SOUTH AFRICAN GOOD PRACTICE GUIDELINES FOR OPERATIONAL MONITORING FOR BATS AT WIND ENERGY FACILITIES

2nd edition

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Contents

1. INTRODUCTION AND SCOPE

These good practice guidelines are based on experience at South African operational wind energy facilities (WEFs), relevant published scientific literature, guidance documents from North America and Europe for wildlife studies at operational WEFs, and input from the South African Bat Assessment Association (SABAA). They are to be used as a guideline in developing protocols for monitoring bat activity and fatalities at operating WEFs in South Africa. The objective of this document is to provide users with a standard protocol to monitor and estimate bat mortality, facilitating comparison between fatality rates across different WEFs. By standardising protocols, comparable estimates can be achieved which will be valuable for understanding different levels of risk (Kunz *et al*. 2007). Protocols prescribed in this document will change as the impacts of wind turbines on bats in South Africa emerge. This document should be read in conjunction with the bat threshold guidance (MacEwan *et al*. 2020a) and mitigation guidance (Aronson *et al*. 2018) to assist in the management of impacts to bats at operating wind energy facilities based on incoming fatality data. Impacts to bats must be managed using an adaptive approach whereby the monitoring data dictate appropriate management responses.

Operational fatality studies are primarily concerned with assessing the patterns and fatality rates for bats and birds at a WEF and involve searching for bat and bird carcasses beneath wind turbines (Strickland *et al*. 2011). This might identify species suffering mortality, specific periods of high risk (e.g. seasonally) and the environmental context of high bat and bird mortality. Because of their life-history characteristics, which includes low fecundity (i.e. low rates of producing and raising young), bat populations are slow to recover from disturbances and declines (Barclay & Harder 2003; Voigt & Kingston, 2016), and extinction might occur. This in turn runs the risk of infringing the National Environmental Management: Biodiversity Act 10 of 2004, unless mitigation is implemented. Without sufficient information on bat activity and mortality after installation and during operation of wind turbines, effective mitigation or adaptive management cannot be proposed and instigated to reduce any substantive risk to bat populations.

Operational fatality monitoring should be designed to answer the following questions:

1. What are the bat fatality rates for the facility?
2. What are the fatality rates for species of concern (e.g. species with high conservation status, rare species and species at high risk of fatality)?
3. Do bat fatalities vary within a facility in relation to site characteristics?
4. How do the fatality rates compare with those from facilities in similar landscapes with similar species composition?
5. What is the composition of fatalities with respect to migrating and resident bat species?
6. What is the relationship between bat activity and bat fatality?
7. What is the relationship between bat fatality and environmental variables (e.g. wind speed)?
8. What is the relationship between bat fatality and season?
9. Do fatality rates suggest the need for measures to reduce impacts?
10. Which mitigation methods are the most effective?

2. OPERATIONAL MONTORING PROTOCOL

The first two years of a WEFs operation are the most important period in which to collect post-construction information because this is when any change in bat activity is likely to occur. Two years will also allow for interannual variation in activity and fatality to be captured, contributing to a greater understanding of impact and risk. **A minimum of two years' operational monitoring must be undertaken but impacts should continue to be monitored and assessed throughout the lifespan of the facility as outlined in this document in consultation with a suitably qualified bat specialist**. Where more severe impacts have been identified or predicted, an extended period of data collection might be needed to assess the effectiveness of any mitigation proposed. Developers must coordinate with landowners and specialists to ensure full access to the WEF for the duration of the monitoring programme.

Fatality monitoring results should allow comparisons with other WEFs and provide a basis for determining if operational changes or other mitigation measures at the WEF are appropriate. Therefore, search protocols should be standardised to the greatest extent practicable and they should include methods for adequately accounting for sampling biases (e.g. searcher efficiency, scavenger removal of carcasses, density-weighed proportion of searchable area). Operational monitoring is divided into two parallel phases described below: 1) Acoustic Monitoring and 2) Carcass Searches. A summary of minimum requirements is provided in **Appendix 1**.

ANY DEVIATION FROM RECOMMENDED SURVEY GUIDELINES SHOULD BE ACKNOWLEDGED CLEARLY IN ANY REPORTS AND ACCOMPANIED WITH A CLEAR RATIONALE THAT IS INFORMED BY SCIENTIFIC KNOWLEDGE, EVIDENCE AND EXPERTISE.

2.1 Acoustic Monitoring

For consistency, operational acoustic monitoring should use the same sampling regimes, methods, sites (including the meteorological mast(s) if this/these has/have not been decommissioned), duration, equipment and techniques used during pre-construction monitoring (Arizona Game and Fish Department 2012), unless these are seriously flawed or best practice standards have changed in which case the acoustic monitoring should adhere to the latest available guidance. Similarity between operational and pre-construction monitoring may facilitate direct comparisons between the two datasets to allow inferences about how the baseline levels of bat activity have responded to the construction of the wind energy facility. In addition, acoustic data can also be used to support adjustments to mitigation measures such as curtailment regimes by providing data on bat activity. If no pre-construction acoustic monitoring was conducted or if the pre-construction monitoring did not follow best practice guidelines, then refer to MacEwan *et al*. (2020b, or subsequent editions) for the recommended methodologies to be used for acoustic monitoring.

It is a minimum requirement to monitor bat activity in the area of greatest risk (i.e. the rotor-swept zone). To achieve this, acoustic detectors must be installed on meteorological mast(s) if these are available. In circumstances where no met mast is available to monitor bat activity at height, then monitoring from the nacelle of at least one turbine or other mast or structure within the rotor swept zone is a minimum requirement. These data may be used to relate activity patterns of bats to observed fatalities. Electromagnetic interference from the turbine might influence acoustic data and this should be investigated and tested to ensure data reliability. Equipment that can counteract electromagnetic interference is available commercially.

2.2 Carcass Searching

The principal method to determine fatality rates is the carcass search (Kunz *et al.* 2007; Strickland *et al.* 2011). Permission to possess bat carcasses or live bats (most likely injured bats) should be obtained from the relevant provincial environmental authority prior to commencement of carcass searches. Methods to deal with live, injured and dead bats are provided in **Appendix 3**. All survey staff should ensure that they are fully inoculated against rabies. All maintenance personnel and other people working at or visiting a facility should be instructed not to remove any carcasses (bats or birds) they discover but should report these to the search team. Once all necessary data have been collected from carcasses, it is recommended (and highly encouraged) that they be deposited with a museum (unless carcasses are to be used for field bias trials). Records of bat fatality and fatality estimates must be kept in a central database[1] that can be accessed by various stakeholders. This will facilitate greater understanding of bat-wind energy impacts including cumulative impacts and hence insight into management options for bat fatality and WEF operation.

The use of trained dogs for carcass searches can be significantly more successful and efficient than human observers (Arnett 2006; Mathews *et al*. 2013; Paula *et al*. 2011, Smallwood *et al*. 2020) although testing of this South Africa had been limited. Dog and human observer teams can therefore be used for carcass searches if feasible. It is unlikely that the use of dogs would replace human searchers because there are a number of ethical restrictions when using dogs and because it is difficult to scale up dog searching to the same degree as is achievable using human searches. The intention is that dog searching can be used to complement human searching if required at certain WEFs such as when rare species or species of conservation concern are likely to be impacted. The feasibility of this can be investigated on a case by case basis by the relevant personnel involved in the monitoring.

2.2.1 Duration and Frequency of Monitoring

A minimum of two years of operational monitoring must be undertaken to commence **as soon as turbines become operational (i.e. when blades begin spinning, regardless of grid connection)**. If the project is commissioned in phases, monitoring for each phase must begin when that phase begins operation (Ontario Ministry of Natural Resources 2011). Beyond the minimum two-year period, monitoring of impacts must continue throughout the lifespan of the facility. The scope of this monitoring must be informed by the findings of the initial two years of operational monitoring. For example, if bat fatalities approach or exceed threshold levels (MacEwan *et al*. 2020a) or if the initial two-year period was not undertaken according to the minimum requirements of these guidelines, monitoring must continue into a third year, and possibly longer. **However, as a minimum, following the initial**

[1] A central database to host bat activity and fatality data from wind energy facility projects is in development.

two-year period, monitoring must be repeated again for an entire year in year five, and again every five years thereafter, for a year, which is aligned with best practice guidelines for birds (Jenkins *et al*. 2015). These minimum requirements are provided to guide developers, operators, and those executing the monitoring to plan monitoring efforts. However, it is crucial that any monitoring undertaken be done so in an adaptive manner that responds to findings on the WEF at any time. This could result in either an intensification or relaxation of monitoring efforts, or an adjustment of monitoring techniques, in response to bat fatalities.

The search interval (i.e. the interval between carcass searches at individual turbines) is a key parameter influencing the overall quality of an operational monitoring programme at some WEFs, especially where scavenging rates are high and searcher efficiency low. The search interval should therefore be dictated by carcass removal trials but kept as short, and consistent, as practicable. If carcass removal is high (e.g. carcasses are removed after one or two days), then shorter search intervals are necessary to achieve reasonably accurate estimates of fatalities (Strickland *et al*. 2011). For example, if carcasses are removed after two days, the search interval should match this.

Initially, turbines should be searched twice a week until scavenger removal trials are performed to determine a more appropriate search interval for the WEF. Regardless of the search interval employed, if certain turbines cause high levels of fatality, the monitoring protocol should be adjusted such that carcass searches occur at these turbines on a daily basis because episodic fatality events are more likely to be detected (Arnett 2005; U.S. Fish & Wildlife Service 2012). In certain regions, it might be appropriate to increase the frequency with which turbines are searched during the months bats are active, and to decrease the frequency during periods of inactivity. In addition, carcass persistence varies across seasons (J. Aronson, unpublished data) which may also allow for varying search intervals across the monitoring period.

2.2.2 Number of Turbines to Monitor

All turbines at a WEF, regardless of the number of turbines, must be searched according to the search interval for at least the first year of the monitoring period. Depending on findings after this first year, the number of turbines searched may be scaled down, or alternatively, the search intervals at some turbines may be differentiated such that some are searched more frequently, and others less frequently in subsequent years.

2.2.3 Delineation of Carcass Search Plots

Evidence suggests that more than 80 % of dead and injured bats fall within half the maximum distance from the blade's tip to the ground (Kerns *et al*. 2005). Therefore, the search plot size must be determined by the wind turbine technology used at each specific site. For example, if the highest point of a turbine's blades are 120 m from the ground (i.e. the top of the rotor swept zone), the search plot should extend 60 m in all directions. Searches should be symmetrically centred on each selected turbine using either a square, rectangular or circular search plot (Cooper-Bohannon *et al*. 2009, Ontario Ministry of Natural Resources

2011) depending on turbine locations, arrangements and surrounding terrain.

Within the search plots, parallel transects, spaced no more than 6 m apart, should be walked, yielding a search width of 3 m on either side of the transect line. Transect spacing will need to be decreased to < 3 m for sites with thick vegetation or terrain that reduces visibility. Areas of very low visibility such as dense bush, forest, very tall grass, crops or rocky outcrops with lots of crevices can be omitted from the search plot and accounted for in the fatality estimate calculations.

At sites and/or turbines where access and visibility is particularly poor, it is acceptable to focus searching on the road and hardstand areas surrounding each turbine. In these situations, roads and hardstands must be searched out until the search plot size. For example, if the search plot size is 50 m, as determined by the size of the turbine blades, then the roads and hardstands must be searched out until 50 m. The benefit of focusing searching on roads and hardstands is that these areas allow for a higher probability of detection, a smaller area is searched which reduces the time spent at each turbine and hence more turbines can be searched each day, as well as on a more consistent basis, and limitations in searchable area due to access or visibility which result in highly variable search effort across facilities is avoided (Huso 2019). However, when limiting searching to road and hardstands, the search plot size can be greatly reduced which means some carcasses can be missed even if they would have been able to be detected which can reduce the precision of fatality estimates (Huso 2019). In addition, for some WEFs the turbines are not centred on hardstand areas which may result in areas that could yield a high probability of finding carcasses (i.e. areas near the turbine where most carcasses fall, but not on the hardstand or road) not being searched. Thus, the decision as to the appropriate search area to employ must be WEF and turbine specific.

2.2.4 Habitat Mapping, Visibility Classes and Carcass Fall Patterns

Searchable areas vary and often do not allow surveys to consistently extend to the maximum search plot radius, especially in areas with dense vegetation (Huso & Dalthorp 2013; Strickland *et al*. 2011). Therefore, the habitat in each search plot should be mapped and visibility classes established according to the habitat type and the percentage and height of the ground cover. Habitat mapping must take place once per season to account for phenological changes in vegetation patterns throughout the year. SABAA recommends the following visibility classes adapted from the Ontario Ministry of Natural Resources (2011):

Table 1: Habitat Visibility Classes

Visibility Class	% Ground Cover	Vegetation Height
Class 1 (Easy)	≥ 90 % bare ground	≤ 15 cm tall
Class 2 (Moderate)	50 % bare ground	≥ 15cm tall
Class 3 (Difficult)	Little or no bare ground	≥ 25 % ≥ 30cm tall

In addition, bat carcasses fall at different distances and densities from turbines, with most being concentrated nearer to the turbine (Kerns *et al*. 2005; Huso & Dalthorp 2013). Failing to account for this can have a large influence on overall fatality estimates, thus the relationship between carcass density and distance from turbines must be taken into account (Huso & Dalthorp 2013). Measurements of the distance each carcass is found from the turbine base must be recorded (see Appendix 2) and incorporated, together with the proportion of area searched, into the fatality estimation in GenEst (see 2.2.7) by determining the Density Weighted Proportion[2] (DWP) for each turbine at which carcasses were found.

2.2.5 General Search Protocol

All search staff should be well trained to perform the tasks set out in these guidelines. The training should include background to the work, an introduction to bat ecology, the impacts of wind energy on biodiversity, field work skills, data collection techniques, appropriate usage of equipment, bat handling, carcass processing and data management. Continuous training, motivation and mentorship of the search team(s) is very important to maximise search effort. In circumstances where the search team is employed directly by the operator, efforts to ensure independence must be established between the stakeholders involved.

Staff trained in proper search techniques should look for bat carcasses along transects within each search plot, and record and collect all carcasses located in the searchable areas. The order in which turbines are searched should be randomised for each search to minimise the chance of predators removing carcasses from specific turbines before they can be searched (Cooper-Bohannon *et al*. 2009). This randomisation should be balanced against practical constraints of accessing turbines for searches that are spread far apart. The starting point and direction walked should also be randomised and recorded for each search.

Data to be recorded for each search are described in **Appendix 2**. If a carcass is found, the searchers should complete a Fatality Report Sheet (**Appendix 2**). At least four photographs (full body view top, full body view bottom, clear close-up face and ears and a clear close-up tail photo) of each carcass should be taken *in situ* and should include a ruler or other standard item used for scale. Rubber gloves should be used to handle any carcass to eliminate any possible transmission of disease and to reduce possible human scent bias for carcasses subsequently used for field bias trials. Carcasses should be placed in plastic Ziploc® bags, labelled with a unique carcass ID number and frozen for storage (or preserved with alcohol; see **Appendix 3**). Carcasses found can be used later on for searcher efficiency or carcass removal trials. Staff members must not dispose of any waste (e.g. plastic bags/latex gloves/paper towel, etc.) that has come into contact with bat carcasses, via normal waste disposal routes (bins – landfill site). Such waste products should be incinerated by a company able to deal with 'soft waste'. For remote sites where such actions might not be possible, all contaminated material must be treated with a bleach solution typically containing 5 % sodium hypochlorite (1 part bleach to 99 parts water). Contaminated material must be submerged/in contact with bleach solution for a minimum of 15 minutes, prior to disposal.

Although not a minimum requirement of these guidelines, it is advisable that the proximate cause of death of bats found beneath wind turbines be determined, if feasible, as this information may be important in the event of any disputes, for research purposes and to possibly relate to mitigation. However, several factors can confound the diagnosis, especially when barotrauma is suspected and a range of techniques; including X-ray (to identify any fractured bones), histopathology and necropsy are needed to correctly identify the cause of death (Grodsky *et al*. 2011; Rollins *et al*. 2012). If deemed necessary by the specialist, the environmental authority, or if requested by a WEF operator, these methods may be

[2] The proportion of total mortality expected to fall within searched areas.

performed on a random sub-sample of fresh carcasses ensuring that additional fresh carcasses are available for field bias trials.

2.2.6 Field Bias and Error Estimation

The number of bat fatalities observed at a wind energy facility is a minimum estimate of actual fatality (Huso 2019). Staff employed to search for carcasses might miss carcasses during searches, scavengers might remove carcasses before they can be detected, injured bats might survive long enough to leave the search plot, fatalities can occur outside the search period and carcasses can land outside the search area. Some of these detection biases can be quantified to adjust the estimates of bat fatality whereas others, such as crippling bias (Smallwood 2007), are more difficult to account for.

Searcher efficiency and scavenger removal have a large impact on overall fatality estimates. Field bias trials should therefore be performed as often as possible to account for these, but a minimum of once per season (New Brunswick Fish and Wildlife Branch 2011; Ontario Ministry of Natural Resources 2011; Strickland *et al*. 2011). As far as possible, bat carcasses should be used for these trials. If unavailable, other small mammal carcasses (e.g. dark-coloured mice, or rats) can be used (Cooper-Bohannon *et al*. 2009; Strickland *et al*. 2011). These are preferable to bird carcasses because detectability and scavenging rates are likely to differ between these groups (Strickland *et al*. 2011). Small plastic bats have also been used successfully for searcher efficiency trials to increase sample sizes and to eliminate waiting for sufficient numbers of bat carcasses to be found (Johnson *et al*. 2004).

2.2.6.1 Searcher Efficiency

These trials entail placing a known number of bat carcasses of various conditions (e.g. fresh, decomposed, desiccated, intact and partially scavenged) and/or decoys at randomly distributed locations in search plots beneath wind turbines (Strickland *et al*. 2011). Searchers then search the plots as normal and the specialist is able to compare the number of carcasses/decoys that the searchers find with the number of carcasses/decoys placed. Separate trials should be conducted for each individual searcher or search team (including teams using dogs). As far as practicable, searchers should not be aware that they are taking part in a trial and should have no information about carcass/decoy placement. These trials should take place during the scheduled carcass searches with carcasses/decoys placed by the lead researcher (or their selected representative) earlier in the same morning before normal searches commence. One of the seasonal trials should be conducted at the start of the monitoring programme to determine the baseline searcher efficiency.

From the pool of turbines used for carcass searches, a list of random turbine numbers, and random direction and distances from these turbines, should be generated for the placement of trial bats (Cooper-Bohannon *et al*. 2009; Strickland *et al*. 2011). Bat carcasses used should be discreetly marked (e.g. by clipping a toe or ear) so that they can be identified as trial carcasses. At each randomly selected site, carcasses should be dropped from waist height instead of being placed directly on the ground. A minimum of 10 carcasses per visibility class (and size classes if using carcasses of varying size) should be used per season for each searcher for the trials; assuming none are removed by scavengers (Ontario Ministry of Natural Resources 2011; Strickland *et al*. 2011) to ensure reliable estimates are generated.

For example, if there are three visibility classes, and two size classes a total of 60 trial carcasses will be needed (3 x 2 x 10 = 60 trial carcasses per season). Data collected for each trial carcass prior to placement should include the date and the GPS coordinates of placement, carcass size, species (if known), turbine number, distance and direction from the turbine and the visibility class. The lead researcher (or their selected representative) should be present on the day of the trial and should record the trial carcasses/decoys recovered by the searches. Any carcasses/decoys not recovered must be collected by the lead researcher (or their selected representative) after the trial to avoid attracting scavengers and to re-use for subsequent trials.

2.2.6.1 Carcass Persistence

To estimate the number of carcasses removed by scavengers, carcasses are placed in known, randomly located sites within the study area. The locations where the carcasses were placed are revisited over several days and the presence or absence of any carcass noted. An average persistence time is then calculated (Strickland *et al*. 2011). To avoid attracting scavengers to areas below turbines, to reduce trampling in the actual search plots and to prevent searches confusing carcasses used to test searcher efficiency with those to measure carcass persistence, carcass removal trials should be conducted in separate plots between turbines. Effort should be made to evenly distribute carcasses among the different visibility classes (Strickland *et al*. 2011). Carcasses should be placed using gloves (and boots) to avoid imparting human scent that might affect scavengers and bias the trial (New Brunswick Fish and Wildlife Branch 2011; Ontario Ministry of Natural Resources 2011). Carcasses should be clearly marked to distinguish them as experimental carcasses.

It is preferable to use carcasses found during the routine carcass searches for the scavenger removal trials. These carcasses should be as fresh as possible because frozen or decomposed carcasses are less attractive to scavengers (New York State Department of Environmental Conservation 2009; Ontario Ministry of Natural Resources 2011). If frozen carcasses are used, they should be completely thawed prior to the commencement of the trial.

For each trial, a minimum of 10 carcasses, evenly distributed across the visibility classes (and size classes if using carcasses of varying size) should be used per season to ensure reliable estimates are generated. To avoid over-seeding the area and attracting scavengers, no more than three carcasses should be placed at any particular plot. The trial carcasses should be monitored every day until they have been completely removed or decomposed (New Brunswick Fish and Wildlife Branch 2011; Ontario Ministry of Natural Resources 2011).

2.2.7 Estimators of Fatality

The observed mortality rates from the carcass searches need to be adjusted to account for detection biases. Several statistical methods have been developed for this purpose to provide estimates of mortality rates for bats (e.g. Huso 2011; Huso & Dalthorp 2014; Kerns *et al*. 2005; Korner-Nievergelt *et al*. 2011), and these and other estimators are reviewed by Strickland *et al*. (2011) and Bernardino *et al*. (2013). Due to a need to develop a universal, user-friendly general estimator, Simonis *et al*. (2018) developed the General Estimator (GenEst). GenEst must be used to estimate bat fatality to allow for consistency and facilitate comparison across WEFs. However, when the number of fatalities is very low or zero, Evidence of Absence software (Dalthorp *et al*. 2007) may be more appropriate.

All estimators assume that the number of carcasses is zero at the beginning of the survey (Bernardino *et al*. 2013). This may not be the case for example if searching commenced a period of time after turbines began operating, or if there were gaps in searching between years, which would allow carcasses to accumulate assuming they were not scavenged or completely decomposed. This may result in a misleadingly high carcass count at the commencement of searching and influence fatality estimation. To reduce this bias, clean out searches must be performed for all turbines searched to ensure that all carcasses found during the subsequent searches are associated with events that occurred during the period of systematic surveys (Bernardino *et al*. 2013). As an alternative, data from the first search of each turbine can be excluded from the fatality estimation (Korner-Nievergelt *et al*. 2011).

Estimates of bat mortality should be presented as the number of fatalities per MW per year (fatalities/MW/year), the number of fatalities per turbine (fatalities/turbine), and/or the number of fatalities per facility (fatalities/facility). If the estimated values exceeds threshold guidance (MacEwan *et al*. 2020 or subsequent editions), fatality minimization strategies must be implemented. Mitigation options include using deterrents or various forms of curtailment (see Aronson *et al*. 2018 and references therein for options). If significant mortality occurs at a facility and operational mitigation is implemented, operational monitoring must be extended for an additional minimum of two years from the implementation of this mitigation to evaluate its effectiveness but ideally three years (Ontario Ministry of Natural Resources 2011). Depending on the outcome of the initial period of operational bat monitoring, the WEFs environmental management programme may need to be updated to reflect any decisions taken to perform mitigation.

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4. APPENDIX 1 – MINIMUM REQUIREMENTS SUMMARY

- A minimum of two years of operational monitoring is required (acoustic monitoring and carcass searches).
- Monitoring must be conducted again in year five, and every five years thereafter.
- Acoustic monitoring as per the pre-construction monitoring programme if acceptable or according to MacEwan *et al*. (2020b, or subsequent editions). At least one ultrasonic microphone should be installed within rotor sweep height.
- The search interval must be twice a week initially to be updated using carcass removal rates by scavengers for the specific study area.
- All turbines must be searched according to the search interval for the first year. This can be reduced or adjusted in subsequent years based on the findings of the first year.
- The search plot must cover a radius around the turbine of at least half the distance from the maximum blade tip height to the ground. For example, if turbines blades extend 120 m from the tip to the ground (i.e. the top of the rotor swept zone), the search plot should extend 60 m in all directions.
- Transects within each plot should be spaced a maximum of 6 m apart yielding a search width of 3 m on either side of the transect line. This should be decreased in areas with low visibility.
- Field bias assessments should be conducted as often as possible, but a minimum of once per season is required, including at the start of the monitoring programme to set baselines.
- A minimum of 10 carcasses per visibility (and size) class should be used per season for each searcher or search team for the searcher efficiency trials.
- For each carcass removal trial, a minimum of 10 carcasses, evenly distributed across the visibility (and size) classes, should be used. No more than three carcasses should be placed at any particular search plot at any given time. The trial carcasses should be monitored every day until they have been completely removed or decomposed.
- GenEst (Simonis *et al*. 2018) or subsequent versions must be used to estimate bat fatality.
- If fatality minimisation strategies are implemented, the effectiveness of the strategies must be thoroughly tested by extending the initial monitoring period by an additional two years.
- Records of bat fatality and fatality estimates must be kept in a central database that can be accessed by various stakeholders to facilitate greater understanding of bat-wind energy impacts including cumulative impacts.

5. APPENDIX 2 – EXAMPLE DATA SHEETS

5.1 Information for each Search Plot

Site:____ Date:__________________________________

Searcher(s):____

Turbine No.	Search Start Time	Search End Time	Start Point/Direction	No. of Bat Carcasses Found	Notes (weather, turbine maintenance etc.)

5.2 Fatality Report Sheet

Site Name:	**Photo Number:**
Carcass ID No.:	**Searcher(s):**
Recovery Date:	**Time Found:**
Turbine No.:	**Co-ordinates:**

HABITAT INFORMATION (within a 3 m radius around carcass)

Dominant Habitat Rocks ☐ Bare Ground ☐ Vegetation ☐ Other: ___________________

Visibility Class Easy ☐ Moderate ☐ Difficult ☐ Very Difficult ☐

Slope <25° ☐ 50° ☐ >75° ☐

Distance from turbine base____

Other Notes____

CARCASS INFORMATION

Live ☐ Dead ☐

If Live Euthanised ☐ Released ☐ Taken to Rehab Centre ☐

If Dead Used for Field Bias Trials ☐ Taken as Voucher ☐

Field Species ID____

Sex Male ☐ Female ☐ Unknown ☐

Describe obvious injuries____

Evidence of Scavenging Yes ☐ No ☐ **Possible Scavengers**_______________________________

Carcass Condition Fresh ☐ Decomposing - early ☐ Decomposing - late ☐ Desiccated ☐

Infestation None ☐ Flies ☐ Maggots ☐ Ants ☐ Beetles ☐ Other:

Estimated Time of Death Previous Night ☐ 2-3 Days ☐ 4-7 Days ☐ 1-2 weeks ☐ >2 weeks ☐

Eyes Round/fluid filled ☐ Dehydrated ☐ Sunken ☐ Empty☐

Notes

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6. APPENDIX 3

Written by E. Richardson and L. Richards

6.1 Procedure for Dealing with Live and Injured Bats

The level of treatment and care offered to injured bats depends on the training, skill and motivation of the personnel involved. Training in all the techniques discussed below can be obtained from an experienced wildlife veterinarian or from specialist bat rehabilitators. Handling injured bats should not be attempted by untrained personnel. If there is no training offered, and little motivation to care, injured bats are best humanely euthanised and the bodies lodged with a museum so that the injuries and death may be recorded. However bats are intelligent and can learn: grounded bats treated and returned to the wild may learn to avoid turbines and thus safeguard future generations.

Bats (live or dead) may not be handled except with the correct permits from the responsible provincial authorities. Live bats should be handled with soft, close-fitting, bite-proof gloves (gardening or pigskin gloves) and with a soft flannel or fleece cloth. All personnel handling live or dead bats should be fully inoculated against rabies. Although canine rabies has never been found in a bat in Africa, African bats may carry one of two Lyssaviruses which might infect humans. Accidental bites and scratches should be washed well with soap and water and treated with an iodine-based ointment. A medical professional should be consulted as soon as possible after such injury. Live bats should not be handled by inexperienced or untrained people.

IT SHOULD BE IMPRESSED UPON ALL HANDLERS THAT BATS ARE INTELLIGENT AND SENTIENT MAMMALS AND HANDLING SHOULD BE ACCORDINGLY

Assessment of Injuries

Rehydration
Bats are best rehydrated with a subcutaneous injection of Lactated Ringer's solution. Many of the bats at highest risk of harm from wind turbines (e.g. Molossidae and Miniopteridae) do not drink free water and cannot be effectively rehydrated orally.

Shock
Shock can be treated with oral Rescue Remedy drops (available from chemists and supermarkets) or with Metacam® (Meloxicam) which is more effective but only available from veterinary professionals.

Feeding
Insect-eating bats can be fed mealworms (the best food for insect-eating bats but difficult to keep in field conditions), Whiskas® cat food (not a balanced diet and thus for short-term use only), and Nutrostim® (a high-calorie food supplement useful for Pipistrelles and Serotines). Fruit bats can be fed any soft, non-citrus fruit or Purity® Pear baby food.

Euthanasia

There is no simple way to euthanise bats in a field situation and the method used depends on the experience of the handler.

1. Halothane or Isoflurane are anaesthetics which are the method of choice for bat euthanasia. The bat is placed in a small container with the halothane and left until heartbeat has ceased. However halothane is a Schedule 5 drug, can only be obtained from a veterinarian, and evaporates unless correctly stored.

2. Cervical dislocation, stunning and decapitation should only be used by experienced handlers and as a last resort. Brain activity may persist for 13 seconds or more after decapitation and the skull may be damaged too badly for correct identification.

Table 2: Classification and Assessment of Injuries with Recommended Option for Providing Care to Bats

Level of Injury	Description	Care Needed
Level 1	No obvious injuries, no blood or broken bones visible. Dehydration, shock. Bruises where bat can fold and move wings. Holes in wing membranes where trailing edge is intact.	Field care. Treat for dehydration and shock. Release same day.
Level 2	No broken long bones (might be small breaks in phalanges) or blood visible. Bruises where bat cannot fold or move wings. Bat unwilling to fly.	Field care. Treat for dehydration and shock.
Level 3	Broken long bones, tears through trailing edge of wings. Concussion.	Specialist care. Treat for dehydration and shock.
Level 4	Broken skull or jaw, spinal injuries where bat cannot move hind legs. Blood in mouth and nose indicating barotrauma injury.	Euthanise.

Additional Guidance

Lollar, A. and Schmidt-French, B. 2002. Captive Care and Medical Reference for the Rehabilitation of Insectivorous Bats. Bat World, Texas. ISBN 0-9638248-3-X

Klug, B. J., and E. F. Baerwald. 2010. Incidence and Management of Live and Injured Bats at Wind Energy Facilities. Journal of Wildlife Rehabilitation 30: 11 – 16.

6.2 Procedure for Dealing with Dead Bats

Dead bats which are not needed for field bias trials should always be lodged with a museum which can provide accurate species identification, cause of death, and long-term storage. Dead bats should be preserved with alcohol as formalin-preserved animals are harder to manipulate to determine the cause of death, and alcohol preservation is needed for genetic sampling. Dead bats can be frozen temporarily but need to be preserved in alcohol for transport and identification. Bats should be identified, measured, and weighed before being preserved. An identification label should be tied firmly to a leg. The following information must accompany all specimens:

- *Date and time when carcass was located/found*
- *Collectors name and surname*
- *Locality in the following format: Province, District/Municipality, Town/Suburb, etc. (e.g. KwaZulu-Natal: uMkhanyakude District, Mtubatuba, Nkosi Mtuba Road)*
- *GPS locality*[3]
- *State of body (e.g. fresh, poor, badly decomposed)*
- *Any evidence of scavenging of the body (this may be important for noting bodily damage during autopsies)*

The abdomen should be injected with 90 % ethanol to ensure that the internal organs are adequately preserved and can be sampled for genetic material at a later stage. The bat should then be placed in 70 % ethanol for at least three days to allow the tissues to be preserved. To prevent deterioration of the bodies during preservation the volume of alcohol should be more than three times the volume of the bodies.

Once preserved, the specimens can be drained of excess alcohol, wrapped in muslin cloth, and placed in appropriate packaging for transport. Carcasses should be packaged in strict accordance to UN3373 category B packing instructions - this includes leak-proof packaging, and triplicate layering[4]. Packages should be clearly marked "UN3373 category B - biological material for research purposes". Transportation of carcass material should follow International Air Transport Association (IATA) packing instruction 650 (for UN3373 material), on passenger and cargo aircraft and Cargo Aircraft only. The above also applies to consignments shipped via road freight. For further information on the packing requirements for UN3373 category B, please visit https://apps.who.int/iris/bitstream/handle/10665/325884/WHO-WHE-CPI-2019.20-eng.pdf?ua=1.

These requirements are subject to change. Please visit the World Health Organisation website to ensure compliance with the most recent guidelines. A declaration needs to be fixed to the outside of the package stating that IATA regulations have been followed prior to shipping the package. In accordance with the Convention of Biological Diversity – Nagoya Protocol, copies of all permits (scientific/collecting, export, import) must accompany the package or be provided in electronic format to the relevant receiving organisation. Packages

[3] Sensitive information, such as precise GPS coordinates, may be redacted / embargoed should this be a condition of donation.

[4] Guidance on regulations for the transport of infectious substances 2019–2020. Geneva: World Health Organization; 2019 (WHO/WHE/CPI/2019.20). Licence: CC BY-NC-SA 3.0 IGO.

can be couriered to either:

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