Final progress report of a 12-month preconstruction bat monitoring study

For the proposed Brandvalley Wind Energy Facility, Western and Northern Cape

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For:	12 Month pre-construction bat activity monitoring

Independence:

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Applicable Legislation:

Legislation dealing with biodiversity applies to bats and includes the following:

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; Especially sections 2, 56 & 97).

The act calls for the management and conservation of all biological diversity within South Africa. Bats constitute an important component of South African biodiversity and therefore all species receive additional attention to those listed as Threatened or Protected.

South African good practice guidelines for surveying bats in wind farm developments. Sowler, S. and Stoffberg, S. 2014.

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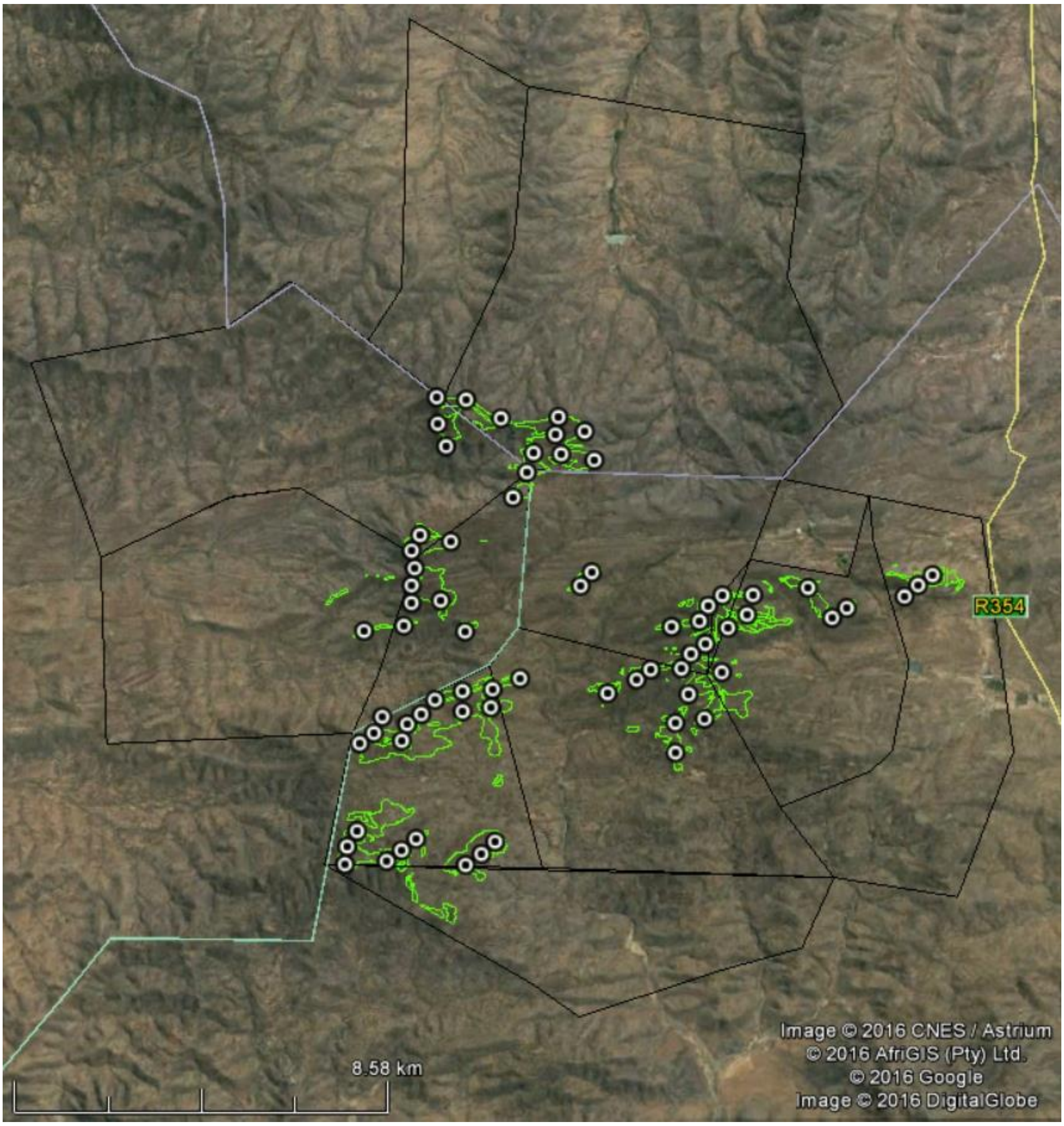


Figure 1: Map overview of the proposed layout for Brandvalley wind farm, black lines indicate the farm portions on which the development areas are located. Development areas are indicated in green and are the only areas that are suitable for turbine placement.

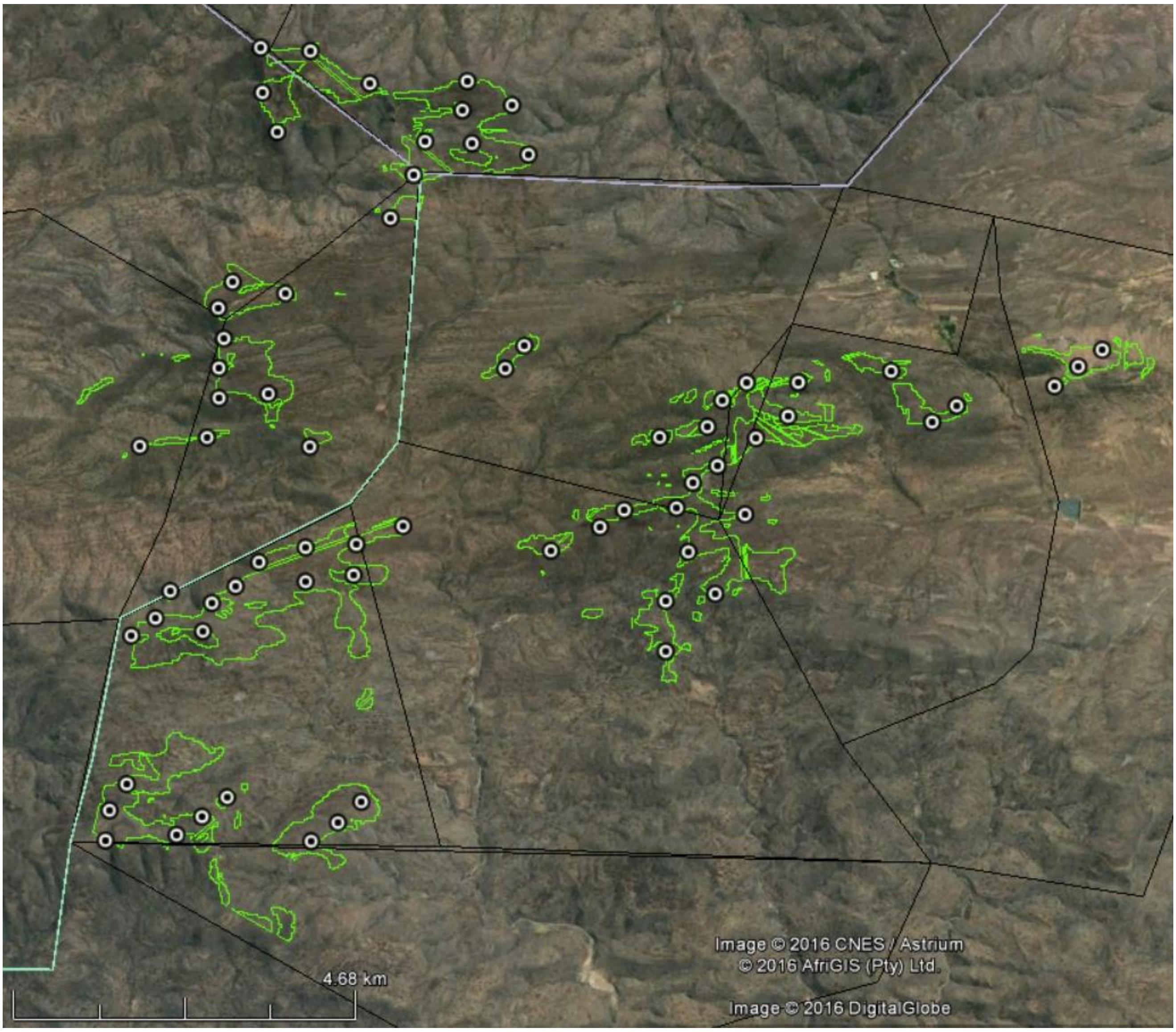


Figure 2: Map overview of the development areas (indicated in green) of the proposed Brandvalley WEF turbine layout.

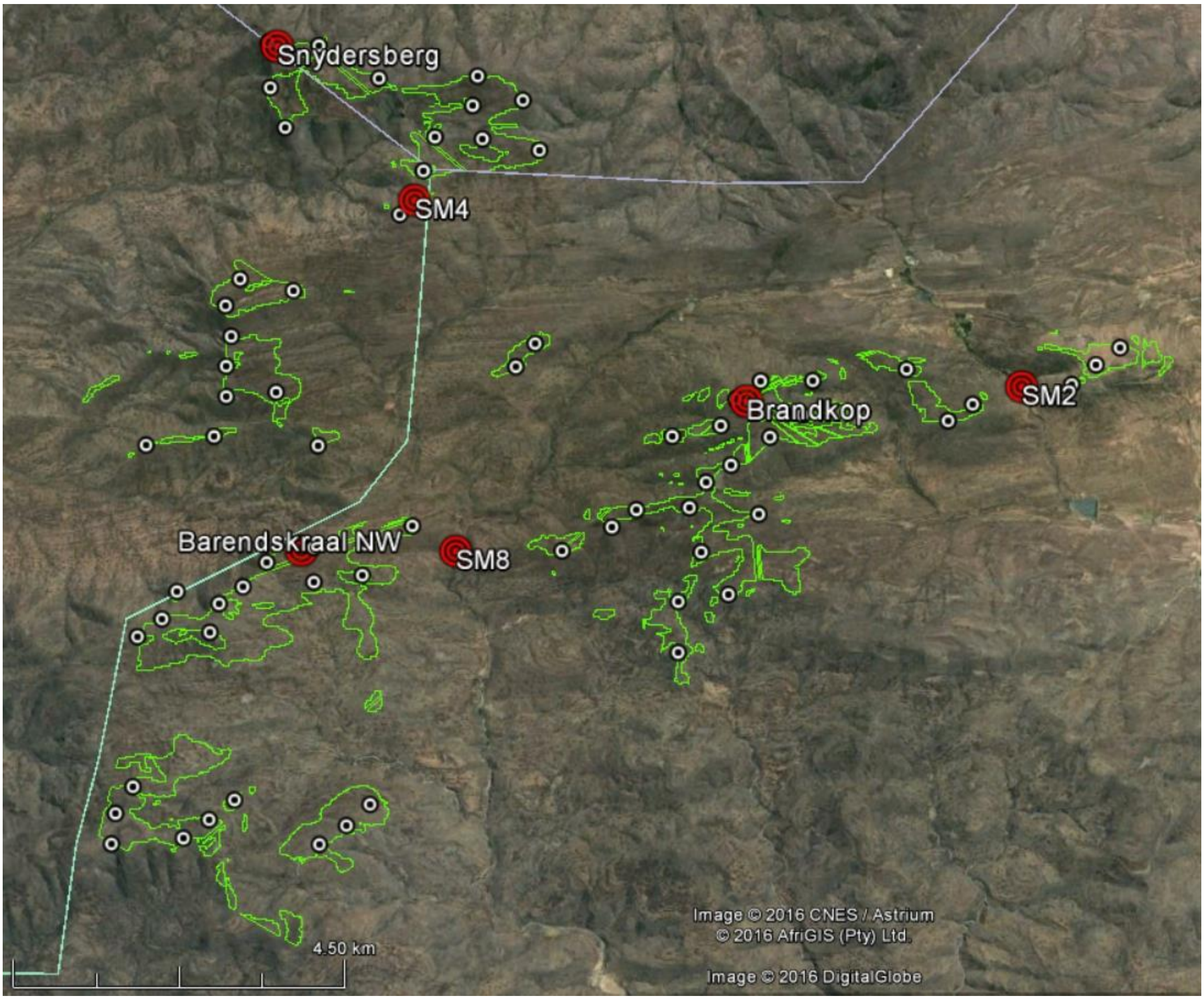


Figure 3: Map overview of passive bat monitoring systems for the proposed Brandvalley wind farm.

1 OBJECTIVES AND TERMS OF REFERENCE FOR PRECONSTRUCTION STUDY

- Study bat species assemblage and abundance on the site.
- Study temporal distribution of bat activity across the night as well as the four seasons of the year in order to detect peaks and troughs in activity.
- Determine whether weather variables (wind, temperature, humidity and barometric pressure) influence bat activity.
- Determine the weather range in which bats are mostly active.
- Develop long-term baseline data for use during operational monitoring.
- Identify which turbines need to have special attention with regards to bat monitoring during the operational phase and if and identify if any turbines occur in sensitive areas and need to be shifted into less sensitive areas or removed from the layout.
- Detail the types of mitigation measures that are possible if bat mortality rates are found to be unacceptable, including the potential times/ circumstances which may result in high mortality rates.

2 INTRODUCTION

2.1 Basic Site Information

This is the final impact assessment report for a twelve month bat monitoring study at the proposed Brandvalley Wind Energy Facility. The site is situated approx. 40km north from Matjiesfontein and immediately adjacent to the border between the Western Cape and Northern Cape along the R354 to Sutherland. The development initially consisted of several different phases of wind farms which were ultimately split into two projects, namely the Brandvalley Wind Farm and the Rietkloof Wind Farm. Both projects consist of 70 proposed turbine positions where Brandvalley is situated North of Rietkloof.

A pre-construction bat monitoring study is being conducted to cover all of the developable areas of both projects. However, this report will only assess and discuss the bat monitoring study relevant to the Brandvalley development.

The total developable area for the Brandvalley project referred to as the development areas, where turbines may be moved to during possible layout iterations, amounts to a total of only 1 113.9 ha. The development areas collectively formed the focus area of the preconstruction bat monitoring study.

Brandvalley WEF will have an energy generation capacity (at point of grid feed-in) of up to 140 megawatt (MW), and will include the following:

- Up to 70 potential wind turbine positions (between 1.5MW and 4MW in capacity

each), each with a foundation of 25m in diameter and 4m in depth.
- The hub height of each turbine will be up to 120m, and the rotor diameter up to 140m. The develop indicates that the height of blades off the ground will be, at maximum, 20m to 190m.
- Permanent compacted hard-standing laydown areas for each wind turbine (70mx50m, total 24.5ha) will be required during construction and for on-going maintenance purposes.
- Electrical turbine transformers (690V/33kV) adjacent to each turbine (typical footprint of 2m x 2m, but can be up to 10m x 10m at certain locations) would be required to increase the voltage to 33kV.
- Underground 33kV cabling between turbines buried along access roads, where feasible.
- Internal access roads up to 12m wide, including structures for storm-water control would be required to access each turbine location and turning circles. Where possible, existing roads will be upgraded.
- 33kV overhead power lines linking groups of wind turbines to onsite 33/132kV substation(s). A number of potential electrical 33kV powerlines will be required in order to connect wind turbines to the preferred onsite substation. The layout of the 33kV powerlines will be informed by sensitive features identified. The facility will consist of both above and below ground 33kV electrical infrastructure depending on what will require the shortest distance and result in the least amount of impacts to the environment.
- A number of potential 33/132kV onsite substation location(s) will be assessed.
- Up to 4 x 120m tall wind measuring lattice masts strategically placed within the wind farm development footprint to collect data on wind conditions during the operational phase.
- Temporary infrastructure including a large construction camp (~10ha) and an on-site concrete batching plant (~1ha) for use during the construction phase.
- Fencing will be limited around the construction camp and the entire facility would not necessarily need to be fenced off. The height of fences around the construction camp are anticipated to be up to 4m.

Temporary infrastructure to obtain water from available local sources/ new or existing boreholes. Water will potentially be stored in temporary water storage tanks. The necessary approvals from the DWS will be applied for separately to this EIA process.

The following alternatives are proposed:

1. Project area location alternative: One project location alternative namely Brandvalley Wind Farm
2. Access road location alternatives: two access road alternatives namely access road alternative 1 and access road alternative 2
3. Construction camp alternatives namely construction camp 1, 2, or 3.

4. Four onsite substation location alternatives namely substation alternative 1, 2, 3 or 4.
5. Technology alternative: One technology alternative namely a WEF

2.2 Basic Bat Information

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. However, the dependence of a bat on each of these factors depends on the species, its behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above mentioned factors.

The site is evaluated by comparing the amount of surface rock (possible roosting space), topography (influencing surface rock in most cases), vegetation (possible roosting spaces and foraging sites), climate (can influence insect numbers and availability of fruit), and presence of surface water (influences insects and acts as a source of drinking water) to identify bat species that may be impacted by wind turbines. These comparisons are done chiefly by studying the geographic literature of each site, available satellite imagery and observations during site visits. Species probability of occurrence based on the above mentioned factors are estimated for the site and the surrounding larger area (see Section 4.2).

General bat diversity, abundance and activity are determined by the use of a bat detector. A bat detector is a device capable of detecting and recording the ultrasonic echolocation calls of bats which may then be analysed with the use of computer software. A real time expansion type bat detector records bat echolocation in its true ultrasonic state which is then effectively slowed down 10 times during data analysis. Thus the bat calls become audible to the human ear, but still retains all of the harmonics and characteristics of the call from which bat species with characteristic echolocation calls can be identified. Although this type of bat detection equipment is advanced technology, it is not necessarily possible to identify all bat species by just their echolocation calls. Recordings may be affected by the weather conditions (i.e. humidity) and openness of the terrain (bats may adjust call frequencies). The range of detecting a bat is also dependent on the volume of the bat call. Nevertheless it is a very accurate method of recording bat activity.

2.3 The Bats of South Africa

Bats form part of the Order Chiroptera and are the second largest group of mammals after rodents. They are the only mammals to have developed true powered flight and have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are compact and light, thereby reducing the total body weight. This unique wing profile allows for the manipulation wing camber and shape, exploiting functions such as agility and manoeuvrability. This adaption surpasses the static design of the bird wings in function and enables bats to utilize a wide variety of food sources, including, but not limited to, a large diversity of insects (Neuweiler 2000). Species based facial features may differ considerably as a result of differing life styles, particularly in relation to varying feeding and echolocation navigation strategies. Most South African bats are insectivorous and are capable of consuming vast quantities of insects on a nightly basis (Taylor 2000, Tuttle and Hensley 2001) however, they have also been found to feed on amphibians, fruit, nectar and other invertebrates. As a result, insectivorous bats are the predominant predators of nocturnal flying insects in South Africa and contribute greatly to the suppression of these numbers. Their prey also includes agricultural pests such as moths and vectors for diseases such as mosquitoes (Rautenbach 1982, Taylor 2000).

Urban development and agricultural practices have contributed to the deterioration of bat populations on a global scale. Public participation and funding of bat conservation are often hindered by negative public perceptions and unawareness of the ecological importance of bats. Some species choose to roost in domestic residences, causing disturbance and thereby decreasing any esteem that bats may have established. Other species may occur in large communities in buildings, posing as a potential health hazard to residents in addition to their nuisance value. Unfortunately, the negative association with bats obscures their importance as an essential component of ecological systems and their value as natural pest control agents, which actually serves as an advantage to humans.

Many bat species roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities, within the same population, concurrently (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum and according to O'Shea *et al*. (2003), bats may live for up to 30 years, thereby limiting the amount of pups born due to this increased life expectancy. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity and the relatively low predation of bats when compared to other small mammals. Therefore, bat populations are not able to adequately recover after mass mortalities and major roost disturbances.

2.4 Bats and Wind Turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesized that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, most bat mortalities have been found to be caused by barotrauma (Baerwald *et al*. 2008). This is a condition where low air pressure found around the moving blades of wind turbines, causes the lungs of a bat to collapse, resulting in fatal internal haemorrhaging (Kunz *et al*. 2007). Baerwald *et al*. (2008) found that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma. A study conducted by Arnett (2005) recorded a total of 398 and 262 bat fatalities in two surveys at the Mountaineer Wind Energy Centre in Tucker County, West Virginia and at the Meyersdale Wind Energy Centre in Somerset County, Pennsylvania, respectively. These surveys took place during a 6 week study period from 31 July 2004 to 13 September 2004. In some studies, such as that taken in Kewaunee County (Howe *et al.* 2002), bat fatalities were found exceed bird fatalities by up to three-fold.

Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water, in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure as roosting spaces or that swarms of insects may get trapped in low pressure air pockets around the turbine, also encouraging the presence of bats. The presence of lights on wind turbines have also been identified as possible causes for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect densities that are attracted to the lights and subsequently encourage foraging activity of bats (Johnson *et al*. 2003). Clearings around wind turbines, in previously forested areas, may also improve conditions for insects, thereby attracting bats to the area and the swishing sound of the turbine blades has been proposed as possible sources for disorienting bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may also affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesized, from personal observations that the echolocation capabilities of bats are designed to locate smaller insect prey or avoid stationary objects, and may not be primarily focused on the detection of unnatural objects moving sideways across the flight path.

Whatever the reason for bat fatalities in relation to wind turbines, it is clear that this is a grave ecological problem which requires attention. During a study by Arnett *et al*. (2009), 10 turbines monitored over a period of 3 months showed 124 bat fatalities in South-central

Pennsylvania (America), which can cumulatively have a catastrophic long term effect on bat populations if this rate of fatality continues. Most bat species only reproduce once a year, bearing one young per female, therefore their numbers are slow to recover from mass mortalities. It is very difficult to assess the true number of bat deaths in relation to wind turbines, due to carcasses being removed from sites through predation, the rate of which differs from site to site as a result of habitat type, species of predator and their numbers (Howe *et al*. 2002, Johnson *et al*. 2003). Mitigation measures are being researched and experimented with globally, but are still only effective on a small scale. An exception is the implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed. This relies on the principle that the prey of bats will not be found in areas of strong winds and more energy is required for the bats to fly under these conditions. It is thought, that by the implementation of such a measure, that bats in the area are not likely to experience as great an impact as when the turbine blades move slowly in low wind speeds. However, this measure is currently not effective enough to translate the impact of wind turbines on bats to a category of low concern.

3 METHODOLOGY

Bat activity were monitored using active and passive bat monitoring techniques. Active monitoring was done through site visits with transects made with a vehicle mounted bat detector, and passive detection were done through the mounting of passive bat monitoring systems. A total of six systems were installed, three on met masts each with microphones at 10m and 50m, and three on 10m short masts. Considering the total developable area that may be utilised for turbine placement only 1 113.9 ha, even if widely dispersed, in this regard it far exceeds the minimum requirements of the 3rd Edition of the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler and Stoffberg, 2012) by utilising surplus systems at height.

The first site visit was conducted over 27 January – 3 February 2015 whereby five short mast bat monitoring systems were installed namely, Short Masts 1, 2, 4, 7 and 8. The meteorological masts were not yet installed on site at this stage. A further installation was performed over 29 April – 1 May 2015 wherein the bat monitoring system of Short Mast 1 was decommissioned and moved to Met Mast North. Thus, monitoring at height commenced in the beginning of May 2015.

The monitoring systems consists of SM2BAT+ time expansion type bat detectors that are powered by 12V 18Ah sealed lead acid batteries and 20W solar panels that provide recharging power to the batteries. Each system also has an 8 amp low voltage protection regulator and SM2PWR step down transformer. Four SD memory cards, class 10 speed, with a capacity of 32GB each were utilized within each SM2BAT+ detector; this is to ensure substantial memory space with high quality recordings even under conditions of multiple false wind triggers.

Weatherproof ultrasound microphones were mounted at heights of 9.5 meters on the short 10m masts, while two microphones were mounted at 10m and 50m heights on the meteorological mast. These microphones were then connected to the SM2BAT+ bat detectors.

Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were correlated with latitude and longitude). Trigger mode is the setting for a bat detector in which any frequency which exceeds 16 KHz and 18 dB will trigger the detector to record for the duration of the sound and 500 ms after the sound has ceased, this latter period is known as a trigger window. All signals are recorded in WAC0 lossless compression format.

The table below summarizes the above mentioned equipment set up.

3.1 Site Visits

Site visit dates	**First Visit**	27 January – 3 February 2015 (Installation of systems)
	Second Visit	04 – 09 May 2015 (SM1 moved to Brandkop)
	Third Visit	03 – 08 August 2015 (SM7 moved to Snydersberg. Barendskraal mast was set up)
	Fourth Visit	30 November – 5 December 2015
	Fifth Visit	31 March – 2 April 2016
	Sixth Visit	2 May 2016
Met mast passive bat detection systems	**Amount on site**	3
	Microphone heights	10m; 50m
Short mast passive bat detection systems	**Amount on site**	3
	Microphone	9.5m

height	
Type of passive bat detector	SM2BAT+, Real Time Expansion (RTE) type (Figure 5).
Recording schedule	Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were automatically adjusted with latitude, longitude and season).
Trigger threshold	>16KHz, 18dB
Trigger window (time of recording after trigger ceased)	500 ms
Microphone gain setting	36dB
Compression	WAC0
Single memory card size (each systems uses 4 cards)	32GB
Battery size	18Ah; 12V
Solar panel output	20 Watts
Solar charge regulator	8 Amp with low voltage/deep discharge protection
Other methods	Terrain was investigated during the day.


Figure 4: Short mast monitoring system

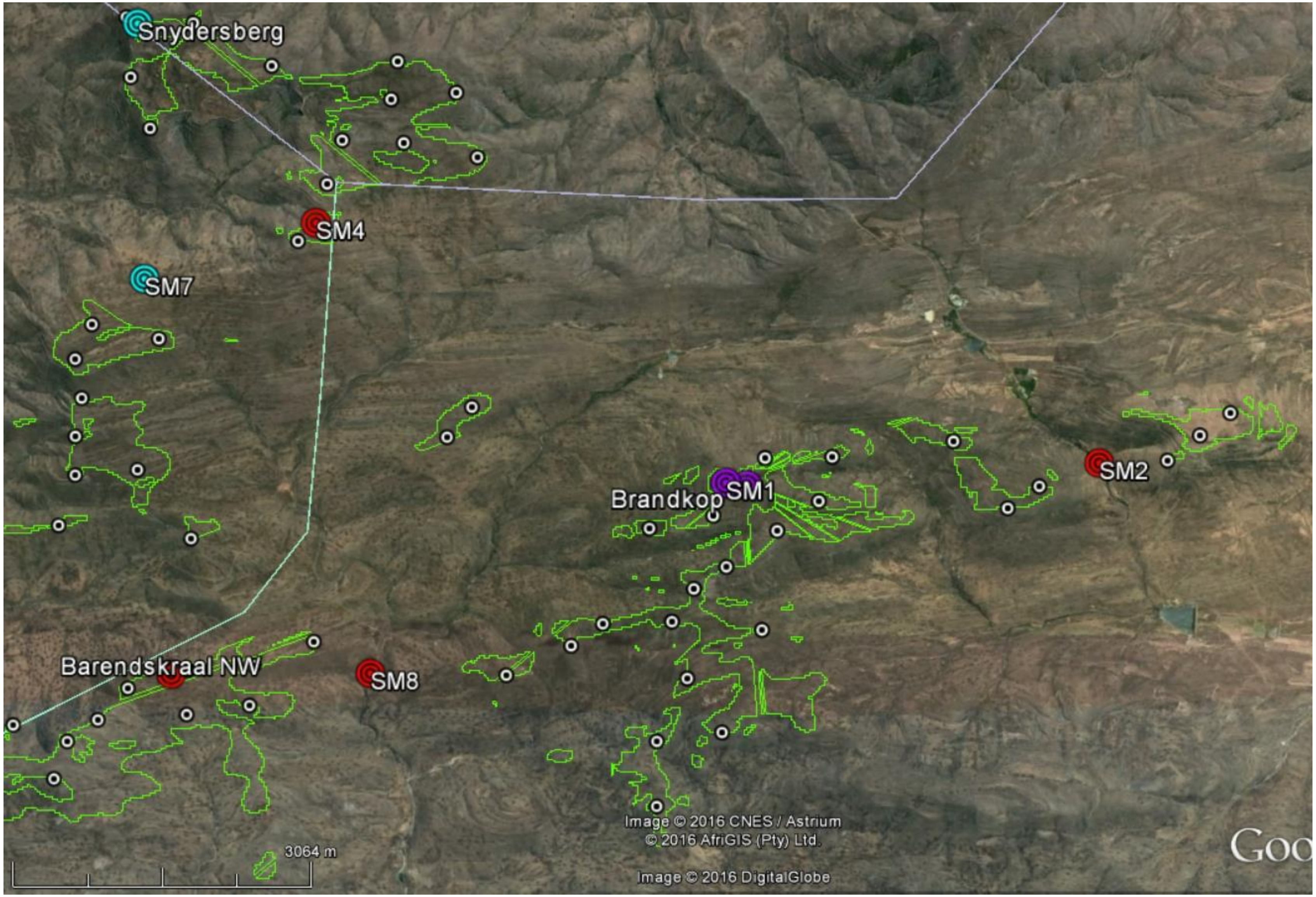


Figure 5: Change in location of SM 1 moved to Brandkop, and SM7 moved to Snydersberg.

The movements of SM 1 to Brandkop and SM7 to Snydersberg increased additional monitoring of bats at height and therefore in applicable airspace, whilst retaining a microphone at 10m for continuity. The SM1 and Brandkop locations are very close to each other and therefore the data can be considered as identical. SM7 and Snydersberg have similarities in habitat to each other, and the benefit of additional microphones at height motivates this movement.

The data were analysed by classifying (as near to species level as possible) and counting positive bat passes detected by the passive systems. A bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms (one echolocation call can consist of numerous pulses). A new bat pass is identified by a >500ms period between pulses. These bat passes were summed into 10 minute intervals which were used to calculate nocturnal distribution patterns over time. Bat activity were grouped into 10 minute periods. Only nocturnal, dusk and dawn values of environmental parameters from the wind data were used, as this is the only time insectivorous bats are active. Times of sunset and sunrise were adjusted with the time of year.

The bat activity were correlated with the environmental parameters; wind speed and air temperature, to identify optimal foraging conditions and periods of high bat activity.

3.2 Assumptions and Limitations

Distribution maps of South African bat species still require further refinement such that the bat species proposed to occur on the site (that were not detected) are assumed accurate. If a species has a distribution marginal to the site it was assumed to occur in the area. The literature based table of species probability of occurrence may include a higher number of bat species than actually present.

The migratory paths of bats are largely unknown, thus limiting the ability to determine if the wind farm will have a large scale effect on migratory species. This limitation however will be overcome with this long-term sensitivity assessment.

The satellite imagery partly used to develop the sensitivity map may be slightly imprecise due to land changes occurring since the imagery was taken.

Species identification with the use of bat detection and echolocation is less accurate when compared to morphological identification, nevertheless it is a very certain and accurate indication of bat activity and their presence with no harmful effects on bats being surveyed.

It is not possible to determine actual individual bat numbers from acoustic bat activity data, whether gathered with transects or the passive monitoring systems. However, bat passes per night are internationally used and recognized as a comparative unit for indicating levels of bat activity in an area.

Spatial distribution of bats over the study area cannot be accurately determined by means of transects, although the passive systems can provide comparative data for different areas of the site. Transects may still possibly uncover high activity in areas where it is not necessarily expected and thereby increase insight into the site.

Exact foraging distances from bat roosts or exact commuting pathways cannot be determined by the current methodology. Radio telemetry tracking of tagged bats is required to provide such information if needed.

Costly radar technology is required to provide more quantitative data on actual bat numbers as well as spatial distribution of multiple bats.

4 RESULTS AND DISCUSSION

4.1 Land Use, Vegetation, Climate and Topography

The site is situated in two vegetation units: Central Mountain Shale Renosterveld and Koedoesberge-Moordenaars Karoo. Central Mountain Shale Renosterveld occupies the largest part of the site and all of the proposed turbine locations and it is surrounded by Koedoesberge-Moordenaars Karoo. (**Figure 6**).

The Central Mountain Shale Renosterveld vegetation unit consists of slopes and broad ridges of low mountains and escarpments, with tall shrubland dominated by renosterbos. Also there are large suites of mainly non succulent karoo shrubs with rich geophytic flora in the undergrowth. The geology of the area consists of clayey soils overlaying Adelaide subgroup mudstones and subordinate sandstones. Glenrosa and Mispah forms are prominent. The area has an Arid to Semi-arid climate with relatively even rainfall but still showing an increase in autumn and winter. Temperatures in the area range from a maximum of 29.9° in January and a minimum of 0.9° in July. There is a frost incidence 20-50 days a year. Erosion is moderate.

The Koedoesberge-Moordenaars Karoo vegetation unit consists of slightly undulating to hilly landscape covered by low succulent shrubs, as well as scattered tall shrubs. 'White' grass is also visible on plains, the most conspicuous dominant being dwarf shrubs of Pteronia, Drosanthemum and Galenia. Mudstone (mainly), shale and sandstone of the Adelaide subgroup make up the geology. It is accompanied by sandstone, shale and mudstone of the Permian Waterford formation and sandstone and shale from other Ecca Group Formations as well as Dwyka group diamictites. This geology gives rise to shallow, skeletal soils. There is a probability of rain for the entire year but rainfall is higher in winter. The incidence of frost is relatively high. Conservation is least threatened with a target of 19%. Only a small part enjoys statutory conservation in the Gamkapoort Nature Reserve. It is transformed only to a very small extent. No serious alien plant invasions are recorded. Erosion is moderate (88%) and only to lesser extent high or very low. (Mucina and Rutherford 2006).

Vegetation units and geology are of great importance as these may serve as suitable sites for the roosting of bats and support of their foraging habits (Monadjem *et al.* 2010). Houses and buildings may also serve as suitable roosting spaces (Taylor 2000; Monadjem *et al.* 2010). The importance of the vegetation units and associated geomorphology serving as potential roosting and foraging sites have been described in **Table 1**.

Table 1: Potential of the vegetation to serve as suitable roosting and foraging spaces for bats.

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Central Mountain Shale Renosterveld	Moderate - High	Moderate	The mountain ridges, slopes and escarpments provide a wide variety of landscape features to enable the successful roosting and foraging of several insectivorous bat species.
Koedoesberge-Moordenaars Karoo	Moderate - High	Moderate	The landscape features provides roosting space for bat species inhabiting rock crevices and caverns. The shrub vegetation provides a foraging niche which can be filled by clutter-edge and open air foraging bat species.

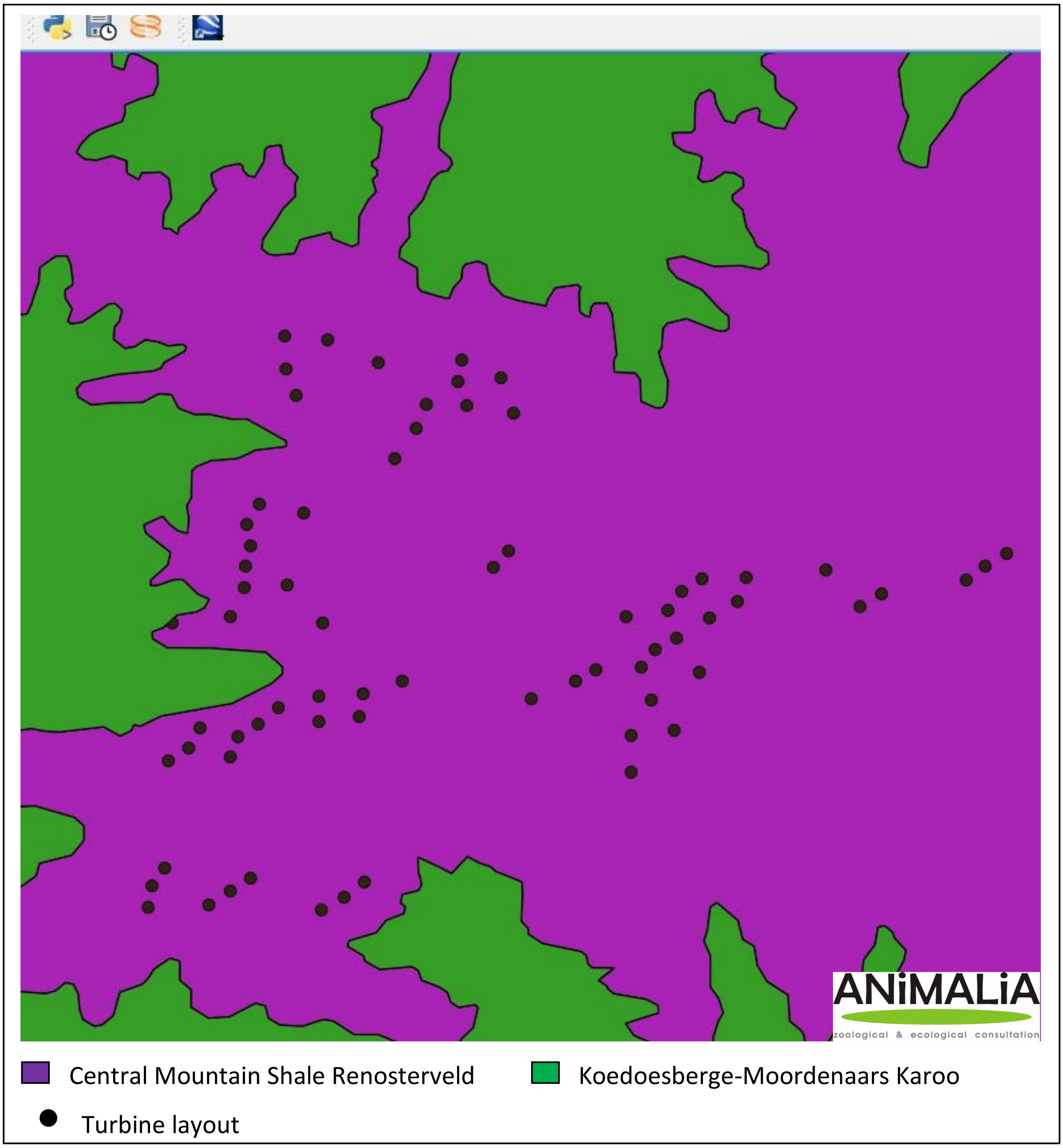


Figure 6: Vegetation units present on the site (Mucina and Rutherford 2006).

4.2 Literature Based Species Probability of Occurrence

"Probability of Occurrence" is assigned based on consideration of the presence of roosting sites and foraging habitats on the site, compared to literature described preferences. The probability of occurrence is described by a percentage indicative of the likelihood of encountering the bat species.

The column of "Likely risk of impact" describes the likelihood of risk of fatality from direct collision or barotrauma with wind turbine blades for each bat species. The risk was assigned by Sowler and Stoffberg (2014) based on species distributions, altitudes at which they fly and distances they traverse; and assumes a 100% probability of occurrence. The ecology of most applicable bat species recorded in the vicinity of the site is discussed below.

Table 2: Table of species that may be roosting or foraging on the study area, the possible site specific roosts, and their probability of occurrence based on literature (Monadjem *et al.* 2010).

Table 3: Table of species that may be roosting or foraging on the study area, the possible site specific roosts, and their probability of occurrence based on literature (Monadjem *et al.* 2010).

Species name	Common Name	Probability of occurrence (%)	Conservation status	Possible Roosting Sites Occupied in Study Area	Foraging Habits (indicative of possible foraging sites in study area)	Likely Risk of Impact (Sowler and Stoffberg, 2014)
Rhinolophus clivosus	Geoffroy's horseshoe bat	20-30	Least Concern	Culverts, rock hollows and any other suitable hollow. Usually roosts in caves and mine adits	Clutter forager, may be found near dwellings and in denser vegetative valleys.	Low
Nycteris thebaica	Egyptian slit-faced bat	20-30	Least Concern	Hollows and culverts under roads.	Clutter forager, may be found near dwellings and in denser vegetative valleys.	Low
Tadarida aegyptiaca	Egyptian free-tailed bat	90-100	Least Concern	Caves, rock crevices, under exfoliating rocks, in hollow trees, and behind the bark of dead trees	Open-air forager	High
Sauromys petrophilus	Robert's flat-headed bat	90-100	Least Concern	Narrow cracks and slabs of exfoliating rock. Rocky habitat in dry woodland, mountain fynbos or arid scrub.	Open-air forager	High
Miniopterus natalensis	Natal long-fingered bat	90-100	Near Threatened	Cave and hollow dependent, but forage abroad. Also take refuge in culverts and vertical hollows, holes.	Clutter-edge forager	Medium - High
Eptesicus hottentotus	Long-tailed serotine	80-90	Least Concern	Roosts in rock crevices	Clutter-edge forager	Medium - High
Myotis tricolor	Temmink'smyotis	40-50	Least Concern	Usually roosts gregariously in caves, and sometimes culverts or other hollows. No known caves or mine	Clutter-edge forager	Medium - High

				adits close to site.		
Neoromicia capensis	Cape serotine	90-100	Least Concern	Roosts under the bark of trees and under roofs of houses.	Clutter-edge forager	Medium - High

4.3 Ecology of bat species that may be largely impacted by the Brandvalley WEF

There are several bat species in the vicinity of the site that occur commonly in the area. These species are of importance based on their likelihood of being impacted by the proposed WEF, due to high abundances and certain behavioural traits. The relevant species are discussed below.

Miniopterus natalensis

Miniopterus natalensis, also commonly referred to as the Natal long-fingered bat, occurs widely across the country but mostly within the southern and eastern regions and is listed as Near Threatened (Monadjem *et al*. 2010).

This bat is a cave-dependent species and identification of suitable roosting sites may be more important in determining its presence in an area than the presence of surrounding vegetation. It occurs in large numbers when roosting in caves with approximately 260 000 bats observed making seasonal use of the De Hoop Guano Cave in the Western Cape, South Africa. Culverts and mines have also been observed as roosting sites for either single bats or small colonies. Separate roosting sites are used for winter hibernation activities and summer maternity behaviour, with the winter hibernacula generally occurring at higher altitudes in more temperate areas and the summer hibernacula occurring at lower altitudes in warmer areas of the country (Monadjem *et al*. 2010).

Mating and fertilisation usually occur during March and April and is followed by a period of delayed implantation until July/August. Birth of a single pup usually occurs between October and December as the females congregate at maternity roosts (Monadjem *et al.* 2010; van der Merwe 1979).

The Natal long-fingered bat undertakes short migratory journeys between hibernaculum and maternity roosts. Due to this migratory behaviour, they are considered to be at high risk of fatality from wind turbines if a wind farm is placed within a migratory path (Sowler and Stoffberg 2014). The mass movement of bats during migratory periods could result in mass casualties if wind turbines are positioned over a mass migratory route and such turbines are not effectively mitigated. Very little is known about the migratory behaviour and paths of *M. natalensis* in South Africa with migration distances exceeding 150 kilometres. If the site is located within a migratory path the bat detection systems should detect high numbers and activity of the Natal long-fingered bat. This will be examined over the course of the 12 month monitoring survey.

A study by Vincent *et al.* (2011) of the habitat preference for foraging activities of *M. schreibersii* in Southern France showed that urban areas were the most used habitat category (54.0%), followed by open areas (19.8 %), woodlands (15.5%), orchards and parks (9.1 %), and water bodies (1.5 %). On a finer scale, urban areas and deciduous or mixed woodlands were preferred as foraging habitats (types of artificial lighting effects were unmeasured in the urban areas during this study), followed by crops and vineyards, pastures, meadows and scrublands bordered by hedgerows or next to woodland, orchards, parks and water bodies (Vincent *et al*. 2011). Similar preferences for habitat use and foraging activities of *M. natalensis* in South Africa are expected. Therefore areas of wooded and agricultural habitats were prioritised in the sensitivity maps as *M. natalensis* has a higher vulnerability to mortality from turbines in these areas.

Sowler and Stoffberg (2014) advise that *M. natalensis* faces a medium to high risk of fatality due to wind turbines. This evaluation was based on broad ecological features and excluded migratory information.

Tadarida aegyptiaca

The Egyptian Free-tailed Bat, *Tadarida aegyptiaca*, is a Least Concern species as it has a wide distribution and high abundance throughout South Africa, and is part of the Free-tailed bat family (Molossidae). It occurs from the Western Cape of South Africa, north through to Namibia and southern Angola; and through Zimbabwe to central and northern Mozambique (Monadjem *et al*. 2010). This species is protected by national legislation in South Africa (ACR 2010).

They roost communally in small (dozens) to medium-sized (hundreds) groups in caves, rock crevices, under exfoliating rocks, in hollow trees and behind the bark of dead trees. *Tadarida aegyptiaca* has also adapted to roosting in buildings, in particular roofs of houses (Monadjem *et al*. 2010). Thus man-made structures and large trees on the site would be important roosts for this species.

Tadarida aegyptiaca forages over a wide range of habitats, flying above the vegetation canopy. It appears that the vegetation has little influence on foraging behaviour as the species forages over desert, semi-arid scrub, savanna, grassland and agricultural lands. Its presence is strongly associated with permanent water bodies due to concentrated densities of insect prey (Monadjem *et al*. 2010).

The Egyptian Free-tailed bat is considered to have a High likelihood of risk of fatality due to wind turbines (Sowler and Stoffberg 2014). Due to the high abundance and widespread distribution of this species, high mortality rates due to wind turbines would be a cause of concern as these species have more significant ecological roles than the rarer bat species.

After a gestation of four months, a single young is born, usually in November or December, when females give birth once a year. In males, spermatogenesis occurs from February to

July and mating occurs in August. Maternity colonies are apparently established by females in November.

Neoromicia capensis

Neoromicia capensis is commonly called the Cape serotine and has a conservation status of Least Concern as it is found in high numbers and is widespread over much of Sub-Saharan Africa.

High mortality rates of this species due to wind turbines would be a cause of concern as *N. capensis* is abundant and widespread and as such has a more significant role to play within the local ecosystem than the rarer bat species. They do not undertake migrations and thus are considered residents of the site.

It roosts individually or in small groups of two to three bats in a variety of shelters, such as under the bark of trees, at the base of aloe leaves, and under the roofs of houses. They will use most man-made structures as day roosts which can be found throughout the site and surrounding areas (Monadjem *et al*. 2010).

They are tolerant of a wide range of environmental conditions as they survive and prosper within arid semi-desert areas to montane grasslands, forests, and savannas; indicating that they may occupy several habitat types across the site, and are amenable towards habitat changes. They are however clutter-edge foragers, meaning they prefer to hunt on the edge of vegetation clutter mostly, but can occasionally forage in open spaces. They are thought to have a Medium-High likelihood of risk of fatality due to wind turbines (Sowler and Stoffberg 2014).

Mating takes place from the end of March until the beginning of April. Spermatozoa are stored in the uterine horns of the female from April until August, when ovulation and fertilisation occurs. They give birth to twins during late October and November but single pups, triplets and quadruplets have also been recorded (van der Merwe 1994 and Lynch 1989).

4.4 Transects

Spatial distribution of bats over the study area cannot be accurately determined by means of transects. Therefore, transects are mostly utilised to simply increase insight into the site and did not form the primary methodology of the assessment. Additionally, the roads that could be driven for transects were mostly in valleys and less on ridges where turbines are proposed, habitats within the valleys are more favourable to bats than habitat on the ridges.

4.4.1 First Site Visit

Transects were not carried out over the first site visit due to the demanding nature of monitoring system installation.

4.4.2 Second Site Visit

The transect bat detector did not record any clear bat calls due to a microphone port connection issue that was discovered after the transects.

4.4.3 Third Site Visit

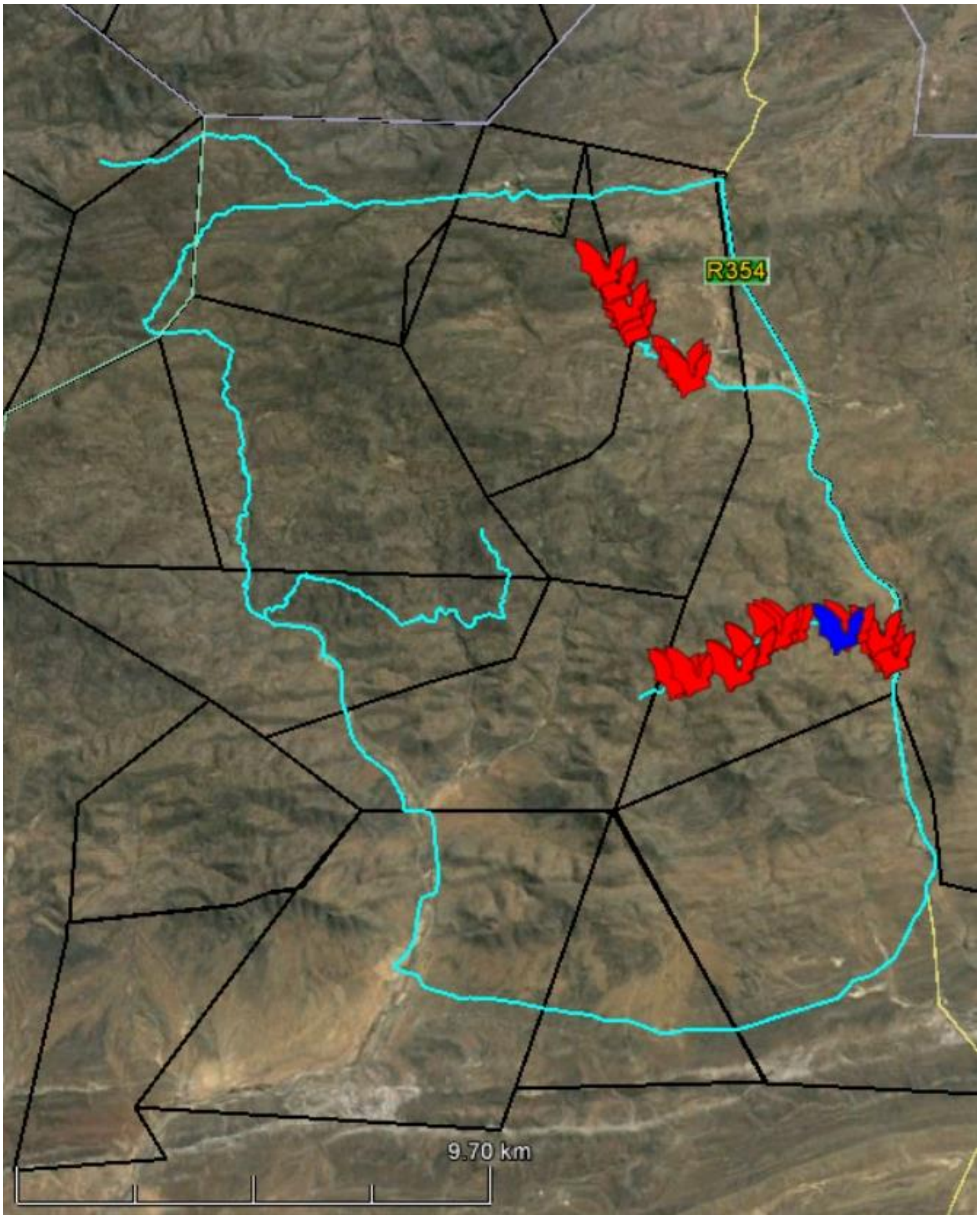
Table 4: Transect survey effort for the third site visit.

TRANSECT NIGHTS	DISTANCE TRAVELLED (km)	DURATION
4 August 2015	17	1 h 20 min
5 August 2015	51	3 hrs 40 min
6 August 2015	44	2 hrs
7 August 2015	32	2 hrs 20 min

Table 5: Climatic conditions during the third site visit.

TRANSECT NIGHT	TEMPERATURE (°C)	PRECIPITATION (mm)	WIND SPEED (km/h)
4 August 2015	9	0	16
5 August 2015	12	0	3.2

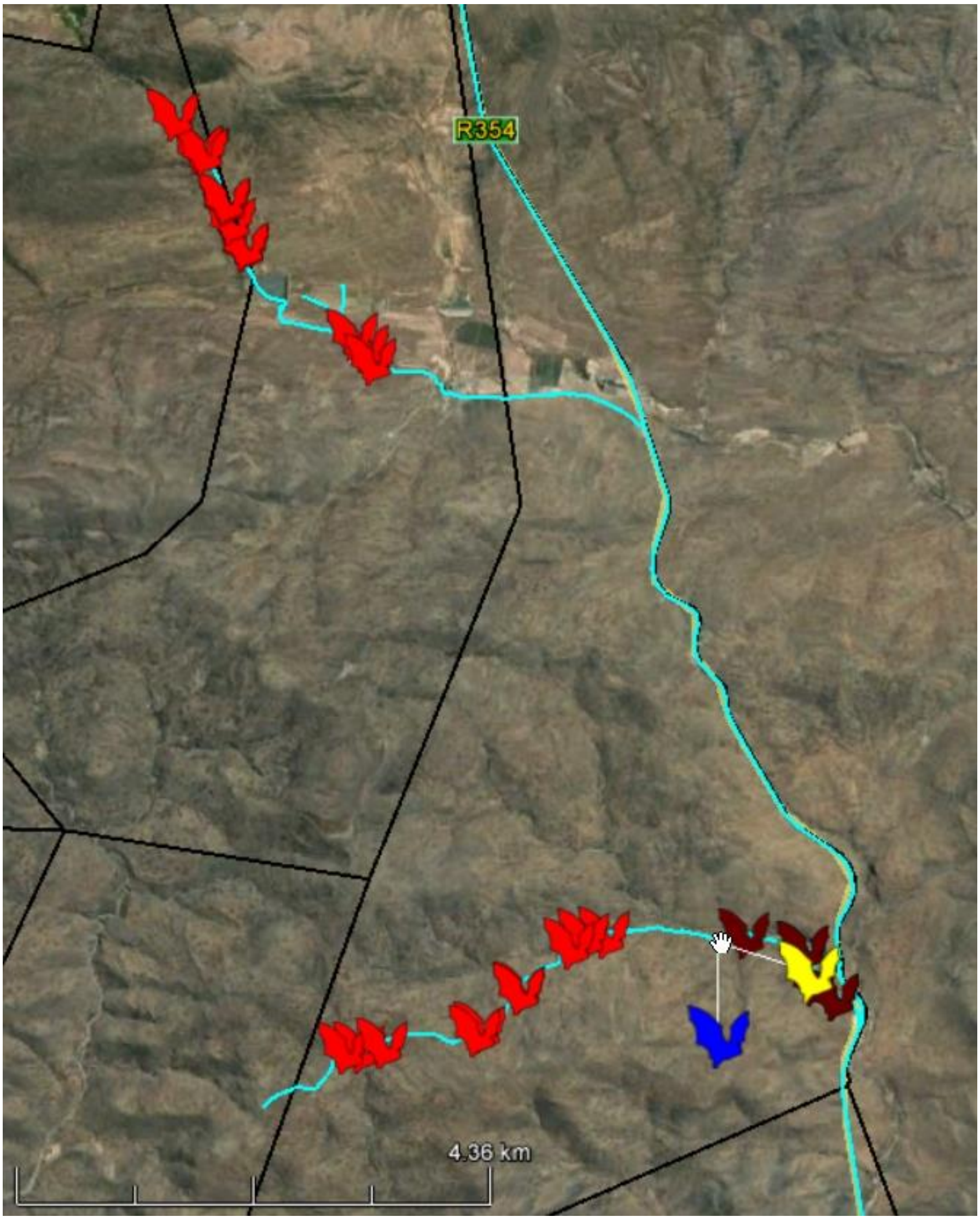
6 August 2015	**17**	**0**	**6.4**
7 August 2015	**18**	**0**	**8**



Tadarida aegyptiaca ***Eptesicus hottentotus***

Track traversed

Figure 7: Transect route of the third site visit, note the increased bat activity after sunset where transects were started in the East of the site.



Tadarida aegyptiaca ***Eptesicus hottentotus***

Neoromicia capensis **Track traversed**

Figure 8: Transect route of the third site visit.

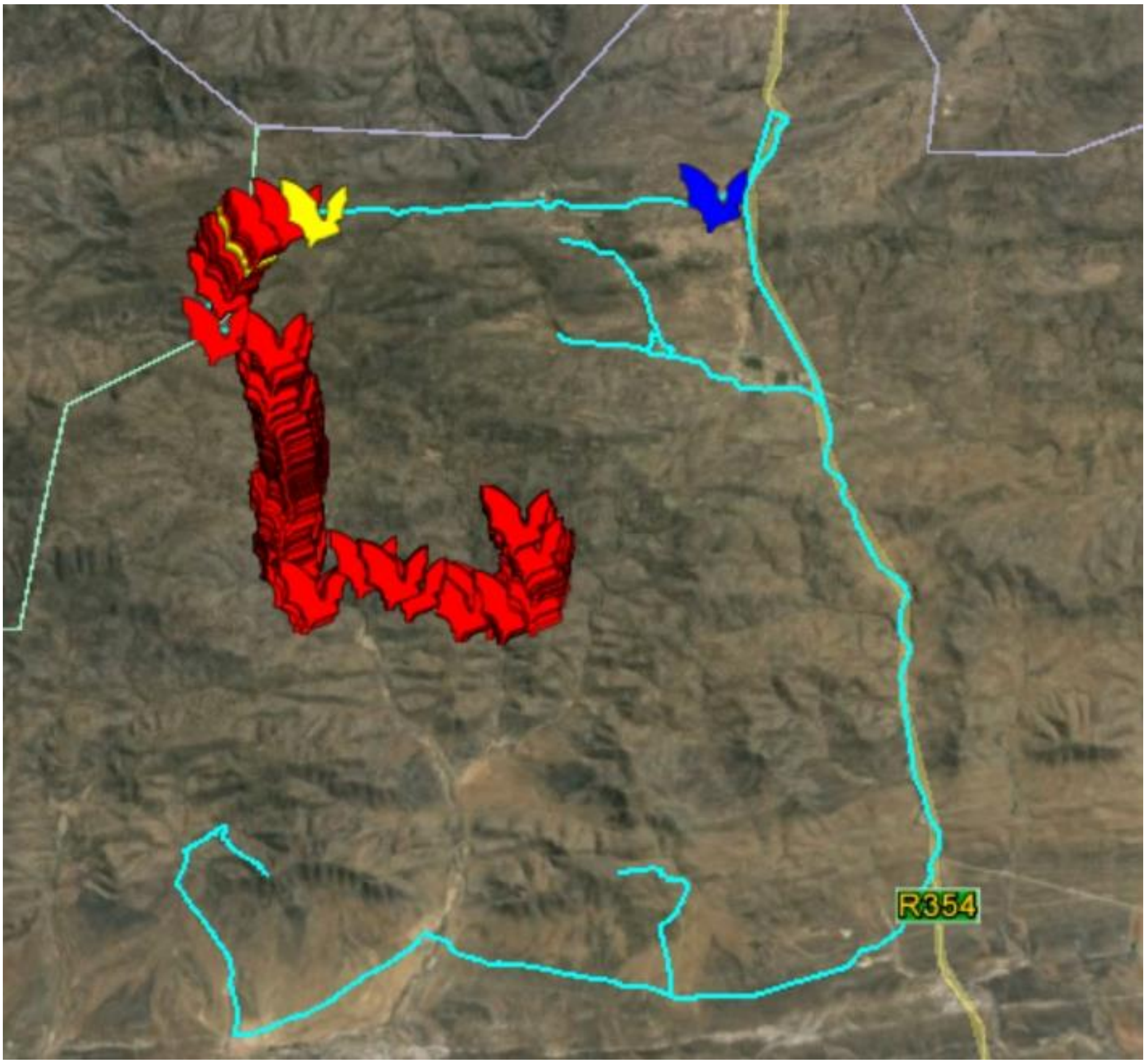
4.4.4 Fourth Site Visit

Table 5: Transect survey effort for the fourth site visit.

TRANSECT NIGHTS	DISTANCE TRAVELLED (km)	DURATION
1 December 2015	16	1 hr 50 min
2 December 2015	45	4 hrs
4 December 2015	84	3 hrs

Table 6: Climatic conditions during the fourth site visit.

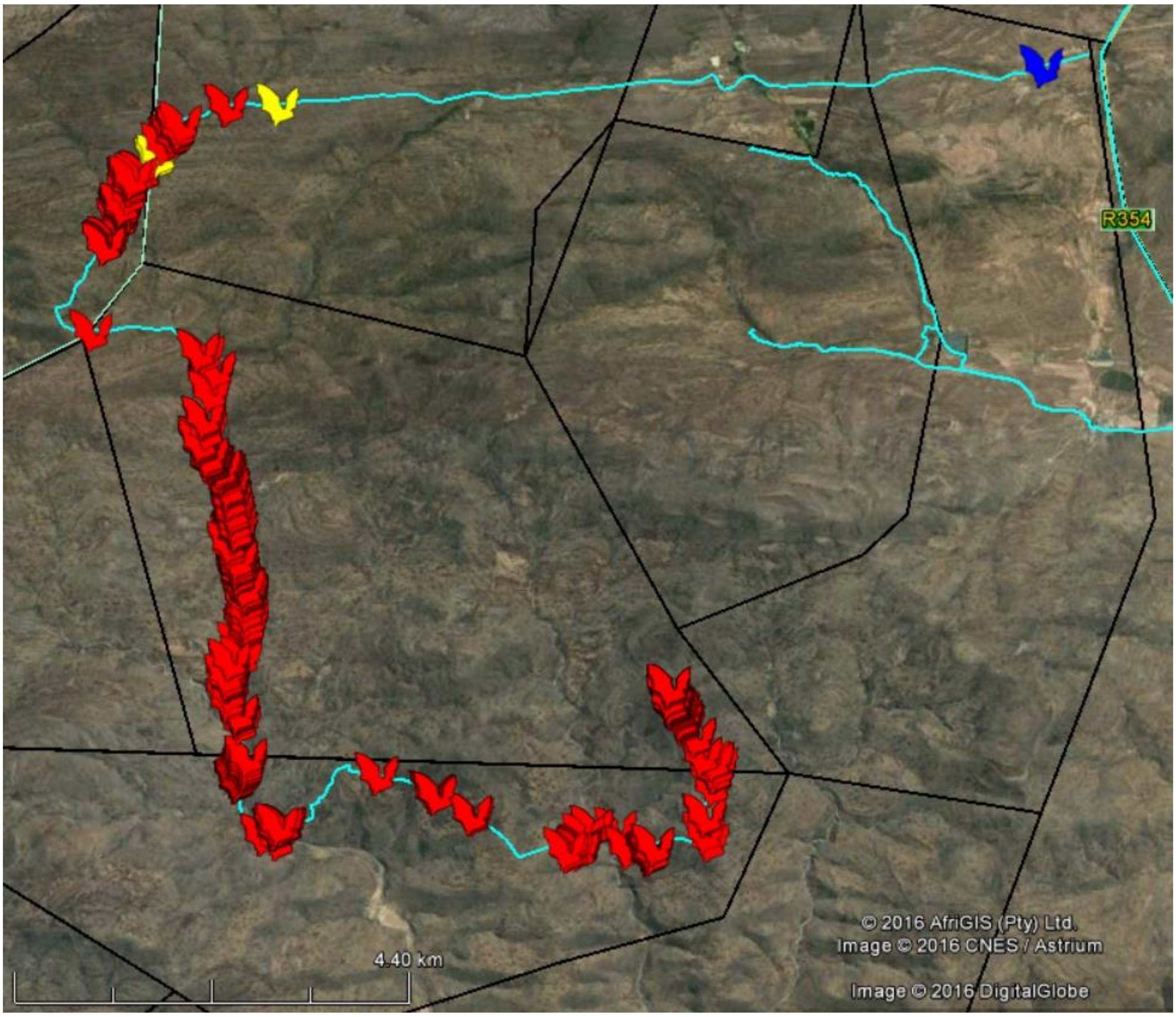
TRANSECT NIGHT	TEMPERATURE (°C)	PRECIPITATION (mm)	WIND SPEED (km/h)
1 December 2015	29	0	16
2 December 2015	26	0	17.7
4 December 2015	27	0	17.7



Tadarida aegyptiaca ***Eptesicus hottentotus***

Neoromicia capensis **Track traversed**

Figure 9: Transect route of the fourth site visit, note the increased bat activity early evening where transects were started in the South West of the site.



Tadarida aegyptiaca

Neoromicia capensis

Track traversed

Figure 10: Transect route of the fourth site visit.

4.5 Sensitivity Map

There is no preference to any of the location alternatives for the associated infrastructures namely: access road, construction camp and substation.

Figure 11 - 14 depicts the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are most probable to occur on site. Thus the sensitivity map is based on species ecology and habitat preferences. This map can be used as a pre-construction mitigation in terms of improving turbine placement with regards to bat preferred habitats on site.

Table 7: Description of parameters used in the construction of a sensitivity map

Last iteration	June 2015
High sensitivity buffer	On a flat surface the distance from the base of a turbine is either 200m or 150m from a sensitivity, depending on terrain and the type of sensitivity. Based on a rotor diameter of 140m and 120m hub height, the distance of a turbine blade tip to the nearest ground level sensitivity will be 160m in the case of a 200m horizontal buffer, and 120m in the case of a 150m horizontal buffer. However, in cases where 200m or 150m overlapped with a proposed turbine position, the difference in elevation between the turbine position and sensitivity (at a lower elevation in this case) has been incorporated in the formula which effectively increases that specific turbines hub height (in relation to the sensitivity). Formula used: $b=\sqrt{((160 \textit{ or } 120+bl)^2 -(hh+ed)^2)}$, derived from Mitchell-Jones & Carlin (2009). Where: b= horizontal buffer distance to turbine base bl = blade length hh= hub height ed= elevation difference between turbine base and sensitivity

Moderate sensitivity buffer	100m radial buffer
	The presence of probable hollows/overhangs, rock faces and clumps of larger woody plants. These features provide natural roosting spaces and tend to attract insect prey.
	The different vegetation types and presence of riparian/water drainage habitat is used as indicators of probable foraging areas.
	Open water sources, be it man-made farm dams or natural streams and wetlands, are important sources of drinking water and provide habitat that host insect prey.
	Areas frequented often by cattle and livestock (e.g. congregation areas and kraal areas) were assigned a moderate sensitivity since large groups of animals tend to attract insects.

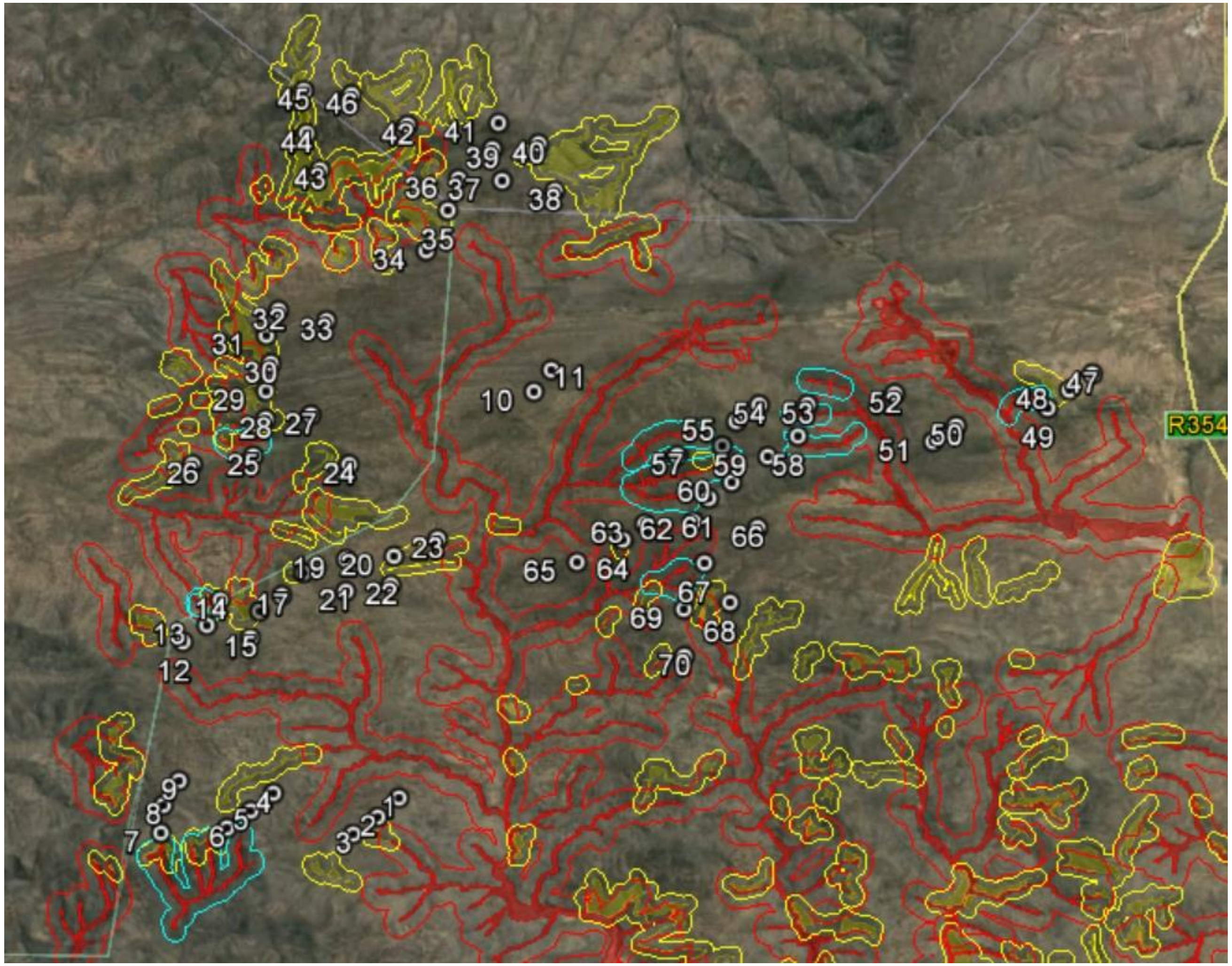
Table 8: Description of sensitivity categories utilized in the sensitivity map

Sensitivity	**Description**
Moderate Sensitivity	Areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within or close to these areas must acquire priority (not excluding all other turbines) during pre/post-construction studies and mitigation measures, if any is needed.
High Sensitivity	Areas that are deemed critical for resident bat populations, capable of elevated levels of bat activity and support greater bat diversity than the rest of the site. These areas are 'no-go' areas and turbines must not be placed in these areas.

Areas not depicted as having a Moderate or High Bat Sensitivity is considered of a Low Bat Sensitivity category.

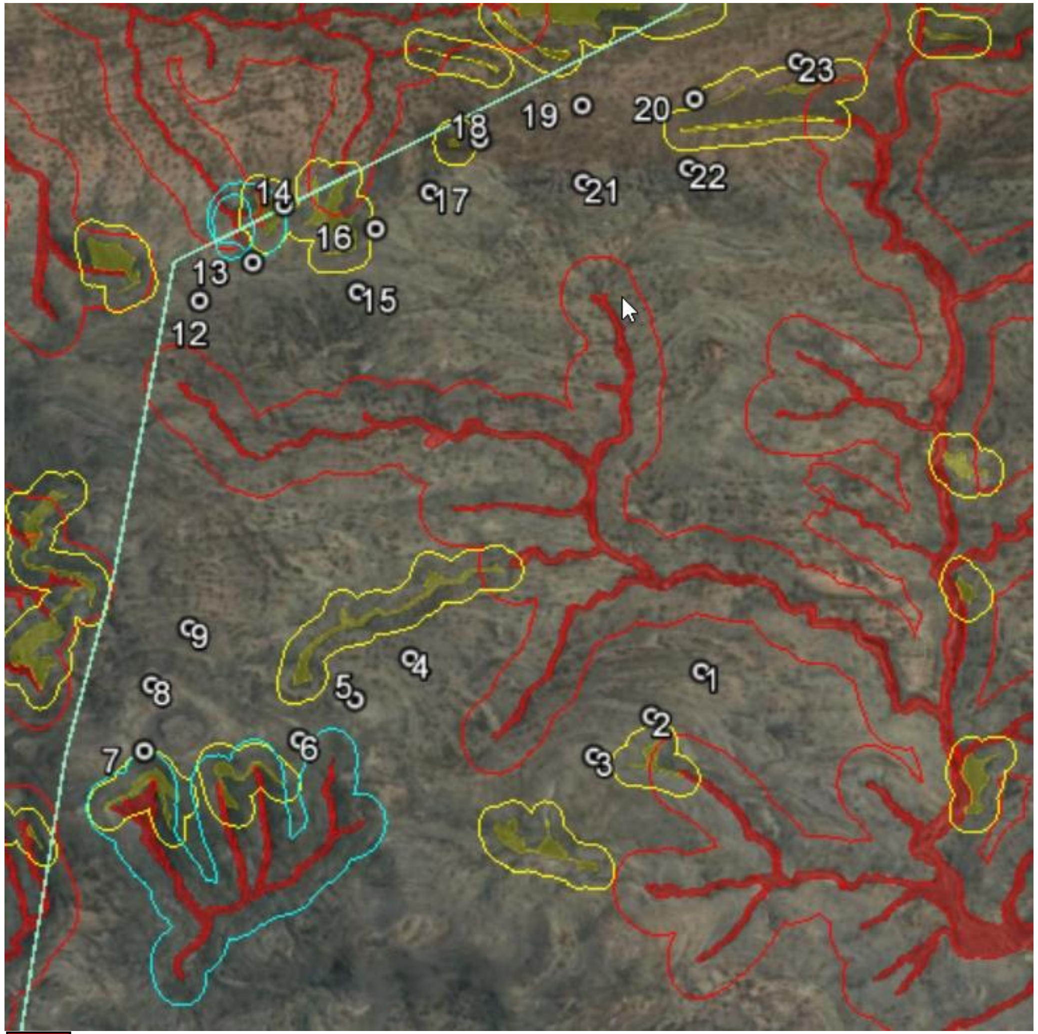
Table 9: Turbines located within bat sensitive areas and their respective buffers

Bat sensitive area	**Turbine number**
High sensitivity	None
High sensitivity buffer	None
Moderate sensitivity	None
Moderate sensitivity buffer	Turbines 14, 28 – 31, 42 – 45



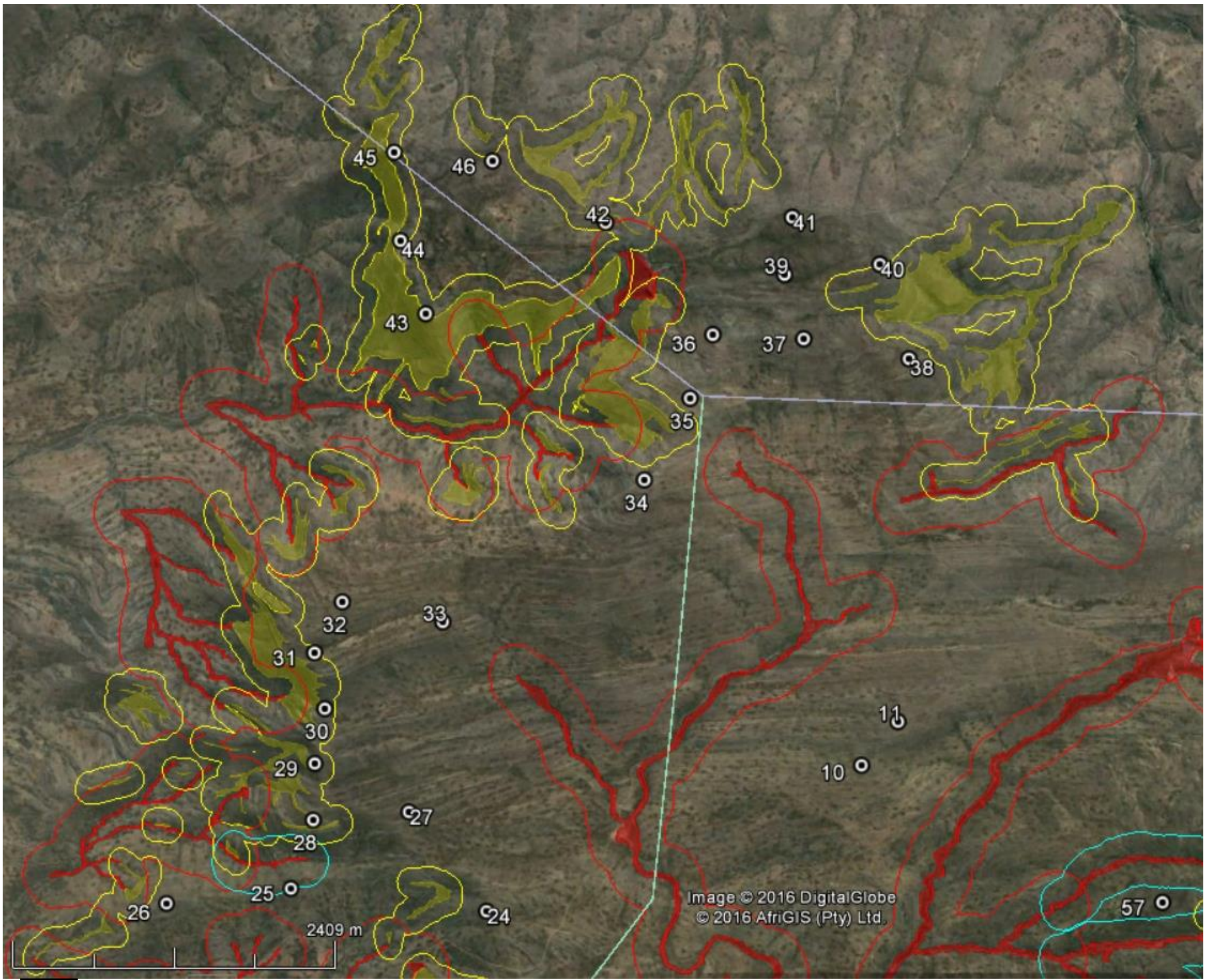
High bat sensitivity area
High bat sensitivity buffer
Turbine specific high bat sensitivity buffer
Moderate bat sensitivity area
Moderate bat sensitivity buffer

Figure 11: Bat sensitivity map of the Brandvalley site.



■ (red)	High bat sensitivity area	— (red)	High bat sensitivity buffer	— (blue)	Turbine specific high bat sensitivity buffer
■ (yellow)	Moderate bat sensitivity area	— (yellow)	Moderate bat sensitivity buffer		

Figure 12: Bat sensitivity map of the South Western part of the site.



High bat sensitivity area

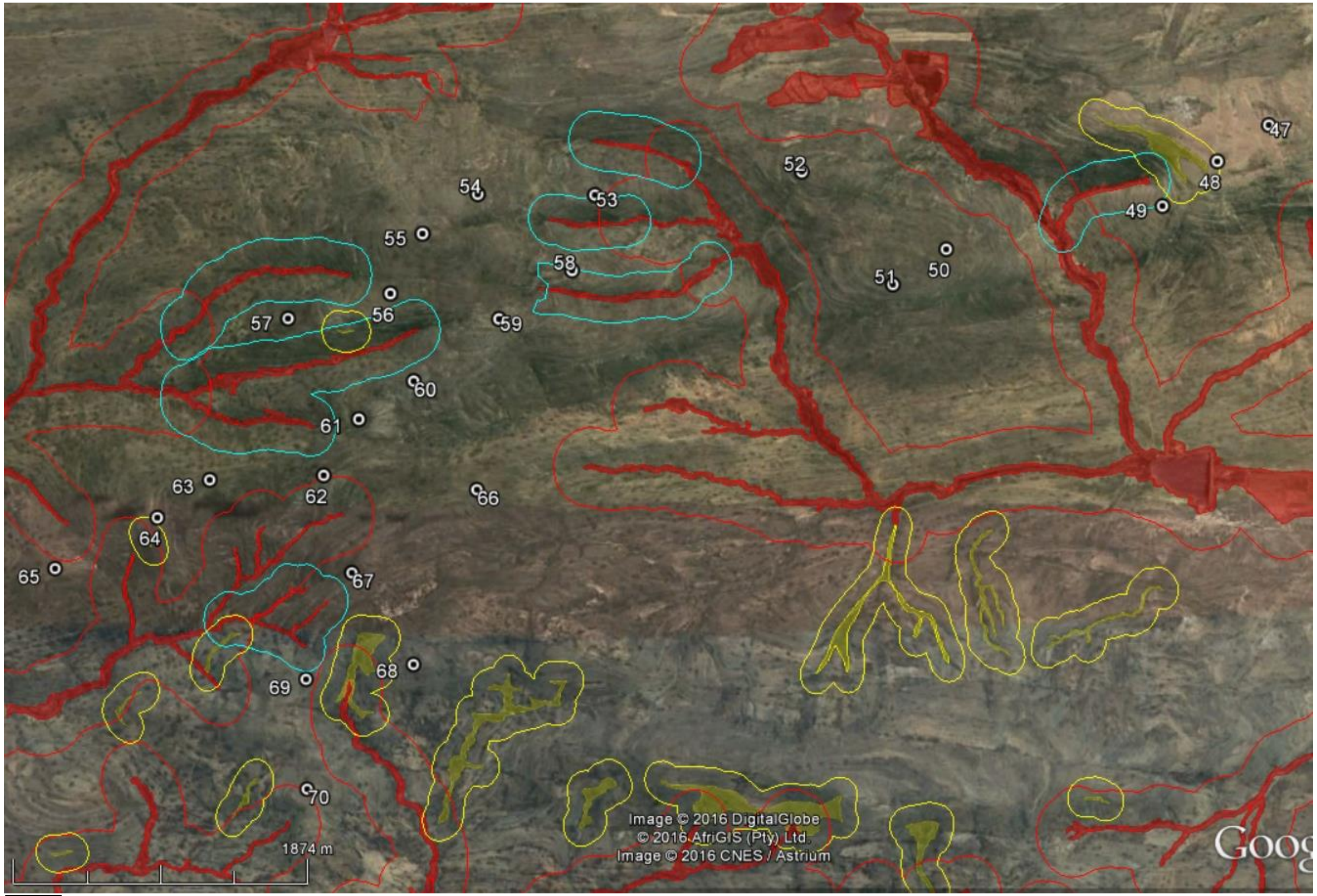
Moderate bat sensitivity area

High bat sensitivity buffer

Moderate bat sensitivity buffer

Turbine specific high bat sensitivity buffer

Figure 13: Bat sensitivity map of the Nortern portion of the site



High bat sensitivity area | High bat sensitivity buffer | Turbine specific high bat sensitivity buffer
Moderate bat sensitivity area | Moderate bat sensitivity buffer

Figure 14: Bat sensitivity map of the Eastern portion of the site

4.6 Passive data

The long term monitoring data is presented below in terms of composition and abundance, temporal distribution and relation with wind and temperature conditions. The results of the systems have been differentiated from one another as they are positioned in different localities and thus are exposed to different environmental conditions. The systems are also within different habitats, which may affect the presence of certain bat species and their activity patterns.

Specific issues encountered with the passive systems are indicated in **Table 10** below, where no issue is described next to a data gap it indicates depreciation in battery capacity. The 2000 error refers to the bat detectors time adjusting back to the year 2000 at any given time of the day or night, this data could not be incorporated into the analysis. During the site visit in May 2015 SM1 was moved to Brandkop met mast, and in August 2015 SM7 was moved to Snydersberg and Barendskraal NW met mast was set up.

Short mast 2 (SM2) and Short mast 8 (SM8) were both located in valley areas where more favourable habitat for bats occur, compared to the development areas. Therefore, these two systems served as controls to compare against bat activity in the development areas.

Table 10: Periods over which the monitoring systems were operational and gathered data, bat calls were not necessarily recorded during all these time periods.

	SM1	Brandkop	SM2	SM4	SM7	Snydersberg	SM8	Barendskraal NW
Feb 2015	1 – 4th (Loose connection)	N/A	1 – 28th	1 – 28th	1-28th	N/A	1-28th	N/A
Mar 2015	None	N/A	1 – 31st	1 – 31st	1-31st	N/A	1 – 6th 11 – 14th 20 – 21st 30 – 31st	N/A
Apr 2015	None	N/A	1 – 30th	7 nights evenly spread over month (until variable times)	1 – 30th	N/A	1st 7 – 9th 15 – 16th 21 – 22nd 29 – 30th	N/A
May 2015	System	8 – 31st (until	24 nights	5 – 17th	1-31st	N/A	5 – 31st	N/A

	moved to Brandkop	4:40am)	evenly spread over month (until 23:00)	22 – 24th (until 3:30am) 30 – 31st				
June 2015	N/A	1 – 30th (until 2:40am)	20 nights evenly spread over month (until variable times after midnight)	4 – 5th 12 – 13th 24 – 25th	1 – 30th	N/A	1 – 30th	N/A
Jul 2015	N/A	1 – 13th (until 2:15am)	26 nights evenly spread over month (until variable times after midnight)	6 – 7th 14 – 15th 20 – 25th (until 2:40am) 28 – 29th	1-31st	N/A	1-31st	N/A
Aug 2015	N/A	5-31st (2000 error)	1 – 19th (until variable times after	4 – 31st (replaced charge	1 – 5th (Moved to Snydersberg)	6 – 31st	1 – 31st	6 – 31st

			midnight)	regulator)				
Sept 2015	N/A	1 – 5th (2000 error) 5 – 30th (2000 error until 19:00)	1 – 30th (2000 error)	1 – 30th	N/A	1 – 30th	1 – 30th	1 – 3rd
Oct 2015	N/A	None (firmware crash)	1 – 31st (2000 error)	1 – 31st	N/A	1 – 31st	1 – 31st	None (firmware crash)
Nov 2015	N/A	None (firmware crash)	1 – 30th (2000 error) (loose connection was fixed	1 – 30th	N/A	1 – 30th	1 – 30th	None (firmware crash)
Dec 2015	N/A	13 nights evenly spread over month (until 20:15)	4 – 31st	1 – 31st	N/A	1 – 31st	1 – 31st	3 – 31st
Jan 2016	N/A	13 nights evenly spread over month (until 20:15)	1 – 31st	1 – 30th	N/A	1 – 29th	1 – 30th	1 – 14th
Feb 2016	N/A	13 nights	1-29th	1-29th	N/A	None	1-29th	None

		evenly spread over month (until 19:45).				(Unknown cause)		(Unknown cause)
Mar 2016	N/A	13 nights evenly spread over month (until 19:00).	1-31st	1 – 31st	N/A	None (Unknown cause)	1 – 18th	None (Unknown cause)
April	N/A	Intermittent nights until 19:30	1-16th Thereafter 6 nights (until variable times after 21:00)	1-30th	N/A	2000 error	2000 error	2000 error

4.6.1 Abundances and composition of bat assemblage

Figures 15 - 20 display the bat species assemblages, and number of bat passes detected per species, at each monitoring station, over the monitoring period.

The species were identified by parameters of peak frequency, slope, duration and bandwidth of their echolocation calls recorded by the passive monitoring systems. This diversity is relatively normal for this area of the Northern Cape.

SM2 and SM8 (**Figures 15 & 17**) recorded significantly higher levels of bat activity within the sensitive valley terrain, in comparison with the other systems within the turbine development areas on the ridges with less favourable habitat for bat.

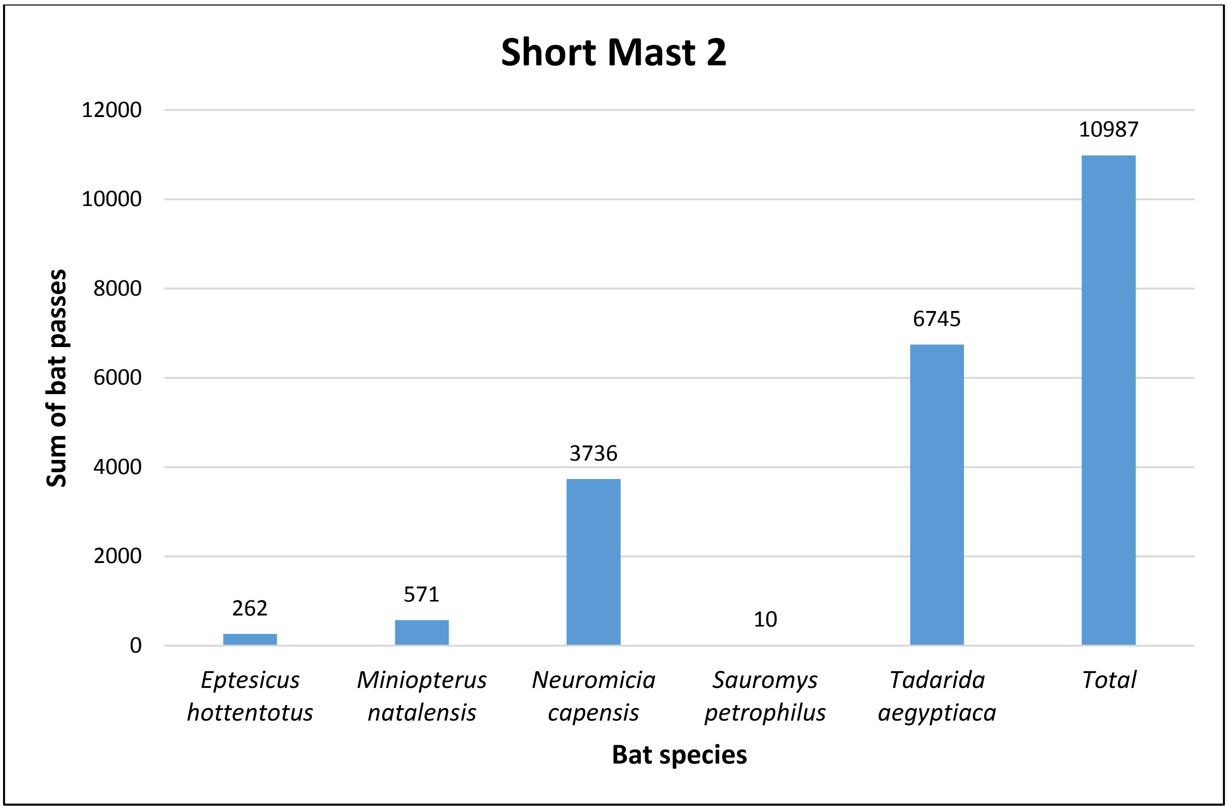


Figure 15: Species assemblage detected by Short mast 2 over the monitoring period

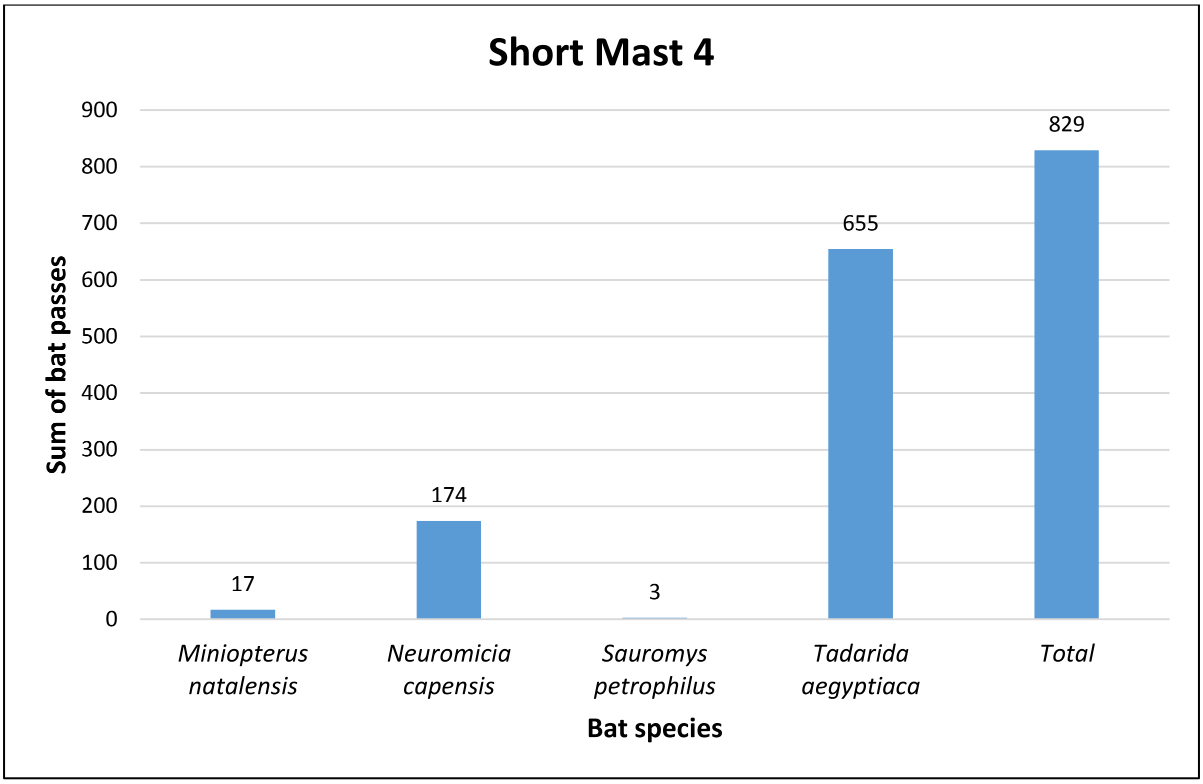


Figure 16: Species assemblage detected by Short mast 4 over the monitoring period

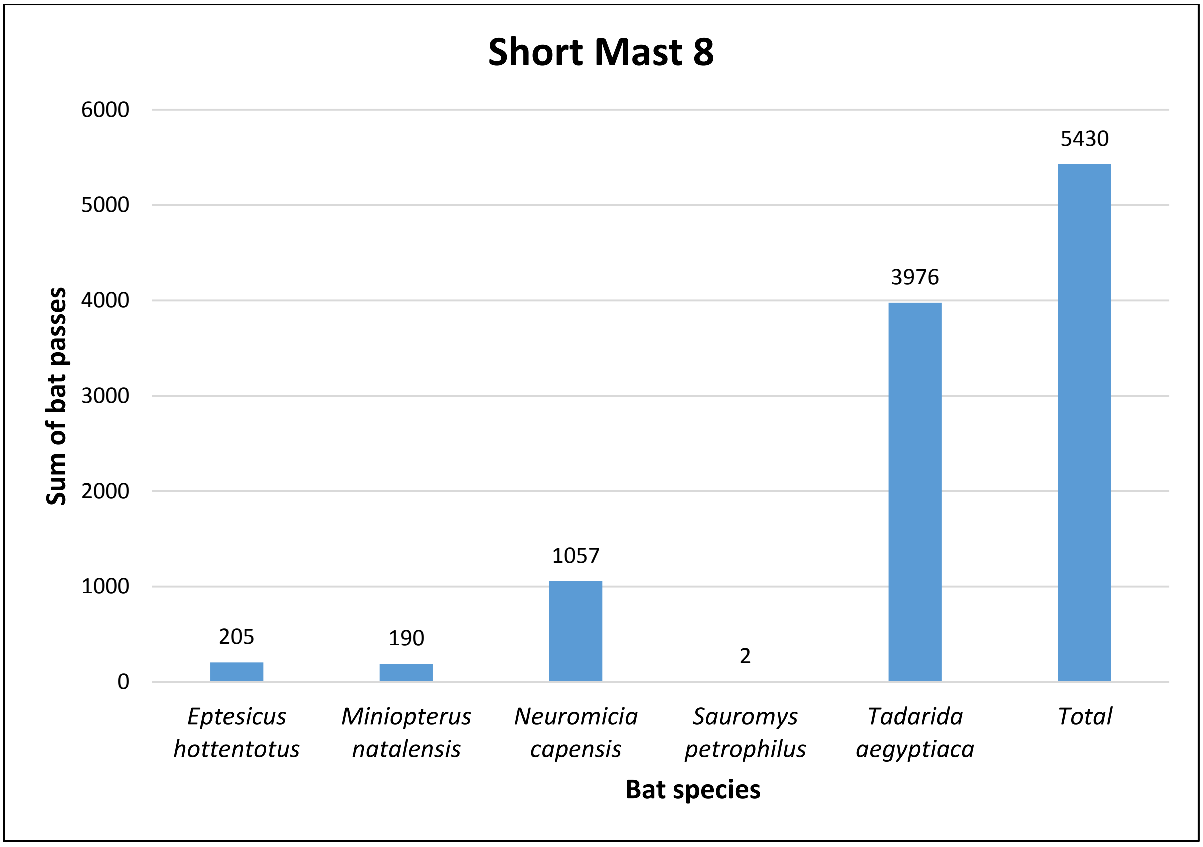


Figure 17: Species assemblage detected by Short mast 8 over the monitoring period

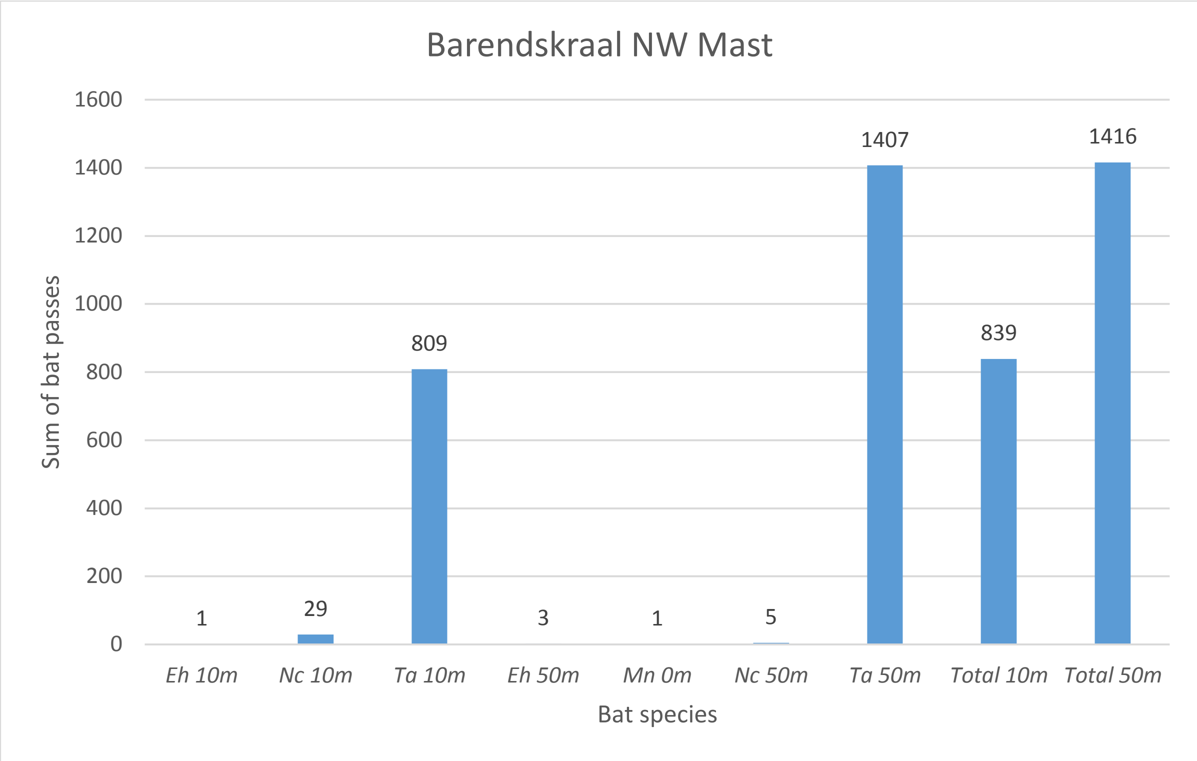


Figure 18: Species assemblage detected by Met mast Barendskraal NW over the monitoring period.

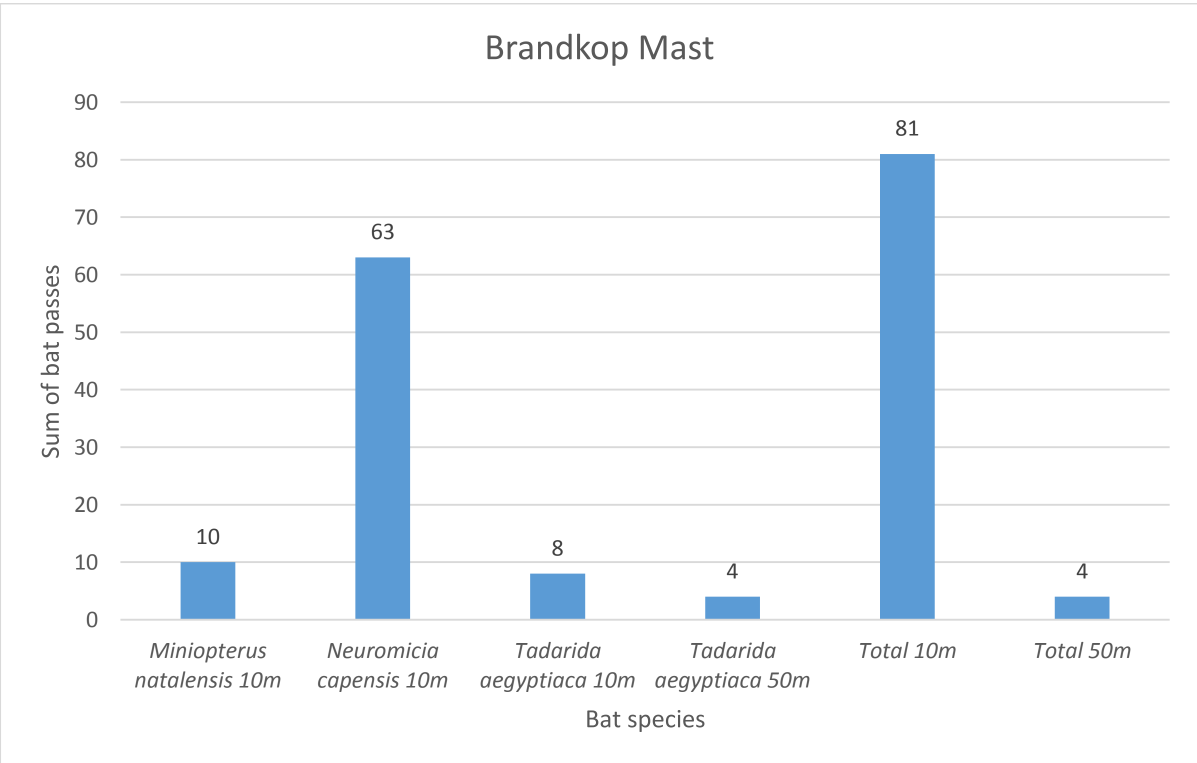


Figure 19: Species assemblage detected by Met mast Brandkop over the monitoring period.

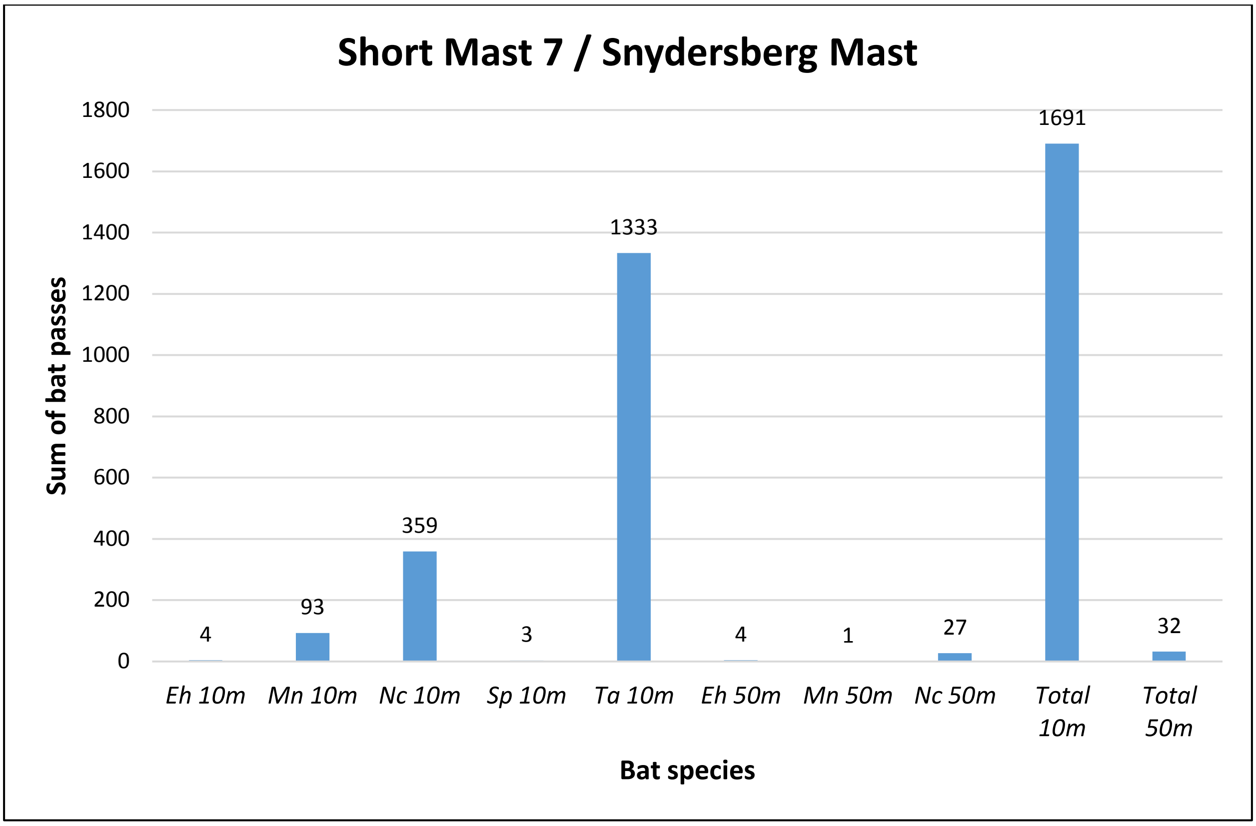


Figure 20: Species assemblage detected by Met mast Snydersberg over the monitoring period.

4.6.2 Average bat passes per night

The number of bat passes per month were averaged on a nightly basis, based on the number of nights that the systems were properly operational (**Figures 21 - 26**).

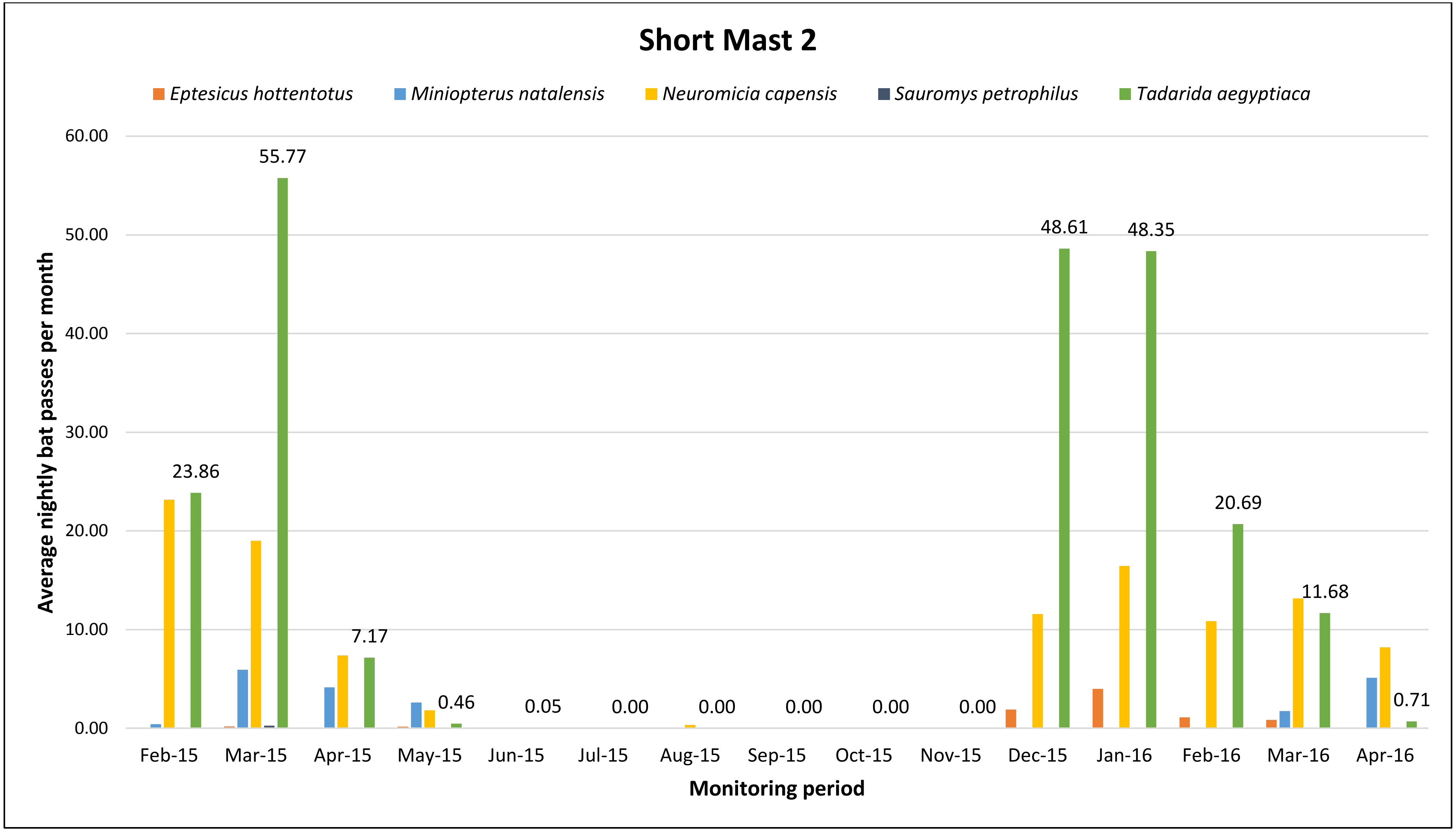


Figure 21: Average nightly passes per month for Short mast 2 over the monitoring period

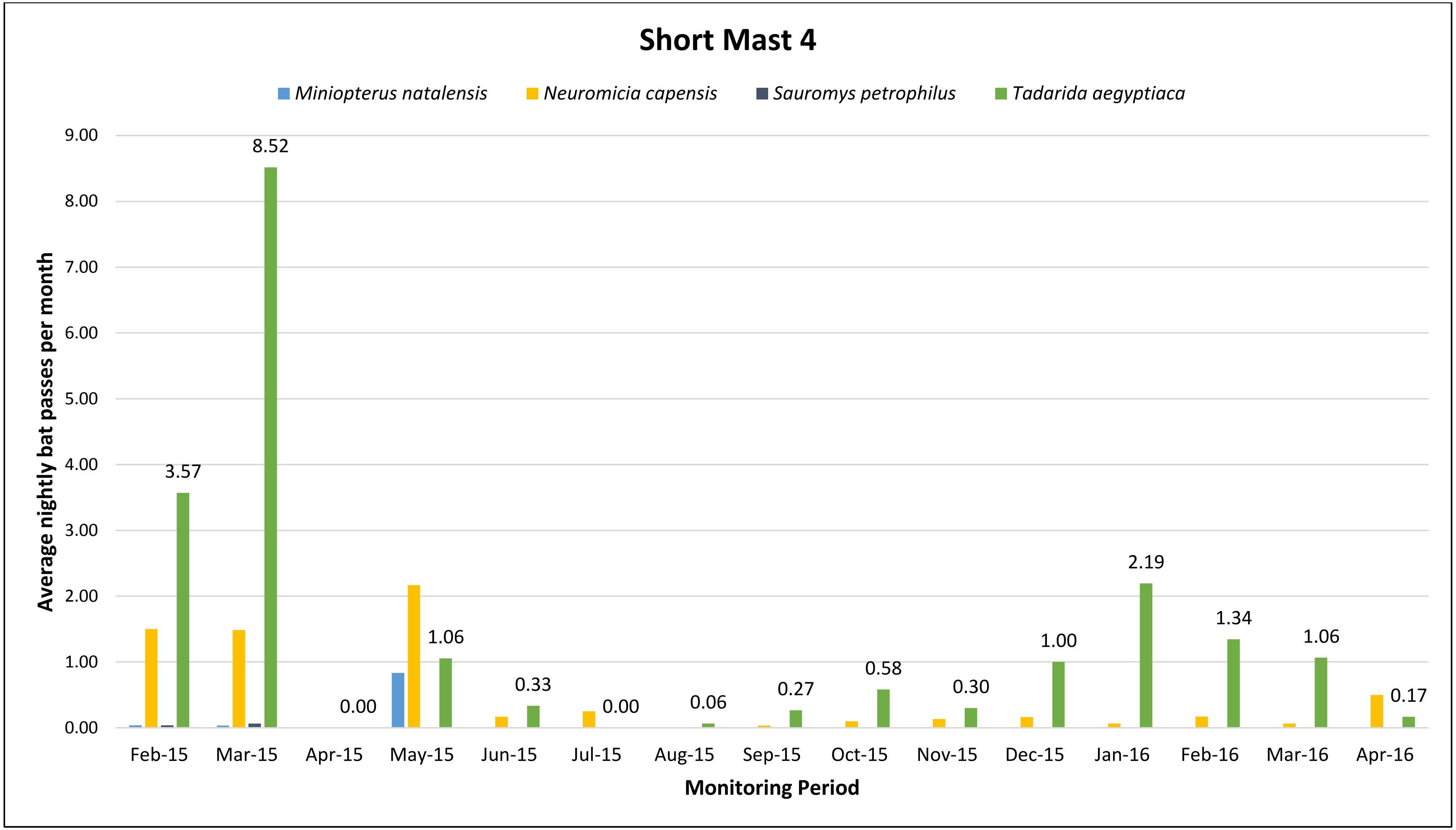


Figure 22: Average nightly passes per month for Short mast 4 over the monitoring period

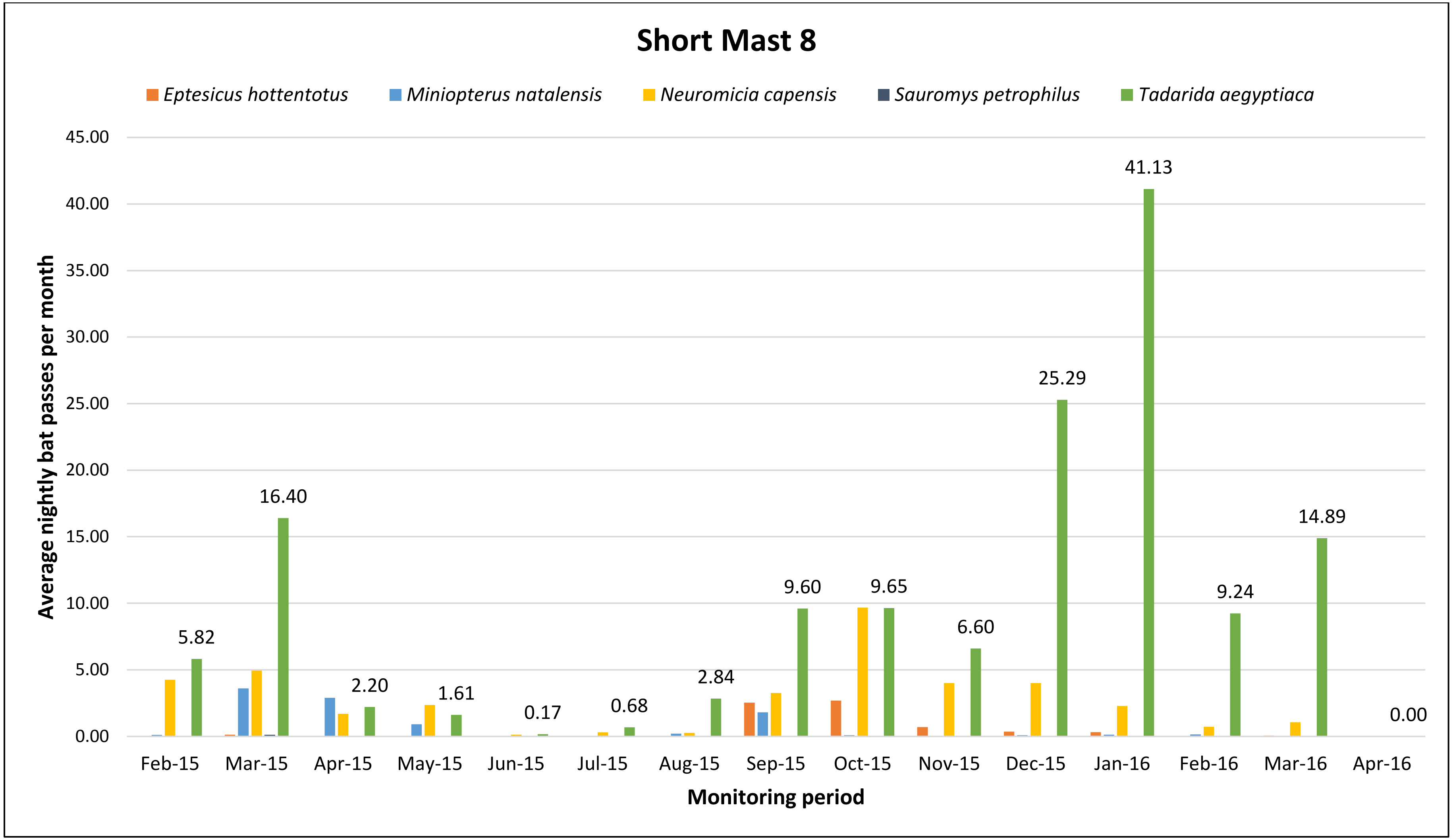


Figure 23: Average nightly passes per month for Short mast 8 over the monitoring period

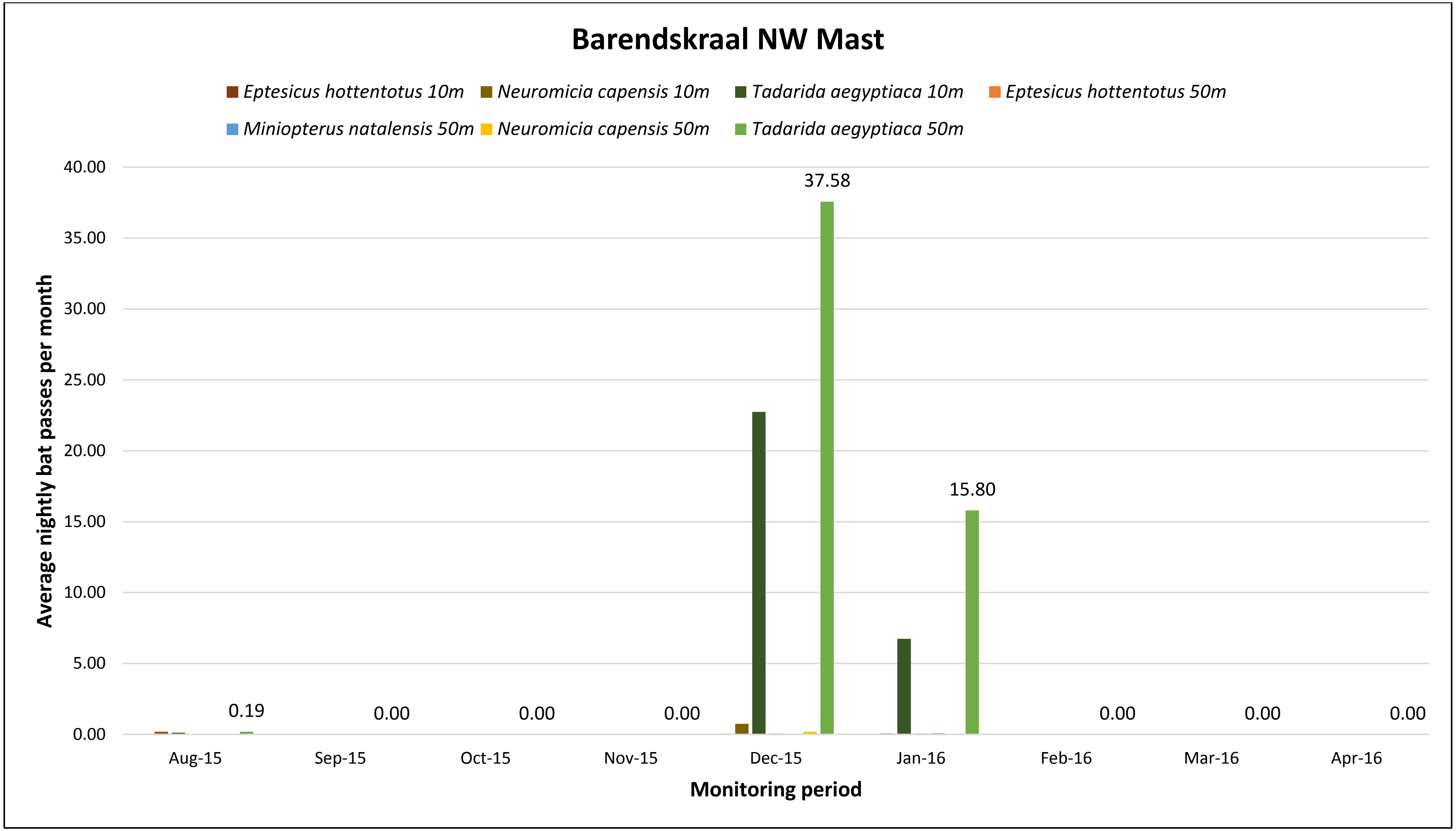


Figure 24: Average nightly passes per month for Met mast Barendskraal NW over the monitoring period

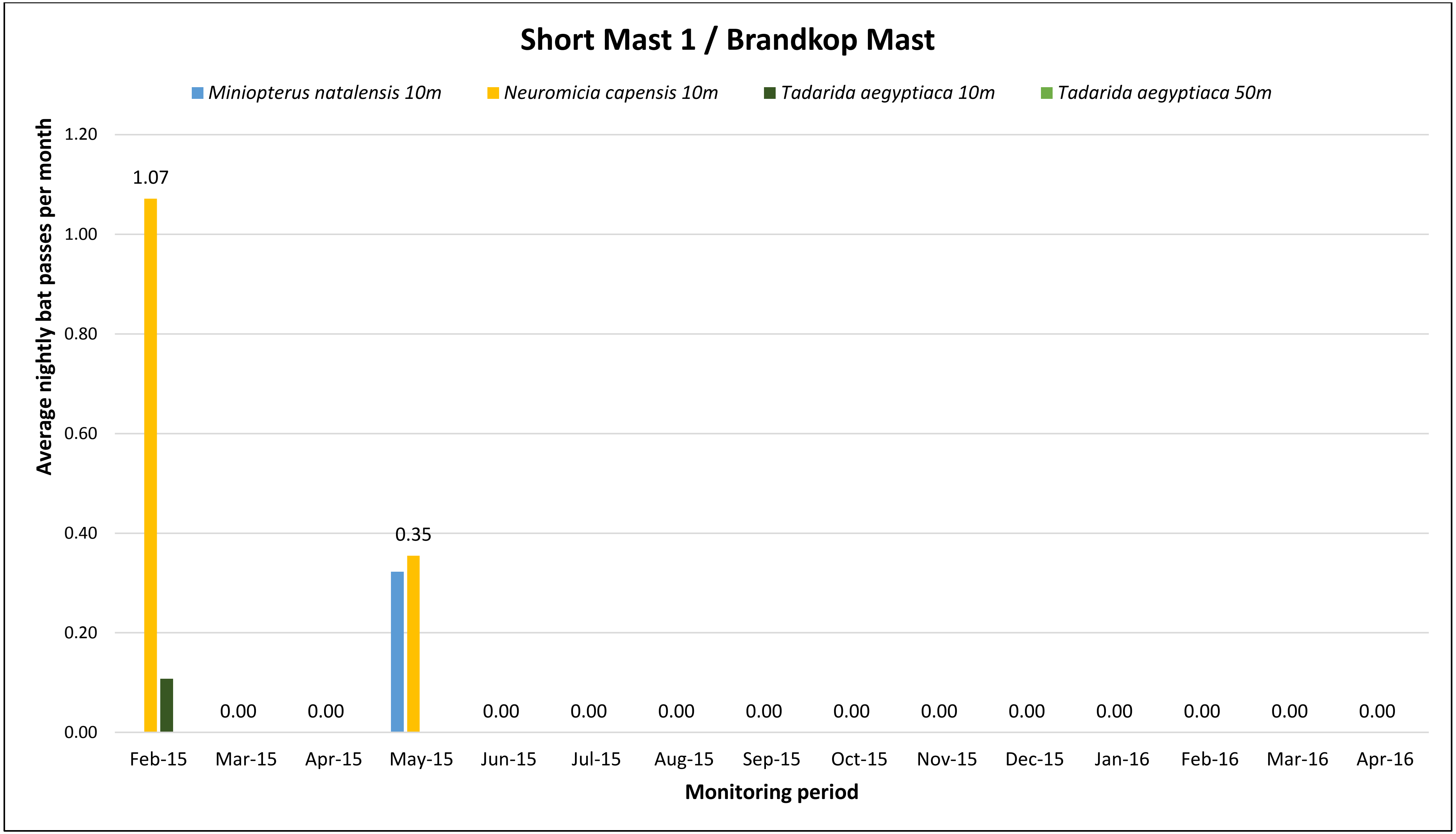


Figure 25: Average nightly passes per month for Met mast Brandkop over the monitoring period.

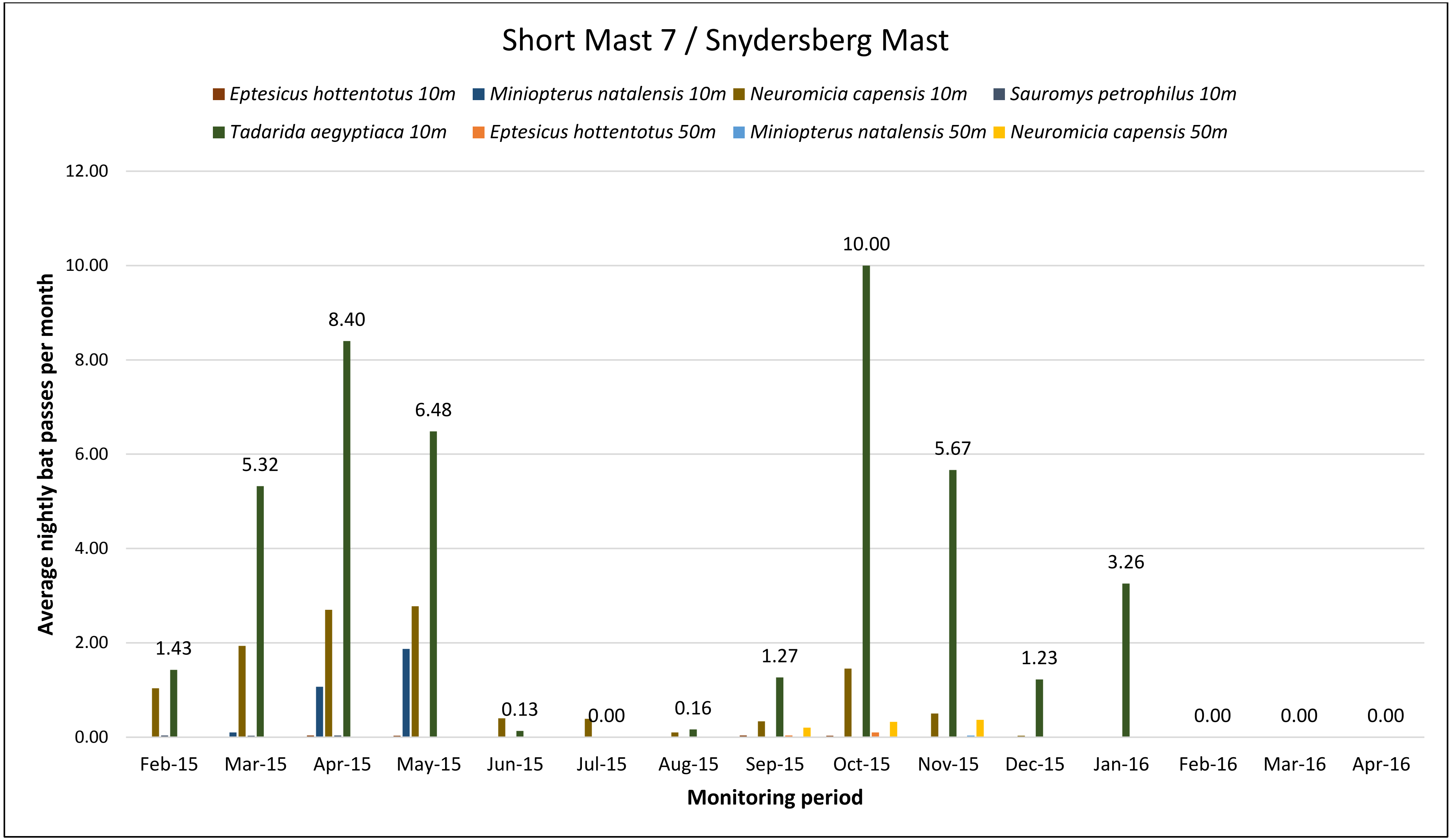


Figure 26: Average nightly passes per month for Met mast Snydersberg over the monitoring period

4.6.3 Distribution of bat activity across the night per season

The distribution of bat activity across the night, per season, has been analysed in this section. The 12 month monitoring period was divided based on generic calendar seasons outlined in **Table 11**.

Table 11: Time frame of each season

Season	Monitoring period
Winter	**1 June – 31 August**
Spring	**1 September – 30 November**
Summer	**1 December – 28 February**
Autumn	**1 March – 31 May**

The number of bat passes per 10 minute interval over the seasonal monitoring periods were summed to generate the figures of bat activity over the time of night. Higher levels of activity indicate preference for activity over a particular period of the night. These periods were then used to inform mitigation implementation when and where needed. Once again, peak activity times are mostly an amalgamation of the activity of *T. aegyptiaca* and *N. capensis*. The figures show that there are seldom cases of other species being highly active in the absence of high activity levels of these two abundant species.

Where bat passes during a specific season (e.g. winter) were very low, such seasonal data were not incorporated in the below graphs. Instead the below graphs focus on the higher bat activity seasons and months, which is informative to the assessment.

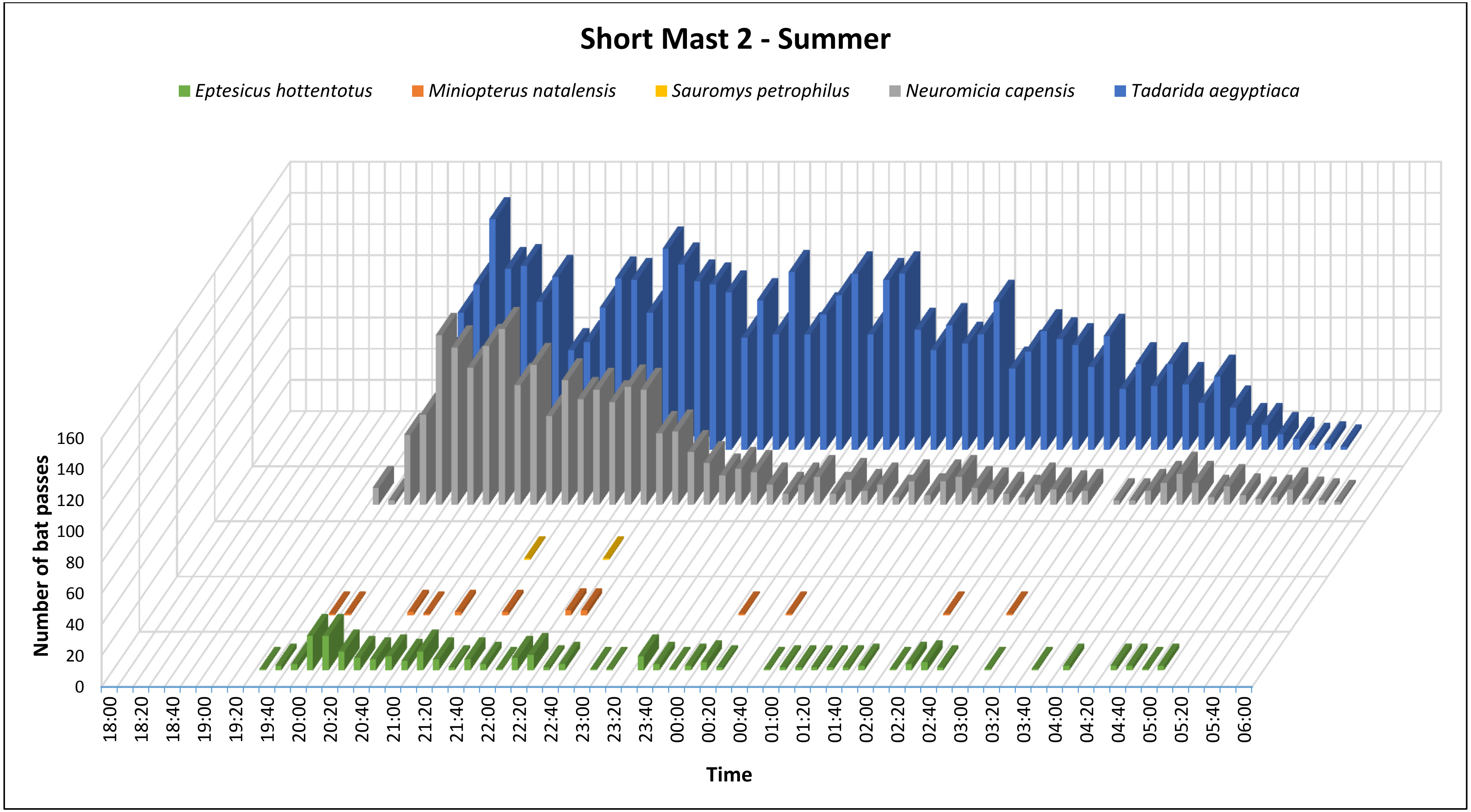


Figure 33: Temporal distribution of activity across the night as detected by Short mast 2 in summer.

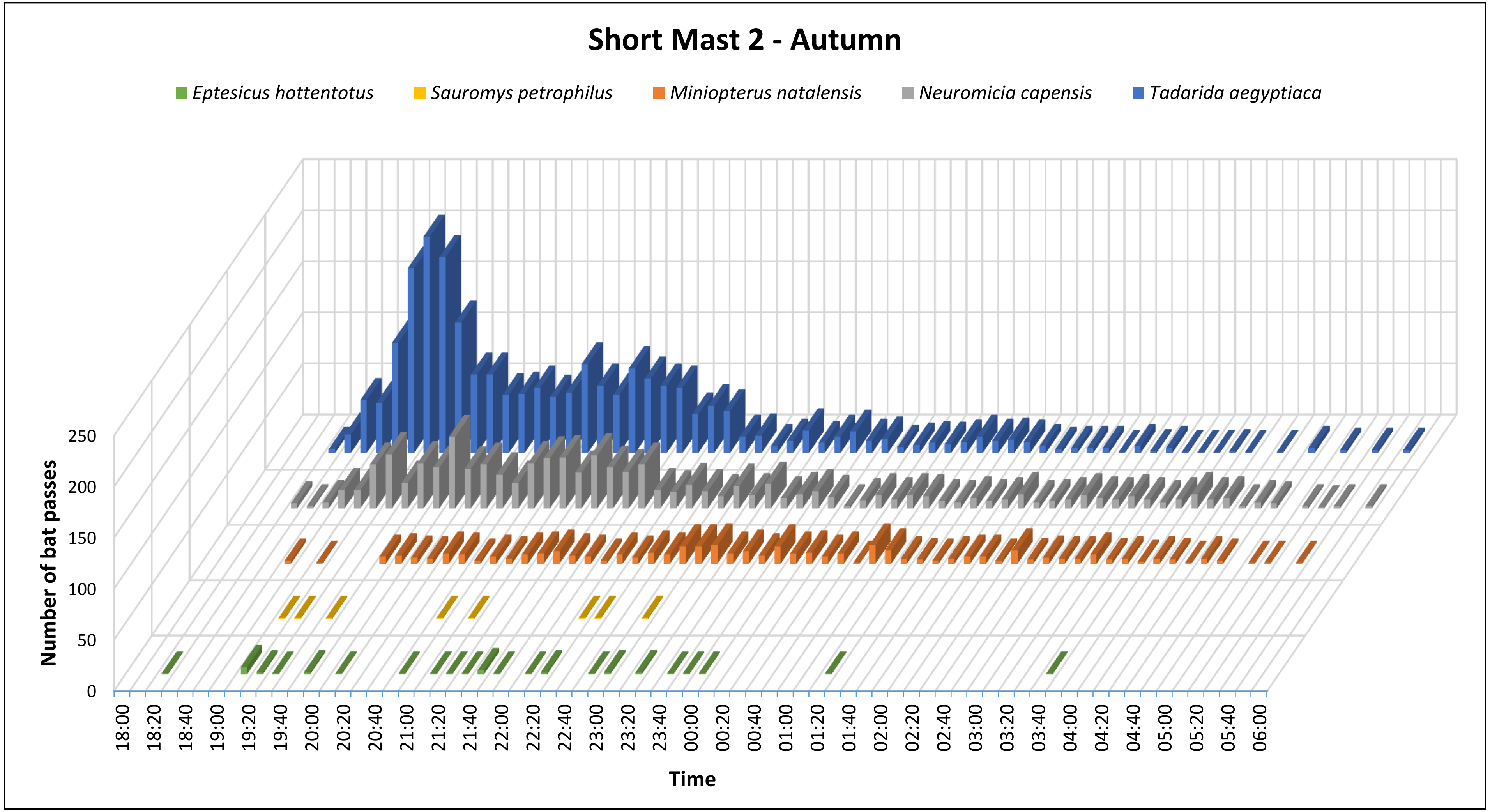


Figure 34: Temporal distribution of activity across the night as detected by Short mast 2 in autumn.

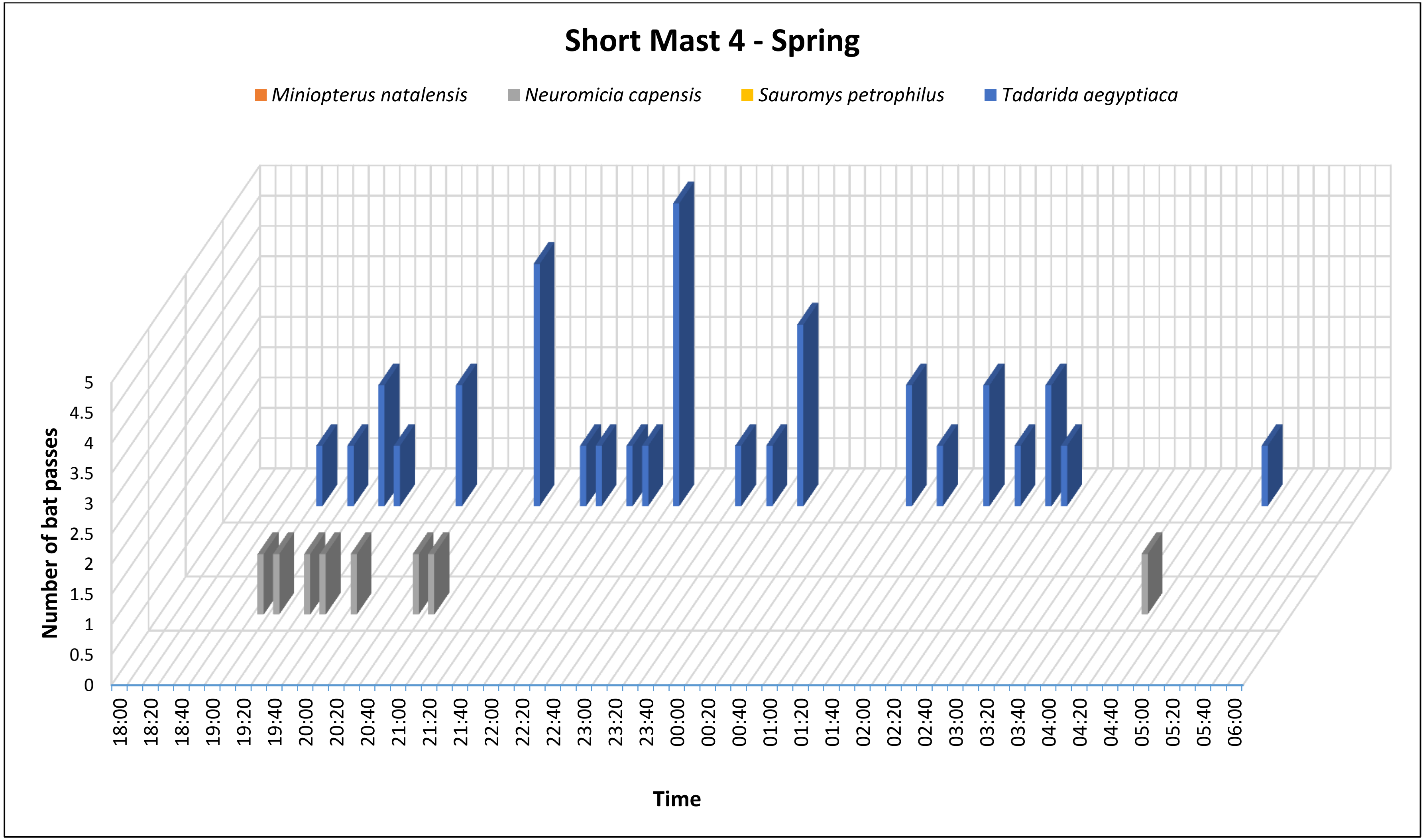


Figure 35: Temporal distribution of activity across the night as detected by Short mast 4 in spring.

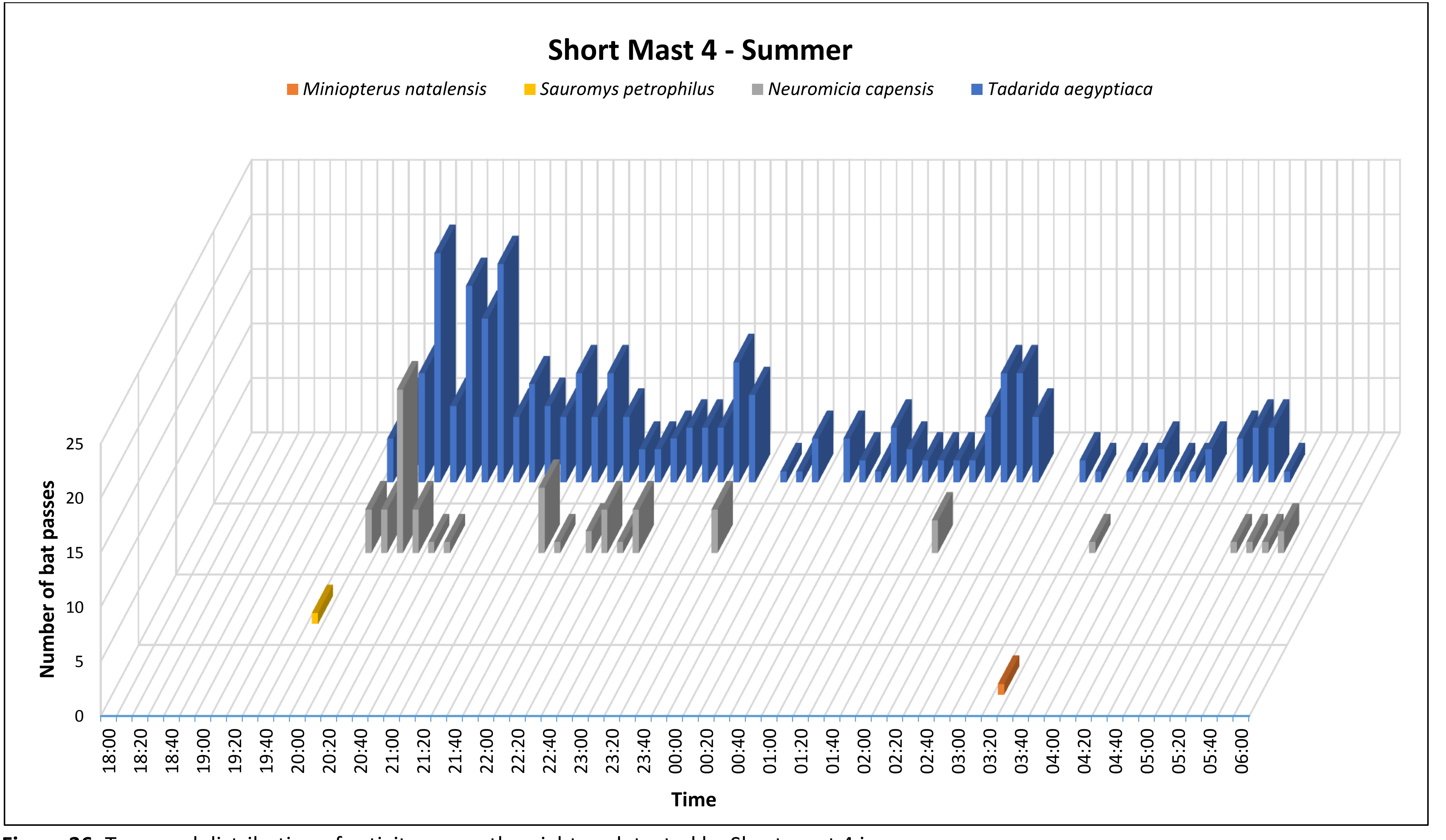


Figure 36: Temporal distribution of activity across the night as detected by Short mast 4 in summer.

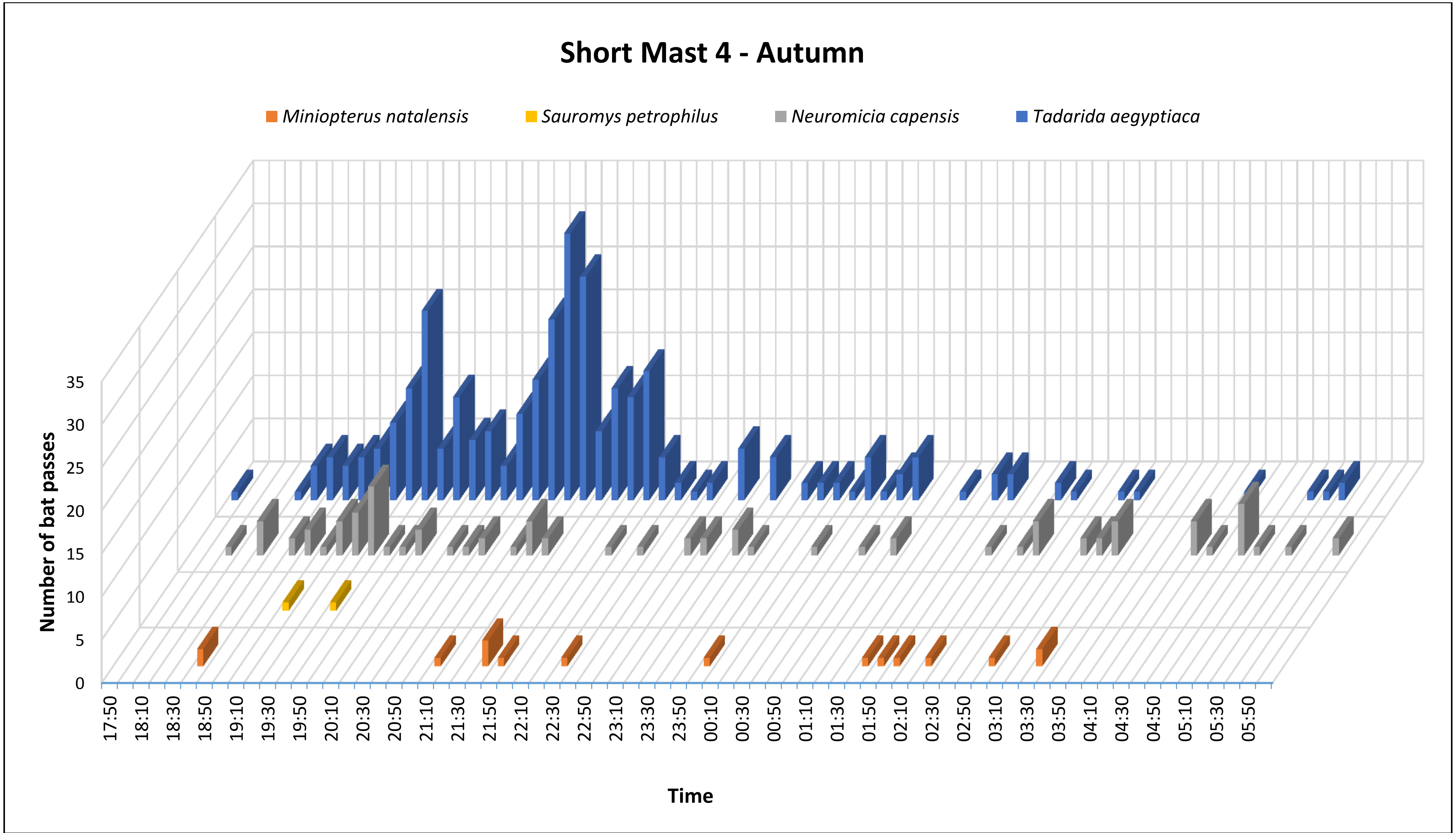


Figure 37: Temporal distribution of activity across the night as detected by Short mast 4 in autumn.

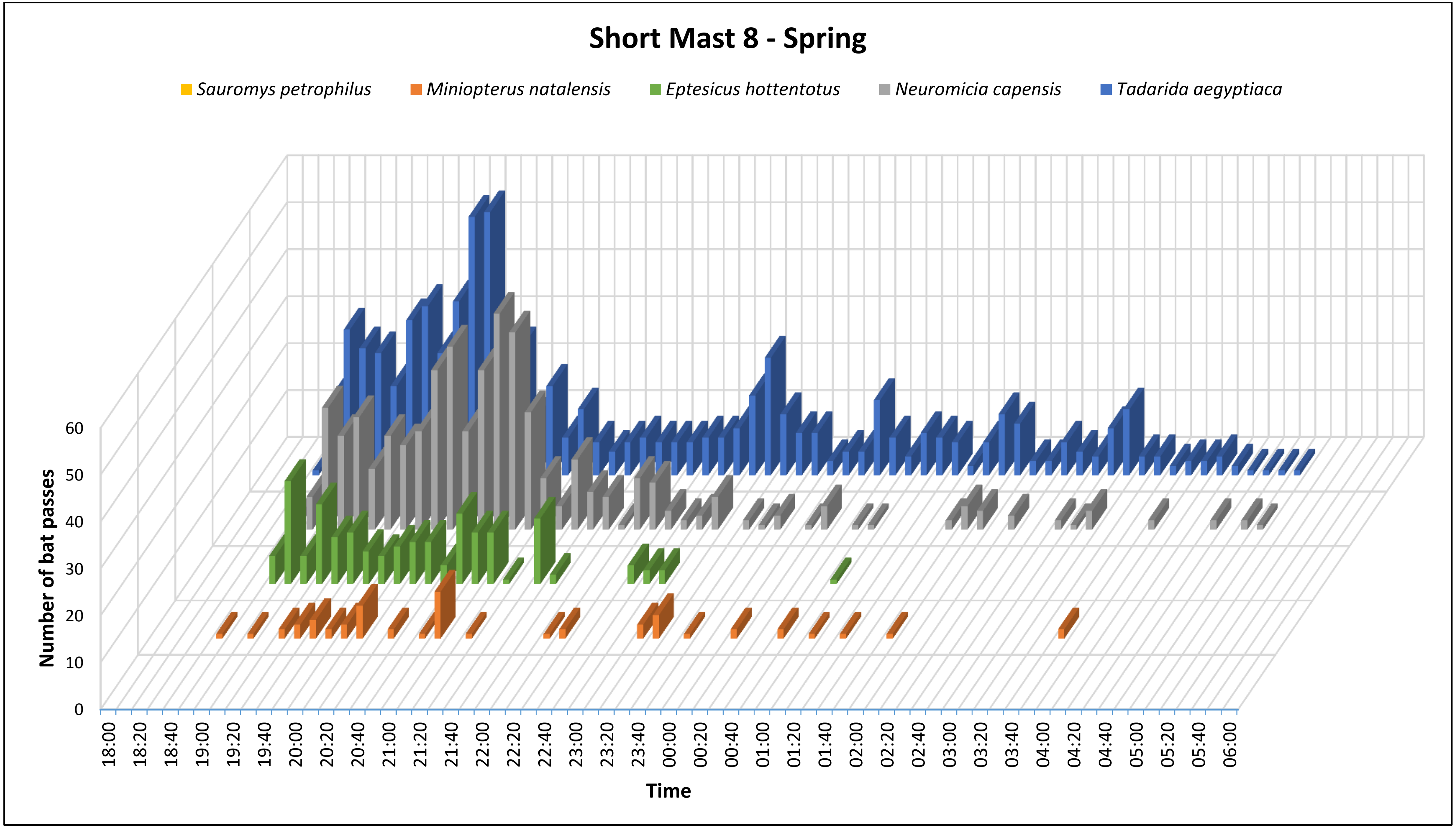


Figure 38: Temporal distribution of activity across the night as detected by Short mast 8 in spring.

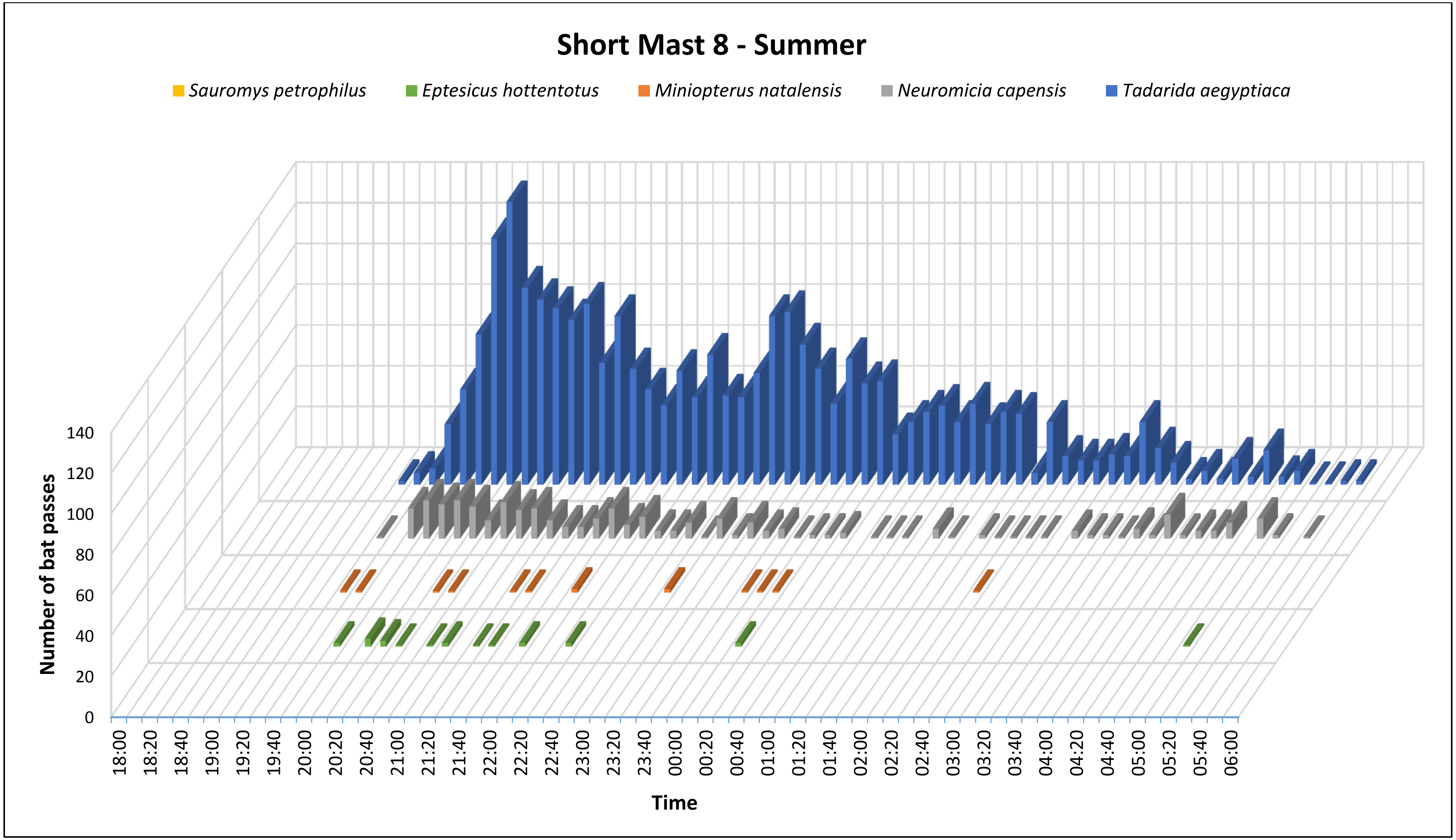


Figure 39: Temporal distribution of activity across the night as detected by Short mast 8 in summer.

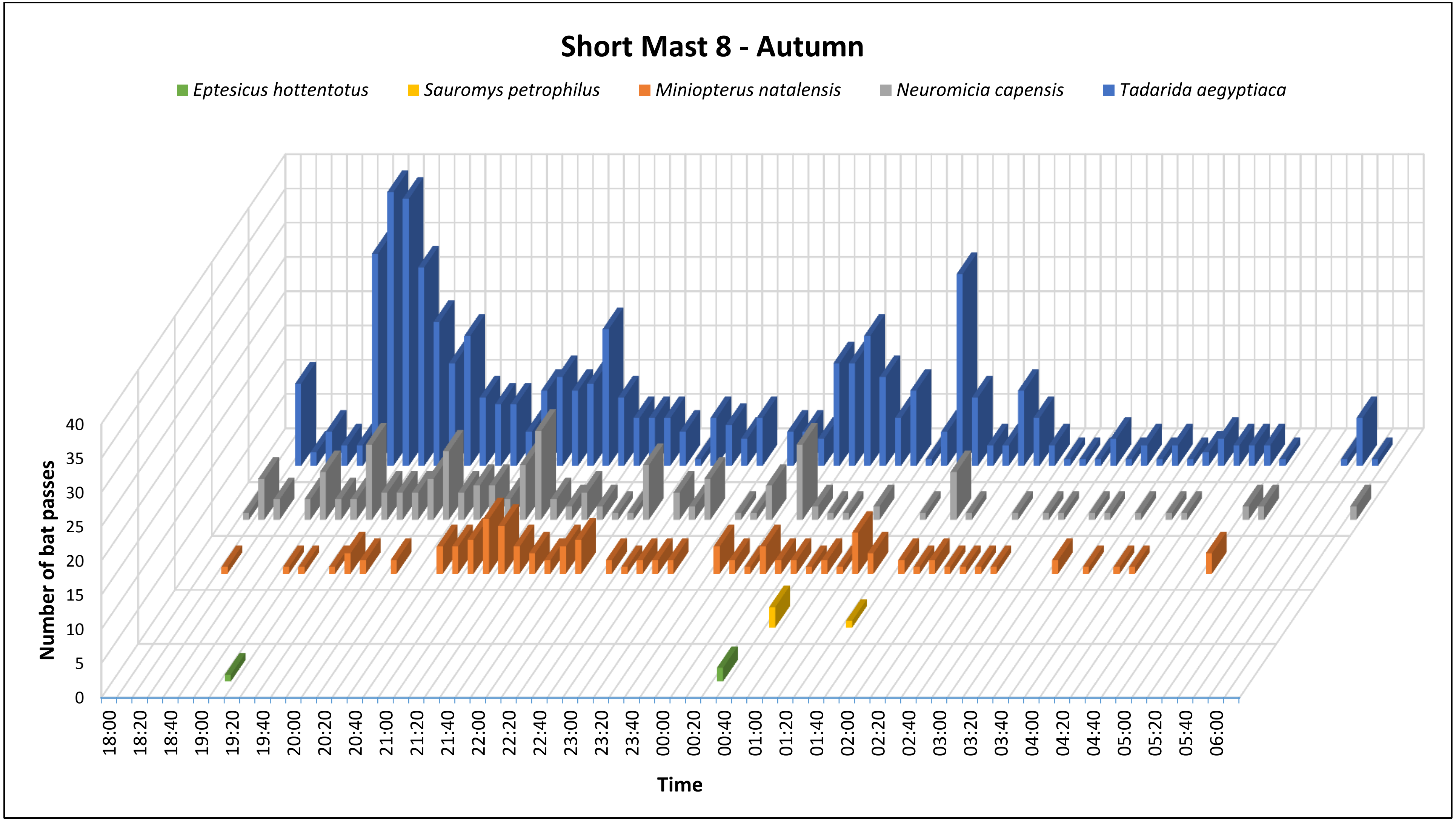


Figure 40: Temporal distribution of activity across the night as detected by Short mast 8 in autumn.

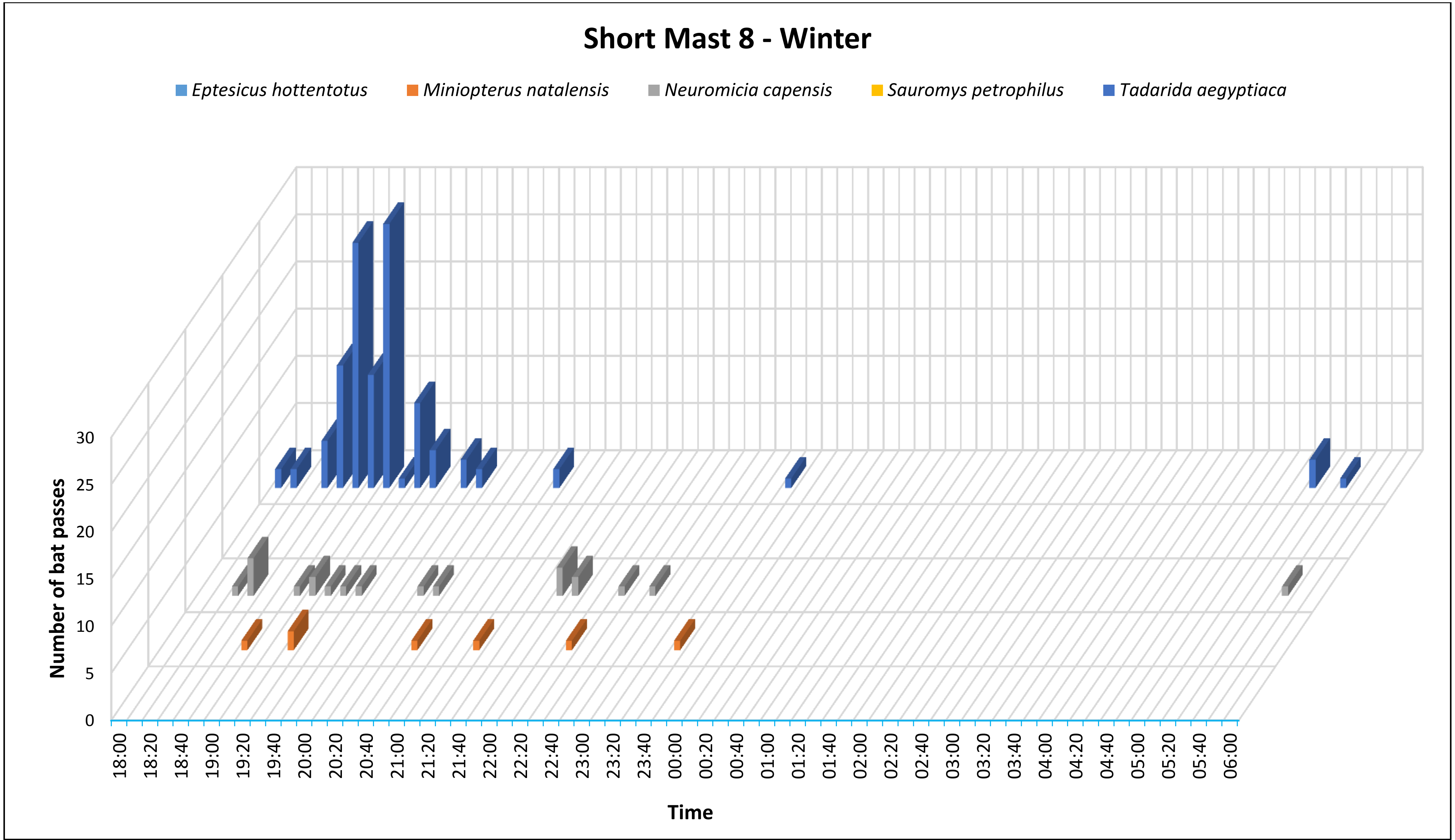


Figure 41: Temporal distribution of activity across the night as detected by Short mast 8 in winter.

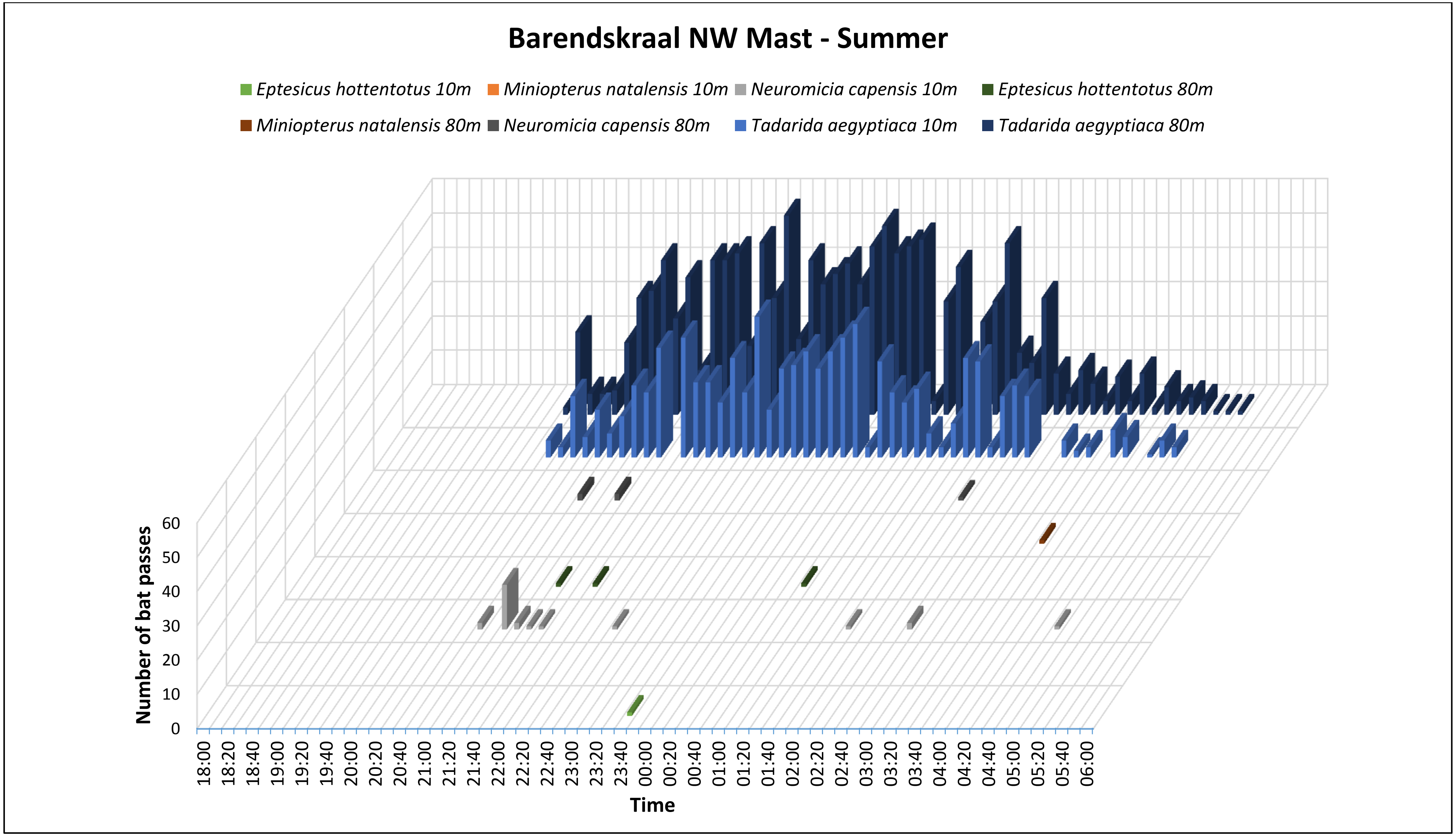


Figure 42: Temporal distribution of activity across the night as detected by Barendskraal Met mast in summer.

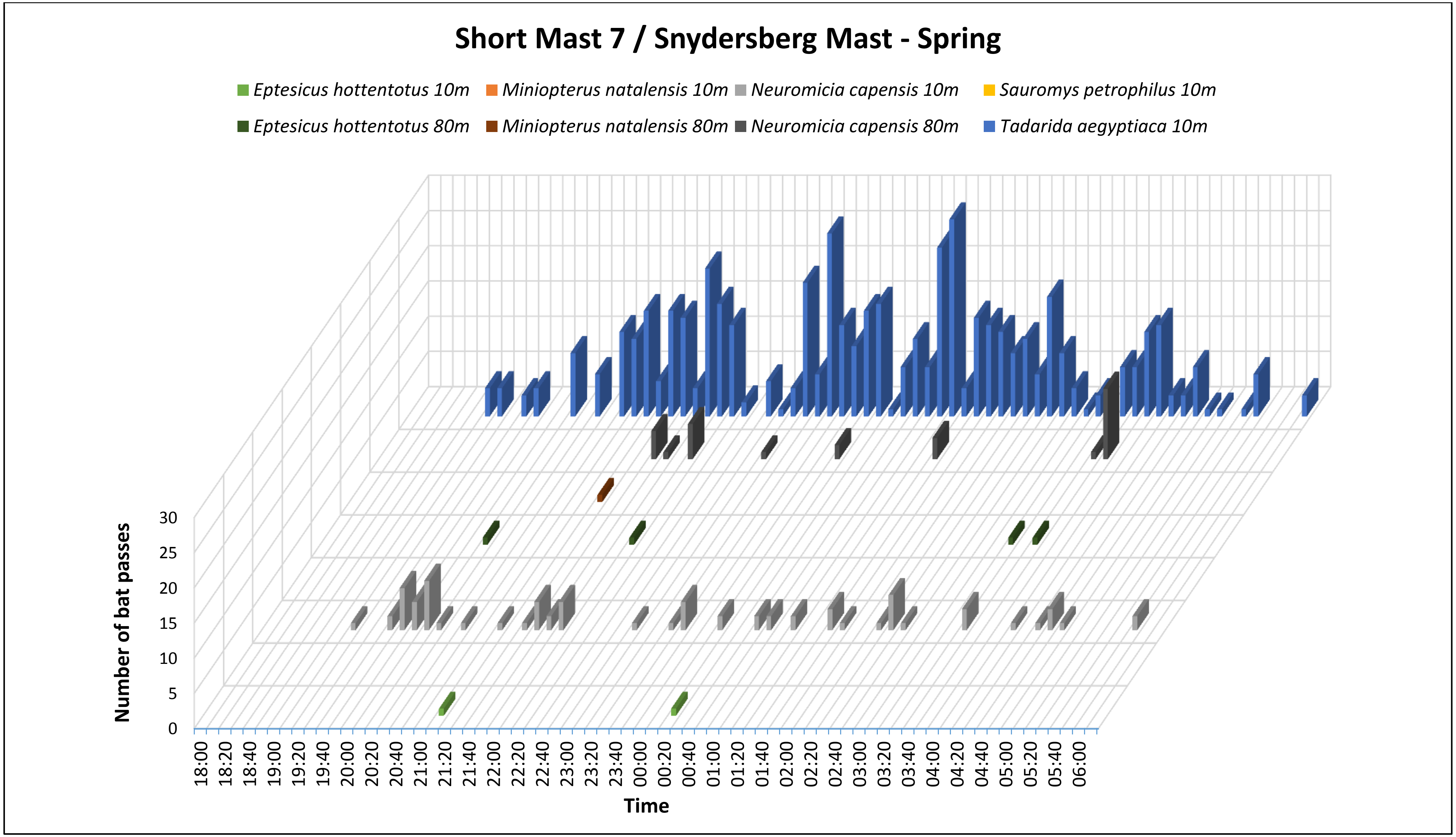


Figure 43: Temporal distribution of activity across the night as detected by SM7 / Snydersberg Met mast in spring.

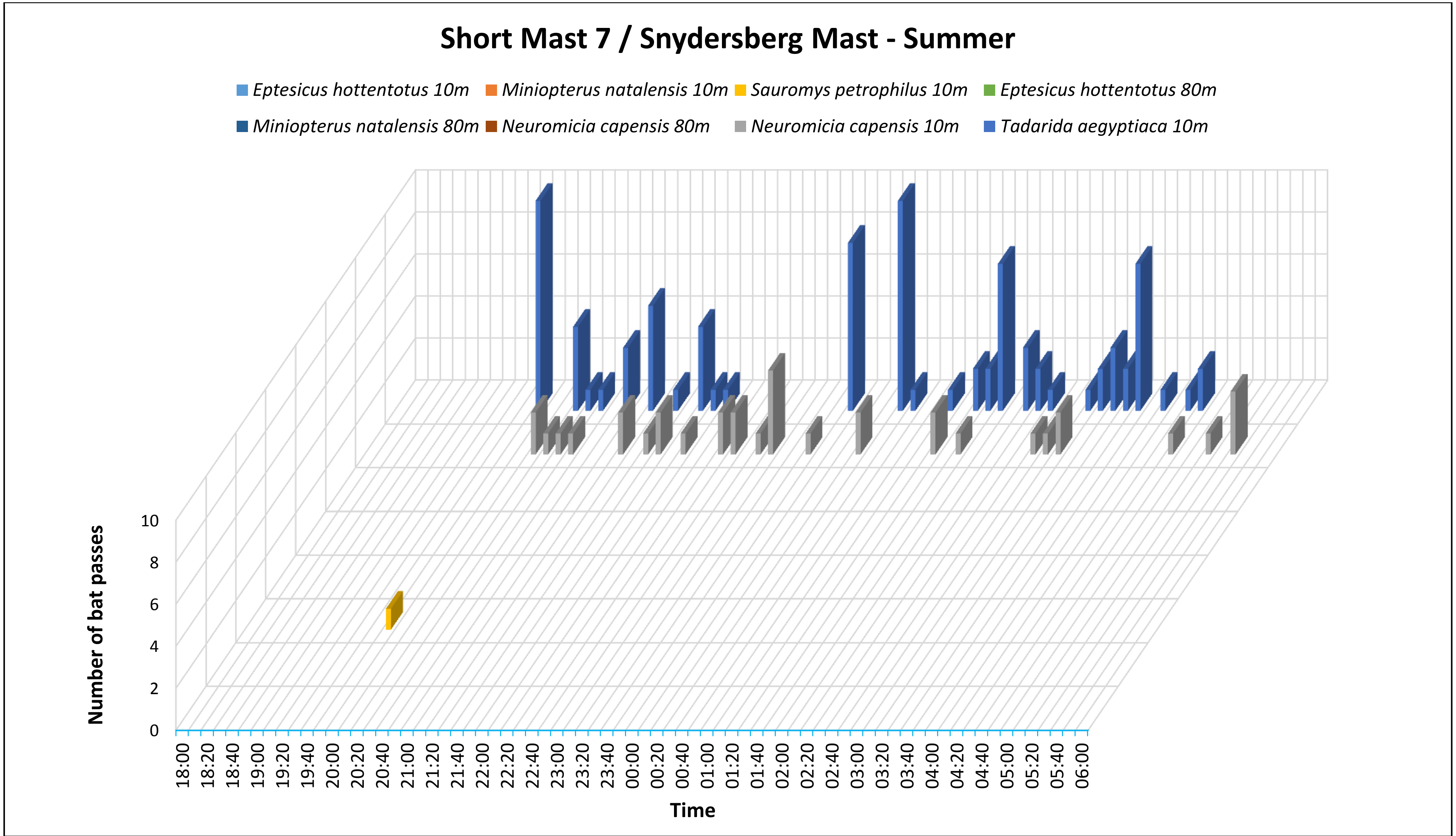


Figure 44: Temporal distribution of activity across the night as detected by SM7 / Snydersberg Met mast in summer.

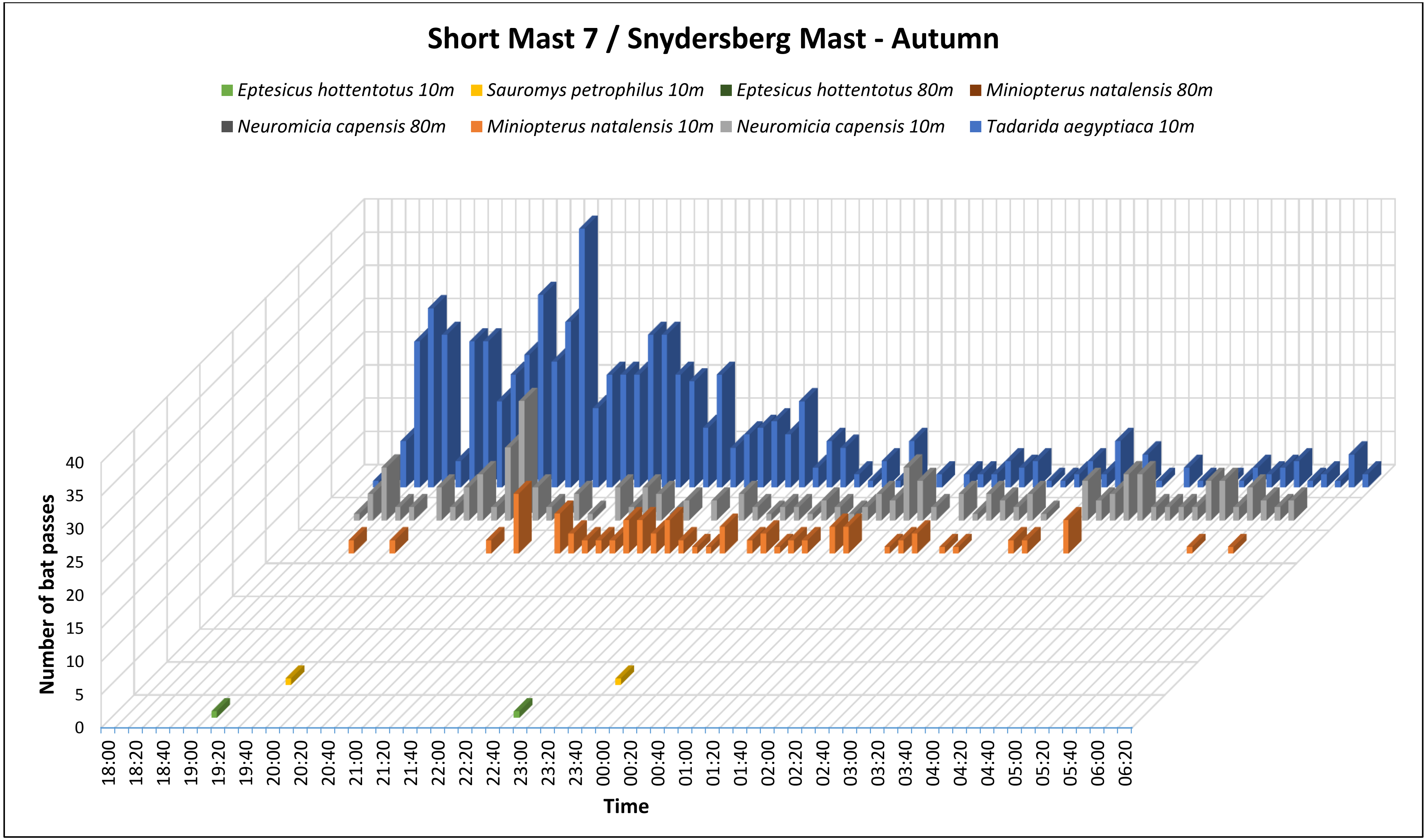


Figure 45: Temporal distribution of activity across the night as detected by SM7 / Snydersberg Met mast in autumn.

4.6.4 Relationship between Bat Activity and Weather Conditions

Several sources of literature, referred to below, describe how numerous bat species are influenced by weather conditions. Weather may influence bats in terms of lowering activity, changing time of emergence and flight time. It is also important to understand that environmental factors are never isolated and therefore a combination of the environmental factors can have synergistic or otherwise contradictory influences on bat activity. For instance, a combination of high temperatures and low wind speeds will be more favourable to bat activity than low temperatures and low wind speed, whereas low temperature and high wind speed will be the least favourable for bats. Below are short descriptions of how wind speed and temperature influence bat activity.

Wind speed

Some bat species show reduced activity in windy conditions. Strong winds have been found to suppress flight activity in bats by making flight difficult (O'Farrell *et al.,* 1967). Several studies at proposed and operating wind facilities in the United States have documented discernibly lower bat activity during 'high' (usually > 6.0 m/s) wind speeds (Arnett *et al*., 2010).

Wind speed and direction also affects availability of insect prey as insects on the wing often accumulate on the lee side of wind breaks such as tree lines (Peng *et al.,* 1992). So at edges exposed to wind, flight activity of insects, and thus bats may be suppressed and at edges to the lee side of wind, bat activity may be greater. However, the turbine localities are situated on the ridges of the site such that they will be in areas exposed to the wind and not protected by vegetation or structure.

Temperature

Flight activity of bats generally increases with temperature. Flights are of shorter duration on cooler nights and extended on warmer nights.

Rachwald (1992) noted that distinct peaks of activity disappeared in warm weather such that activity was mostly continuous through the night. During nights of low temperatures bats intensified foraging shortly after sunset (Corbet and Harris, 1991).

Peng (1991) found that many families of aerial dipteran insects preferred warm conditions for flight. A preference among insects for warm conditions has been reported by many authors suggesting that temperature is an important regulator of bat activity, through its effects on insect prey availability.

The results below present figures of the sum of bat passes that were detected within specific wind speed and temperature categories. However, the distribution of bat activity within each wind speed and temperature range may be biased due to the frequency of occurrence of each wind speed and temperature range. Thus the number of bat passes were 'normalised' wherein the frequency with which each wind speed and temperature range were recorded was taken into account. The 'normalised' sum of bat passes per wind speed and temperature range are presented below. Cumulative percentages of the normalised sum of bat passes per wind speed and temperature ranges are also presented. The lowest wind speed at which 80% of bats were detected (of the normalised sum of bat passes) are used to inform mitigation.

The aim of this analysis is to determine the wind speed and temperature range within which 80% of bat passes are detected. Ultimately these values of wind speed and temperature will be used to mitigate turbine operation where needed based on conserving 80% of detected bat passes, keeping in mind the synergistic or otherwise contradictory effects that the combination of wind speeds and temperatures can have on bat activity.

Time periods used in the analysis below for each monitoring system were identified in Sections 4.6.3 and 4.6.4 as periods of elevated activity. The analysis was not performed for time frames of lower activity levels. The time periods used in the analysis below corresponds with the time periods and systems used to inform mitigation in Section 6:

SM4

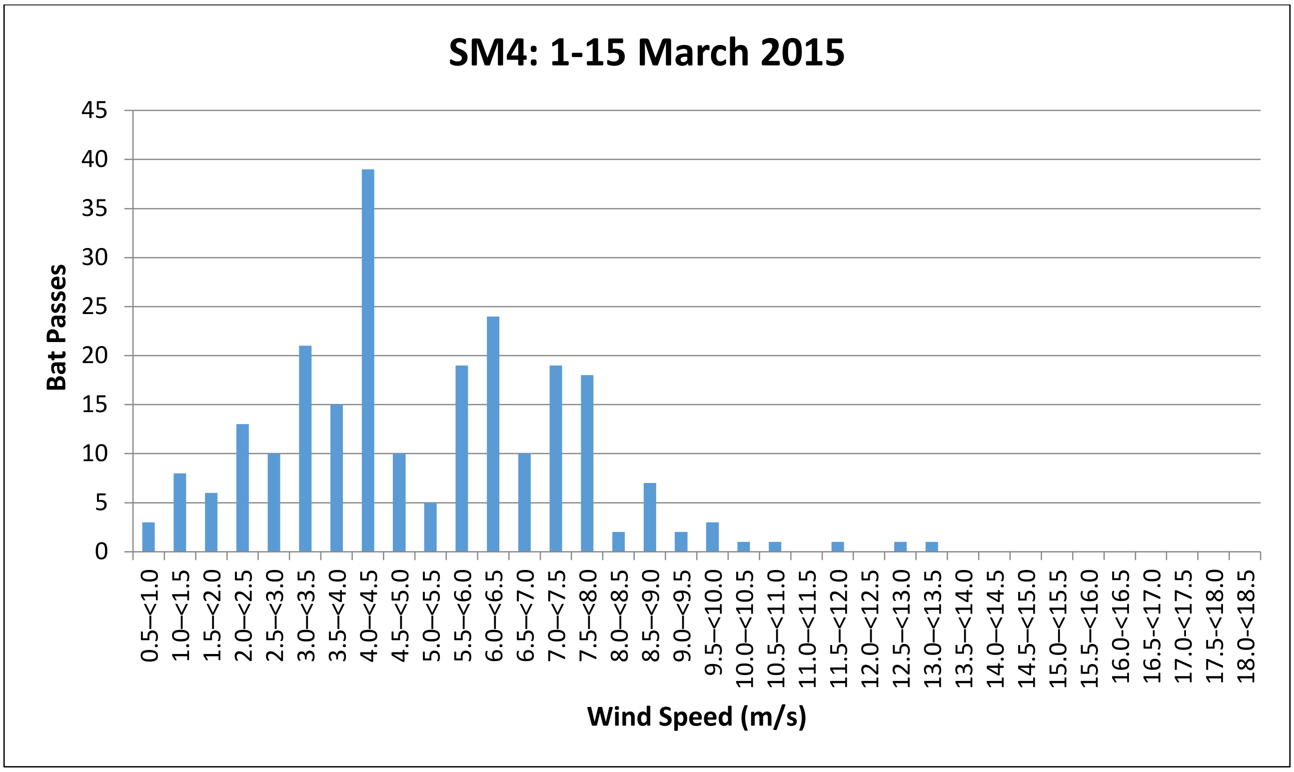
- 1 - 15 March 2015

Snydersberg

- The month of October

Barendskraal NW

- 1 December 2015 - 10 January 2016



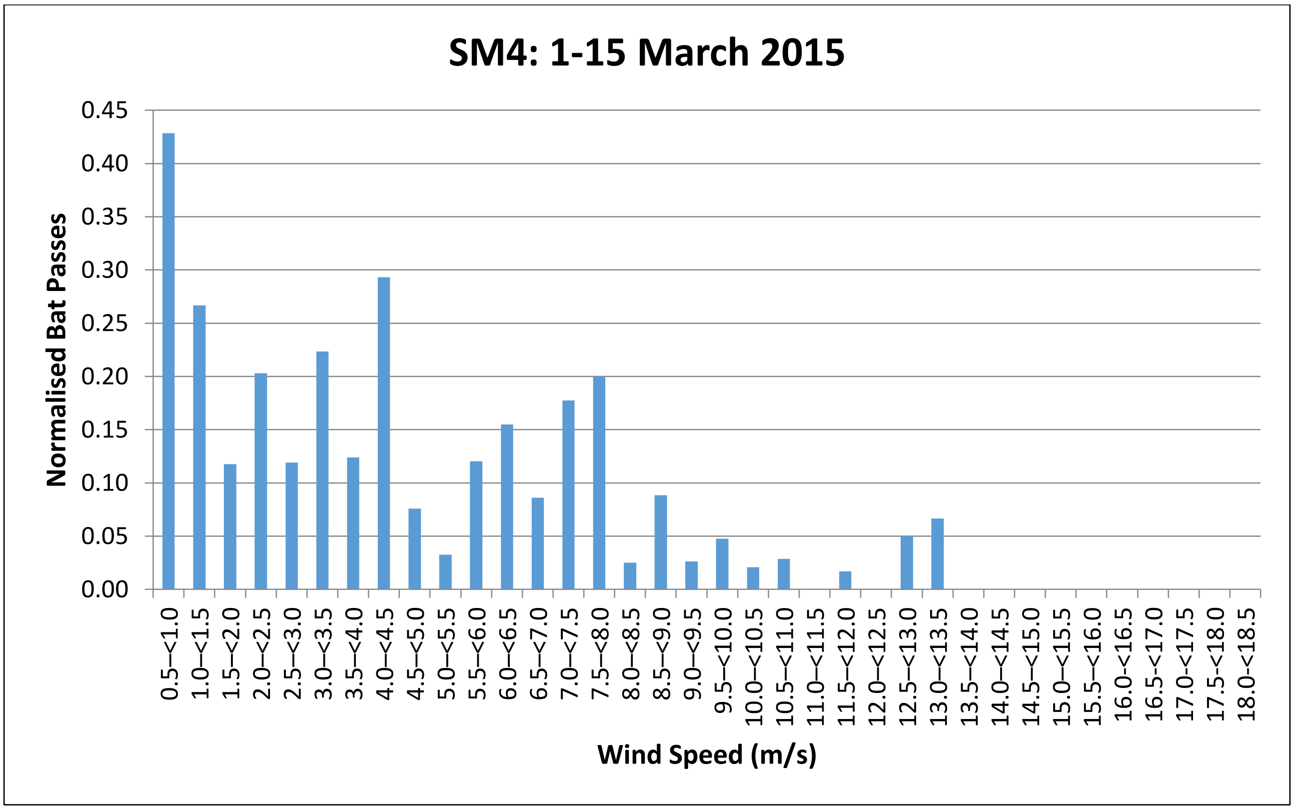


Figure 46: Sum of bat passes (top) and normalised passes (bottom) per wind speed category for SM4.

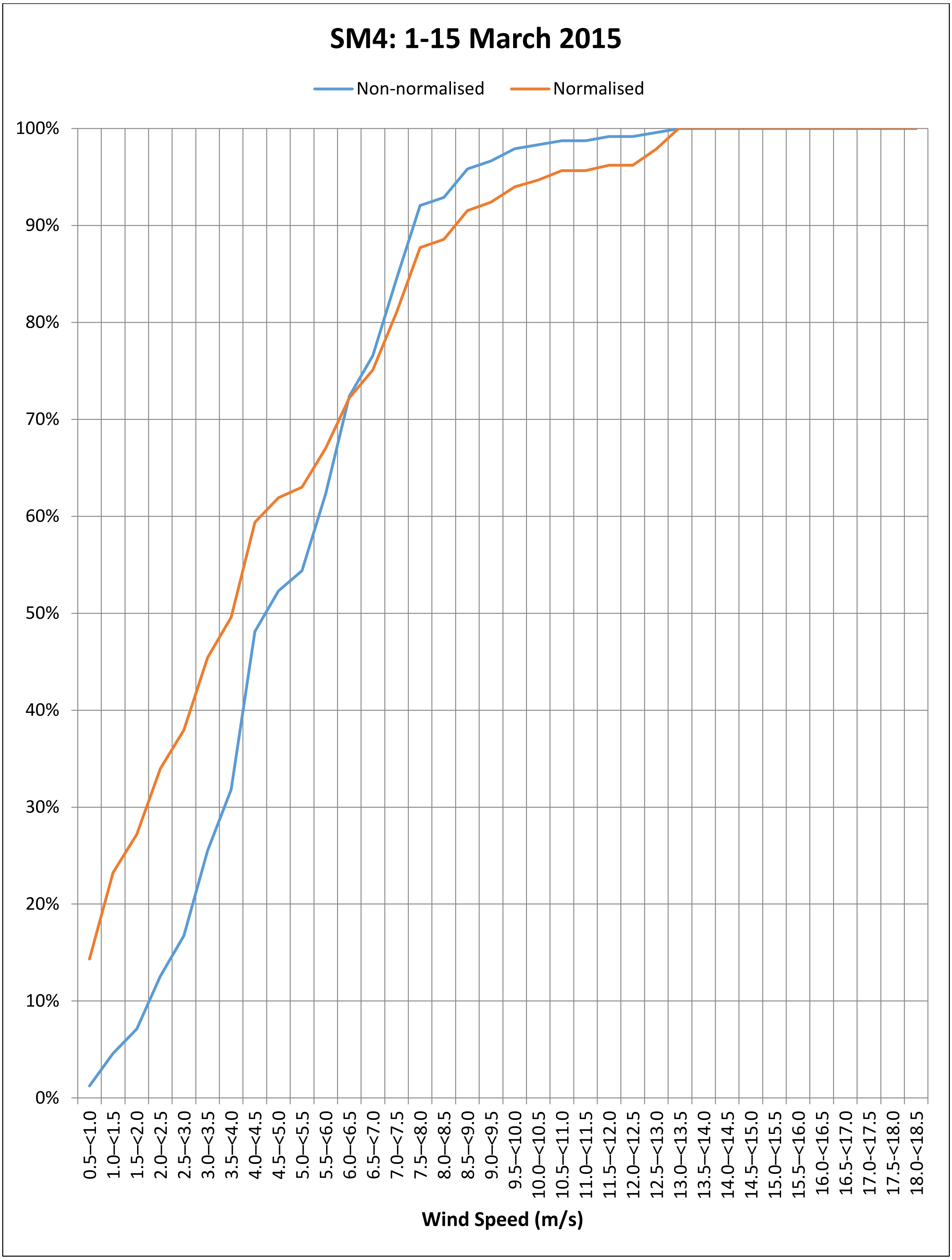


Figure 47: Cumulative percentage of normalised and non-normalised bat passes per wind speed category for SM4.

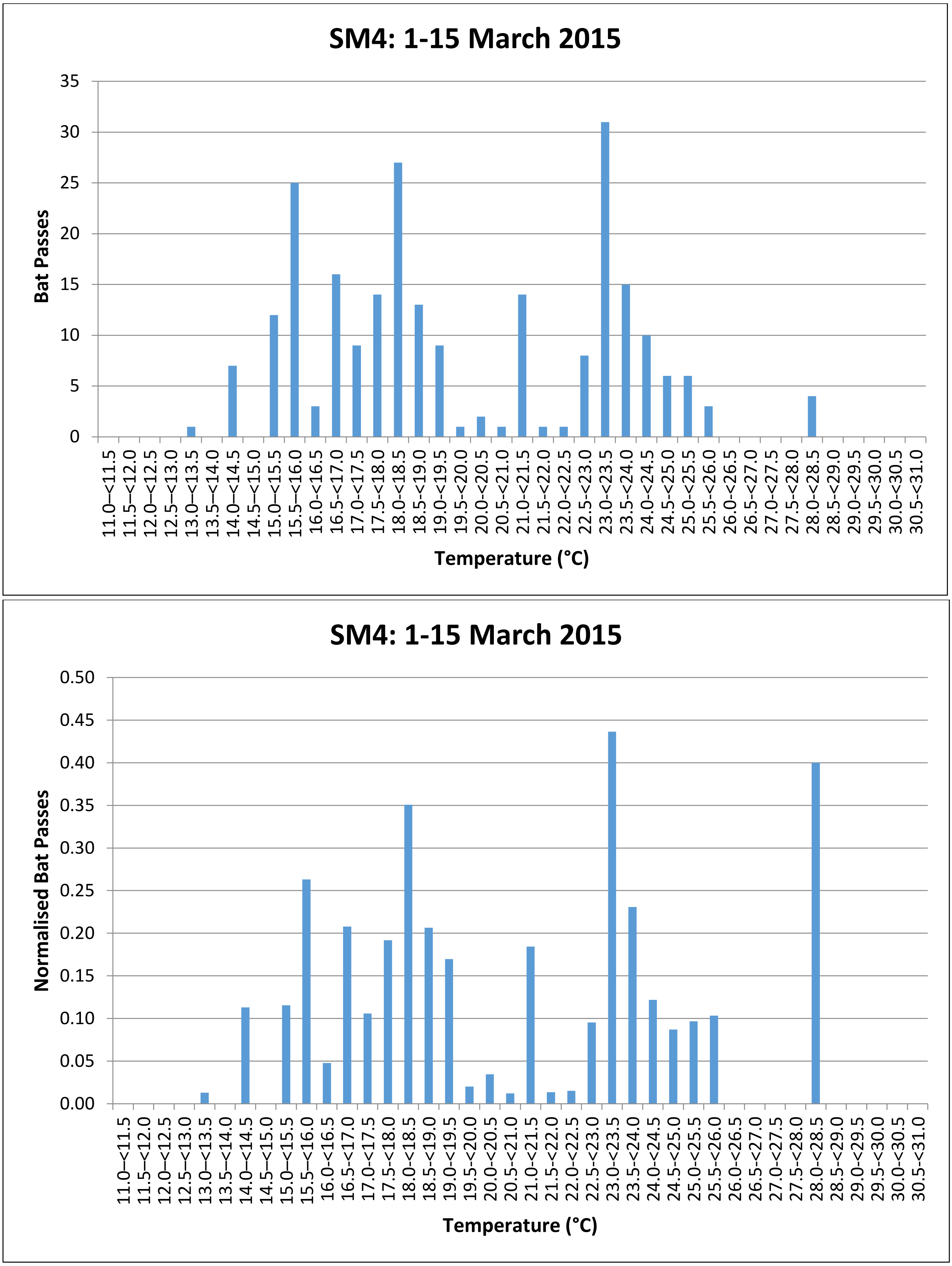


Figure 48: Sum of bat passes (top) and normalised passes (bottom) per temperature category for SM4.

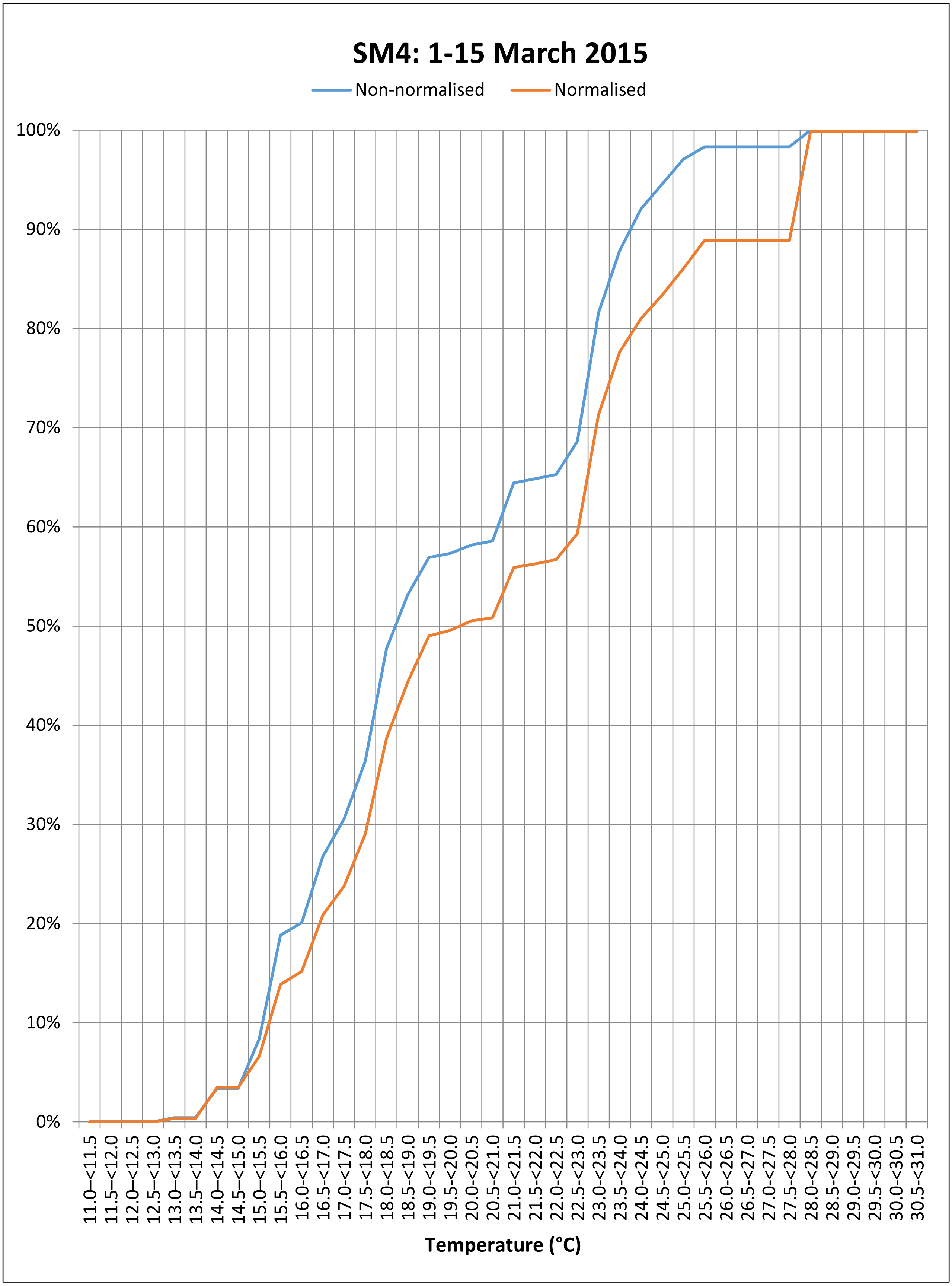
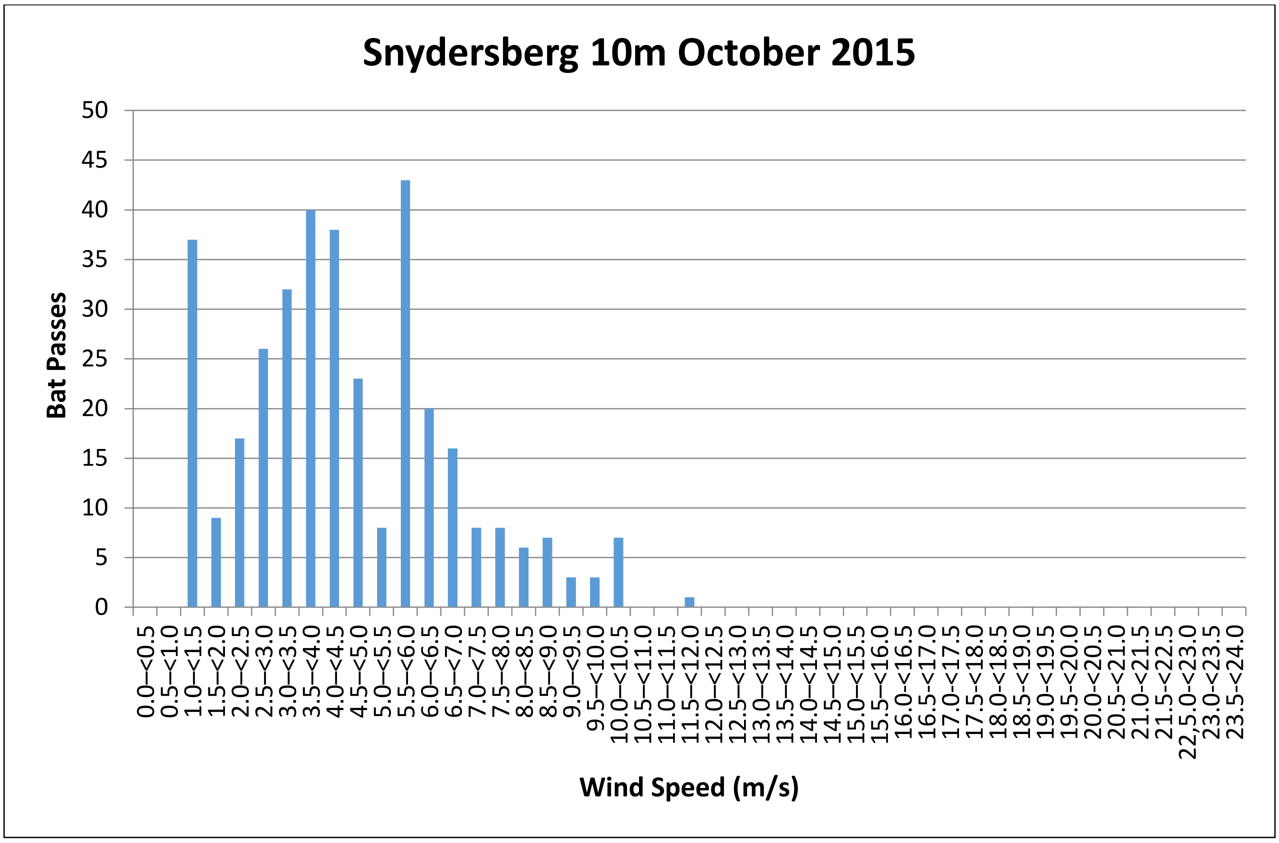


Figure 49: Cumulative percentage of normalised and non-normalised bat passes per temperature category for MS4.



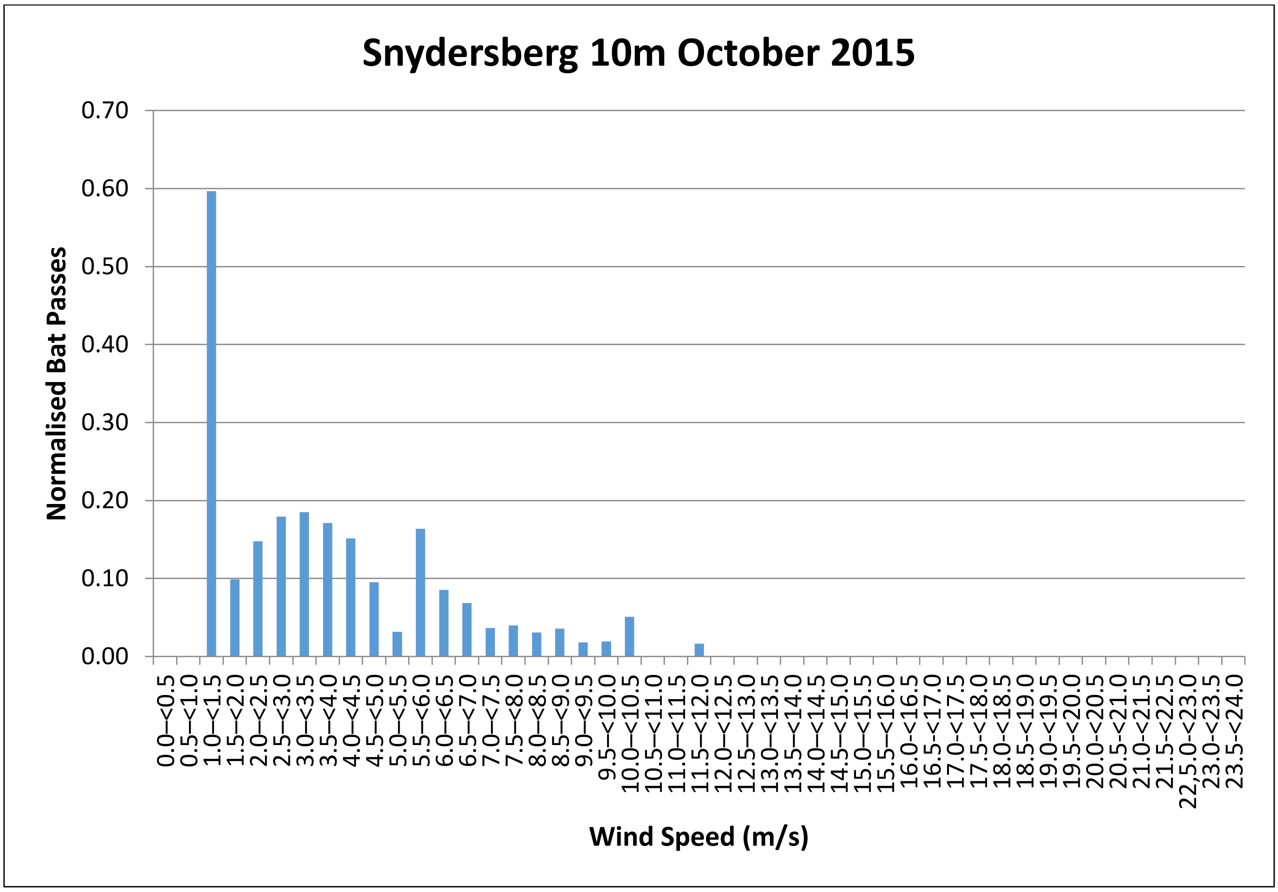


Figure 50: Sum of bat passes (top) and normalised passes (bottom) per wind speed category for Snydersberg Met Mast.

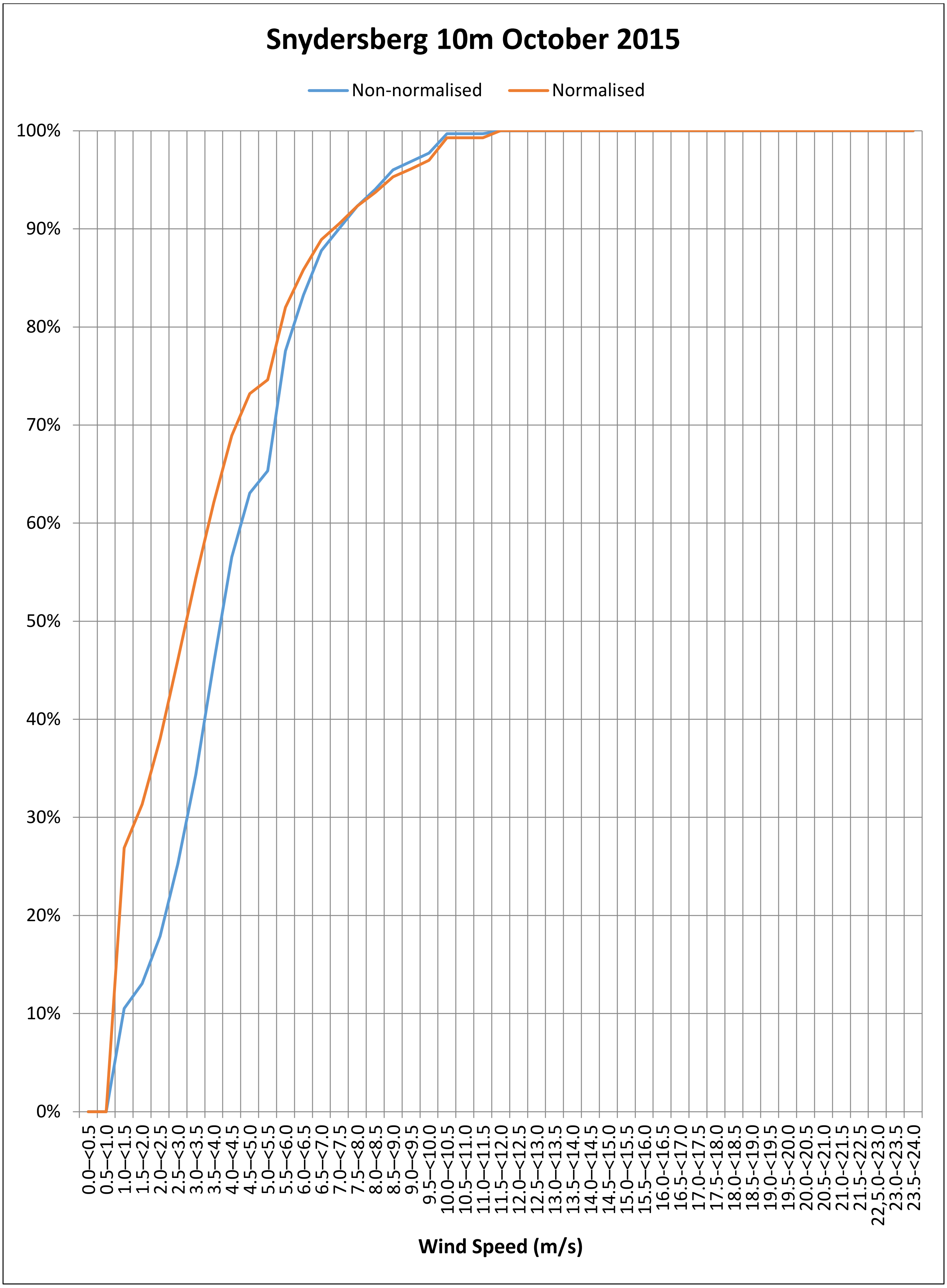
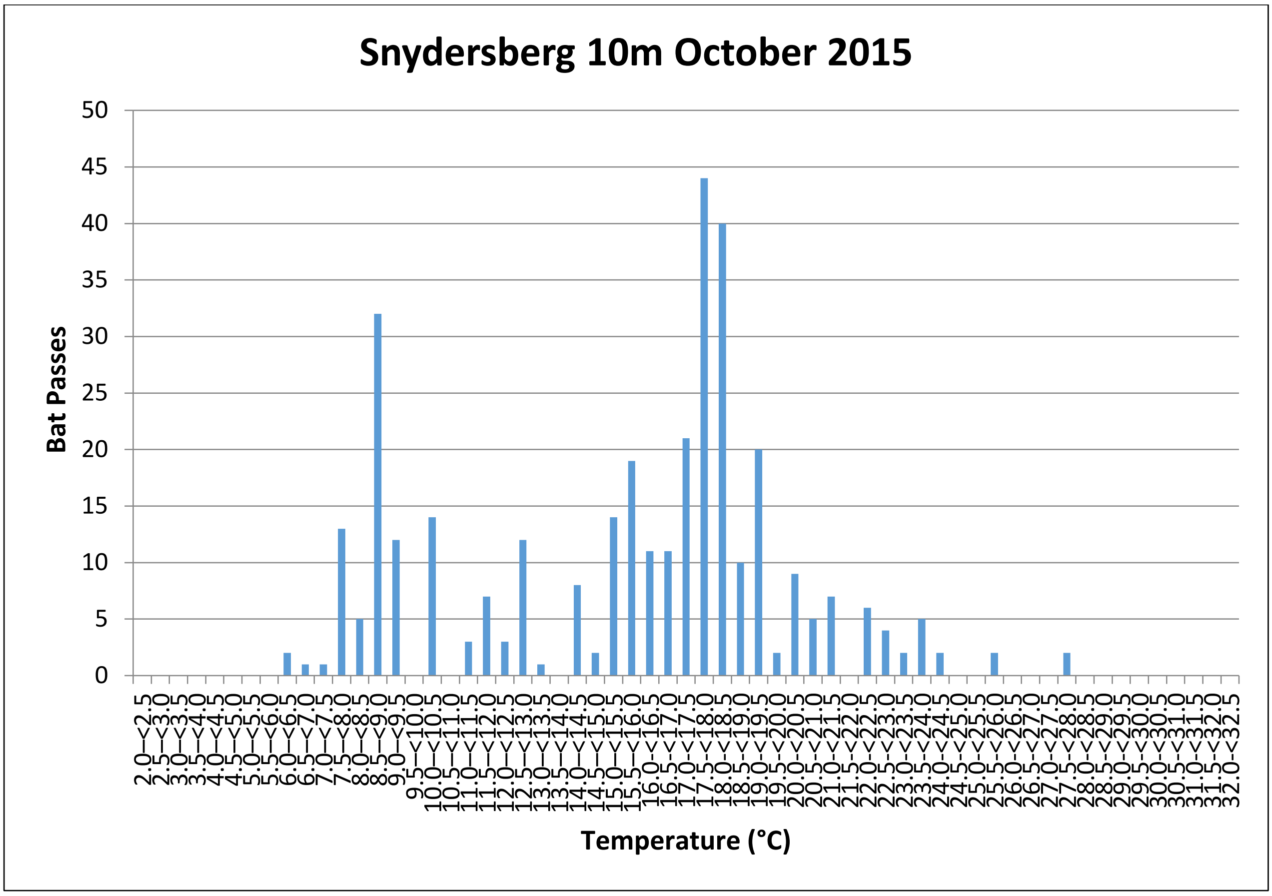


Figure 51: Cumulative percentage of normalised and non-normalised bat passes per wind speed category for Snydersberg Met Mast.



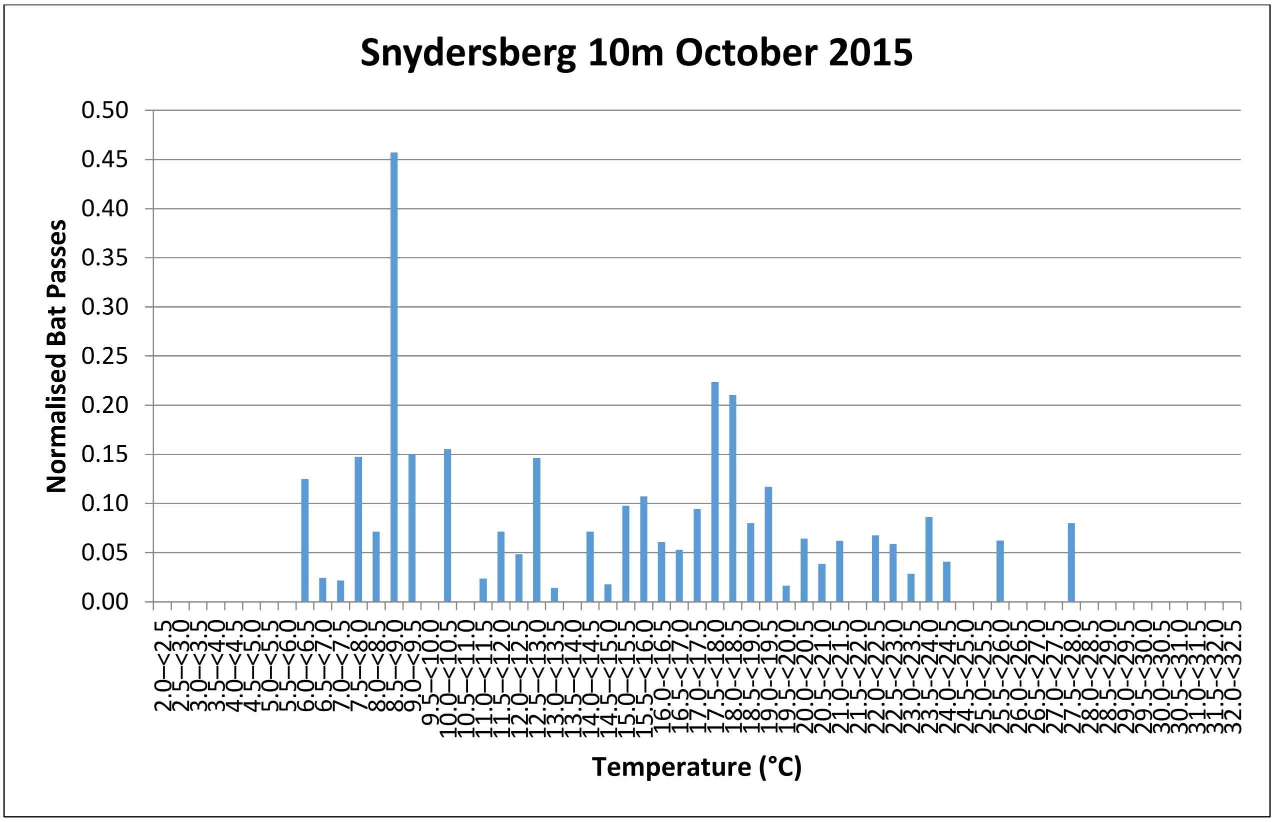


Figure 52: Sum of bat passes (top) and normalised passes (bottom) per temperature category for Snydersberg Met Mast.

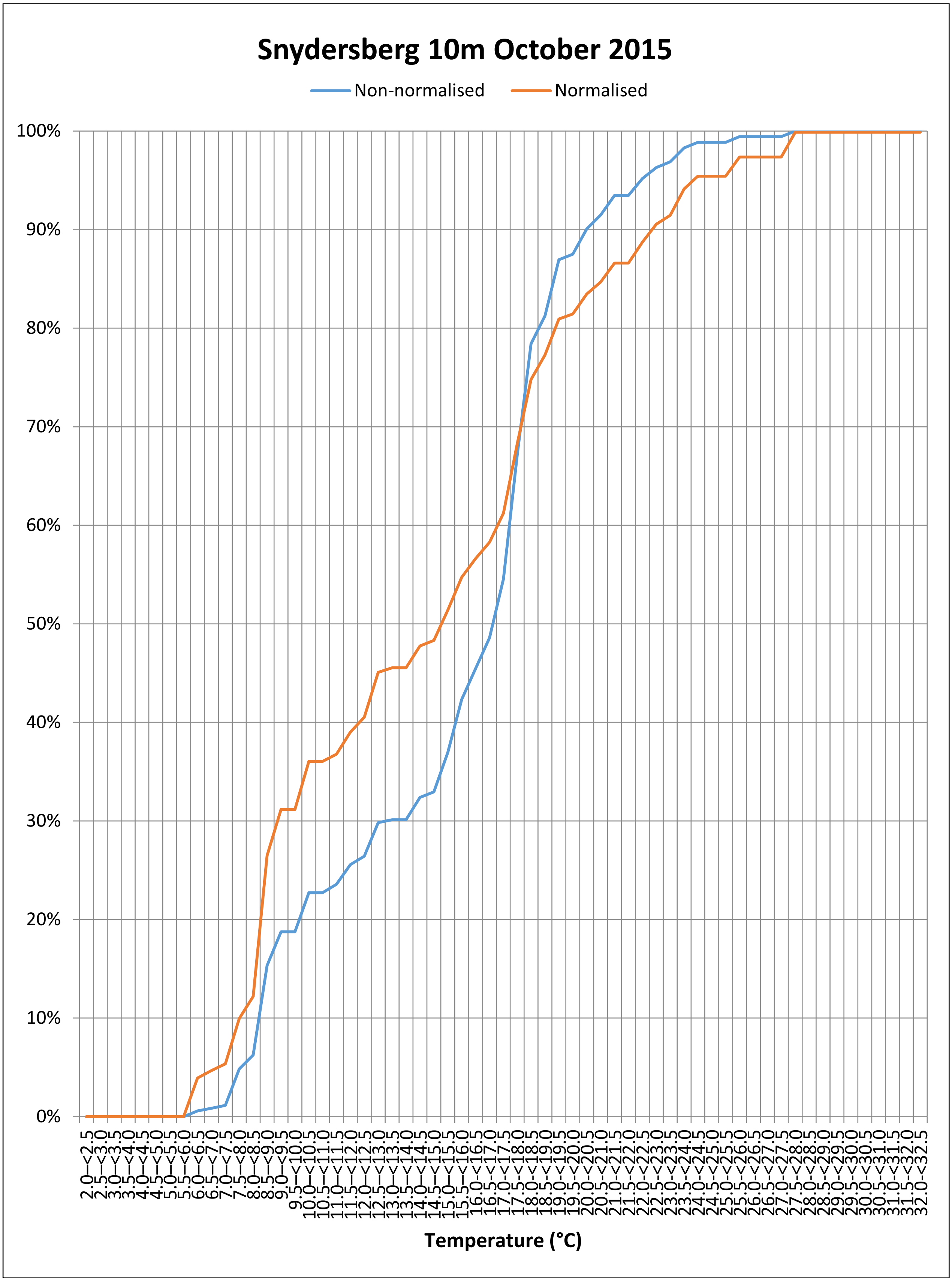
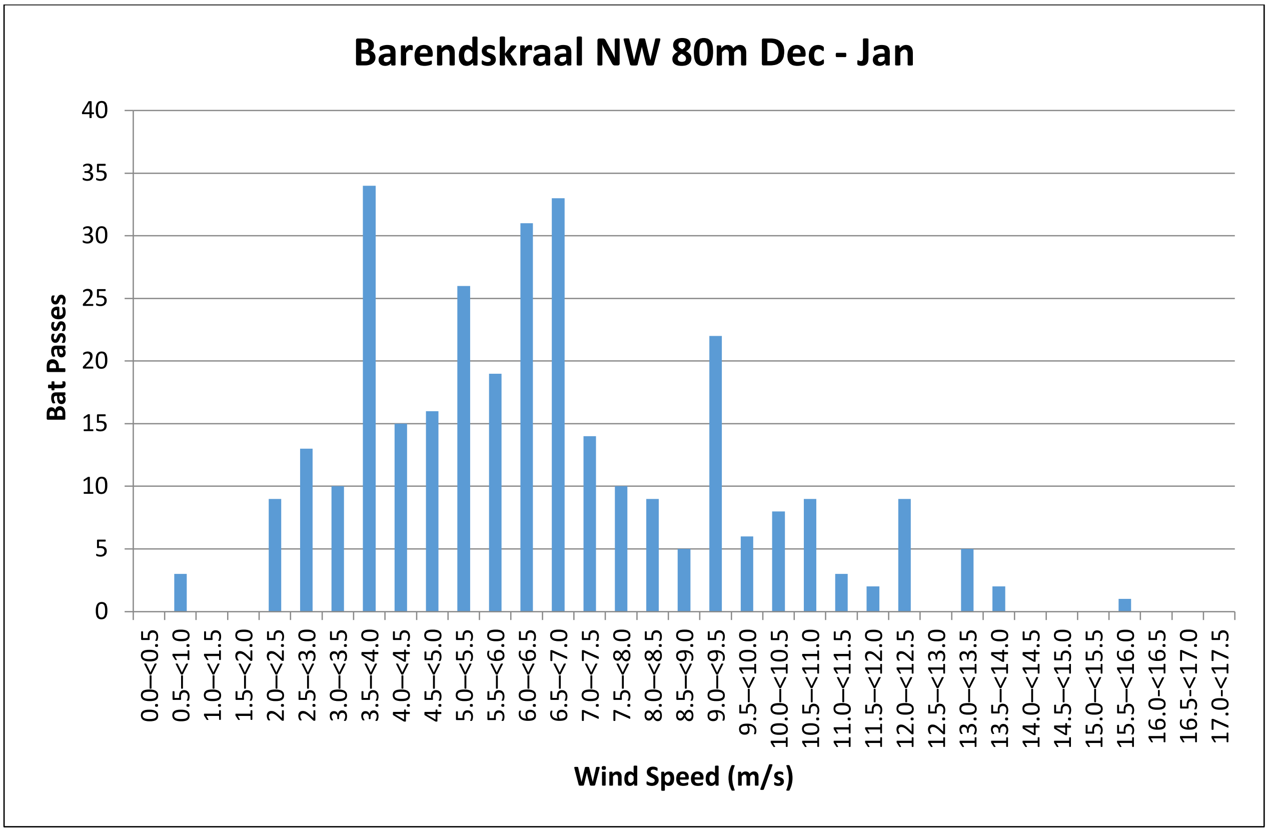


Figure 53: Cumulative percentage of normalised and non-normalised bat passes per temperature category Snydersberg Met Mast.



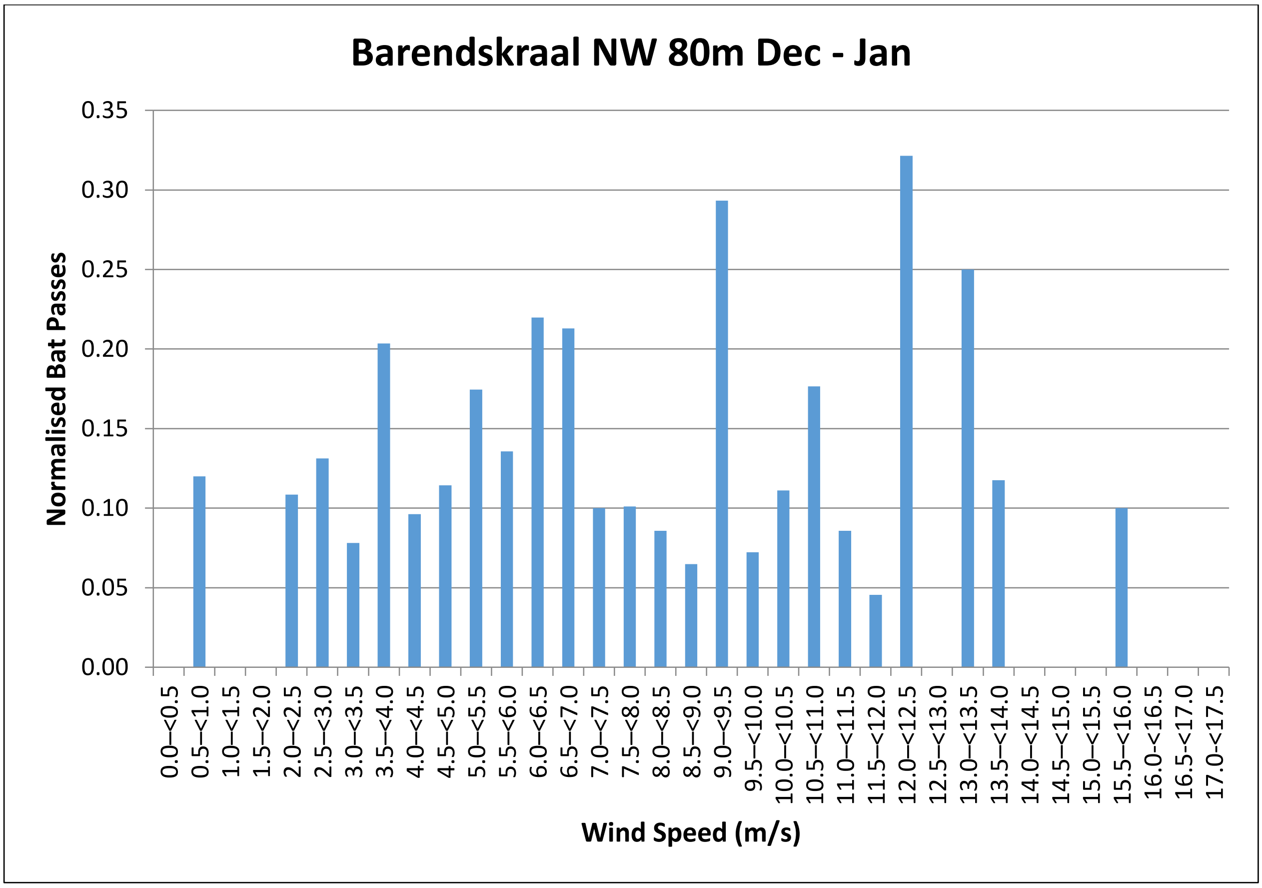


Figure 54: Sum of bat passes (top) and normalised passes (bottom) per wind speed category for Barendskraal NW Met Mast.

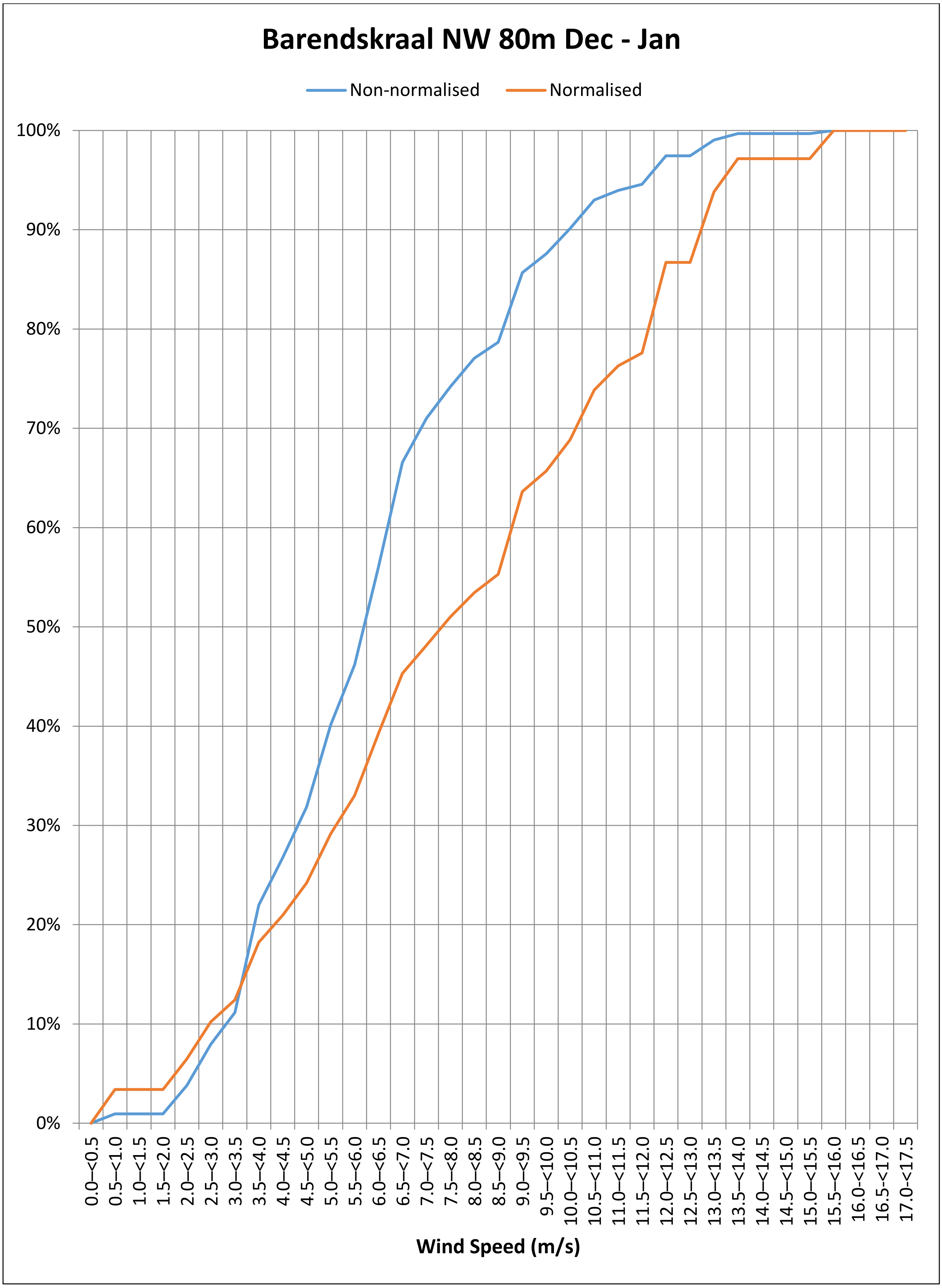
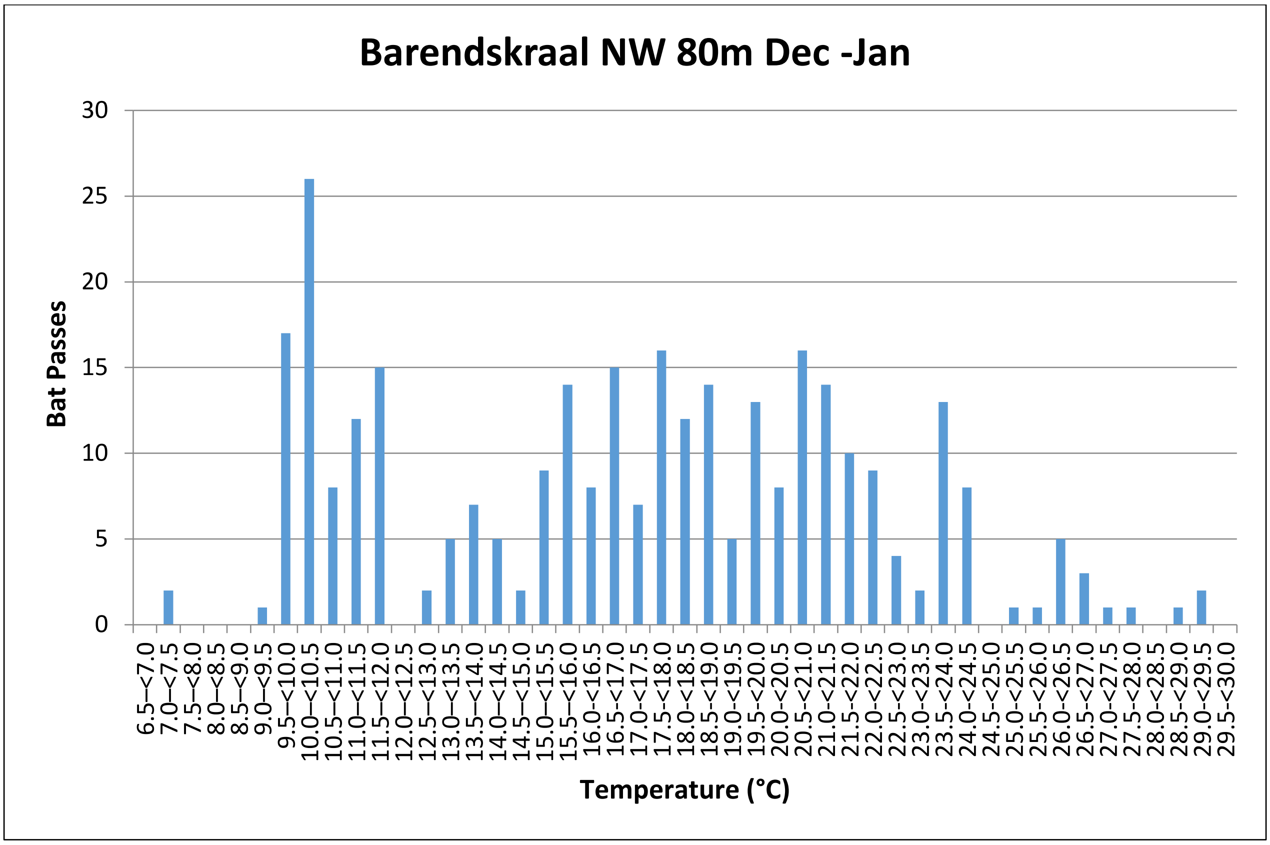


Figure 55: Cumulative percentage of normalised and non-normalised bat passes per wind speed category for Barendskraal NW Met Mast.



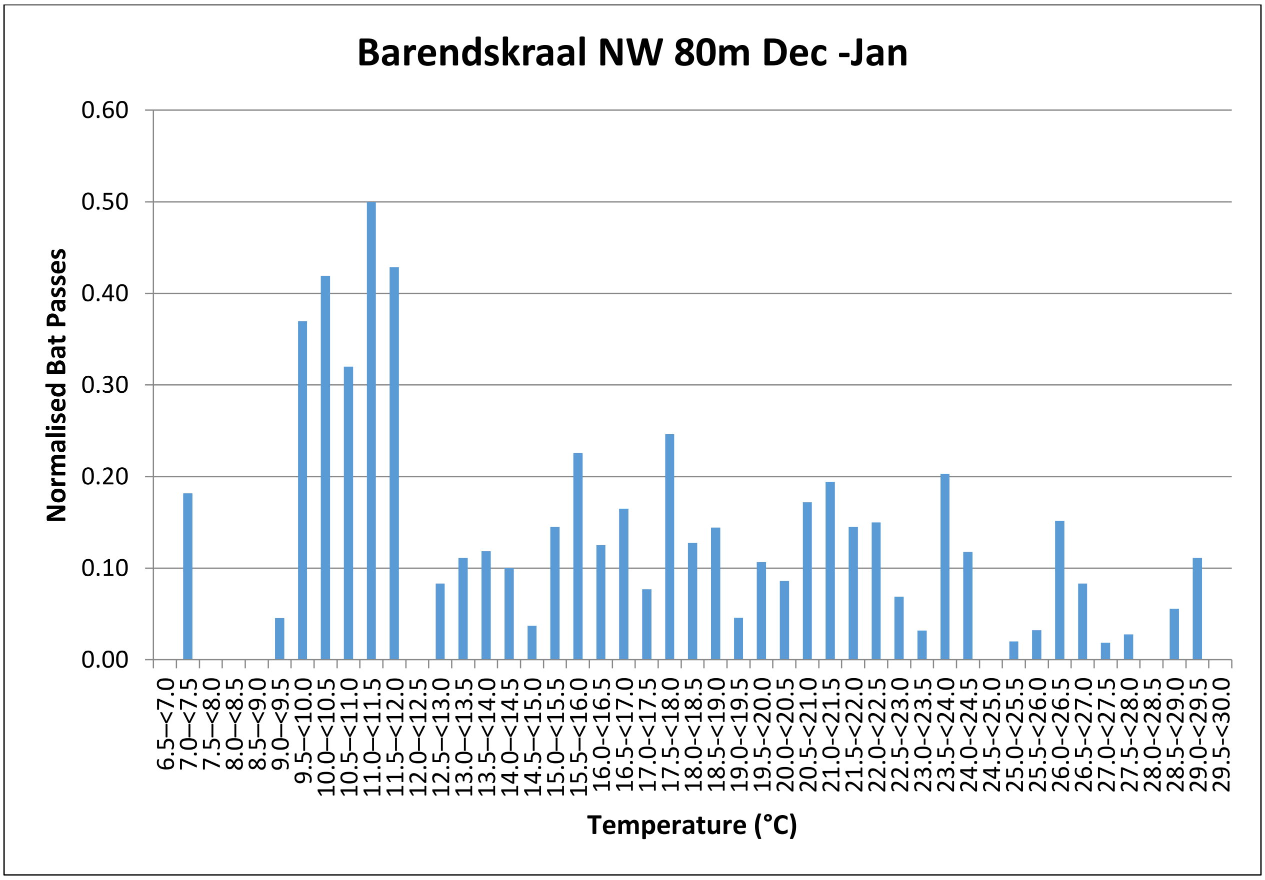


Figure 56: Sum of bat passes (top) and normalised passes (bottom) per temperature category for Barendskraal NW Met Mast.

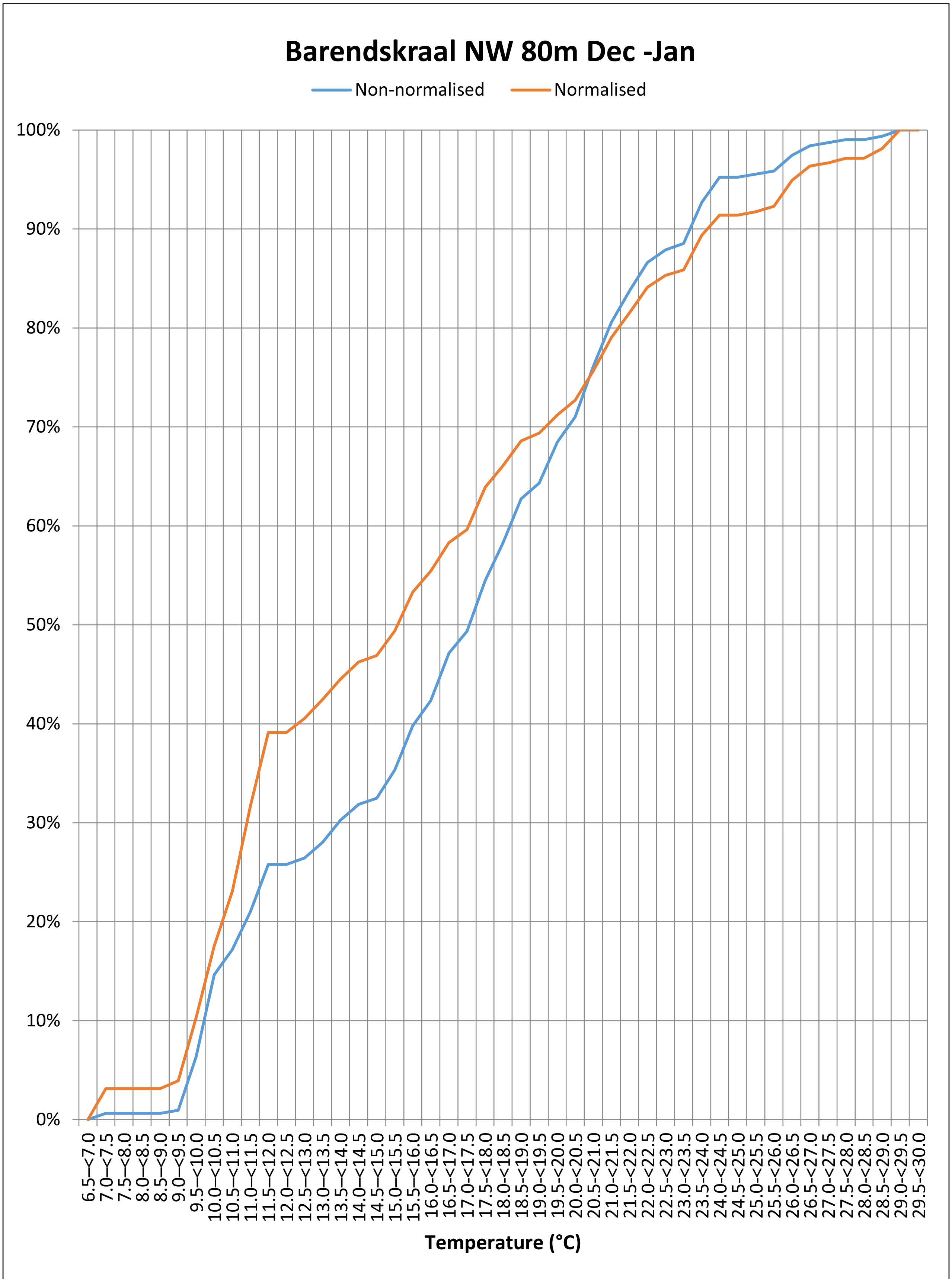


Figure 57: Cumulative percentage of normalised and non-normalised bat passes per temperature category for Barendskraal NW Met Mast.

5 IMPACT ASSESSMENT OF PROPOSED WEF ON BAT FAUNA

5.1 Construction phase

5.1.1 Impact: Destruction of bat roosts due to earthworks and blasting

Cause and comment:

During construction, the earthworks and especially blasting can damage bat roosts in rock crevices. Intense blasting close to a rock crevice roost, if applicable, can cause mortality to the inhabitants of the roost.

Mitigation measures:

Adhere to the sensitivity map during turbine placement. Blasting should be minimised and used only when necessary.

Significance statement table:

Impact	Effect			Risk or Likelihood	Overall significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Short term	Localised	Severe	Probable	(9) Moderate -
With Mitigation	Short term	Localised	Moderate	May Occur	(6) Low -

5.1.2 Impact: Loss of foraging habitat

Cause and comment:

Some minimal foraging habitat will be permanently lost by construction of turbines and access roads. Temporary foraging habitat loss will occur during construction due to storage areas and movement of heavy vehicles.

Mitigation measures:

Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or construction vehicles and keep to designated roads with all construction vehicles. Damaged areas not required after construction should be rehabilitated by an experienced vegetation succession specialist.

Significance statement table:

Impact	Effect			Risk or Likelihood	Overall significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Permanent	Localised	Slight	Probable	(9) Moderate -
With Mitigation	Permanent	Localised	Slight	May Occur	(8) Low -

5.2 Operational phase

5.2.1 Impact: Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration)

Cause and comment:

The concerns of foraging bats in relation to wind turbines is discussed in Section 2.4. If the impact is too severe (e.g. in the case of no mitigation) local bat populations may not recover from mortalities.

Mitigation measures:

See Section 6 below on mitigation options and recommendations for minimising risk of mortalities. Adhere to the sensitivity maps, apply proposed mitigations to any further layout revisions, avoid areas of High bat sensitivity and their buffers as well as preferably avoid areas of Moderate bat sensitivity and their buffers.

Significance statement table:

Impact	Effect			Risk or Likelihood	Overall significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Long term	Study area	Severe	Definite	(13) High -
With Mitigation	Long term	Study area	Slight	May Occur	(8) Low -

5.2.2 Impact: Cumulative bat mortalities due to direct blade impact or barotrauma during foraging (resident and migrating bats affected).

Cause and comment:

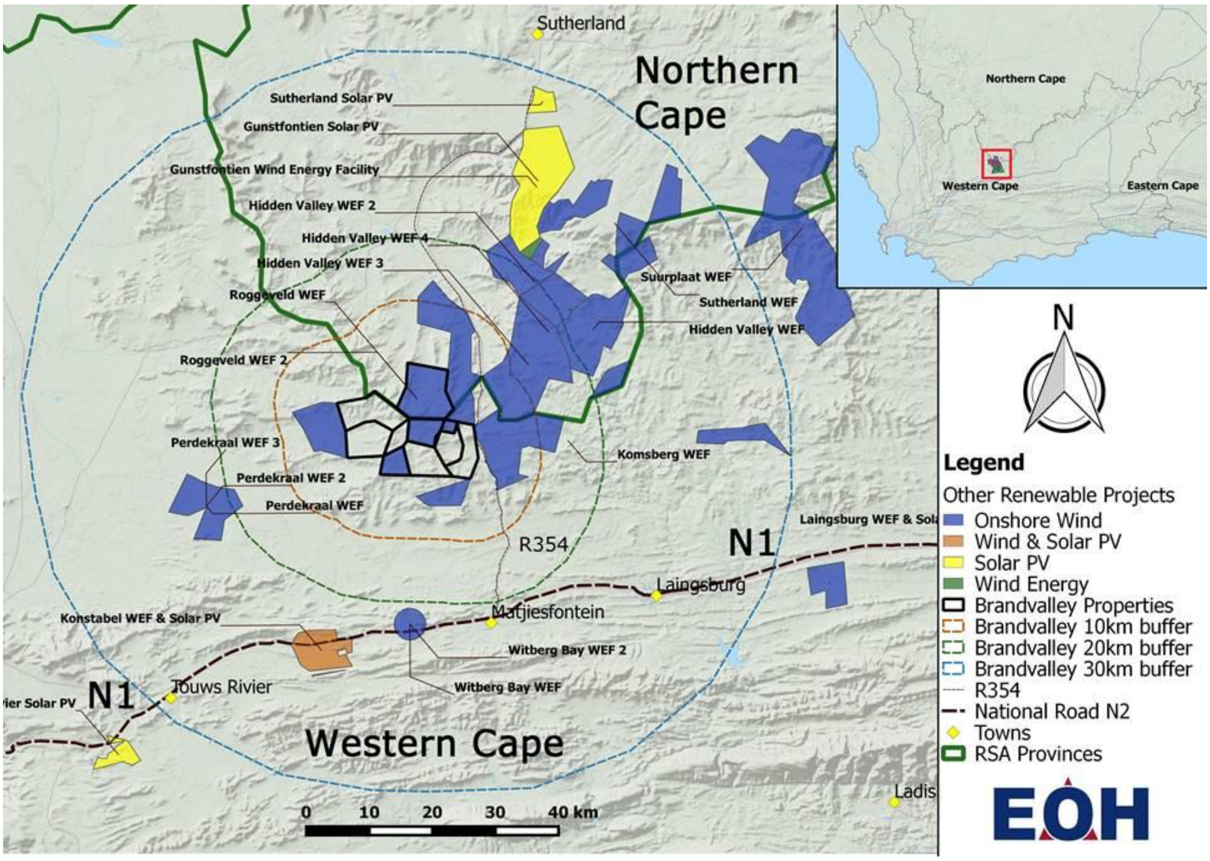


Figure 58: Proposed and approved renewable energy developments in a 10km, 20km and 30km radius of the Brandvalley site.

Mortalities of bats due to wind turbines during foraging and migration can have significant ecological consequences as the bat species at risk are insectivorous and thereby contribute significantly to the control of flying insects at night. On a project specific level insect numbers in a certain habitat can increase if significant numbers of bats are killed off. But if such an impact is present on multiple projects in close vicinity of each other, insect numbers can increase regionally and possibly cause outbreaks of colonies of certain insect species.

Additionally, if migrating bats are killed off it can have detrimental effects on the cave ecology of the caves that a specific colony utilises. This is due to the fact that bat guano is the primary form of energy input into a cave ecology system, given that no sunshine that allows photosynthesis exists in cave ecosystems.

Mitigation measures:

The High sensitivity valley areas can serve as commuting corridors for bats in the larger area, potentially lowering the cumulative effects of several WEF's in an area. Also adhere to recommended mitigation measures for this project during operation. It is essential that project specific mitigations be applied and adhered to for each project, as overarching regional mitigation measures are more complex and less feasible due to habitat and ecological differences between project sites. Adhere to the sensitivity map during any further turbine layout revisions, and preferably attempt to avoid placement of turbines in Moderate sensitivity areas, where possible.

Significance statement table:

Impact	**Effect**			**Risk or Likelihood**	**Overall significance**
	Temporal Scale	**Spatial Scale**	**Severity of Impact**		
Without Mitigation	Long term	Regional	Severe	Probable	(13) High -
With Mitigation	Long term	Regional	Moderate	May Occur	(10) Moderate -

5.2.3 Impact: Artificial lighting

Cause and comment:

During operation strong artificial lights that may be used at the turbine base or immediate surrounding infrastructure will attract insects and thereby also bats. This will significantly increase the likelihood of impact to bats foraging around such lights. Additionally, only certain species of bats will readily forage around strong lights, whereas others avoid such lights even if there is insect prey available, which can draw insect prey away from other natural areas and thereby artificially favour only certain species.

Mitigation measures:

Utilise lights with wavelengths that attract less insects (low thermal/infrared signature). If not required for safety or security purposes, lights should be switched off when not in use or equipped with passive motion sensors.

Significance statement table:

Impact	Effect			Risk or Likelihood	Overall significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Long term	Study area	Severe	Definite	(13) High -
With Mitigation	Long term	Study area	Slight	May Occur	(8) Low -

5.3 Decommissioning phase

5.3.1 Impact: Loss of foraging habitat

Cause and comment:

Some minimal foraging habitat will be temporarily lost during decommissioning of turbines and access roads. Temporary foraging habitat loss will occur due to storage areas and movement of heavy vehicles.

Mitigation measures:

Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or heavy vehicles and keep to designated roads with all heavy vehicles. Damaged areas not required after construction should be rehabilitated by an experienced vegetation succession specialist.

Significance statement table:

Impact	Effect			Risk or Likelihood	Overall significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Short term	Localised	Slight	Probable	(6) Low -
With Mitigation	Short term	Localised	Slight	May Occur	(5) Low -

6 PROPOSED INITIAL MITIGATION MEASURES AND DETAILS

The correct placement of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area, and should be considered as the preferred option for mitigation. The tables below are based on the passive data collected. They infer mitigation be applied during the peak activity periods and times, and when the advised wind speed and temperature ranges are prevailing **simultaneously** (considering conditions in which 80% of bat activity occurred).

Bat activity at 80m height is used in cases where elevated activity occurred at this height. In other cases bat activity at 10m were used, since bats are expected to move in an upwards fashion towards turbine blades (bat activity negatively correlated with height above ground).

The below turbines are linked to the passive systems below by means of proximity and/or similarities in habitat and terrain. The sensitivity map also influences which turbines may possibly require mitigation.

SM4: Turbines 28 – 31

Snydersberg: Turbines 42, 43, 44, 45

Barendskraal NW: Turbines 14

Table 12: The times of implementation of mitigation measures is preliminarily recommended (considering more than 80% bat activity, normalised data) as follows:

	Terms of mitigation implementation
Spring peak activity (times to implement curtailment/ mitigation)	Snydersberg: Month of October 21:00 – 02:00
Environmental conditions in which to implement curtailment/ mitigation	Below 5m/s measured at nacelle height Above 9°C
Autumn peak activity (times to implement curtailment/ mitigation)	SM4: 1 -15 March Sunset – 22:00
Environmental conditions in which to implement curtailment/ mitigation	Below 7m/s measured at nacelle height Above 17°C
Summer peak activity (times to implement curtailment/ mitigation)	Barendskraal NW: 1 December – 10 January 1 December – 15 January 20:00 – 01:00
Environmental conditions in which to implement curtailment/ mitigation	Below 9m/s measured at nacelle height Above 11°C

Where mitigation by location is not possible, other options that may be utilized include curtailment, blade feathering, blade lock, acoustic deterrents or light lures. The following terminology applies:

Curtailment:

Curtailment is defined as the act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by locking or feathering the turbine blades.

Cut-in speed:

The cut-in speed is the wind speed at which the generator is connected to the grid and producing electricity. For some turbines, their blades will spin at full or partial RPMs below cut-in speed when no electricity is being produced.

Feathering or Feathered:

Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation. Normally operating turbine blades are angled almost perpendicular to the wind at all times.

Free-wheeling:

Free-wheeling occurs when the blades are allowed to rotate below the cut-in speed or even when fully feathered and parallel to the wind. In contrast, blades can be "locked" and cannot rotate, which is a mandatory situation when turbines are being accessed by operations personnel.

Increasing cut-in speed:

The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed, and turbines are programmed to stay locked or feathered at 90° until the increased cut-in speed is reached over some average number of minutes (usually 5 – 10 min), thus triggering the turbine blades to pitch back "into the wind" and begin to spin normally and produce power.

Blade locking or feathering that renders blades motionless below the manufacturers cut in speed, and don't allow free rotation without the gearbox engaged, is more desirable for the conservation of bats than allowing free rotation below the manufacturer's cut in speed. This is because bats can still collide with rotating blades even when no electricity is being produced.

Acoustic deterrents are a developing technology and will need investigation closer to time of wind farm operation.

Light lures refer to the concept where strong lights are placed on the periphery (or only a few sides) of the wind farm to lure insects and therefore bats away from the turbines. However, the long term effects on bat populations and local ecology of this method is unknown.

Habitat modification, with the aim of augmenting bat habitat around the wind farm in an effort to lure bats away from turbines, is not recommended. Such a method can be adversely intrusive on other fauna and flora and the ecology of the areas being modified. Additionally it is unknown whether such a method may actually increase the bat numbers of the broader area, causing them to move into the wind farm site due to resource pressure.

Currently the most effective method of mitigation, after correct turbine placement, is alteration of blade speeds and cut-in speeds under environmental conditions favourable to bats.

A basic "6 levels of mitigation" (by blade manipulation or curtailment), from light to aggressive mitigation is structured as follows:

1. No curtailment (free-wheeling is unhindered below manufacturer’s cut in speed so all momentum is retained, thus normal operation).
2. Partial feathering (45 degree angle) of blades below manufacturer’s cut-in speed in order to allow the free-wheeling blades half the speed it would have had without feathering (some momentum is retained below the cut in speed).
3. Ninety degree feathering of blades below manufacturer’s cut-in speed so it is exactly parallel to the wind direction as to minimize free-wheeling blade rotation as much as possible without locking the blades.
4. Ninety degree feathering of blades below manufacturer’s cut-in speed, with partial feathering (45 degree angle) between the manufacturer’s cut-in speed and mitigation cut-in conditions.
5. Ninety degree feathering of blades below mitigation cut in conditions.
6. Ninety degree feathering throughout the entire night.

It is recommended that curtailment be applied initially at the start of operation at Level 3 during the climatic conditions and time frames outlined in Table 12. However, actual impacts on bats will be monitored during the operational phase monitoring, and the recommended mitigation measures and levels of curtailment will be adjusted according to the results of the operational monitoring. This is an adaptive management approach, and it is crucial that any suggested changes to the initial proposed mitigation schedule be implemented within maximum 2 weeks from the date of the recommendation, unless the recommendation refers to a time period later in the future (e.g. the following similar season/climatic condition).

7 CONCLUSION

The first site was visit was end of January 2015, wherein five SM2BAT+ detectors were installed on five 10m masts. During the site visit in May 2015, SM1 was moved to Brandkop met mast and in August 2015, SM7 was moved to Snydersberg and Barendskraal NW met mast was set up.

A total of six systems were installed, three on met masts each with microphones at 10m and 80m, and three on 10m short masts. Considering the total developable area that may be utilised for turbine placement only 1 113.9 ha, even if widely dispersed, in this regard it far exceeds the minimum requirements of the 3rd Edition of the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler and Stoffberg, 2012) by utilising surplus systems at height. The development areas collectively formed the focus area of the preconstruction bat monitoring study.

A sensitivity map was drawn up indicating potential roosting and foraging areas. The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity. High Bat Sensitivity areas are 'no – go' areas due to expected elevated rates of bat fatalities due to wind turbines. Thus turbines located within the boundary of the High Bat Sensitivity buffers are required to be moved or removed. No turbines are located within High bat sensitivity buffers on the Brandvalley site. The High sensitivity valley areas can also serve as commuting corridors for bats in the larger area, potentially lowering the cumulative effects of several WEF's in an area.

The turbines located within Moderate Bat Sensitivity areas and buffers must be prioritized during operational monitoring and may require initial mitigation measures. Note that the mitigation schedules provided in this report is preliminary and may be altered as needed during operational monitoring, this is referred to as an adaptive management approach.

Peak activity times across the night and monitoring period were identified, as well as wind speed and temperature parameters during which most bat activity was detected. Mitigations are expected to be implemented once the turbines become operational. The proposed mitigation schedule follows the precautionary approach strongly and therefore the mitigations will be adjusted and refined during a post-construction bat monitoring study.

The control systems SM2 and SM8 recorded significantly higher bat activity than the other systems. These control systems are located in valleys demarcated and buffered as having a High bat sensitivity, compared to the development areas that are located in habitat less favourable for bats on top of the ridges.

If all recommendations and mitigation measures are followed and included in the conditions of the Environmental Authorisation, Animalia has no objection to the authorisation of the proposed project.

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