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Original article

Keeping bats cool in the winter: hibernating bats and their exposure to 'hot' incandescent lamplight

Anne-Jifke Haarsma & Eva de Hullu

In order to monitor bat population trends, an annual census is performed of all known underground *hibernacula* in Europe. During these censuses, bats are sometimes found to show signs of arousal, presumably from non-tactile stimuli caused by the observer, e.g. air currents, sound, light or an increase in temperature. We assume that heat and/or light from a torch can play a role in awaking hibernating bats. Observers use different light sources, which produce different amounts of heat. We experimentally tested the heat produced by three commonly used torches: two incandescent torches (krypton and halogen) and one LED torch. We performed the experiment on 28 January 2007 in an old brick kiln in Windesheim (Overijssel Province, the Netherlands), which is used by hibernating bats. The results show that temperatures in a crevice significantly increased when using the 'hot' incandescent torch types. The effect of these torches on both air and surface temperature was significant after both 10 and 30 seconds. Under the assumption that an increase of the ambient temperature by 5°C or more can cause a bat to arouse from torpor, we conclude that using 'hot' torches such as incandescent (halogen) lights poses a risk to the animals under study. To minimise heat disturbance from light sources, we recommend LED torches as the best available alternative.

Key words:arousal stimuli, bats, Chiroptera, LED light, non-tactile disturbance, survey method, torch

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Methods on how to avoid unnecessary disturbance of bats during the hibernation period are important to bat researchers visiting bat *hibernacula*. There are very few studies on factors that affect bat disturbance. However, most researchers know instinctively how to avoid disturbance. In this article, we discuss the impact of one of most easily avoided disturbance factors, i.e. light.

The northern hemisphere is characterised by severe winter conditions, when feeding opportunities decline and low ambient temperatures increase heat loss and thus increase the thermoregulatory costs of bats. Because they are small flying animals, bats are not able to accumulate large fat reserves to maintain a constant body temperature. They have two other ways of coping with this problem: hibernation and migration (Davis 1970, Fleming & Eby 2003). Most European temperate zone bats are 'resident', usually selecting underground hibernation sites, such as fortifications, natural and man-made caves and ice cellars (Mitchell-Jones et al. 2007). During hibernation, the bats reduce the difference between body and ambient temperature to an absolute minimum (i.e. become torpid) acting like heterotherms. This technique allows them to survive the winter with just a small amount of body fat (on average a maximum of 25% of their body weight). Bats hibernate from autumn to spring (on average for 190 days in northern Europe) although the exact period varies between the species. This period is characterised by prolonged bouts of torpor, punctuated with periodic arousals, on average every two weeks, during which the bats return to endothermy (e.g. Daan & Wichers 1968, Brack & Twente 1985, Harmata 1985, 1987).

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According to Daan (1972), species of the genus *Myotis* such as the whiskered bat *M. mystacinus*, the Daubenton's bat *M. daubentonii* and the pond bat *M. dasycneme* wake up on average 9.0-13.3 times during a winter. These arousal frequencies are much lower than those given by Dunbar & Tomasi (2006) for the eastern red bat *Lasiurus borealis* in Canada, where a maximum of 39 arousals was recorded at an ambient temperature of 10°C. Also the Greater Horseshoe Bats *Rhinolophus ferrumequinum* and the common Pipistrelle bat *Pipistrellus pipistrellus*, both European bat species, arouse more frequently than the three Myotis species (Avery 1985, Park et al. 2000), probably due to their ability to forage during the winter. Bats arouse more readily in warm conditions than in cold conditions (e.g. Ransome 1971, Park et al. 2000, Humphries et al. 2002, Boyles et al. 2007), a phenomenon also known in other mammals (e.g. Geiser & Kenagy 1988, Ortmann & Heldmaier 2000). In laboratory experiments, researchers (Thomas et al. 1990) found that the little brown bat *Myotis lucifugus* uses approximately 84% of its winter fat reserve to cover the cost of arousals, whereas only 16% is needed to maintain the low metabolic rate. The energy expenditure during 80 days of hibernation is equivalent to one hour of flight (Kokurewicz 2004). During the warming phase of arousals, the heat generated (mainly by burning fat in brown adipose tissue and muscle shivering) causes the body temperature to rise from near ambient to euthermic levels (Smalley 1963, Hayward & Ball 1966). The whole process takes an average of 30 minutes (Barclay et al. 1996, Lee et al. 2002). A bat can stay aroused from hibernation torpor for 15 hours or longer (Twente & Twente 1987, Speakman et al. 1991, Park et al. 2000) with animals tending to remain endothermic longer at higher ambient temperatures (Harmata 1985). Researchers have assumed that these periods of arousal are necessary for bats to eliminate accumulated metabolites, urine, escape from predators or to adjust to changes in the temperature of their *hibernacula* (e.g. Prendergast et al. 2002, Humphries et al. 2003, Davydov 2004). Other activities undertaken during these arousals include drinking and copulation (McCracken & Wilkinson 2000, Kokurewicz 2004, Boyles et al. 2006).

Arousals are sometimes externally induced by disturbance resulting from exposure to air currents (Pflitsch & Piasecki 2003), heat, light, sounds and physical contact (Davis 1970, Speakman et al. 1991, Thomas 1995, Thomas & Geiser 1997, Johnson et al. 1998). The annual bat census of all known underground *hibernacula* (Mitchell-Jones et al. 2007) undertaken in order to monitor bat population can potentially be a source of such disturbance. The census is performed between 15 December and 15 February. Bat observers use torches, binoculars and sometimes mirrors (to look behind corners) to search for bats (e.g. Mitchell-Jones & McLeish 1999, Smirnov et al. 2007). In the European census, bats are never handled for identification and most bat observers try to avoid creating non-tactile stimuli. Nevertheless, during these censuses, bats are sometimes found to show signs of arousal. During a field experiment in a *hibernaculum*, Thomas (1995) concluded that visits by bat observers caused a dramatic increase in the flight activity of bats, beginning within 30 minutes of the visit, peaking 1.0-7.5 hours later, and remaining significantly above baseline level for up to 8.5 hours. The increased level of activity is not just caused by bat observers, but also indirectly by the bats themselves. One arousing bat can start a cascade of arousals from other bats in the same *hibernaculum*. The first bat may wake up a second bat, by sound or tactile stimuli (for example an active bat attempting to reinsert itself into a hibernating cluster or male bats trying to mate with the hibernating females).

Bats lose 2-3.2% of their body weight during one arousal (Daan 1972, Boyles & Brack 2009), so additional, externally induced, arousals are an unwelcome burden on their energy budget. These arousals may mean that the bats will not have adequate fat reserves to sustain them through the winter. During a bat census, not all non-tactile stimuli can be avoided. Bat observers are a source of sound, light and heat. The light from a torch is often directed at the bat, especially to identify bats hidden deep in a crevice. We assume this can cause an arousal stimulus. Besides light, a torch also produces heat, another potential arousal stimulus. In this paper, we present an experiment aimed at determining if commonly used torches can raise the temperature in crevices by more than a threshold value and provide an arousal stimulus to bats hidden in crevices. As we did not want to repeat arousal experiments, we used the threshold value for arousal found by Speakman et al. (1991). During a study performed in a respirometry chamber, Speakman et al. (1991) found bats responded very strongly to a temperature increase of 5°C. The experiment did not permit drawing any further conclusions, such as a sex-specific response rate, the effect of signal inhibition after repeated stimuli or the respond rate during different hibernation temperatures. As the sex and

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Figure 1. The exterior of the Old brick kiln in Windesheim, Overijssel, the Netherlands, with entrances to the chambers shown. All the chambers are of the same size and made with the same kind of bricks.

hibernation history of bats found during a census is always unknown, we can safely assume the minimum level of warming needed for an arousal stimulus is 5°C.

Material and methods

To measure the amount of heat produced by a torch light illuminating a small crevice, we experimentally tested the effect of crevice volume, torch type and duration of the treatment on changes in temperature of the crevice. These tests were performed with and without a bat present.

Description of variables

On 28 January 2007, during 11:00-18:30, we performed the experiment in an old brick kiln in Windesheim, Overijssel Province, the Netherlands (Fig. 1). We chose this location for the regular and recurring nature of its crevices. There was an absence of wind (0 Bft) during the experiment and a continuous moderate drizzle. Approximately 20 bats, belonging to two species: the natterer's bat *M. nattereri* and the brown long-eared bat *Plecotus auritus* are known to hibernate in this location.

We were interested in the effect of a torch in changing air temperature (δT_a) or the surface temperature (δT_{surf}) of the surrounding stone. We assumed that a temperature increase of 5°C could act as a wake-up stimulus for a hibernating bat. For practical reasons, we measured whether a torch was able to heat up a small confined space (crevice) in a hibernation location. We incorporated the following variables: the volume of the crevice, torch type, duration of treatment and bat present or not.

Volume of the crevice

We selected 10 similar crevices, which we named A-J (Figs. 2 and 3), all cube-shaped and located in the ceiling. The volume of each crevice was measured with a ruler (Table 1).

Duration of treatments

We studied the effect of the duration of an observation on the temperature in a crevice by comparing standard durations of 10 and 30 seconds (the time usually needed to determine the species of a bat).

Torch type

To determine the effect of the torch type on the temperature in a crevice, we used the three torch types most commonly used by bat observers (Table 2). All three types of torches were similar in size,

Figure 2. Detailed interior of a chamber of the Old brick kiln showing the locations of the crevices B, I and J marked with arrows.

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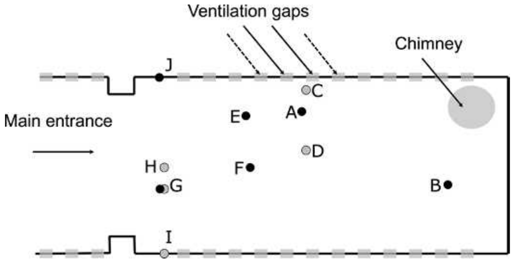

Figure 3. Ground plan of the test room. Grey circles are locations with bats and black without bats. Location G had shown both conditions. The room has an air chimney and several ventilation gaps at ground level. The main entrance is located at the lee side of the wind.

Table 1. Width, length, depth and volume of the 10 crevices A-J. See Figure 3 for the location of each of these crevices. The crevices with a dead bat are marked with an asterisk.

	Width (cm)	Length (cm)	Depth (cm)	Volume (cm^3)
A	1.75	9.00	17.3	272.48
B	1.15	9.35	14.0	150.54
C*	1.80	8.70	17.7	277.18
D*	1.25	8.80	17.1	188.10
E	1.15	9.00	17.7	183.20
F	1.00	8.25	14.7	121.28
G*	2.05	8.15	16.8	280.69
H*	1.20	9.20	17.7	195.41
I*	2.00	11.15	5.70	127.11
J	2.35	11.50	5.60	151.34

shape and focus abilities. We tested the torches in a fully focussed state. Because of the short duration of the experiment (a total of 1,100 seconds), the effect of battery energy decrease (and therefore a reduction in heat production or light level of the torch) was not taken into account. Each light source produces heat. Some of the heat is conducted away from the light source by the anodised aluminium body of the Maglite. The remaining heat is emitted to the surroundings by convection and radiation. For our purpose, only heat reaching the bat (or stone) is relevant. In order to compare the heat production of each torch, we measured the difference in the temperature of the glass before and after a burn time of 15 minutes.

Bat present or not

To simulate the effect of the lighting treatments on bats present in crevices, we used five dead bats which were either found mummified (i.e. dried; N = 2) or had been preserved in ethanol and dried for a minimum of two hours until their fur was completely dry and they had their 'normal' weight again (N = 3; Table 3). Each dead bat was placed in the entrance of a crevice and was given 60 minutes to adapt to the local temperature. During this time they reached near-ambient temperature, which corresponds to the temperature of live hibernating bats (e.g. Eisentraut 1934, Brack & Twente 1985, Park et al. 2000). A dead bat was placed at random in crevices C, D, G, H and I, and crevices A, B, E, F and J were left empty (Table 4).

Temperature measuring devices

Bats in a crevice are affected by air temperature (T_a) and surface temperature (T_{surf}) of the surrounding stones. The surface temperature can also affect the air temperature, especially in a confined space, such as a crevice. We used two devices to measure temperature fluctuations: a Raytek ST80, a non-contact infrared thermometer (Distance to spot size: 50:1, accuracy ± 1% and a resolution of 0.1°C) and a Digitron 2080R, a hand held air thermometer (Accuracy ± 1.5% and a resolution of 0.1°C). Both thermometers were calibrated once a year.

Experimental design

We treated each crevice in five different ways (see Table 4): 30 seconds of lighting with each of the three torch types and 10 seconds of lighting with the MagCharge and the MagLite. To simulate an observer looking in a crevice for bats, we held the torches at a distance of 2-3 centimetres from the crevice entrance (Fig. 4) or, when a dead bat was present, at eight centimetres from the crevice entrance. Extra influence from the body heat of the observer was prevented: torches were held at arms

Table 2. Details about the three torches used for the experiment. All the tested torches were manufactured by MagLite. Specifications were used as stated by the manufacturer. The heat production of each torch is expressed as the difference in the temperature of the glass before and after a burn time of 15 minutes.

Brand and model	Type of batteries	Type of bulb	Lumen	Watt	Heat production of torch (°C)
MagCharge	Accu (5 cel)	Halogen	218	8.4	± 70
Common MagLite	D (3 cel)	Krypton	39	2.7	± 15
LED MagLite	D (3 cel)	LED replacement bulb (terralux)	50	1.0	± 0

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Table 3. Characteristics of the five bats used in this experiment. The bats differed in species, age and preservation technique. Each was placed in a different crevice. One bat was equipped with an I button for a short time period.

Species	Age	Preservation technique	Dry weight (g)	Crevice	I-button	Time period
Common pipistrelle	adult	ethanol	4.0	D	yes	14:20-17:35
	juvenile	ethanol	2.2	H	no	
Serotine *Eptesicus serotinus*	adult	ethanol	24.1	G	no	
Common pipistrelle	adult	mummy	2.2	C	no	
Brown long-eared bat	adult	mummy	3.0	I	no	

length with the observer staying as far back as possible from the crevice. Using this design, we standardised the distance between source of heat (the torch) and the recipient of the heat (the stone or the bat). We paused for 10-60 minutes between treatments to allow the crevice or bat to regain 'normal' temperature.

We measured both surface and air temperature immediately before and after the treatment. Before the treatment, the temperature (both T_{surf} and T_a) was read three times from the device to correct for small temperature fluctuations, and we used the average of these measurements. We measured surface temperature (T_{surf}) on the stone at a point in the centre of the crevice. When there was a bat present, we could not measure the surface temperature of this location, but measured the surface temperature of the bat itself. After the treatment, we took three readings of the T_{surf}. We used only the maximum T_{surf} in our analyses, because of the quick drop back to the original temperature after the treatment and because the highest temperature would be the one most likely to arouse a hibernating bat from torpor. Before and after the treatment, we measured air temperature (T_a) at a depth of eight centimetres in the centre of the crevice (or as deep as possible for the two crevices with depths of < 8 cm), using a long thermocouple (type K with a length of two metres). When a bat was present, we measured the air temperature behind it. To prevent observer bias, one observer lit the crevice, while the other one performed the temperature readings. We performed only one T_a after the treatment, again because of the quick drop to original temperature after the treatment.

Real-time monitoring of temperature

We also wanted to monitor the time it took to warm up a (dead) bat under the various treatments. For a real-time monitoring of temperature fluctuations, we used a small temperature logger. The logger, an adapted version of an I button (Maxim innovated delivered), had a total weight of 0.7 g and was inserted under the skin of a dead bat. It was set to measure the bat's temperature every minute. The I button was fitted to bat number one in crevice D from 14:20 to 17:35. We subjected the dead bat (with the logger) to six random treatments of 60 and 120 seconds duration.

Statistical analysis

We carried out statistical analyses using SPSS version 15, and we used Spearman's rank correlation coefficient to test the relation between the dependent variables 'change in T_{surf}' and 'change in T_a' and the independent variable 'volume of crevice'. We used an ANCOVA to test for a relation between the two possible response variables and the covariates: torch type, duration of light exposure and the absence or presence of a bat.

Table 4. Treatments which the 10 crevices (A-I) experienced during the field experiment.

		Torch type		
Crevice	With or without bat dummy	Common MagLite	LED MagLite	MagCharge
A, B, E, F, J	Without	30 seconds	30 seconds 10 seconds	30 seconds 10 seconds
C, D, G, H, I	With	30 seconds	30 seconds 10 seconds	30 seconds 10 seconds

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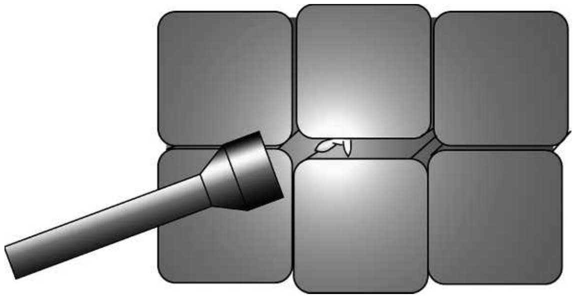

Figure 4. The research set up showing a bat in the crevice illuminated by a torch held 2-3 centimetres away from the crevice entrance.

Results

Fluctuations in air and surface temperatures

During the experiment, the surface and air temperature in all crevices remained fairly constant in both time and space. The T_{surf} varied between 5.4 and 2.4°C, and averaged 4.4°C. Towards the evening, the T_{surf} in the crevices dropped by about 0.1°C every 60 minutes. This was caused by a decline in the outside temperature. The T_a varied between 5.3 and 3.7°C with an average of 4.4°C. The T_a in the crevices did not change as the evening approached. We found no significant correlation between change in air temperature and surface temperature and the outside temperature.

Differences between the volume of crevices

Although the overall shape of all the crevices was very similar (see Table 1), their volume varied: the smallest crevice (F) had a volume of 121 cm^3 and the largest (G) 280 cm^3. There was no relation between the volume of the crevices and the dependent variable change in temperature before and after treatment for both δT_{surf} and δT_a (Table 5).

Torch type and treatment duration

The results show a significant relation between the torch type used and the change in T_{surf} and T_a during the treatments (see Table 5). During a treatment using a MagCharge, the T_a increased by as much as 6.3°C and the T_{surf} by 8.3°C. Using the other torch types (Led and common Maglite), the changes in temperature were less pronounced (Led Maglite maximum $T_a = 1.0$ and $T_{surf} = 0.7$°C; common Maglite $T_a = 0.8$ and $T_{surf} = 0.8$°C).

We tested whether this difference was affected by the duration of the treatment (see Table 5). No significant relation was found between the duration of the treatment and the two dependent variables δT_{surf} and δT_a. The short and long treatments (10 and 30 seconds, respectively) had similar effects on the change in temperature (Fig. 5). In 10 seconds, the T_a of crevices heated up with an average of 0.1°C and the T_{surf} increased by an average of 1.1°C. In 30 seconds, the T_a increased by 0.5 and the T_{surf} with 1.5°C, respectively.

Presence or absence of a bat in a crevice

The presence or absence of a bat in a crevice had a significant effect on the δT_{surf} (see Table 5). When a bat was present, much higher values of δT_{surf} were observed than when there was no bat (average T_{surf} with a bat = 2.2 and T_{surf} without a bat = 0.6°C). The relation between absence or presence of a bat and δT_a was not significant (average T_a with a bat = 0.2 and T_a without a bat = 0.4°C).

Interaction between the presence or absence of a bat and torch type

The relations between torch type and δT_{surf} were significant when a bat was present and absent, (bat absent $F(1.28) = 19.565$, $P < 0.005$, $r = 0.64$; bat present $F(1.24) = 27.765$, $P < 0.005$, $r = 0.74$). In both

Table 5. Results of the Spearman rank correlation coefficient and ANCOVA with two dependent variables: changes in air temperature (δT_a) and in surface temperature (δT_{surf}). The effect between the dependent variables and torch type, duration of treatment, volume of crevice and absence or presence of bat are given.

	Factor	Test	N	Df	Df error	P	r
δT_{surf}	Torch type	F = 25.764		1	49	0.0005	0.57
	Duration of treatment	F = 0.674		1	49	N.S	0.09
	Volume of crevice	Spearman = -0.047	54			N.S	
	Absence or presence of bat	F = 14.714		1	49	0.0005	0.47
δT_a	Torch type	F = 6.935		1	49	0.011	0.34
	Duration of treatment	F = 0.944		1	49	N.S	0.16
	Volume of crevice	Spearman = -0.037	54			N.S	
	Absence or presence of bat	F = 0.108		1	49	N.S	0.04

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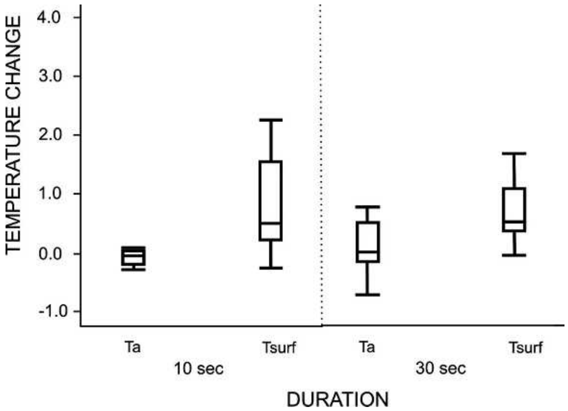

Figure 5. Change in air temperature (T_a) and surface temperature (T_{surf}) for two treatment durations: 10 and 30 seconds with median, middle 50% and top/bottom 25% of the scores indicated.

situations, the T_{surf} increased during the treatment, although the amount of the increase differed according to the torch type used. The MacCharge had the largest effect on δT_{surf} and this was most pronounced when a bat was present (Fig. 6). The Led and common Maglite had very little effect on the T_a and T_{surf}.

Real-time monitoring of temperature

Bat number one in crevice D was shone upon six times using different torch types (Fig. 7). During the experiment, the temperature of the logger increased from 5.5 to 8.5°C. Within a minute after a treatment using a torch, the temperature of the logger (and the bat) started increasing. Temperature reactions could be registered in the bat using the temperature logger, after treatment using all the torch types. Longer treatments (i.e. a duration of 120 and 60 seconds) yielded a larger increase in temperature.

Discussion

We recorded small changes in air temperature during the experimental treatments in cavities where dead bats were present, in contrast to treatments without dead bats. The air temperature was always measured at standard depth in the centre of each crevice. When a bat was present, the air temperature was measured behind the bat (using the thermocouple). We assume that the bat impeded the air current, as the air temperature behind the bat did not change during the treatments. In our experiment, we standardised the distance between the end of the torch and the point where the light hits stone or a bat. This allowed us to measure the surface temperature at a standardised distance from the heat source. The ambient temperature was always measured behind the bat and thus not at a standardised distance. In future experiments, we suggest using crevices with a standard depth. In such an experiment, a bat or a small stone can be used to change the size of the crevice to a standard depth.

The surface temperature was measured using an infrared sensor. When a bat was present, we measured the surface temperature of the bat rather than of the stone. Although we standardised the distance between the measuring device and spot of measurement, we did not correct for the difference in material. We assume there is a difference in conductivity between bat tissue and stone.

In our experiment, we used dead bat specimens. Living tissue will respond differently to heat than dead tissue. Living tissues are highly non-homogenous and heat transfer through such a medium is unpredictable (Liu 2008). The results of our experiment using living bats would probably have been different. In our experiment, we proved that torch light can raise the air temperature of a crevice above a

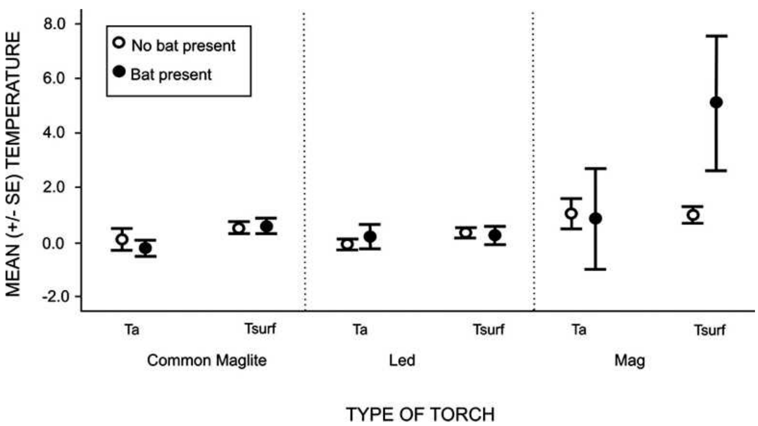

Figure 6. Mean (± SE) temperature change of the three different types of torches used expressed as the mean change in air temperature (T_a) and surface temperature (T_{surf}) for bat present and bat not present.

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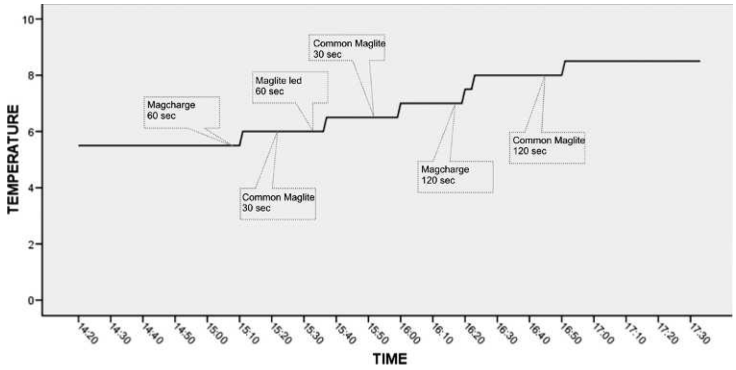

Figure 7. Change in temperature measured using an I button temperature logger, attached to a common Pipistrelle (an adult weighing four grams) hidden in crevice D.

threshold value, but it does not prove whether bats are able to sense the direct heat of a torch or not.

In our study, we mainly focussed on the influence of heat produced by a torch. Speakman et al. (1991) showed that light can also be an arousal stimulus, but supplied no details about the intensities required. Further experiments are needed to fully understand the impact of light as an arousal stimulus.

Conclusions and recommendations

In our experiment, we showed that crevices significantly heat up when using a torch, sometimes even above the threshold of 5°C, which is known to cause an arousal stimulus. Using a 'hot' halogen torch, such as the MagCharge, the air temperature in the crevices could increase by 6.3°C in 10-30 seconds. The surface temperature increased even more during same period of time, reaching a maximum increase of 8.3°C in comparison with maximum temperature changes caused by a 'cold' torch such as a LED MagLite and the common Maglite with a Krypton bulb; these two types of torches after 30 seconds caused a maximum increase in air temperature of 1.0°C and surface temperature of 0.8°C. In this experiment, we recorded increases in temperature in all the crevices, irrespective of their volume (121-280 cm^3). Our results show a significant relation between the type of torch used and the change in temperature measured. This relation was not affected by the duration of the treatment. The effect on air temperature of an incandescent (halogen) light was significant after both 10 and 30 seconds.

This shows that 'hot' torches pose a greater risk to bats than 'cold' torches. Our results become even more evident when a bat is present in the crevice. Our experiment shows that an observer using a hot torch is more likely to arouse a bat by increasing both the air and surface temperature (of its body and the surrounding stone).

It is still unclear whether bats can be aroused by temperature increases of < 5°C. It is, however, suggested that the timing of any disturbance may be critical, with disturbances at the beginning or end of a torpor bout being more likely to cause arousal (Speakman et al. 1991, Thomas 1995). In a study on winter survival in Poland, Ruczynski et al. (2005) did a monthly count of the number of dead bats and concluded that bats are more sensitive to arousal at both the beginning and end of the hibernation period than during the middle of winter when hibernation is deeper. It is likely that these periods correspond with periods of light sleep and easy arousal.

For monitoring purposes, all known bat *hibernacula* in Europe are counted annually and the results are used to calculate population trends. Observation effort, timing and technique needs to be constant from year to year. Based on our experiment, we would advise against using heat producing lights such as MagCharges, Petromax lanterns and carbide lamps. We furthermore recommend that bat observers visiting *hibernacula* use the precautions, formulated by Lefevre (2001), Dijkstra & Korsten (2005) and Mitchell-Jones & McLeish (1999), to prevent arousing hibernating bats, as detailed below. Lamplight should not be shone directly onto bats, particularly from a close range. Minimise the amount of light and fit your materials to the object of research. At close range, less light is needed to spot the most important characteristics.

- Minimise and control the number of photographs taken, ask census participants not to take unnecessary pictures as bats may suffer from the heat and light produced by flash strobes and the photographer's body heat.
- Do not touch bats or move objects that bats are attached to.

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- Lower your voice, especially in the direct vicinity of a large number of bats or near a free hanging bat. The frequency and loudness of a sound has a great effect on sound transmission. The sounds of a fence hitting a wall, the jangling of keys or items hitting a wall carry very far.
- Avoid shining light in the (closed) eyes of a bat. Most observers rely on facial characteristics to identify bats. Yet there are many other characteristics such as length of its body, overall shape, size of feet, extrusion of ears that can be used to identify species. If bat observers would learn to use these recommendations, much disturbance could be prevented.

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