Final Progress Report of a 12 month Long-Term Bat Monitoring Study

- For the proposed Inyanda Roodeplaat Wind Energy Facility near Uitenhage, Eastern Cape Province

Compiled by: Carel Malouf & Werner Marais

Reviewed by: Monika Moir & Werner Marais

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PREPARED FOR:

Vulisango Holdings

by

zoological & ecological consultation

CK 2009/057469/23

P.O. Box 6892
Weltevredenpark
Gauteng
1715
☎+27 78 190 3316

✉werner@animalia-consult.co.za

www.animalia-consult.co.za

Ref: R-1503-10

Appointment of Specialist

Specialist Company:	Animalia Zoological & Ecological Consultation CC
Fieldwork conducted by:	Werner Marais & Chantal Kruger & Carel Malouf
Report done by:	Carel Malouf
Overseen/reviewed by:	Werner Marais
Appointed by:	Vulisango Holdings
For:	12 Month pre-construction bat activity monitoring

Independence:

Animalia Zoological & Ecological Consultation CC has no connection with the developer. Animalia Zoological & Ecological Consultation CC is not a legal or financial subsidiary of the developer; remuneration for services by the developer in relation to this proposal is not linked to approval by decision-making authorities responsible for permitting this proposal and the consultancy has no interest in secondary or downstream developments as a result of the authorization of this project.

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.

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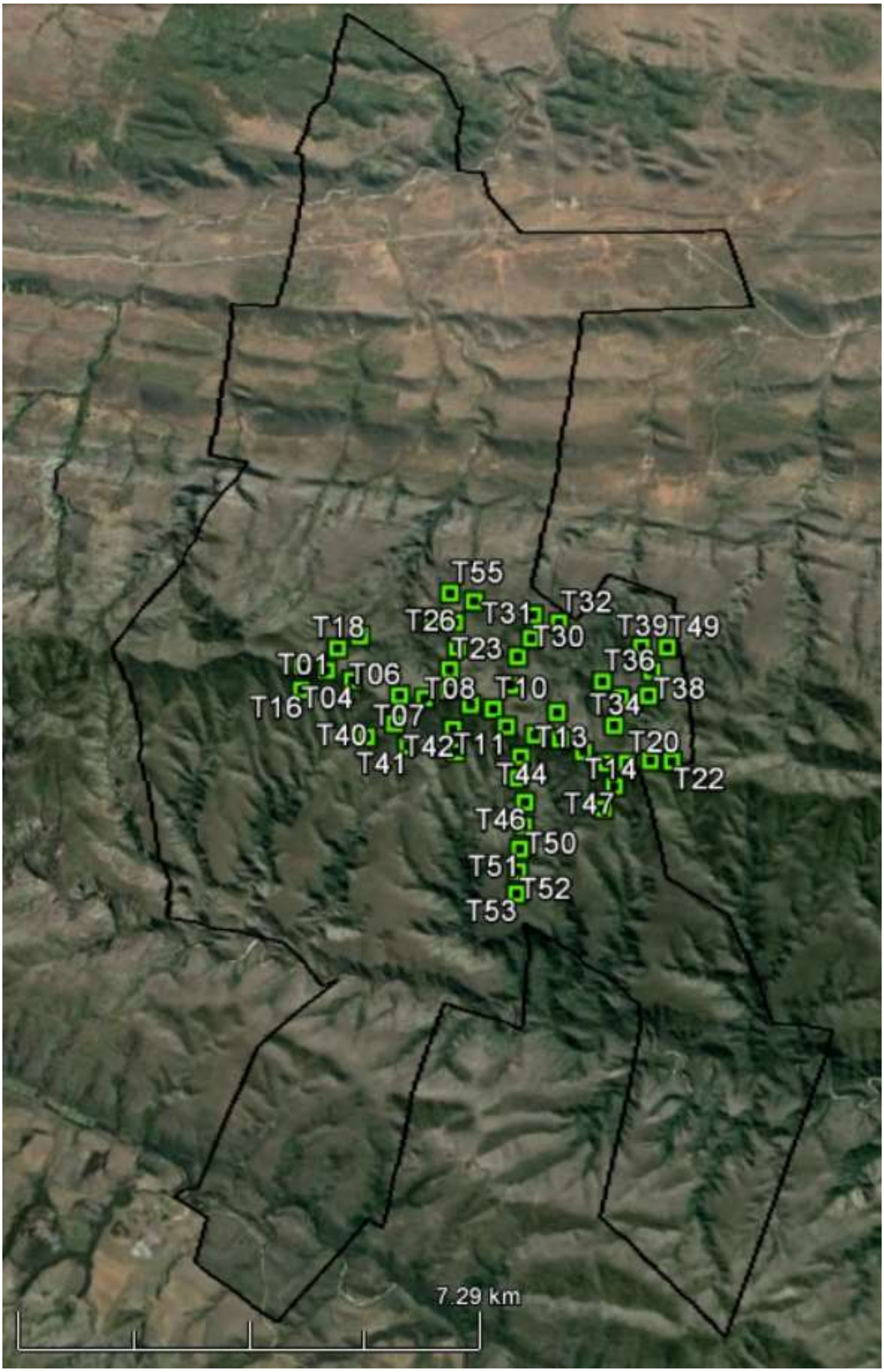


Figure 1: Map overview of the proposed Roodeplaat WEF turbine layout.

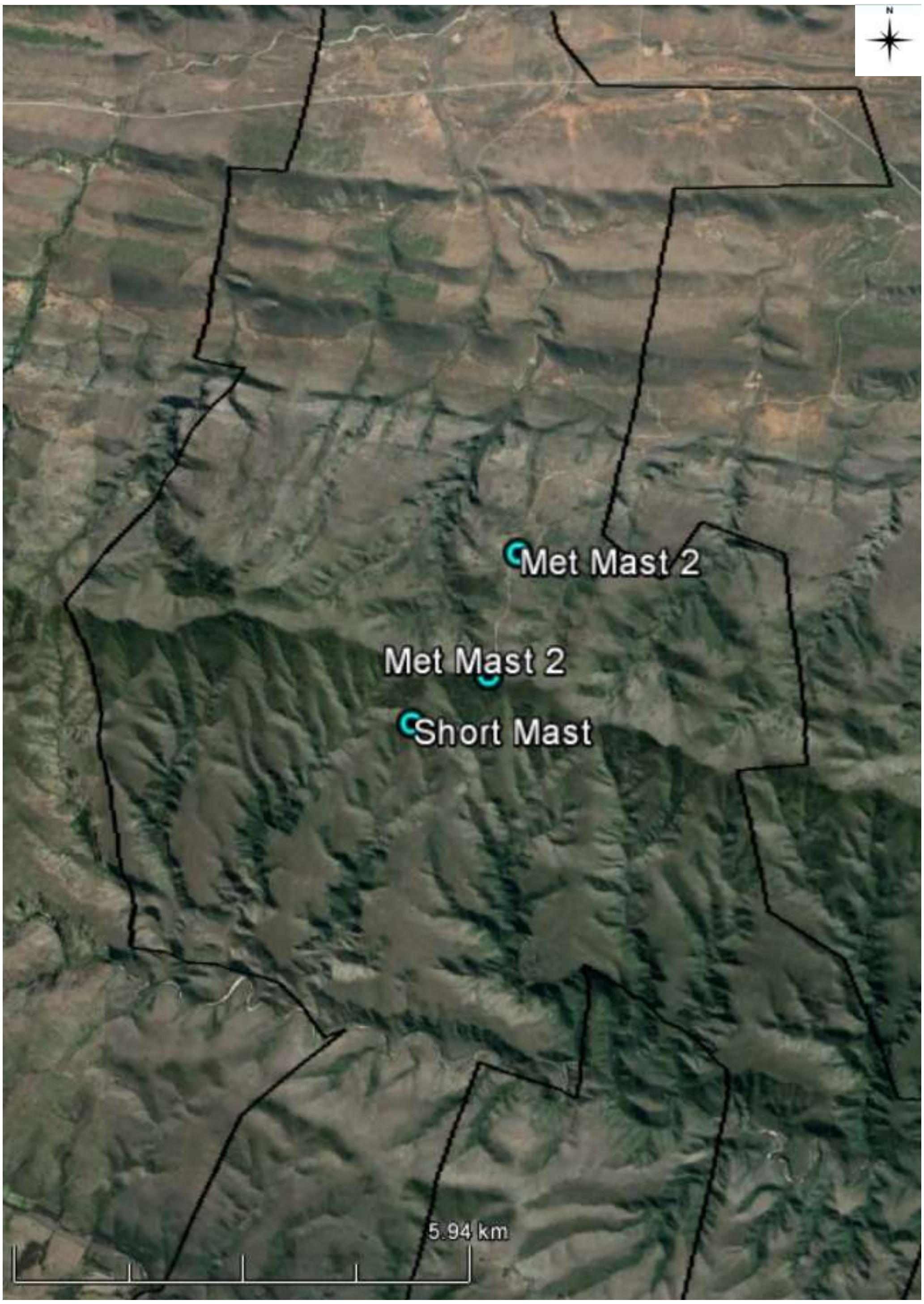


Figure 2: Overview of the passive monitoring systems on the Roodeplaat WEF.

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 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 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

This is the final progress report for a twelve-month bat monitoring study at the proposed Roodeplaat Wind Energy Facility near Uitenhage, Eastern Cape.

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. The importance of these factors can vary greatly between bat species, their respective 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 in terms of 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. This evaluation is 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, is 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 bat detectors. 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 retain 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.

2.1 The Bats of South Africa

Bats form the Order Chiroptera and are the second largest group of mammals after rodents (Rodentia). 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 of wing camber and shape, facilitating functions such as agility and manoeuvrability. This adaptation 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 histories – particularly as a result of the various foraging and echolocation strategies evident among bats. 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 (e.g. spiders and scorpions). 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 and economic value 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 (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. Moreover, according to O'Shea *et al*. (2003), bats may live for up to 30 years thereby limiting the number 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. However, in contrast the relatively low reproduction rates of bats results in populations having a low recovery rate from mass mortalities and major roost disturbances.

2.2 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). Bat mortalities due to turbines have been attributed to be caused by direct impact with the blades and by barotrauma (Baerwald *et al*. 2008). Barotrauma 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). Rollins *et al.* (2012) carried out a histopathological study to assess whether direct collision or barotrauma was the major cause of mortality. They found an increased incidence of fractures, external lacerations and features of traumatic injury (diaphragmatic hernia, subcutaneous hemorrhage, and bone marrow emboli) in bats killed at wind farms. 73% of bats had lesions consistent with traumatic injury whereas there was a 20% incidence of ruptured tympana, a sensitive marker of barotrauma in humans. Thus the data of this study strongly suggests that traumatic injury from direct collision with turbine blades was the major cause of bat mortality at wind farms and barotrauma is a minor etiology.

Additionally, it has been hypothesized that barotrauma causes mortality only if the bat is within a very short distance of the turbine blade tip such that collision with the blades is a much more likely cause of death.

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 to 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 has been monitored using active and passive bat monitoring techniques. Active monitoring has been done through site visits with transects made throughout the site with a vehicle-mounted bat detector. Passive detection has been performed with the mounting of passive bat monitoring systems placed on three monitoring masts on site. Specifically, one short 10m mast and two meteorological masts (**Figure 2**).

The monitoring systems consisted of SM2BAT time expansion bat detectors that were powered by 12V, 18Ah, sealed lead acid batteries and 20W solar panels that provided recharging power to the batteries. Each system also had 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 was to ensure substantial memory space with high quality recordings even under conditions of multiple false wind triggers.

One weatherproof ultrasound microphone was mounted at a height of 10 meters on the short mast, while two microphones were mounted at 10m and 50m on each of the meteorological masts. 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 was the setting for a bat detector in which any frequency which exceeds 16 kHz and -18dB will trigger the detector to record for the duration of the sound and 500ms after the sound has ceased, this latter period is known as a trigger window. All signals were recorded in WAC0 lossless compression format. The table below summarizes the above-mentioned equipment setup.

3.1 Site Visits

Site visit dates		First Visit	3 – 5 & 18 July 2013
		Second Visit	6 – 10 October 2013
		Third Visit	6 - 10 February 2014
		Fourth Visit	27 – 31 May 2014
		Fifth Visit	14 – 18 July 2014
Met mast passive bat detection systems	**Quantity on site**	2	
	Microphone heights	10m; 50m	
Short mast passive bat detection systems	**Quantity on site**	1	
	Microphone height	10m	

Replacements/ Repairs/ Comments	
First site visit	The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Crows have been found to peck at microphones and subsequently destroying them. Hence, measures were taken for protection against birds, without noticeably compromising effectiveness. The bat detectors were installed within their weatherproof containers and all peripherals attached. Monitoring at 50m height will provide an assessment of the bat activity occurring within rotor-sweep height.
Second site visit	All the systems were fully operational apart from the short mast that had a microphone failure and as such the microphone had to be replaced. Also the battery on Met mast 2 was replaced with a stronger battery.
Third site visit	All systems were fully operational.
Fourth site visit	All systems were fully operational.
Fifth site visit	All systems were fully operational.
Type of bat detector	SM2BAT, Real Time Expansion (RTE) type
Recording schedule	Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were automatically adjusted in relation to latitude, longitude and season).
Trigger threshold	>16KHz, -18dB
Trigger window (time of recording after trigger	500ms

ceased)	
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	6 - 8 Amp with low voltage/deep discharge protection
Other methods	Terrain was investigated during the day for roosting and foraging habitat.

Figure 3: SM2BAT+ detector with four 32 GB SDHC memory cards.

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. Attempts to overcome this limitation, however, will be made during 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 as well as a measure of relative abundance.
- 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 existing impacts on the study area are very low with activity limited to wild game farming and extremely sparse dispersion of buildings and residences. The roads in the area are gravel.

The site occupies five vegetation units, namely Albany alluvial vegetation, Groot thicket, Sundays thicket, Kouga sandstone fynbos and Kouga grassy sandstone fynbos (Figure 7). The mean maximum and minimum temperatures are 37.7°C in January and -3.1°C in July.

The northern area of the site occupies a large area of Groot Thicket which forms part of the Albany Thicket Biome (Figure 7). This biome is characterised by dense, woody, semi-succulent and thorny vegetation with *Portulacaria afra* (Spekboom) abundant under favourable conditions. Grass species are usually poorly developed with dominant stem and leaf succulents. The soils on steeper slopes are derived from arenites and shales and range from red, clayey soils to rocky soils. This unit is found between altitudes of 200m and 1100m. The vegetation unit is subjected to non-seasonal rainfall with a mean annual precipitation of 290 mm. The Groot Thicket is considered Least threatened with about 11 % conserved mainly in the Greater Addo Elephant National Park, Guerna Wilderness Area and Baviaanskloof conservation area (Mucina & Rutherford, 2006).

A small band of Sundays Thicket separates the Groot Thicket from the Kouga Grassy Sandstone Fynbos (Figure 7). Part of the Albany thicket biome, this unit is found at an altitude of 0-800m. This unit is characterised by tall, dense thicket with many spinescent species and trees, shrubs and succulents. Considered of Least concern, 19 % is protected in National parks and private conservation areas as well as private game farms. When degraded it resembles secondary thornveld or grassland (Mucina& Rutherford, 2006).

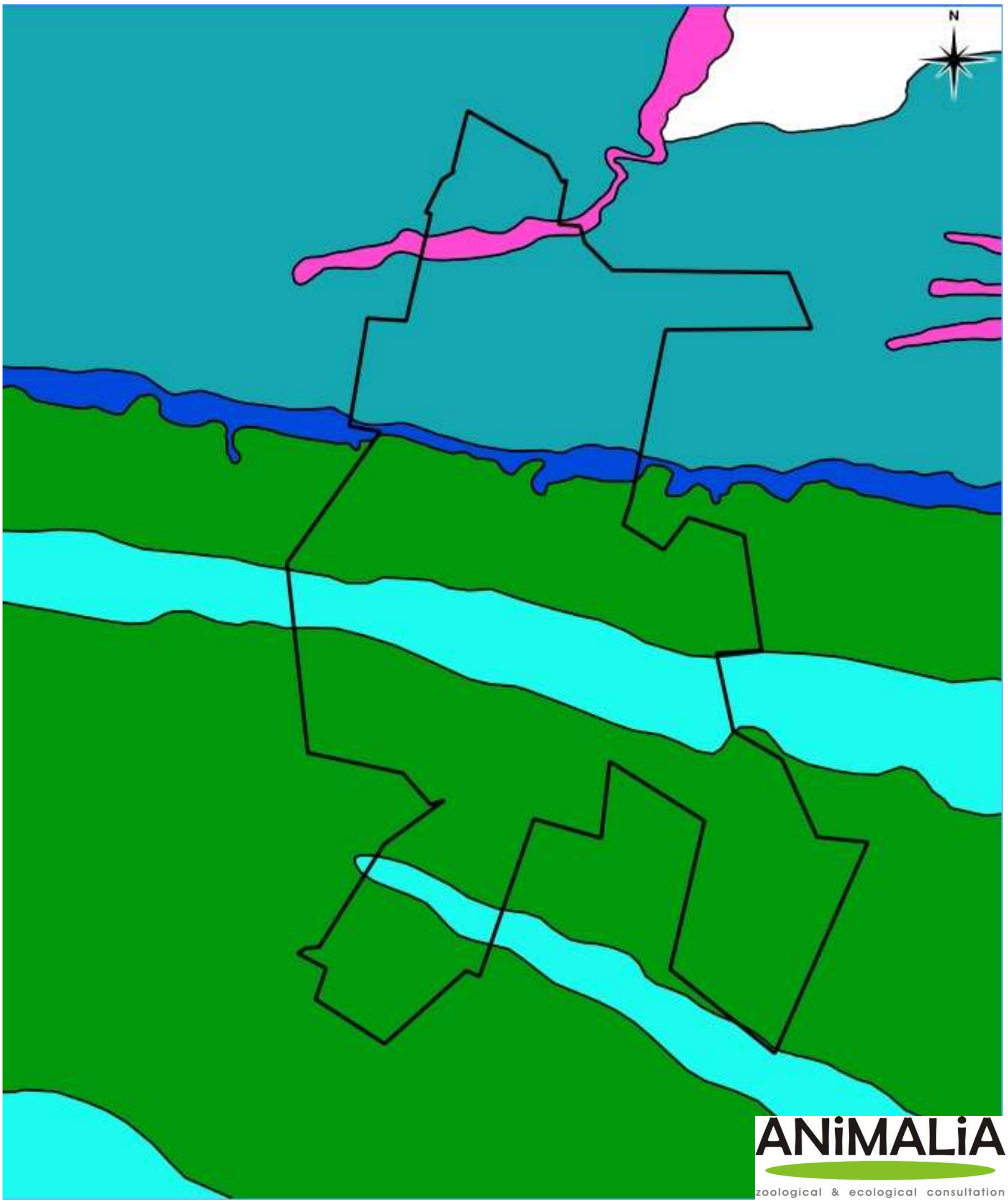
The lower southern area of the site occupies a vegetation unit of Kouga Grassy Sandstone Fynbos that surrounds bands of Kouga Sandstone Fynbos. Both these units fall within the Fynbos biome (Mucina & Rutherford, 2006). The substrate ranges between acidic lithosol soils derived from sandstone of the Table mountain group and quartzitic sandstone of the Witteberg group. Kouga Grassy Sandstone Fynbos is found at altitudes from 220m to 1220m with a southerly aspect and is characterised by long, rounded mountain chains that range from moderately steep to gently sloping. The high altitude slopes are dominated by low fynbos with the intermediate slopes forming tall shrub stratum dominated by Proteaceae shrubs (Mucina & Rutherford, 2006). The Kouga Sandstone Fynbos is found on the northern, lower slopes and is characterised by low shrubland and grassland where soil leaching is less severe. Both units are considered least threatened with 20% of Kouga Grassy Sandstone Fynbos and 40% of Kouga Sandstone Fynbos conserved in wilderness areas and private game farms. Annual precipitation ranges between 270-800mm with a mean of 567 mm and shows a peak in March and October.

Albany Alluvial Vegetation occupies a small region in the northern area of the site (Figure 7). This unit forms part of the Azonal Inland Vegetation and is part of the Albany Thicket biome, with an altitude ranging from 20-1000m. There are two main types of vegetation patterns observed in these zones, namely, riverine thicket and thornveld (*Acacia natalitia*). The thornveld generally occurs inland on wide floodplains while riverine thicket occurs in narrow floodplain zones. Soils usually have high clay content and alluvial deposits and can become flooded during local storms. The temperatures experienced in the river valleys are often higher than those experienced in the surrounding areas due to the exposed steep slopes. This zone is considered endangered with only 6% conserved in National parks and private conservation areas and more than half of the area has been transformed for cultivation, urban development, road building and plantations.

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

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Albany Alluvial Vegetation	Moderate – High	High	The presence of trees and crevices can provide roosting potential while the watercourses can provide water access and foraging area.
Sundays Thicket	Moderate-High	Moderate - High	The trees and animal burrows have roosting potential while the vegetation provides foraging potential for insectivorous bats.
Groot Thicket	Moderate - High	Moderate -High	Trees and vegetation present in kloof areas can provide good roosting and foraging areas while the flatter areas can provide

			foraging areas for clutter foragers.
Kouga Grassy Sandstone Fynbos	Low-Moderate	Low on the high lying areas Moderate on the low lying area	The vegetation and riparian areas can provide foraging and roosting habitat while the higher lying regions can provide roosting habitat.
Kouga Sandstone Fynbos	Moderate – high	Moderate to high	Outcroppings and crevices found on the slopes can provide roosting potential while the shrubland can provide foraging areas.



Site boundary
Albany Alluvial Vegetation
Sundays Thicket
Groot Thicket
Kouga Grassy Sandstone Fynbos
Kouga Sandstone Fynbos

Figure 4: 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 expected numbers of individuals present on site and the frequency with which the site will be visited by the species (in other words 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 travel; 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).

Species name	Common name	Probability of Occurrence (%)	Conservation Status	Possible roosting sites occupied on site	Foraging habits (indicative of possible foraging areas on site)	Likely Risk of Impact (Sowler & Stoffberg, 2014)
Rousettus aegyptiacus	Egyptian rousette bat	50 - 60	Least concern	Presence of caves in the larger mountainous area is possible, however no caves were found on the site.	Feed mostly on. fruiting trees in riparian areas, highly unlikely to cross over mountain tops.	Medium - High
Rhinolophus capensis	Cape horseshoe bat	20 - 30	Near threatened	Presence of caves in the larger mountainous area is possible, however no caves were found on the site.	Clutter forager feeding predominantly on Coleoptera and Lepidoptera. Most probable in valley areas.	Low
Rhinolophus clivosus	Geoffroy's horseshoe bat	40 - 50	Least concern	Roosts gregariously in caves and mine adits, no known caves close to the study site, but possible.	Establish feeding stations during the night under trees or the verandas of houses. Clutter forager	Low

				But may also utilise any other cavities in rock formations as found on the site, absent from low lying areas, often found in mountainous areas.	with a diet comprised mainly of Lepidoptera and Coleoptera. More probable in cluttered valley areas.	
Taphozous mauritianus	Mauritian tomb bat	10 - 20	Least concern	Roosts on rock faces, tree trunks, walls favouring sides in the shade. Males and females roost separately from one another. Preferring open habitats and avoiding closed forest interior and is dependent upon surface water.	Open air forager feeding on Lepidoptera, Isopterans and Coleoptera.	High
Nycteris thebaica	Egyptian slit-faced bat	10 - 20	Least Concern	Roosts during the day in caves, burrows, culverts and trunks of large trees. Presence of caves in the larger mountainous area is possible, however no	Clutter forager. Diet varies according to the season between Orthoptera, Coleopteraand Lepidoptera as well as a	Low

				caves were found on the site. May prefer cluttered habitats more. On edge of distribution.	number of other insects and arachnids.	
Rhinolophus swinnyi	Swinny's horseshoe bat	10-20	Near Threatened	Roosts in caves. Presence of caves in the larger mountainous area is possible, however no caves were found on the site. But also cavities, culverts.	Clutter forager that feeds mainly on Lepidoptera	Low
Tadarida aegyptiaca	Egyptian free-tailed bat	90 - 100	Least concern	Roosts in caves, crevices, hollow trees, buildings, and any other suitable crevices. Presence of caves in the larger mountainous area is possible, however no caves were found on the site.	Open-air forager with a diet consisting mainly of Diptera, Hemiptera, Coleoptera and to some extent Lepidoptera. Strong flier that can forage on the mountain top.	High
Miniopterus fraterculus	Lesser long-fingered	40 - 60	Least concern	Its distribution is dependent upon the availability of caves and is	Clutter edge forager, feeding on Lepidoptera, Diptera, Hemiptera and	Medium - High

	bat			found in temperate areas. Separate caves are used as summer roosts and winter hibernacula. Presence of caves in the larger mountainous area is possible, however no caves were found on the site.	Coleoptera. May forage on mountain top.	
Miniopterus natalensis	Natal long-fingered bat	90 - 100	Near Threatened	Cave-dependent. Presence of caves in the larger mountainous area is possible, however no caves were found on the site. But also utilises other smaller hollows found on site, where they from small colonies or roost individually.	Clutter-edge forager. Feeds on a variety of aerial prey including Diptera, Hemiptera, Coleoptera, Lepidoptera and Isoptera. On edge of distribution. May forage on mountain top.	Medium - High
Neoromicia capensis	Cape serotine	90 - 100	Least Concern	Roosts in bark of trees, at the base of aloe leaves, inside roofs, and other	Clutter-edge forager feeding mainly on Coleoptera, Hemiptera,	Medium - High

				suitable hollows/crevices.	Lepidoptera and Neuroptera. May be found on mountain top.	
Kerivoula lanosa	Lesser Woolly bat	10- 20	Least Concern	Little is known of this species but is thought to roost in riparian areas	It is a clutter forager. No information is available on its diet	Low
Epomophorus wahlbergi	Wahlberg's Epauletted Fruit bat	10-20	Least Concern	Feeds on fruit, nectar, pollen and flowers. Prefers riparian areas, highly unlikely to cross over mountain tops.	They feed while hovering or land on a branch next to a fruit or flower	Medium-High
Scotophilus dinganii	Yellow-bellied House Bat	10-20	Least Concern	Roosts mainly in holes in trees and roofs of houses. It avoids open habitats such as grasslands and karoo	A clutter forager that feeds mainly on medium-sized Coleoptera as well as Hemiptera, Hymenoptera, Isoptera and Diptera	Medium- High
Pipistrellus hesperidus	Dusky Pipistrelle	20-30	Least Concern	Roosting areas are associated with riparian vegetation and forest patches as well as crevices	It feeds on Coleoptera, Hemiptera, Diptera, and Lepidoptera	Medium

				formed from exfoliating rock		
Eptesicus hottentotus	Long-tailed serotine	90 - 100	Least Concern	It is a crevice dweller roosting in rock crevices, and any other suitable crevices found on site.	It seems to prefer woodland habitats, and has been caught in granitic hills and near rocky outcrops	Medium

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

There are three bat species recorded on site that commonly occur in the area due to their probability of occurrence and widespread distribution. These species are of importance based on their likelihood of being impacted by the proposed WEF, which is a combination of abundance and behaviour. 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.

A study by Vincent *et al.* (2011) on the activity and foraging habitats of Miniopteridae found that the individual home ranges of lactating females were significantly larger than that of pregnant females. It was also found that the bats predominately made use of urban areas (54%) followed by open areas (19.8%), woodlands (15.5%) orchards and parks (9.1%) and water bodies (1.5%) when selecting habitats. Foraging areas were also investigated with the majority again occurring in urban areas (46%); however a lot of foraging also occurred in woodland areas (22%), crop and vineyard areas (8%), pastures, meadows and scrubland (4%) and water bodies (4%).

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.

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 & Lynch 1989).

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. 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 rock crevices, under exfoliating rocks, caves, hollow trees and behind the bark of dead trees. *T. aegyptiaca* has also adapted to roosting in buildings, in particular roofs of houses (Monadjem *et al*. 2010).

The Egyptian Free-tailed bat 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, savannah, 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 by wind turbines (Sowler and Stoffberg 2014). Due to the high abundance and widespread distribution of this species, high mortality rates by wind turbines would be a cause of concern as these species have more significant ecological roles than the rarer bat species. The sensitivity maps are strongly informed by the areas that may be used by this species.

After a gestation of four months, a single pup 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 (Bernard and Tsita 1995). Maternity colonies are apparently established by females in November (Herselman 1980).

Several North American studies indicate the impact of wind turbines to be highest on migratory bats, however there is evidence to the impact on resident species. Fatalities from turbines increase during natural changes in the behaviour of bats leading to increased activity in the vicinity of turbines. Increases in non-migrating bat mortalities around wind turbines in North America corresponded with when bats engage in mating activity (Cryan and Barclay 2009). This long term assessment also indicated if seasonal peaks occur in species activity and bat presence.

4.4 Transects

Transects were not carried out over the first site visit.

4.4.1 Second Site Transects

The driven transect was done using a Wildlife Acoustics SM2BAT+ detector. The routes were chosen randomly based on the condition of the roads and location at time of sunset.

Table 3: Average weather conditions experienced during the driven transects.

Date	Temperature	Rain	Wind	Humidity
7 October 2013	16°C	0.0mm	14 km/h	77%
8 October 2013	20°C	0.0mm	11 km/h	80%

(Weather information taken from www.worldweatheronline.com for Uitenhage, EC)

Table 4: Distance and time frames of driven transect

Date	Distance	Duration	Start	End
7 October 2013	23.15	3 hrs 16 min	19:54	23:10
8 October 2013	24.14	3 hrs 51 min	18:20	22:11

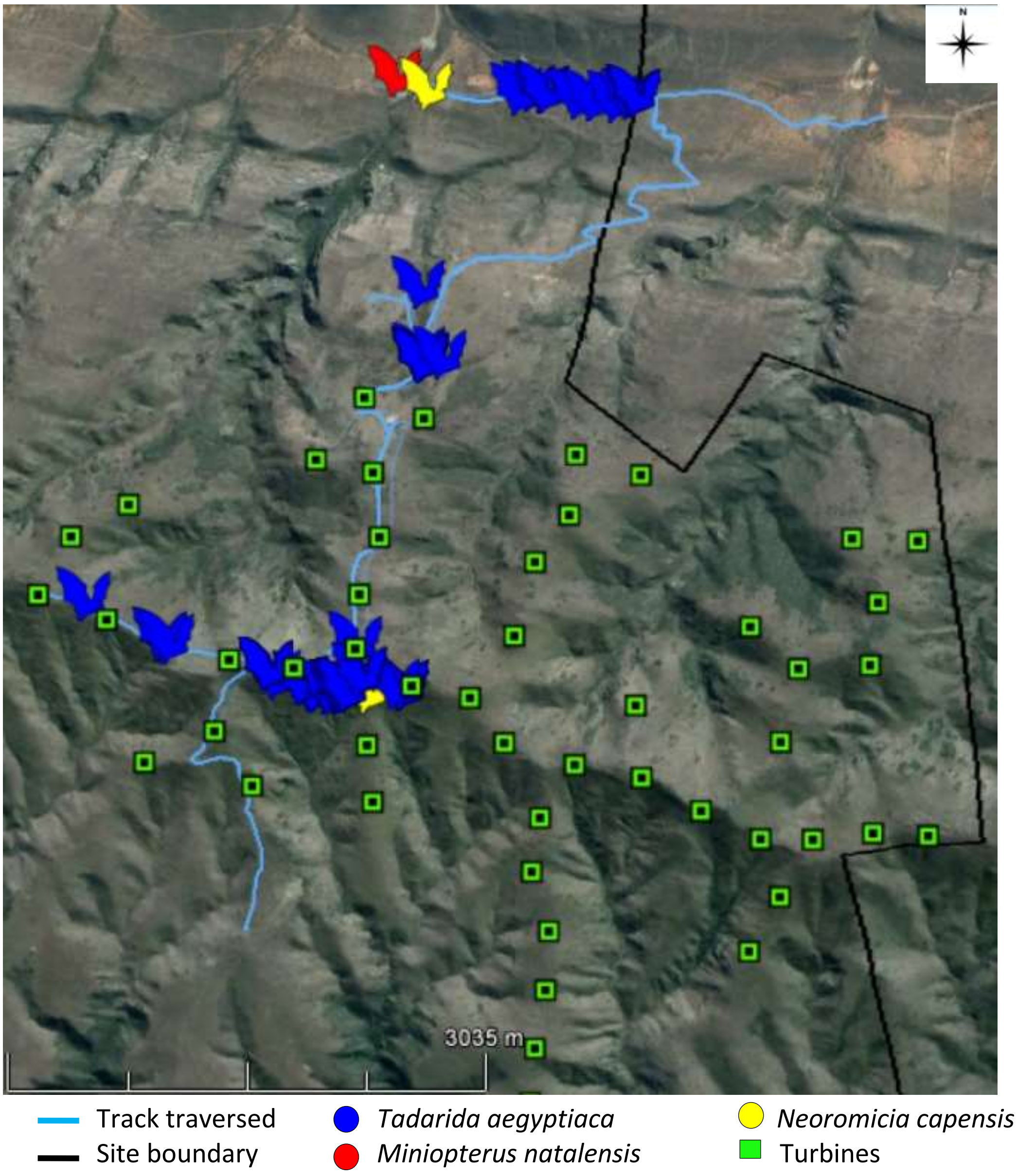
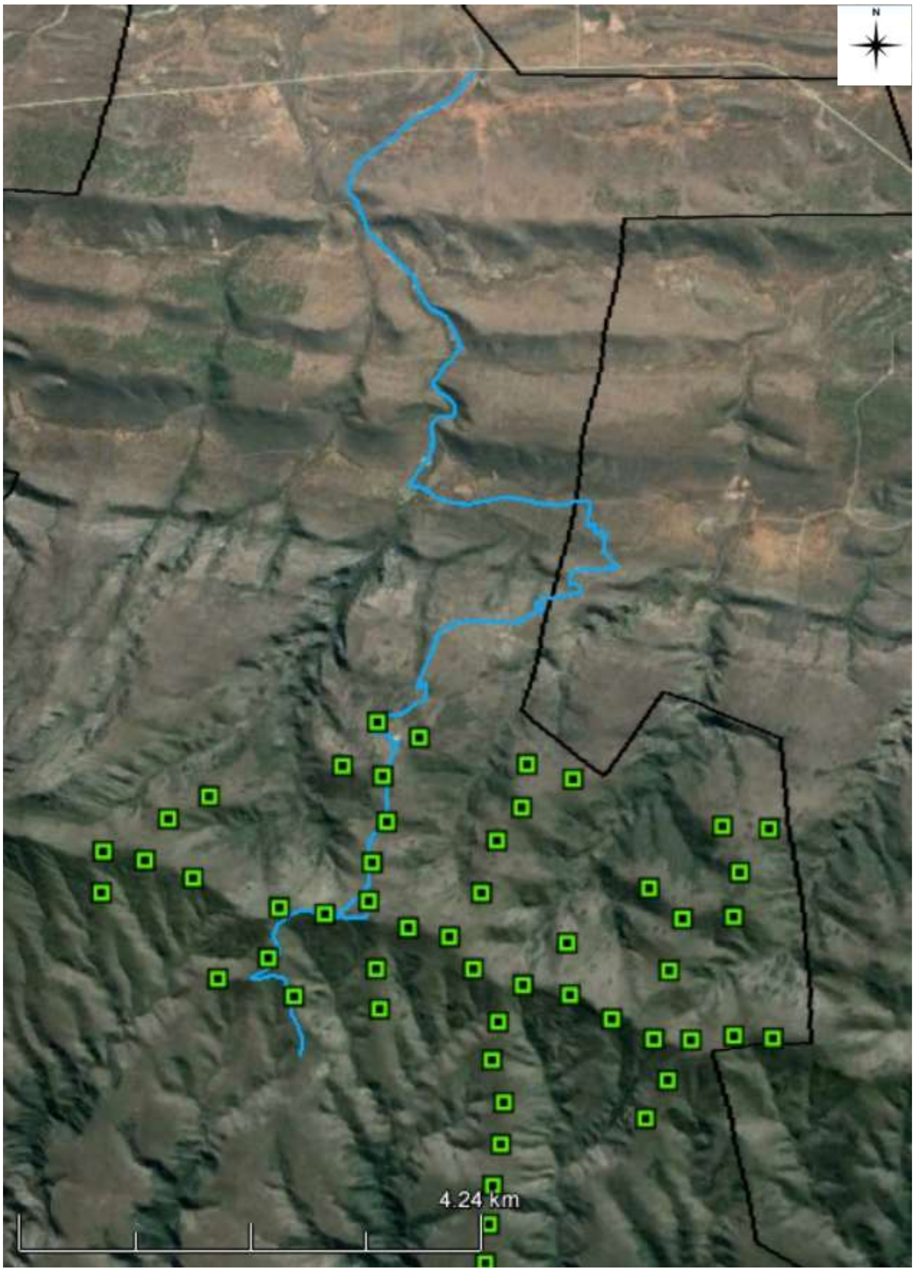


Figure 5: Bat species detected during transects carried out over October 2013

Three bat species were detected during transects, namely *Neoromicia capensis, Miniopterus natalensis* and *Tadarida aegyptiaca*.

4.4.2 Third Site Transects

The driven transect was done using a Wildlife Acoustics EM3 detector. No data was recorded as there was a problem with the audio jack of the EM3.



Track traversed
Turbines
Site boundary

Figure 6: Track driven during transects carried out over February 2014

4.4.3 Fourth Site Transects

The driven transect was done using a Wildlife Acoustics SM2BAT+ detector. The routes were chosen randomly based on the condition of the roads and location at time of sunset.

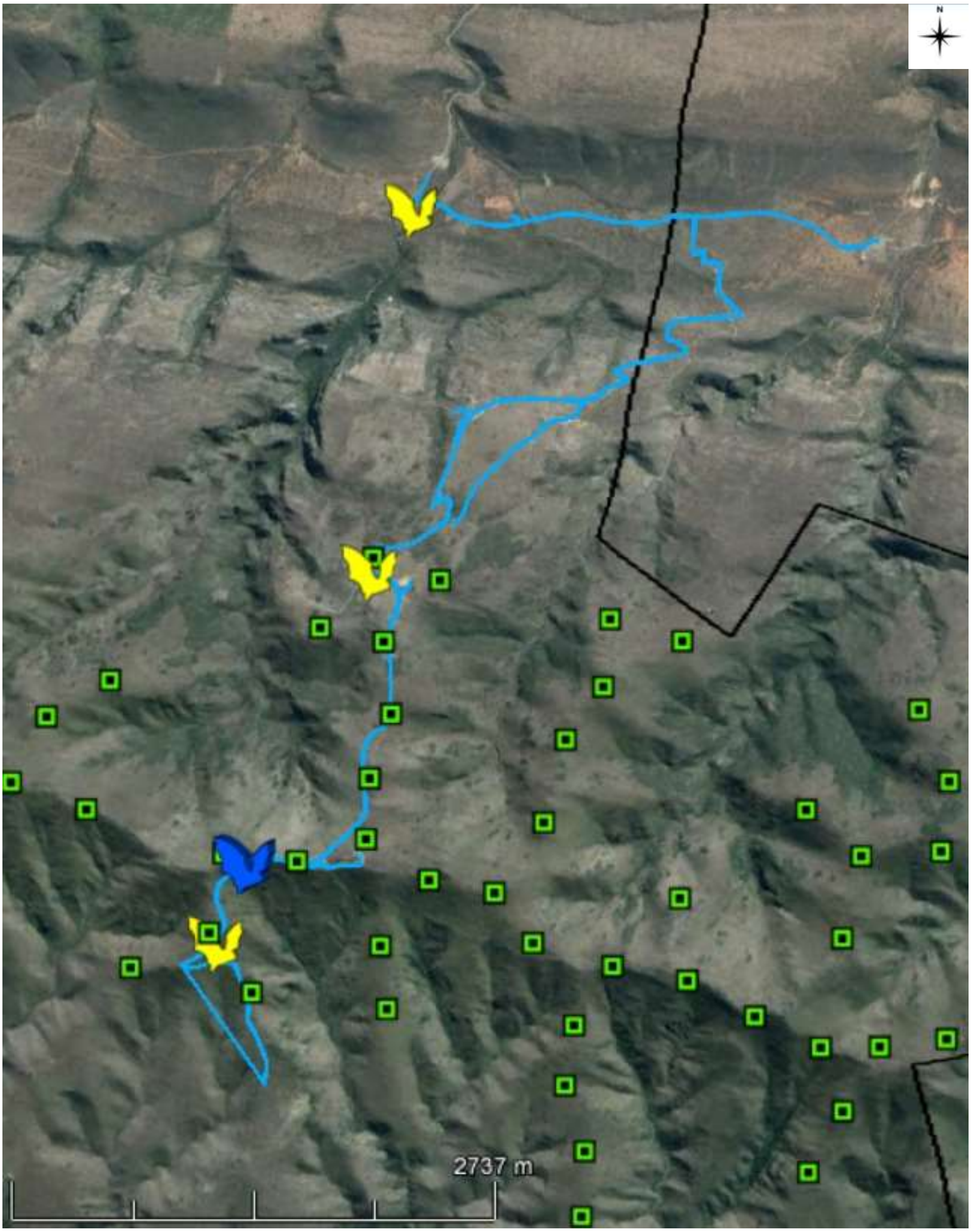
Table 5: Average weather conditions experienced during the driven transects.

Date	Temperature	Rain	Wind	Humidity
27 May 2014	23°C	0.0mm	14 km/h	43%
28 May 2014	17°C	0.0mm	21 km/h	74%

(Weather information taken from www.worldweatheronline.com for Uitenhage, EC)

Table 6: Distance and time frames of driven transect

Date	Distance	Duration	Start	End
27 May 2014	10.6	2 hrs 40 min	17:50	20:30
28 May 2014	22.53	3 hrs 40 min	17:20	21:00



Track traversed
Site boundary
Tadarida aegyptiaca
Miniopterus natalensis
Neoromicia capensis
Turbines

Figure 7: Bat species detected during transects carried out over May 2014

4.4.4 Fifth Site Transects

The driven transect was done using a Wildlife Acoustics SM2BAT+ detector. The routes were chosen randomly based on the condition of the roads and location at time of sunset.

Table 7: Average weather conditions experienced during the driven transects.

Date	Temperature	Rain	Wind	Humidity
16 July 2014	18°C	0.0mm	23 km/h	34%

(Weather information taken from www.worldweatheronline.com for Uitenhage, EC)

Table 8: Distance and time frames of driven transect

Date	Distance	Duration	Start	End
16 July 2014	43.2	3 hrs 40 min	17:50	20:30

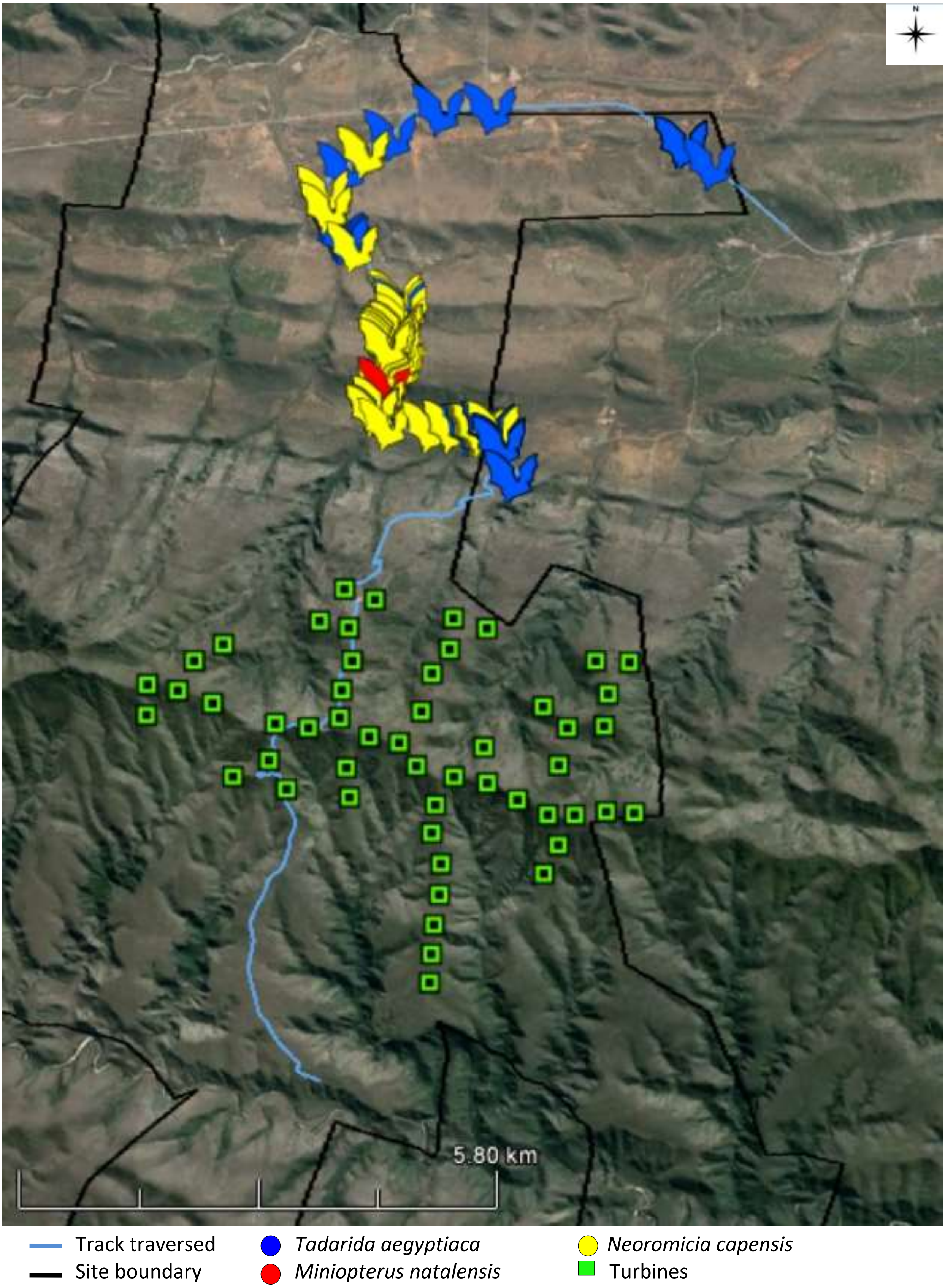


Figure 8: Transect routes wherein no bat activity was detected over July 2014.

4.5 Sensitivity Map

Figures 9 - 11 depict the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are confirmed and 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.

Last iteration	February 2016
High sensitivity buffer	350m
Moderate sensitivity buffer	150m
Features used to develop the sensitivity map	Manmade structures, such as farm houses, barns, sheds, road culverts, these type of structures provide easily accessible roosting sites.
	The presence 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.

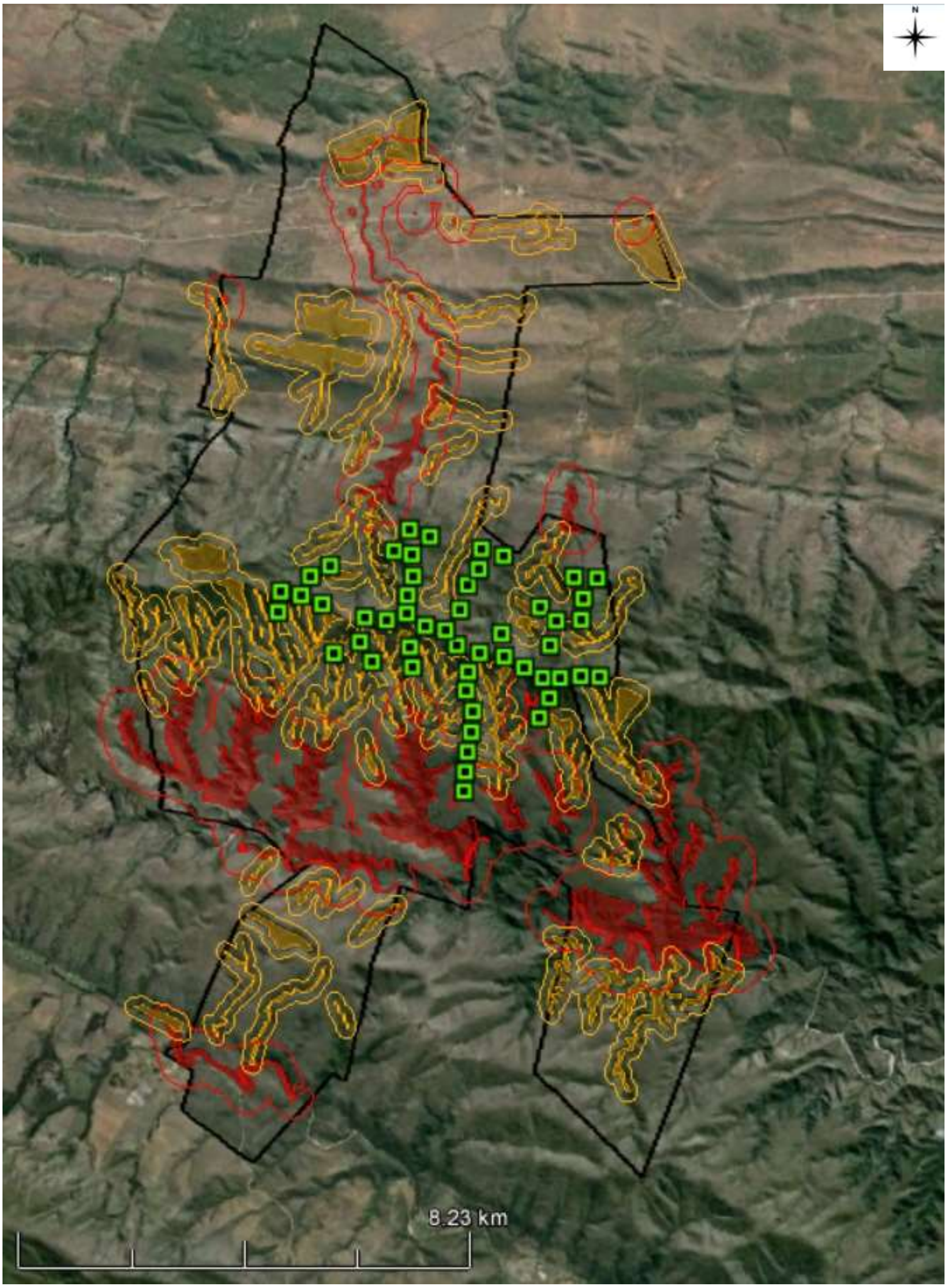
The areas designated as having a High Bat Sensitivity **(Table 9)** implicates that no turbines should be placed in these areas and their respective buffer zones, due to the elevated impacts it can have on bat mortalities. If turbines are located within the Moderate Bat Sensitivity zone or its buffer zone, they must receive special attention and preference for post-construction monitoring and implementation of mitigations during the operational phase outlined in **Section 6**.

Table 9: 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 and their buffers 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 AND their buffer zones.

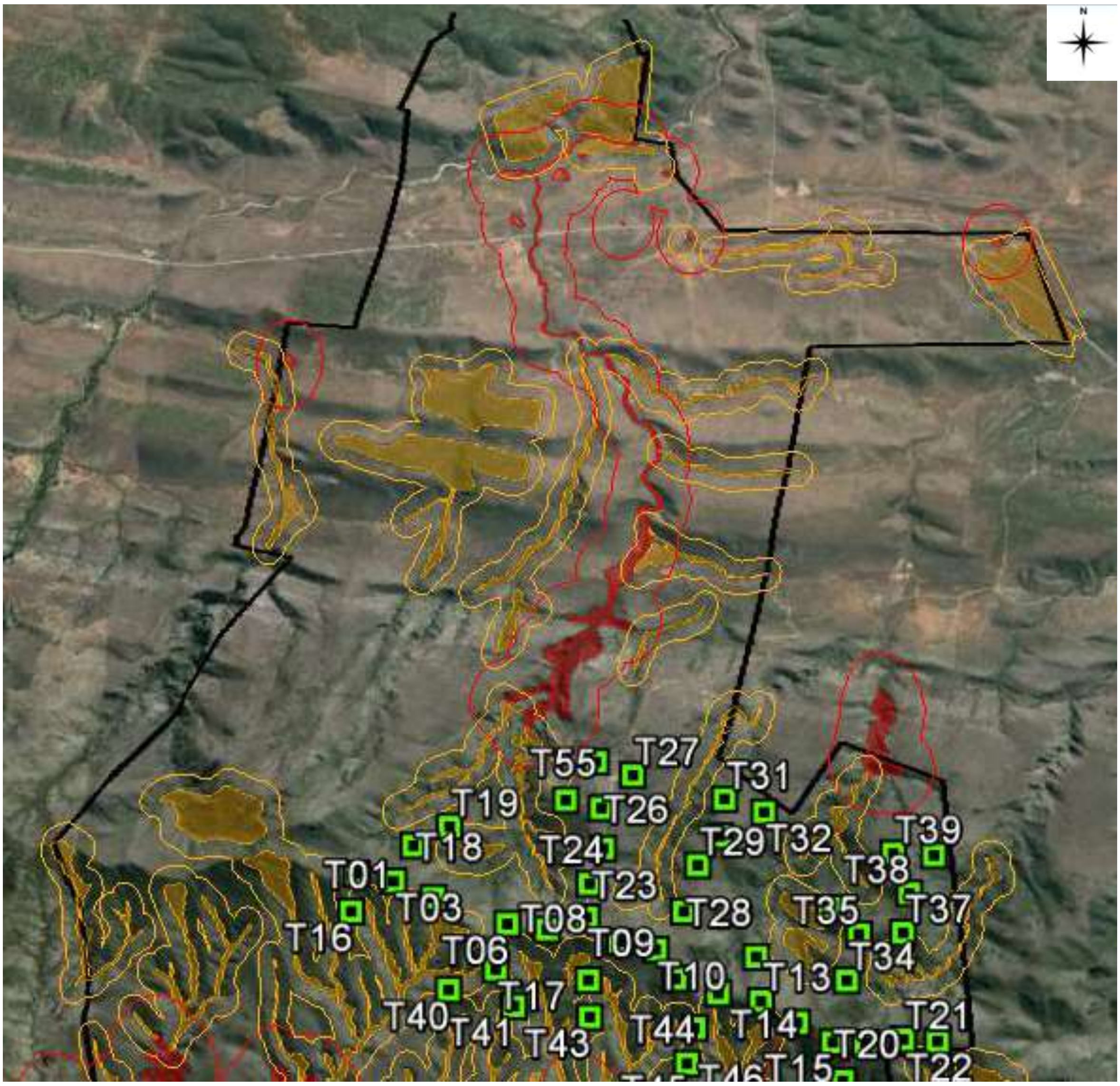
Table 10: Turbines located within bat sensitive areas and buffers

Bat sensitive area	Proposed turbine layout
High bat sensitivity area	None
High bat sensitivity buffer	Turbine 15, 47, 48, 52, 53
Moderate bat sensitivity area	None
Moderate bat sensitivity buffer	Turbine 4, 12, 16, 17, 19, 36, 37, 40, 41, 42, 44, 46, 51



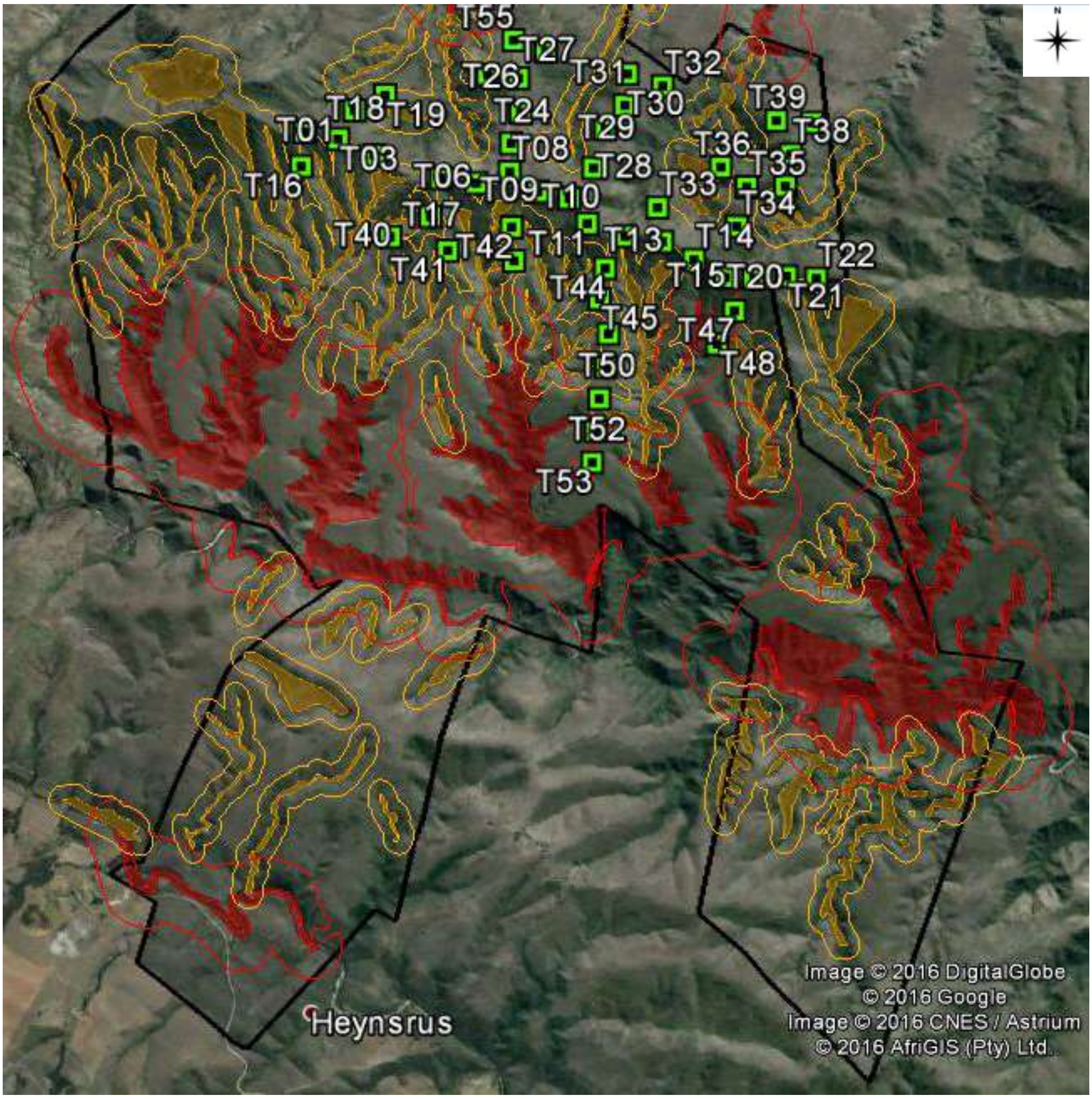
High bat sensitivity area
Moderate bat sensitivity area
Proposed turbine locations
High bat sensitivity buffer
Moderate bat sensitivity buffer

Figure 9: Bat sensitivity map of the Roodeplaat site.



High bat sensitivity area
Moderate bat sensitivity area
Proposed turbine locations
High bat sensitivity buffer
Moderate bat sensitivity buffer

Figure 10: Bat sensitivity map of the northern portion of the Roodeplaat site



High bat sensitivity area

Moderate bat sensitivity area

Proposed turbine locations

High bat sensitivity buffer

Moderate bat sensitivity buffer

Figure 11: Bat sensitivity map of the southern portion of the Roodeplaat site

4.6 Passive Data

4.6.1 Abundances and Composition of Bat Assemblages

Average bat passes detected per bat detector night and total number of bat passes detected over the monitoring period by all systems are displayed in **Figures 12 - 14**. Four bat species were detected by the passive monitoring systems, namely, *Eptesicus hottentotus, Miniopterus natalensis, Neoromicia capensis* and *Tadarida aegyptiaca.*

Met mast 1 recorded a significantly higher number of bat passes compared to the other two systems (**Figure 13**). As expected, in general higher bat activity was detected at 10m height than 50m height by the met mast monitoring systems (**Figures 13-14**).

Tadarida aegyptiaca are the most abundant bat species recorded by all systems. Common and abundant species, such as *Neoromicia capensis, Tadarida aegyptiaca* and *Miniopterus natalensis*, are of a larger value to the local ecosystems as they provide a greater contribution to most ecological services than the rarer species due to their higher numbers.

Miniopterus natalensis is the only migratory species detected on site. The results of the full 12 months have been analysed for the presence of a migratory event and no migratory event was detected by the four passive monitoring systems. Thus the results are indicative of the site not being within a migratory route.

The average number of passes per night per month for the Masts were low over the winter months with a gradual increase over spring and summer. Average passes per night peaked over January, February and March 2014 with a general decline from April 2014 to the end of the July 2014 (**Figures 15-17**). Activity remained elevated from October 2013 to March 2014, with a general decline into winter 2014.

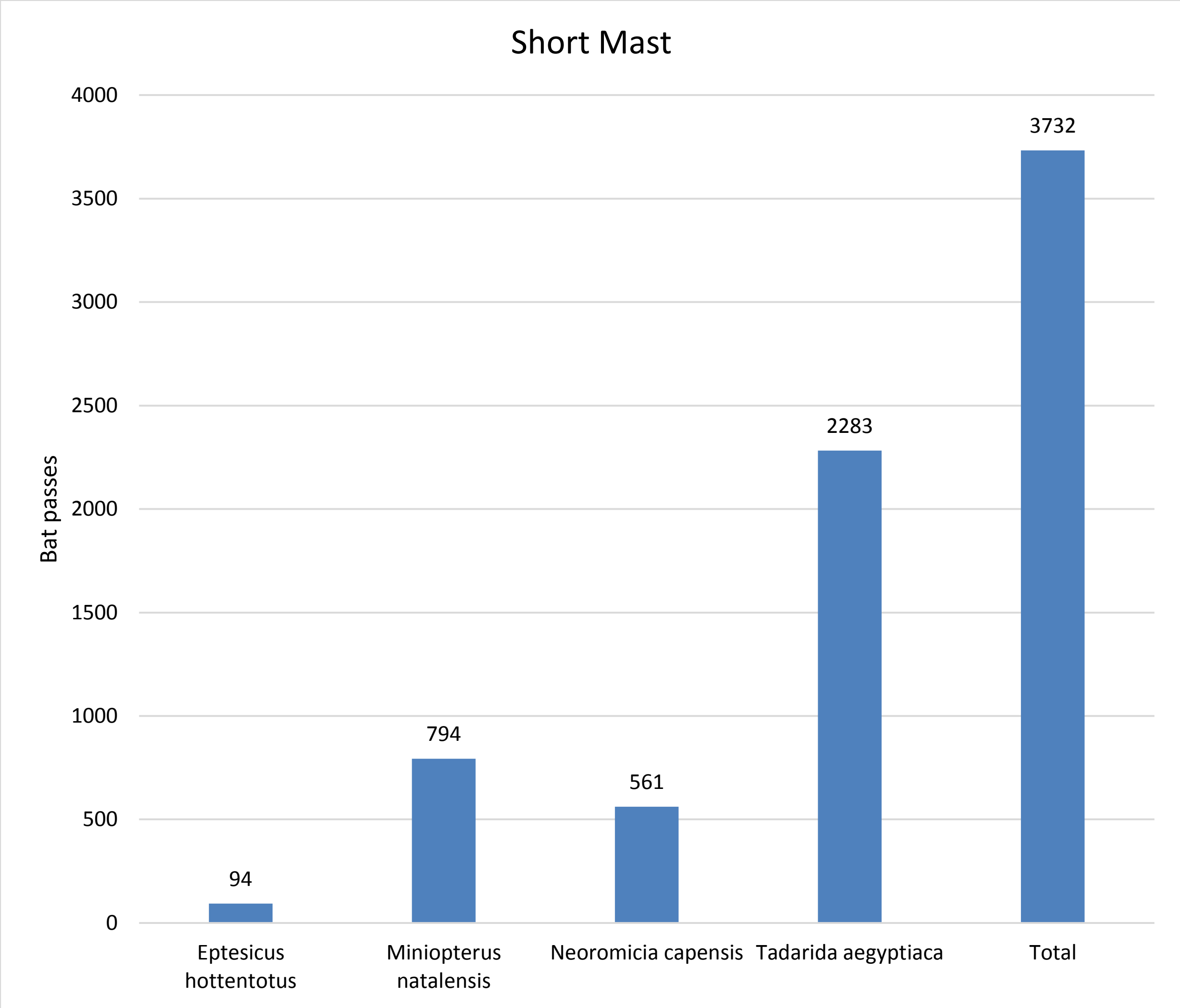


Figure 12: Total bat passes recorded by the detector on Short Mast (SM).

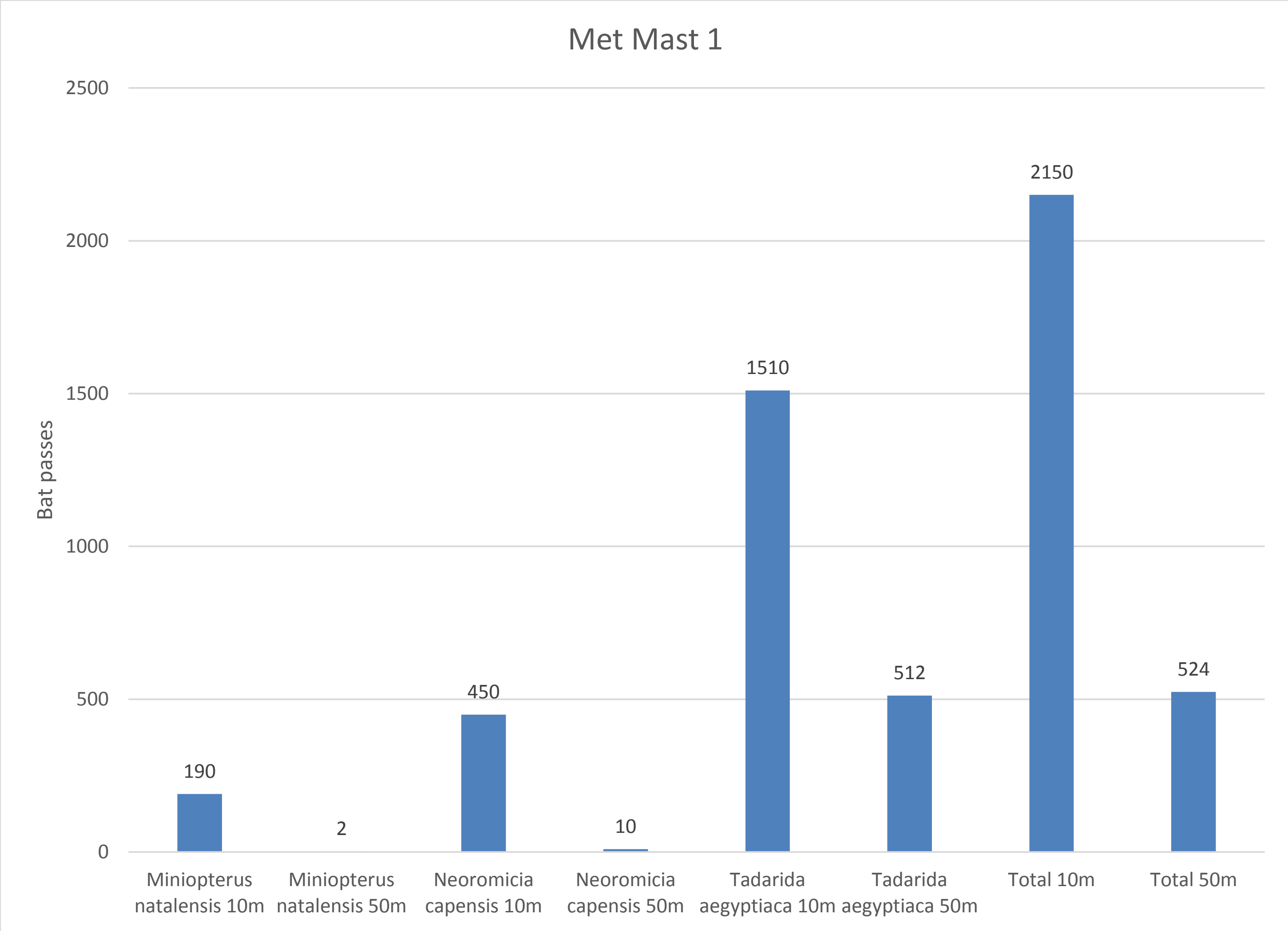


Figure 133: Total bat passes recorded by the detector on Met Mast 1 (Met1).

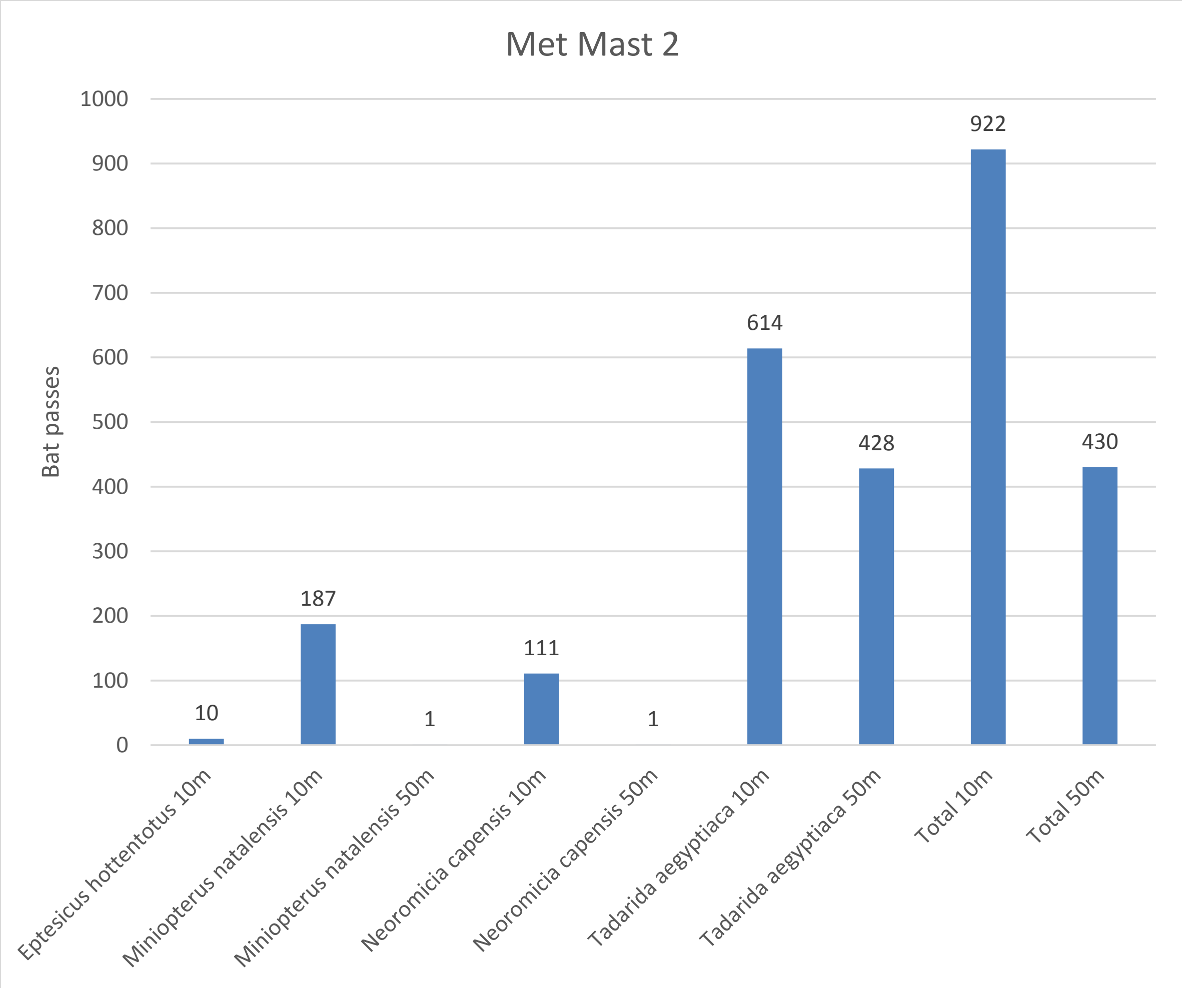


Figure 14: Total bat passes recorded by the detector on Met Mast 2 (Met2).

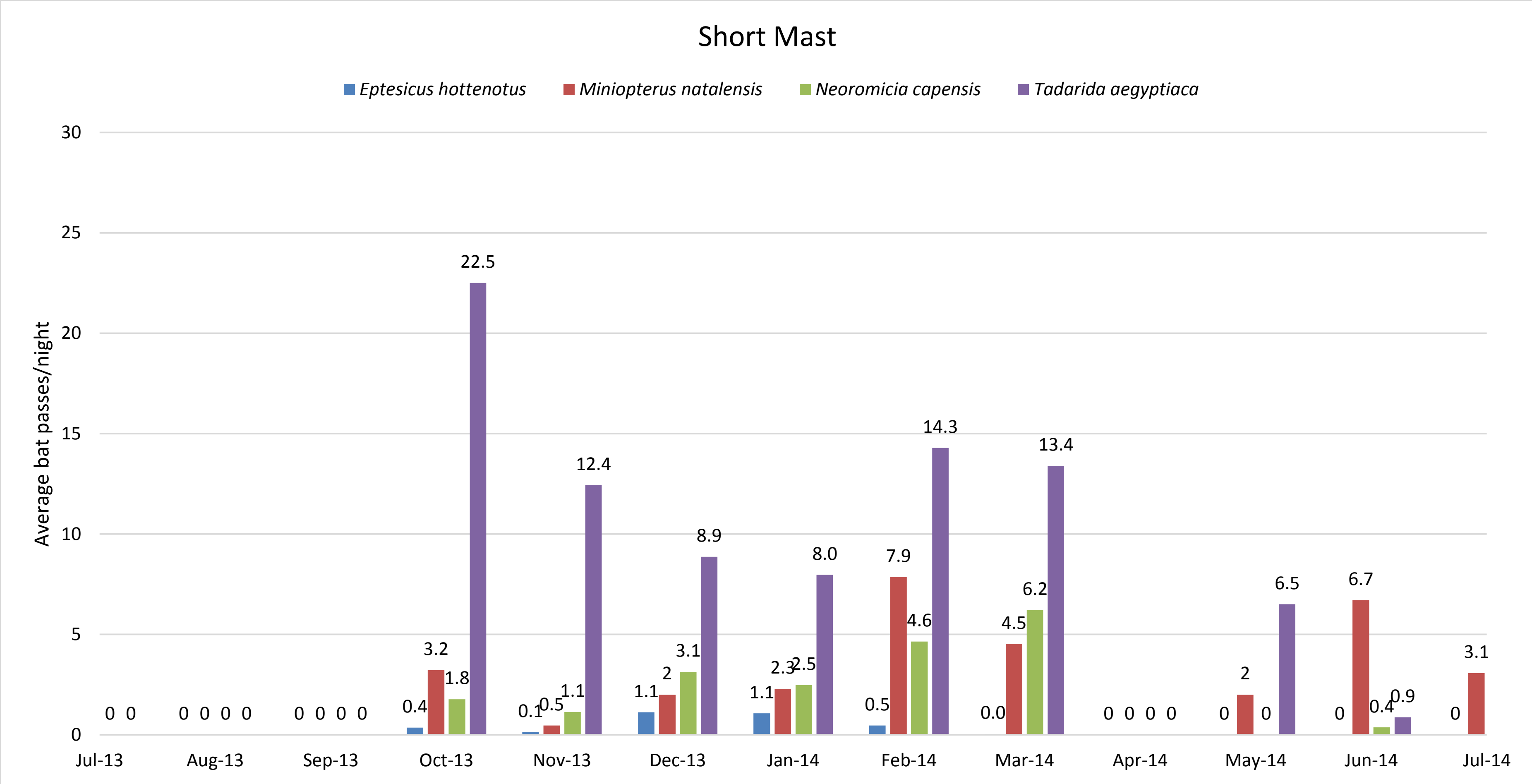


Figure 15: Average bat passes recorded by the detector on Short Mast (SM).

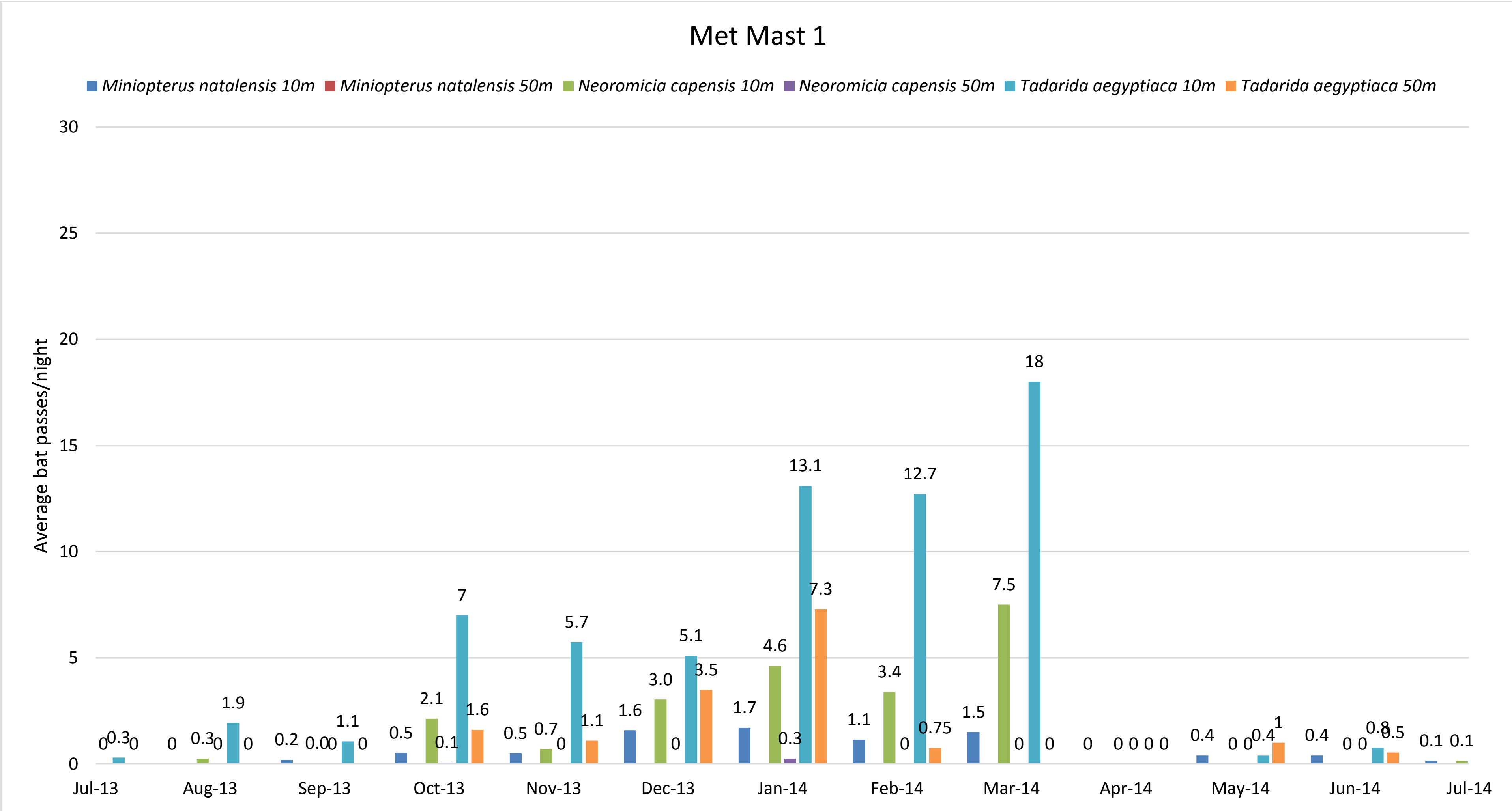


Figure 16: Average bat passes recorded by the detector on Met Mast 1 (Met1).

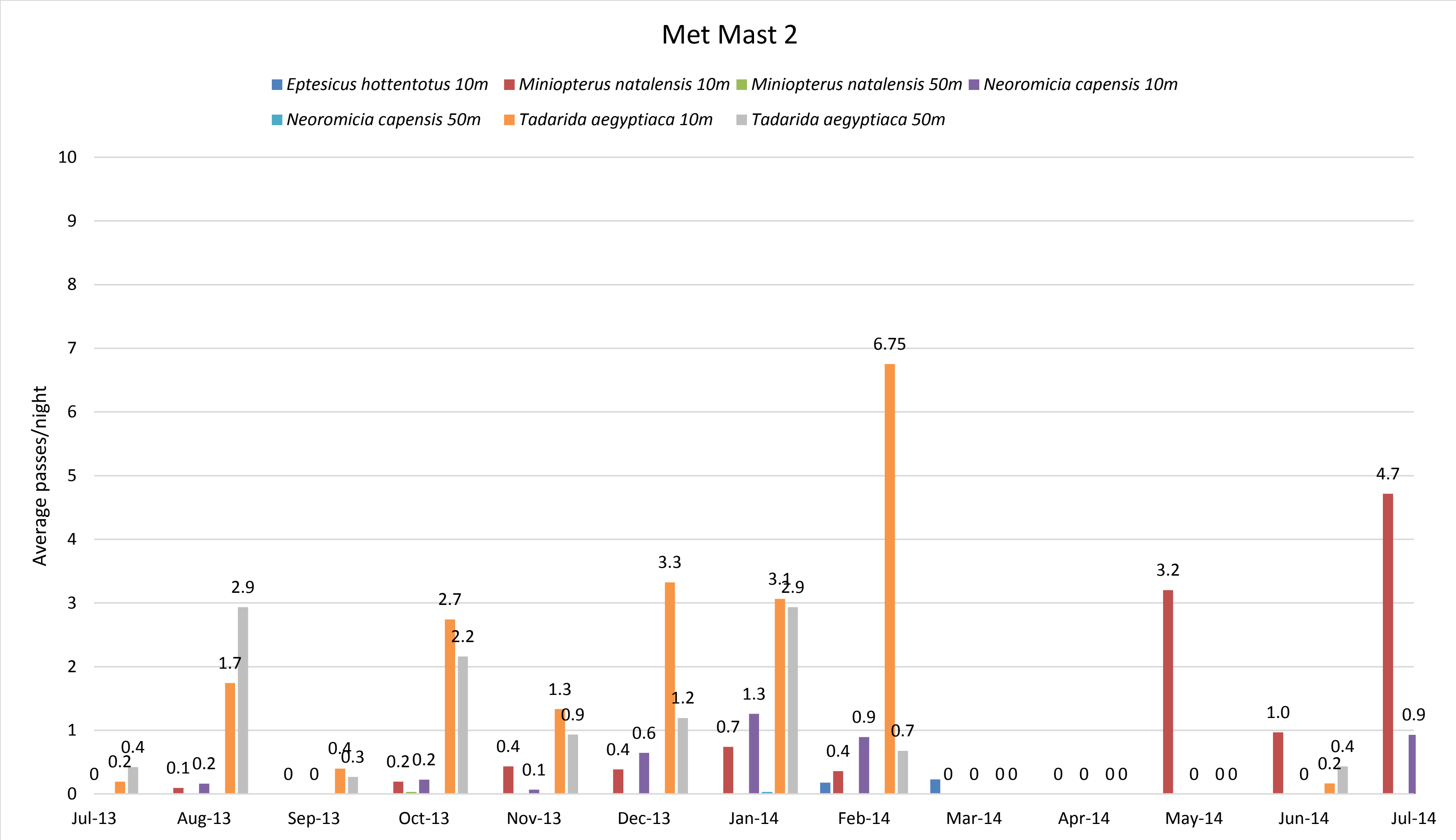


Figure 17: Average bat passes recorded by the detector on Met Mast 2 (Met2).

4.6.2 Temporal Distribution

The sum of all bat passes recorded by the detection systems of the particular species are displayed per night over the entire monitoring period (**Figures 18-20**). The bat passes across the times of night have been displayed in **Figures 21 - 32**. These figures give an indication of the specific date periods and time periods where high activity was detected and by each system. Periods of elevated bat activity as depicted in **Figures 18 - 32** are as follows:

- **Short mast**

Start of October – end of November 2013 (spring) over the time of sunset – 04:00

- **Met mast 1**

Mid-October 2013 – late February 2014 (spring and summer) over the time of sunset – 04:00

- **Met mast 2**

Mid-August – end August 2013, and start of Jan – end of February 2014 (part of winter and summer) over the times of sunset - 00:00

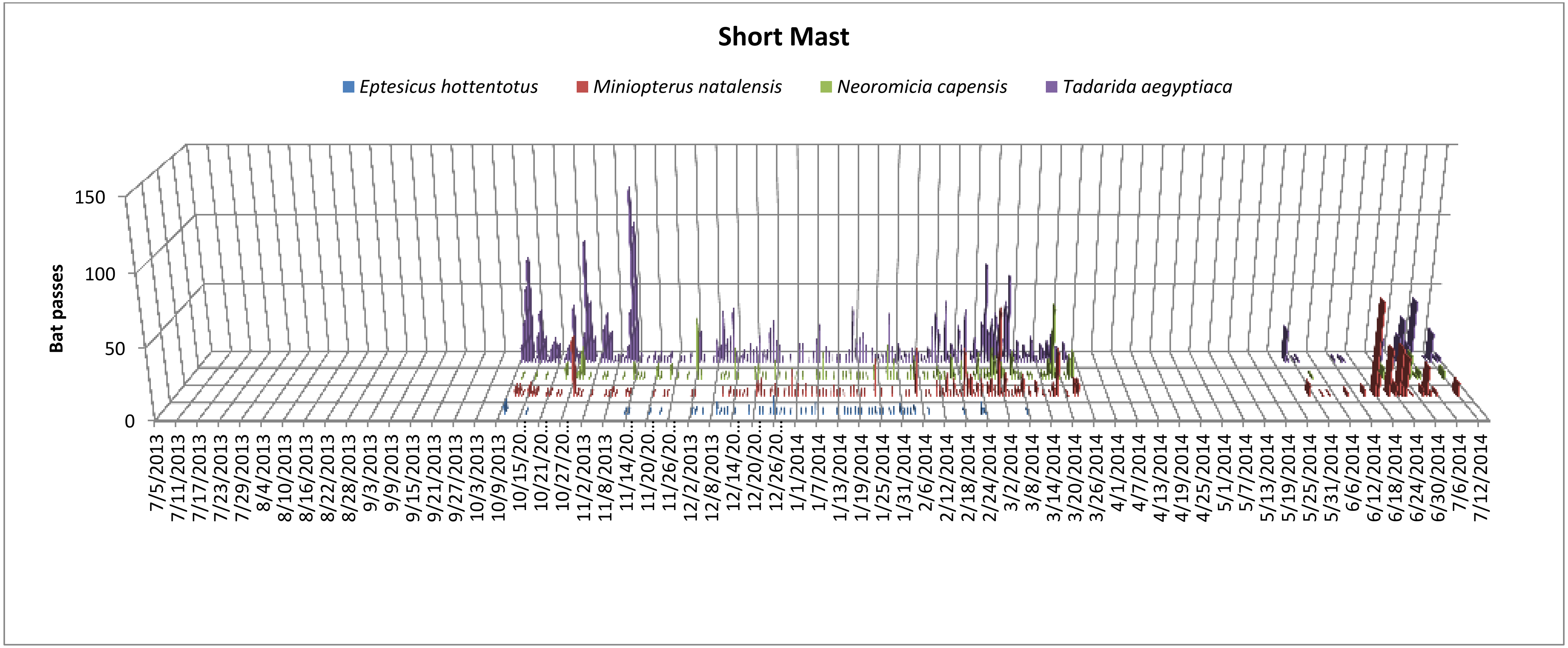


Figure 18: Temporal distribution of bat passes detected by Short Mast (SM).

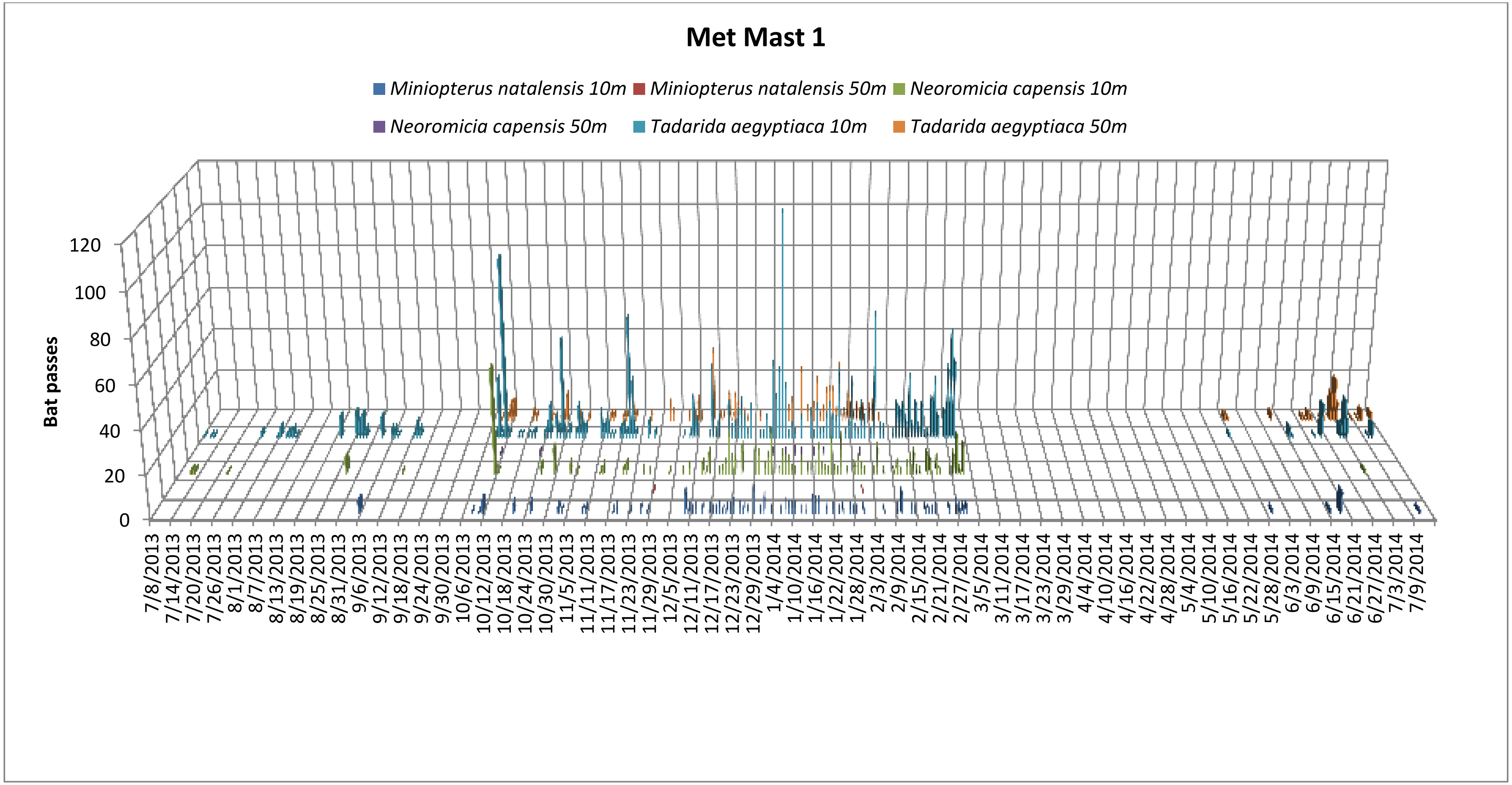


Figure 19: Temporal distribution of bat passes detected by Met Mast 1 (Met1).

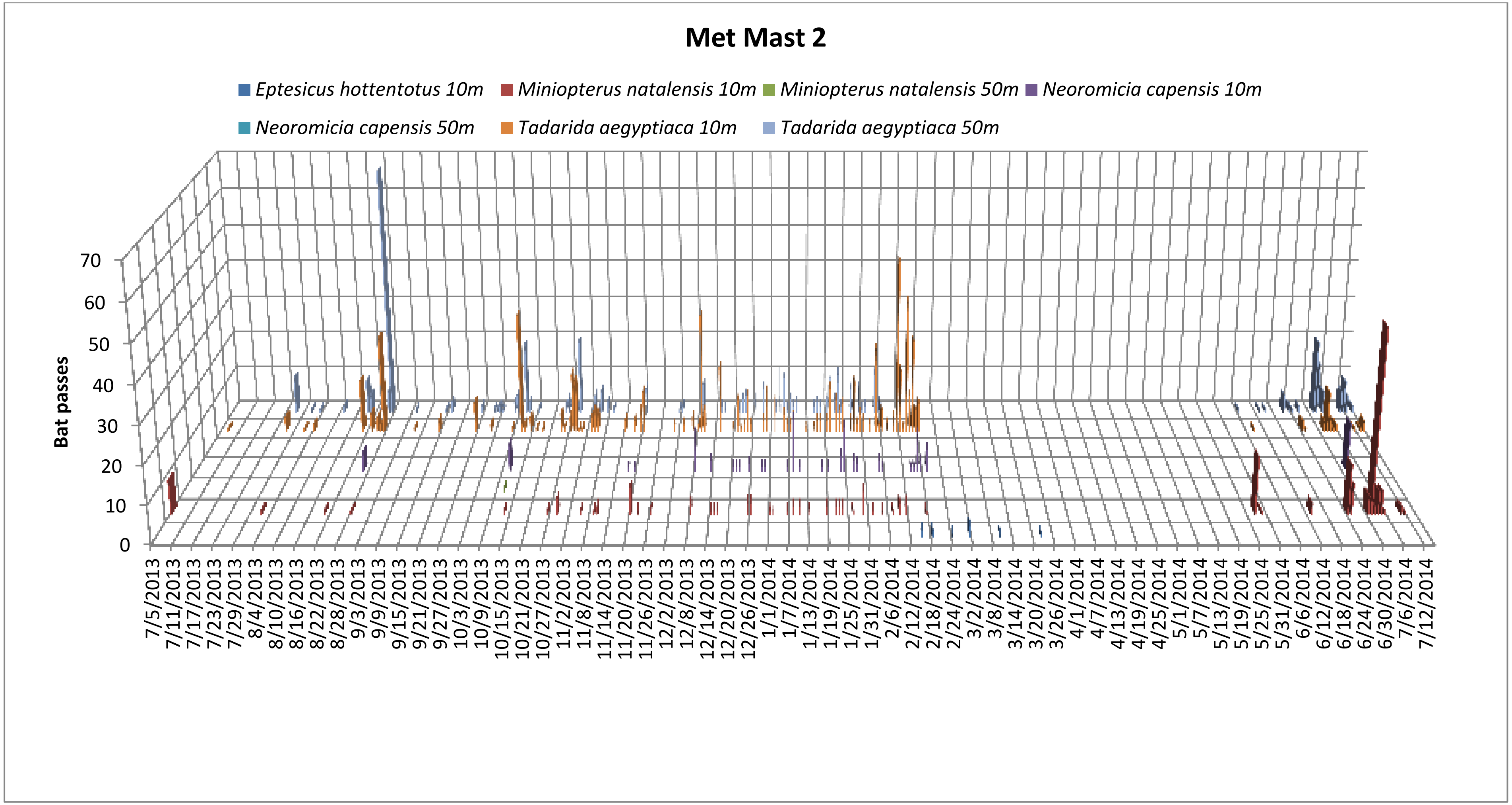


Figure 20: Temporal distribution of bat passes detected by Met Mast 2 (Met2).

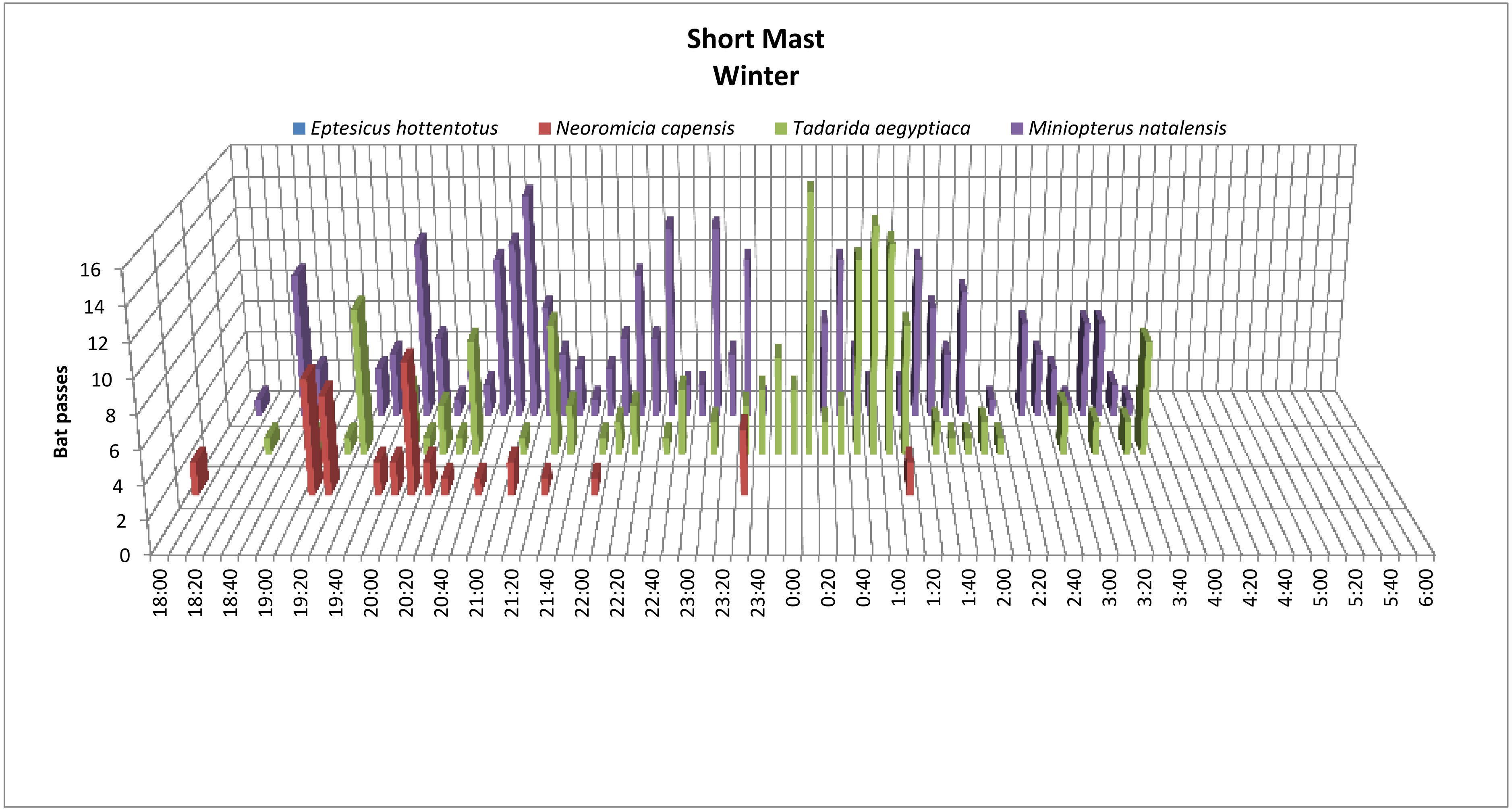


Figure 21: Time of night activity over the winter monitoring period recorded at Short Mast (SM).

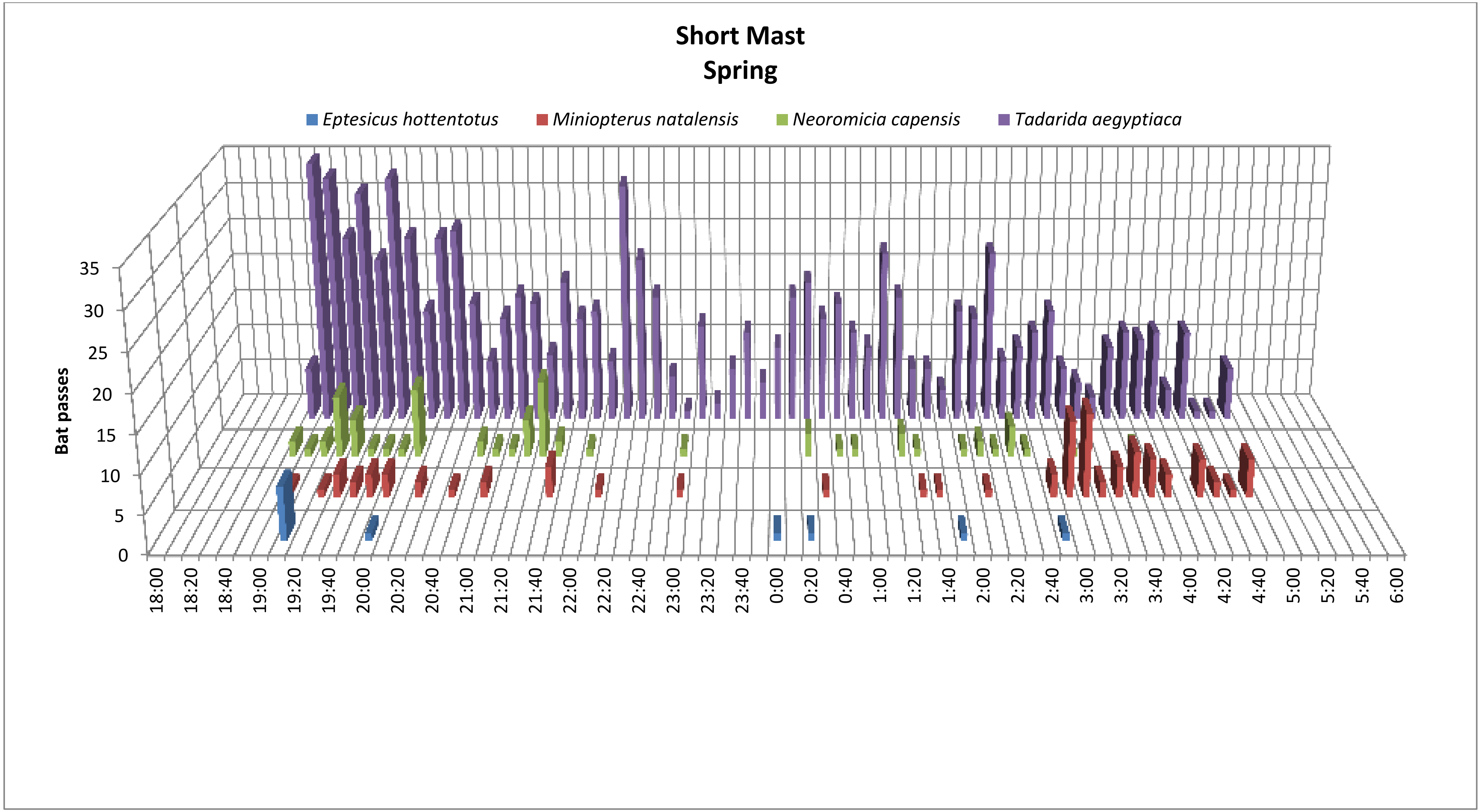


Figure 22: Time of night activity over the spring monitoring period recorded at Short Mast (SM).

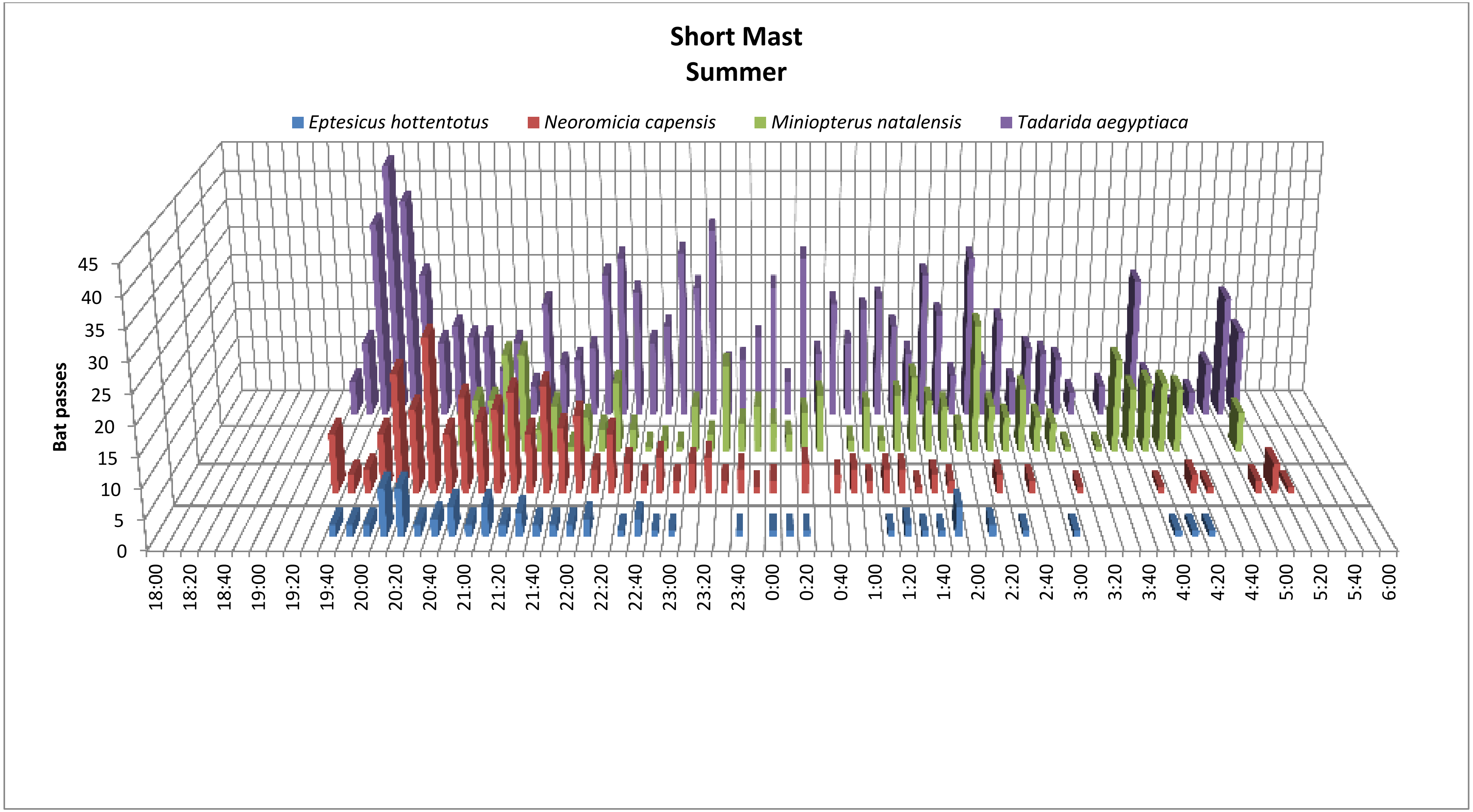


Figure 23: Time of night activity over the summer monitoring period recorded at Short Mast (SM).

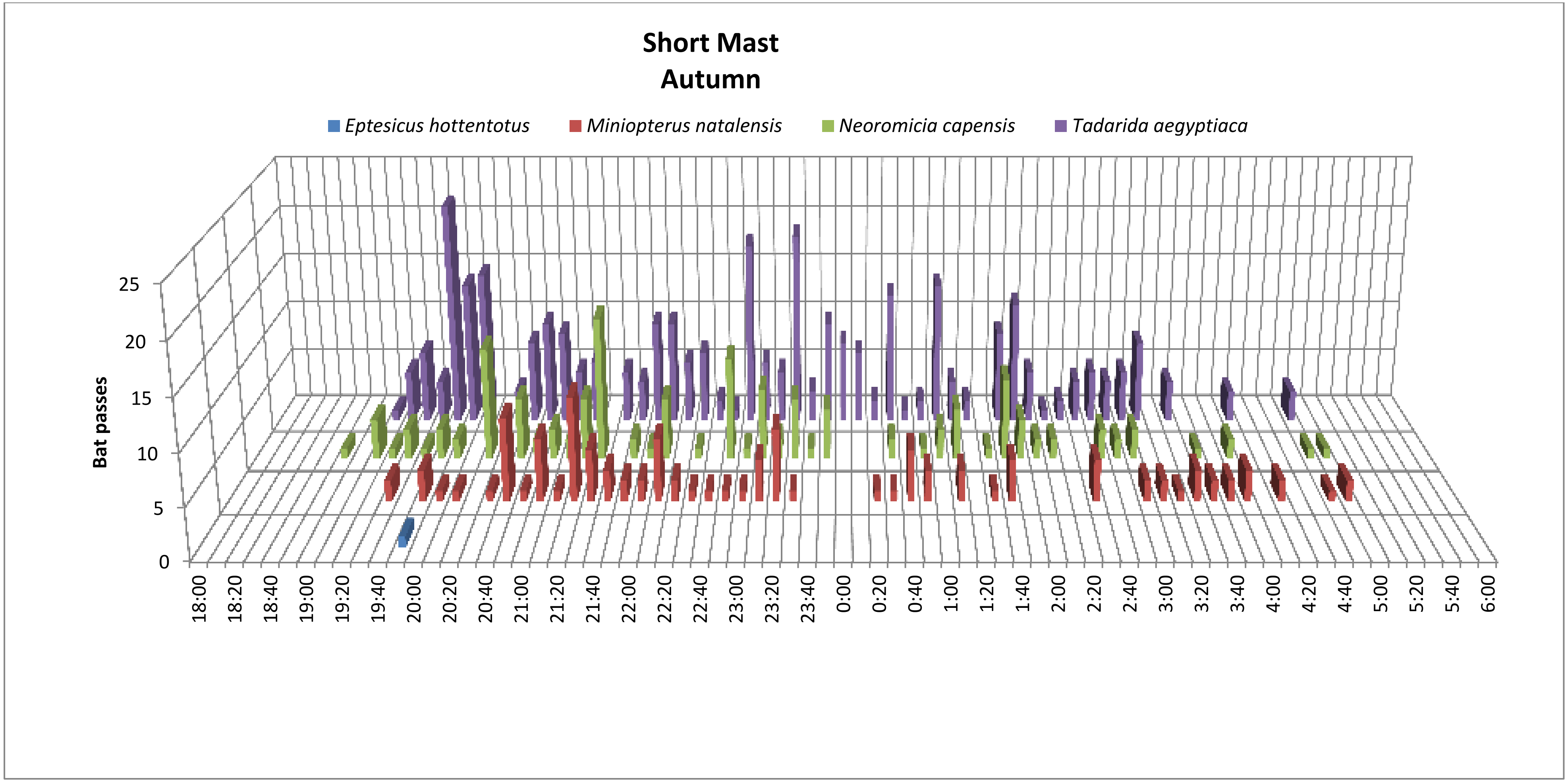


Figure 24: Time of night activity over the autumn monitoring period recorded at Short Mast (SM).

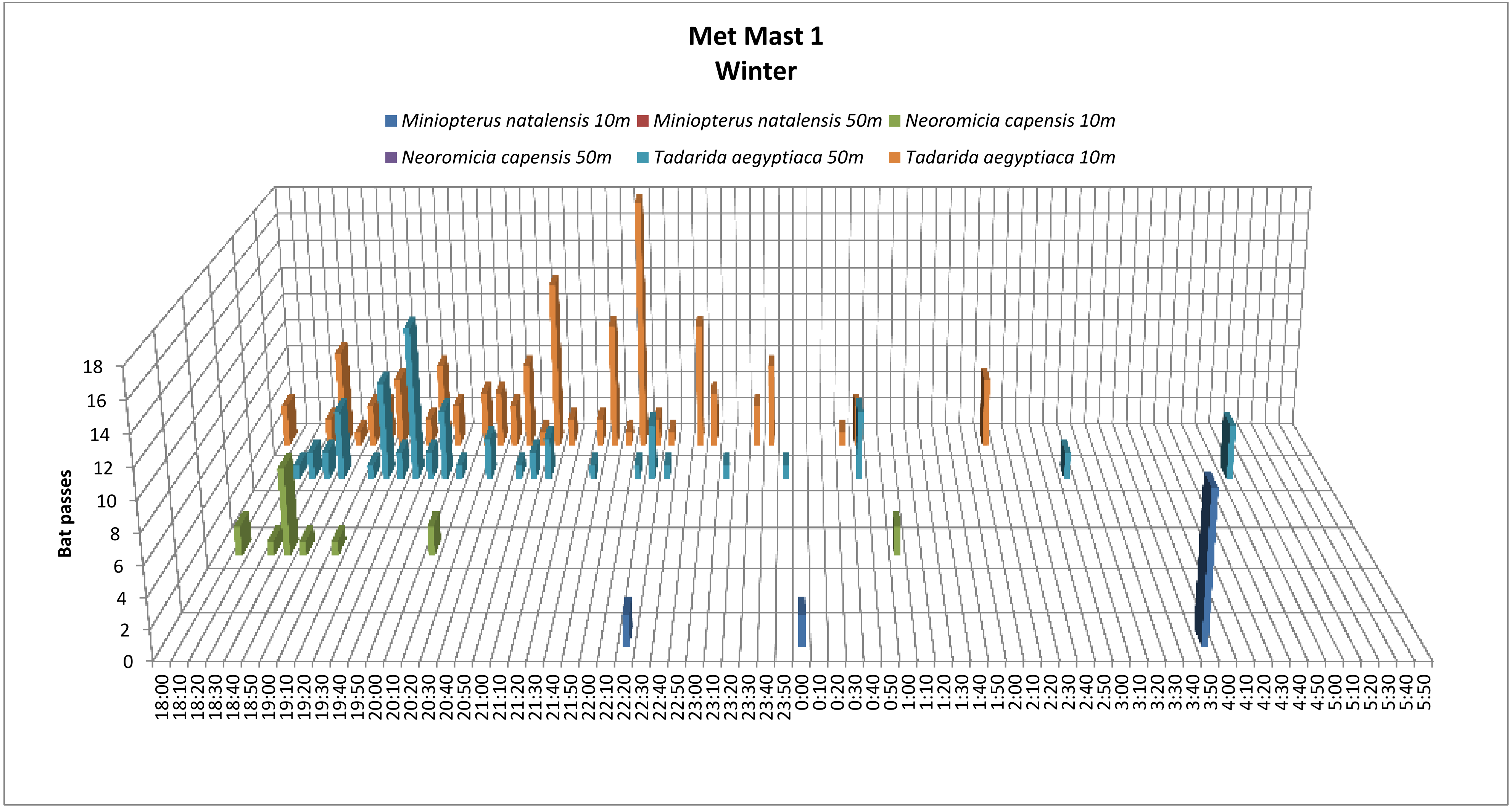


Figure 25: Time of night activity over the winter monitoring period recorded at Met Mast 1 (Met1).

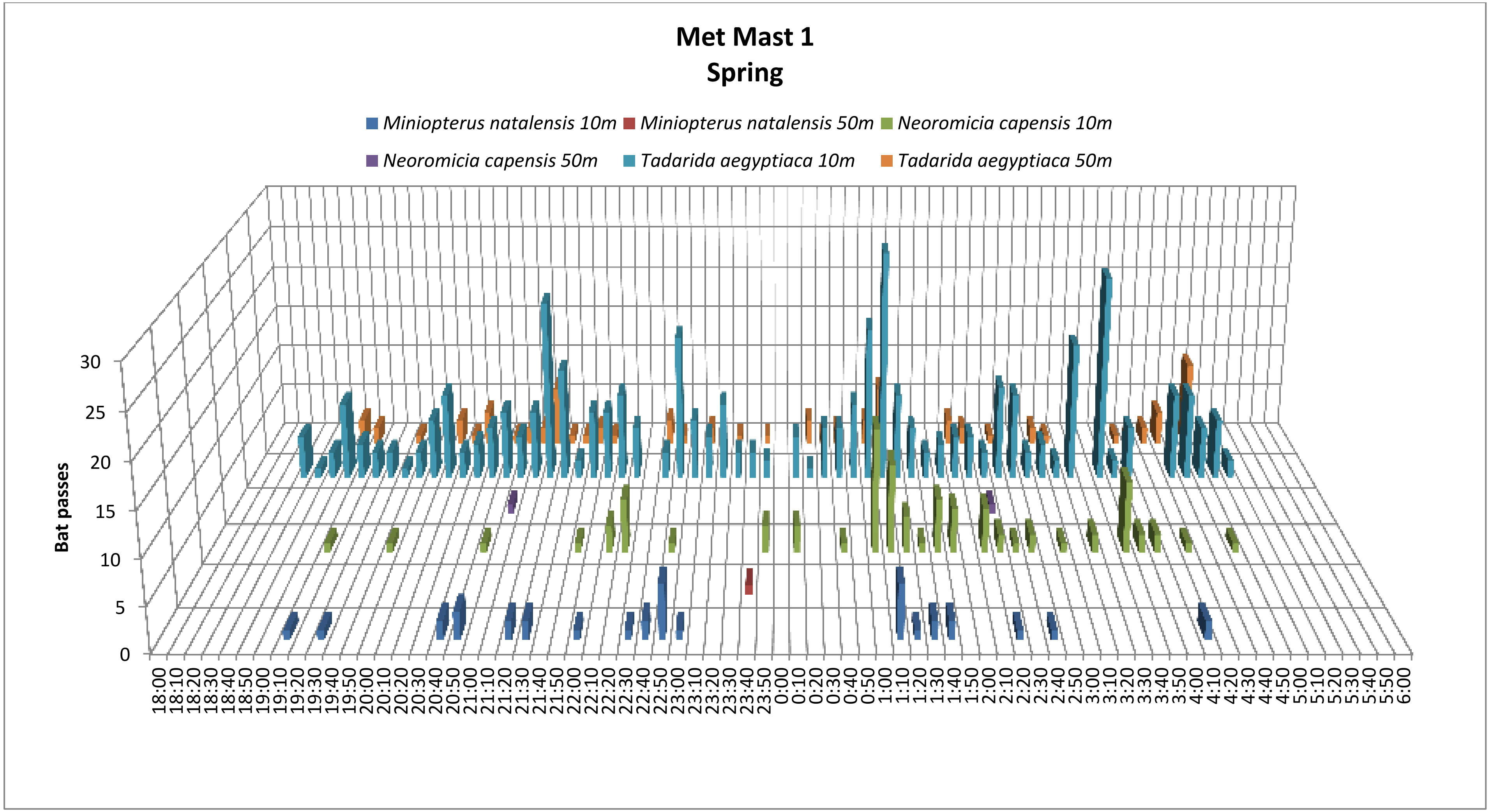


Figure 26: Time of night activity over the spring monitoring period recorded at Met Mast 1 (Met1).

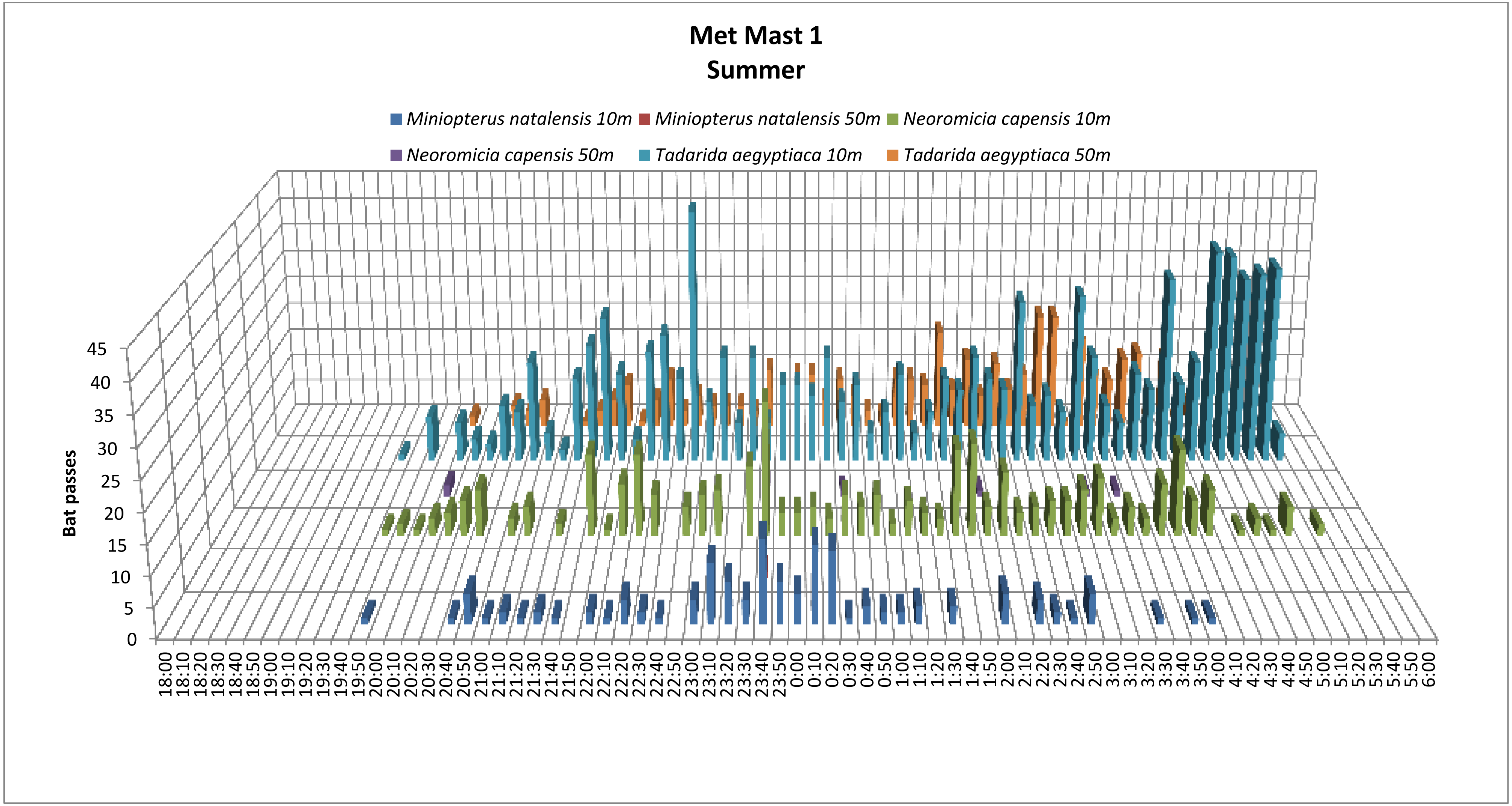


Figure 27: Time of night activity over the summer monitoring period recorded at Met Mast 1 (Met1).

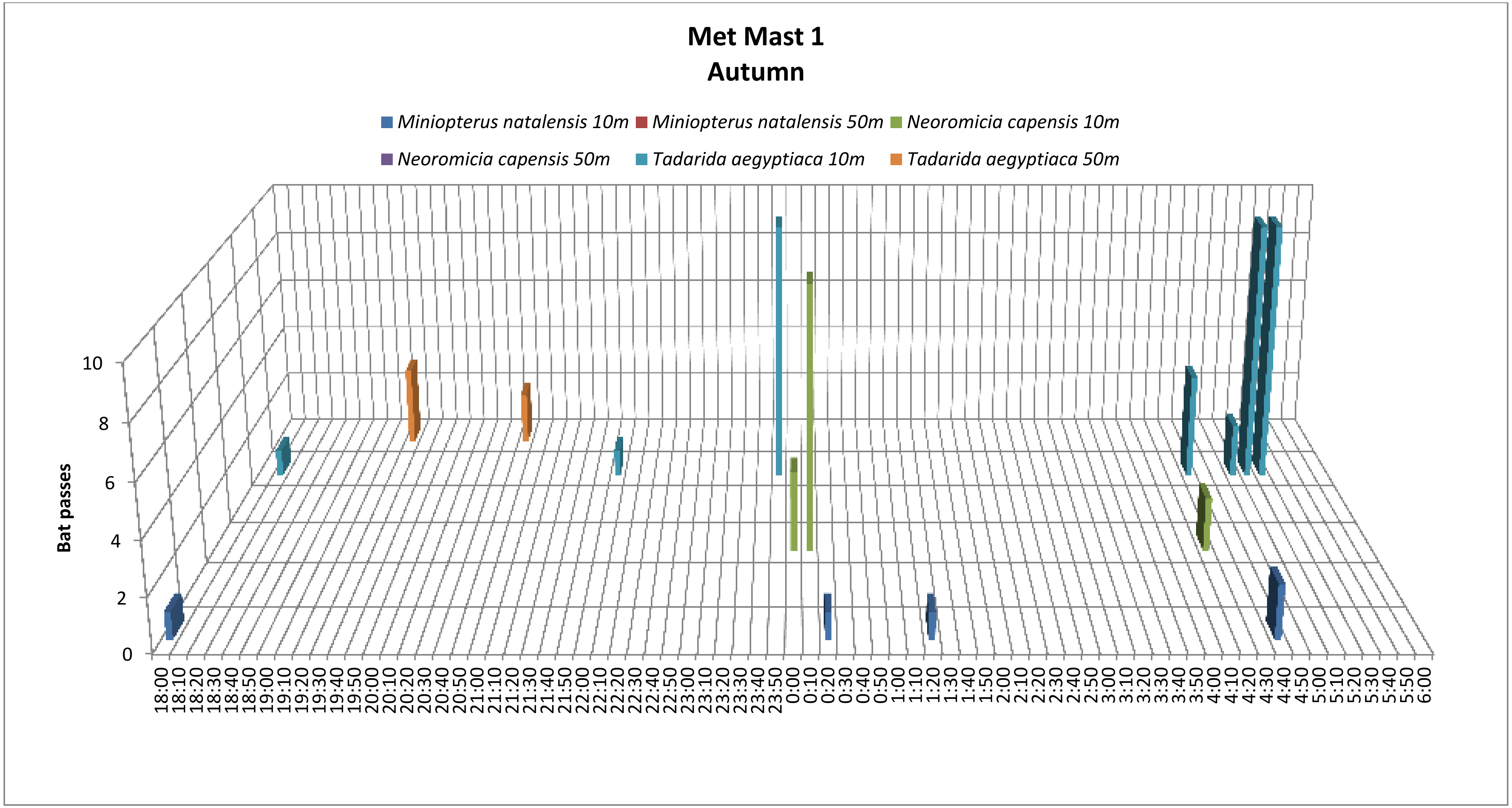


Figure 28: Time of night activity over the autumn monitoring period recorded at Met Mast 1 (Met1).

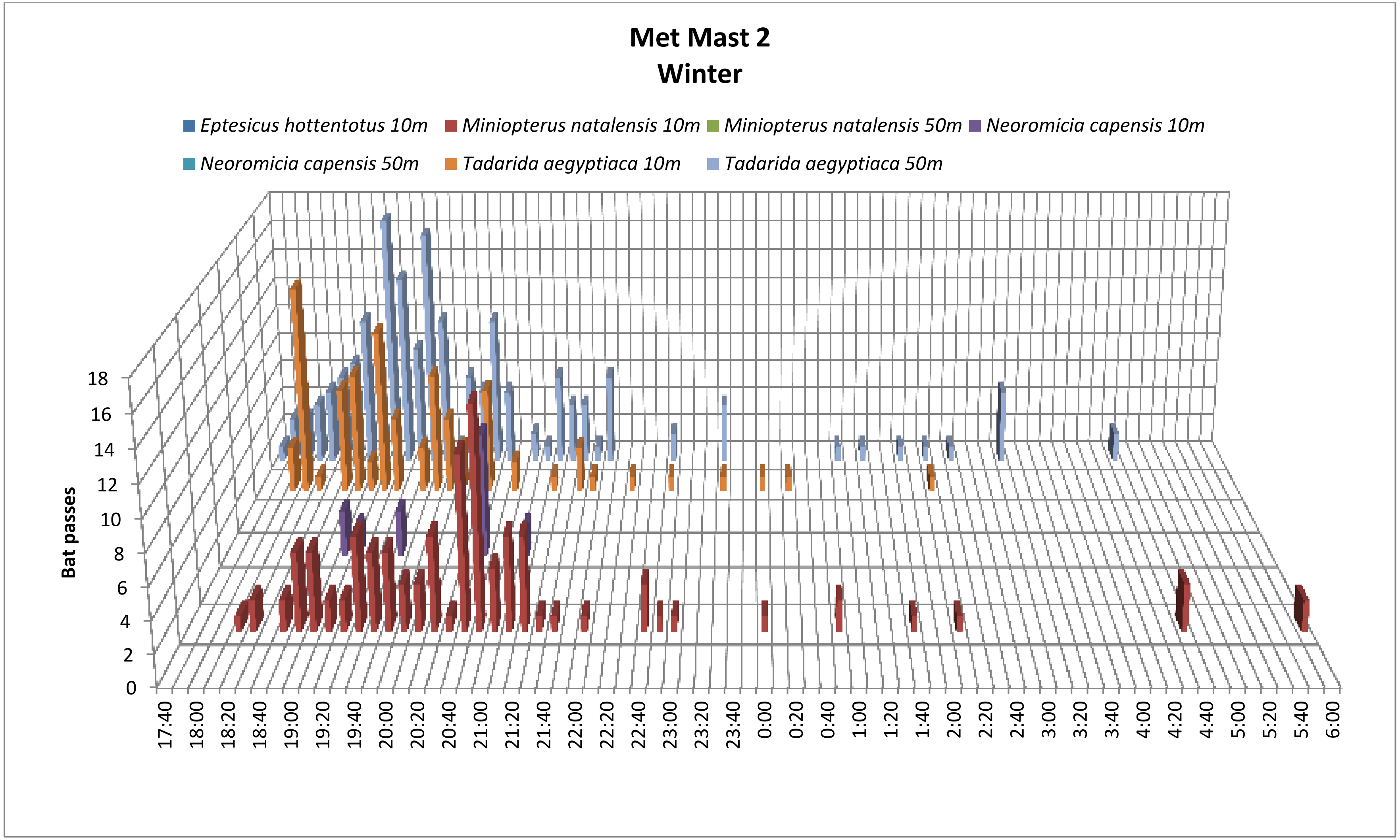


Figure 29: Time of night activity over the winter monitoring period recorded at Met Mast 2 (Met2).

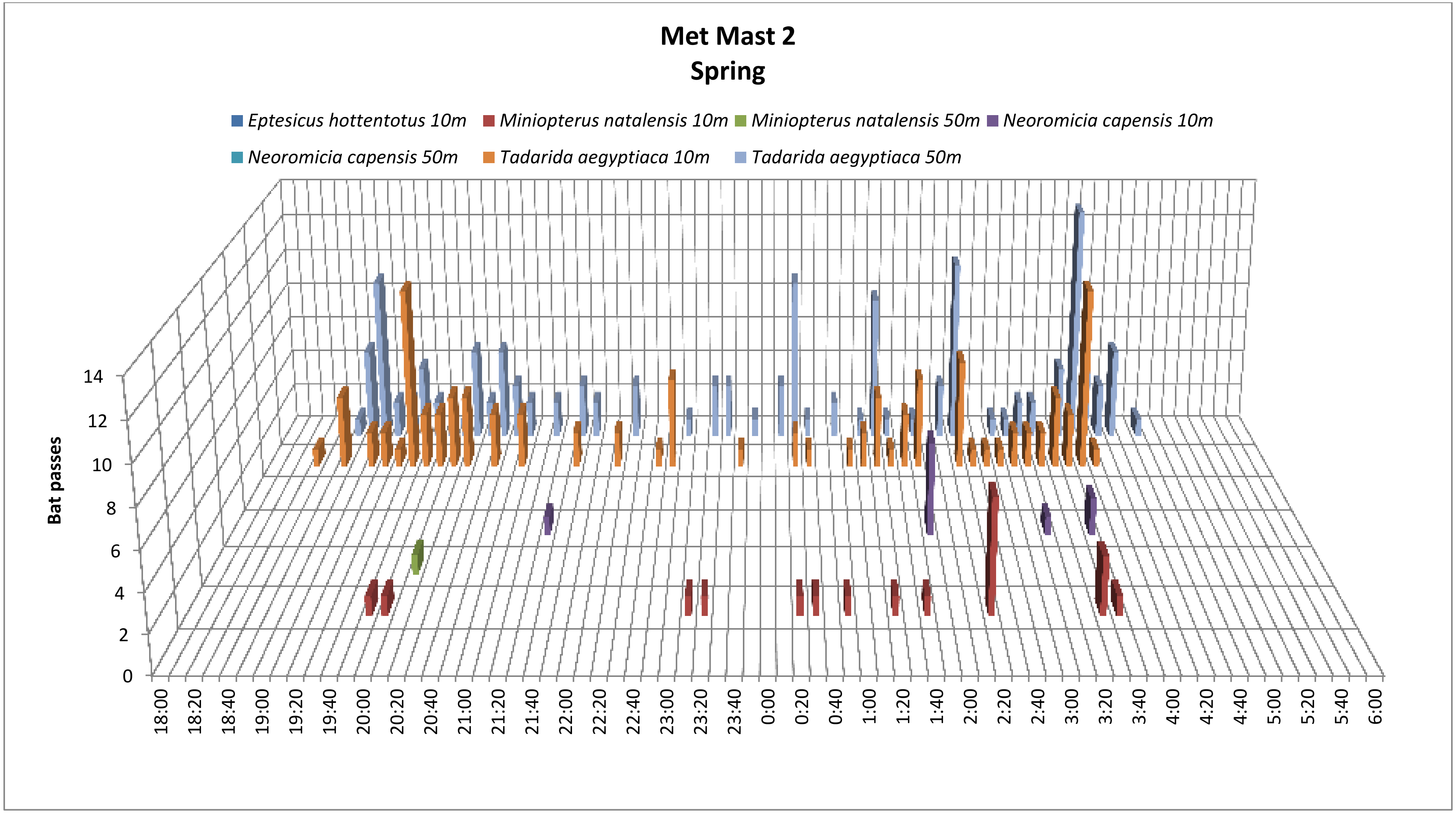


Figure 30: Time of night activity over the spring monitoring period recorded at Met Mast 2 (Met2).

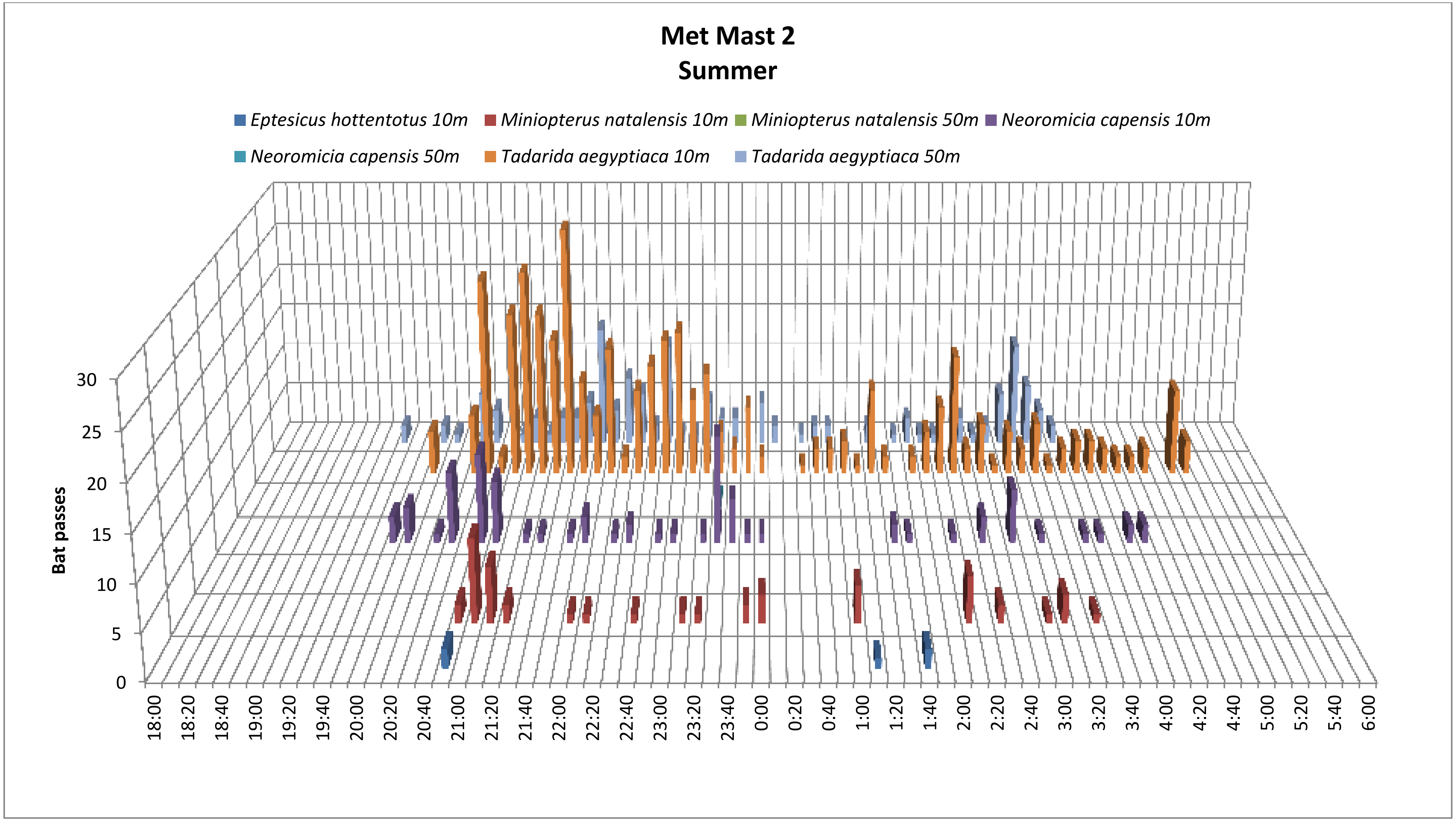


Figure 31: Time of night activity over the summer monitoring period recorded at Met Mast 2 (Met2).

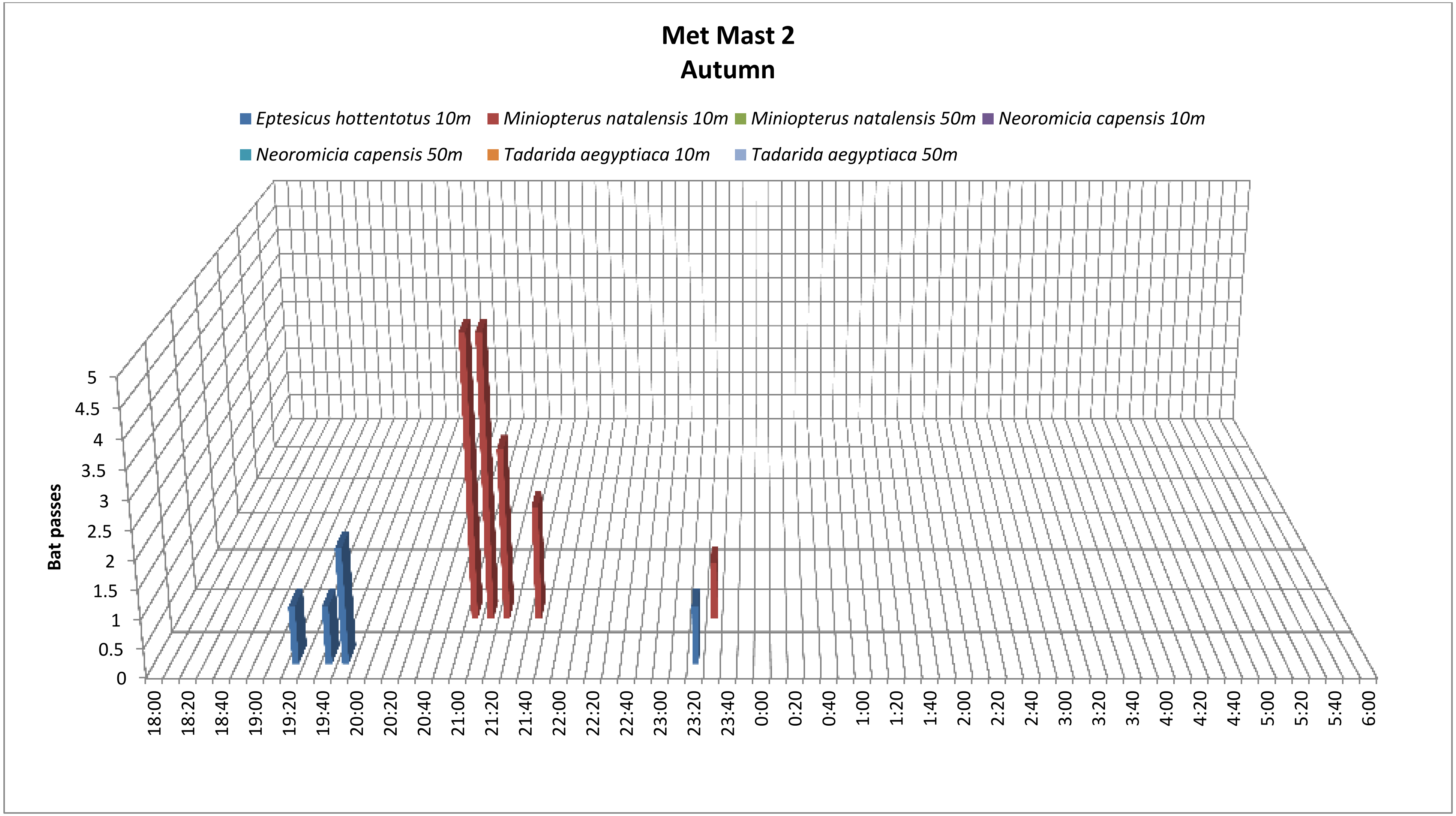


Figure 32: Time of night activity over the autumn monitoring period recorded at Met Mast 2 (Met2).

4.6.3 Relation between Bat Activity and Weather Conditions

Several sources of literature 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 note the 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, temperature and barometric pressure influences 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' wind speeds (Arnett *et al*. 2009).

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. This relationship is used in the sensitivity map whereby the larger vegetation and man-made structures provide shelter from the wind. 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 (flies) 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.

5 PROPOSED MITIGATION MEASURE 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.

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

Curtailment:

Curtailment is 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:

Cut-in speed is defined as the wind speed at which the generator is connected to the grid and producing electricity..

Feathering or Feathered:

Adjusting the angle/pitch 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 producing power.

Blade locking or full feathering below the manufacturers cut in speed, that locks or significantly reduces the speed the blades turn, is more desirable for the conservation of bats than allowing free rotation with no feathering below the manufacturers cut in speed.

Acoustic deterrents are a developing technology and will need investigation as a possible option for mitigation if during operation mitigation is found to be required

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. 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.

Power modes for turbines are the various operational modes linked to cut in and cut out and tip speeds for turbines that the turbines are designed to be able to operate at without overstraining the turbines. Different modes are used to reduce the noise output of the turbines (which also reduces the energy output) and the greater the reduction in noise the slightly slower the tip speeds are. Thus using lower noise modes will reduce the tip speed of the turbines

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 presented below:

1. No curtailment (free-wheeling is unhindered below manufacturers cut in speed so all momentum is retained, thus normal operation).
2. Feathering blades below manufacturers cut-in speed to as close to 70 degrees as possible or more so as to reduce the free-wheeling blade rotation
3. Feathering of blades below manufacturers cut-in speed to as close to 90 degrees as possible so as to minimise free-wheeling blade rotation as much as possible without locking the blades.
4. 90 Degree feathering of blades below manufacturers cut in speed, with reduced power mode settings between manufacturers’ cut-in speed and mitigation cut-in conditions.
5. 90 Degree feathering of blades below mitigation cut in conditions.
6. 90 Degree feathering throughout the entire night.

A preliminary recommendation would be that curtailment mitigation initiates at **Level 4** for the months, times and weather conditions determined from the data obtained to be the times most likely for increased bat activity and therefore increased likelihood of impact. These times and weather conditions are outlined in Section 6 below. If such mitigation is undertaken, then depending on the results of the post construction mortality monitoring the mitigation can be either relaxed or intensified (moving down or up in the levels) up to a maximum intensity of **Level 5.** This is an adaptive mitigation management approach that will require changes in the mitigation plan to be implemented immediately and in real time during the post construction monitoring.

6 MITIGATION SCHEDULE

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. However the monitoring systems detected significant peaks in activity over the 12 month monitoring period. Bat species active over these time frames need to be protected from the impacts of wind turbines. Thus preliminary mitigations are advised for all potential risk turbines according to the parameters listed in the tables below.

The tables infer mitigation be applied during the peak activity periods and times, and when the indicated wind speed and temperature ranges are prevailing **simultaneously**. These wind speed and temperature values are the averages as measured by the met masts over the peak bat activity dates and time of the night.

This schedule is intended to be used initially at the start of the operational phase, however the exact mitigation parameters will be adjusted and adapted as determined by the operational monitoring data. These changes may be applied within a few weeks after operation commenced.

The times of implementation of mitigation measures is preliminarily recommended as follows:

Table 11: According to bat activity measured at the short mast.

	Terms of mitigation implementation to be applied to turbines 16, 36, 40, 41, 42, 51
Period of peak activity (times to implement curtailment/ mitigation)	Start of October – end of November
	Sunset – 4:00
Environmental conditions in which turbines must be mitigated	Below 8 m/s (measured at 61m); Above 13.0°C (measured at 5m)

Table 12: According to bat activity measured at Met mast 1.

	Terms of mitigation implementation to be applied to turbines 4, 12
Period of peak activity (times to implement curtailment/ mitigation)	Mid October – end of February
	Sunset – 22:00 and 00:00 – 04:00 (Oct, Nov) Sunset – sunrise (Dec, Jan, Feb)
Environmental conditions in which turbines must be mitigated	Oct, Nov: Below 9 m/s (measured at 61m); Above 14.0°C (measured at 5m) Dec, Jan, Feb: Below 9 m/s (measured at 61m); Above 14.0°C (measured at 5m)

Table 13: According to bat activity measured at Met mast 2.

	Terms of mitigation implementation to be applied to turbines 19, 37
Period of peak activity (times to implement curtailment/ mitigation)	Mid-August – end August 2013; Sunset – 21:00
	1 January – end of February; Sunset – 00:00
Environmental conditions in which turbines must be mitigated	Aug: Below 8 m/s (measured at 61m); Above 15.0°C (measured at 5m) Jan, Feb: Below 9 m/s (measured at 61m); Above 18.0°C (measured at 5m)

7 IMPACT ASSESSMENT OF PROPOSED WEF ON BAT FAUNA

7.1 Construction phase

Impact: During construction, the earthworks can damage bat roosts in rock crevices.								
	Spatial Extent	**Intensity**	**Duration**	**Consequence**	**Probability**	**Significance**	**+-**	**Confidence**
Before Management	Local	Medium	Long term	Medium	Possible	Low	-	High
Management Measures								
Adhere to the sensitivity map during turbine placement								
After Management	Local	Low	Long term	Low	Possible	Very Low	-	High
No-go Option	N/A							

Impact: Some foraging habitat will be permanently lost by construction of turbines, access roads and associated infrastructure.								
	Spatial Extent	**Intensity**	**Duration**	**Consequence**	**Probability**	**Significance**	**+-**	**Confidence**
Before Management	Local	Medium	Long term	Medium	Possible	Low	-	High
Management Measures								
Adhere to the sensitivity map (for practical reasons only applicable to turbine locations). 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.								
After Management	Local	Low	Long term	Low	Possible	Very Low	-	High
No-go Option	N/A							

7.2 Operational phase

Impact: Bat mortalities due to operational turbine blades. The concerns of foraging bats in relation to wind turbines is discussed in Section 2.2.								
	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+-	Confidence
Before Management	Regional	Medium	Long term	High	Probable	High	-	High
Management Measures								
Adhere to the sensitivity map (for practical reasons only applicable to turbine locations). Apply outlined mitigations to any further layout revisions, no turbines should be placed in areas of High bat sensitivity and their buffers as well as preferably avoid areas of Moderate bat sensitivity and their buffers for turbine layout. Also see Sections 5 and 6 on mitigation options and recommendations for minimising risk of mortalities.								
After Management	Regional	Low	Long term	Medium	Possible	Low	-	Medium
No-go Option	N/A							

Impact: During operation if strong artificial lights are used at the facility (for example at turbine bases), it will attract insects and thereby also bats. This increases the likelihood of impacts on bats by the wind turbines. Additionally, only certain species of bats will readily forage around strong lights, whereas others avoid such lights even if there is insect prey available. This can draw insect prey away from other natural areas and thereby artificially favour certain species, affecting bat diversity in the area.								
	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+-	Confidence
Before Management	Local	Medium	Long term	Medium	Definite	Medium	-	High
Management Measures								
Utilise lights with wavelengths that attract less insects (low thermal/infrared signature). Any lights at turbine bases must be equipped with passive motion sensors as to only switch on when a person is nearby. If not required for safety or security purposes, lights should be switched off when not in use.								
After Management	Local	Low	Long term	Low	Possible	Very Low	-	High
No-go Option	N/A							

8 OPERATIONAL MONITORING PRELIMINARY METHODOLOGY OUTLINE

8.1 Introduction

Operational phase monitoring and research programs across North America and Europe have identified bats to be vulnerable to mortality due to wind turbines in the long term. Bats are particularly vulnerable to non-natural causes of mortality as they are long-lived animals with low reproductive fecundity. Additionally, there is relatively little scientific knowledge about bat populations and migration routes. It is recommended that a minimum of two year operational monitoring be undertaken as soon as turbines are functional, with auditing continuing throughout the lifespan of the Roodeplaat WEF.

The primary objectives of the operational phase monitoring programme would be to:

- Determine the bat fatality rates for the Roodeplaat WEF
- Determine the fatality rates for species of concern
- Determine the fatality rates for migratory and resident bat species
- Study the relation of bat fatalities within all habitats, geology and vegetation types found in turbine areas
- Compare the bat fatality rates with those from wind farms in similar habitat types where possible
- Determine the relationship between bat activity and bat fatality
- Understand the relationship between bat fatality and weather conditions
- Study the temporal distribution of bat fatalities across the night and seasons
- Determine whether mitigation measures are necessary to reduce bat fatality rates, and if necessary recommend detailed mitigation measures

8.2 Methodology

Operational monitoring methodology is divided into two components, namely acoustic monitoring and carcass searches. <u>On conclusion of the first year an adapted methodology will be outlined for the second year of monitoring.</u>

8.2.1 Acoustic monitoring

Acoustics detectors and ultrasonic microphones will be used to monitor bat activity. They will be installed on the meteorological mast and/or a sub-sample of turbine nacelles to monitor activity in the rotor-swept path of high risk and select turbines.

8.2.2 Carcass searches

Carcass searches will be undertaken to determine bat fatality rates. This component of the methodology will be combined with that of the carcass searches for the bird monitoring programme.

Locals will be trained in proper search techniques to carry out the carcass searches and to record and collect all carcasses located. Searches will begin as early in the morning as possible to reduce carcass removal by scavengers. The order in which turbines are searched will ideally be randomly selected for each day to reduce carcass removal by predators from specific turbines before they can be searched. Search intervals will be a maximum of one week.

All necessary information will be recorded when a carcass is found. The carcass will then be bagged and labelled and kept refrigerated for species identification and to determine the cause of death by the specialist. Fatality monitoring will be carried out over all seasons of the year.

The necessary searcher efficiency and scavenger removal trials will be carried out at least once per season to calculate field bias and error estimation.

8.3 Wind turbine mitigation

Data collected throughout the monitoring programme will be used to inform and direct mitigation if the Roodeplaat WEF or specific turbines is found to be causing significant bat mortality. If mitigations are implemented, monitoring the effectiveness of the applied techniques will be necessary to evaluate and refine the success and economic efficiency of the mitigation.

8.4 Deliverables

- Four monitoring reports will be submitted for the first year, on conclusion of the first year an adapted reporting and methodology schedule will be outlined for the second year of monitoring. Reports will include descriptions of the field protocols and sampling methods. Raw data will be included in the reports as appendices, and methods for data analysis shall be transparent.
- A contingency plan will be compiled which informs immediate actions to be taken in the case of a significant mortality event, or if mitigation measures fail. A contingency

plan will consist of additional mitigation measures to be implemented in the event that significant negative impacts are observed from a single mortality survey.

- An adaptive management approach to the operational monitoring programme.

The methodology of the assessment will comply with requirements pertaining to the South African Good Practice Guidelines for Operational Monitoring for Bats at Wind Energy Facilities (the latest version available at the time of commencement), which will be a mandatory requirement for all specialists.

9 CONCLUSION

The site was visited over the period of 14 – 18 July 2014 wherein the three passive monitoring systems were decommissioned and all data was downloaded. The monitoring systems served the purpose of recording bat activity every night for the 12 month pre-construction study period. This data has been used to outline mitigation measures to be implemented upon operation of the wind farm.

The valley and kloof areas can offer adequate roosting sites, high insect abundance and surface water while the mountain slopes may provide roosting sites in the form of rock crevices and caverns. The alluvial vegetation zone may lead to increased quantities of insects during favourable climatic conditions. This may lead to an increase in bat numbers during these times.

The time periods of data loss due to system faults were short and intermittent such that the loss is an insignificant influencer to the monitoring campaign results.

A sensitivity map was drawn up indicating bat sensitive roosting and foraging areas (**Figures 9 - 11**). The Moderate bat sensitivity areas and associated buffer zones must be prioritised during operational monitoring, and these turbines will require initial mitigation measures listed in **Sections 5 and 6**. The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity. High Bat Sensitivity areas and their respective buffers are 'no – go' areas due to the expected elevated rates of bat fatalities due to wind turbines, and no turbines should be placed within these areas.

No turbines are currently located within a moderate bat sensitivity area. Turbines 4, 12, 16, 17, 19, 36, 37, 40, 41, 42, 44, 46 and 51 are located within the moderate sensitivity buffers. Turbines 15, 47, 48, 52 and 53 are located within the high bat sensitivity buffers. No turbines are located in high sensitivity areas.

Should the facility be authorised, a minimum of two-year operational monitoring must be undertaken as soon as turbines are functional, with auditing continuing throughout the lifespan of the Inyanda Roodeplaat WEF.

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Reviewed and signed off by:

Werner Marais

Zoologist and Ecologist

MSc (Biodiversity & Conservation, UJ)

Pr.Sci.Nat. – SACNASP

(Zoological Science)

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