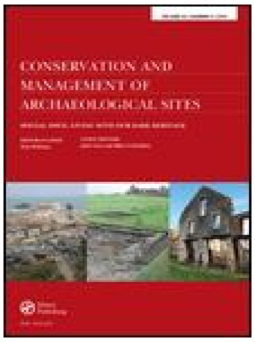

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Account of an Informed Bat Exclusion at the Temple of Deir el-Shelwit, Luxor, Egypt

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The conservation of the painted Roman-era reliefs in the temple of Deir el Shelwit in Luxor, Egypt, was recently initiated by the American Research Center in Egypt (ARCE). As a critical step in a series of preliminary preventive conservation measures undertaken at the temple, a resident bat colony was excluded to control further deterioration of the painted reliefs and stone fabric (Figure 1). In consultation with a bat biologist, a comprehensive humane, low-tech emergency exclusion programme was designed and implemented, which included roost location, behavioural surveys, species identification, sealing of building openings, bat exclusion and the design of an alternate roost site. This programme may serve as a useful example for other conservation projects in Luxor, since it provides much-needed information on the behaviour of local bats, as well as relevant insights gained from the exclusion procedure.

KEYWORDS Egypt, preventive conservation, painted reliefs, stone conservation, bats

Background

Deir el-Shelwit and the conservation project

Deir el-Shelwit is a Roman-era (first–second century CE) sandstone temple on Luxor's West Bank (Zivie, 1977: 154, 157) (Figure 2). Although located in one of the most visited areas in Egypt, the temple remains isolated from tourist activity, which is concentrated around better-known sites such as the Valleys of the Kings and Queens, approximately 5 km away. The temple has never officially been open for visitation by the public, and in fact has been locked for a number of years.

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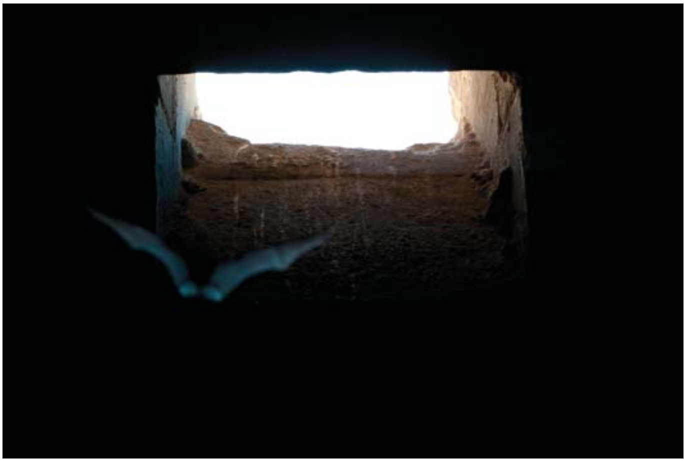

FIGURE 1 *Asellia tridens* in Deir el Shelwit.
Image: Owen Murray/© American Research Center in Egypt 2012

FIGURE 2 Exterior of Deir el Shelwit, facing north.
Image: © American Research Center in Egypt 2012

Deir el-Shelwit is dedicated to the cult of Isis and Monthu (Zivie, 1977: 160). It is a relatively small temple, composed of a central chamber, or *naos*, with an antechamber (*pronaos*) and surrounding corridor, four side chapels and a roof terrace (Figure 3). The façade and interior walls of the *naos* are decorated in painted high-relief with inscriptions and scenes of Roman emperors making offerings to a variety of Egyptian gods (Figure 4). While a relatively modest temple, Deir el-Shelwit is nonetheless

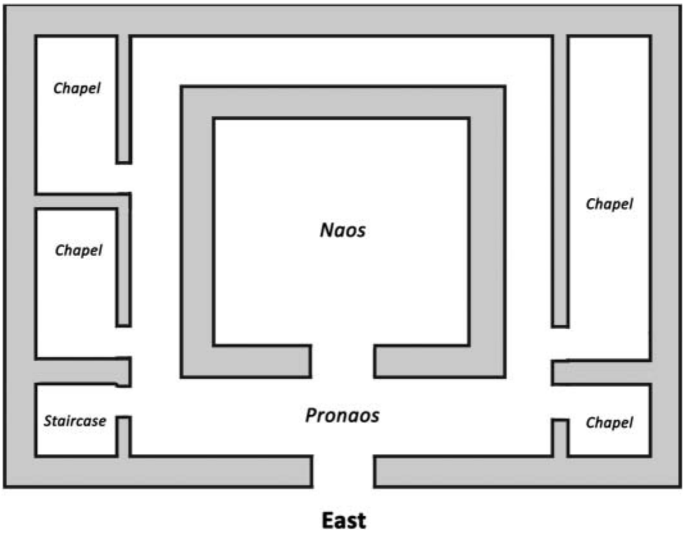

FIGURE 3 Floorplan of Deir el Shelwit (not to scale).

interesting for comparison with larger contemporary sites, and is considered one of last of such temples built in Egypt (Zivie 1977; 1982).

The project initiated by the American Research Center in Egypt (ARCE) in 2012[1] aimed to conserve the painted *naos* reliefs as part of a professional training programme for Egyptian conservators, ultimately making the temple accessible to visitors. This programme employed a team of lead conservators and around twenty student conservators, as well as rotating teams of workers. The project concentrated mainly on the cleaning of the *naos* reliefs, which were blackened by dirt and soot deposits as well as other soiling materials, such as bat excreta. The remedial conservation and training phases of the project began in the autumn of 2012. The preceding spring campaign, reported on here, concentrated on preventive conservation measures that were considered necessary before beginning remedial work, to better ensure the longevity of the monument as well as the utility of the planned cleaning. Measures included an overall structural assessment, roof repairs to prevent water infiltration, and the bat exclusion.

The decision to remove the bats

With high ceilings, multiple chambers, and small windows, the interior of Deir el-Shelwit is cool, dark, and protected from the high winds characteristic of the surrounding desert. These factors, combined with the temple's isolated location at the interface between the desert and cultivated lands, make Deir el-Shelwit an ideal habitat for bats (Figure 5). Although the temple fabric and reliefs do not appear to have undergone any significant conservation or restoration in the past, a comprehensive epigraphic and architectural study was conducted in the 1980s (Zivie, 1982). Interestingly, no mention was made of the presence of bats in the temple at that time, perhaps due to a wasp infestation (Zivie, 1977: 155; Frantz, 1986: 266; BCI, 2012: 2). The present bat colony therefore would appear to have inhabited the temple sometime after 1977.

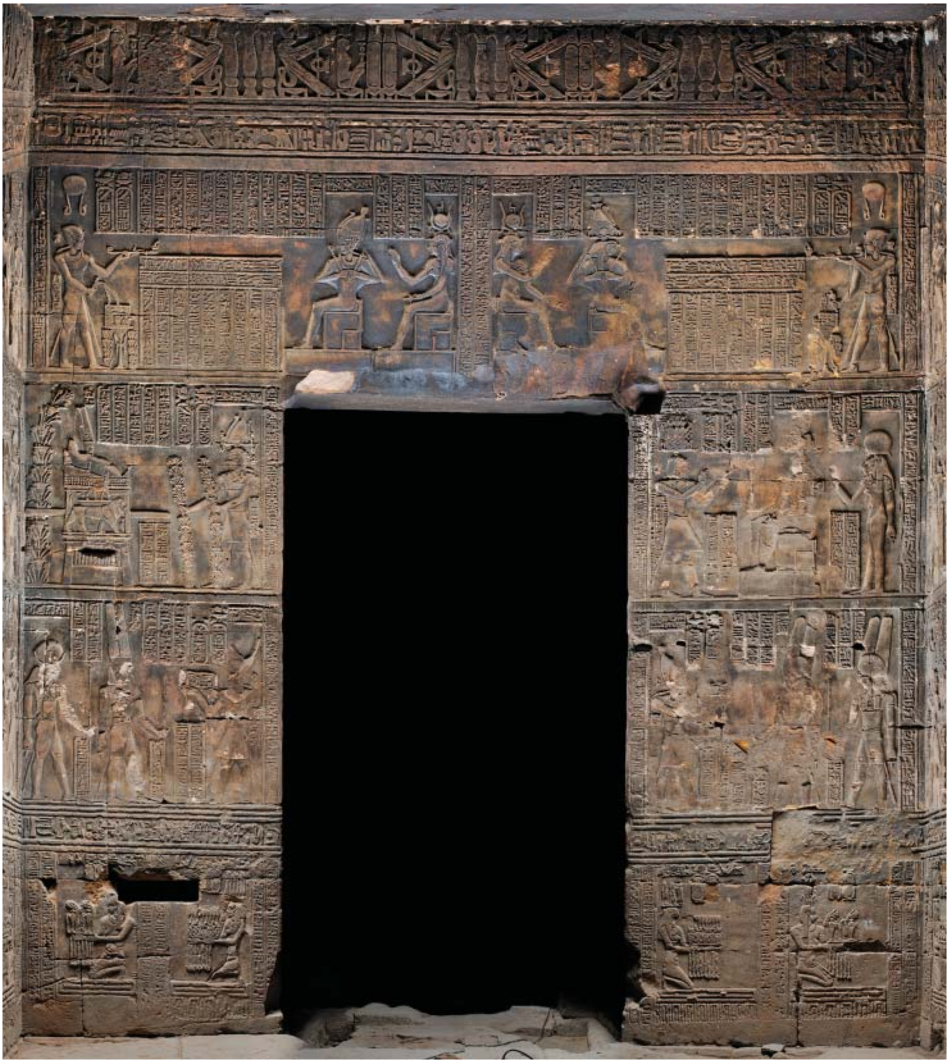

FIGURE 4 Reliefs on the interior east wall of naos.
Image: Owen Murray/©American Research Center in Egypt 2012

The removal of the bats was considered an essential first step in the project initiated in 2012 because these animals pose an ongoing threat to the painted reliefs as well as to workers and future visitors to the temple:

- bat roosting can cause mechanical damage to original surfaces (Paine, 1993)
- urine and guano can stain and cause chemical deterioration of stone and paint layers (Paine, 1993)
- guano can carry or host a variety of fungal and bacterial growth which can be harmful to humans, principally *Histoplasma capsulatum* (Lenhart et al., 2004); and
- bats can be carriers of rabies (Greenhall and Frantz, 1994: D-16-17) and other viral diseases.

FIGURE 5 Aerial view of Deir el Shelwit, clearly showing its location at the interface between desert and cultivated lands (arrow indicates the temple).
Image: © American Research Center in Egypt 2012

However, it must also be kept in mind that bats play an essential and often overlooked role in local ecologies, as pollinators, as a natural means of controlling insect population level, and as producers of fertilizing material. Extermination, a common and cruel approach to removing resident bats, is neither necessary, nor can it prevent future infestations. Extermination is not even the easiest means of bat removal: trapped, decomposing animal remains can create additional conservation and hygiene problems, which may be quite difficult to resolve (Kern, 1995: 139). Therefore, priority was placed on developing a compassionate and responsible removal strategy, which would minimize harm to the colony as well as to individual bats, and control, in so far as possible, the risks of recolonization. The strategy also took into account the conservation of the monument and its decoration as well as human health concerns, during removal as well as in the long-term.

For a variety of reasons, the bat clearance was the first step carried out in the project. First, due to health and safety concerns, it was considered that other work should not begin in the temple until the bats and their guano were removed. It was also necessary to remove the colony quickly: bats are long-lived, highly social, and intelligent mammals. Their young, normally one per year at most, are born live and flightless, must nurse and are thus highly vulnerable. It was therefore critical to relocate the colony before the spring birth of the flightless young, who would otherwise not have been able to leave the temple on their own until the fall (Frantz, 1986: 262; Kern, 1995: 139). This would have effectively pushed exclusion into the next field campaign, at which time it would become impractical due to the arrival of the majority of project participants and the intensive work scheduled to begin. Although the exclusion took place in late spring, close to the bats' birth period, research and discussion with bat experts reassured us that expelling the bats at this time would not pose a significant risk to the pregnant females nor to the colony (Frantz, 1986: 262), since bats are known to maintain alternate roost sites (Frantz, 1986: 266; Dietz et al., 2009; 2012), and would be able to quickly relocate themselves.

Bats in Egypt: the problem in context

Bat and bird infestations can be considered one of the most important and widespread conservation problems in Egyptian monuments. Monument façades and interiors often are filled with roost sites, and their surfaces are streaked with excreta, even following recent conservation. While efforts are sometimes made to keep animals out, such as placing screening over openings, these solutions are rarely maintained, allowing animals to reinhabit the monuments.

No published references describing bat exclusions were found for this region. Exclusion and relocation is the normal procedure for bat removal in Europe and North America, where the importance of these animals is understood and appreciated, their behaviour is well studied, and they benefit from legal protections (Greenhall and Frantz, 1994: D-15; Howard, 2009; Hutson, 1995). However, bats have no legal protection in Egypt (GCI, 2012), and their behaviour has not yet been sufficiently studied in this region (Dietz, 2005: 2). The Getty Conservation Institute and Ministry of State for Antiquities have carried out humane bat exclusions on Luxor's West Bank, including clearances from six tombs in the Valley of the Queens (GCI, 2009: 151); however, no other such projects were identified.

It was therefore considered that the well-researched and documented bat exclusion designed for Deir el-Shelwit offers an important example for future conservation projects in the area.

The project

Bat exclusion follows a series of basic steps which result in the bats spontaneously vacating the affected building (Greenhall and Frantz, 1994: D-16-17). This is achieved by systematically sealing all openings, leaving only a few accessible for bat egress. After the bats exit through these openings for their nocturnal foraging, these points are also closed, thereby preventing the bats from re-entering the building. Table 1 records this process as implemented at Deir el-Shelwit, divided into individual, sequential steps. Each step is discussed in more detail in the following sections, together with observations and results of their implementation.

Evening bat watch

The first step in a bat exclusion is a bat watch, involving the passive observation of the monument from the outside at dusk or dawn, without disturbing the resident bat colony (Kern, 1995: 139–40). This allows bats to follow their normal pattern of activity, making it possible to identify the main access points (primary egress points) and to estimate the number of individuals resident. Evening bat watches should be initiated just before sunset, and continued until bats can be observed exiting the building.

TABLE 1

STEPS IN THE BAT EXCLUSION AT DEIR EL-SHELWIT

Activity	Purpose	Method	Time required
Evening bat watch	Determine major points of egress, estimate colony size, and time of exit	Observe temple from exterior from just before sunset until bats are seen exiting	1–2 hours for 2 nights
Colony survey	Determine roosting locations, number of species, number of individuals, and if flightless young are present	Inspect and record roosting in temple interior	A few hours
Bat identification	Determine species, rarity, potential sensitivities, life cycle, and other relevant behavioural characteristics	Photograph, research, consulted with C. Dietz	A few hours for photography, time for bibliographic research, email discussions
Initial cleaning of temple	Remove bulk of guano deposits	Clean with trowels using appropriate personal protection	3 days
Closure of exit points	Seal the building at night to prevent re-entry by bats once they have exited, restricting bat movement to one or two major unsealed exit points	Temporary: block openings with foam Permanent: construct and install screening for windows and doors; fill and repoint cracks and gaps in building fabric	1 week for temporary measures; 1.5 months for permanent closures
Bat exclusion	Clear bats from building and prevent re-entry	Allow bats to leave for normal evening foraging through one or two major open exit points, then close off these exit points Repeat as necessary until all bats are out	5 nights
Building an alternate roost	Provide a new roost for bats, located adjacent to or near the monument. Reduce tendency to re-inhabit the temple. Allow bats to continue living in current ecosystem	Build an alternate roost	1 week for design; Approximately 1 month for construction, depending on permissions, availability of workers and materials
Final clean up	Remove any new guano deposited between first cleaning and exclusion; clean temple thoroughly	Vacuum, brush with personal protection	2–3 days

At Deir el-Shelwit, observers were stationed at the four corners of the temple, about 5–10 m from the building, giving each person full view of two façades and minimizing disturbance of the bats. Shortly before sunset the bats began to chatter within the temple, and the exodus occurred in waves within the first hour after sunset. It was also observed that bats would not exit on very windy evenings, and it was assumed that in these cases they waited until the wind died down before exiting. The primary egress points were identified as the four windows accessing the staircase, and two of the windows giving access to the roof terraces.

Colony survey

A colony survey was conducted during the day on 23 April, before initiating any work within the temple, and with a minimal number of staff (the authors and an ARCE photographer, Owen Murray) in order to reduce the disturbance to the roost sites and allow observation of the bats' normal habits. Each temple chamber was inspected to determine the location of roosts and the approximate number of resident individuals. Locating the roost sites allowed us to ascertain that no flightless young were present before beginning the exclusion,[2] and to determine the number of colonies and/or species inhabiting the temple, since multiple species commonly cohabitate (Greenhall and Frantz, 1994: D-9; GCI, 2012; Dietz, 2009; 2012). Determining the roost locations also allowed better monitoring of the success rate of the exclusion procedure.

It proved difficult to determine exact roost locations because the bats continually fled from one chamber to another. Guano deposits proved to be the best indicator of roost locations, corroborated by the bats' repeated movements to specific areas corresponding with these deposits. Eventually it was possible to map a number of main roost locations throughout the temple. The colony size was estimated at three to five hundred individuals, and no flightless young were observed. It appeared that only one species of bat was present, and the concerted movements of the group suggested that they were all individuals of a single colony.

Bat identification

The bats were photographed during the survey, both to document the infestation and to identify the species present. Images were sent to Dr Christian Dietz, bat biologist at the Department of Animal Physiology, University of Tübingen, for identification (Figures 6 and 7). Based on the photographs, Dietz was able to identify the species as *Asellia tridens*, the trident leaf-nosed bat. Dietz observed no other species in the photos, which concurred with observations made during the survey.

Asellia tridens is a common, insectivorous, desert-dwelling bat which occurs throughout North Africa, the Middle East, and into Central Asia (Dietz, 2009). It is listed as a 'species of least concern' by the International Union for Conservation of Nature and Natural Resources (i.e. not endangered or threatened) (Kock et al., 2008), and while well studied and documented in other regions of the world, very little information is available about the specific behaviour of *Asellia tridens* in Upper Egypt — a condition common to other local bat species (Dietz, 2012). Therefore, all assumptions about the *Asellia tridens* living in Deir el-Shelwit were based on their documented behaviour in other regions, which Dietz extrapolated to fit with the environmental and seasonal conditions specific to the Luxor area. Even this small amount of information was enough to significantly affect the exclusion plan, and will be discussed where relevant below.

For example, an understanding of the bats' life cycle was key in determining the scheduling of the exclusion. Previously available information reported that the mating and pregnancy season of Luxor bats in general was between mid-March and July (GCI, 2012). Dietz, however, pointed out that *Asellia tridens* begin giving birth in Israel in mid-May, with the latest births taking place at the end of June. The young are able to fly by mid-August. Since Luxor is farther south, Dietz estimated that

FIGURE 6 Part of the *Asellia tridens* colony roosting in corridor of Deir el Shelwit. Note excrement staining and accretion on walls and ceiling.
Image: Owen Murray/© American Research Center in Egypt 2012

Asellia tridens births there could begin in the second week of April, with the peak of the birth season at the end of May. Since work in Deir el-Shelwit began the last week of April, it was necessary to move very quickly to complete the exclusion before the bats began giving birth, or it would not have been possible to remove them before the end of the campaign. Dietz provided assurance that the sudden exclusion, just before the birth period, would not put pregnant females, unborn young, or the colony at significant risk since *Asellia tridens* fly up to 10–20 km in a normal night for foraging (Dietz, 2009); thus movement to the mountains and sheltering caves 4 km from Deir el-Shelwit would not cause undue stress.

Health and safety

Because bats are known carriers of infectious agents such as rabies and fungi, health and safety precautions must be taken before beginning work in infested areas (Lenhart et al., 2004). Ideally, samples should be taken from guano deposits and analysed for the presence of problematic fungi before beginning work in infested areas, thus allowing an accurate assessment of risk and necessary levels of personal protection for all workers.

There was unfortunately not sufficient time to undertake this important step before beginning the exclusion. The risk from fungal growth was assumed to be relatively low at the temple, given the extremely dry conditions in Luxor, the degree of air

FIGURE 7 Detail of a Deir el Shelwit *Asellia tridens*. *Image: Owen Murray/© American Research Center in Egypt 2012*

circulation within the monument, and the relative thinness of the deposits (Greenhall and Frantz, 1994: D-15). The incidence of rabies in *Asellia tridens* is also rare (Dietz, 2012). Nonetheless, comprehensive health and safety precautions were implemented (Lenhart et al., 2004: 4).

The risks of working in the temple were discussed with all workers (local and foreign conservators and workers). Each person was provided with appropriate respiratory protection and gloves, instructions for minimizing exposure to guano contaminants, and suggestions for interacting with the bats to avoid physical contact and panic by either species. Workers were asked to keep their voices down, move slowly, and crouch when passing though doorways, climbing the stairs or entering lower-ceilinged chapels, so that bats would have space to fly overhead when seeking to escape.

Clean up

Once the survey and identification were completed, dust and guano deposits were removed from the floors and stairwell of the temple to protect workers. Dust movement was kept to a minimum during cleaning by favouring collection with trowels rather than brooms, and all debris was regularly removed from the temple as it accumulated. The debris was reviewed for any significant archaeological fragments before disposal.

Disturbance of the bats and therefore potential contact with the workers was minimized by beginning work in the *naos* and northern chapels, and then moving anti-clockwise around the back of the *naos* to clean the southern chapels and stairwell. In this way the bats were able to shelter in the southern chambers and avoid the workers by then fleeing to the northern chambers via the *pronaos*.

Closure of egress points

After the bulk of the guano had been removed it was possible to begin more extensive work inside the temple. The first task was to seal all openings in the outer building fabric which could provide access to the temple interior. Dietz suggested that all cracks and openings larger than ~2 × 4 cm be sealed, while some authors argue that even openings larger than ~0.6 × 3.8 cm should be considered accessible to bats, depending on the species (Greenhall and Frantz, 1994: D-13; Frantz, 1986: 261). In Deir el-Shelwit problematic openings in the exterior fabric included:

- two doors, one at the front of the temple and one at the top of the stairs;
- four windows on the roof terraces;
- four windows in the staircase;
- three small and one very large skylight in the side chapels; and
- cracks in the building fabric: 1–10 cm wide, generally following the joins between sandstone blocks but in some cases running through the body of the blocks.[3]

Doors and windows were closed with screening fitted over wooden frames, constructed by a team of local carpenters. This closure system was selected since it would only minimally reduce the amount of light and airflow. The amount of light can be considered integral to both the temple's current appearance and its original function (Finnestad, 1997: 211–13), while consistency of airflow is essential in preventing the creation of new environmental conditions within the temple which might promote the deterioration of painted reliefs and stone, and/or create conditions favourable to fungus or other biological growth. The wooden frames were constructed to fit flush with the architecture, and in some places were held in place by wooden wedges since the frames could not be attached to the monument by screws or nails. Dietz suggested the use of screening with openings no larger than 1.5 cm^2 in order to prevent re-entry (2012), and therefore a heavy duty, stainless steel screening with a mesh size of 1 cm^2 was chosen. This material was preferred over thin aluminium or iron mesh since it is more durable, resistant to animal and human abuses, and more chemically stable. Plastic mesh was ruled out due to the extreme temperatures and sun exposure typical of Luxor.

Cracks were filled with a 1 part lime: 2.5 parts sand and brick dust mortar, pigmented to match the surrounding sandstone. The largest openings were first filled with a coarse gravel mixture, and then sealed with a finer mortar mix. Cracks were filled to about 0.5–1 cm below the level of the surrounding stone. In this way the repairs remain visually discreet but also prevent the use of recesses as roosting sites for birds or other animals.

Emergency repointing and filling of the largest cracks was completed in one week by the conservation team. During that same period as many of the architectural openings were screened as possible, while any others were temporarily blocked with foam. Even once screened, windows were blocked with foam until after the exclusion was completed, to prevent bats from running into the screening, a material which can be confusing to their navigational systems. This emergency closure effort left only two of the major egress points (roof terrace windows) available for continued use by the bats, and allowed us to begin excluding them less than two weeks after commencing site work.

After the emergency closure, a team of local workers was hired to complete the repointing of the exterior fabric, and local carpenters continued construction of the permanent frames for the windows and doors. This activity was pursued throughout the remaining month until the temple fabric was thoroughly sealed in a more permanent manner.

Bat exclusion

Once the emergency closure measures were completed and a second survey conducted to ensure the absence of flightless young, it was possible to begin excluding the bats. Research had been conducted into methods of bat exclusion before undertaking the process, but the removal nonetheless proceeded to some extent by trial and error. While some devices have proved useful in encouraging bats to leave a roost (lights, air movement, and naphthalene[4] [Kern, 1995: 142; Greenhall and Frantz, 1994: D-22]) others, such as ultrasonic devices, air compressors, or smoke, are considered ineffective or even counterproductive (Greenhall and Frantz, 1994: D-22; Kern, 1995: 142; Dietz, 2012). In fact, bats tend to hide and become entrenched when their roost sites are threatened, often seeking refuge in cracks and crevices rather than fleeing (Dietz, 2012). Experts therefore agree that the most successful and recommended means of addressing a bat infestation is through exclusion, which usually involves the observation of bat egress, followed by night-time closure of all openings in the building fabric to prevent re-entry (Dietz, 2012; Frantz, 1986: 261; Kern, 1995: 139; Greenhall and Frantz, 1994: D-18).

Many reports of bat exclusions in North America and Europe discuss the use of temporary exit valve systems, which eliminate the necessity of night-time closures. Valves allow bats to exit by their normal routes, but impede their re-entry (Frantz, 1986; Greenhall and Frantz, 1994: D-19; Kern, 1995: 140). The valves can be installed and left in place over a series of nights, during which the bats can exit the building and remain trapped outside. The use of valves would seem ideal, particularly for a bat exclusion on an archaeological site, where working at night can be bureaucratically difficult to arrange. However, Dietz warned that, while the valve systems work very well in the case of *Myotis* species and other species of the family *Vespertilionidae*, they might not work as well for *Asellia tridens*, who are dexterous fliers with the ability to manoeuvre through very small spaces. *Asellia tridens* also will not crawl or push their way through openings, so flap-type valves would probably impede their exit, while they might be able to navigate any tube-type systems. Dietz therefore recommended, for the safety of the bats and rapid success of the exclusion, that we follow the night exclusion plan. He said that generally *Asellia tridens* exit the roost one hour after sunset, as observed, but the first bats will begin to return as early as an hour later. Therefore it would be best to close the exit points between one and two hours after sunset, and simply repeat the operation the next night if any bats remained in the temple. He suggested not disturbing the bats the day before this operation, in order to avoid upsetting their normal behaviour.

Our experience at Deir el-Shelwit concurred with the advice of these various experts. Each exclusion session was begun approximately thirty minutes before sunset. On the first night, an effort was made to scare the bats from the building by making loud noises and turning on bright lights. While this allowed us to clear them from the stairwell and small chapels, the bats refused to exit the temple, and in fact seemed to become entrenched. It was decided to block the doors of the cleared staircase and chapels with wooden panels, so that the bats could not return to them, and were therefore confined to the corridor. One window leading from the corridor to a roof terrace was left unblocked that night, while all other exits were closed. The bats were then left undisturbed for three nights, allowing them to become accustomed to using the single open window as an exit (Kern, 1995: 139), after which another exclusion was attempted. This time the temple was not entered until approximately an hour after sunset, which allowed the bats to leave as they would for normal nightly foraging, with no encouragement, interruption, or stress. Upon entering the temple, only twenty bats remained, and after unsuccessfully attempting to chase them out, the roof window was blocked to prevent the exited colony members from returning that night. The temple was left completely sealed over night.

The next day, the window was unblocked in the afternoon, and we entered the temple again one hour after sunset. This time we found only six bats inside, succeeded in chasing one out, and again blocked up the roof window. We repeated this process over the course of two more nights, during which time we found three and finally no bats inside the temple. Following the complete removal, the windows were sealed permanently with the wood and mesh screening, and all foam removed from the structure. Boards over the chapel doors were left in place to facilitate further exclusions in case of rapid recolonization, but removed at the end of the season to allow normal airflow through the temple to resume.

Final clean-up

A final cleaning of the temple floors and stairwell was then carried out, in order to remove new guano which had been deposited in the time between the first cleaning and the removal of the bats, and also to more thoroughly remove the remains of older deposits.

Alternate roost

Because of its isolated location at the edge of cultivated lands, with their abundance of water, plants, and insects, it seems very likely that the excluded colony and/or other bat colonies will seek to reinhabit Deir el-Shelwit. Moreover, the exclusion deprived the bats of a prime roosting location, and might result in their elimination from the local ecosystem. It therefore seemed important to provide the colony with an alternate roost located close to the temple.

In the weeks while the exclusion was being carried out, a bat house was designed. Ideally, an alternate roost should be in place about two to six weeks before the exclusion to allow the bats to discover and become accustomed to it (BCI, 2012: 2). However, due to the emergency nature of the exclusion at Deir el-Shelwit, there was not time to plan and build a house before removing the bats. Nonetheless, it is felt that constructing the bat house is still worthwhile, even after completing the bat exclusion, since it could allow the bats to reintegrate into their original ecosystem, and reduce the likelihood of recolonization of the temple.

However, bats' criteria for roost selection is not yet fully understood, and further research is needed into the design of successful alternate roosts, especially since it depends greatly on behavioural and environmental factors and may be considered quite site-specific (Greenhall and Frantz, 1994: D-23). Nonetheless, some general rules are recognized: the house should be located as close as possible to the original roost location and at least 8 m from trees or wires where aerial predators could lurk (BCI, 2012: 2). Climatic conditions such as temperature within the roost are important factors in its success. Air flow also affects sanitary conditions, and deposition and removal of guano should also be considered in this regard (Greenhall and Frantz, 1994: D-23). *Asellia tridens* in particular roost in underground cavities and prefer deep, dark, sheltered spaces. Successful alternate roosts have been built for this species in Israel by burying military bunkers under dirt and rocks, essentially creating artificial caves with 2 m high ceilings (Dietz, 2012).

The bat house designed for Deir el-Shelwit will have a long corridor providing access to a high-ceilinged central chamber for roosting (Figure 8). It will be built of adobe (earthen brick), a locally obtained, low-cost material with good insulating properties, which will aesthetically integrate the structure into its surroundings. The design incorporates the following factors:

- thermal insulation: the adobe brick walls will be 0.3–0.5 m thick; the entry corridor wraps around the central chamber to increase insulation, with a double roof serving the same purpose
- air flow: the entry window in the outer wall and smaller windows in both roofs should provide low, but sufficient levels of airflow
- light: the windows will be small and unaligned; thus, no direct light can enter the central roosting chamber
- protection: there will be no openings at ground level, thereby reducing access to the roost by local ground-dwellers, including humans
- location: the house will be built as near as possible to the temple, far from trees, wires, roads, and paths (Figure 9); and
- guano deposition: this is the only unresolved aspect of the house, and it is hoped that either it will be resolved naturally or that periodic cleaning can be undertaken.

Of course, only time and the bats will tell whether our design is effective.

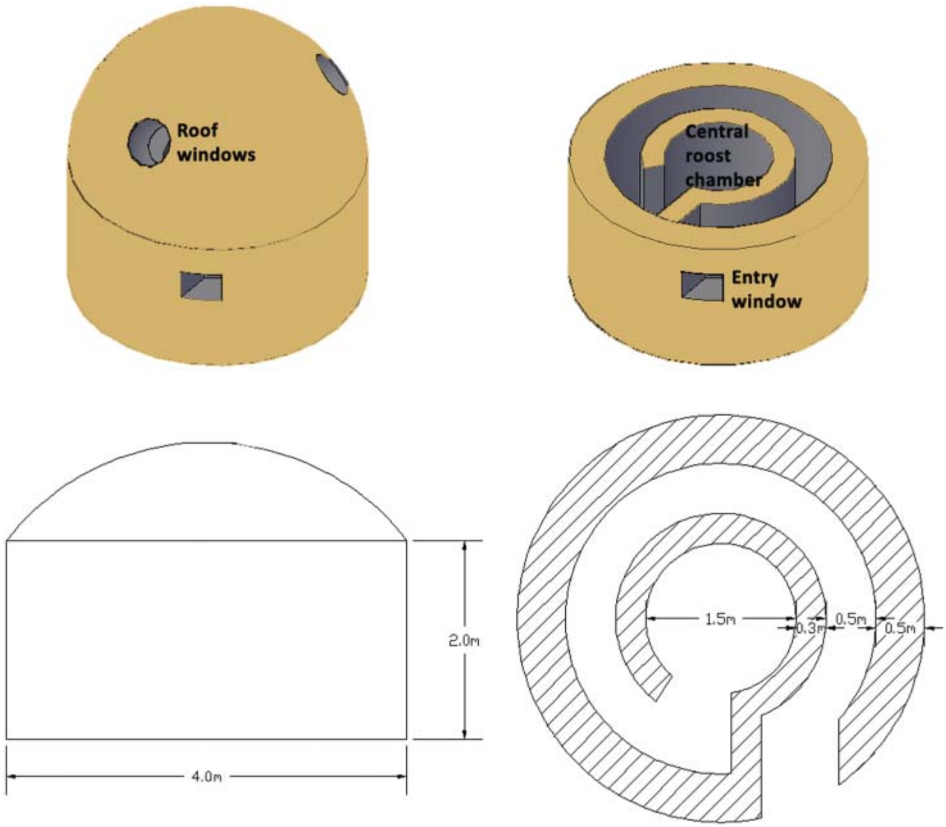

FIGURE 8 Proposed bat house design.
Design: J. Porter; Drawings: M. Moktar/© American Research Center in Egypt 2012

Conclusions

The process followed here resulted in the successful and humane emergency removal of a bat colony at the temple of Deir el-Shelwit. The removal was surprisingly straightforward, given the large number of bats that originally inhabited the temple, and the logistics of carrying out such an operation (including night work) at an archaeological site. It is important to emphasize that the design and success of the exclusion relied heavily on an understanding of the particular habits and lifecycle of the bat species in question, as provided by research and consultation with a bat ecologist, as well as local environmental conditions.

Removing the bats is, of course, only the first step in a successful overall exclusion plan; its long-term success will depend on regular monitoring and maintenance of the temple and closure systems. It is expected that this will be adequately carried out during the remaining two years of ARCE's project at Deir el-Shelwit. However, it is not clear what will happen after this time. Examples of failed closure systems can be observed at historic sites throughout Egypt — small holes in screens and frames go unpatched, eventually allowing animal life to reinhabit interior spaces. Although

FIGURE 9 General proposed location for bat house, indicated in red.

closure materials at Deir el-Shelwit were selected in so far as possible with durability in mind, if not properly maintained it is likely that these too will fail and the temple will be recolonized by bats within a matter of years. The freshly cleaned and conserved painted reliefs would then again be subject to soiling and deterioration by bat excreta, but this time without their protective coating of dirt and dust.

The challenges of implementing successful long-term bat exclusions in the Luxor area become evident when placed in the general context of conservation in this region, where aesthetic considerations and the expansion of tourism are often prioritized at the expense of preventive measures essential to the long-term protection of the heritage. It is hoped that, by working with local authorities and enhancing awareness of projects of this type within the Egyptological community and perhaps even with tourists (through publication and informational signage), a shift in focus might occur over time. In the meantime it is hoped that the strategy outlined here may act as a step in the right direction and serve as an example for future bat exclusions across Egypt and even in other regions of the world.

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Notes

[1] Funding for the project was provided as part of a larger, multi-project grant from the United States Agency for International Development (USAID).

[2] Nursery colonies often form 'baby clusters' wherein groups of non-reproducing close female kin guard groups of flightless young, which can be observed as groupings of small pink newborns (Dietz, 2012).

[3] These cracks were examined during a structural assessment carried out at the end of the campaign. Stabilization issues will be evaluated and addressed as necessary in later campaigns based on the results of this assessment.

[4] Naphthalene is the only chemical registered for use as a bat repellent by the United States Environmental Protection Agency and no chemicals are registered for use as toxicants (Greenhall and Frantz, 1994: D-22; Kern, 1995: 142).

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