the entrances to all known Combe Down Mines (Byfield, Firs, Grey Gables, Mount Pleasant, St Winifreds and Entry Hill), showed that some horseshoe bats used all of these mines through most of the summer months. The Byfield/Firs Complex, however, was the only mine system that was used by a maternity colony of Greater horseshoe bats. It numbered some 47 adults that summer. By 2007 the number of adults had reached 135. The number of babies born rose from 14 in 2001, to 38 in 2006 and 2007. After exclusion from Byfield Mine in late 2007, the maternity colony could not be located in the Springs of 2008 and 2009. However, in late June 2008, it took up residence in some high rifts in Horsecombe Mine. About 65 adults were present in July and August that summer. The number of babies born in 2008 was not known as access was not possible due to Health and Safety restrictions.

DIET AND FORAGING HABITAT

In the summer of 2000, Geoff Billington was commissioned by Bat Pro Ltd. to carry out a radio-tracking (R-T) study of the Greater horseshoe bats using Byfield. He was supervised by Dr (now Professor) Gareth Jones, of Bristol University. Gareth refined his R-T methodology whilst supervising Laurent Duvergé whilst he carried out a major study for his PhD in the early 1990s. See Appendix 2 for a review of Laurent's thesis (Duvergé, 1996). It includes important terms and findings, many of which have not been published elsewhere.

Geoff tagged 26 bats from Byfield in two periods of the 2000 summer. They were May/June and August. The prime aims of the study were to identify commuting routes, foraging areas and night roosts used by this colony, so that it could inform planners faced with making development decisions. These aims were achieved for the two study periods. He concluded that these bats primarily foraged along tall hedgerows, scrub and broad-leaved woodland edges in and around fields. They also often used wooded watercourses along streams, rivers and canals. They rarely used urban areas for either foraging or commuting.

The two key foraging areas (Chart IV of his report), out of 20 identified, were in Horsecombe and Southstoke valleys. Many GH bats foraged in them for long periods and on many nights. Combe Hay was the next most important area, being used for long periods for foraging by fewer bats on fewer nights. Dunkerton, Englishcombe and Wrightlington were all used for long periods by very few bats on only a few nights. Midford, Tucking Mill and Freshford were all regularly used for short periods by some bats, especially in May and June. The remaining eleven areas were used for short periods by a few bats, at infrequent intervals.

Horsecombe Vale and Southstoke Valley are closest to the Byfield mine (within 2 km). From these areas, a few bats turned eastwards and most turned either westwards or southwards to reach more distant areas, but only in mid summer. A maximum linear gap of about 12 metres seemed to be the limit for crossing points along commuting toutes. Odd Down, is quite close to Byfield, and was used regularly by some bats, but only for short periods, suggesting it was used mainly for commuting to other areas such as West Odd Down and Englishcombe. These last two areas were visited by few bats, but they sometimes foraged at Englishcombe for long periods. The urban areas of Bath close to Byfield, such as North Odd Down (Tumps) were rarely used, and then only for short periods in August. The Twerton/Newbridge area was not used during the 2000 R-T study period. A key issue for developers was the reported very narrow commuting link between Odd Down and the more distant foraging areas of West Odd Down and Englishcombe.

Billington reported a mean range to foraging areas of <3 km until late May, and about 5 km in June and August. However, it should be noted that Duvergé showed that this distance falls to <1 km in Spring and Autumn for adults, and <0.75 for juveniles when they start to forage. These periods were not studied by Billington, so we have no prior evidence for the distances travelled in spring and autumn by Combe Down GH bats. Map A summarises his main foraging and commuting areas identified within 5 km of Byfield mine. Yellow areas are known foraging or commuting routes; brown stripes contain commuting routes of uncertain accuracy, and purple stripes contain foraging area(s) of uncertain location. Map B has been modified using Billington's Chart IV data. His yellow areas have been changed to orange for Horsecombe (< 1km from Byfield); light green for Southstoke (< 2 km); dark green for Combe Hay, Midford, Tucking Mill, Freshford and Odd Down (1 – 4 km), and purple for Dunkerton and Englishcombe (over 4 km). This order reflects their importance to the Byfield GH bats in 2000. Remaining yellow areas were of least importance. The 1km, 2km and 3km radius distances from the Byfield Mine entrance are also shown.

From 2005, the Batscapes Project was instigated for a 3 year period, to promote horseshoe bat awareness. It also gave landowners of the key areas and sites identified by Billington in 2000, advice and financial assistance to improve habitats for horseshoe bats.

BRERC was consulted and asked to provide data on the locations of horseshoe bat records around Bath.

Summaries of the locations of Batscapes Project areas, based largely on Billington's 2000 findings, and BRERC 4 & 6 figure records for Greater horseshoe bats are provided in Map B. Records concentrate to the south and south-west of Bath City, close to the mine roosts.

From 2000 to the present time, dietary studies (involving the amounts and quality of the diet) using monthly dropping samples collected from Greater horseshoe bats in Byfield, have been carried out (see Bat Pro Report to BNES Council, 2004 for an account). The results have been compared with concurrent samples collected from Woodchester Mansion in Gloucestershire, about 30 miles away to the north. The impact of amounts eaten and diet quality upon the reproductive performance of the two colonies, especially birth timing, have been compared each year. In all years the Byfield babies are born later than those at Woodchester as a result of lower levels of consumption of inferior insect prey in sp[3]ring. In summers that follow warm springs, such as 2007, the difference in diet and birth timing is slight. However, after cold springs, there can be a three week delay of mean birth timing at Combe Down, compared with Woodchester. Late birth timing is linked with poorer juvenile growth, long term survival and hence population levels (Ransome 1989).

Habitat quality, and land management practices strongly influence the availability of preferred insect prey to Greater horseshoe bats (Ransome 1996). Duvergé (1996) showed that these bats primarily foraged within 5m of tall hedgerows, scrub and woodland edge where they meet permanent grassland that is either left to grow to maturity, or grazed by cattle, sheep or horses. Woodlands, and permanent grasslands that are allowed to grow uncut, or are only cut late for hay-making in late June or July, can generate large moth populations from mid May to August, especially in warm summers. Permanent cattle or sheep-grazed pastures generate dung fauna (beetles & flies), for a significant part of the remaining summer months, through winter up to April. The *Aphodius* dung beetles that fly in August are especially important when young bats start to forage for themselves. Grazed grassland is also favoured by Cockchafers and Tipulids, since they need short grass to reach the soil in which they lay their eggs.

Grazed areas close to hibernacula and maternity roosts are recommended as part of the environmental prescriptions to enable successful winter and spring foraging (Ransome 2002), and to favour juvenile growth (Ransome 1997). High moth populations favour late pregnancy and lactation by reproducing female bats. These can be further away from the roost, but preferably within 4 km range to be well used by significant numbers of bats.

Incubators installed inside maternity roosts can offset the survival problems caused by late birth-timing (Ransome 1998), and so boost population growth, or recovery at threatened colonies. The rapid increase in the Byfield maternity colony following incubator installation by the CDSM Project, and the spectacular rise in the Cheddar GH population strongly supports this assertion.

[3] Bat Pro Ltd. Specialists in carrying out bat surveys, mitigation and monitoring for development licences.

SUMMARY POINTS

- Horseshoe bat populations in the Combe Down SAC, as elsewhere, are influenced by summer and winter roost quality; foraging habitat quality within commuting range, and climatic conditions. The Combe Down SAC Greater horseshoe bat population functions essentially as a discrete unit within the overall SAC. Bats from different maternity colonies congregate at major hibernation roosts, and genetic interchange among colonies occurs at autumn and spring mating sites. Females rarely switch breeding from their natal roost.

- Improvements of the summer and winter roost conditions in Byfield by the CDSM Project, by ventilation and incubator installation, have resulted in high-quality roosting conditions from 2001 to 2007. Exclusion in 2008 to allow works in Byfield have temporarily forced bats to choose other mines, one of which (Shaft Complex) had compensatory improvements provided in anticipation of exclusion. Although winter use of the Shaft Complex by horseshoe bats has markedly increased, GH bats preferred to breed in Horsecombe Mine in summer 2008, and it looks as if this will be repeated in 2009. Horsecombe Mine is very close to their main traditional foraging area.

- The Batscapes Project has helped to improve some foraging habitats for the Combe Down colony since 2005. However, the cessation of intensive grazing in the Horsecombe Valley in the 1980s led to a successional change to scrub and long grassland. This must have had a major impact on the insect fauna generated, reducing dung beetles and flies, cockchafers and Tipulids, but boosting moths. The reduced dung beetles, cockchafers and Tipulids explains the late births of Byfield GH bats, compared with those at Woodchester, since these insects fly in spring.

- Greater horseshoe bats prefer to feed on dung beetles, either *Aphodius* or *Geotrupes,* from August through the winter to April; Cockchafers in early May, and Moths from late May to early August. If these prey items are unavailable, they will eat Tipulids, Ophion wasps, and finally dung flies as a last resort. Lesser horseshoe bats mainly eat a variety of small Dipterans, including Nematocerans (especially Tipulids and midges) and dung flies, but also significant amounts of small moths in spring and summer. In some localities they eat caddis flies, neuropterans and small wasps. They are outstanding winter foragers, coping with temperatures down to 2 °C.

- Greater horseshoe bats generally commute from their roosts to foraging areas within 3 to 5 km of their roosts in mid summer. In Spring and Autumn they travel much shorter distances, generally less than 1 km. Lesser horseshoes forage very close to their roosts, and even spend much of their time foraging around mine entrances. The distances they travel in summer seem to be in the range of 2 - 3 km (Schofield 1996). One study in November showed a mean of 1.2 km, with a maximum of 2.1 km (Williams 2001).

- Climatic conditions since 2000 were very favourable up to 2007, and with the Byfield roost improvements, helped to achieve significant rises in both Combe Down horseshoe bat populations, and those at Woodchester Mansion. From 2007 the summers have been very wet, and had frequent cold and windy spells. In 2008, the spring was very cold and wet, and was followed by the winter of 2008/9, which was one of the coldest since the early 1980s.

- The combination of deteriorating climate and exclusion from Byfield has recently produced difficult breeding conditions for the Greater horseshoe bat maternity colony. Winter populations are less affected. Lesser horseshoe bats have never bred there, so their reproduction should not have been affected. Works have proceeded as fast as possible to allow bats back into Byfield in the summer of 2009. If they return to roost inside the incubator chamber, and the climate improves, the Greater horseshoe bat population should rise again.

1. INTRODUCTION TO THE DUSK SURVEYS CARRIED OUT

These surveys were undertaken by Bat Pro Ltd. Staff, supervised by Roger Ransome (English Nature bat survey licence No 20073256) assisted by additional surveyors sub-contracted from local consultancies. In 2008, surveys were conducted monthly from June to September. In 2009 April and May surveys were conducted to complete the seven monthly samples required to cover one complete season.

1.1 Description of the Locations sampled.

Map 1 shows distribution of the 20 sampled sites (blue arrows); Horsecombe Mine entrance (red arrow) and other mine entrance areas with SSI status (red blobs or circles). The sampled sites were grouped into six locations, described below.

1.1.1 **Location 1: Horsecombe Vale.** A steep-sided valley between North Road & Midford Lane that is closest to the Byfield Mine (from which all bats were excluded under licence in September 2007), and also Horsecombe Mine. It is only sparsely grazed by two highland cattle. In 2008 grass and other vegetation grew very strongly within the valley, probably providing very good moth levels in May & June. A spring at the head of the valley produces a significant stream, dammed to produce a small pond, that are well screened by deciduous woodland in the valley bottom. Scrub development is generally quite advanced. Identified by Billington (2000) as a key foraging site for Greater horseshoe bats. See Maps 2 and 3. Only the most westerly, higher parts of the vale were sampled in the present study.

1.1.2 **Location 2: Southstoke area of Cam Valley.** The region around the village of Southstoke with its range of old buildings showing good bat roost opportunities. Good range of habitat for foraging by many bat species with both grazed and ungrazed pasture within large fields delimited by tree lines and woodland blocks. A small area of maize was planted that included a pond created in May 2008 for game birds. Identified by Billington (2000) as a key foraging site for Greater horseshoe bats. See Maps 2 and 4. Only the higher, more northerly parts were sampled in this study. These parts were exposed to the prevailing south-westerly winds that often blew during the present study period.

1.1.3 **Location 3: Odd Down.** The flatter land to the east of the Park & Ride facility. Initially (June 2008) only the land to the west of Sulis Manor was sampled. In July a second area to the east of Sulis Manor that linked up with the Cam Valley was added. The most northerly parts of both areas on both sides of Sulis Manor were arable land used to grow broad beans in 2008, and cereals in 2009. The southern edges were fringed with a narrow band (about 12 m wide) of young (about 12 years old?) ash plantations with thick grassland beneath. The ash plantations included some other deciduous trees, and occasional conifers. Further south, below the footpath, the land drops steeply into continuous deciduous woodland along the ridge before flattening somewhat with some large open areas, parts of which were used for maize growing. Billington (2000) regarded it as a minor foraging site for Greater horseshoe bats. See Maps 2 and 4. This location was a possible development site, and so was subjected to the most detailed surveys.

1.1.4 **Location 4: West of Odd Down.** Land to the west of the Park & Ride and the Radstock Road. Consists of a very large field adjacent to Vernham Wood to the south below the Bristol Cottages on Kilkenny Lane. Field permanently grazed by some 42 young cattle in 2008. Significant stream runs along the field/wood border. Billington (2000) regarded it as a minor foraging site for Greater horseshoe bats. See Maps 2 and 5. Due to its location between Odd Down and Englishcombe, it was a possible key commuting route, and so was well sampled.

1.1.5 **Location 5: North of Odd Down.** An area called the Tumps on flat land that is more or less enclosed by long-standing urban development. Deciduous woodland with some marshy ground covers the steeper slopes on the west and northern edges leading up to the flat land. Most of the flat land is amenity grassland, but a BMX track and some scrubland is adjacent to the woodland. Billington (2000) reported rare foraging use by Greater horseshoe bats. See Map 2. Sampling at two locations was undertaken to check this status.

1.1.6 **Location 6: Newbridge/Twerton.** A large open arable area containing Seven Acre Wood – deciduous wood on gently sloping land. In 2008 the fields were planted with cereals that were harvested in late July. Low hedgerows with gaps tenuously link the woodland to better foraging habitat for bats to the west at Newton St Lo, and south-east at the Caravan Park with its river and adjacent Nature Reserve. Billington (2000) reported no foraging use by Greater horseshoe bats of this area, but 2 night roosts at Claysend Farm not very far away. See Maps 2 and 6. Although this was also a potential development site, due to problems with theft of equipment, sampling was restricted to two sites that could be continuously observed.

2. SAMPLING SITES

The first survey was carried out in June 2008 to trial the methodology. At this time two sampling sites per location were mainly used (total 13 sites). As the method proved to be successful in locating commuting and foraging horseshoe bats, the specification was increased to 20 sites from July onwards.
At Twerton during the July survey, a static system was stolen by 3 youths on bicycles. As a result of this, future surveys used two static systems at Twerton that could be simultaneously viewed from a single surveyor position. This prevented the surveyor from ranging more widely around this location. At other locations camouflaged material was used from August to make the static systems less visible to persons using the public footpaths during surveys.

At North Odd Down, the curiosity of the cattle and potential damage to equipment forced the surveyor to move the two static systems into the woodland behind barbed wire fencing. Subsequently two small areas were ringed with electric fencing to allow safe sampling in the grazed field areas.

The grid references and habitat descriptions for all static sites are provided in Table 2.1. Appendix 1 provides photos of static sites taken in June and July 2008.

Table 2.1 below shows the description of each site by location & the name used for each one.

Location and detailed Map number	Name of site & Position	Surrounding habitat conditions
Horsecombe Map 3	Horsecombe A 51° 21' 22.43" N 2° 21' 35.96" W	Near stream in valley bottom with pool beneath overhanging trees just below spring
Horsecombe Map 3	Horsecombe B 51° 21' 18.20" N 2° 21' 25.28" W	In tall grassland near tall tree line and hawthorn bushes near far gate to grazed field
Horsecombe Map 3	Horsecombe C 51° 21' 19.93" N 2° 21' 40.34" W	Off steep path in tall grassland near buddleia, hawthorn &other bushes near top of the bank
Horsecombe Map 3	**Horsecombe D** 51° 21' 24.78" N 2° 21' 31.75" W	Near sheep sheds within mixed short grass & orchard nearby half way up bank below mine
Southstoke (Cam Valley) Map 4	Southstoke A 51° 20' 56.24" N 2° 22' 04.80" W	At gap in tree line between hay fields linking woodland blocks west of Southstoke Village
Southstoke (Cam Valley) Map 4	Southstoke B 51° 20' 57.66" N 2° 22' 09.24" W	Corner of woodland block near newly created pond and maize field
Southstoke (Cam Valley) Map 4	**Southstoke C** 51° 21' 00.81" N 2° 22' 23.57" W	In tall grassland amongst trees and developing scrubland adjacent to woodland towards Odd Down
Southstoke (Cam Valley) Map 4	**Southstoke D** 51° 20' 51.29" N 2° 22' 05.46" W	Beneath tall tree adjacent to low hedgerow at corner of wood low down in valley
Odd Down Map 4	Odd Down A 51° 21' 07.00" N 2° 22' 58.43" W	Tall grassland in angle between high hedgerows near Park & Ride. Behind football clubhouse & near floodlit pitch..
Odd Down Map 4	Odd Down B 51° 20' 59.57" N 2° 22' 52.81" W	Inside young ash plantation in tall grassland just off public footpath near gate.
Odd Down Map 4	**Odd Down C** 51° 21' 02.74" N 2° 22' 46.74" W	Near bush in low hedge on footpath running between two open arable fields.
Odd Down Map 4	**Odd Down D** 51° 21' 04.38" N 2° 22' 26.67" W	Corner of arable field with broad beans near high hedgerow of Sulis Manor grounds & young ash plantation
Odd Down Map 4	**Odd Down E** 51° 21' 04.52" N 2° 22' 12.79" W	East side of broad bean arable field in tall grassland within young ash plantation near end of stone wall
W Odd Down Map 5	Vernham A 51° 21' 18.13" N 2° 23' 08.03" W	Grazed field corner of Vernham wood sheltered by bushes & tall trees
W Odd Down	Vernham B 51° 21' 20.97" N	Grazed field edge near fence and stream under overhanging woodland trees of Vernham wood

Map 5	2° 23' 15.02" W	
W Odd Down Map 5	**Vernham C** 51° 21' 16.74" N 2° 23' 08.53" W	Within Vernham woodl across stream some 8m away from field edge inside dense woodland
N Odd Down Map 2	Tumps A 51° 21' 50.39" N 2° 22' 28.24" W	In a sheltered area near wood edge 10 m from footpath within tall scrubby vegetation (mostly Policeman's helmet)
N Odd Down Map 2	Tumps B 51° 21' 51.19" N 2° 22' 31.60" W	Sheltered area with tall vegetation near wood edge below corner of BMX circuit & just off footpath
Twerton Map 6	Twerton A 51° 23' 02.74" N 2° 25' 01.95" W	Woodland (Seven Acre Wood); south-east corner abutting on to cereal arable field
Twerton Map 6	Twerton B 51° 23' 04.19" N 2° 24' 59.21" W	Woodland edge; north-east corner abutting on to cereal arable field

Bold sites were only added to the sampling areas from July 2008

3. METHODOLOGY USED FOR THE DUSK BAT SURVEYS

3.1 Introduction

Detailed habitat use by bats is often investigated by the use of radio-tracking. Bats are caught by hand net, mist net or harp trap, and a radio tag is glued between the shoulder blades after shaving off the fur. Either two persons are needed to locate bats by triangulation, or a single person uses signal strength to deduce bat activities. Whichever method is used, the object is to follow bats throughout the night to discover their commuting routes, foraging areas and night roosts. Tags can adhere for up to 21 days and provide extensive data, but often fall off much sooner. An average of 7 days is typical.

Radio-tracking can provide detailed data about the foraging use of habitats through the night made by certain bats at specific times of year. It is a labour-intensive procedure that can provide unique data on habitat use. If enough bats are tagged, and the study lasts over a significant period of the summer, it can provide a reliable picture of the location of key foraging areas required to sustain a given bat colony. Geoff Billington, supervised by the then Dr (now Professor) Gareth Jones of Bristol University, completed a study in two sessions - late May to June; and August - during 2000 (see Billington 2000; or Bat Pro Ltd report of 2001 for a summary). He was assisted by Jane Sedgeley, and so was able to use triangulation,

The drawbacks to radio-tracking as a method of assessing overall use by bats of particular areas of land include:

- The numbers of bats that can be tracked simultaneously is usually fairly small, so the bats followed may not be representative of the colony being studied

- Once bats have been caught and tagged, the study has to follow immediately, whatever the weather conditions that occur.

- Bats cannot be tagged during the late pregnancy period (late June/early July), as the additional stress to females is unacceptable.

- Bats cannot usefully be tagged in September as many disperse to more distant roosts, or in April/early May when they often remain in daytime torpor. Few data are generated at these times.

Foraging habitat surveys used in this study

The methodology used was based upon the use of static recording systems, supplemented by surveyor observations, which have been widely used by Bat Pro staff over many years to assess habitat use by bats at night. The methods used

overcome many of the drawbacks outlined above, and are suitable to assess specific habitat areas for foraging use by all types of bats in a quantitative manner. However, this methodology has its own limitations, and does not provide an alternative to thorough radio-tracking studies. The two methods should be regarded as complementary ways of determining habitat use by bats.
Bat Mitigation Guidelines (2004) p 25 gives a methodology for dusk surveys to be carried out for planning applications involving significant areas (greater than 1ha) within 4 km of greater horseshoe bat roosts. Key recommendations are as follows.

- Surveys should pay particular attention to known greater horseshoe bat feeding habitat.
- Surveys should be carried out on two separate evenings per month from May to September.
- Study dates should be chosen to be during favourable weather conditions as far as was possible given the erratic summer weather in 2008 and 2009.
- Surveys should cover the period of peak activity for the bats – from sunset for the next 3 hours.
- Surveys should preferably use broad-band detectors to provide a record of calls obtained.

This methodology was largely adopted, apart from using one instead of two surveys per month. Also the study was not able to start until June. However, as April and May surveys were added later, the time scope exceeded that recommended.

In order to cover the extensive areas that needed to be sampled, involving 20 sites, each monthly survey had to be carried out on two nights for logistical reasons (staff and equipment availability). Twelve sites were sampled on one night, and eight on the other. The two nights were as close together as weather conditions permitted.

One survey per location per month was regarded as acceptable by English Nature for the Bathampton floodplain surveys in the summer of 2003. Broad-band detectors were used that recorded continuously at 3 fixed locations. All bat species were sampled for 3 hours per dusk survey each month from May to September at three locations. A total of 45 hours were sampled in that study.

Bat activity over the Bath urban study areas was sampled continuously, using time-expansion static systems, throughout the late hibernation/early pregnancy period (April/May); late pregnancy period (June/ July); lactation & weaning (late July/August), and the dispersal period (September).

No stress to bats resulted from the methods adopted. Thirteen sites were sampled for 3 hours in June, and 20 sites for 3 hours per site from July to September 2008, and in April and May 2009 (total of 6 months, rather than the 5 specified). The 39 hours sampled in June 2009 plus 300 hours subsequently (60 hours x 5 months) equals 339 hours sampled. However, 3 hours of sampling time were lost at Twerton due to theft of equipment, so 336 hours of continuous sampling time was available for analysis.

This far exceeds the time normally spent recording bat calls using surveyors walking transects over a three-hour period, especially if they use heterodyne recorders. The sampling time obtained in this study greatly exceeds the sampling time that would have occurred if two surveys per month had been conducted using heterodyne detectors. In addition, observations by surveyors walking around the locations using heterodyne detectors were also noted on proformas, but not recorded for Batsound analysis. See Appendix 4 for a fuller rationale for the methods used.

3.2 Static surveys

3.2.1 Surveyors were responsible for overseeing the setting up, correct operation and safety of up to 4 static broad-band detector systems (each with a Tranquility transect broad-band detector; a Sony ICD P520 dictation recorder & 6v battery pack) set at fixed sites within locations where bats, especially horseshoe bats, where likely to either commute or forage. Their sites and general locations are shown on Maps 1 to 6. The habitats they were placed in are described in Table 2.1, and photographs in Appendix 1.

3.2.2 The equipment was placed on a low stool, about 0.6m above ground level as horseshoe bats commute at about 1-2 m height above ground level. This height is also suitable for vesper bats that fly much higher, as long as they are within detection range, since their calls radiate out in all directions. The species most likely to cause detection problems is the Brown long-eared bat, whose calls are often very weak. The surveyors regularly checked the safety of the systems from a distance, once set up at dusk. Systems may be either stolen, or damaged by grazing animals. Each system automatically recorded bat calls onto the Sony digital recorder, which was set in voice-activated mode. It has a time facility that records the precise time of any bat calls detected at the site.

3.2.3 Weather data (temperature, windspeed, light level, rainfall) operating during the session, was recorded by one surveyor throughout each dusk survey.

3.2.4 Bat call recordings were later downloaded to computer and analysed using Batsound software (Pettersen Electronik). The precise times of all recorded horseshoe bat calls were noted by species and site location from the Sony recorder. Also the presence or absence of all identifiable vesper bat types at each location, as per the contract specification. Please note that *Nyctalus* species calls cannot always be separated into the two UK species (Noctule and Leisler's bats), and the *Myotis* species can only be separated into two groups – the 'Natterer's/Bechsteins' and 'other Myotis'. All other UK bats can usually be identified to species.

3.2.5 Note that the setting on the Tranquility transect was a 320 ms sample time in order to be able to record several calls in each sample. Tranquility transect sampled calls were replayed 32 times slower in order to reduce the frequencies within the sensitivity range of the Sony ICD recorder. Hence it took 10.24 seconds to replay each sample – from (320 x 32)/1000. During this period the detector is deaf to any further calls. Hence the detector is only able to sample for about 3.1% of the sampling time. In one minute, a maximum of 5 call blocks, or passes, can be recorded. Hence the system samples the level of bat call activity in a consistent, but not continuous, manner. Each call block sample can be treated as a bat pass. The 320 ms sample allows inter-pulse intervals to be calculated for vesper bats. This is an important characteristic in the identification of some bat species, such as *Nyctalus* bats.

3.2.6 Since bats were not aware of the static systems, their behavior was normal. Static systems are superior at recording the presence of horseshoe bats compared with surveyors carrying out transects using the same detectors. This is because horseshoe bats are predator-sensitive, and shun movements and/or light sources. They also fly low and/or close to vegetation where they are hard to see even when flying soon after sunset, and almost impossible to see later on in cloudy conditions.

3.3 Roving surveys

3.3.1 Surveyors were primarily responsible for setting up, and ensuring the safety of up to 4 static broad-band detector systems within their location. In addition they were required to record the time, position and nature of any horseshoe bat activity they observed onto maps as they moved around checking the static systems from a distance. They did not do this in any formal way.

3.3.2 Surveyors used heterodyne ultrasonic (usually Pettersen D210s) to detect horseshoe bat calls as they either commuted or foraged. These detectors were tuned to either 83 kHz (for Greater horseshoe bats), or 110 kHz (for Lesser horseshoe bats). Surveyors frequently switched tuning frequency to search for the two species. Heterodyne detectors are very sensitive to bat calls, and often allow a surveyor to hear the presence of a horseshoe bat before they can be seen, or when sightings are impossible.

3.3.3 Sightings of horseshoe bats became more difficult with time after sunset, especially on cloudy nights. As the surveys progressed, it became more difficult to decide what the bats were doing.

3.3.4 Heterodyne bat calls were not recorded as they are unsuitable for analysis using Batsound software.

3.3.5 Horseshoe bats respond to human movements and/or light sources, moving quickly away from both. As they fly low and close to vegetation they are hard to see even when flying soon after sunset.

3.3.6 Appendix 4 gives a fuller comparison of types of detectors and their uses in surveys.

4. DATA FROM THE DUSK SURVEYS

4.1 Summary data by static site

The presentation of data is complicated by the inconsistent number of sites sampled between the June 2008 and subsequent monthly dusk surveys. Table 4.1.1 summarises the horseshoe bat data for the 13 sites sampled from June to September 2008, and in April and May 2009.

Table 4.1.1 Horseshoe bat passes at 13 sites by month using static systems

Site name (each sampled for 18 hours in total)	29th Apr /1st May 2009	18th /20th May 2009	24th /25th June 2008	21/22nd July 2008	8th/12th Aug 2008	8th/13th Sept 2008	*Totals June to September (passes/hr)*
Horsecombe A	6 GH	4 GH	2 GH	2 GH	1 GH	1 GH	***16 GH (0.89)***
(pond/stream)	None	None	None	None	None	None	***None(0.00)***
Horsecombe B	1 GH	None	2 GH	2 GH	3 GH	None	***8 GH (0.44)***
(far field)	None	None	None	None	None	None	***None(0.00)***
Horsecombe C	None	None	3 GH	2 GH	2 GH	None	***7 GH (0.39)***
(buddleias)	None	None	None	1 LH	4 LH	1 LH	***6 LH (0.33)***
Southstoke A	None	1 GH	1 GH	8 GH	7 GH	10 GH	***27 GH (1.50)***
	None	3 LH	1 LH	6 LH	None	6 LH	***16 LH (0.89)***
Southstoke B	None	None	2 GH	None	None	None	***2 GH (0.17)***
	2 LH	None	None	1 LH	None	None	***3 LH (0.17)***
Odd Down A	None	None	None	None	None	None	***None (0.0)***
	None	None	None	None	None	None	***None (0.00)***
Odd Down B	None	1 GH	3 GH	None	None	1 GH	***5 GH (0.28)***
	None	None	2 LH	1 LH	2 LH	None	***5 LH (0.28)***
W Odd Down A	None	None	None	1 GH	None	None	***1 GH (0.06)***
	None	None	None	None	None	None	***None (0.00)***
W Odd Down B	None	1 GH	None	None	None	None	***1 GH (0.06)***
	None	1 LH	None	1 LH	None	7 LH	***9 LH (0.50)***
N Odd Down A	None	None	None	None	None	None	***None (0.00)***
	3 LH	None	None	None	1 LH	1 LH	***5 LH (0.28)***
N Odd Down B	None	None	None	1 GH	None	None	***1 GH (0.06)***
	None	None	None	None	None	None	***None (0.00)***
Twerton A	None	None	None	Kit stolen	None	None	***None?***
	1 LH	None	None	None?	None	None	***1 LH (0.06)***
Twerton B	None	1 GH	None	None	None	None	***1 GH (0.06)***
	None	None	None	None	None	None	***None (0.00)***
Total horseshoe bat passes	***7 GH***	***8 GH***	***13 GH***	***16 GH***	***13 GH***	***12 GH***	***69 GH (0.295)***
	6 LH	***4 LH***	***3 LH***	***10 LH***	***7 LH***	***15 LH***	***45 LH (0.192)***

NB. Greater horseshoe passes are in black. Lesser horseshoe passes are in red. Total 234 hours sampled. Mean 0.295 passes/hour GH; 0.195 passes/hour LH. Max = 1.50 passes/hour GH; 0.89 passes/hour LH.

From July, and in April and May 2009, 7 further sites were included to improve the sample size in the crucial areas. Table 4.1.2 summarises the data obtained.

Table 4.1.2 Summary of horseshoe bat passes in 20 sites using static systems

Site name	29th Apr /1st May 2009	18th /20th May 2009	24th /25th June (estd)	21/22nd July	8th/12th Aug	8th/13th Sept	*Totals June-Sept (passes/hr)*
Horsecombe A	6 GH	4 GH	2 GH	2 GH	1 GH	1 GH	***16 GH (0.89)***
(pond/stream)	None	None	None	None	None	None	***None(0.00)***
Horsecombe B	1 GH	None	2 GH	2 GH	3 GH	None	***8 GH (0.44)***
(far field)	None	None	None	None	None	None	***None(0.00)***
Horsecombe C	None	None	3 GH	2 GH	2 GH	None	***7 GH (0.39)***
(buddleias)	None	None	None	1 LH	4 LH	1 LH	***6 LH (0.33)***
Horsecombe D	None	None	No sample	2 GH	2 GH	None	***5 GH (0.28)***
(sheep sheds)	8 LH	1 LH	(1 GH 2 LH)	3 LH	2 LH	2 LH	***18 LH (1.00)***
Southstoke A	None	1 GH	1 GH	8 GH	7 GH	10 GH	***27 GH (1.50)***
(tree-line near gap)	None	3 LH	1 LH	6 LH	None	6 LH	***16 LH (0.89)***
Southstoke B	None	None	2 GH	None	None	None	***2 GH (0.11)***
(field corner)	2 LH	None	None	1 LH	None	None	***3 LH (0.17)***
Southstoke C	None	None	No sample	2 GH	None	None	***3 GH (0.17)***
(glade in scrub)	None	1 LH	(1 GH 0 LH)	None	None	None	***1 LH (0.06)***
Southstoke D	None	None	No sample	None	None	None	***None(0.00)***
(valley nr woods)	1 LH	None	(0 GH 0 LH)	None	None	None	***1 LH (0.06)***
Odd Down A	None	None	None	None	None	None	***None (0.0)***
	None	None	None	None	None	None	***0 LH (0.00)***
Odd Down B	None	1 GH	3 GH	None	None	1 GH	***5 GH (0.28)***
	None	None	2 LH	1 LH	2 LH	None	***5 LH (0.28)***
Odd Down C	None	None	No sample	None	None	None	***None***
(open arable field)	None	1 LH	(0 GH 0 LH)	None	None	None	***1 LH (0.06)***
Odd Down D	None	None	No sample	None	None	1 GH	***1 GH (0.06)***
(edge arable field)	None	None	(0 GH 0 LH)	None	None	None	***0 LH (0.00)***
Odd Down E	None	None	No sample	1 GH	1 GH	None	***3 GH (0.17)***
(ash plantation)	8 LH	None	(1 GH 1 LH)	1 LH	None	3 LH	***13 LH (0.72)***
W Odd Down A	None	None	None	1 GH	None	None	***1 GH (0.06)***
(field corner/wood)	None	None	None	None	None	None	***None (0.00)***
W Odd Down B	1 GH	1 GH	None	None	None	None	***2 GH (0.11)***
(field/wood overhang)	4 LH	1 LH	None	1 LH	None	7 LH	***13 LH (0.72)***
W Odd Down C	None	None	No sample	Data stolen	None	None	***0 GH (0.00)***
(5m into wood)	3 LH	None	(0 GH 1 LH)	None	None	None	***4 LH (0.22)***

N Odd Down A	None	None	None	None	None	None	***None (0.00)***
(edge wood/scrub)	3 LH	None	None	None	1 LH	1 LH	***5 LH (0.28)***
N Odd Down B	None	None	None	1 GH	None	None	***1 GH (0.06)***
(edge scrub/bmx track)	None	None	None	None	None	None	***None (0.00)***
Twerton A	None	None	None	Kit stolen	None	None	***None?***
(arable/wood edge)	1 LH	None	None	None?	None	None	***1 LH (0.07)***
Twerton B	None	1 GH	None	None	None	None	***1 GH (0.06)***
(arable/wood edge)	None	None	None	None	None	None	***None (0.00)***
Total horseshoe bat passes	***8 GH***	***7 GH***	***13 GH (3)***	***21 GH***	***16 GH***	***13 GH***	***81 GH (0.229)***
	31 LH	***7 LH***	***3 LH (4)***	***14 LH***	***9 LH***	***20 LH***	***88 LH (0.249)***

NB. Greater horseshoe passes are in black. Lesser horseshoe passes are in red. Figures in brackets are additional estimated data. They are included in the final column totals. Total 354 hours sampled (20 x 18 hours less 6 hours for stolen kit).

To make the raw data more easily comprehensible, in table 4.1.3 below they are combined into totals per major location in order of distance from Horsecombe Mine, the main roost in summer 2008. Pass rates are again calculated in order to provide comparable data.

Table 4.1.3 Summary of horseshoe bat passes in all locations using static systems

Location name (n sites sampled)	**29th Apr / 1st May 2009**	**18th/20th May 2009**	**24th /25th June 2008**	**21/22nd July 2008**	**8th/12th Aug 2008**	**8th/13th Sept 2008**	**Totals Apr-Sept**	***Pass rate: passes/hr***
Horsecombe	7 GH	3 GH	8 GH	8 GH	8 GH	1 GH	**35 GH**	***0.686***
(4)	9 LH	1 LH	2 LH	4 LH	6 LH	3 LH	**25 LH**	***0.490***
Southstoke	None	1 GH	4 GH	10 GH	7 GH	10 GH	**32 GH**	***0.627***
(4)	3 LH	4 LH	1 LH	7 LH	None	6 LH	**21 LH**	***0.412***
Odd Down	None	1 GH	4 GH	1 GH	1 GH	2 GH	**9 GH**	***0.107***
(5)	8 LH	1 LH	3 LH	2 LH	2 LH	3 LH	**19 LH**	***0.226***
W Odd Down	1 GH	1 GH	None	1 GH	None	None	**3 GH**	***0.059***
(3)	7 LH	1 LH	1 LH	1 LH	None	7 LH	**17 LH**	***0.333***
N Odd Down	None	None	None	1 GH	None	None	**1 GH**	***0.028***
(2)	3 LH	None	None	None	1 LH	1 LH	**5 LH**	***0.139***
Twerton	None	1 GH	None	None	None	None	**1 GH**	***0.030***
(2)	1 LH	None	None	None	None	None	**1 LH**	***0.030***
Total horseshoe bat passes	***8 GH***	***7 GH***	***16 GH***	***21 GH***	***16 GH***	***13 GH***	***81 GH***	***0.229***
	31 LH	***7 LH***	***7 LH***	***14 LH***	***9 LH***	***20 LH***	***88 LH***	***0.249***

NB. Greater horseshoe passes are in black. Lesser horseshoe passes are in red. Total 354 hours sampled.

Comments on data shown in tables 4.1.2 and 4.1.3

Greater horseshoe bat data

Table 4.1.2 shows that the greater horseshoe bat pass rates vary from 0 to 1.5 per hour over the six months, according to the site sampled. The mean was 0.229 passses/hour for all sites combined. Although these appear to show very low, or even insignificant levels of bat activity, it is necessary to appreciate the scale of the sampling compared with the likely area that the bats utilise for commuting and foraging. As the range of detectable calls by a single time-expansion detector seems to be about 8 metres, the maximum area of detection is about 137 m^2. This area assumes that calls radiate evenly from the bat in all directions. In fact these bats emit their calls horizontally via their nostrils in a highly directional manner, so this area is likely to be an overestimate.

If we assume the 137 m^2 estimate is correct, and that 20 hectares of land (200,000 m^2) is involved in the combined sampled areas (probably a minimum figure), then about 0.0685% of the areas were sampled by each static detector system. The 20 systems combined would have sampled about 1.37% of the areas. Hence we should multiply the data by 73 to obtain estimates of the true figures for the whole area sampled. Mean data (0.229 passes/hour), when transformed becomes 16.7 passes per hour, or 0.279 passes/minute. The maximum figure of 1.5 becomes 109.5 passes/hour, or 1.83 passes/minute. The latter figure is well below the upper limit of 5 passes/minute set by the static system (refer to section 3.2.5 above).

Lesser horseshoe bat data

Table 4.1.2 shows that the lesser horseshoe bat pass rates species vary from 0 to 1.0/hour over the six months, according to the site sampled. The mean was 0.249 passses/hour for all sites. These data are subject to the same kind of considerations as for the greater horseshoe bats. The range of detectable calls by a single time-expansion detectors seems to be about 5 metres, so the likely area of detection is about 53.6 m^2. This area also assumes that calls radiate evenly from the bat in all directions. In fact these bats also emit their calls horizontally via their nostrils in a highly directional manner, so this area is likely to be an overestimate.

Assuming the 53.6 m^2 estimate is correct, and that 20 hectares of land (200,000 m^2) is involved in the combined sampled areas (a minimum figure), then about 0.0268% of the areas were sampled by each static detector system. The 20 systems combined would have sampled about 0.536% of the areas. Hence we should multiply the data by 178 to obtain estimates of the true figures for the whole area sampled. Mean data, which was 0.231 passes/hour, becomes 41.1 passes per hour, or 0.685 passes/minute. The maximum figure of 1.0 becomes 178 passes/hour, or 2.97 passes/minute. The latter figure is also beneath the upper limit of 5 passes/minute set by the system (refer to section 3.2.5 above).

Similarly data from table 4.1.3 can be transformed as shown in table 4.1.4 below.

Table 4.1.4 Summary and transformed data by main location

Location name (n sites sampled)	Totals Apr-Sept	Pass rate: passes/hour	*Transformed pass rate (passes/hour)*
Horsecombe	**35 GH**	**0.49**	***35.5***
(4)	**25 LH**	**0.36**	***64.1***
Southstoke	**32 GH**	**0.44**	***32.1***
(4)	**21 LH**	**0.29**	***51.6***
Odd Down	**9 GH**	**0.10**	***7.3***
(5)	**19 LH**	**0.21**	***37.8***
W Odd Down	**3 GH**	**0.06**	***4.4***
(3)	**17 LH**	**0.31**	***56.0***
N Odd Down	**1 GH**	**0.03**	***2.2***
(2)	**5 LH**	**0.14**	***24.9***
Twerton	**1 GH**	**0.03**	***2.2***
(2)	**1 LH**	**0.03**	***5.3***
Total horseshoe bat passes	***81 GH***	***0.229***	***16.7***
	88 LH	***0.249***	***44.3***

NB. Greater horseshoe passes are in black. Lesser horseshoe passes are in red. Total 354 hours sampled, including estimated data. For transformation explanation see text above.

Summary comments

The transformed data in table 4.1.4 should not be regarded as providing reliable actual data for horseshoe bat pass rates over the study area for two important reasons. Firstly the 20 hectare estimate is of doubtful accuracy. Secondly, horseshoe bats do not randomly use habitats for commuting and foraging. They are highly selective, commuting within 5m of linear features such as tree-lines and woodland edges. When foraging they also tend to remain within 5m of linear features (Duvergé 1996). This behaviour was used to help select the static system sites, and also the routes taken by the roving surveyors to enhance the chances of detecting them. The data collected is therefore not randomly collected, but heavily biased.

What the calculations do indicate, however, is that the higher level of raw data often obtained for greater horseshoe bat calls does not necessarily mean that more of them were commuting or foraging over the particular location than lesser horseshoe bats. In fact the opposite is probably the case, due to range detection differences inherent in the methodology used as discussed above. Similar considerations affect the detection of vesper bat calls. Pipistrelles and Noctules can be detected over much larger ranges than Brown long-eared bats.

During the summer of 2008, exit counts of horseshoe bats leaving the various Combe Down Mines and the Mount Pleasant derelict office at dusk showed peaks of about 90 adult Lesser horseshoes and 45 adult Greater horseshoes. These data more closely reflect the call ratios of the transformed figures, and so provide support for the use of transformed data in making activity assessments.

What tables 4.1.2 to 4.1.4 show, whichever data is used, is that the levels of each horseshoe bat species activity varies markedly:

- with the month of the study
- with the location
- with the specific site sampled within a particular location

These variations will be explored in the following sections after considering the detailed data.

4.2 Activity level changes by month and time after sunset

Table 4.2.1 shows the times of all horseshoe bat data collected by the static systems by month and site.

Table 4.2.1 Horseshoe bat passes in 20 sites by survey date and time using static systems

Site name	29 Apr 1 May 2009	18/20th May 2009	24/25th June 2008	21/22nd July 2008	8th/12th August 2008	8th/13th September 2008
Sunset time	**20.28**	**21.00**	**21.30 hrs**	**21.12 hrs**	**20.39 hrs**	**19.40 hrs**
Horsecombe A (pond)	6 @ 20.58 20.59 21.06 21.08 21.09 21.16 None	4 @ 21.50 21.53 21.54 22.02 None	2 @ 23.00 & 00.24 None	2 @ 22.11 & 22.51 None	1 @ 21.52 (+1 @ 23.48 after survey end) None	1 @ 20.28 None
Horsecombe B (far field)	1 @ 20.44 1 @ 22.46	None None	2 @ 23.03 & 23.20 check None	2 @ 21.49 21.50 None	3 @ 22.30; 23.20; 23.43 (+1 @ 23.55 after survey end) None	None None
Horsecombe C (buddleias)	None None	None None	3 @ 22.11: 22.12 & 23.01 None	2 @ 22.11 22.26 1 @ 22.30	2 @ 21.12 & 21.18 4 @ 21.12; 21.17 (2 passes) & 21.18	None 1 @ 21.48
Horsecombe D (Botley shed)	None 8 @ 21.33 21.34 22.09 22.21 22.54 23.09 23.19 23.42	None 1 @ 21.29	No sample	2 @ 21.41 & 21.50 3 @ 22.28; 22.38 & 22.50	2 @ 22.03 & 22.40 2 @ 22.37; 23.37 (+ 1 @ 00.07 after survey end)	None 2 @ 20.29 & 22.03
Southstoke A	None None	1 @ 21.48 3 @ 22.03 22.15 22.56	1 @ 22.24 1 @ 21.54	8 @ 21.44 (2 passes); 21.48; 21.45; 21.46; 21.51(2 passes); 21.53 6 @ 22.21; 22.27; 22.45; 23.54; 23.56; 23.57	7 @ 21.00; 21.01 (2 passes); 21.02 (2 passes); 21.04; 21.07 None	10 @ 20.00; 20.01; 20.03 (3 passes) 20.04; 20.05; 20.08; 20.10; 20.35 6 @ 21.17; 21.38; 22.03; 22.10; 22.17; 22.19
Southstoke B	None 2 @ 22.01 22.35	None None	2 @ 22.10 & 22.24 None	None 1 @ 23.15	None None	None None
Southstoke C	None None	None 1 @ 22.32	No sample	2 @ 21.57 & 22.22 None	None None	None None
Southstoke D	None 1 @ 22.08	None None	No sample	None None	None None	None None

Odd Down A	None	None	None	None	None	None
	None	None	None	None	None	None
Odd Down B	None	1 @ 22.03	3 @ 22.10; 22.18 & 22.33	None	None	1 @ 20.22
	None	None	2 @ 23.29 & 23.49	1 @ 00.11	2 @ 21.34 & 21.37	None
Odd Down C	None	None	No sample	None	None	None
	None	1 @ 21.48		None	None	None
Odd Down D	None	None	No sample	None	None	1 @ 20.52
	None	None		None	None	None
Odd Down E	None	None	No sample	1 @ 23.18	1 @ 21.09	None
	8 @ 20.56 21.09 21.12 21.16 21.17 21.18 21.49 22.12	None		1 @ 23.19	None	3 @ 20.16; 21.00; 21.57
W Odd Down A	None	None	None	1 @ 22.52	None	None
	None	None	None	None	None	None
W Odd Down B	1 @ 21.50	1 @ 22.06	None	None	None	None
	3 @ 21.22 21.34 21.44 23.07	1 @ 22.37	None	1 @ 21.55	None	7 @ these times: 20.39; 20.45; 20.54; 21.20; 22.02; 22.05; 22.42
W Odd Down C	None	None	No sample	Data stolen next day	None	None
	3 @ 21.30 21.31 21.59	None			None	None
N Odd Down A	None	None	None	None	None	None
	3 @ 21.25 21.27 21.32	None	None	None	1 @ 22.17	1 @ 20.11
N Odd Down B	None	None	None	1 @ 21.54	None	None
	None	None	None	None	None	None
Twerton A	None	None	None	Kit stolen by youths	None	None
	1 @ 23.18	None	None		None	None
Twerton B	None	1 @ 22.05	None	None	None	None
	None	None	None	None	None	None
Total horseshoe bat passes	8 GH	8 GH	10 GH	21 GH	16 GH	13 GH
	30 LH	7 GH	3 LH	14 LH	9 LH	20 LH
Temp. range	29th :16.7 °C dsk; 12.2 °C end 1st : 16.3 °C dsk; 7.0 °C end	18th : 12.3 °C dsk; 7.6 °C end 20th : 16.3 °C dsk; 10.3 °C end	15.4 °C dsk; 13.0 °C @ 00.15	21st :16.7 °C dsk; 10.3 °C end 22nd: 18.1 °C dsk; 12.0 °C end	8th :15.9 °C dsk; 10.2 °C end 12th : 14.7 °C dsk; 12.7 °C end	8th : 17.0 °C dsk; 12.2 °C end 13th : 15.2 °C dsk; 9.9 °C at end
Windspeed	29th: Force 1 at dsk; force 4-5 after 2 hrs 1st: Calm through whole survey	18th Calm at dsk & at end. 20th: Calm at dsk; slight wind at	Force 3 SW dsk; 5 @ 23hrs; 1 @ 00.15	Force 2 SW dsk; 1 SW at end	Calm 8th. 12th 2-3 W dsk; then 2 falling to 1 at end	Calm through both surveys

		end					
Rainfall	*0 both nights*	*0 both nights*	*0*	*0*		*0 on 8th; Rain at 22.00 on 12th. Heavy from 22.30 – survey abandoned early*	8th Drizzle started 22.00hrs; heavier from 22.20 – survey completed 0 on 13th

NB. Greater horseshoe bat passes are in black type. Lesser horseshoe bat passes are in red type. Note estimated passes from June cannot be included.

This table is difficult to assimilate, and it is perhaps best to use it for detailed examination of specific points after the following summary figures and tables have been considered.

Figures 1 to 4 show passes recorded from Greater horseshoe bats at the four locations where reasonable levels of data were obtained. Figures 4 to 6 show the same data for Lesser horseshoes. The complete data for Figures 1 to 6 are provided in table 4.2.3, plus those from the other locations with insufficient data to produce viable figures. Table 4.2.2 below summarises roving surveyor observations collected whilst moving about the locations.

Figure 1: Greater horseshoe passes by hour post sunset for Horsecombe sites combined.

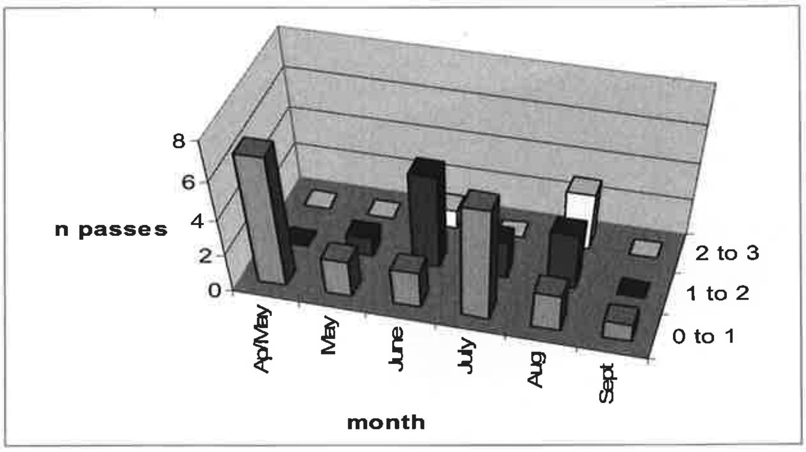


Figure 2: Greater horseshoe passes by hour post sunset for Southstoke sites combined.

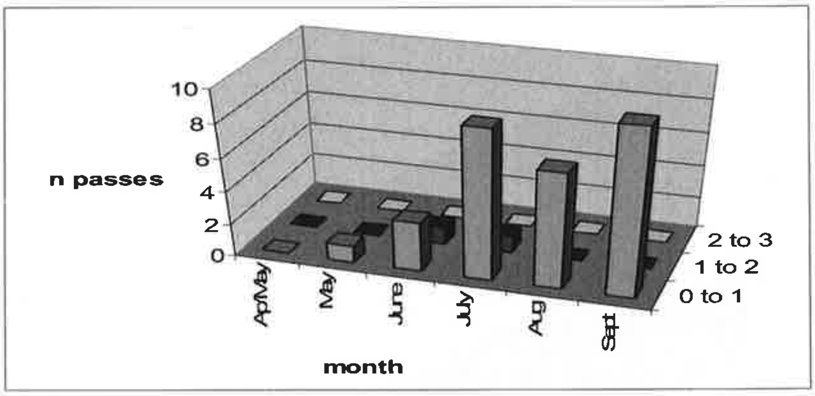


Figure 3: Greater horseshoe passes by hour post sunset for Odd Down sites combined.

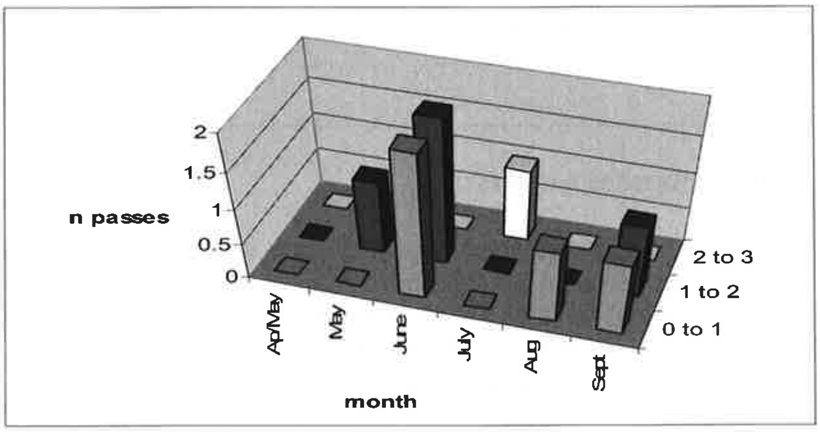


Figure 4: Greater horseshoe passes by hour post sunset for West of Odd Down sites combined.

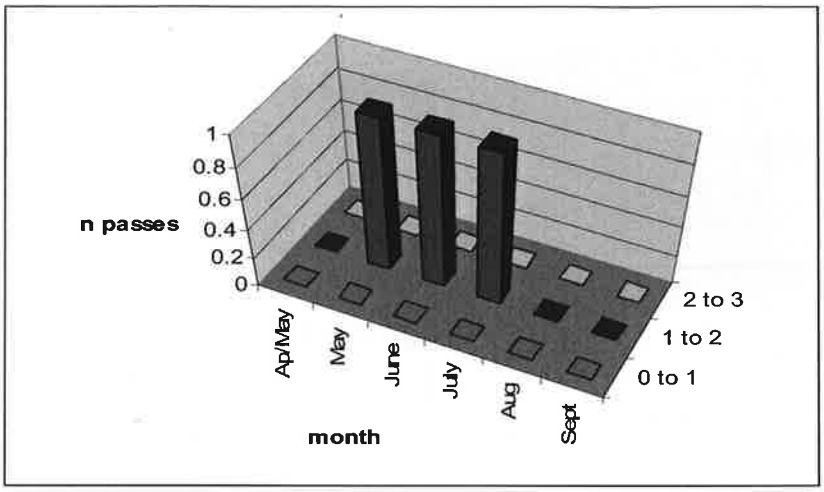
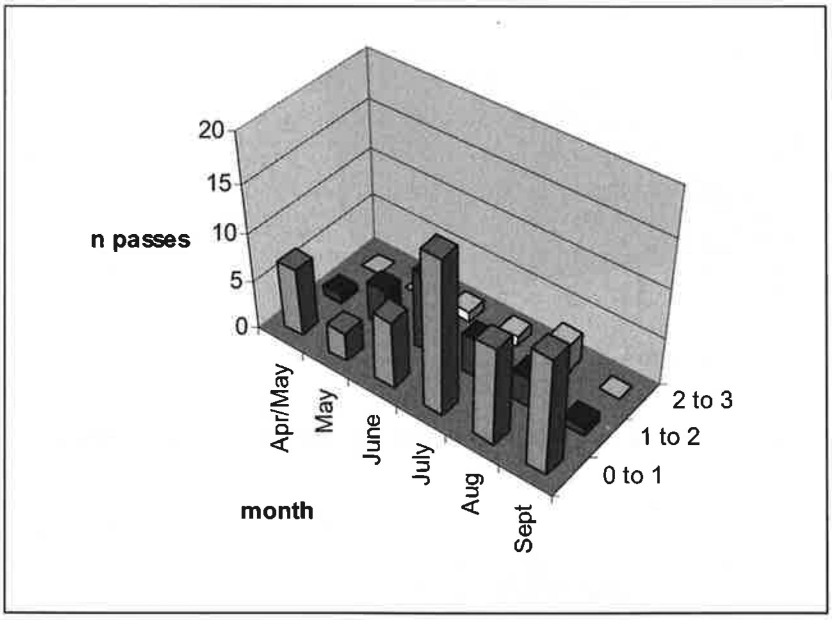


Figure 5: Greater horseshoe passes by hour post sunset for all sampled sites combined.



Comments on the Greater horseshoe bat pass data

Figures 1 to 4 and Table 4.2, show different patterns of time use at the four locations. At Horsecombe (Fig. 1), passes were recorded for up to three hours in June and August, and for up to two hours in July. The numbers of passes recorded was the highest, and occurred in all months of the surveys. This suggests that these bats make major foraging use of the location throughout the whole summer period.

At Southstoke, passes were recorded in increasingly larger numbers from May to July, and at high levels until September. The passes were almost all recorded in the first hour. Close examination of pass times in table 4.2.1 and visual observations by roving surveyors (table 4.2.2 below), confirm that these bats commuted rapidly through Southstoke site A, and carried on towards Odd Down usually without stopping to forage there near any of the other sampled sites. Presumably the bats commuted back later on in the night via other routes, or used night roosts until after the surveys had ceased.

At Odd Down, which is further from Byfield (about 2 km), the pass evidence showed that these bats did not commute to any of the sites, or forage there in late April. This agrees with Duverge's findings. However, small numbers of bats foraged there, especially in May and June, when moths are normally being eaten (Ransome 1996, and diet data from the Combe Down Mines Stabilisation Project 2004). In August and September, when dung beetles were probably the main prey item, most GH must have foraged elsewhere.

At West Odd Down, which is even further from Byfield (about 3 km), the pass data shows GH commuting or foraging in late April, August or September. Even from May to July, only a single bat was detected each night, at a time when moths are normally being eaten. As the habitat consists of mature deciduous woodland adjacent to grazed pastures, and the distance from Byfield is well within Duvergé's limits, it appears that GH bats are already deterred from reaching this location by the existing urban developments. Woodland/grazed permanent pasture was identified by Duvergé as their favoured habitat type.

At Twerton/Newbridge, a single GH pass was recorded in late May 2009. No use was found of this area by Billington. It is about 5 km from Byfield. It may be that the bat concerned was using a local roost at the time. There are historical records of an outbuilding in the Newton St Loe College. Clearly this is not an important foraging area, since the deciduous woodland is surrounded by arable cultivation, usually cereals.

Figure 5, and Table 4.2,3 below summarises all pass data for all sites. It shows that GH bat activity concentrates within the first hour after sunset in most months, with the second hour important from May to August.

Figure 6: Lesser horseshoe passes by hour post sunset for Horsecombe sites combined.

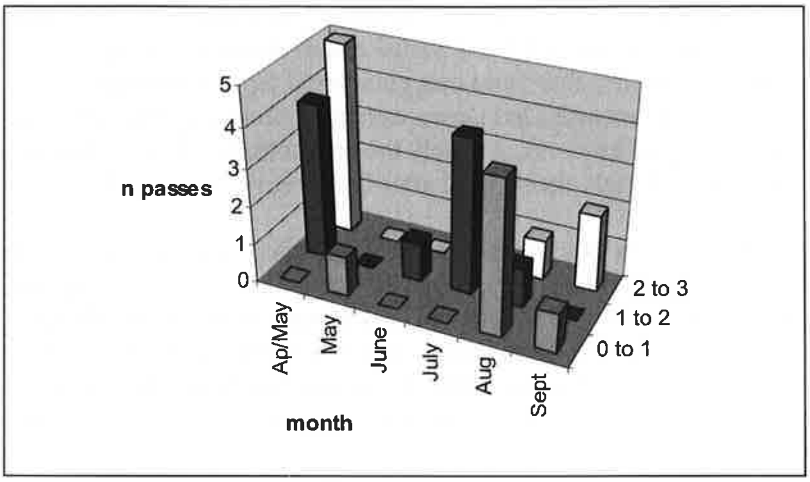


Figure 7: Lesser horseshoe passes by hour post sunset for Southstoke sites combined.

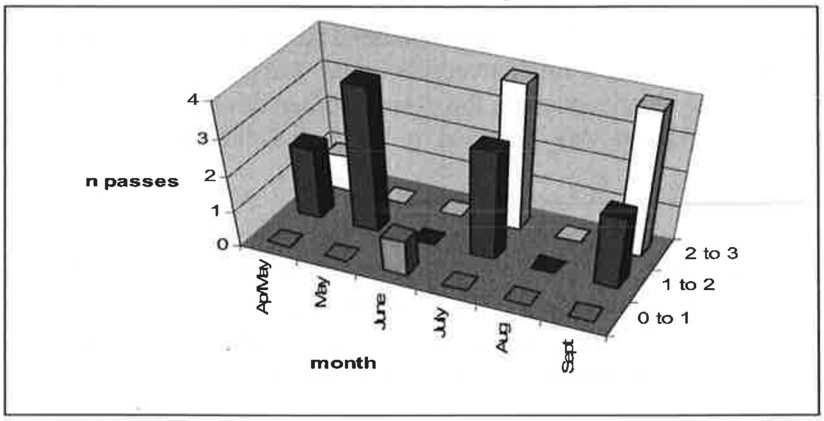


Figure 8: Lesser horseshoe passes by hour post sunset for Odd Down sites combined.

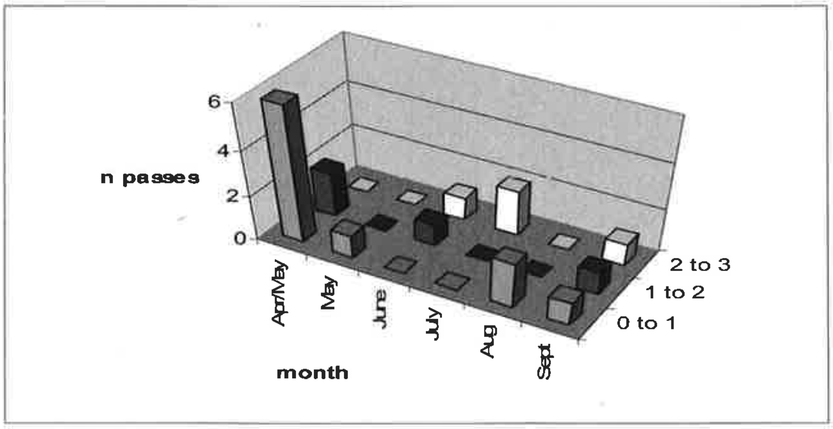


Figure 9: Lesser horseshoe passes by hour post sunset for West of Odd Down sites combined.

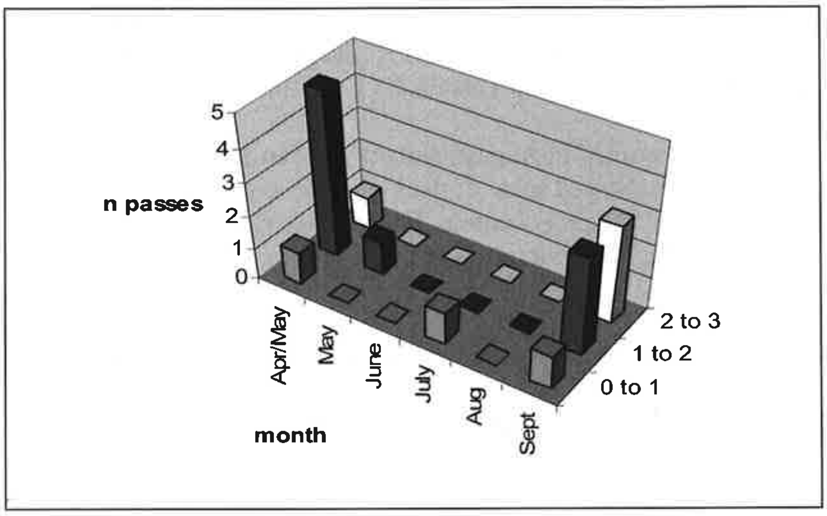
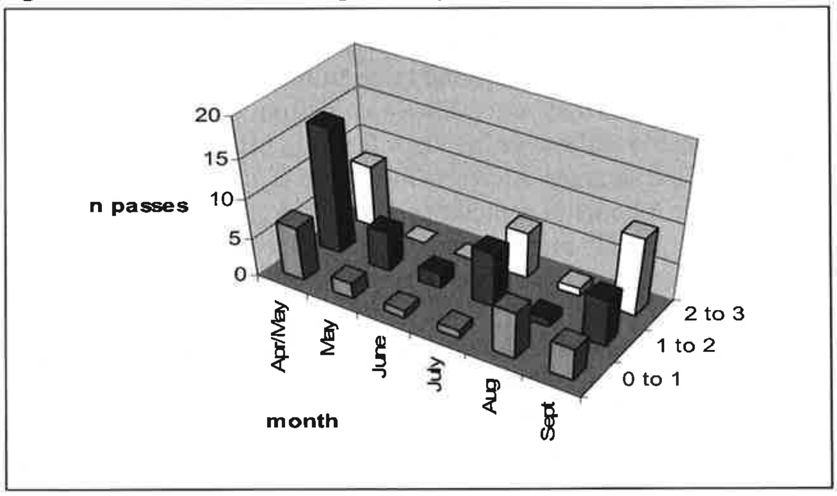


Figure 10: Lesser horseshoe passes by hour post sunset for all sites combined.



Comments on the Lesser horseshoe bat pass data

Figures 6 to 10 and Table 4.2, show the more limited data obtained for Lesser horseshoe bats (usually <5 passes per location per date and time slot). Their calls are weaker than those of Greater horseshoe bats, and so detection is more difficult (see comments in section 4.1 above). Data show no consistent pattern of time use at the four sites over the 6 months. The month sampled seems to have had the greatest impact at all sites.

At Horsecombe data showed no consistent pattern of monthly, or time period after dusk. Horsecombe Mine is known to be an important summer roost for these bats, with up to 40 present. However, by July 2008, GH bats had established their maternity roost there after exclusion from Byfield. The LH were effectively evicted by them. This agressive interaction between active summer horseshoe bats in roosts has been noted previously, especially with incubator chambers in the Shaft Complex. Possibly it also occurs at the foraging areas as well. There seems to be a strong tendency for LH bats to forage at Horsecombe later, and for much longer than GH. This is true of many other locations (compare Figures 5 and 10, and summaries in Table 4.2.3 below).

At Southstoke, no passes were recorded in August, and only one in June. In contrast the May, July and September months showed some of the highest levels of use in the second and third hours post sunset, when foraging occurred. Even in late April, several passes were recorded later after dusk. The daytime roosts of these bats are unknown. Possibly they come from Horsecombe Mine.

At Odd Down, passes were recorded for up to three hours in September, and for 2 hours in April and June, suggesting that the bats were mainly foraging. This was confirmed by frequent surveyor observations, especially within the young ash plantations with long grass that runs along the southern edge of the arable fields (see table 4.2.2 below).

Close examination of pass times in table 4.2.1 and visual observations by roving surveyors (table 4.2.2 below), provides no evidence for rapid commuting through Southstoke towards Odd Down soon after sunset, as was a feature of Greater horseshoe behaviour. Either the Lesser horseshoe bats detected came from local roosts, possibly in Southstoke Village or Sulis Manor, or they move slowly away from more distant roosts, foraging as they travel. Presumably the bats switch their foraging habitat locations as available prey change through the summer. At West Odd Down B, one or more Lesser horseshoe bats foraged for up to 3 hours in September over cattle-grazed pasture, and again in late April. These were the only months when this happened (table 4.2.1). It may be that a transitory spring and autumn roost is located nearby.

Tables 4.2.1 and 4.2.2 also show data that is not presented in the figures. It is worth noting that small numbers of Greater and Lesser horseshoe bat passes were recorded in the North of Odd Down location, but only by the static detectors. This reflects the results of Billington's Greater horseshoe radio-tracking study carried out in 2000. It suggests that the bats continue to forage in similar areas, and at similar levels.

No dietary evidence is available for this area, but the species is known to feed on small moths, nematoceran dipterans and dung flies.

Table 4.2.2 Horseshoe bat passes recorded by location, time and survey date by roving surveyors

Site name	29th Apr/ 1st May 2009	18/20th May 2009	24th June 2008 (sunset 21.30 hrs)	21/22 July 2008 (sunset 21.12 hrs)	8th/12th August 2008 (sunset 20.39 hrs)	8th September 2008 (sunset 19.40 hrs)	Totals
Horsecombe	1 @ 21.09 nr pond; 1 @ 21.16 nr pond; 1 @ 21.29 near stream gate. 1 @ 22.55 edge tennis court First 3 commuting Last foraging?	3 @ 21.50; 21.52; 22.08 commute nr steam gate 1 @ 21.57 nr pond 1 @ 22.55 nr buddleias foraging 2 @ 23.10; 23.18 foraging hedgerow	1 @ 23.05 1 @ 23.35 1 @ 00.02	2 @ 21.39; 21.41 commuting 1 @ 21.50 commuting 1 @ 22.35 foraging 2 @ 23.15 & 23.22 brief	1 @ 20.55 commuting along hedge 1 @ 21.33 foraging 1 @ 22.59 foraging 1 @ 22.15 foraging	1 @ 19.57 commute nr stream 1 @ 22.04 foraging 1 @ 22.25 foraging	22 GH 5 LH
Southstoke	1 @ 21.15 nr small pond 1 @ 22.40 tree-line on path. Foraging?	1 @ 22.25; hedgerow corner 1 @ 22.45 along hedge foraging		4 from 21.40 to 21.52 commuting out 1 @ 23.35 commuting back	2 @ 21.02 commute W on track	1 @ 20.10 on road commute 1 @ 20.15 commute	9 GH 4 LH
Odd Down	7 @ 21.15; 21.20; 21.22; 21.29; 21.50; 22.33; 22.47 all foraging in D/E ash plantations 3 @ 21.40; 21.44; 21.52; foraging edge ash & path nr	2 @ 21.58; 22.23 commuting along path B/C 7 @ 22.01; 22.10; 22.12; 22.23; 22.46; 22.50; 23.10 foraging in D & E ash	1 @ 22.05 foraging B 1 @ 22.20 foraging B/C 1 @ 22.38 commuti	2 @ 22.55 & 23.12 commuting path B/C 1 @ 22.37 3 @ 21.46; 21.49; 21.50 commuting path D	1 @ 21.03 not seen near C 1 @ 21.57 briefly near B 1 @ 21.05; not seen D/E 1 @ 21.35	1 @ 20.08 commuting path B/C 1 @ 20.19 commuting path near D 1 @	14 GH 34 LH

	B/C	plantation 6 @ 22.20; 22.32; 22.41; 22.47; 23.02; 23.11 in B/C ash plantation 1 @ 23.26 foraging over scrub	ng 1 @ 23.07 foraging B	1 @ 21.51 foraging near D 1 @ 23.18 foraging near C	foraging near E	19.58 foraging nr gate at B 1 @ 20.02 foraging near E 2 @ 20.06 foraging near C 2 @ 20.15 foraging near E	
W Odd Down	0 0	0 0	0 0	0 0	0 0	0 0	0 GH 0 LH
N Odd Down	0 0	0 0	0 0	0 0	0 0	0 0	0 GH 0 LH
Twerton	0 0	0 0	0 0	0 0	0 0	0 0	0 GH 0 LH
Total passes	**4 GH** **12 LH**	**7 GH** **18 LH**	**6 GH** **1 LH**	**17 GH** **2 LH**	**6 GH** **2 LH**	**5 GH** **8 LH**	**45 GH** **43 LH**

NB. Greater horseshoe bat passes are printed in black. Lesser horseshoe bat passes are printed in red. See Map2 for specific locations of passes at Odd Down and Southstoke over the whole study period.

Table 4.2.3 Horseshoe bat passes by time post sunset in locations by static systems

Location name (hour post dusk)	29 Apr 1st May 2009	18/20th May 2009	24/25th June	21/22nd July 2008	8th/12th Aug 2008	8th/13th Sept 2008	Totals Apr-Sept	Passes/hr Sampled
Horsecombe (1st)	7 GH	2 GH	2 GH	6 GH	2 GH	1 GH	**20 GH**	**0.69**
		1 LH			4 LH	1 LH	**6 LH**	**0.31**
Horsecombe (2nd)		1 GH	5 GH	2 GH	3 GH		**11 GH**	**0.63**
	4 LH			4 LH	1 LH		**9 LH**	**0.38**
Horsecombe (3rd)			1 GH		3 GH		**4 GH**	**0.25**
	5 LH				1 LH	2 LH	**8 LH**	**0.06**
Southstoke (1st)		1 GH	3 GH	9 GH	7 GH	10 GH	**30 GH**	**1.81**
			1 LH				**1 LH**	**0.06**
Southstoke (2nd)			1 GH	1 GH			**2 GH**	**0.13**
	2 LH	4 LH		3 LH		2 LH	**11 LH**	**0.31**
Southstoke (3rd)							**0 GH**	**0.0**
	1 LH			4 LH		4 LH	**9 LH**	**0.5**
Odd Down (1st)			2 GH		1 GH	1 GH	**4 GH**	**0.20**
	6 LH	1 LH			2 LH	1 LH	**10 LH**	**0.15**
Odd Down (2nd)		1 GH	2 GH			1 GH	**4 GH**	**0.15**
	2 LH		1 LH			1 LH	**4 LH**	**0.10**
Odd Down (3rd)				1 GH			**1 GH**	**0.05**
			1 LH	2 LH		1 LH	**4 LH**	**0.20**
W Odd Down (1st)							**0 GH**	**0.00**
	1 LH			1 LH		1 LH	**3 LH**	**0.18**
W Odd Down (2nd)	1 GH	1 GH		1 GH			**3 GH**	**0.09**
	5 LH	1 LH				3 LH	**9 LH**	**0.27**
W Odd Down (3rd)							**0 GH**	**0.00**
	1 LH					3 LH	**4 LH**	**0.27**
N Odd Down (1st)				1 GH			**1 GH**	**0.13**
						1 LH	**1 LH**	**0.13**
N Odd Down (2nd)							**0 GH**	**0.00**
	3 LH				1 LH		**4 LH**	**0.26**
N Odd Down (3rd)							**0 GH**	**0.00**
							0 LH	**0.00**
Twerton (3 hours)	1 LH	1 GH					**1 GH**	**003**
	3rd hr	2nd hr					**1 LH**	**0.03**
All sites (1st)	7 GH	3 GH	7 GH	16 GH	10 GH	12 GH	**55 GH**	**0.487**
	7 LH	2 LH	1 LH	1 LH	6 LH	4 LH	**21 LH**	**0.186**
All sites (2nd)	1 GH	4 GH	8 GH	4 GH	3 GH	1 GH	**21 GH**	**0.186**
	16 LH	5 LH	2 LH	7 LH	1 LH	6 LH	**37 LH**	**0.327**
All sites (3rd)	0 GH	0 GH	1 GH	1 GH	3 GH	0 GH	**5 GH**	**0.044**
	8 LH	0 LH	0 LH	6 LH	1 LH	10 LH	**25 LH**	**0.221**
Total horseshoe bat passes	**8 GH**	**7 GH**	**16 GH**	**21 GH**	**16 GH**	**13 GH**	**81 GH**	**0239**
	31 LH	**7 LH**	**3 LH**	**14 LH**	**9 LH**	**20 LH**	**84 LH**	**0.248**

NB. Greater horseshoe passes are in black. Lesser horseshoe passes are in red. Total 339 hours sampled (20 sites for 18 hours = 360 hours; less 5 x 3 for estimated calls in June, and 6 hours for stolen kit.).

4.3 Activity at specific static sites within locations

Tables 4.1.2 summarises, and 4.2.1 shows detailed data for specific sites. Examination of both, show that data are strongly influenced by the precise position chosen to sample. The most extreme example of this is shown by the four Southstoke sites (table 4.1.2). Site A showed the highest pass levels of all sites for both horseshoe bat species. Site D, which was located on the opposite side of the field, showed only a single LH pass. Sites B and C had very low levels of horseshoe bat calls. Data from table 4.2.1 for Southstoke A show that Greater horseshoe bat passes were limited to very brief time slots, as bats commuted past soon after sunset. Roving surveyor observations (table 4.2.2) revealed a few foraging LH, but only commuting GH bats. This apparent confliction with Billington's study, is probably due to the fact that all of the present study sites were located just below the crest of the hill. No sampling was done in the more favourable foraging habitat towards the bottom of the valley.

In contrast, Horsecombe sites showed more uniform pass rates for Greater horseshoe bats among the four sites sampled between June and September. This suggests that most of the Horsecombe Valley is used by them for most of the mid summer. It is the location that is closest to both Horsecombe and Byfield Mines. The former was used as an underground roost for breeding in summer 2008; the latter was the maternity roost site until exclusion at the end of summer 2007. Billington emphasised the importance of Horsecombe Valley to foraging Greater horseshoe bats in his 2000 study. The tables show that Lesser horseshoe bats made a more restricted use of the Horsecombe Valley sites. This may reflect their low level of use of Horsecombe Mine until September 2008, possibly due to GH aggression, as discussed above.

The absence of most GH bats from Horsecombe Mine from late April to late June in 2009 at an unknown roost elsewhere, may explain the very low levels of GH passes in those months, particularly at the more distant sites.

At Odd Down, where five sites were sampled, both horseshoe bat species were detected by static systems, and observed by surveyors, foraging at certain sites. Bats avoided the open arable field areas, but regularly used various parts of the young ash plantations that bordered these fields. This behaviour was not noted by Billington (2000), who reported little use by Greater horseshoe bats of the Odd Down area. In 2000 the ash plantation bordering the arable fields would have been very young, and probably lacked sufficient cover for foraging by horseshoe bats at that time. Since then the trees and undergrowth have developed considerably, providing cover and becoming a richer source of moths. Lesser horseshoe bats made frequent and prolonged use of particular sections of these plantations, especially in cool and and/or windy weather in Spring (see table 4.2.2; April and May). Suitable habitat features for generating moths present at site A, close to the Park and Ride, did not attract horseshoes to forage near the football clubhouse and floodlit pitch. Billington used maps were dated about

1975. The subsequent development of the area before 2000, with a housing development and the Park and Ride across the commuting link he showed, makes its regular use as a key link to West Odd Down and Englishcombe questionable. The present study showed no horseshoe bat use of Odd Down site A.

At West Odd Down, three sites were sampled. At site C, within Vernham Wood, only during heavy rain in April were Lesser horseshoe bat passes detected out of 5 sampling attempts. At site A at the woodland/grazed pasture edge, a single Greater horseshoe pass was detected in 6 attempts. At site B, in a similar woodland edge location, but well sheltered by overhanging tree canopy, 2 GH and 13 Lesser horseshoe calls were detected in 6 samples, most of them in April, May and September. These are months when dung insects are eaten. Billington (2000), also reported little use by Greater horseshoe bats of the West Odd Down area, but his study only covered the May/June and August periods.

At North Odd Down, two sites were sampled. Both Greater and Lesser horseshoe bat passes were detected over the 6 successful sampling attempts. Both sites were located at woodland/scrub edge, adjacent to the BMX cycle track some 250 metres apart. A single Greater horseshoe pass was detected in July at site A. Five Lesser horseshoe passes were detected at site B spread over April, August and September. Billington (2000), also reported little use by Greater horseshoe bats of the North Odd Down area. This agrees with the current findings.

At Twerton, two sites were sampled at the woodland/arable field edge. A single GH (at site B), and a single LH bat pass (at site A), were detected over the five successful sampling attempts at site A, and 6 at site B. Billington (2000), reported no use by Greater horseshoe bats of the Twerton, Seven Acre Wood area. This may suggest that the current methodology is superior at detecting use by foraging horseshoe bats, or that the bats have extended their habitat use since 2000. LH bats have been previously been recorded nearby at the Nature Reserve at Twerton during a summer bat walk.
Clearly the level of use of this location by horseshoe bats is very low.

Summary

The use of specific sites by Greater horseshoe bats, and hence their importance to them, is influenced by:

- Distance from their daytime roosts
- Proximity to urban areas with bright lights
- Availability of safe, sheltered commuting links from the roost to the foraging area
- Quality of foraging habitat, via its ability to generate the relevant insect prey required by the species at high levels for successful capture
- Topography, via its impact on the climatic conditions prevailing at sites.
- Climatic factors. Bats avoided open, exposed areas to the prevailing wind, and valley bottoms below steep slopes that showed rapid cooling in calm, clear conditions.

GH bats at Combe Down primarily used foraging areas that were within 1 km of their daytime roosts from April to late May, and again in September. The diet of GH during these months consist mainly of dung beetles, cockchafers and Tipulids. The distance to foraging areas increased to 4 km from late May to August, at a time when moths are mainly eaten.

Urban areas, especially those lit by bright lights were rarely used for foraging by GH bats, even when very close to the roost. However, these bats clearly have to cross quite broad roads that are lit by street lighting, such as Midford and Radstock Roads, to reach some of their favoured foraging areas.

Horseshoe bats favoured the use of habitats that generated many moths from late May to August at times when they commuted longer distances. They almost always avoided arable land for foraging. This confirms Duvergé's findings. The flat land at Odd Down is dominated by open arable fields. Most of it is of no value to horseshoe bats, either for commuting or foraging. However, the ash plantation strips at the southern edge of the arable fields are important foraging areas, especially for Lesser horseshoe bats, one pass of which was recorded over the edge of the arable field.

Bats did not always forage in the best-quality habitats for generating their preferred prey. This was the case whether the bats were foraging on dung beetles etc, or moths. These areas were sometimes less favoured due to climatic influences, either on insect flight, or wind speed. Below 12 °C many summer moths do not fly. Table 4.2.1 shows that such temperatures occurred in mid summer 2008, and again in April and May 2009, even at higher levels of the slopes. Wind is also a significant factor affecting bat foraging. When strong south-westerly winds occurred, bats sought the shelter of tall, dense trees or hedgerows.

There is no evidence supporting the current use of a slender commuting route from Odd Down through the Park and Ride area. Billington's maps were dated during the mid 1970s, before the Park and Ride, and a housing development were constructed. These obstacles to commuting GH bats have already been in place for many years. The present study indicates that GH bats commute along two routes. Firstly the pathway below the ridge top. Secondly along the pathway running south of Sulis Manor. Both run towards West Odd Down. Bats would have to cross the Radstock Road to reach the fields below at an unidentified point in mid summer, when they travel longer distances to forage.

4.4 Vesper bats recorded at the various sites

Table 4.4.1 shows a summary of all data obtained through the four months. No attempt was made to assess the relative levels of presence at the sites.

Table 4.4.1 Vesper bats recorded by site and survey date by static systems

Site name	April early May 2009	Late May 2009	Late June 2008	Late July 2008	Mid August 2008	Mid Sept. 2008	Summary (minimum n species)
Horsecombe A (beneath ash tree canopy near pond and streams)	**P45;** Myotis sp.; Nyctalus sp.	**P45; P55;** Myotis sp.	**P45; P55;** Myotis sp. including Natterer's?	**P45; P55;** Myotis sp. **Noctule**	**P45; P55;** Myotis sp.	**P45; P55;** Myotis sp.; **Serotine**	**P45; P55;** Myotis sp.; **Serotine; Noctule** (5)
Horsecombe B (far field, near gate to field with highland cattle)	**P55;** Myotis sp. **Serotine**	**P45;** Myotis sp. **Serotine; Noctule;**	**P45**	**P45; P55;** Myotis sp. Nyctalus sp.	**P45; P55; Serotine; Noctule**	**P45; P55;** Nyctalus sp; (Leislers?)	**P45; P55;** Myotis sp.; **Serotine; Noctule** (5)
Horsecombe C (high up grassy bank near buddleias)	**P45; P55;** Myotis sp.; **Leislers**	**P45;** Nyctalus sp.	**P45**	**P45; Noctule; Serotine**	**P45; P55;** Myotis sp.; **Serotine; Noctule**	**P45; P55; Serotine;** Nyctalus sp	**P45; P55;** Myotis sp.; **Serotine; Noctule; Leislers.** (6)
Horsecombe D (The Botley's sheep shed)	**P45;** Myotis sp. **Serotine**	**P45; P55;** Myotis sp.	No sample	**P45; P55;** Myotis sp. **Noctule**	**P45;** Myotis sp.; **Serotine**	**P45; P55;** Myotis sp.; Nyctalus sp.	**P45; P55;** Myotis sp.; **Serotine; Noctule** (5)
Southstoke A (under canopy near gap in tree-line connecting wooded blocks)	**P45;** Myotis sp. **Serotine**	**P45; P55;** Myotis sp. **Serotine; Leislers.**	**P45; P55;** Myotis sp. Nyctalus sp Leisler's? **BLE**	**P45;** Myotis sp.; **Serotine; Noctule**	**P45;** Myotis sp.; **Serotine; Noctule**	**P45; Serotine;** Myotis sp.; Nyctalus sp.	**P45; P55;** Myotis sp.; **Serotine; BLE; Noctule. Leislers.** (7)
Southstoke B (corner of hedge near new pond & maize field)	**P45; P55;** Myotis sp. **Serotine;** Nyctalus sp.	**P45; P55;** Myotis sp. **Serotine; Noctule; Leislers..**	**P45; P55;** Serotine?	**P45; P55; Noctule**	**P45; P55;** Myotis sp.; **Serotine**	**P55; Serotine;** Nyctalus sp (Leislers?)	**P45; P55;** Myotis sp.; **Serotine; Noctule. Leislers.** (6)
Southstoke C (in grassy glade amongst tall bushes)	**P45; P55;** Myotis sp. **Serotine;** Nyctalus sp.; **BLE**	**P45; P55;** Myotis sp.; **Leislers.**	No sample	**P55;** Myotis sp. **Serotine**	**P45; Serotine;** Nyctalus sp.	**P45; P55;** Myotis sp.; Nyctalus sp	**P45; P55;** Myotis sp.; **Serotine; BLE; Leislers.** (6)
Southstoke D (edge of field used for hay; beneath large overhanging tree canopy)	**P45; P55;** Myotis sp.; Nyctalus sp.	**P45; P55;** Myotis sp. **Serotine; Noctule; Leisters..**	No sample	**P45;** Myotis sp. **Noctule**	**P45; Serotine; Noctule**	**P45; P55;** Myotis sp.; **Noctule; Leislers**	**P45; P55;** Myotis sp.; **Serotine; Noctule, Leislers** (6)
Odd Down A (corner grassy field behind football club & near floodlit pitch)	Myotis sp.; Nyctalus sp	Myotis sp.; Nyctalus sp.	**P45; Noctule; Serotine**	**P55;** Myotis sp. **Noctule;** Serotine?	**P45; P55;** Myotis sp.; **Noctule**	**P55;** Myotis sp.	**P45; P55;** Myotis sp.; **Serotine; Noctule** (5)
Odd Down B (young ash plantation/arable.	**P45;** Myotis sp. **Serotine; Noctule.**	**P45; Leislers.**	**P45; P55;** Nyctalus 2 sp? Myotis	**P45; P55;** Myotis sp.	**P55;** Myotis sp.; **Noctule**	**P45; P55;** Myotis sp.; Nyctalus sp	**P45; P55;** Myotis sp.; **Serotine; Noctule; Leislers.**

Edge with tall trees)			sp.; **Serotine**	Nyctalus sp.			(6)
Odd Down C (arable field in sparse hedgerow with short trees)	**P45; P55;** Myotis sp. **Serotine.**	**P45; P55;** Myotis sp.; **Noctule.**	No sample	**P45;** Nyctalus sp.	**P45;** Myotis sp.; **Noctule**	**P45; P55; Serotine;** Nyctalus sp	**P45; P55;** Myotis sp.; **Serotine;** **Noctule** (5)
Odd Down D (10m from young ash plantation in arable bean field. 10m from hedge with tall trees)	**P45; P55;** Myotis sp.; Nyctalus sp	**P45; P55; Serotine; Leislers.**	No sample	**P45; P55;** Myotis sp. **Serotine**	**P45; P55; Noctule**	**P45; P55;** Myotis sp.; **Leislers**	**P45; P55;** Myotis sp.; **Serotine; Noctule; Leislers.** (6)
Odd Down E (at edge of young ash plantation and arable field with beans)	**P45; Noctule.**	**P45;** Myotis sp. **Noctule.**	No sample	Myotis sp.	**P45;** Myotis sp.; **Noctule**	**P45; P55;** Myotis sp.; **Serotine; BLE.**	**P45; P55;** Myotis sp.; **Serotine; Noctule; BLE** (6)
W Odd Down A (wood/pasture edge in open corner)	**P45; P55;** Myotis sp. **Serotine?; Leislers.**	**P45;** Myotis sp. **Noctule; Leislers.**	**P45; Serotine**	**P45;** Myotis sp. **Noctule;** Leislers?	**P45; Serotine**	**P45; P55;** Myotis sp.; **Serotine; Noctule; BLE.**	**P45; P55;** Myotis sp.; **Serotine; BLE. Noctule; Leislers.** (7)
W Odd Down B (wood/pasture edge under overhang)	**P45;** Myotis sp.; **Leislers**	**P45; P55;** Myotis sp.; **Leislers.**	**P45**	**P45; P55;** Myotis sp.	**P45; P55;** Myotis sp.; **Serotine; Noctule**	**P45; P55;** Myotis sp.; Nyctalus sp. (Noctule?)	**P45; P55;** Myotis sp.; **Serotine; Noctule; Leislers.** (6)
W Odd Down C (inside deciduous wood near stream)	**P45;** Myotis sp.; **Leislers**	Nyctalus sp.	No sample	Sony stolen at Twerton	Nyctalus sp.	**P45;** Myotis sp.; **Serotine;** Nyctalus sp. (Noctule?)	**P45; P55;** Myotis sp.; **Serotine; Leislers..** (5)
N Odd Down A (scrubland edge near tall deciduous wood)	**P45; P55;** Myotis sp. **Serotine; BLE**	**Noctule.**	Nyctalus sp; **Serotine**	**P45;** Myotis sp.; **Noctule;** Serotine?	**P45; P55**	**P45; P55;** Myotis sp.; Nyctalus sp. (Leislers?)	**P45; P55;** Myotis sp.; **Serotine; BLE; Noctule** (6)
N Odd Down B (scrubland edge near sparse deciduous wood & BMX track)	**P45;** Myotis sp.	**P45;** Myotis sp.; Nyctalus sp.	Myotis sp.	**P45;** Myotis sp. **Serotine; BLE**	**P45; P55; Serotine**	**P45; P55;** Myotis sp.; Nyctalus sp.	**P45; P55;** Myotis sp.; **Serotine; BLE; Noctule.** (6)
Twerton A (edge of deciduous woodland within arable land)	**P45; P55;** Myotis sp. **Serotine; Noctule.**	**P45; P55; Noctule;**	**P45;** Nyctalus sp.; Myotis sp.	Kit stolen	**P45; P55;** Myotis sp.; **Serotine**	**P55;** Myotis sp.	**P45; P55;** Myotis sp.; **Serotine; Noctule.** (5)
Twerton B (edge of deciduous woodland within arable land)	**P45; P55; Noctule.**	**P45; P55;** Nyctalus sp.	**P45;** Nyctalus sp.	**P45; P55; Noctule; Serotine;** BLE?	**P45; P55;** Myotis sp.; Nyctalus sp.	**P45; P55;** Nyctalus sp.; Serotine?	**P45; P55;** Myotis sp.; **Serotine; Noctule** (5)
Total Vesper bat types	**P45; P55;** Myotis sp. **Serotine; BLE; Noctule; Leislers.** (min. 7 sp.)	**P45; P55;** Myotis sp. **Serotine; Noctule; Leislers.** (min 6 sp.)	**P45; P55;** Myotis sp. Nyctalus sp.; **Serotine; BLE** (min. 6 sp.)	**P45; P55;** Nyctalus sp.; Myotis sp. **Serotine; B.L.E** (min. 6 sp.)	**P45; P55;** Myotis sp.; **Noctule; Serotine** (min. 6 sp.)	**P45; P55;** Myotis sp.; **Noctule; Leislers; Serotine; BLE** (min. 7 sp.)	**P45; P55;** Myotis sp.; **Serotine; Noctule; Leislers; BLE.** (min. 7 species, but probably 10 with common Myotis bats)

Key: P45 = Common pipistrelle; P55 = Soprano pipistrelle; BLE. = Brown long-eared bat. Normal type names are genera, not species. Bold names are species that have been definitely recognised from their calls. Doubtful identification has been ignored in column 6 totals.

Comments

A minimum of 6 vesper bat species occurred at all 20 sampled sites combined over the six months of sampling. Specific sites showed different species/types of bats, even when quite close to each other. Totals were obtained by counting 'Myotis sp.'as a single species. This number is a minimum, since at least 4 Myotis bats are commonly found hibernating in the Combe Down Mines in winter. They are Daubenton's bat, Natterer's bat, Whiskered bat and Brandt's bat. The endangered Bechstein's bat is also found there. Hence there were likely to be at least 9 vesper bat species foraging in the whole study area, and possibly 10, if Bechstein's bat is included.

The total number of vesper bat types recorded in each month varied only slightly from month to month, and among site totals. Most variation was among different months at the same site.

The Tumps area of North Odd Down, surrounded by urban development, had at least 6 vesper bat species. This may be because it is a substantial area, containing mixed habitats, including deciduous woodland, amenity grassland and extensive scrub.

The Twerton area, where a substantial deciduous woodland was surrounded on all sides by arable cereal fields, also had a minimum of 5 vesper bat species. Either the lack of significant linear features linking the woodland edge to more favourable habitats, does not prevent these bats from crossing the fields to forage around the woodland, or they roost within the woodland.

5. STATUS OF BATS REVEALED BY DUSK SURVEYS

Table 5.1 summarises the current status of the bats identified by the surveys. Data summarised and discussed above.

Table 5.1 Distribution and conservation status of bats known, or believed to forage over Bath Urban study locations. From Hutson, 1993, Action Plan for the Conservation of bats in the United Kingdom, updated by subsequent review in 2007.

Common name	Species name	Distribution/Status	IUCN Status
Greater horseshoe bat	***Rhinolophus ferrumequinum***	**Restricted/Rare**	**Endangered**
Lesser horseshoe bat	***Rhinolophus hipposideros***	**Restricted/Rare**	**Endangered**
Natterer's bat	*Myotis nattereri*	Widespread/Frequent	Lower risk
Daubenton's bat	*Myotis daubentonii*	Widespread/Common	Lower risk
Whiskered bat	*Myotis mystacinus*	Widespread/Scarce	Lower risk
Brandt's bat	*Myotis brandti*	Widespread/Scarce	Lower risk
Soprano pipistrelle bat	*Pipistrellus pygmaeus*	Widespread/Common	Not listed
Common pipistrelle bat	*Pipistrellus pipistrellus*	Widespread/Common	Least concern
Brown long-eared bat	***Plecotus auritus***	**Widespread/Common**	**Lower risk**
Leisler's bat	*Nyctalus leisleri*	Widespread/Scarce	Near threatened
Noctule bat	*Nyctalus noctula*	Widespread/Common	Lower risk

Bold species are on the UK BAP list, but the Brown Long-eared bat has not yet had its action plan produced.

6. SUMMARY OF SURVEY FINDINGS

1) Nine bat species were shown by surveyors and static systems to forage over the whole study area. Since 4 common species were likely to be represented among, the Myotis calls, the true number is probably 12 species. They were Greater and Lesser horseshoe bats; Common and Soprano pipistrelles; probably at least four Myotis species – Daubenton's, Natterer's, Whiskered and Brandt's bats; Noctule and Leislers; Brown long-eared bat and Serotine. Bechstein's bat is also known to hibernate in the Combe Down mines. Their calls cannot easily be distinguished from Natterer's in the field, so their presence was not verified by the methods used.

2) Static systems were more effective at detecting horseshoe bat calls, and other rare species, than roving surveyors. The data collected were quantitative. This is normally the case. Roving surveyors, however, provided valuable observations of what the horseshoe bats were doing in other parts of the locations. Their data were only qualitative.

3) Use of the specified locations within the study area by Greater horseshoe bats is variable according to site and location. Distance from the daytime roost, and month of study are key factors, as are quality of habitat. Habitat vegetation influences insect prey availability, and habitat structure affects the willingness of these bats to forage in an area.

4) Horsecombe Vale was by far the most important foraging area over the whole period from April to September. This confirms Billington's radio-tracking findings from 2000. It is well used for foraging for the first 3 hours of the night when moths were mainly eaten from June to August, and the bats used Horsescombe Mine as a maternity roost in daytime. Activity concentrated in the first hour or two after sunset. It was also the main foraging area used in Spring, probably because it is very close to the mine, which was used as the main hibernation site for the species during winter 2008/9. The absence of significant grazing regimes in the Vale seems to be a key factor in the poor foraging success of the Combe Down colony in spring. This leads to late births in most summers.

5) The Southstoke sites sampled seem to be located primarily along key commuting routes to Odd Down and beyond, soon after dusk. They probably foraged on moths generated by the overgrown grasslands, developing scrubland and young ash plantations. The latter were not identified by Billington as important areas. This is probably because the plantations were very young in 2000.

6) Vernham Wood was not an important foraging area, agreeing with Billington's findings. The present study did not support the existence of the key commuting link between Sulis Manor and Vernham Wood. Static data and surveyor observations confirmed that they commute along two routes to the south when travelling westwards.

7) The Tumps and Twerton locations were very rarely used by Greater horseshoe bats in any month.

8) Use of the specified locations by Lesser horseshoe bats is also variable according to site, location and month of study. Lesser horseshoe bats foraged for longer periods than Greater horseshoe bats, and generally later after sunset. They may occupy more local roost sites than the Greater horseshoe bats, since their passes were recorded over a much more widespread area, despite their lower commuting distances.

9) Both horseshoe bats avoided using the field corner behind the clubhouse at Odd Down, despite it being a good habitat for moth generation. This was probably due to the bright floodlights used for night matches by the Football Club, and/or the Park and Ride (see 5 above).

10) At Odd Down, Lesser horseshoe bats primarily used the non-arable areas, especially the scrub near the top of the ridge, and the young ash plantation strips where moths seemed abundant in mid summer.

11) Only 2 horseshoe bats, one GH & 1 LH, were detected foraging around the woodland at Twerton. This may be due to its long distance from Combe Down, and/or the dominance of the surrounding arable land.

12) Horseshoe bats preferential use of sheltered areas at the top of the ridges for foraging at Southstoke and Odd Down, rather than in the open valleys below, may be linked to their exposure to westerly winds on windy nights, and rapid temperature falls after dusk on calm nights. Temperatures fall too low for moths to fly on calm, clear nights, even in mid summer.

13) The habitats and sites used by Greater horseshoe bats, changed as their diet switched from moths to primarily dung beetles in September. The situation was reversed in Spring.

14) At least 7 and probably 10 species of vesper bats foraged over the whole study area. Even the poorest sites, such those at Twerton, had a minimum of 6 species using them.

7. RECOMMENDATIONS

In order of priority, the security of the horseshoe bat populations should be aided by implementing the following habitat recommendations:

1) Horsecombe Vale, since it is within 1 km of Byfield and Horsecombe Mines, is the crucial foraging area for the GH colony, especially when juveniles begin to forage. This is true in every month of the year, but it is especially important from September to mid May, before these bats travel longer distances to forage. From late May to August it provides very good habitat for generating moths, but these are also available at other, more distant locations. The land should be managed to ensure that it is capable of generating substantial levels of dung beetles (*Aphodius* in summer, and *Geotrupes* from November to April). This requires the creation of significant grazed habitat close to the mines. Grazers can be sheep or cattle in winter and spring, and cattle from mid July to October. More distant parts can be used to generate large moth populations.

2) Retain & improve commuting links, especially at key points linking important foraging areas among the Horsecome, Southstoke, Odd Down, Combe Hay, Midford and Tucking Mill.

3) Safeguard and/or enhance the important foraging areas within a 3 to 4 km range of Byfield, especially within Southstoke, Combe Hay, Midford and Tucking Mill. This may best be achieved through agri-support schemes. A key land management issue for all areas, as at Horsecombe, is the problem of successional changes that convert short grassland into long grass, then scrub, and finally dense woodland. Ensure that a mixed grazed ecosystem, with areas of long grass with shrubs and/or trees in a parkland setting is kept.

4) At Odd Down, which is also within 3 – 4 km of Byfield, retain the ash plantations have developed over 12 years or so to become a favoured foraging area for horseshoe bats. Ensure that succession towards dense woodland does not progress too far, and suppress the growth of long grass. Pollarding the trees may be the long-term answer.

5) Plant more tree-lines and thick hedgerows across large open grazed fields to provide breaks against prevailing winds, and additional commuting routes. Create a patchwork of small fields, using the system of 'ley farming' that rotated field use as described by Panes (2005), over a 10 to 13 year cycle.

6) Create broad grassy rides through existing large woodland blocks to increase available sheltered woodland edge habitat that encourage all bats to forage within them.

7) Create commuting crossing points further afield, such as near the Park & Ride to allow access to more distant foraging locations..

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We also thank Mr M Russell for permission to use the football club's car park near Radstock Road Park and Ride during surveys.

Finally we acknowledge the assistance of Dr Karen Renshaw in providing initial advice and maps for planning the surveys and this report.

9. REFERENCES

1 Bat Pro Ltd (2001) Combe Down Bat Surveys and Assessments 2000: Part of the Candidate Special Area of Conservation. *Report to Bath and North East Somerset Council*

2 Bat Pro Ltd (2004) Combe Down Mines: Greater Horseshoe Bat Diet Report from October 2001 to September 2003: Part of the Candidate Special Area of Conservation. *Report to Bath and North East Somerset Council*

3 Billington, G. (2000) Combe Down Greater Horseshoe Bats: radio tracking study. *Report commissioned by Bat Pro Ltd on behalf of Bath and North East Somerset Council*

4 Duvergé, P.L (1996): Foraging activity, habitat use, development of juveniles, and diet of the greater horseshoe bat (*Rhinolophus ferrumequinum* - Schreber 1774) in south-west England. Unpublished Ph.D. Thesis. University of Bristol.

5 Mitchell-Jones, A.J. (2004) Bat Mitigation Guidelines. *English Nature*

6 Ransome, R.D. (1989) Population changes of Greater horseshoe bats studied near Bristol over the past twenty-six years. *Biol. J. Linn. Soc.* **38**, 71-82.

5 Ransome, R.D. (1996) The management of feeding areas for greater horseshoe bats. *English Nature Research Reports* **No. 174**, 1-74.

6 Ransome, R.D. (1997) The management of greater horseshoe bat feeding areas to enhance population levels. *English Nature Research Reports* **No. 241**, 1-63.

8 Ransome, R.D. (1998a) The impact of maternity roost conditions on populations of greater horseshoe bats. *English Nature Research Reports* **No. 292**, 1-80.

9 Ransome, R.D. (2002) Winter feeding studies on greater horseshoe bats. *English Nature Research Reports,* **No. 449,** 1-47.

10 Schofield, H.W. (1996) The ecology and conservation biology of *Rhinolophus hipposideros,* the lesser horseshoe bat. Unpublished Ph.D. thesis. University of Aberdeen.

11. Stanes, R. (2005) Old Farming Days – Life on the land in Devon and Cornwall. Halsgrove, Tiverton, Devon. 160 pp.

12 Williams, C.A. (2001) The winter ecology of *Rhinolophus hipposideros,* the lesser horseshoe bat. Unpublished Ph.D. Thesis. The Open University.

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Ref: BatPro Final Report Bath Urban Surveys 09 (v4)

APPENDIX 1: Bath Urban Dusk Bat Surveys

Photographs of static sites used in 2008. Most taken in June, with some in December.

Horsecombe A – static system placed at red file position. Stream & pool off right.

Horsecombe B – static system placed in tall grassland near hawthorn bushes.

Horsecombe C – static system placed in tall grassland high on bank near bushes.

Horsecombe D – static system placed near sheep buildings on grassy bank.

Southstoke A – static system placed beneath canopy cover near gap in tree line

Southstoke B – static system placed close to trees behind fence post

Southstoke C – static system placed in glade centre surrounded by bushes and small trees

Southstoke D – static system placed beneath large tree on extreme left across field.

Southstoke D – close up of static system position beneath large ash tree

Odd Down A – static system placed in tall grass close to trees in field corner

Odd Down B – static system placed in small grassy clearing within plantation of young trees

Odd Down C – static system placed on small grassy area beneath the ash tree in sparse hedge between two arable bean fields

Odd Down D – distant view of static system location 15 metres from corner of bean field near public path along woodland edge (front) and young ash plantation (left)

Odd Down D – static system on stool placed in bean field corner showing camouflage cover used in vulnerable locations

Odd Down E – static system placed in centre of the grassy area of young ash plantation adjacent to bean field

Vernham sites A and C. Distant view across field with Vernham wood behind. A is on the extreme right edge; C is inside the woodland edge.

Vernham site A. Close up of sheltered site below the cattle-grazed field before electric fencing was erected.

Vernham site B. Sheltered by overhanging branches. Protected from cattle by electric fence.

Vernham site C. Placed within wood across stream. Protected from cattle by fence.

Tumps A – static system placed close to trees on left. BMX track in distance.

Tumps B – static system placed within bushes on right of path. BMX track on left.

Twerton A and B – static systems placed beneath tree overhangs on right far apart.

Twerton A – static system placed beneath tree overhangs. View towards wood from field.

APPENDIX 2

BRIEF REVIEW OF LAURENT DUVERGE'S THESIS REGARDING FORAGING & HABITAT USE BY GREATER HORSESHOE BATS

Duvergé, P.L 1996: Foraging activity, habitat use, development of juveniles, and diet of the greater horseshoe bat (*Rhinolophus ferrumequinum* - Schreber 1774) in south-west England. Unpublished Ph.D. Thesis. University of Bristol.

This Thesis summarises what is probably the most detailed, complex, study of GH habitat use ever carried out. It covered virtually all of the 'summer' activity period from late April to late October. Only late pregnant bats were not tagged.

He used compositional analysis to determine whether bats selected their foraging habitat types.

Unfortunately much of his data has never been published.

Sites:

Three lowland UK sites studied: Brockley/Kingswood/Clapton south of Bristol; Woodchester Mansion/Park & Iford Manor. All sites are not far from Combe Down.

He carried out R-T studies in 3 sessions over 3 summers from 1991 to 1993.

Sessions:

Spring – from late April (28th) to mid June (14th)

Summer – from mid July (16th) to mid September (16th)

Autumn – from 15th September to 25th October

Total 67 individual bats tagged over this period.

Results

He confirmed that the bats made seasonal **use of woodland and pasture**. In spring they forage **within woodland**, especially **ancient, semi-natural deciduous ones (ASNW)**, and in late summer they move to **permanent grazed pastures**, as shown by Jones & Morton (1992).
Tracked mother/young pairs at Woodchester and showed they foraged independently (Ransome 1996 showed they ate different diets).

He defined a **foraging area** as an area within which a bat may spend some time on these activities (about 30 minutes or longer), and a **foraging bout** as a period of time during which foraging occurs (**usually from one to 2.5 hours**). Overall, of 226 foraging sites identified, 38 were in ASNW & 86 in cattle-grazed pastures (PCG) in a total of 13 habitat types. If all six of his woodland types are combined, 33% of the foraging areas were in some type of woodland. If all types of grazed grasslands are combined, then 63% of the foraging areas were in grazed areas adjacent to woodland or thick hedgerows.

Only 4.4% of foraging areas were located in urban (U), scrub or arable (AR) areas.

Bouts are separated from other bouts by a period of resting during which rapid digestion and egestion of faeces occurs, permitting the consumption of more food. Inter-bout periods may be spent in daytime roosts, or in temporary **night roosts**.

These bats have a consistent specialized hunting technique, and use foraging areas with a similar structure. They travel quickly (**commute**) from the roost to a foraging area, flying about **1 to 2 metres above grassland**, along the side of linear features such as tall hedgerows and woodland edge.

NB bats were rarely observed directly commuting, or foraging. These activities were largely deduced from radio signal characteristics. However, in some instances bats tolerated him being closer than 50m, and he was able to observe detailed foraging behaviour.

In his study sites, summer foraging areas of adults were located within **3-4 km** of maternity roosts, and the mean adult range in one extensive study was about **2.2 km**. About 75% of the foraging areas are located within the mean adult range. Whatever the commuting distance needed to reach foraging areas, bats flew about 21-25 km total distance in a night. Two individuals were shown to fly 51 and 35 km in a night respectively.

Foraging areas of adults in spring and autumn are much closer to the roost, usually **< 1 km,** than in mid summer (August due to inability to track in July lactation period). Also Juveniles forage at distances **<0.75 km** when they first start to forage when aged about 30 days.

Within a **foraging area**, which averages **6-7 hectares**, bats mainly use localized favoured spots or core areas of **0.35 hectares** average size (about a 19m by 19m plot). They hunt within them, mainly by either **hawking** along the edges of linear habitat features (usually **within 5 metres** of woodland edge or hedgerows), or by **perching on a twig some 2 metres from the ground** and scanning for passing prey which they intercept, using their long echolocation pulses. Selected twigs are bare, and in the range 5-10mm diameter. They are often created by cattle kept in fields, with adjacent thick and tall hedgerows or deciduous woodland, which are permanently grazed.

Most prey are caught close to the ground, possibly because they fly slower as they take off or land. Most prey either emerge from the soil beneath short grassland; oviposit in it, or feed on the dung of domestic animals. Besides hawking and perch-feeding, **gleaning of prey** from vegetation can occur, during which the bat may even hover.

The **bare twigs used for perching** may be selected for their safety from predators, as well as their size and position relative to good prey-capture opportunities. Another aspect is cover. Besides protecting the bat from predator attacks, the location of a perch may also shelter it during rainfall. Tall hedgerows, or woodland edge delimiting pastures grazed by cattle, tend to be favoured core foraging areas. Cattle graze the lower hedge levels, creating an umbrella shape and bare twigs at about 2 metres height, which the bats find attractive for perching. They also generate high concentrations of dung close to hedges when they rest to ruminate in the shelter provided by a hedge. The dung attracts concentrations of nocturnal dung beetles as potential prey.

After a successful prey capture, the perch may also be used whilst a large prey item is dismembered, and the less digestible parts discarded.

These bats may forage **once, twice or three times a night** according to season and reproductive class. Normally adults forage for about 3 hours each night, but the time may be lengthened or shortened by sex, reproductive condition and climatic factors. Foraging for **most members of a colony concentrates soon after dusk** when conditions are usually most favourable for the flight of their prey.

A bat does not spend the whole of a night's foraging in a single foraging area, but frequently switches to other areas. Adult bats normally use between 2 and 11 different foraging areas in a single night. There is currently no evidence for foraging areas being treated as territories belonging to a specific individual or group of bats. (But Rossiter subsequently found associations between related older female bats that shared night roosts as well).

Foraging area switching behaviour may also be a predator-avoidance strategy, or just an attempt at finding more concentrated prey sources.
Foraging ranges found at all three roosts of his roosts were usually less than 4km. This distance is exceeded at other sites in the UK, especially ones in Wales (Stebbings 1982, Duvergé pers. comm.) and Berry Head, Devon (Robinson *et al* 2000).

APPENDIX 3 – JUSTIFICATION OF BAT PRO'S DUSK SURVEY METHODOLOGY FOR BAT HABITAT USE

Bat Pro's methodology is not the standard one recommended by the Bat Conservation Trust and NE. The use of time-expansion detectors has been criticised, because they are less sensitive than heterodyne detectors which are usually used when walking transect routes, and so inferior to them for dusk surveys to assess bat species.

Bat Pro Limited's response

1. Bat Pro Ltd staff have been using a **combination** of static and roving (transect) surveys for bats commercially for some 9 years. This includes several major projects.

2. Dr Roger Ransome has had considerable input into the design of the time-expansion (TE) detectors developed by David Bale over the past 7 years. Their use has been particularly beneficial in the Combe Down Stabilisation Project (nr Bath), where they are used to monitor bat activity levels whilst underground works proceed.

3. We do not agree that heterodyne bat detectors used on transect surveys provide better qualititative, or quantitative, data than static time-expansion detector surveys. Division frequency data is less acceptable to the scientific community than time-expansion data for species identification, but has some advantages, particularly costs.

4. We do not deny that a (cheaper) heterodyne bat detector is much more sensitive than an (expensive) time-expansion detector at detecting the particular bat call that it is tuned for. However, it is worth spending the extra money on purchasing TE detectors for several, very good, practical reasons. Firstly, and crucially, they sample all frequencies from about 11 kHz to 150 kHz **simultaneously**, unlike heterodyne detectors that have to be tuned up or down constantly to be able to listen to all possible bat species flying nearby. Some species may have moved away before their calls are tuned into. The surveyor cannot be tempted into just listening to the easily seen species like the noctule and pipistrelles. Hence TE detectors do not miss out the **whole species range** that is flying in the area, provided each comes close enough to the microphone. Secondly, heterodyne bat detectors give off a constant hiss that makes it **impossible to use as part of a static system** involving a voice-activated digital recorder to store the data, even if only one narrow frequency range was sufficient for the survey objectives. TE detectors are absolutely quiet until an ultrasonic sound is received. David Bale's Tranquility series sample a fixed time slot (40ms, 160ms, 320ms, & 1280ms – according to the model), and play it back straight away automatically. No observer manipulations are needed – hence when used with a voice-operated digital recorder, bat activity can be monitored without any observer influence. Thirdly, by standardising several TE detector system's settings (and keeping them constant) and placing them in the same site facing the same direction

each time, it is possible to compare data from different dates, or years quantitatively.

5. We agree that static TE detector systems are not perfect to determine all aspects of bat use of a large area. It is always better to use a combination of static and roving (transect) TE detectors, as is our policy. The latter allows many more sites to be sampled on a given night, and notes to be taken of what the bats are doing at the various locations, **if they can be seen**. However, the data collected from using both methods, despite the sensitivity argument, **strongly favours the static TE systems as both a better qualitative and especially, a quantitative method**. In four major studies, the static TE systems have detected more species (from 2 to 4 more species, including **brown long-eared bats** that have very weak calls), and many times more calls than simultaneous roving TE transects have in the same areas.

6. It is often stated that detector surveys should not be used for habitat surveys of the horseshoe bats. The reasoning behind this is based on the directionality of their calls, and their weak signals. This is a mistake. TE detectors with VOR recorders are perfectly suitable to locate commuting routes and foraging areas of both species. As the static systems are placed on a 1m high stool, they are perfectly placed to pick up their calls, provided the bats arrive from the direction they are facing.

7. Bat Pro Ltd has spent over £16,000 in the past 4 years on TE detectors for carrying out bat foraging surveys that make efficient use of staff time, and generate high-quality data that is stored, and available for subsequent examination. Our surveys are specifically designed to meet the objectives agreed with the client, and the likely need to provide evidence to Statutory Bodies and others.

8. The dual methodology used by Bat Pro Ltd has been developed with advice from Professor Gareth Jones, and Dr Nancy Vaughan of Bristol University. Dr Roger Ransome, Managing Director of Bat Pro Ltd., and Research Fellow of the University, has been responsible for developing the static systems based on David Bale's detectors. English Nature's officers have commented favourably on the reports submitted to them, and the bat call data presented.

APPENDIX 3

TYPES OF ULTRASONIC RECEIVERS OR BAT DETECTORS

Most British bat species can be identified from their echolocation calls using an appropriate bat detector. This is usually the preferred method of identification to catching bats, as capture involves either mist nets or harp traps. These methods can be quite stressful for bats, and are only usually suitable for studies at local sites, such as roost entrances. A summary of the detector types available is provided below.

Bat echolocation calls (subsequently usually referred to merely as calls) can vary from 15 kHz to 120 kHz in frequency. Calls of some bat species are fairly constant in frequency, whereas others exhibit a large frequency range. There are three main types of detector available at the time these surveys were undertaken. They are described as heterodyne, division frequency, and time-expansion according to the method used to make bat calls audible to humans (upper range 20 kHz in a person with perfect hearing; less than 8kHz in those that have suffered hearing damage).

Each type of detector has its own advantages and disadvantages. There is no such thing as the perfect detector. Rather there are 'horses for courses'.

Heterodyne detectors are cheapest, very sensitive, and work in real time. They create an audible sound to humans by interfering with the incoming frequencies to generate 'beat' notes. They cannot be used to listen to all call frequencies simultaneously, and the sounds cannot be used for sonogram analysis. The surveyor has to decide what frequency to tune to beforehand. If a mistake is made, other species will be missed. In practice, the tuning covers a range of frequencies, usually ± 10 kHz, so several species may be heard at the same frequency.

Use: very good for roost exit counts, or field surveys for single species.

Division frequency detectors are more expensive, sensitive, use real time and can detect multiple call frequencies simultaneously. They usually divide the frequency of the incoming call by 10, retaining the peak energy frequency which can be stored for sonogram analysis. Most of the incoming call characteristics that help with sonogram analysis are lost, however. This means the memory use is very low. The Anabat has a very good system for long-term static monitoring, and software to count calls by type.

Use: best for long-term monitoring of dry roosts and habitats for bat activity.

Time-expansion detectors are the most expensive, less sensitive, and calls are stored directly to an internal memory. All characteristics of the calls are stored, so memory demand is high. The call is later replayed either 10 or 32 times slower than when it was recorded to make it audible to humans. For example, a 100 kHz call would be 10 kHz if time-expanded by 10 (100/10). If divided by 32 it would be 3 kHz (100/32). Both sounds are audible, especially the latter one. If exported to an external memory store, then time is lost whilst the call is replayed. TE calls produce stored calls of the highest quality for sonogram analysis such as Batsound software (Petterssen Elektronik). TE detectors were used in these surveys, despite their extra cost, lower sensitivity, and the potential loss of calls whilst stored data are being replayed, since species identification from calls was a key objective. Furthermore, the static system used generates valuable quantitative data, since the Sony digital recorder generates the exact time of calls. It also allows call analysis in time slots (15 minutes; half hour; one hour etc as required). This is often very important to meet other survey objectives. The Eco Mega TE detector (made by David Bale) is the only detector with water-splash rejection facility. David's cheaper Tranquility Transect, linked to a Sony voice-activated digital recorder (P520), is suitable for dusk surveys in dry conditions.

Use: TE detectors provide the best data for species recognition. Where surveys are required to identify bat types present simultaneously, they are the best ones to use. The Eco Mega is the only detector that can be used in wet underground sites for automatic recording for long periods (up to 2 weeks). Tranquility Transect static system has a 12 hour limit, due to Sony battery problems.

NB The greatest problem with the use of bat calls made by foraging bats to identify species occurs with the genera *Myotis* and *Nyctalus.*

There are five UK *Myotis* species – *Myotis daubentoni; M. mystacinus; M. brandti; M. nattereri & M. bechsteini.* Their calls can be divided into two groups after sonogram analysis:

The Natterer's/Bechstein's group that has calls that start at about 120 kHz and sweep down to below 30 kHz.

The Daubenton's/Whiskered/Brandt's bats that has calls that start below 100 kHz and sweep down to about 35 kHz.

There are two UK *Nyctalus species – Nyctalus noctula & N. leisleri.* Their calls have overlapping peak frequencies, but Noctule calls are usually of a lower frequency (about 16-18 kHz) than Leisler's calls (about 22-24 kHz). Calls around 20 kHz are impossible to assign to one or other species. However, if TE recordings are made, the interpulse interval can be calculated & calls identified to species if the bat is in open space in the search phase of foraging. Noctules have about 300 ms between calls, whereas Leisler's has less than 200 ms.

Social calls

Only TE recorders, since they store all features of calls, can possibly cope with the complexity of bat social calls. Currently research is progressing to produce a library of social calls from underground *Myotis* bats. It promises to be able to identify these bats to species at swarming sites, where social calls are associated with mating activities.

Horseshoe Bat Surveys

Map 1: All Monitoring Sites

Compiled by on 22 December 2008

Scale 1:32000

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Horseshoe Bat Surveys

Map 2: Odd Down and Horsecombe Vale Monitoring Sites

Compiled by on 22 December 2008 **Scale 1:15000**

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Horseshoe Bat Surveys

Map 3: Horsecombe Vale Monitoring Sites

Compiled by on 22 December 2008 Scale 1:5000

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Horseshoe Bat Surveys

Map 4: Southstoke and Odd Down Monitoring Sites

Compiled by on 22 December 2008 **Scale 1:5000**

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Horseshoe Bat Surveys

Map 5: West of Odd Down Monitoring Sites

Compiled by on 22 December 2008

Scale 1:5000

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Horseshoe Bat Surveys

Map6: Twerton Monitoring Sites

Compiled by on 22 December 2008 Scale 1:5000

Bath & North East Somerset Council
Trimbridge House
Trim Street
Bath BA1 2DP
Tel 01225 477000

Map 7 Horseshoe bat post dusk records by roving surveyors 2008 – 2009 near Odd Down & Southstoke