Factors affecting the distribution of *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus* in the Lothians region, Scotland

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Abstract

Until recently it was believed that Bandit pipistrelle (*Pipistrellus pipistrellus*) and Soprano pipistrelle (*P. pygmaeus*) were one species, as such relatively little is known regarding factors that affect their distribution in the UK. The BATS and The Millennium Link project (BaTML) has been surveying different sites on the Union and Forth & Clyde Canals to assess use of these canals by bats. They found a higher incidence of Soprano pipistrelle relative to Bandit pipistrelle than expected. This paper reports on a study which aimed to determine whether the relative abundances of the two species of pipistrelle in woodland and parkland sites, away from the canal, are similar to the abundances found in the Union Canal area, and to determine what factors are affecting their distribution. Four non-canal sites were surveyed between July and September 2004. The data collected from these surveys was compared with four canal sites previously surveyed by BaTML. The results showed that Soprano pipistrelle was more numerous than Bandit pipistrelle at all of the non-canal sites, indicating a higher abundance of Soprano pipistrelle in the Lothian region.

Key words: Bandit, pipistrelle, Soprano, bats, BaTML, Union, Forth & Clyde, canals, bat

Introduction

Until recently it was believed that there was only a single species of pipistrelle bat resident in Britain. However, in the 1990's, it was discovered that what was thought of, initially, as two phonic types were in fact two separate species of pipistrelle bat; the Bandit (or Common) pipistrelle (*Pipistrellus pipistrellus*), and the Soprano pipistrelle (*P. pygmaeus*) (Jones & van Parijs, 1993; Park *et al*., 1996; Barratt *et al.,* 1997; Barlow *et al*., 1997; Jones & Barratt, 1999).

Since virtually all studies carried out prior to the split assumed that there was only one species, there are gaps in the knowledge regarding the distribution and ecology of these two pipistrelle species in the UK.

Both species are found throughout Britain and Ireland, but the Soprano pipistrelle may be more abundant in the north and the Bandit more abundant in the south (Warren *et al,* 2000; Altringham, 2003). This is consistent with findings regarding the distribution of the two species in Europe, which are sympatric over much of the area. The Bandit pipistrelle is the most common species in central Europe, however, it is rare in Scandinavia (Mayer & von Helversen, 2001; Hulva *et al*., 2004).

Soprano pipistrelle appears to be more of a specialist in terms of habitat preference and prey selection (Barlow, 1997; Russ & Montgomery, 2002) showing a greater preference for habitats with water (Russo & Jones, 2003). Bandit pipistrelle, on the other hand, appears to be more of a generalist, albeit including habitats associated with water. As such there seems to be differences in the foraging behaviour and habitat use between the two species (Davidson-Watts, 2004).

Available information indicates that the Soprano pipistrelle appears to be the more common of the two species in the Lothians (Haddow & Herman, 2001), although there are also reasonable numbers of records for Bandit pipistrelle in the area.

Typically, the Bandit pipistrelle echolocates, emitting a frequency of maximum energy (FmaxE), at around 46 kHz, and Soprano pipistrelle at 55 kHz (Russ, 1999). This is very useful when studying these bats in a non-invasive way, using bat detectors, in that quite often it is possible to allocate pipistrelle bats encountered in the UK to one or other of the two species. There is, however, a considerable overlap (48 to 52 kHz) between the two species in their frequency range (Russ, 1999; Altringham, 2003). As such on occasions certain bats cannot be easily allocated.

The BATS and The Millennium Link project (BaTML) has been carrying out echolocation surveys at different sites on the Union and Forth & Clyde Canals, during the period 2001 to 2004, to assess use of these canals by bats (Middleton *et*

al., 2004). In particular they have concentrated on Daubenton's bat, Bandit pipistrelle and Soprano pipistrelle species. BaTML have found at most survey sites across the Central Belt of Scotland, that there appears to be a much higher abundance of Soprano pipistrelle relative to Bandit pipistrelle.

Aims and objectives

One of the questions that the BaTML findings posed was: Is the higher incidence of Soprano pipistrelle compared to Bandit pipistrelle due to different habitat preferences of the species, or is the higher incidence of Soprano pipistrelle a reflection of their general, higher abundance in the Lothian area?

The aim of our study was to determine whether the relative abundances of the two species of pipistrelle bat in woodland and parkland areas, absent of water features, are similar to that found in the Union Canal area. If so, this would indicate a higher abundance of Soprano pipistrelle in the Lothian area, or if the relative abundances are different to those found in the Union Canal area, this would indicate that the species are showing differences in habitat preference.

The Null Hypothesis stated: (1) There is no difference in the relative distribution of the two species between the habitat categories; canal versus non-canal, and woodland versus parkland. (2) The distribution of the two species is unrelated to habitat preference.

Materials and Methods

Project Design

The specific aim of this project was to determine differences in the relative abundance/distribution of the two species of pipistrelle between sites located on the Union Canal and non-water sites between 2 km and 5 km from the canal corridor. As such a comparison between data from the two areas would be required. To achieve this, data was collected from the non-canal sites adopting the methods used by BaTML relating to the collection and analysis of data using a Time Expansion bat detector system (Middleton *et al.*, 2005).

Four canal sites were selected from the 22 sites being monitored by BaTML (Middleton *et al.*, 2004). Four non-canal sites were selected to be surveyed for this study to correspond with each of the canal sites. Each canal site was paired with a non-canal site on the basis that the only difference between them should be the presence of a water body (i.e. the canal). The sites were chosen so that they would be similar in terms of habitat type, vegetation, altitude, rough location and degree of human disturbance (see Table 1 and Appendix I for details). A comparison of the relative abundances of each of the pipistrelle species could then be made between the canal and non-canal sites.

Table 1: The paired canal and non-canal sites

Canal Site	Non-canal Site	Disturbance Level	Non-canal Site Habitat Type
Slateford	Corstorphine Hill	Disturbed	Woodland Urban
Gogar Moor Bridge	Gogarburn Golf Club	Relatively undisturbed	Woodland Rural
Winchburgh North	Dalmahoy Country Club	Disturbed	Parkland Rural
Learielaw	Cammo Estate Park	Relatively undisturbed	Woodland Suburban

Three nights data from each of the four canal survey sites were selected at random from surveys conducted by BaTML during the period April 2001 to September 2004. The results of these surveys were collated/analysed by N Middleton (BaTML), (refer Appendix I). The four non-canal sites were selected, based on the following criteria; survey sites had to be absent of any water features; sites had to concentrate on Urban, Parkland and Woodland areas within 5 km of the canal corridor but no closer than 2 km.

Each site was visited during daylight hours in June, so that habitat and Health & Safety assessments could be made. A survey transect, consisting of 10 designated points, was decided upon and a map of the transect with the designated points was made. The habitat and vegetation coverage was noted for each point within each transect. For a description of the non-canal sites please refer to Appendix II.

Survey Protocol and Data Collection Methods

In order to survey each site for bats we adopted a method whereby they would be recorded using a TED (Courtpan, Tranquility Transect). This would allow the FmaxE to be determined during the analysis stage, using sound analysis software (Pettersson Elektronik AB, BatSound, V3.0) (Middleton *et al.*, 2005). In addition to the TED we also used two heterodyne bat detectors (Magenta Electronics, MK11A) in order to allow us wider coverage and to direct the TED towards any bat activity encountered. It must be borne in mind that the object of these surveys was to encounter as

many bats as possible in order that a comparison of relative abundance, in percentage terms, between the two species, could be made. As such we felt it was acceptable to be pro-active in this manner.

Each of the four non-canal sites were surveyed three times between July and September 2004. Full details of the survey dates are provided in Appendix I. At the start of each night, survey forms were completed detailing the site, sunset time, weather conditions, and surveyors present.

The TED was set to a signal storage time of 0.640 sec and an expansion factor of ten times. These settings mirrored those adopted by BaTML during their surveys (Middleton *et al.*, 2005). The TED was connected to a minidisk recorder (Sony, Walkman, MZ-N710) using a mono lead.

Each survey began at 30 mins after sunset at Point 1 of the transect in question. The TED was turned on and the minidisk player began recording. During the survey, one surveyor managed the TED, one took notes, whilst the other surveyors listened for bats using the Heterodyne Detectors (HD).

Each of the 10 points in the transect was surveyed for four mins. After four mins the surveyors walked to the next point. If bat activity was encountered at any stage between points, the surveyors remained there recording up to a maximum of four mins, before moving to the next point.

Sound Analysis Methods

Analysis of our recorded data was carried out in the laboratory following the methods used by BaTML (Middleton *et al.*, 2005). In summary:

- A sampling rate of 22.05 kHz was used, with 16 bits/sample, a 512 pt FFT and a Hanning window.
- The recorded data was transferred from the minidisk to PC sound analysis software (Pettersson Elektronik AB, BatSound, V3.0).
- Each bat pass was analysed separately, initially using the Spectrogram feature to confirm that the bat was a pipistrelle (Russ, 1999).
- Three calls were randomly selected from each bat pass. A Power Spectrum was created for each call and the FmaxE measured.
- The call was allocated to species based on the average FmaxE measurement of the three calls. The allocation rules were; Bandit pipistrelle (42-48 kHz), Unallocated pipistrelle (48-52 kHz) and Soprano pipistrelle (>52 kHz).
- All relevant information was then noted on Survey Forms (summarised in Appendix I).

Results

An index of activity was calculated for each species in each site, by calculating the average number of bat passes per hour (Law *et al.*, 1998). A bat pass is defined as a sequence of three or more pulses (Law *et al.*, 1998). The equation IBA = Bp/t was used where; IBA = Index of Bat Activity, Bp = Number of Bat Passes and t = Time of survey.

Comparison of the relative abundances of the Bandit pipistrelle and the Soprano pipistrelle

Mann-Whitney U tests were used to determine the differences in relative abundances between the two pipistrelle species. Figure 1 shows the indices of bat activity (IBA) for the two species of pipistrelle at each of the sites surveyed. Overall there was a significant difference between the two species in terms of the relative abundance. The Mann-Whitney U test showed that there were significantly more passes made by Soprano pipistrelle than Bandit pipistrelle at all of the sites. Statistical analysis using the Mann-Whitney U test showed that there were significant differences in the relative abundances (IBA) between all the canal sites, and between all the non-canal sites (refer to Table 2).

Table 2: Results of the Mann-Whitney U tests for Differences in Relative Abundance of the two Species for the Sites

	Test	W Value	P Value	Significance
Difference in relative abundances in All Sites (two-tailed)	Mann-Whitney U	39.0	0.0023	Significant
Difference in relative abundances in All Sites (one-tailed)	Mann-Whitney U	39.0	0.0012	Significant
Difference in relative abundances in All Canal Sites	Mann-Whitney U	12.0	0.0103	Significant
Difference in relative abundances in All Non-canal Sites	Mann-Whitney U	10.0	0.0304	Significant

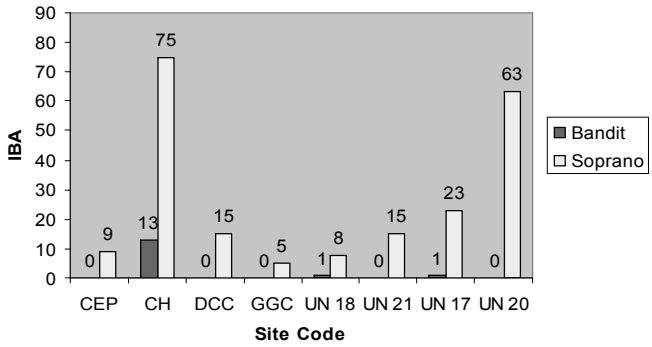

Figure 1: The IBAs for Bandit and Soprano Pipistrelles at each of the survey sites (CEP= Cammo Estate Park, CH= Corstorphine Hill, DCC= Dalmahoy Country Club, GGC= Gogarburn Golf Club, UN18= Learielaw, UN21= Slateford, UN17= Winchburgh North, UN20= Gogar Moor bridge)

The index of activity (IBA) for the Soprano pipistrelle was higher than for the Bandit pipistrelle at all sites surveyed. There was insufficient numbers of the Bandit pipistrelle to perform statistical analysis between the site categories.

Comparison of relative abundances between the habitat categories

To determine the differences in relative abundances for the two species between the different habitat categories (i.e. canal and non-canal; woodland and parkland; urban and rural; disturbed and undisturbed), statistical analysis was performed using the Mann-Whitney U test, a non-parametric statistical test. Stronger parametric tests could not be used because the data was not normally distributed. Kruskal Wallis non-parametric ANOVA was used to determine if there was a statistical difference between the abundance of Soprano pipistrelle between all the site categories.

One of the objectives of this project was to determine if the abundance of Bandit and Soprano pipistrelle was influenced by the type of habitat. Table 3 shows the results of the Mann-Whitney U test used to analyse the differences in the relative distributions of the two species between the different site categories. The type of habitat did not significantly influence the relative abundances of the species; there was proportionally more Soprano pipistrelle in each of the habitat categories.

Canal versus Non-canal Sites

Figure 2 shows the total IBAs for both species of pipistrelle at all of the canal sites, all of the non-canal sites and the total for all eight sites combined. There was no significant difference in the indices of bat activity between the canal and the non-canal sites for the two pipistrelle species. The canal and non-canal sites had similar indices of activity for both pipistrelle species.

Table 3: The results of the statistical tests comparing the relative abundances of the two species between the site categories

	Test	W Value	P Value	Significance
Canal versus Non-Canal Both Species	Mann-Whitney U	4.0	0.6985	Not Significant
Woodland versus Parkland Both Species	Mann-Whitney U	6.0	0.6985	Not Significant
Urban versus Rural Both Species	Mann-Whitney U	5.5	1.0000	Not Significant
Disturbed versus Undisturbed Both Species	Mann-Whitney U	6.0	0.6985	Not Significant
All site categories Soprano Pipistrelle	Kruskal Wallis	5.5	0.702	Not Significant

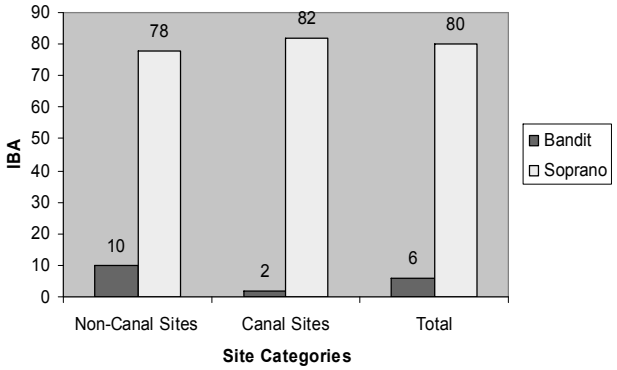

Figure 2: Comparison of IBA for Canal and Non-Canal Sites

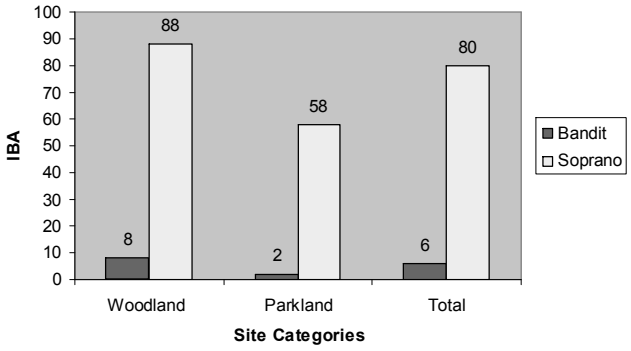

Figure 3: Comparison of IBAs for Woodland and Parkland Sites

Woodland versus Parkland

Figure 3 shows the total IBAs for both species of pipistrelle at the woodland sites, the parkland sites and the total for all eight sites combined. There was no significant difference between the woodland sites and the parkland sites in the indices of bat activity for the two pipistrelle species. The woodland and parkland sites had similar indices of activity for both Soprano and Bandit pipistrelle.

Urban versus Rural

Figure 4 shows the total IBAs for both species of pipistrelle at the urban sites, the rural sites and the total for all eight sites combined. There was no significant difference between the urban sites and the rural sites in the indices of bat activity for the two pipistrelle species. The urban and the rural sites had similar indices of activity for both Soprano and Bandit pipistrelle.

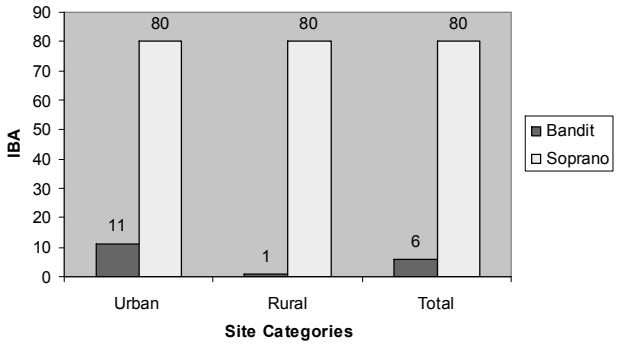

Figure 4: Comparison of IBAs for Urban Sites and Rural Sites

Disturbed versus Undisturbed

Figure 5 shows the total IBAs for both species of pipistrelle at the disturbed sites, the undisturbed sites and the total for all eight sites combined.

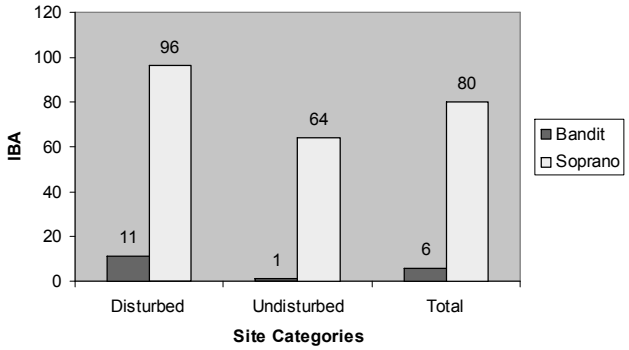

Figure 5: Comparison of IBAs for Disturbed and Undisturbed Sites

There was no significant difference between the disturbed sites and the undisturbed sites in the indices of bat activity for the two pipistrelle species.

The disturbed and the undisturbed sites had similar indices of activity for both the Soprano and the Bandit pipistrelle.

Comparison of relative abundances in the Paired Sites

To determine the differences in activity for the two species between the paired canal and non-canal sites, a Wilcoxon Signed Ranks test was used.

There were no significant differences found in the relative abundances of the two species between the paired sites (refer Table 4). The Indices of bat activity for the canal sites were all similar to those found for the corresponding paired non-canal sites.

Table 4 The results of the statistical tests comparing the IBAs of the two pipistrelle species between the paired sites

	Test	W Value	P Value	Significance
All Canal Sites versus All Non-canal Sites	Wilcoxon Signed ranks	N/A	0.059	Not Significant
Cammo Estate Park versus Learielaw	Mann-Whitney U	5.0	1.0000	Not Significant
Corstorphine Hill versus Slateford	Mann-Whitney U	4.0	0.6985	Not Significant
Dalmahoy Country Club versus Winchburgh North	Mann-Whitney U	6.0	0.6985	Not Significant
Gogarburn Golf Club versus Gogar Moor Bridge	Mann-Whitney U	5.5	1.0000	Not Significant

Unallocated Bat Passes

Mann-Whitney U tests were used to determine whether there was a difference in the proportion of unallocated bat passes in canal versus non-canal sites.

Overall a mean of 27.5 (standard deviation ± 31.319), or 29% of all the bat passes that were recorded could not be allocated to species. Table 5 shows the results of the Mann-Whitney U tests that were used to analyse the differences in the proportion of bat passes (IBA) that were unallocated to species between the different habitat

categories. There were no significant differences in the proportion of bat passes that could not be allocated to species between the site categories.

Table 5: The Results of statistical tests comparing the IBAs of Allocated and Unallocated bat passes between site categories

	Test	W Value	P Value	Significance
Canal versus Non-Canal	Mann-Whitney U	5.0	1.0000	Not Significant
Woodland versus Parkland	Mann-Whitney U	6.0	0.6985	Not Significant
Urban versus Rural	Mann-Whitney U	6.0	0.6985	Not Significant
Disturbed versus Undisturbed	Mann-Whitney U	6.0	0.6985	Not Significant

Weather and Bat Activity

Pearson Correlation's tests were carried out to determine if there was any significant relationship between weather conditions and bat activity.

Table 6: The Results of the Statistical Tests comparing the Weather Conditions and Bat Activity

	Test	R Value	P Value	Significance
Air temperature and IBA for the Soprano Pipistrelle	Pearson's Correlation	-0.711	0.010	Not Significant
Air temperature and IBA for the Bandit Pipistrelle	Pearson's Correlation	-0.590	0.044	Not Significant
Rainfall and IBA for the Soprano Pipistrelle	Insufficient Data	N/A	N/A	N/A
Rainfall and IBA for the Bandit Pipistrelle	Insufficient Data	N/A	N/A	N/A
Cloud Cover and IBA for the Soprano Pipistrelle	Pearson's Correlation	0.401	0.196	Not Significant
Cloud Cover and IBA for the Bandit Pipistrelle	Pearson's Correlation	0.489	0.107	Not Significant
Wind and IBA for the Soprano Pipistrelle	Pearson's Correlation	0.314	0.321	Not Significant
Wind and IBA for the Bandit Pipistrelle	Pearson's Correlation	0.167	0.604	Not Significant

As Table 6 shows, none of the weather conditions had any significant effect on the level of bat activity. This data was only available for the non-canal sites surveyed for this study.

Time of first Bat Pass

Pearson Correlation's tests were carried out to determine if there was any significant relationship between weather conditions and time of the first bat pass, and Mann-Whitney U tests were used to determine the differences in timing of first bat passes between site categories.

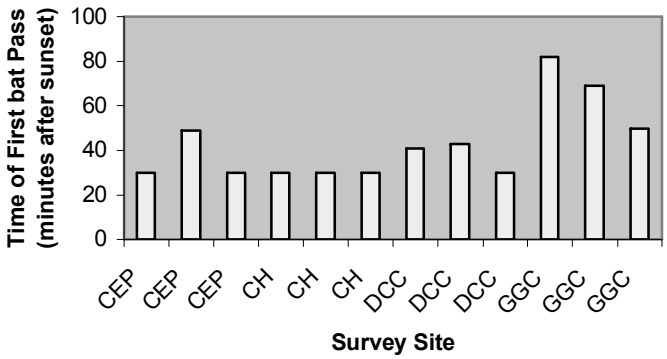

Figure 6: Time of the first bat pass on each of the survey nights

Table 7: Results of statistical tests comparing weather conditions and time of first bat pass and differences between the Sites

	Test	W / R Value	P Value	Significance
Air temperature	Pearson's Correlation	0.470	0.123	Not Significant
Rainfall	Pearson's Correlation	Insufficient data	N/A	N/A
Cloud Cover	Pearson's Correlation	-0.352	0.262	Not Significant
Wind	Pearson's Correlation	-0.220	0.492	Not Significant
Woodland versus Parkland	Mann-Whitney U	113.5	0.0117	Significant
Urban versus Rural	Mann-Whitney U	26.5	0.0403	Significant
Disturbed versus undisturbed	Mann-Whitney U	29.0	0.1044	Not Significant

This data was only available for the non-canal sites surveyed for this project. Figure 6 shows the time

of the first bat pass on each of the survey nights. The mean time of the first bat pass to occur was 42.8 min (standard deviation ± 16.6) after sunset. In the Corstorphine Hill site, there was a lot of activity at point one of the transect so the first bat pass was within the first minute (IBA at point 1 was 16 and the IBA for the site was 120). The activity at Gogarburn was relatively lower (total IBA 15) and the first bat pass was generally much later than at Corstorphine Hill (mean was 67 min, standard deviation ± 13.1). Generally the higher the activity for the sites the less time after sunset for the first bat pass. Table 7 shows the results of the correlation analysis tests between the timing of the first bat and weather conditions and statistical tests on the differences between the sites.

Discussion

It was expected that there would be higher activity of Soprano pipistrelle at canal sites as it is more of a specialist around riparian habitats, while the Bandit is more of a generalist. It was found in this study that there was a higher abundance of Soprano pipistrelle (total IBA 160) compared to Bandit pipistrelle (total IBA 12) at all of the sites surveyed. The results indicate that there is, in general, a higher population number of Soprano pipistrelle in the Lothian area. The total index of activity for the Bandit pipistrelle was much lower than expected. Thus the higher incidence of Soprano pipistrelle at the Union Canal sites appears to be a reflection of the wider distribution of the species in the Lothian region.

Relative Abundances in the Sites
In many of the sites the bat activity was concentrated along the tree line. This is because bats often prefer to forage along vegetation edges rather than in the forest interior (Walsh & Harris, 1996). This may be to facilitate orientation and to maximise foraging success, as insect prey is more abundant along woodland edges (Limpens *et al.,* 1989). The exception to this was when there was bad weather conditions on the survey night (high winds and rainfall). In these cases there was a higher concentration of bat activity in the woodland interiors where insects accumulated in sheltered conditions.

The Corstorphine Hill site had the highest index of bat activity (IBA 120) of all the sites. The reason for this high activity is probably because bats that roost in buildings and trees in the surrounding urban areas use the location as a foraging site. Corstorphine Hill is one of the only large woodland habitats within the city of Edinburgh. The hill acts as a wind barrier and insects accumulate on the leeward side so bat activity is fairly high here and concentrating where insect abundance is highest. Gogar Moor Bridge also had a high IBA (63) though all of the bat passes were Soprano pipistrelles. This site was quite undisturbed and had a good selection of vegetation at various heights.

It has been suggested that bats tend to avoid open areas and prefer to travel along linear vegetation elements (Limpens *et al*., 1989). Studies of European bats in modified landscapes have emphasised the importance of linear strips of vegetation as a form of protective cover (Krull *et al.,* 1991, Walsh & Harris 1996). This seemed to be the case in all of our sites surveyed.

Bat Activity: between Site Categories
It was expected that there would be a higher abundance of Soprano pipistrelle at canal sites relative to non-canal sites. There were relatively higher bat activity levels at two of the sites. There was no significant effect on activity levels for the two species between sites on the canal and sites away from the canal. There was a low number of Bandit pipistrelle at all of the sites so there was not enough data to detect a significant difference between the sites. More data and surveys would add to the ability to detect the factors that affect the abundance of the two species.

Woodland habitats were expected to have a higher bat activity than parkland sites, rural more than urban and undisturbed more than disturbed. There were no significant differences in the relative abundances for either species found between the sites categories. This could be due to insufficient data or to confounding variables. Surveying more site locations would mean a higher probability of discovering differences between different habitats.

Unallocated Bat Passes
Bandit pipistrelle tends to echolocate at a FmaxE of around 46 kHz and Soprano pipistrelle at around 55kHz, but there is a considerable overlap. A high proportion (29%) of the total number of bat passes recorded at the sites could not be allocated to species. This finding is consistent with results currently being considered by BaTML across the Central Belt of Scotland, in the canal corridor.

Weather and Bat Activity
None of the weather variables were shown to have any significant effect on bat activity. The weather conditions did not vary much between the survey nights, e.g. the air temperature did not vary significantly.

Time of the First Bats
Generally pipistrelle bat species are one of the first bats to emerge to forage after sunset (Speakman *et al.*, 1999). Emergence times are influenced by diet, foraging strategy and predation. The timing of the

first bat pass recorded was not influenced by weather conditions. There was a significant difference between urban and rural habitats and between woodland and parkland habitats. The timing of the first pass recorded by ourselves is, more than likely, linked to the distance we were positioned from the respective roosts.

Conclusions

The conclusion of the study is that there are more Soprano than Bandit pipistrelle bats in the Lothian area. The Null hypothesis can be accepted. There appears to be a geographical difference in the distribution of the species in Britain. There is a greater abundance of Sopranos in the north of the country than in the south, and the opposite is true of the Bandit pipistrelle. The Sopranos appeared to be less specialised than previously thought, as there was no significant preference shown for any particular habitat. However these results could be biased by the choice of sites, constraints of sampling time and the adverse weather conditions this summer. More research needs to be conducted on a wider scale regarding the distribution of the two pipistrelle species, the Bandit *Pipistrellus pipistrellus* and the Soprano *Pipistrellus pygmaeus.*

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Appendix I: Total Bat Activity and IBA Scores for each of the Survey Nights

Non-canal Sites

Site Name	Site Code	Survey Date	Bandit pipistrelle	Unallocated pipistrelle	Soprano pipistrelle	Totals
Cammo Estate Park	CEP	03.08.04	0	0	1	**1**
OS Grid Ref: NT175747		19.08.04	0	0	1	**1**
		02.09.04	0	0	24	**24**
		Total Passes	**0**	**0**	**26**	**26**
		IBA	**0**	**0**	**9**	**9**
Corstorphine Hill	CH	10.08.04	22	41	92	**155**
OS Grid Ref: NT202746		31.08.04	0	19	61	**80**
		10.09.04	18	35	72	**125**
		Total Passes	**40**	**95**	**225**	**360**
		IBA	**13**	**32**	**75**	**120**
Dalmahoy Country C	DCC	06.08.04	1	0	2	**3**
OS Grid Ref: NT146682		01.09.04	0	0	17	**17**
		17.09.04	0	9	27	**36**
		Total Passes	**1**	**9**	**46**	**56**
		IBA	**0**	**3**	**15**	**18**
Gogarburn Golf Club	GGC	05.08.04	0	0	1	**1**
OS Grid Ref: NT160721		25.08.04	0	0	4	**4**
		06.09.04	0	0	10	**10**
		Total Passes	**0**	**0**	**15**	**15**
		IBA	**0**	**0**	**5**	**5**
		Grand Total	**41**	**104**	**312**	**457**
		IBA	**10**	**26**	**78**	**114**

Canal Sites

Site Name	Site Code	Survey Date	Bandit pipistrelle	Unallocated pipistrelle	Soprano pipistrelle	Totals
Learielaw	UN18	26.08.02	2	43	10	55
OS Grid Ref: NT085713		10.08.03	1	2	1	4
		28.09.03	1	2	15	18
		Total Passes	**4**	**47**	**26**	**77**
		IBA	**1**	**16**	**8**	**25**
Slateford	UN21	29.08.01	1	3	9	13
OS Grid Ref: NT224708		23.04.02	0	17	28	45
		25.08.03	0	3	8	11
		Total Passes	**1**	**23**	**45**	**69**
		IBA	**0**	**8**	**15**	**23**
Winchburgh North	UN17	09.07.02	1	9	1	11
OS Grid Ref: NT087753		26.04.04	1	13	57	71
		29.07.04	1	4	11	16
		Total Passes	**3**	**26**	**69**	**98**
		IBA	**1**	**8**	**23**	**32**
Gogar Moor Bridge	UN20	13.07.03	0	0	9	9
OS Grid Ref: NT156706		07.09.03	0	0	4	4
		11.05.04	0	20	177	197
		Total Passes	**0**	**20**	**190**	**210**
		IBA	**0**	**7**	**63**	**70**
		Grand Total	**8**	**115**	**330**	**453**
		IBA	**2**	**29**	**82**	**113**

Appendix II: Non-canal Site Descriptions

Cammo Estate Park (OS Grid Ref: NT175747)

Cammo is part of Edinburgh's green belt and is located 8 km from the city centre, just outside the city limits. It is a large estate belonging to the City of Edinburgh Council. The site has grazing land surrounded by sections of woodland, which is relatively undisturbed. The site was classified as 'woodland' habitat. The vegetation along the transect is mainly mature broadleaved trees (such as beech and sycamore) and there is a lot of undergrowth. The survey transect followed a route along a path through the woodland.

Corstorphine Hill (OS Grid Ref: NT202746)

Corstorphine Hill is located in Edinburgh, 2 km from the city centre. It is 161 m above sea level at its highest point and from all angles presents a long, low wood-covered ridge, rising above the western suburbs of Edinburgh. It is a woodland habitat surrounded by urban areas and represents one of the only green areas in the locality for bats to forage in. Corstorphine Hill has been designated as a Regionally Important Geological Site (RIGS) and has also been designated as a Local Nature Reserve. It is one of Edinburgh's largest public parks and is managed by the Ranger Service. Much of the hill is broadleaved woodland, mainly sycamore, with ash, beech and lime. There is about 20% scrub including gorse, birch and rowan. It is a disturbed habitat with much human activity in the area. The transect followed a path from the top of the hill descending to a point near the car park.

Dalmahoy Country Club (OS Grid Ref: NT146682)

This site is located at the Marriot Dalmahoy Hotel and Country Club in Kirknewton, 11 km from Edinburgh city centre. The country club is set in 1,000 acres of parkland surrounded by woodland. This site was classified as 'parkland'. The tree species along the transect are primarily broadleaved (e.g. sycamore, oak and beech). The golf course is highly disturbed habitat, but the woodland at the perimeter is fairly undisturbed. The transect took a route from the far back to the front of the east course, following the linear wooded features on the edge of the golf course.

Gogarburn Golf Club (OS Grid Ref: NT160721)

This site is located on Gogarburn Golf Course near Newbridge in the Lothians, 10 km from Edinburgh city centre. It is a relatively small, flat, parkland golf course that is surrounded by mature deciduous and coniferous woodland, with strips of woodland between greens. This site was classified as 'woodland'. The tree vegetation at this site is primarily broadleaved trees (such as sycamore, oak and beech) with some coniferous tree species (e.g. Scots pine). The woodland through which the survey moved was relatively undisturbed, though the golf course is highly disturbed. The transect followed a track through the woodland, edging the golf course parkland.