Final progress report of a 12 month pre-construction bat monitoring study

# For the proposed Waaihoek Wind Energy Facility near Utrecht, KwaZulu-Natal

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**Appointment of Specialist**

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| Specialist Company: | Animalia Zoological & Ecological Consultation CC |
| Appointed by: | Mainstream Renewable Power Limited |
| 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 subsidiary, legally or financially, 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 (NEMBA), 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 attention additional to those listed as Threatened or Protected.
- NATIONAL ENVIRONMENTAL MANAGEMENT ACT (NEMA), Act 107 of 1998.
  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 attention additional to those listed as Threatened or Protected.
- South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction (February, 2014).

  Guidance is provided on preparing, planning and implementing bat preconstruction monitoring with respect to wind energy facility developments, survey techniques and interpreting results.

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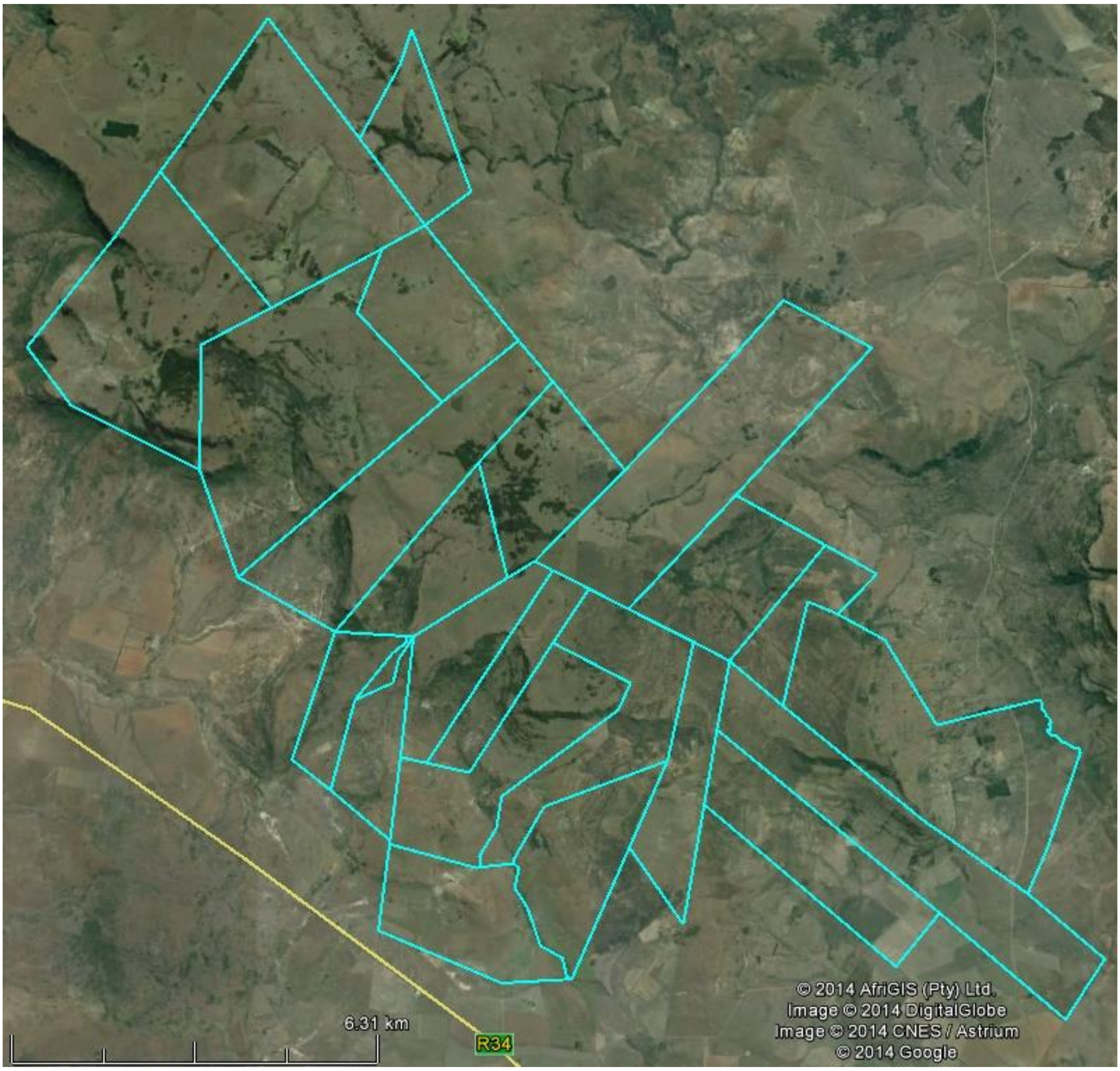



**Figure 1:** Map overview of the proposed Waaihoek WEF site.

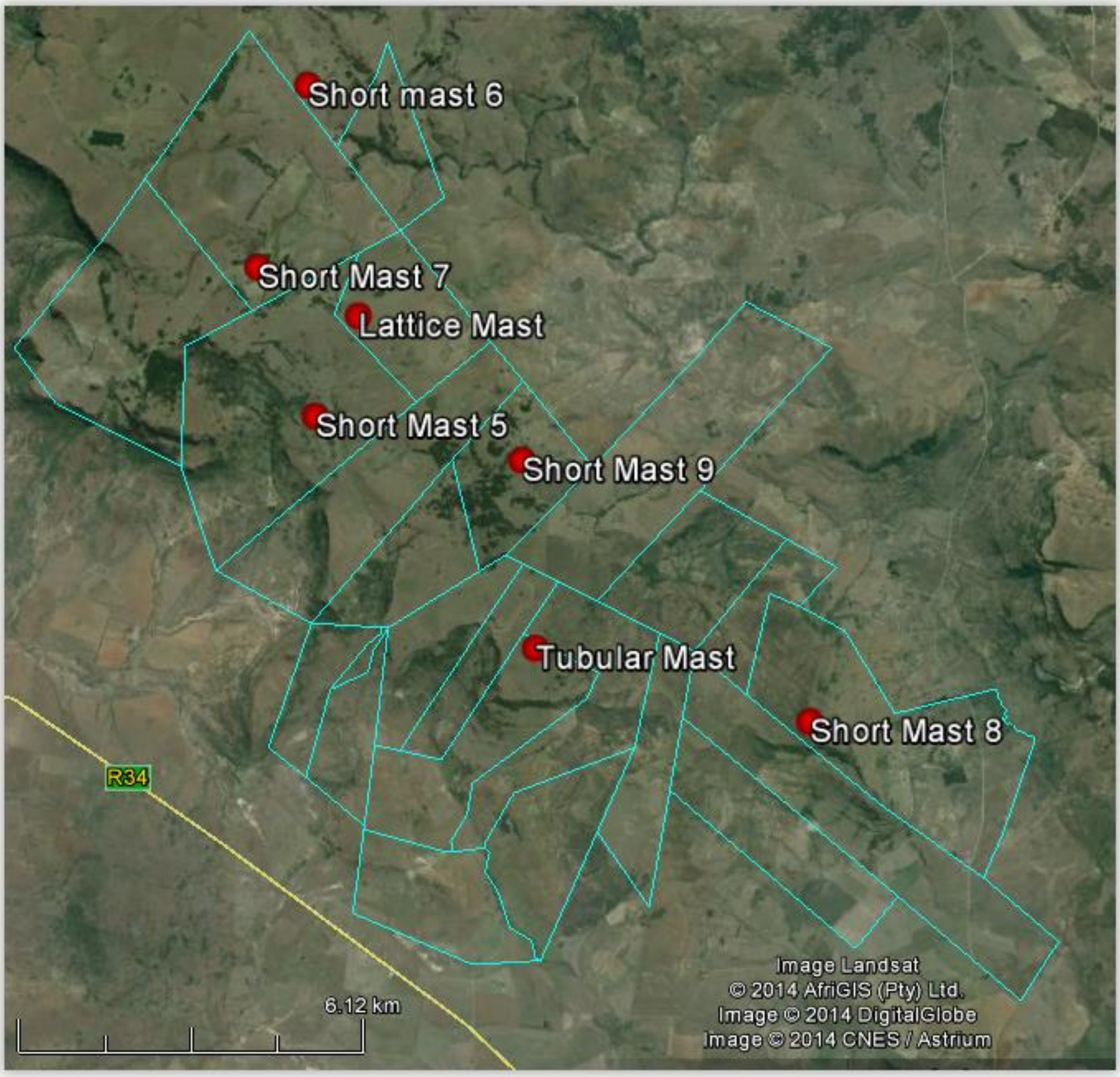



**Figure 2:** Overview of the passive systems on the Waaihoek WEF

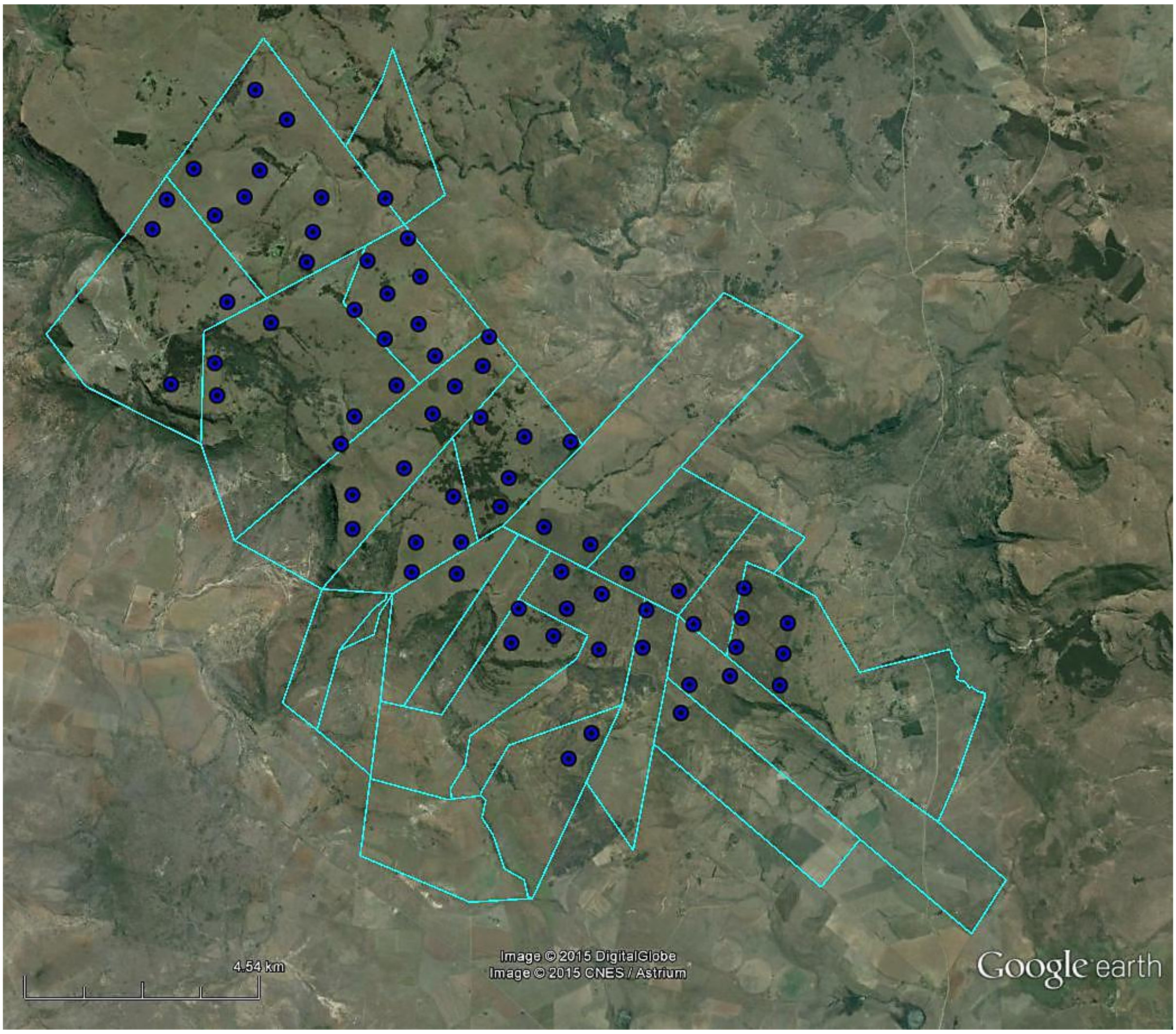



**Figure 3:** Proposed turbine layout on the Waaihoek WEF (dark blue circles).

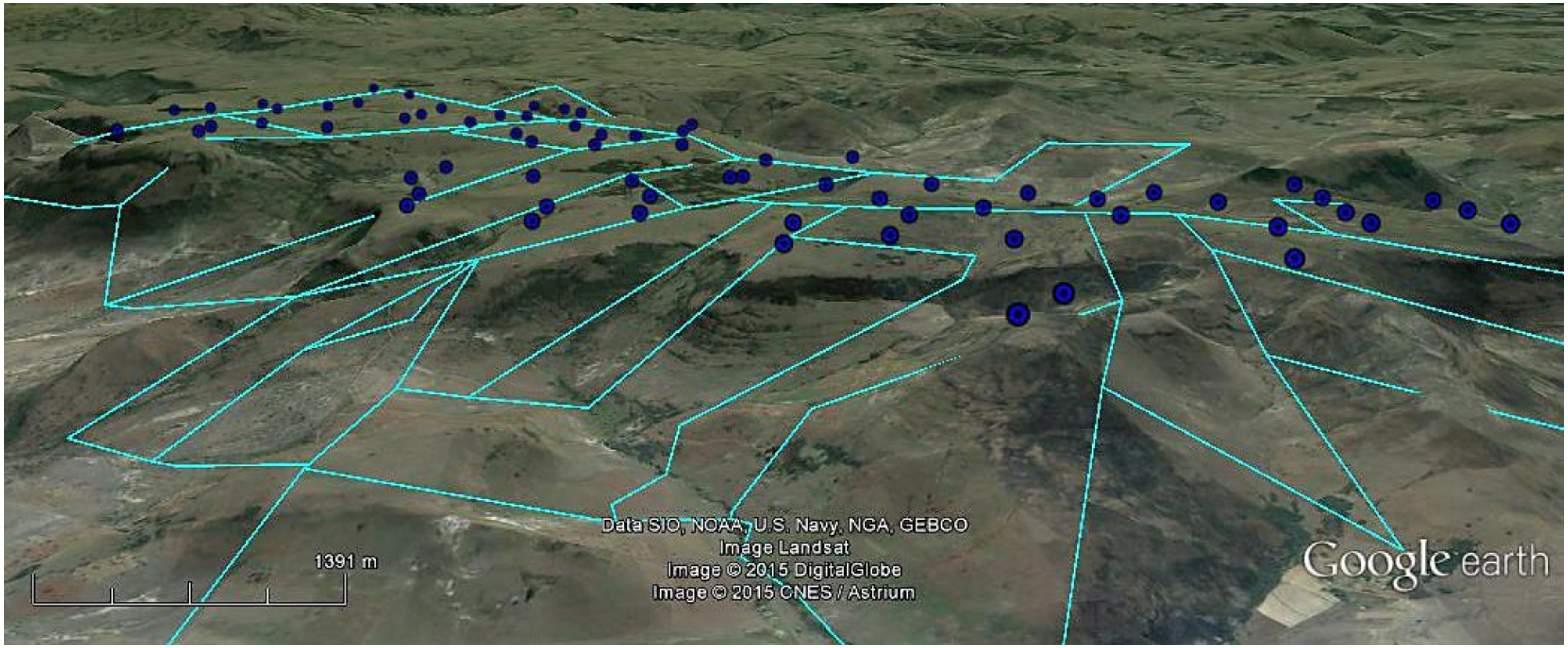



**Figure 4:** 3-Dimensional image of the site showing the raised topography where turbines are proposed (dark blue circles).

# 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 any turbines, if possible, would ideally be dropped from the final wind farm layout.
- Detail the types of mitigation measures that are possible if bat mortalities rates are found to be unacceptable including the potential times/ circumstances which may result in high mortality rates

# 2 INTRODUCTION

This is the fifth progress report for a twelve month bat monitoring study at the proposed Waaihoek Wind Energy Facility near Utrecht in KwaZulu-Natal.

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.

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.

## 2.1 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 of wing camber and shape, exploiting 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 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.

Insectivorous bats consume large amounts of insects each year and as such, control many agricultural and livestock pests. Agricultural pests cause millions of rands of damage to crops and spread disease among livestock with millions more being spent on pesticides to control them. In a United States study it was found that a single colony of 150 brown bats (*Eptesicus fuscus*) consumed nearly 1.3 million pest insects per year (Whitaker, 1995). It is difficult to put an exact value on how much bats save the agricultural industry each year, however, a conservative estimate puts it in the range of $ 3.7 billion while other estimates have it in excess of $50 billion (Boyles *et al,* 2011). A study done by Taylor *et al* (2011) on bats as a potential biological agent on macadamia farms in the Lvubu Valley found that, the majority of insect parts in the studied faecal matter contained approximately 32% Lepidoptera, 25% Coleoptera, 20% Hemiptera, 13% Orthoptera and 10% Blattodea. Nut borers (Lepidoptera) and stinkbugs (Hemiptera) have been found to be responsible for up to 80% damages to a macadamia yield. More research is needed in this area to fully determine the extent of economic loss to the agricultural industry if bat colonies were suddenly lost.

## 2.2 Relation between 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, many 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 was monitored using active and passive bat monitoring techniques. Active monitoring were done through site visits with transects made throughout the site with a vehicle mounted bat detector. Passive monitoring were done by means of static bat detectors mounted on masts, recording bat activity automatically every night.

An experimental security measure was implemented during the installation of four 10m short mast systems. The SM2BAT+, battery, regulator and power adapter were placed in a clear plastic box inside a larger black box that was sunk into the ground and secured in place with concrete (**Figure 5**). A metal cage was placed over the black box and secured with padlocks. Rocks were placed (if available) around the system to prevent animals walking over the solar panels and to discourage plant growth.

The table and figures below summarize the equipment set up.

## 3.1 Site visits

| | | | |
|---|---|---|---|
| **Site visit dates** | | First Visit | 7-11 October 2013 |
| | | Second Visit | 11-17 February 2014 |
| | | Third Visit | 19-25 May 2014 |
| | | Fourth Visit | 1-7 August 2014 |
| | | Fifth Visit | 30 October – 5 November 2014 |
| | | Sixth Visit | 18 – 19 February 2015 (data retrieval) |
| | | Seventh Visit | 9 – 10 July 2015 (data retrieval) |
| **Met mast passive bat detection systems** | **Amount on site** | 2 | |
| | **Microphone heights** | Tubular mast: 10m; 50m ($1^{st}$ - $3^{rd}$ site visit); 25m ($3^{rd}$ – $5^{th}$ site visit)<br>Lattice mast: 10; 50m | |
| | **Mast Locations** | Tubular mast: 27°45'9.73"S; 30°28'1.63"E<br>Lattice mast: 27°42'2.28"S; 30°26'9.51"E (installed on 3 July 2014, final data collected on 9 July 2015) | |
| **Short mast passive bat detection systems** | **Amount on site** | Five<br>Short masts 6 and 7 were installed during the first site visit. Short masts 5, 8 and 9 were | |

| | | |
|---|---|---|
| | | installed during the second site visit. |
| | **Microphone height** | 10m |
| | **Mast Location** | Short mast 5: 27°42'42.62"S; 30°25'49.47"E<br>Short mast 6: 27°39'52.64"S; 30°25'37.74"E<br>Short mast 7: 27°41'34.86"S; 30°25'5.80"E<br>Short mast 8: 27°45'47.90"S; 30°30'54.93"E<br>Short mast 9: 27°43'15.33"S; 30°27'57.12"E |
| **Type of passive 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 with latitude, longitude and season). | |
| **Trigger threshold** | >16KHz, 18dB | |
| **Trigger window (time of recording after trigger ceased)** | 500 milliseconds | |
| **Microphone gain setting** | 36dB | |
| **Compression** | WAC0 | |
| **Single memory card size (each systems uses 4 cards)** | 32GB | |
| **Battery size** | 18Ah; 12V Sealed Lead Acid Battery | |
| **Solar panel output** | 10 Watts | |
| **Solar charge regulator** | 6 - 8 Amp with low voltage/deep discharge protection | |
| **Weather and waterproofing** | The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Measures were taken for protection against birds, without compromising effectiveness significantly. Crows have been found to peck at microphones and subsequently destroying them. | |
| **Auxiliary monitoring methods** | | |
| **Transects** | An EM3 RTE and SM2+ RTE bat detector was used for driving transects across the site (where accessible). This provides further insight into the spatial distribution of bat activity, albeit less systematic and quantitative than the passive monitoring systems. | |

| Repairs/ Replacements /Comments | |
|---|---|
| Second site visit | Short mast 6's regulator and battery was replaced over the second site visit. |
| Third site visit | Over the third site visit, short mast 9's entire system was found to be stolen. This system has not been replaced. Thus no data is available for this system.<br><br>The solar panel and battery of short mast 8 was also stolen, and the box and mast were vandalised. Data up to early March is available for this system. This system has not been replaced.<br><br>The microphone cable of short mast 5 was chewed by cattle. Data was collected up to mid-February. The cable was replaced over the third visit, thus this system was functional.<br><br>The 50m mic cable of the tubular mast was lowered using the pulley system, however it got stuck at approximately 25m and could not be lowered or lifted. The microphone was still functional |
| Fourth site visit | Short mast 5 had snapped in half and the guide ropes had melted as a result of a fire. One set of guide ropes had been chewed by cattle. The mast was thus repaired as much as possible and the microphone was mounted around 4m. New guide ropes were fitted.<br><br>Short mast 7's mic was replaced.<br><br>Battery of the tubular mast system was replaced. |
| Fifth site visit | Short mast 6: decommissioned and all data removed from the SD cards<br><br>Short mast 7: still recording data; all data was downloaded and the system checked.<br><br>Short mast 5: stolen. No data was retrieved from this system during the 5th site visit.<br><br>Lattice Mast: the system is still recording on both microphones; all data was downloaded and system checked.<br><br>Tubular Mast: the system is still recording on both microphones; all |

| | |
|---|---|
| | data was downloaded and the solar charge regulator was replaced. |
| Sixth Visit | Lattice Mast: the system is still recording on both microphones; all data was downloaded and system checked. |
| Seventh Visit | Lattice Mast: the system was still recording on both microphones; all data was downloaded and system checked. One of the SD cards were corrupted and the SD card is sent to a data recovery specialist. |

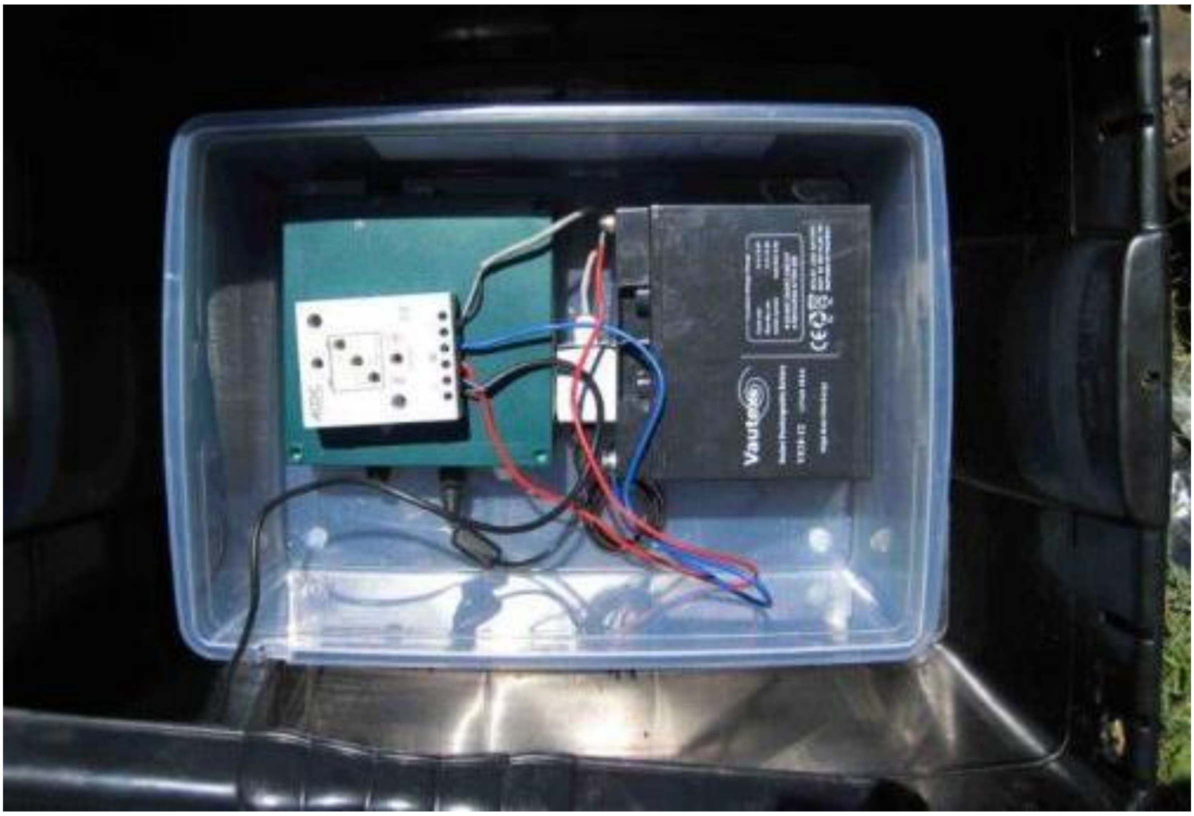


**Figure 5:** The SM2BAT+ placed in the clear box inside a larger black box to be sunk into the ground with concrete.

The passive 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 pulses where the duration of each pulse is ≥2 ms (one echolocation call can consist of numerous pulses). A new bat pass are identified by a >500 ms silent period between pulses. These bat passes were then summed into 10 minute intervals which were used to calculate nocturnal distribution patterns over time. Only nocturnal, dusk and dawn values of environmental parameters from the climatic data were used, as this is the only time that insectivorous bats are active. Times of sunset and sunrise were adjusted with the time of the year.

The bat activity may was correlated with environmental parameters; wind speed and air temperature, to identify optimal climatic conditions for foraging/activity.

## 3.2 Assumptions and limitations

A species list compiled from acoustic detection methods at the locations used, is not comprehensive and exhaustive for the entire site and all habitats on site. Therefore the literature based species probability of occurrence will include more species than detected by the passive systems.
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 area is utilised for farming of livestock and crops, and some scattered farm buildings and small settlements are present.

**Figure 6:** Photograph of the Wakkerstroom Montane Grassland vegetation unit found on the site.

The majority of the areas where turbines are proposed are occupied by the Wakkerstroom Montane Grassland vegetation unit which forms part of the Grassland biome (Error! eference source not found.**6**). Five other vegetation units are found on or near the site (**Figure 7**).

The mean maximum and minimum temperatures for the Wakkerstrom Montane Grassland is 25°C in January and 1°C in June with a mean annual precipitation of 902 mm, and rainfall peaking in midsummer. Winters are very cold and summers mild. This unit occurs at an altitude of 1440m – 2200m and is technically a continuation of the Escarpment that links southern and northern Drakensberg escarpments, consisting of low mountains and undulating plains. Short montane grasslands on the plateaus and short forests as well as

*Leucosidea* thickets on the steep east facing slopes and drainage areas are some of the characteristic vegetation. Mudstones, sandstone and shale of the Madzaringwe and Volksrust Formations were intruded by dolerite dykes and sills (Mucina and Rutherford 2006).

The Kwazulu-Natal Highland Thornveld vegetation unit is part of the Grassland biome. This unit occurs at an altitude of 920 - 1440m and have hilly undulating landscapes with broad valleys supporting tall grasslands usually dominated by the thatching grass *Hyparrhenia hirta*. Woodlands with *Acacia* sp. are scattered across the grasslands. A variety of Karoo Supergroup rocks are present and soils can be resistant to erosion. A mean annual precipitation of 750mm occurs during a total average of 79 rain days and midwinter months of June and July have only 2.6 rain days on average. Summers are warm to hot and winters are cool with 15 frost days on average per year and a mean annual temperature of 16.5°C (Mucina and Rutherford 2006).

The Income Sandy Grassland is very flat extensive areas with relatively shallow poorly drained soils supporting low tussock dominated sourveld and some wooded grasslands with Acacias. Soils are sandy and rocks are sandstones and shales of the Madzaringwe Formation. Most precipitation occurs in summer between October and March with a mean annual precipitation of 750mm, mean annual temperature is just below 17°C (Mucina and Rutherford 2006).

The Northern Afrotemperate Forest unit are restricted to mountain kloofs and low ridges, and occurs only as two small isolated patches on site. Woody trees and dense vegetation are dominating, with sandstones and quartzites forming most of the rocks.

The Eastern Temperate Freshwater Wetlands are situated around stagnant water bodies (lakes, pans, periodically flooded vleis, and edges of calm rivers) and embedded within the Grassland Biome with altitudes varying from 750m – 2000m. They are on flat landscapes where shallow depressions are filled with temporary water bodies (Mucina and Rutherford 2006).

The Paulpietersburg Moist Grassland unit is marginal to the site and not close to any turbines proposed. Only roosting potential is relevant and is dependent on the geology of underlying granite and gneiss, as well as woody vegetation on outcrops. This unit is unlikely to have a significant effect on the bat activity in turbine areas.

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 |
|---|---|---|---|
| **Wakkerstroom Montane Grassland** | Low - Medium | Low - Medium | Lack of roosting space, high altitude with cold winters, strong winds and only mild summers make this vegetation unit less ideal for insects and therefore also bats. However buildings on site may provide some suitable roosting space. |
| **Kwazulu-Natal Highland Thornveld** | Medium - High | Medium - High | Woody Acacias and rock crevices can offer roosting space. Warmer summers and shelter from winds will allow for more insect food availability. Buildings on site may provide some suitable roosting space. |
| **Income Sandy Grassland** | Low-Medium | Medium - High | Natural roosting space are scarce but buildings can offer suitable roosting space. Lower elevation can increase insect food availability for foraging. |
| **Northern Afrotemperate Forest** | High | High | Woody forests can offer multiple roosting spaces and shelter for insects and bats against the elements. However these forests are scarce on site. |
| **Eastern Temperate Freshwater Wetlands** | Low - None | High | Stagnant water and vleis will harbour more insects that will in turn attract insectivorous bats. |
| **Paulpietersburg Moist Grassland** | Medium - High | Medium - High | Granite outcrops with woody trees can offer suitable roosting space and foraging grounds. This unit occurs only marginal to the site. |

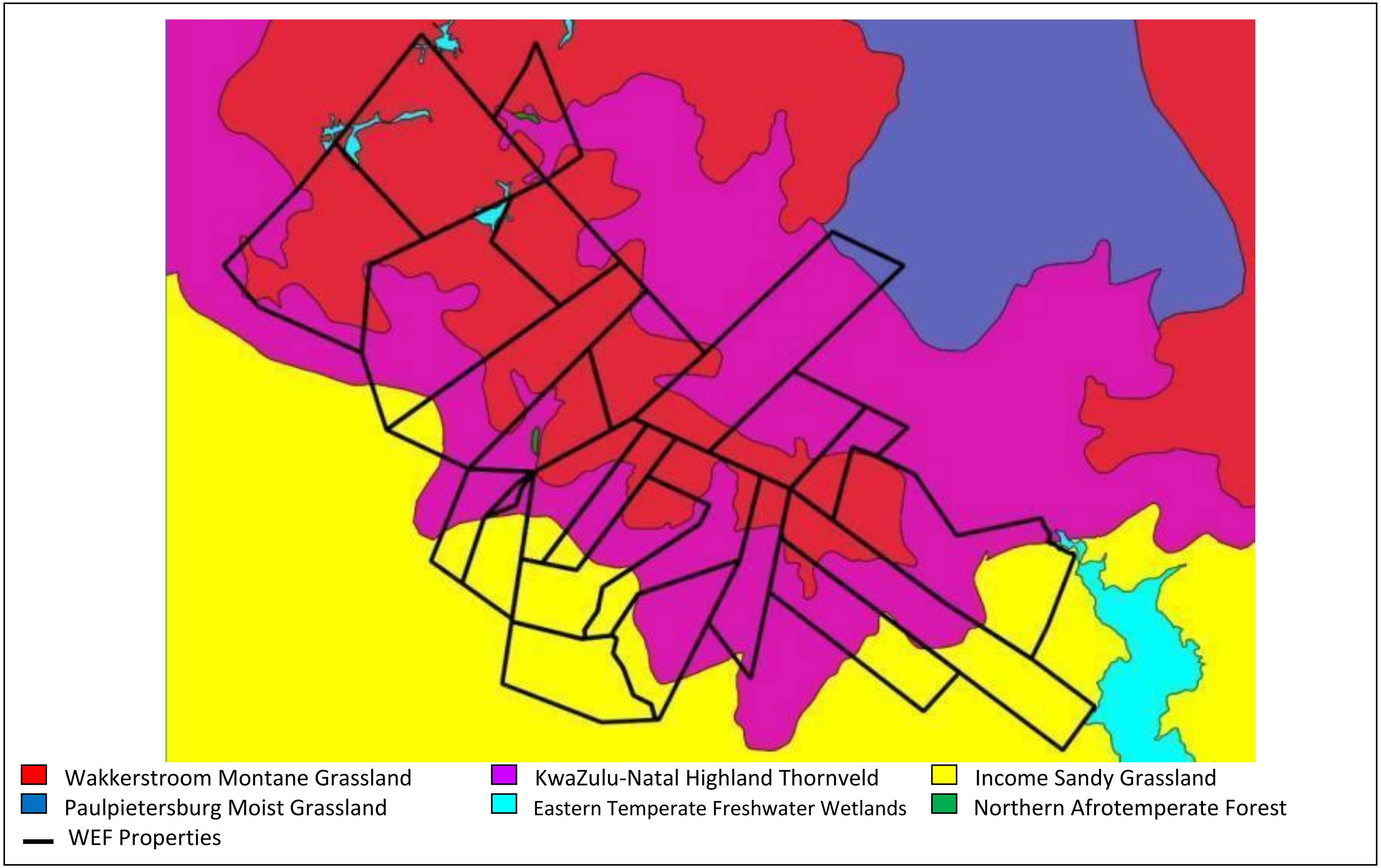



**Figure 7:** Vegetation units present on the site (Mucina and Rutherford 2006).

## 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 at 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 traverse; and assume a 100% probability of occurrence and ignore turbine placement variables. The ecology of most applicable bat species for 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 or near site | Foraging habits (indicative of possible foraging areas on or near site) | Likely Risk of Impact (Sowler & Stoffberg, 2014) |
|---|---|---|---|---|---|---|
| *Cistugo lesueuri* | Lesueur's wing-gland bat | 10 - 20 | Vulnerable | High altitude (> 1500m) rock crevices on sides of escarpment | Montane grassland (>1500m) specifically close to open water sources. | Low - Medium |
| *Cloeotis percivali* | Percival's short-eared trident bat | 10-20 | Vulnerable | Cave and hollow dependent. No known caves in the area and likelihood of cave formation low. | It is a clutter forager that may only utilise the forested valleys and other dense clumps of trees. | Low |
| *Epomophorus crypturus* | Peters's epauletted fruit bat | 10-20 | Least Concern | In valleys and low lying areas where large fruiting trees are present. | Feeds on fruit, nectar, pollen and flowers. It is known to travel several kilometres to reach fruiting trees and does not echolocate. | Medium-High |
| *Epomophorus wahlbergi* | Wahlberg's Epauletted Fruit bat | 30-40 | Least Concern | Roosts in dense foliage of large, leafy trees that can be found within the town of Idutywa. | Feeds on fruit, nectar, pollen and flowers. It is known to travel several kilometres to reach fruiting trees and does not echolocate. It is not known whether it may commute through the site. | Medium-High |
| *Eptesicus hottentotus* | Long-tailed serotine | Confirmed | Least Concern | Crevice dweller that may utilise rock crevices in isolated small and scattered outcrops. | Clutter-edge forager. Its diet comprises mainly Coleoptera. Prefer open surface water for drinking. | Medium |
| *Hipposideros caffer* | Sundevall's leaf-nosed bat | 20-30 | Least Concern | Cave and hollow dependent. No known caves in the area and likelihood of cave formation low. Also opportunistic for utilising large hollow tree trunks. | It is a clutter forager that may only utilise the forested valleys and other dense clumps of trees. | Low |
| *Miniopterus* spp | Genus *Miniopterus* | Confirmed | Near Threatened | Cave and hollow dependent, but have been personally observed to | Clutter-edge forager. Feeds on a variety of aerial prey including Diptera, | Medium - High |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | roost in small groups or individually in culverts. | Hemiptera, Coleoptera, Lepidoptera and Isoptera. May forage in open grassland during suitable weather. | |
| *Mops condylurus* | Angolan free-tailed bat | 40-50 | Least concern | Roosts in any suitable crevice and in the roofs of buildings and houses. Very common species but on edge of distribution. | Open air forager that will utilise open grasslands. | High |
| *Myotis tricolor* | Temmink's myotis | 60-70 | Least Concern | It roosts socially in caves and moves between its winter hibernacula and summer maternity caves. No known caves in the area and likelihood of cave formation low. Observed to roost singly in culverts and other hollows as well. It has a close association with mountainous areas. | A clutter-edge forager that is restricted to aerial prey such as Coleoptera, Hemiptera, Diptera, Neuroptera and Hymenoptera | Medium - High |
| *Neoromicia capensis* | Cape Serotine | Confirmed | Least Concern | Roosts under the bark of trees, at the base of aloe leaves, under roofs and within crevices. Very common and widespread. | Clutter-edge forager feeding mainly on Coleoptera, Hemiptera, Lepidoptera and Neuroptera. May forage over open grassland in suitable weather. | Medium - High |
| *Nycteris thebaica* | Egyptian slit-faced bat | 50-60 | Least Concern | Roosts during the day in burrows, culverts and trunks of large trees. Prefer cluttered habitats more. | Clutter forager. Diet varies according to the season between Orthoptera, Coleoptera and Lepidoptera as well as a number of other insects and arachnids. Only in areas with dense vegetation. | Low |
| *Pipistrellus hesperidus* | Dusky pipistrelle | 30-40 | Least Concern | Well wooded areas in valleys as well as cracks in rocks | Clutter-edge forager that prefers riparian well wooded areas. | Medium |
| *Rhinolophus blasii* | Blasius's horseshoe | 10-20 | Near Threatened | Cave dependent. No known caves in the area and likelihood of cave | It is a clutter forager that may only utilise the forested valleys and other | Low |

| | | | | | | |
|---|---|---|---|---|---|---|
| | bat | | | formation low. | dense clumps of trees. | |
| *Rhinolophus clivosus* | Geoffroy's horseshoe bat | Confirmed | Least Concern | Roosts in any suitable hollow or cave and are opportunistic. No known caves in the area and likelihood of cave formation low. It is a common bat. | It is a clutter forager that may only utilise the forested valleys and other dense clumps of trees. | Low |
| *Rhinolophus darlingi* | Darling's horseshoe bat | 10 -20 | Least Concern | Cave dependent. No known caves in the area and likelihood of cave formation low. | It is a clutter forager that may only utilise the forested valleys and other dense clumps of trees. | Low |
| *Rhinolophus simulator* | Bushveld horseshoe bat | 20-30 | Least Concern | Roosts in any suitable hollow or cave and have been found in culverst. No known caves in the area and likelihood of cave formation low. | It is a clutter forager that may only utilise the forested valleys and other dense clumps of trees. | Low |
| *Rousettus aegyptiacus* | Egyptian rousette | 20-30 | Least Concern | Cave dependent, no known caves in the area and likelihood of cave formation low. Possible hollows in cliffs on escarpment edge slopes. | Feeds on fruit, nectar, pollen and flowers. It is known to travel several kilometres to reach fruiting trees and have a primitive form of echolocation. | Medium-High |
| *Scotophilus dinganii* | Yellow-bellied house bat | Confirmed | 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 |
| *Tadarida aegyptiaca* | Egyptian free-tailed bat | Confirmed | Least concern | Roosts in caves, crevices, hollow trees, buildings, and any other suitable crevices. May be roosting in any crevice found on site, including buildings and trees. Very common and opportunistic. | Open-air forager with a diet consisting mainly of Diptera, Hemiptera, Coleoptera and to some extent Lepidoptera. Strong flier that will forage over the open grasslands. | High |
| *Taphozous mauritianus* | Mauritian tomb bat | Confirmed | Least Concern | Roosts on rock tree trunks and walls favouring sides in the shade. | Open air forager feeding on Lepidoptera, isopteran and | High |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Males and females roost separately from one another. Often found in savannah woodlands, preferring open habitats and avoiding closed forest interior and is dependent upon surface water. | Coleoptera. | |

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

There are five bat species that occur commonly in the area of the site 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. This will be examined over the course of the 12 month monitoring survey.

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 will also be able to indicate seasonal peaks in species activity and bat presence.

### *Epomophorus wahlbergi*

Wahlberg's epauletted fruit bat, *Epomophorus wahlbergi*, has a widespread distribution and has been recorded from the Eastern Cape through to KwaZulu-Natal, Swaziland, Mozambique, Eastern Zimbabwe, Zambia and towards the south of the Democratic Republic of Congo (Monadjem *et al*. 2010). This bat is listed as Least Concern due to a presumed large population and its widespread distribution (Mickleburgh *et al*. 2013).

*E. wahlbergi* has been found to roost within savanna, woodland, forest and forest edge habitats at altitudes not exceeding 2000 metres and areas with a minimum rainfall of 250mm and a mean rainfall of 700mm (Acharya 1992). It feeds on fruit, nectar, pollen and flowers and appears to favour figs, although beetle and other insect remnants have been found in the stomach contents of some individuals (Monadjem *et al*. 2010; Pienaar *et al.* 1987). Although mostly active in the evening, they have been observed flying during the daytime hours (Fenton 1985). They roost in small groups or alone in the foliage of large, leafy trees or shelter caves and can travel many kilometres to reach fruiting trees. A study done in the Kruger National Park by Fenton *et al* (1985) made use of radio telemetry to track bats between their foraging and roosting sites. They found that *E. wahlbergi* can travel up to 13 kilometres to foraging sites and may revisit the same fruiting tree on subsequent visits. They were also found to switch day roost locations within the localised area to possibly reduce the risk of predation.

Wahlberg's epauletted fruit bat is seasonally polyestrous with births occurring throughout the year but peaking during the winter and summer months. The males sing from traditional sites to attract passing females during the breeding season. The calls used combine four short chirps that range from 2.0 khz – 7.5 kHz and is one second in duration. After a gestation period of between five and six months, one to two pups are born (Monadjem *et al*. 2010). The mother carries her young clinging to her chest, while she forages (Fenton 1985).

They are of importance in the dispersal and germination of seeds as well as in pollination. Some plant species require the seeds to be digested before they can germinate such as the *Ficus sp.,* while the dispersal of seeds in their droppings aid in the spread of larger forest trees including those species important to timber production (Sowler and Stoffberg 2014). They are especially important for their ecological role of dispersing seeds to isolated forest patches.

### ***Rousettus aegyptiacus***

The Egyptian rousette, *Rousettus aegyptiacus,* is a large fruit bat that is considered of Least Concern and is found from Cape Town along the coast towards KwaZulu-Natal then continuing from Swaziland, Mozambique, Zambia, Malawi and into the Democratic Republic of Congo (Monadjem *et al*. 2010). It is found up to an elevation of 4000m (Kwiecinski and Griffiths 1999).

*R. aegyptiacus* has a primitive form of echolocation and makes use of repetitive tongue clicks that aid in nightly navigation. These clicks can range between 12 – 70 kHz in frequency and are similar in duration and click structure to that of dolphins (Holland *et al.* 2004). They roost socially in caves and prefer habitats that provide forest cover, roosting areas and abundant fruit trees which influence their distribution more than vegetation associations (Kwiecinski and Griffiths 1999). A colony of over 5000 individuals have been found in the Mission Rocks caves in the Greater St. Lucia Wetland park and over 9000 individuals at the Matlapitsi cave in Tzaneen, Limpop but these numbers can vary seasonally (Monadjem *et al*. 2010).

The Egyptian rousette feeds predominantly on *Ficus spp*. but have also been found to feed on *Litchi chinensis, Syzgium spp., Harpephyllum caffrum, Ekebergia capensis, Prunus africana* and *Diospyros senesis* (Monadjem *et al*., 2010). A study by Jacobsen *et al* (1986) found that they flew approximately 24 kilometres between the roosting area and the feeding site. Once a fruit is selected, it is taken to the roost close to the feeding tree where the pulp and juice is consumed and the seeds spat out. They can consume 50 – 150% of their body mass in fruit each night (Kwiecinski and Griffiths 1999).

During the breeding season, males and females separate, with the males forming bachelor groups and the females forming maternity colonies. *R. aegyptiacus* is polygamous with two breeding seasons (summer and winter) but monoestry has been recorded at higher latitudes (Kwiecinski and Griffiths 1999). Gestation is approximately three to four months with females giving birth to one or two pups. The female bat is the sole caregiver and after 63-70 days the young are capable of flying. They remain with the mother until they have reached adult weight and size then leave to join either the bachelor or maternity colonies (Kwiecinski and Griffiths 1999).

## 4.4 Transects

Transects were not carried out over the first site visit as priority was given to the installation of the passive monitoring systems.

### 4.4.1 Second site visit (late summer)

**Table 3:** Details of sampling effort

| Transect nights | Distance traversed (km) | Time spent |
|---|---|---|
| 12 February 2014 | 49.6 | 4hr 41min |
| 14 February 2014 | 48.4 | 4hr |
| 15 February 2014 | 85.5 | 6hr 30min |
| 16 February 2014 | 72.4 | 4hr 27min |

**Table 4:** Average weather conditions at Utrecht during the transect survey night (taken from http://www.worldweatheronline.com).

| Transect nights | Temperature (˚C) | Rain (mm) | Cloud (%) | Wind (m/s) |
|---|---|---|---|---|
| 12 February 2014 | 12 | 0 | 0 | 1.3 |
| 14 February 2014 | 13 | 0 | 80 | 1.7 |
| 15 February 2014 | 11 | 0 | 80 | 1.3 |
| 16 February 2014 | 12 | 0 | 60 | 1.3 |

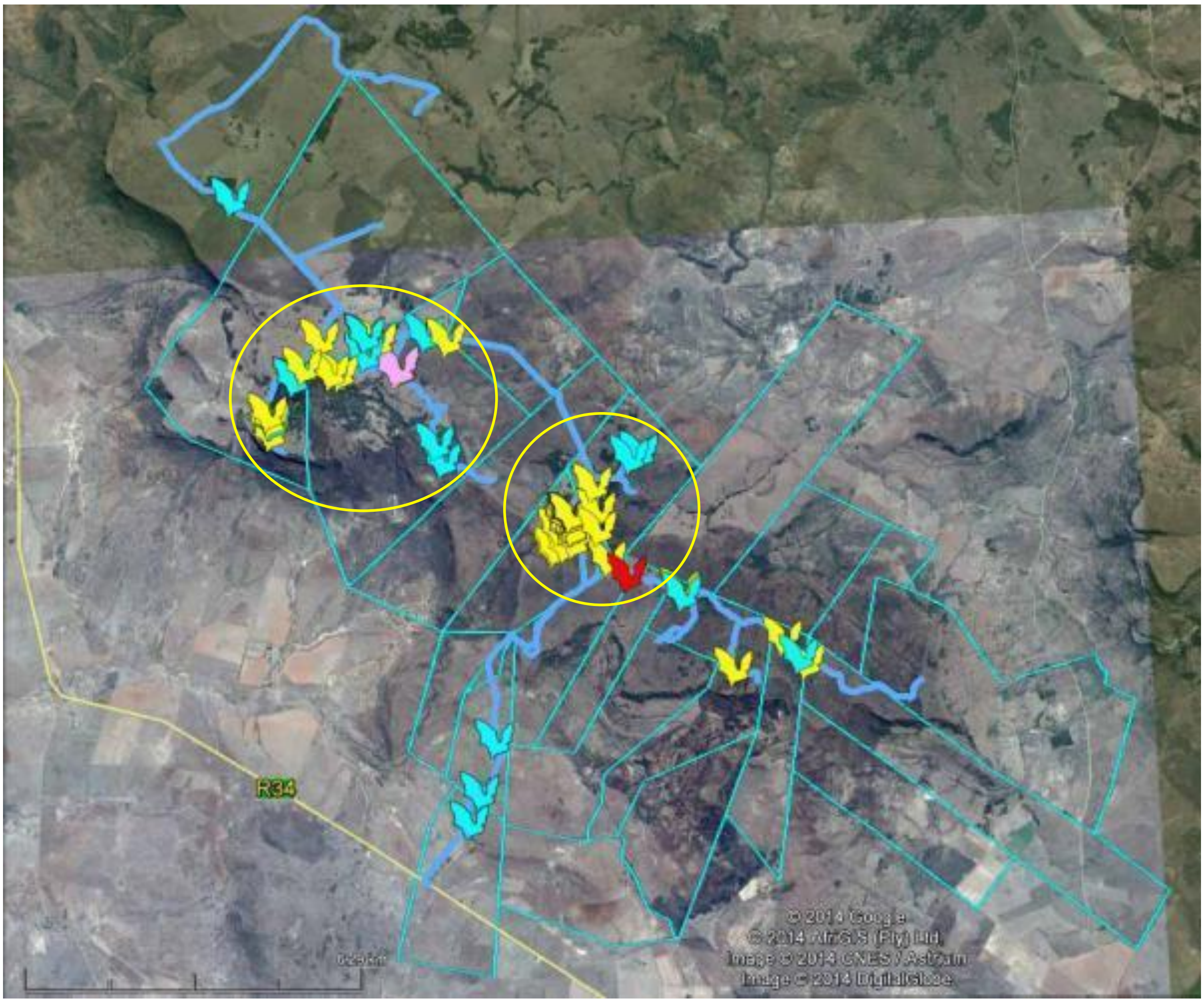



**Figure 8:** Bat species detected and their localities during 12, 14-16 February 2014.

Two areas of high bat activity were detected during the four nights of transects, these areas were concentrated around black wattle clumps (highlighted in the yellow circles). Lower activity was recorded in the open grassland areas.

### 4.4.2 Third site visit (late autumn)

**Table 5:** Details of sampling effort

| Transect nights | Distance traversed (km) | Time spent |
|---|---|---|
| 19 May 2014 | 75.9 | 5hr 24min |
| 20 May 2014 | 55.8 | 4hr 2min |
| 21 May 2014 | 76.1 | 4hr 35min |
| 22 May 2014 | 56 | 3hr 53min |
| 23 May 2014 | 73.7 | 4hr 39min |
| 24 May 2014 | 55.6 | 3hr 41min |

**Table 6:** Average weather conditions at Utrecht during the transect survey night (taken from http://www.worldweatheronline.com).

| Transect nights | Temperature (˚C) | Rain (mm) | Cloud (%) | Wind (m/s) |
|---|---|---|---|---|
| 19 May 2014 | 9 | 0 | 12 | 1.8 |
| 20 May 2014 | 11 | 0 | 34 | 4.9 |
| 21 May 2014 | 9 | 0 | 23 | 2.2 |
| 22 May 2014 | 9 | 0 | 4 | 2.6 |
| 23 May 2014 | 9 | 0 | 7 | 0.4 |
| 24 May 2014 | 11 | 0 | 12 | 3.1 |

Once again, higher activity levels were detected in the areas with clumps of trees. A higher number of *Miniopterus natalensis* passes were detected over the third site visit transects, whereas *Neoromicia capensis* was more abundant over the second site visit transects.

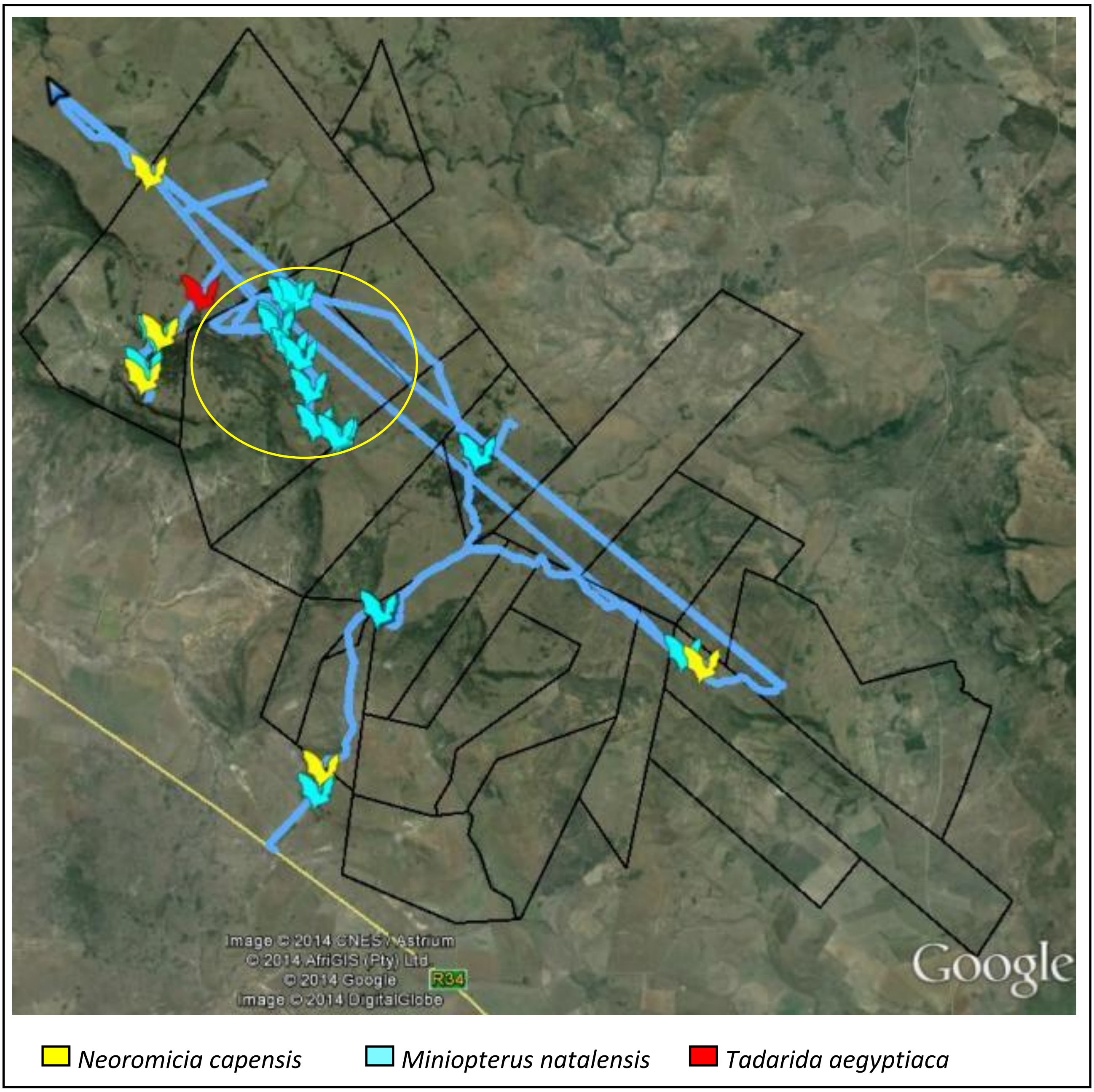



**Figure 9:** Bat species detected and their localities during 19-24 May 2014.

### 4.4.3 Fourth site visit (late winter)

Higher *Neoromicia capensis* activity was detected around a clump of Black Wattle trees, as found with the other transect sessions as well.

**Table 7:** Details of sampling effort

| Transect nights | Distance traversed (km) | Time spent |
|---|---|---|
| 1 August 2014 | 75.8 | 4hr 52min |
| 2 August 2014 | 51.5 | 3hr 50min |
| 3 August 2014 | 67.6 | 4hr 25min |

| | | |
|---|---|---|
| 4 August 2014 | 60 | 3hr 48min |
| 5 August 2014 | 95.9 | 4hr 43min |

**Table 8:** Average weather conditions at Utrecht during the transect survey night (taken from http://www.worldweatheronline.com).

| Transect nights | Temperature (˚C) | Rain (mm) | Cloud (%) | Wind (m/s) |
|---|---|---|---|---|
| 1 August 2014 | 9 | 0 | 0 | 1.8 |
| 2 August 2014 | 9 | 0 | 0 | 2.7 |
| 3 August 2014 | 9 | 0 | 1 | 2.7 |
| 4 August 2014 | 10 | 0 | 0 | 4.4 |
| 5 August 2014 | 10 | 0 | 3 | 2.2 |

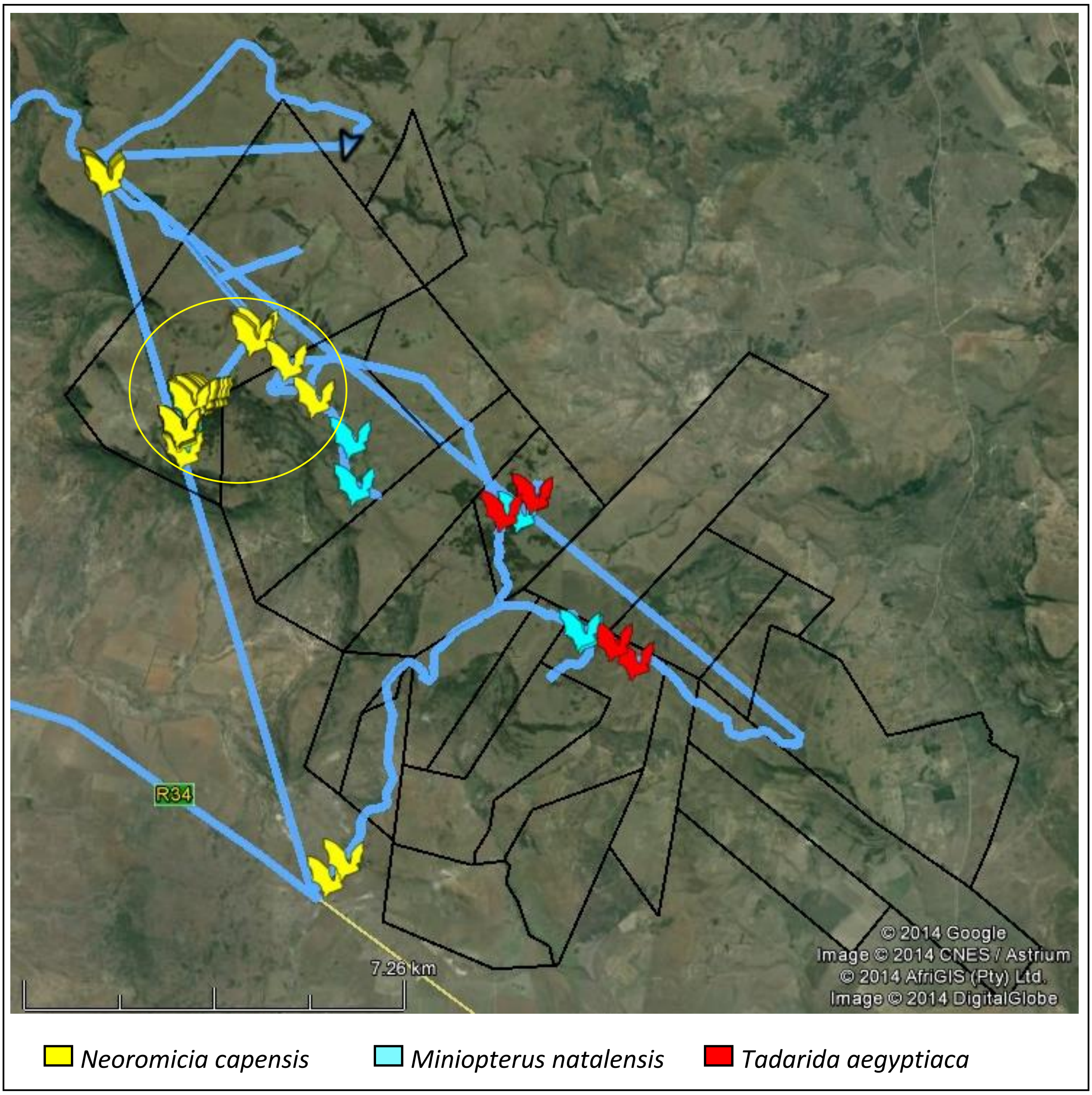



**Figure 10:** Bat species detected and their localities during August 2014.

#### 4.4.4 Fifth site visit (Summer)

Wet weather and heavy mist hampered the transect efforts.

**Table 9:** Details of sampling effort

| Transect nights | Distance traversed (km) | Time spent |
|---|---|---|
| 30 October 2014 | 9.5 | 31 min |
| 31 October 2014 | 33 | 1 hr 51min |
| 2 November 2014 | 55 | 2hrs 45min |
| 4 November 2014 | 17 | 33 min |

**Table 10:** Average weather conditions at Utrecht during the transect survey night (taken from http://www.worldweatheronline.com).

| Transect nights | Temperature (˚C) | Rain (mm) | Cloud (%) | Wind (km/h) |
|---|---|---|---|---|
| 30 October 2014 | 25 | 0.3 | 23 | 9 |
| 31 October 2014 | 21 | 0.8 | 42 | 15 |
| 1 November 2014 | 18 | 2.9 | 56 | 8 |
| 2 November 2014 | 22 | 0.1 | 47 | 5 |
| 3 November 2014 | 19 | 0.6 | 50 | 11 |
| 4 November 2014 | 24 | 0.9 | 15 | 19 |

The unfavourable weather conditions could account for the lowered bat activity during the driven transects. On 31 October during a break in the rain, alates (flying termites) were observed near the wattle stands as well as bats feeding on them. This insect activity were observed in the area circled in **Figure 11**.

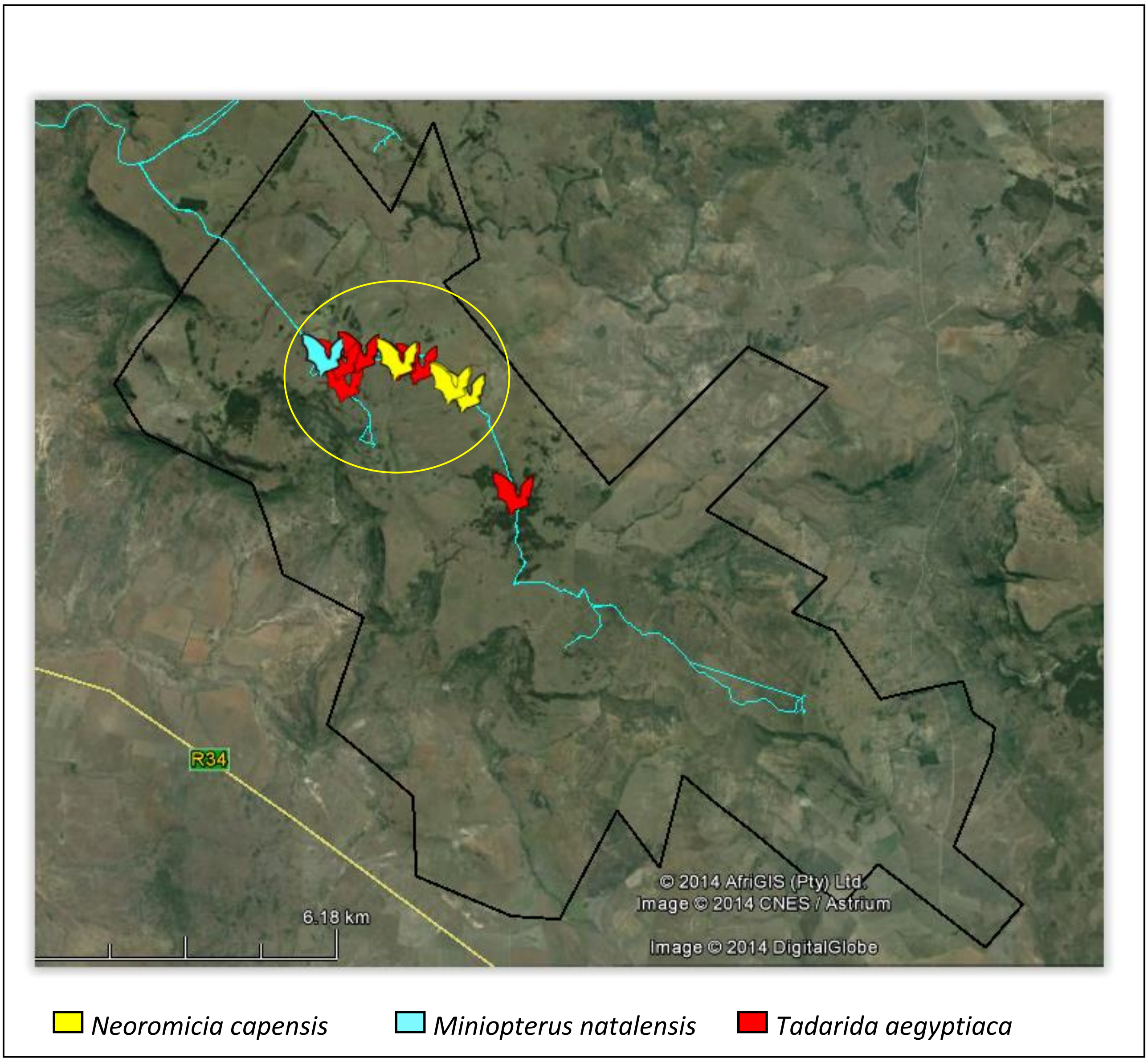



**Figure 11:** Bat species detected and their localities during November 2014.

## 4.5 Sensitivity Map

**Figures 12 – 15** 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 to identify which turbines require special attention with regards to bat monitoring during operation of the wind farm and which turbines should be dropped from the final layout.

| | |
|---|---|
| Last iteration | 24 November 2014 |
| Areas identified as having high bat sensitivity | Water sources - 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.<br>Dense vegetation of shrubs and trees, especially those located on slopes and inside valleys.<br>Slopes that can offer roosting habitat as well as sheltered insect prey areas.<br><br>**Regarding fruit bats:**<br>Northern Afrotemperate Forest, as this isolated forest patch may be depended on fruit bats for seed dispersal and most likely contain tree species utilised by fruit bats such as *Podocarpus latifolius, P. falcatus, Halleria lucida,* and *Ekebergia capensis.* Refer to Appendix A, list of tree species associated with *Epomophorus* sp. in KwaZulu-Natal.<br>The fig tree identified on the slope to the far south east of the site, this tree is located inside a high sensitivity area already. |
| High sensitivity buffers | 500m around the Northern Afrotemperate Forest patch<br>300m around open surface water bodies<br>300m around all other highs sensitivities |
| Areas identified as having moderate bat sensitivity | Waterways on the plateau and smaller valleys where terrain is less favourable to foraging bats, but which will still have a higher moisture availability than immediate surrounding terrain.<br>Areas of lower elevation where turbines are proposed, as these may possibly have less hostile climatic conditions for bats.<br>Rocky outcrop in the far north west of the site. This outcrop may contain suitable roosting habitat but is also at the highest elevation meaning climatic conditions will probably be least favourable to bats on this outcrop. |

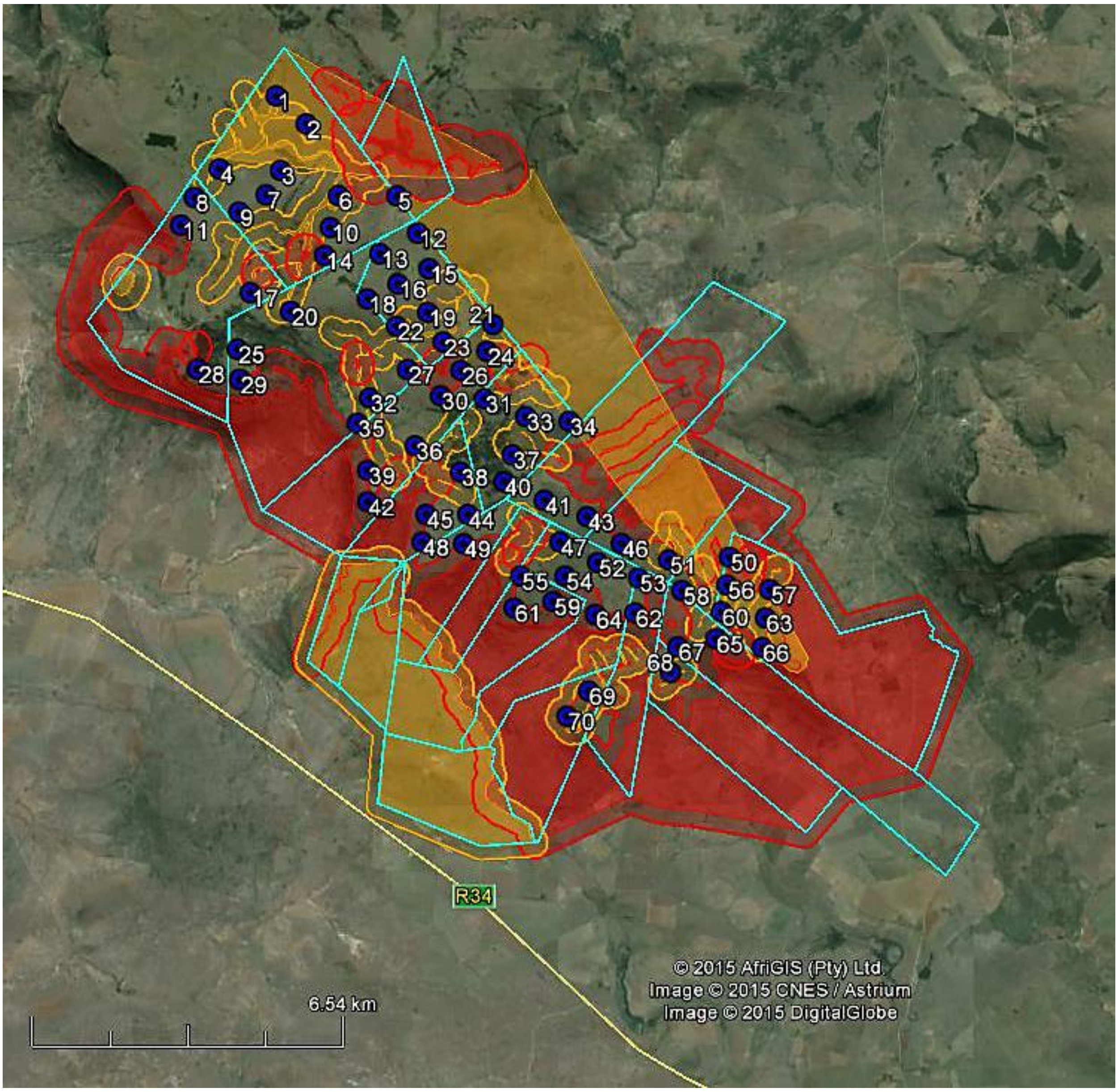
| | |
|---|---|
| | **Fruit bats:**<br>A possible flight path from Northern Afrotemperate Forest to Utrecht and its surrounding terrain.<br>A possible broader flight path that may be used by fruit bats to commute between the Northern Afrotemperate Forest and the identified fig tree. |
| Moderate sensitivity buffers | 250 meters |

**Table 11:** Description of sensitivity categories utilized in the sensitivity map

| Sensitivity | Description |
|---|---|
| Moderate Sensitivity and Moderate Sensitivity Buffer Zone | Areas, or buffers around areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within these areas and their buffers must be prioritised (not excluding all other turbines) during operational monitoring and may require additional mitigation measures if bat mortalities are found to be unacceptably high. |
| High Sensitivity and High Sensitiivty buffer zone | 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 should not be placed in these areas. |

**Table 12:** Turbines located within bat sensitive areas and buffers (indicated by the number the turbine has been assigned in the latest turbine layout)

| **Bat sensitive area** | **Turbine numbers** |
|---|---|
| High bat sensitivity area | None |
| High bat sensitivity buffer | None |
| Moderate bat sensitivity area | None |
| Moderate bat sensitivity buffer | 1, 2, 4, 5, 6, 19 – 24, 32, 35, 37, 50, 51, 56, 57, 60, 63, 66, 68 - 70 |




High Bat Sensitivity

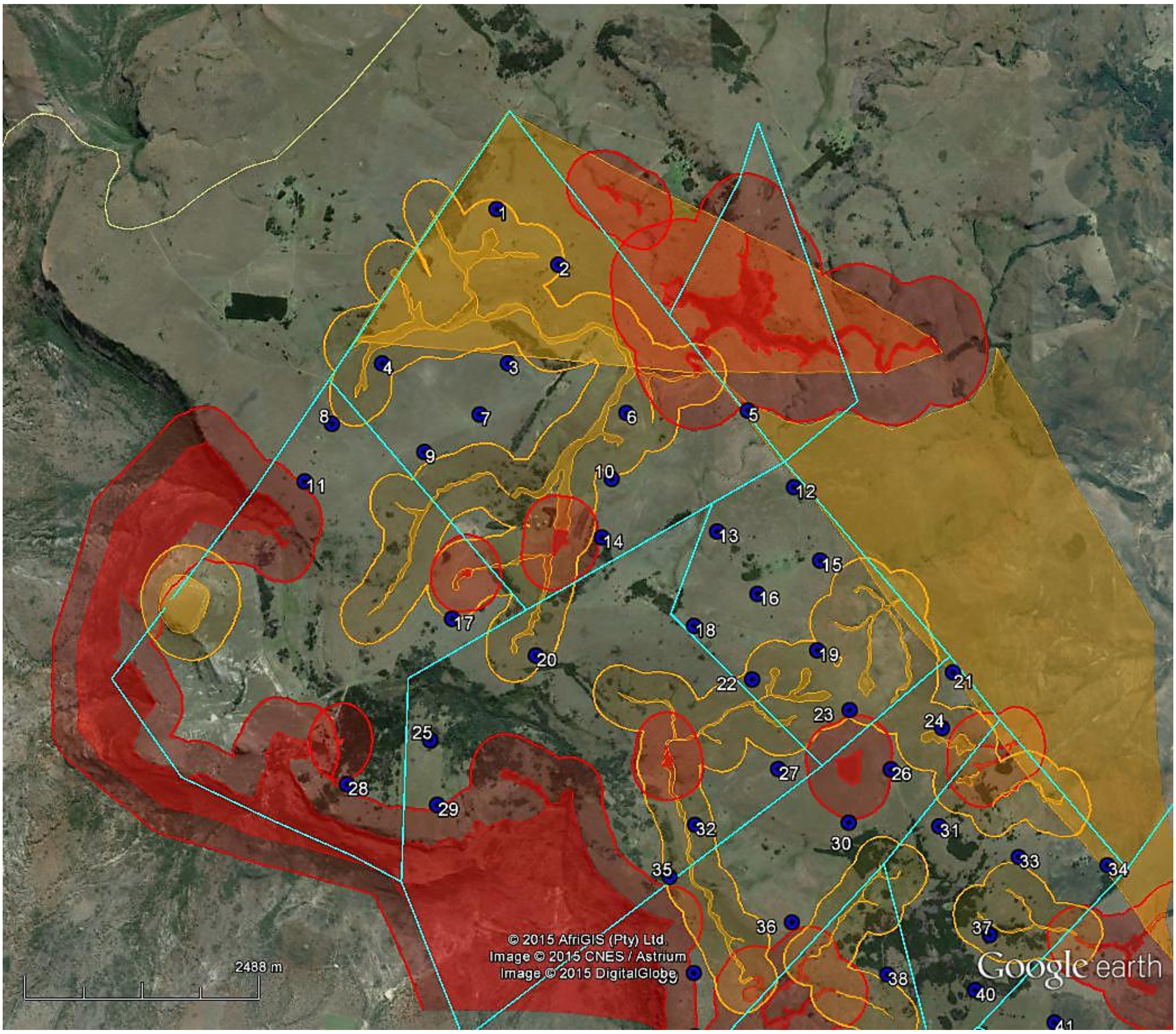
Buffer around high sensitivity

Moderate Bat Sensitivity

Buffer around moderate sensitivity

Proposed turbine localities

**Figure 12:** Bat sensitivity map of the entire site.




**High Bat Sensitivity**

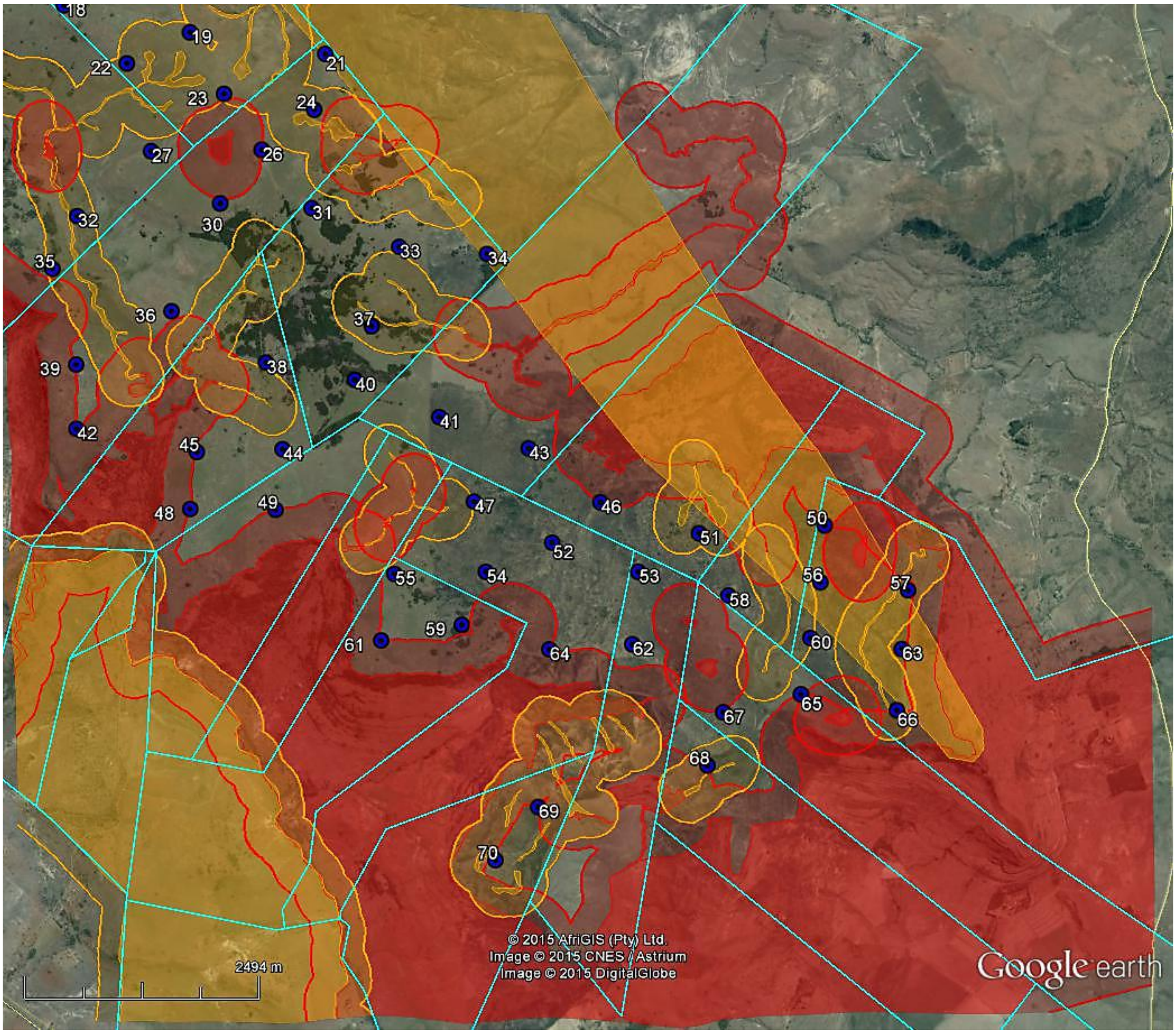
**Buffer around high sensitivity**

**Moderate Bat Sensitivity**

**Buffer around moderate sensitivity**

**Proposed turbine localities**

**Figure 13:** Bat sensitivity map of the northern section of site. Note the probable fruit bat flight path (triangular polygon) at the northernmost tip of the site, it has been designated as Moderate sensitivity.




**High Bat Sensitivity**

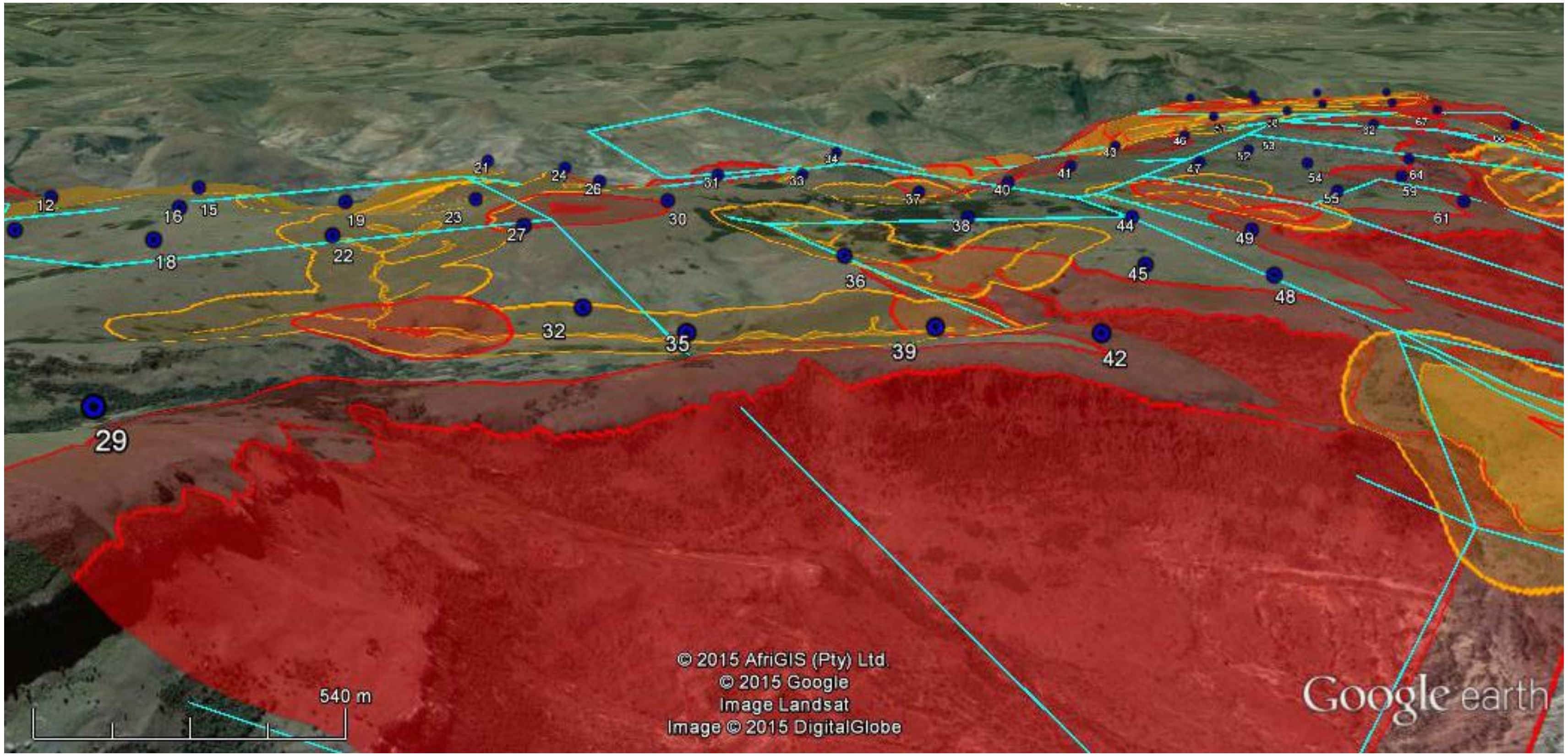
**Buffer around high sensitivity**

**Moderate Bat Sensitivity**

**Buffer around moderate sensitivity**

**Proposed turbine localities**

**Figure 14:** Bat sensitivity map of the southern section of site.




| | | | |
|---|---|---|---|
| ■ | **High Bat Sensitivity** | ■ | **Moderate Bat Sensitivity** |
| □ | **Buffer around high sensitivity** | □ | **Buffer around moderate sensitivity** |
| ● | **Proposed turbine localities** | | |

**Figure 15:** 3-Dimensional bat sensitivity map of the site, indicating cliffs on sides of escarpment to be of a High sensitivity.

## 4.6 Passive Data

The long term monitoring data presented below spans the time frame of October 2013 – November 2014, and for the Lattice mast from July 2015 – March 2015. It presents the composition and abundance of the bat assemblage, and the temporal distribution of bat activity. The results of the monitoring 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.

The monitoring systems of the short masts have one microphone mounted at 10m, while the Tubular and Lattice met masts have two microphones (one mounted at 10m and another at 50m). The 50m mic on the Tubular mast was however lowered to approximately 25m in May 2014 (See Section 3).

### 4.6.1 Abundances and composition of bat assemblage

**Figures 16 - 21** display the bat species, and number of bat passes detected per species over the entire monitoring period, for each monitoring system.

An assemblage of seven different bat species was detected on site by the passive monitoring systems. These species were identified by parameters of peak frequency, slope, duration and bandwidth of their echolocation calls recorded by the passive monitoring systems.

*Taphozous mauritianus* was only detected by short mast 7 monitoring system, and nine passes were detected. Bats belonging to the family Miniopteridae, such as the migratory species, *Miniopterus natalensis,* was detected by all of the monitoring systems, with particularly high detections by short mast 7. However, no migratory event has been detected.

*Tadarida aegyptiaca* and *Neoromicia capensis* were the most abundant species detected by all of the monitoring systems. These two species are the most common and abundant insectivorous bat species found across South Africa. The common and more abundant species are of large value to the local ecosystems as they provide greater ecological services than the more rare species, due to their greater abundance.

Much fewer bat passes were detected by the 50m and 25m microphone heights of the Lattice and Tubular Masts, respectively, compared to the passes recorded at the 10m microphones. Short masts 6 were located next to a manmade dam and Short mast 7 was located near a farm house, both serving as controls.

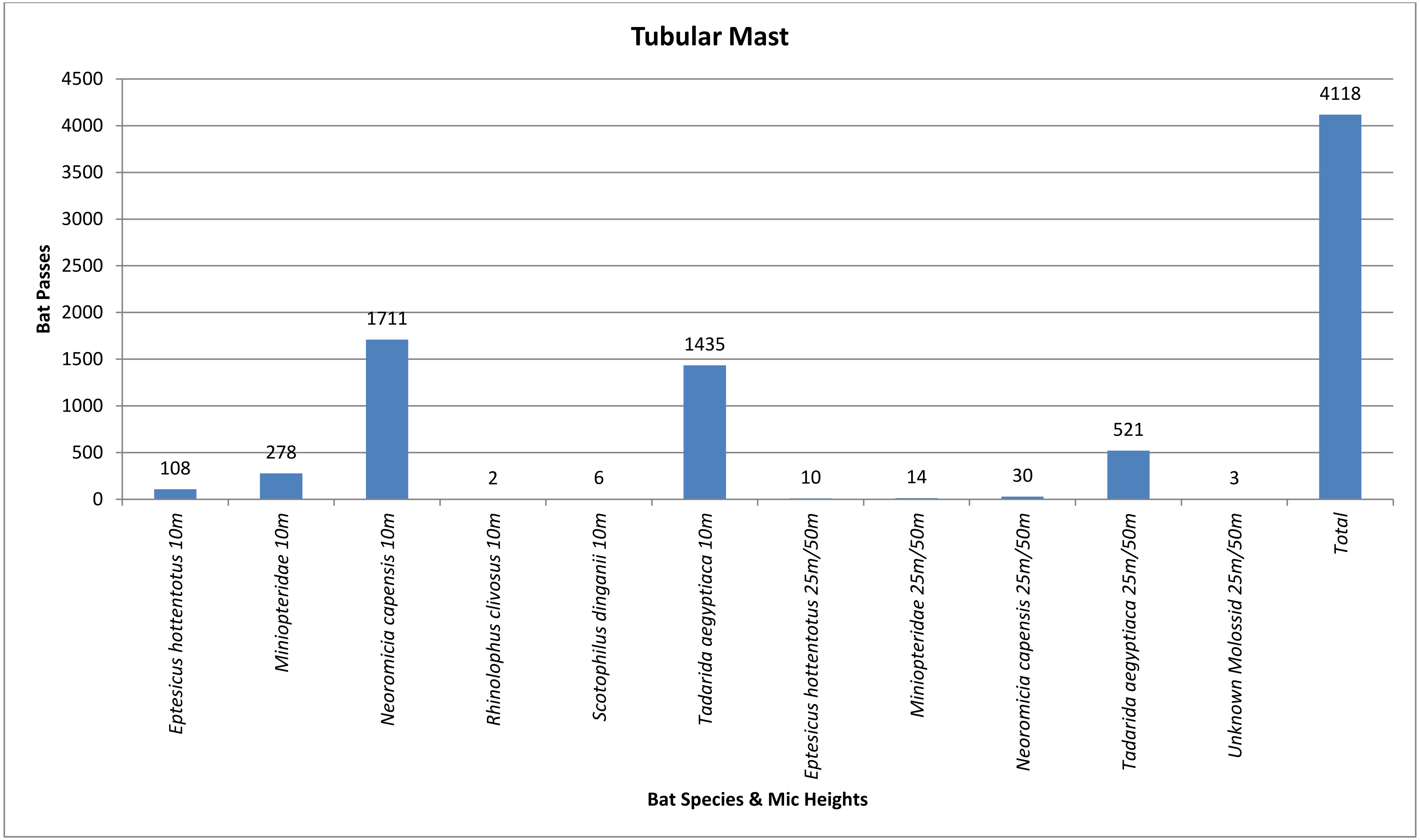



**Figure 16:** Species assemblage detected by the 10m and 25m/50m mic of the Tubular mast passive monitoring system.

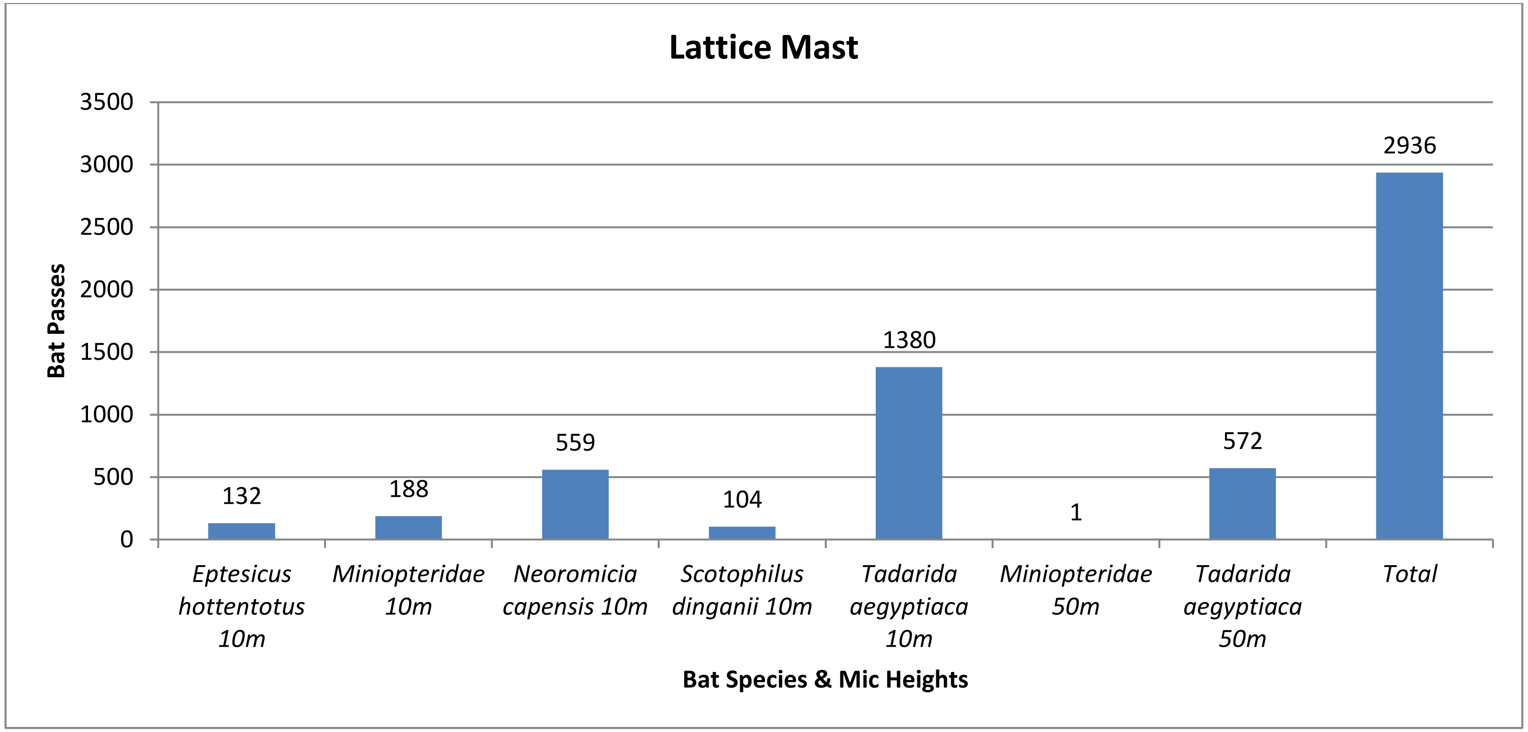



**Figure 17:** Species assemblage detected by the 10m and 50m mic of the Lattice Mast passive monitoring system.

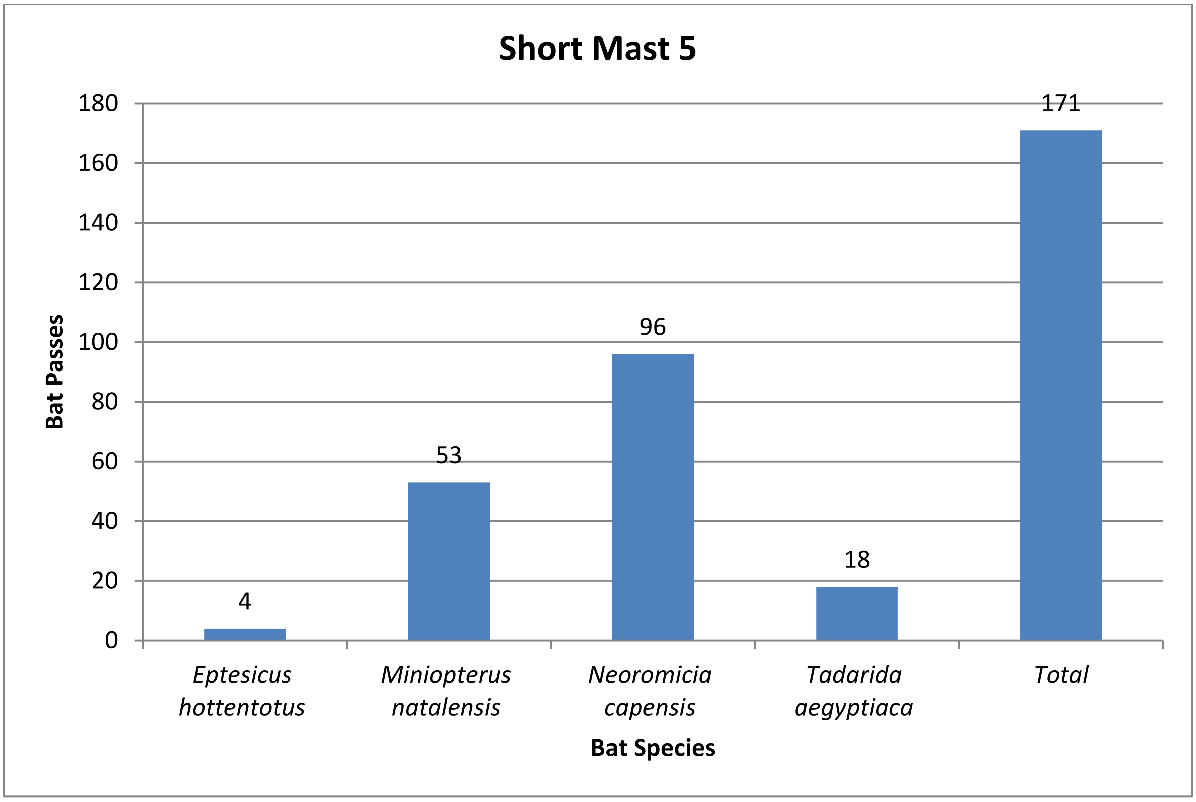



**Figure 18:** Species assemblage detected by the Short Mast 5 passive monitoring system

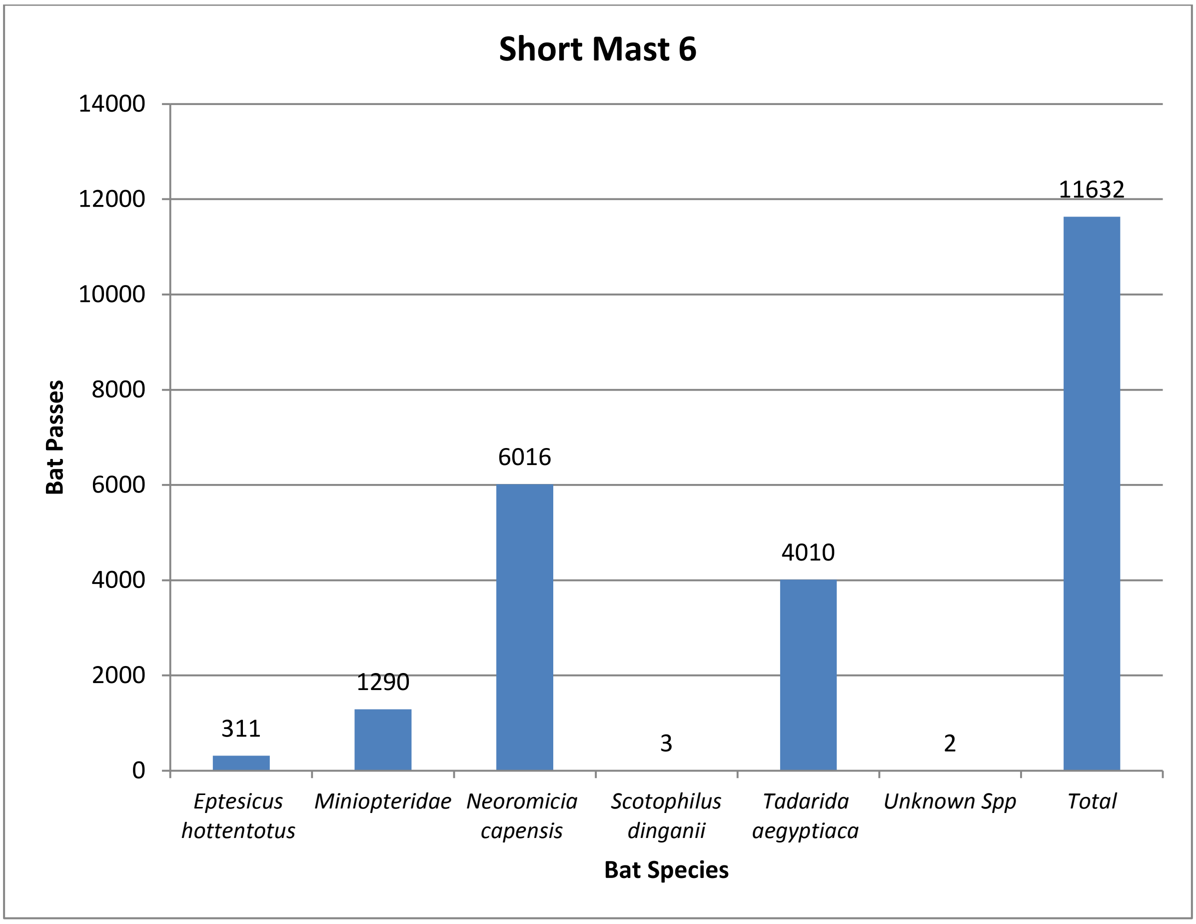



**Figure 19:** Species assemblage detected by the Short Mast 6 passive monitoring system

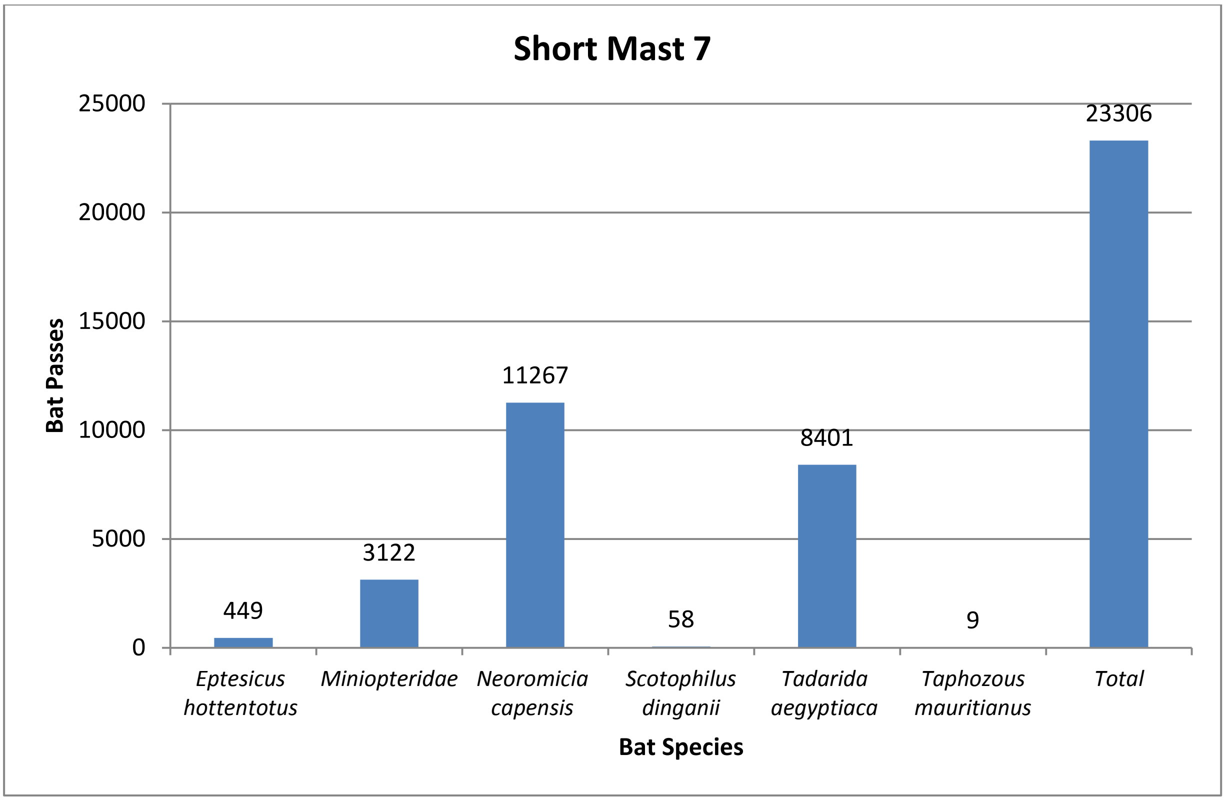



**Figure 20:** Species assemblage detected by the Short Mast 7 passive monitoring system

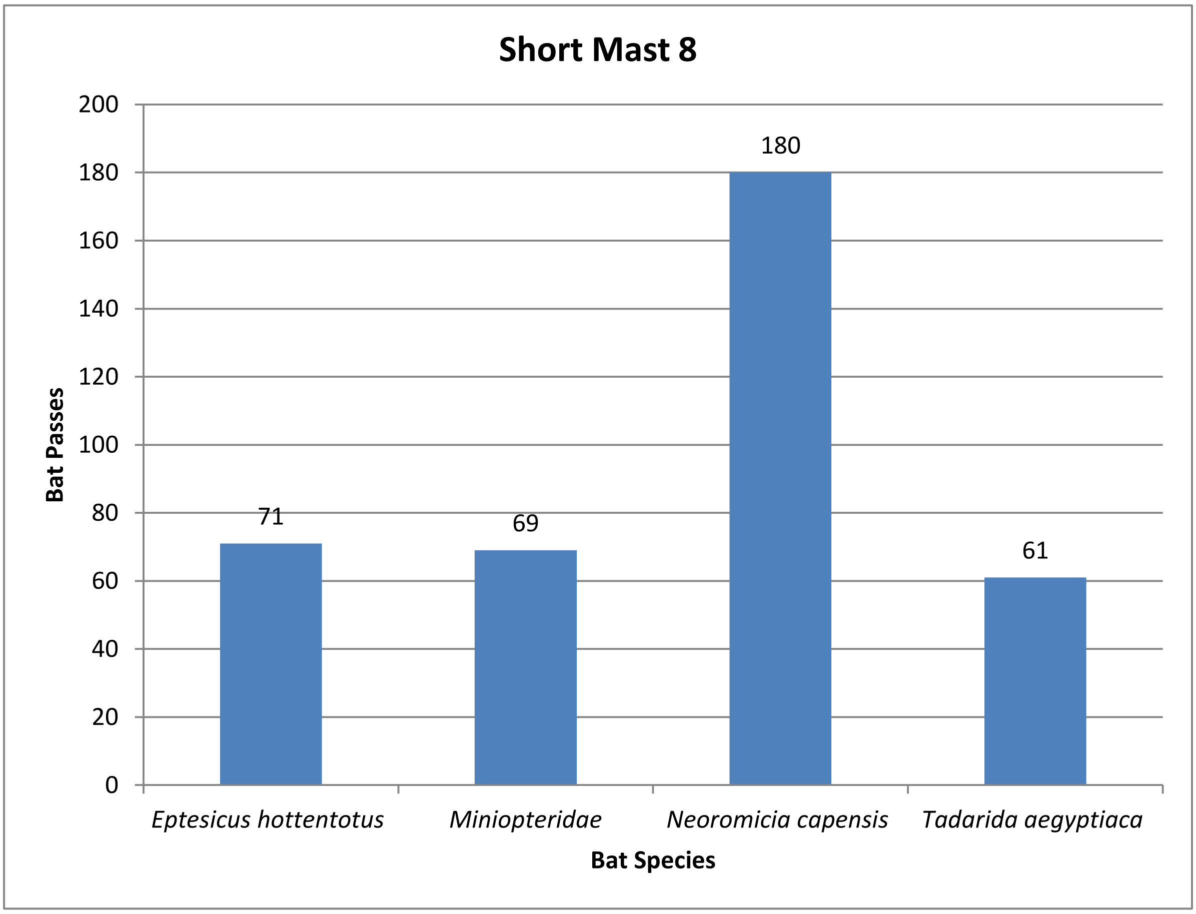



**Figure 21:** Species assemblage detected by the Short Mast 8 passive monitoring system.

**Figures 22 – 27** depict the average bat passes detected per night for each month of the monitoring period. Several of the short mast monitoring systems display blank periods of zero bat detections. These monitoring systems were not functioning over those timeframes, as outlined above in Section 3.

**Figure 22** displays the average nightly passes per month for the Tubular mast monitoring system. Activity peaks over November, February and March with a significant decline in activity over the winter months. Activity starts to increase during October.

**Figure 23** displays an increase during the month of October for the Lattice mast as activity entered the summer months.

**Figure 24** displays peaking activity for Short mast 5 over the month of February.

**Figure 25** displays significantly higher activity from short mast 6 over October, November, February and March. Activity declines into the winter months with an increase shown during September and October.

**Figure 26** displays peak activity over August, September and October 2014 and November 2013 for short mast 7.

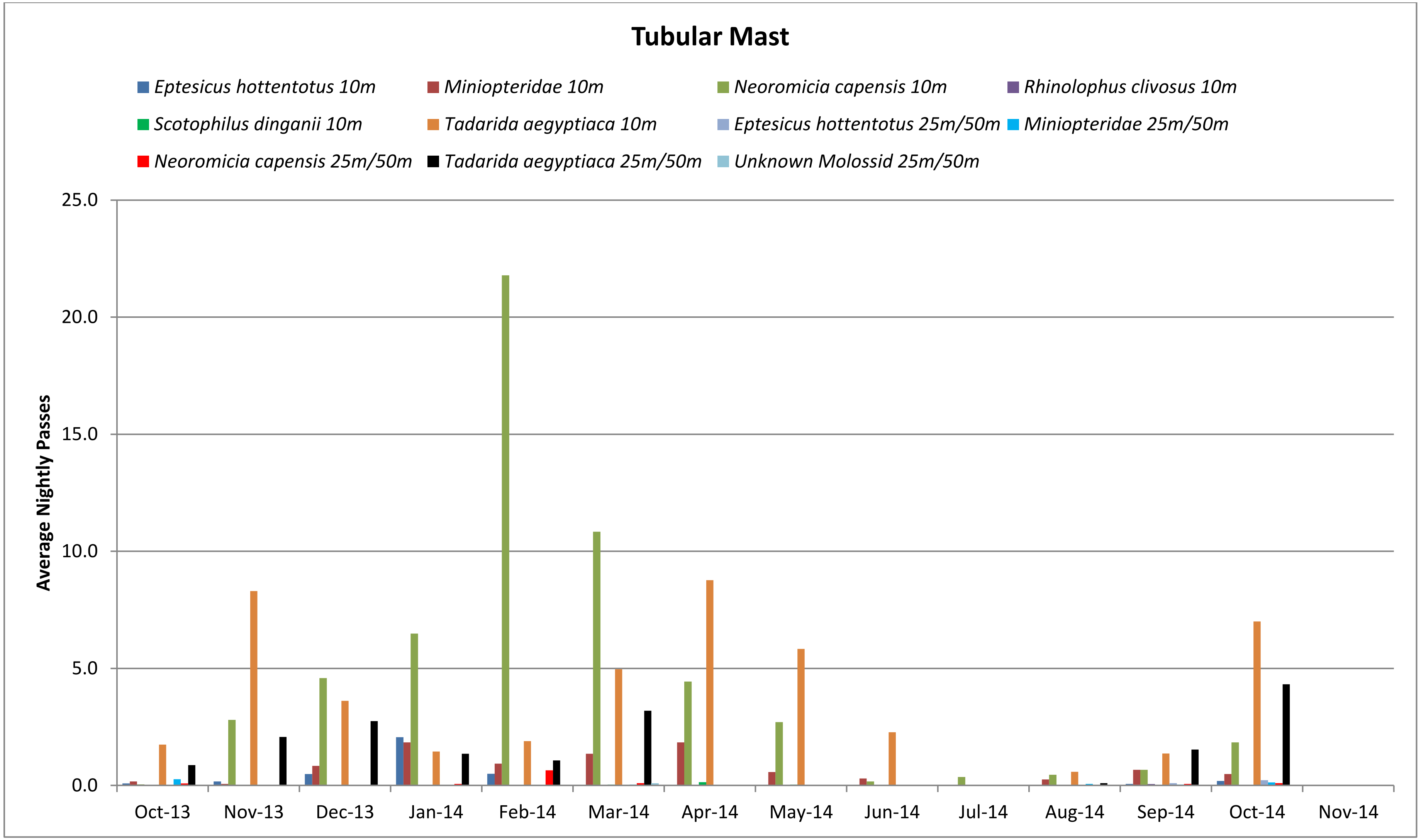



**Figure 22:** Average nightly bat passes per month for the Tubular Mast passive monitoring system.

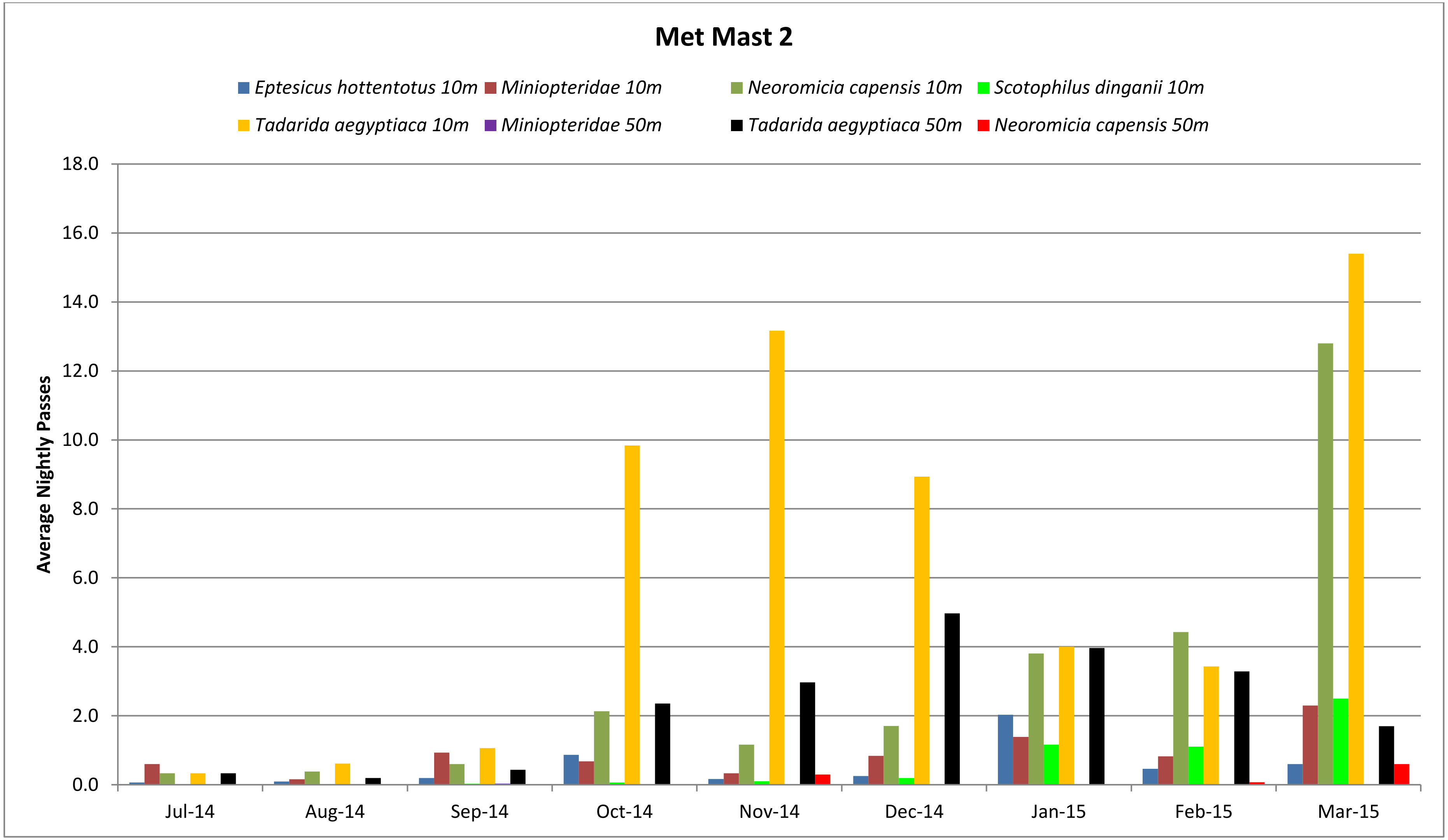



**Figure 23:** Average nightly bat passes per month for the Lattice Mast passive monitoring system.

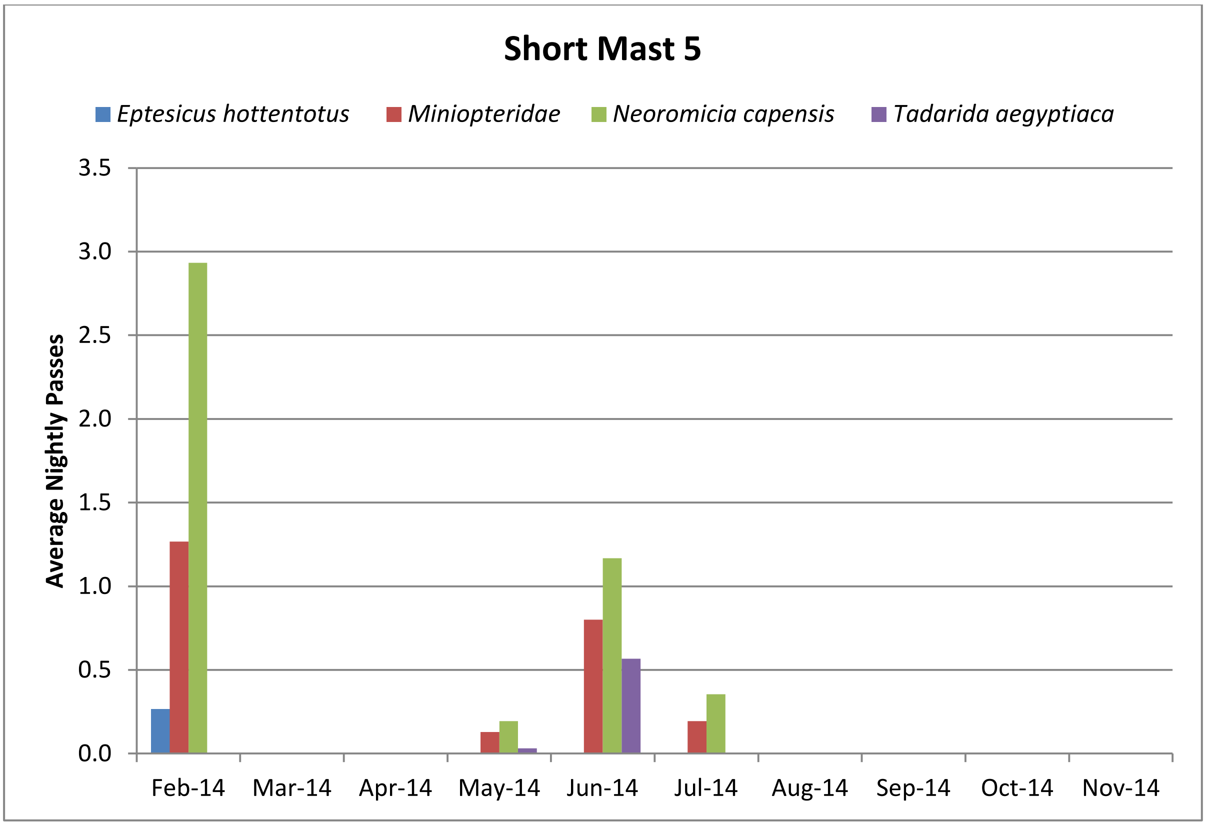



**Figure 24:** Average nightly bat passes per month for Short Mast 5 passive monitoring system

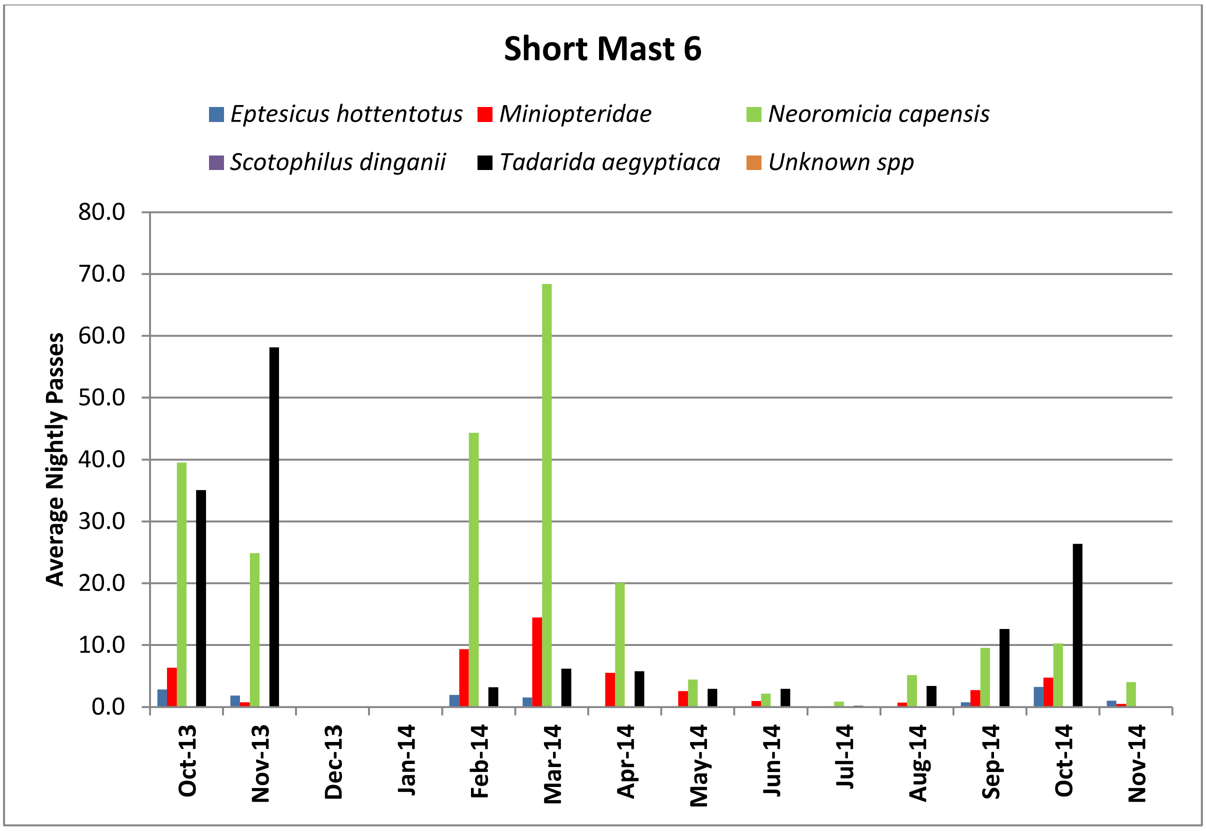



**Figure 25:** Average nightly bat passes per month for Short Mast 6 passive monitoring system

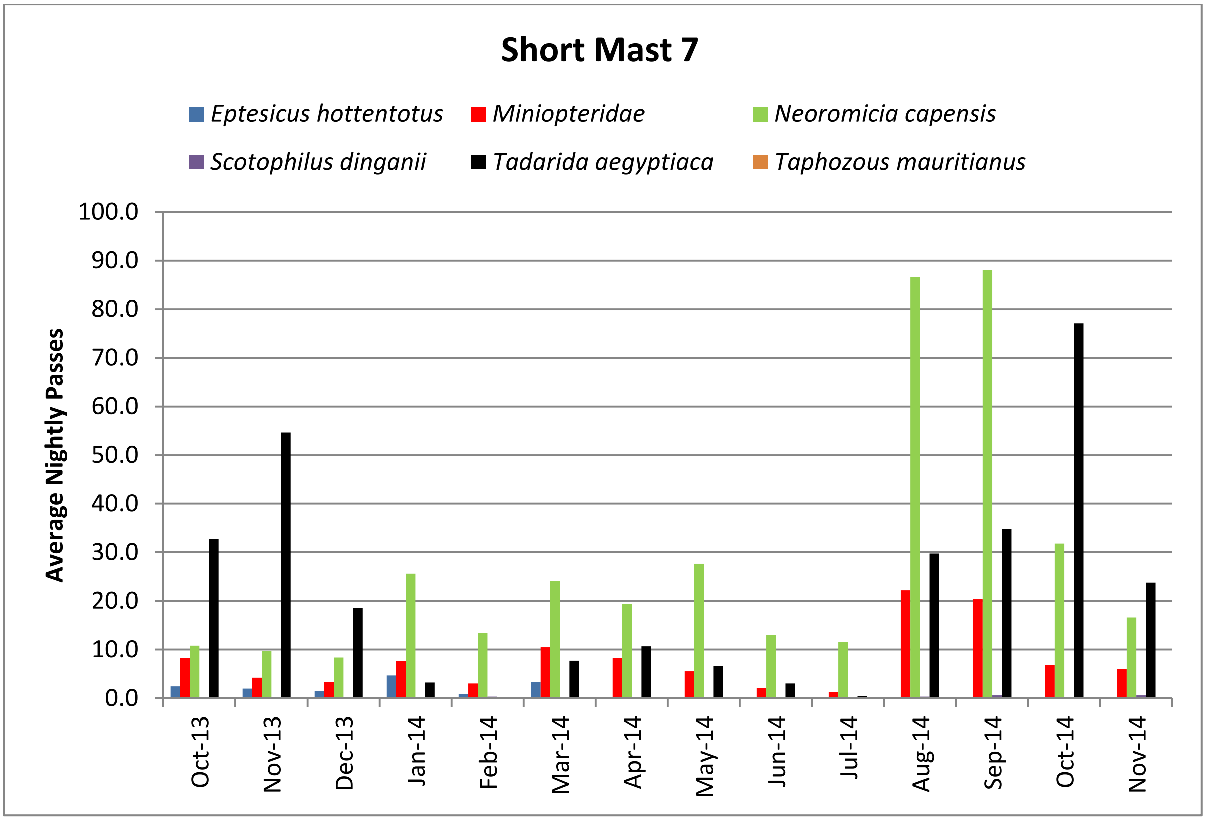



**Figure 26:** Average nightly bat passes per month for Short Mast 7 passive monitoring system

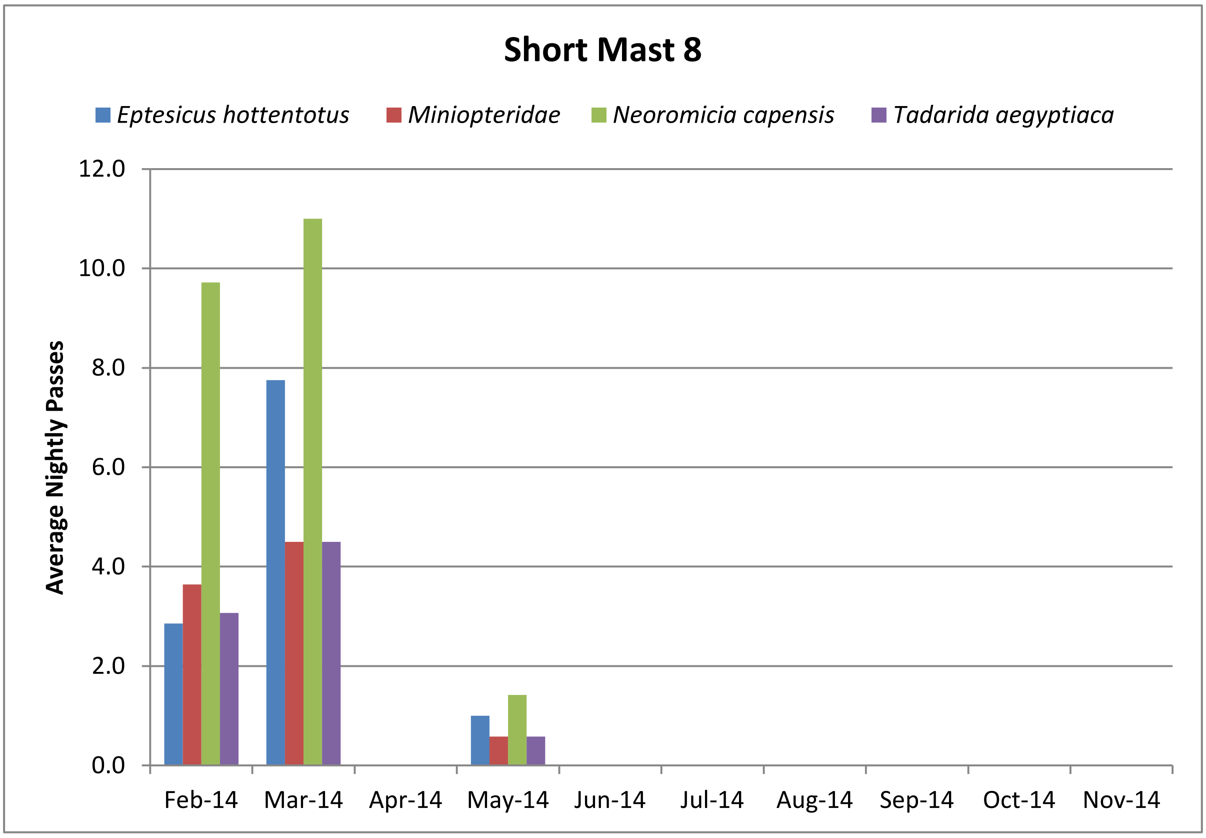



**Figure 27:** Average nightly bat passes per month for Short Mast 8 passive monitoring system

### 4.6.2 Temporal distribution

#### 4.6.2.1 Seasonal distribution over the monitoring period

**Figures 28 - 33** display the sum of passes for each species per night across the monitoring period of October 2013 –March 2015.

#### 4.6.2.2 Time of night distribution over the monitoring period

The distribution of bat activity across the night has been analysed in this section. **Figures 34 – 50** display the number of bat passes over the time of night for the five monitoring periods, namely, October 2013 – February 2014, February – May 2014, May – August 2014, August – November 2014 and November 2014 – March 2015. The high activity periods (over the seasons and night) can be used to inform specific mitigation implementation times where needed.

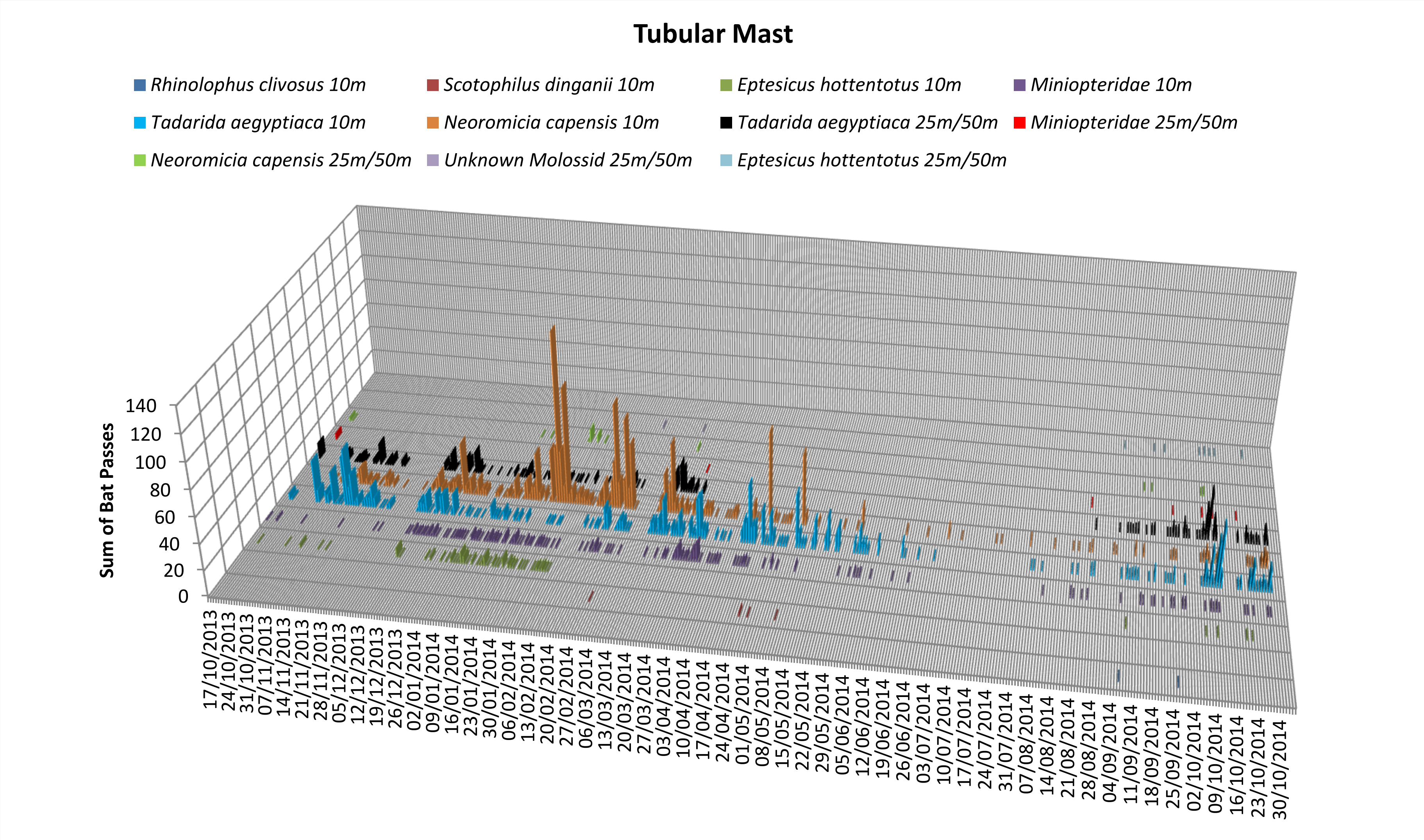



**Figure 28:** Temporal distribution of bat passes over the monitoring period for the Tubular Mast monitoring system

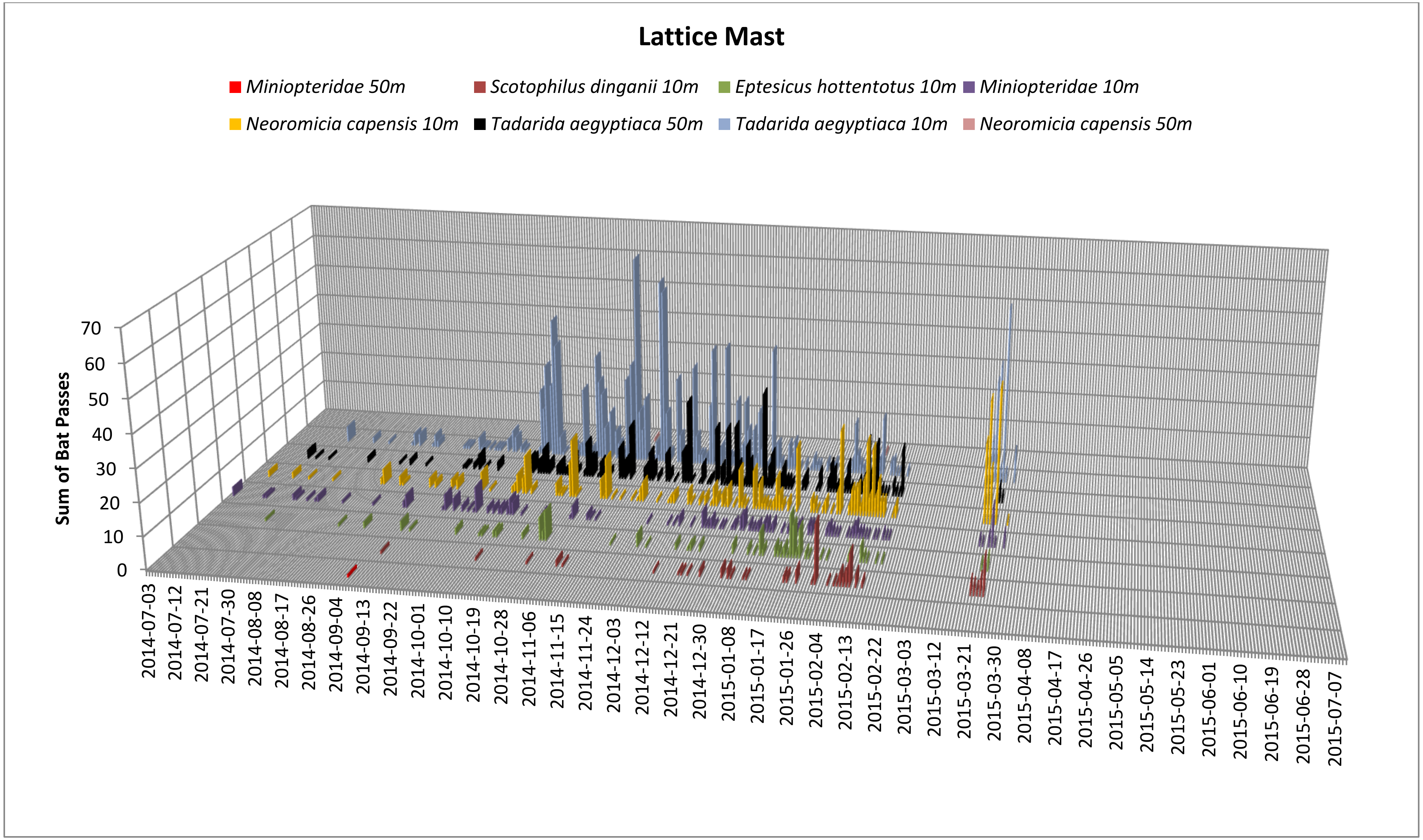



**Figure 29:** Temporal distribution of bat passes over the monitoring period for the Lattice Mast monitoring system

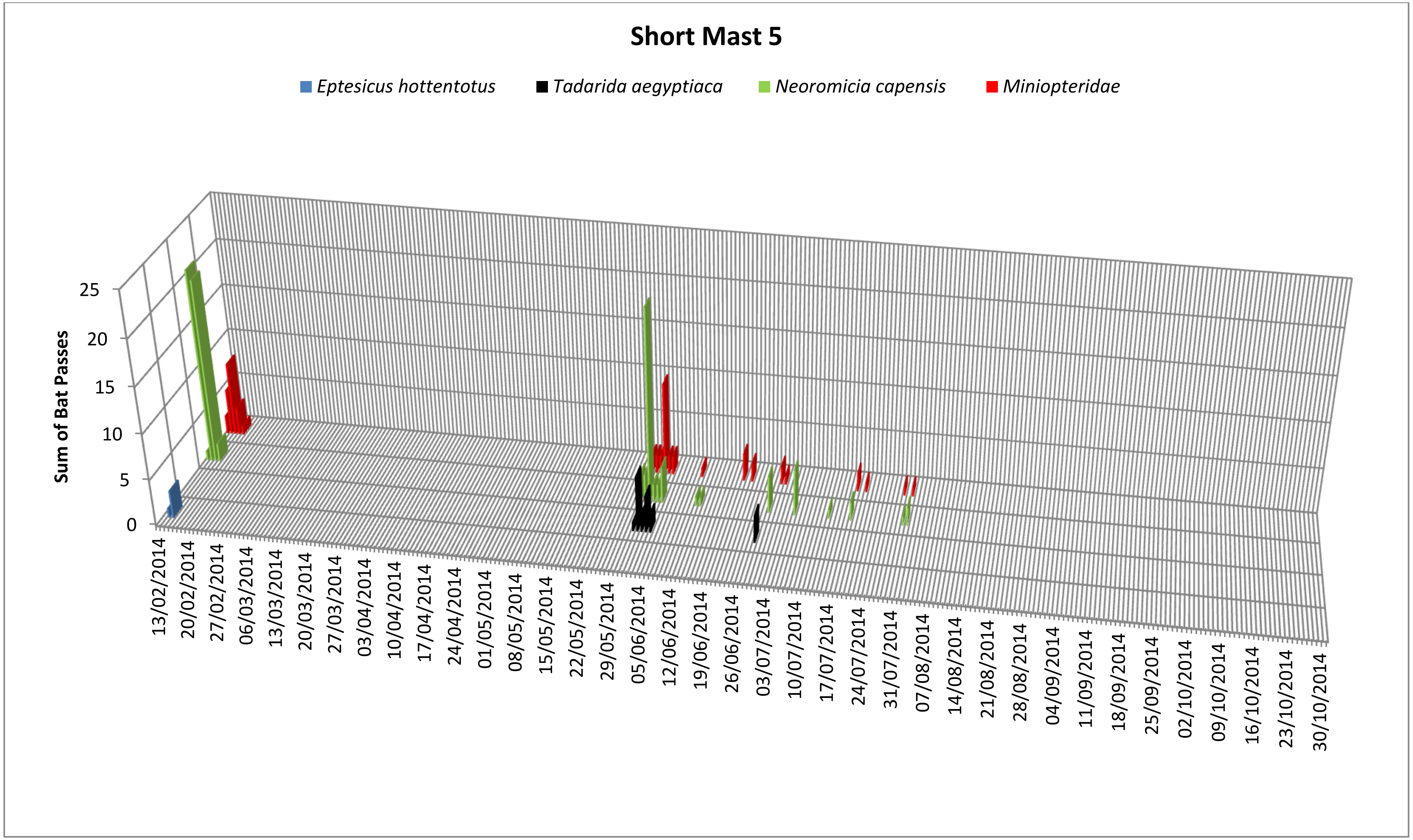



**Figure 30:** Temporal distribution of bat passes over the monitoring period for the Short Mast 5 monitoring system

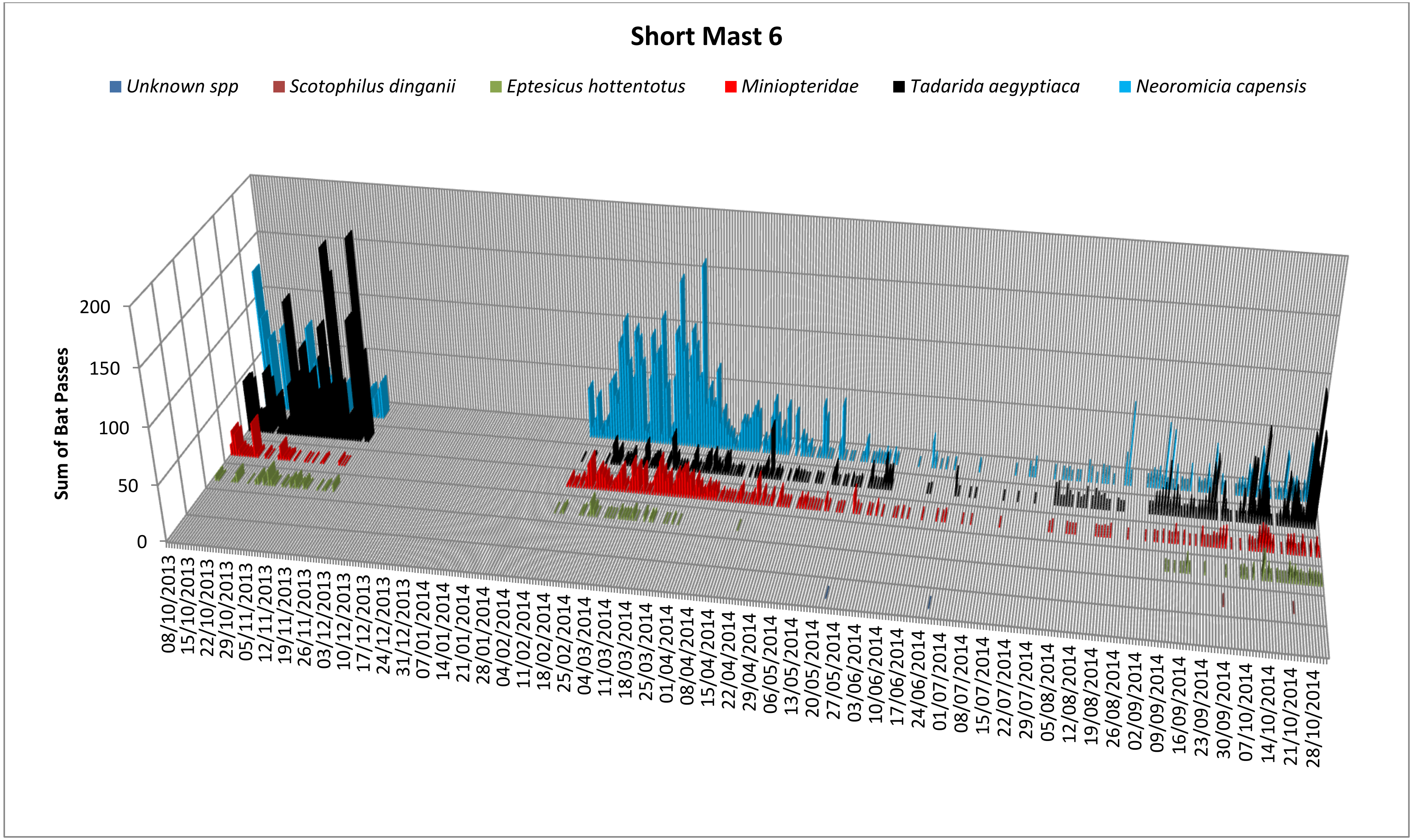



**Figure 31:** Temporal distribution of bat passes over the monitoring period for the Short Mast 6 monitoring system

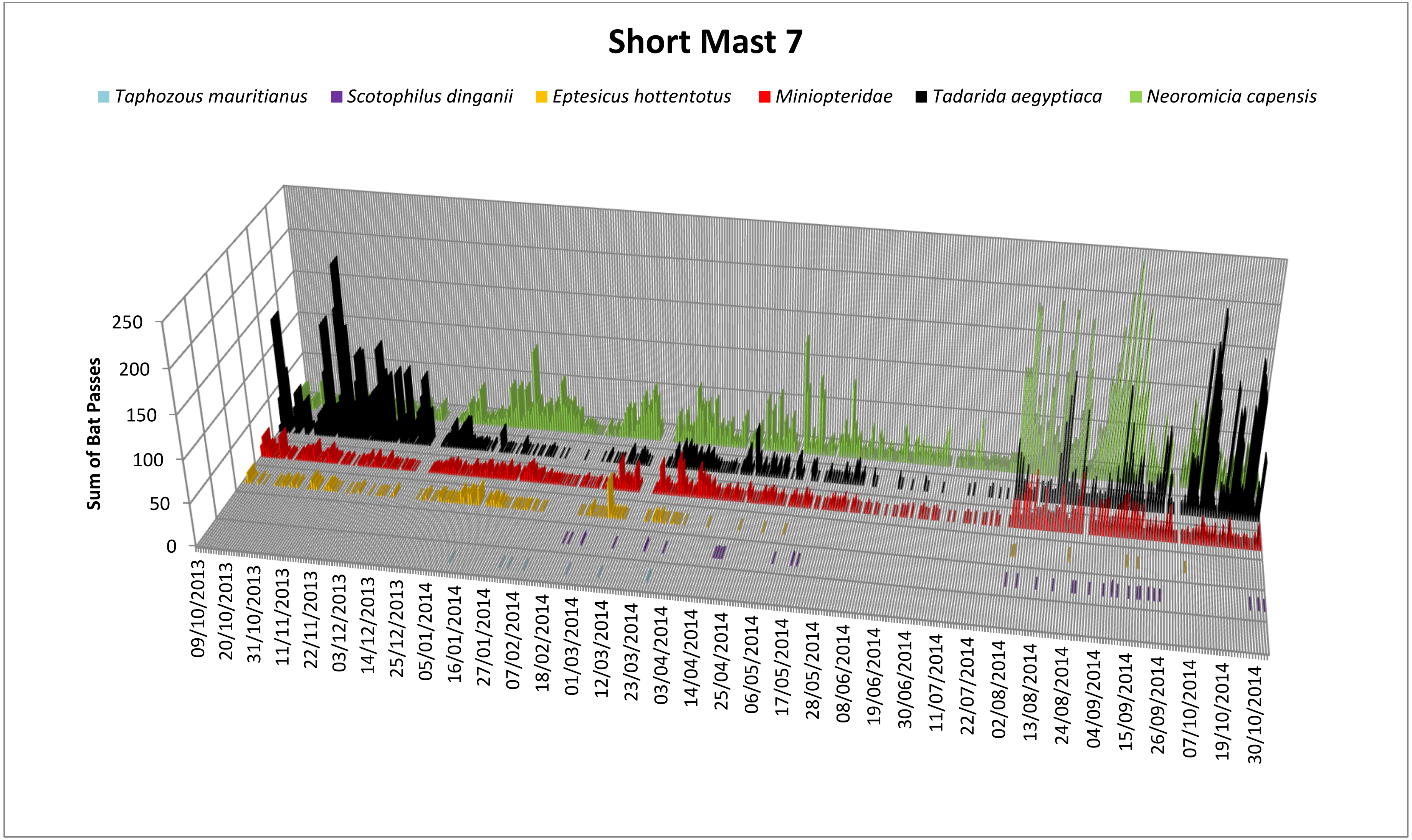



**Figure 32:** Temporal distribution of bat passes over the monitoring period for the Short Mast 7 monitoring system

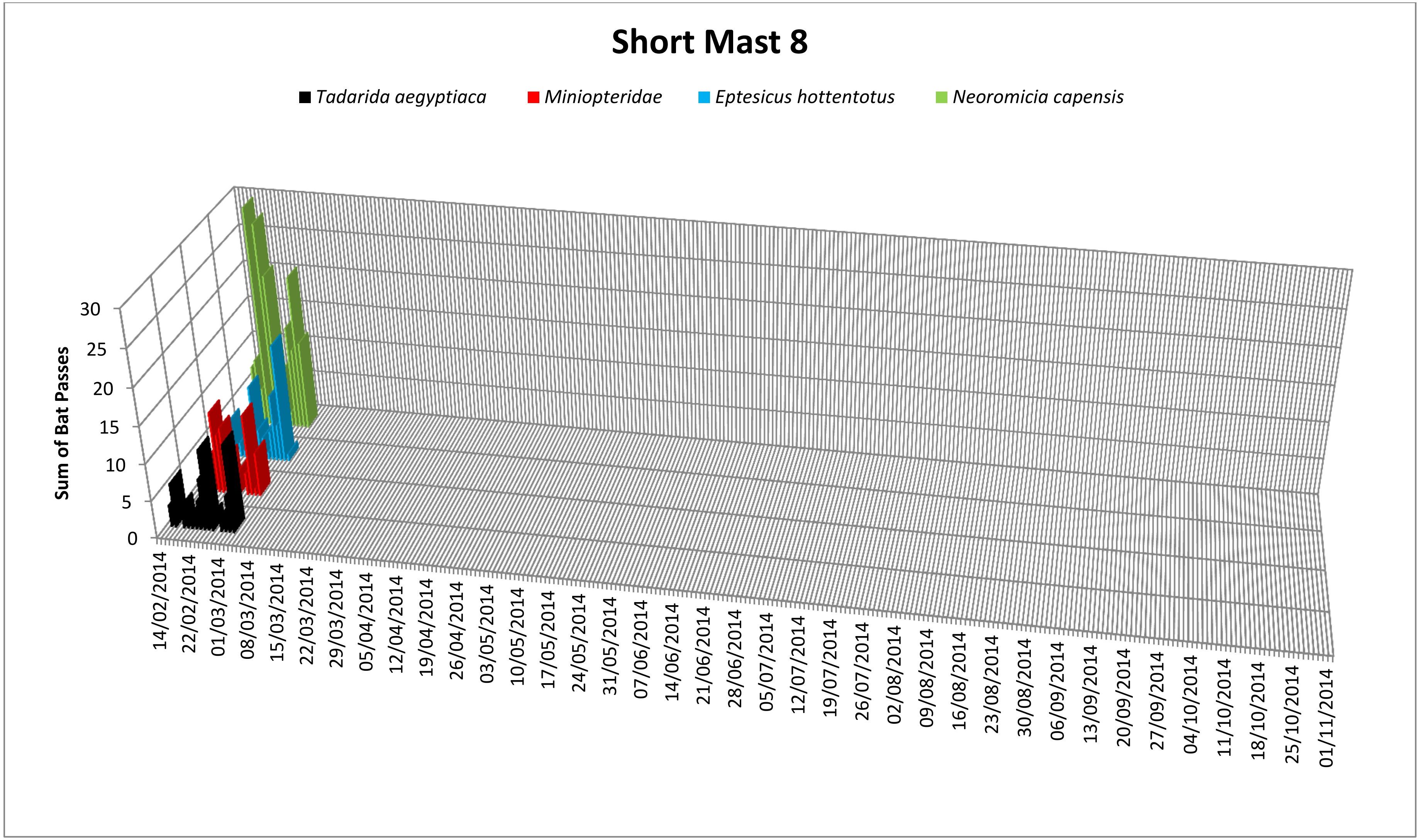



**Figure 33:** Temporal distribution of bat passes over the monitoring period for the Short Mast 8 monitoring system

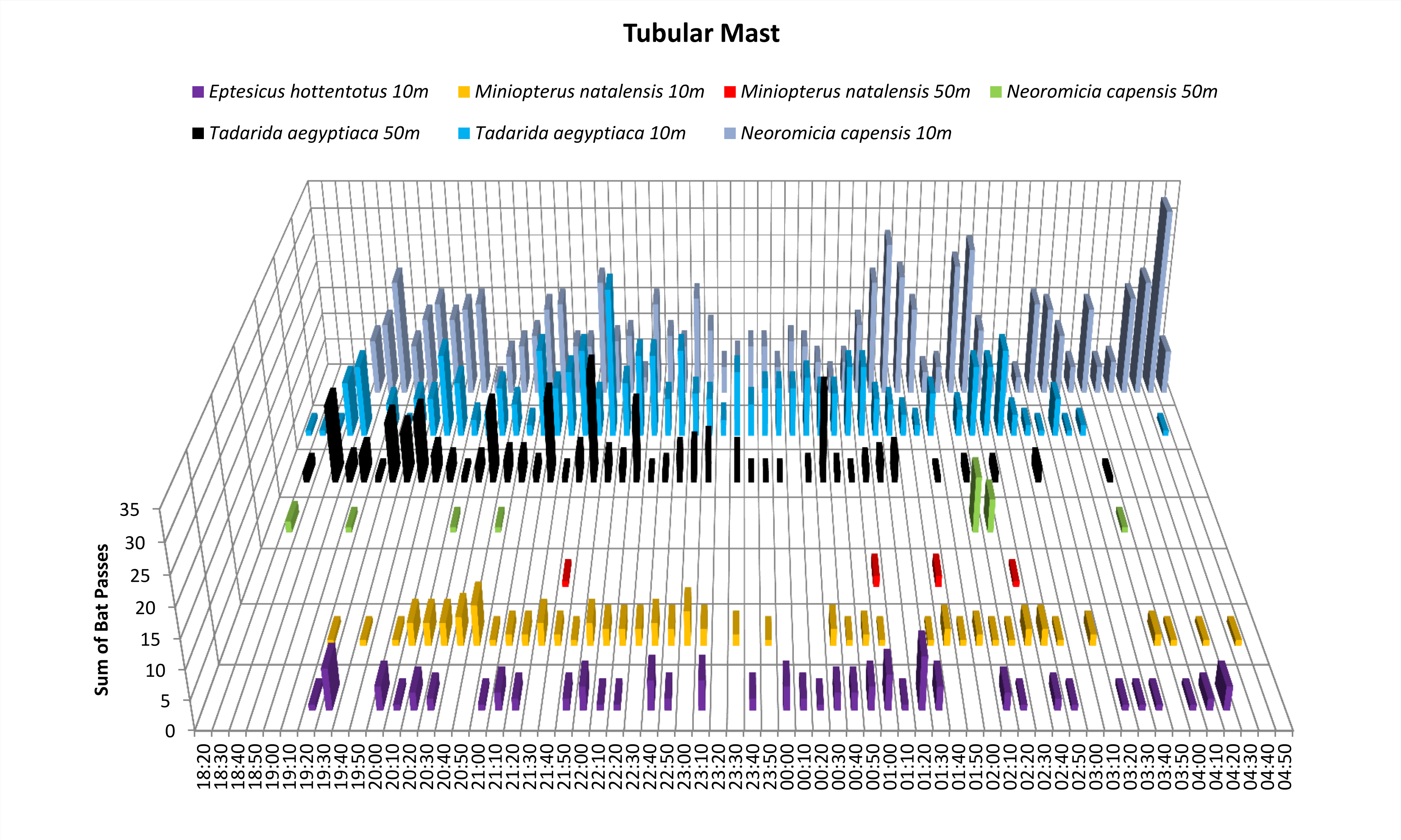



**Figure 34:** Temporal distribution of bat passes over October 2013 – February 2014 for the Tubular Mast monitoring system

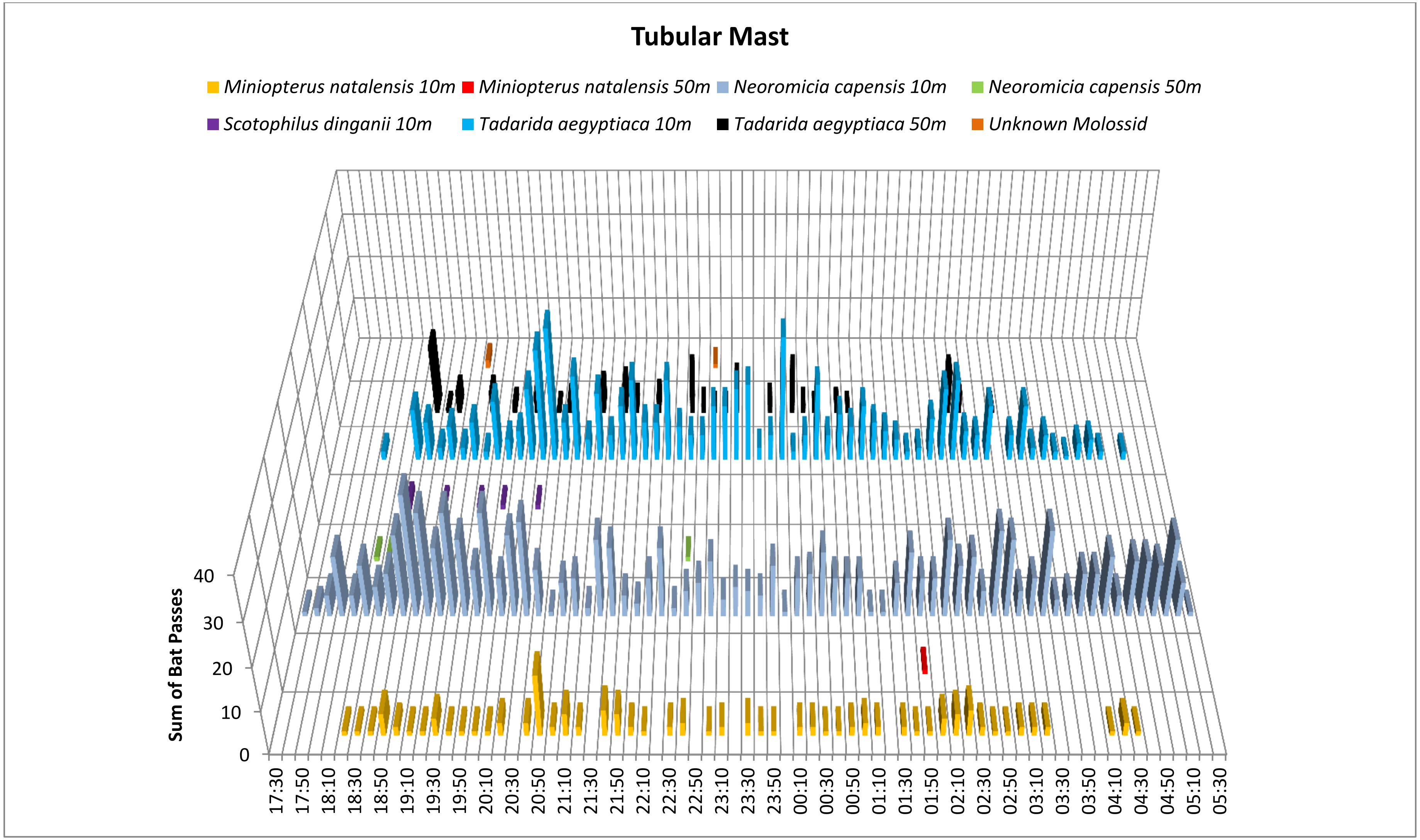



**Figure 35:** Temporal distribution of bat passes over February – May 2014 for the Tubular Mast monitoring system

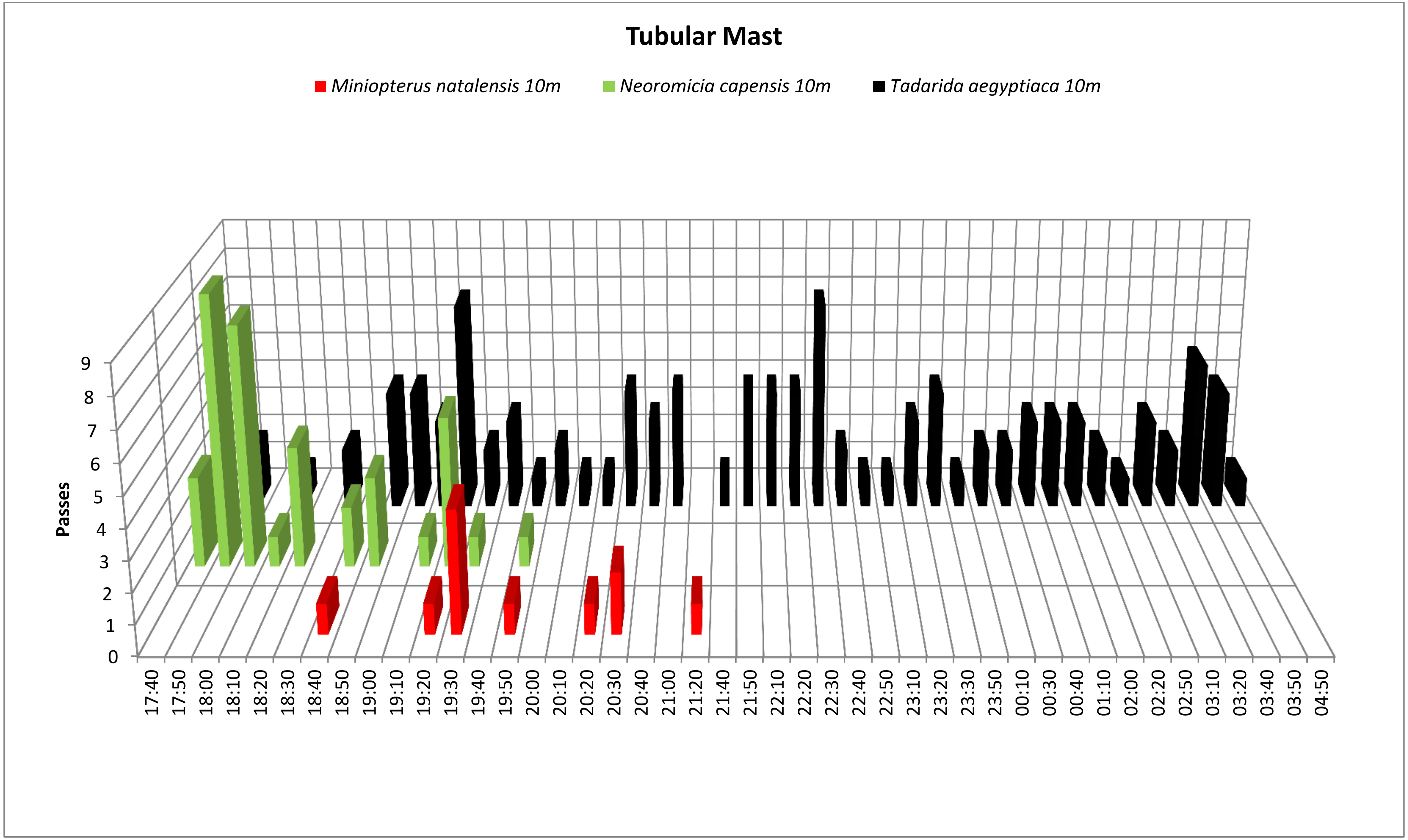



**Figure 36:** Temporal distribution of bat passes over May - August 2014 for the Tubular Mast monitoring system

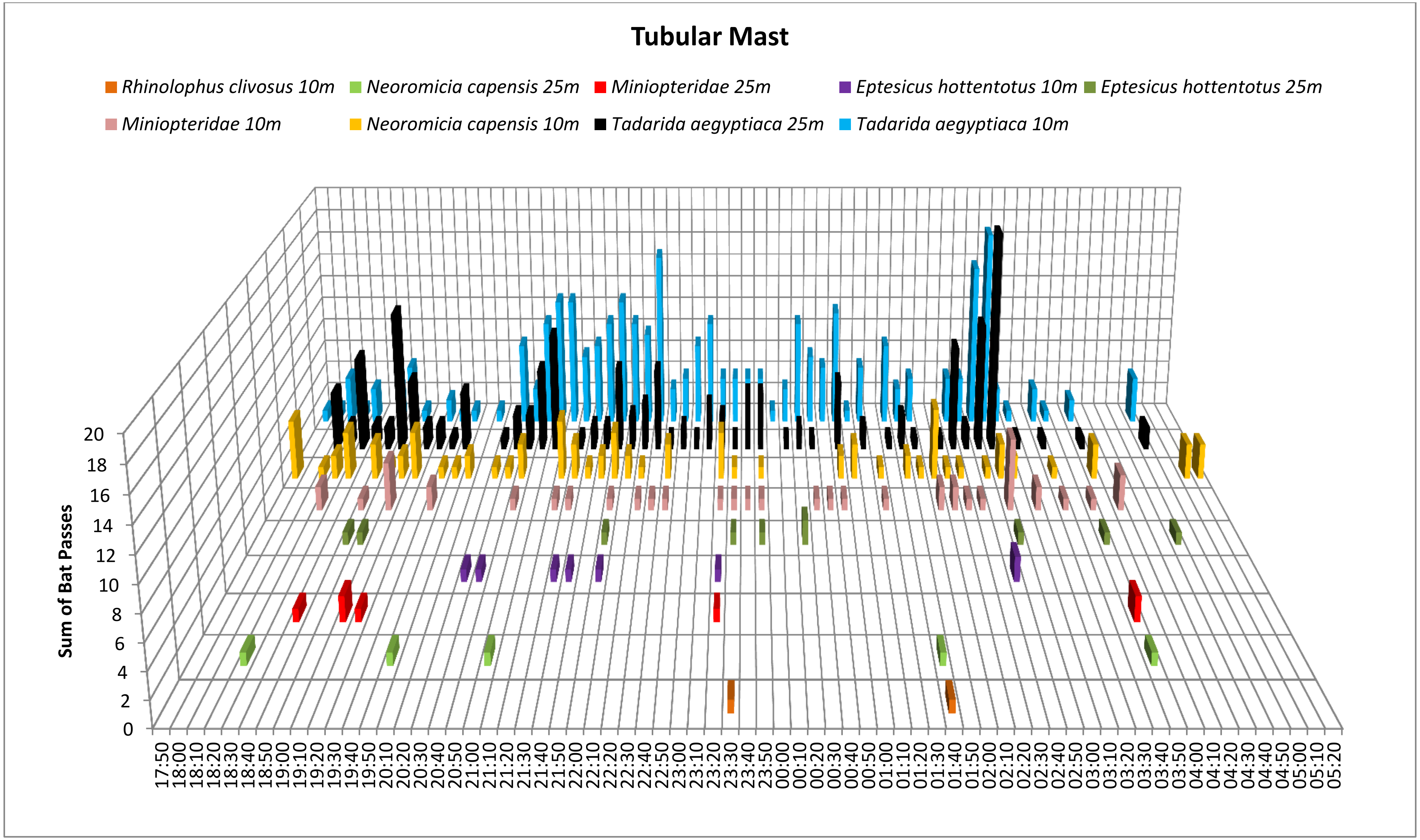



**Figure 37:** Temporal distribution of bat passes over August – November 2014 for the Tubular Mast monitoring system

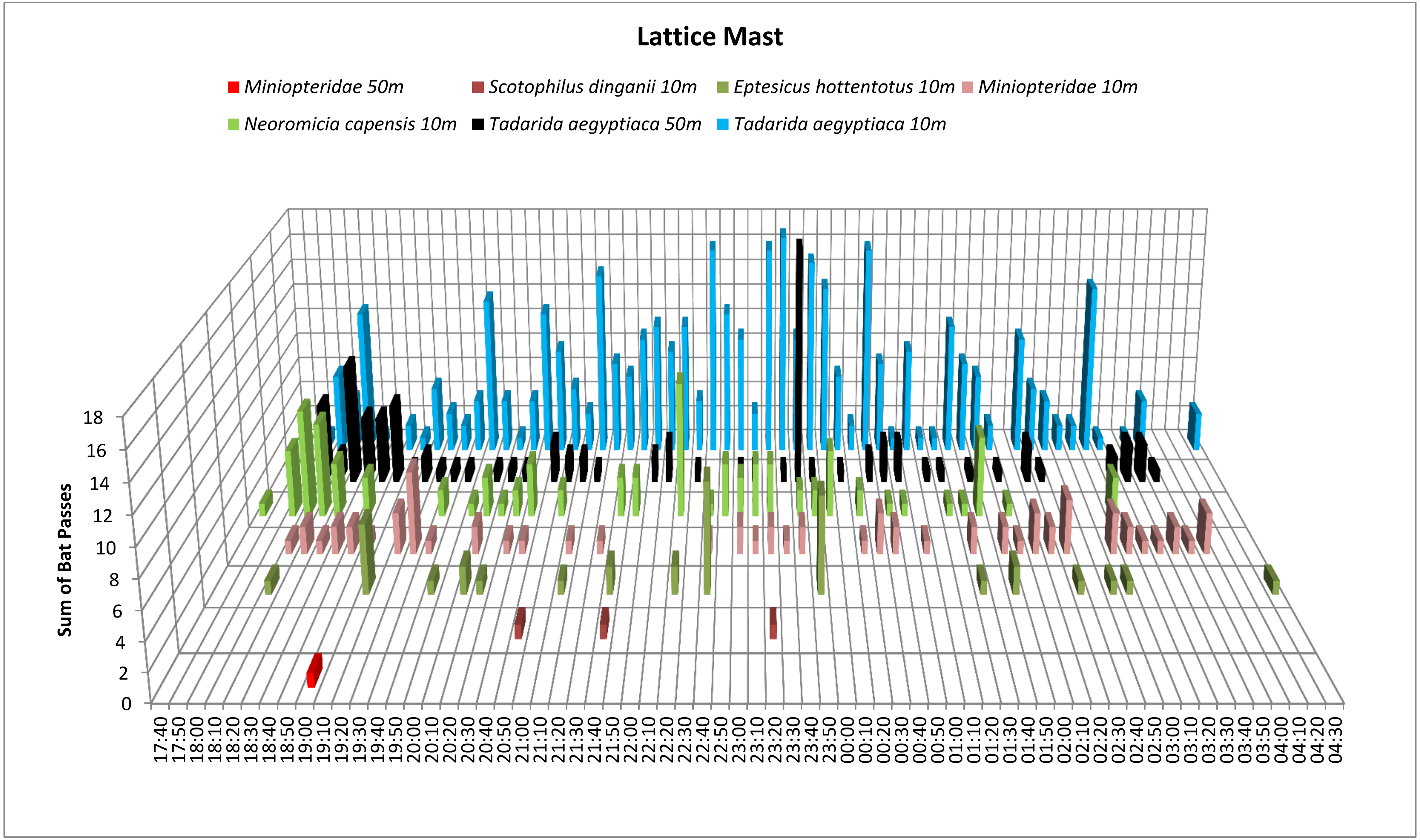



**Figure 38:** Temporal distribution of bat passes over August – November 2014 for the Lattice Mast monitoring system

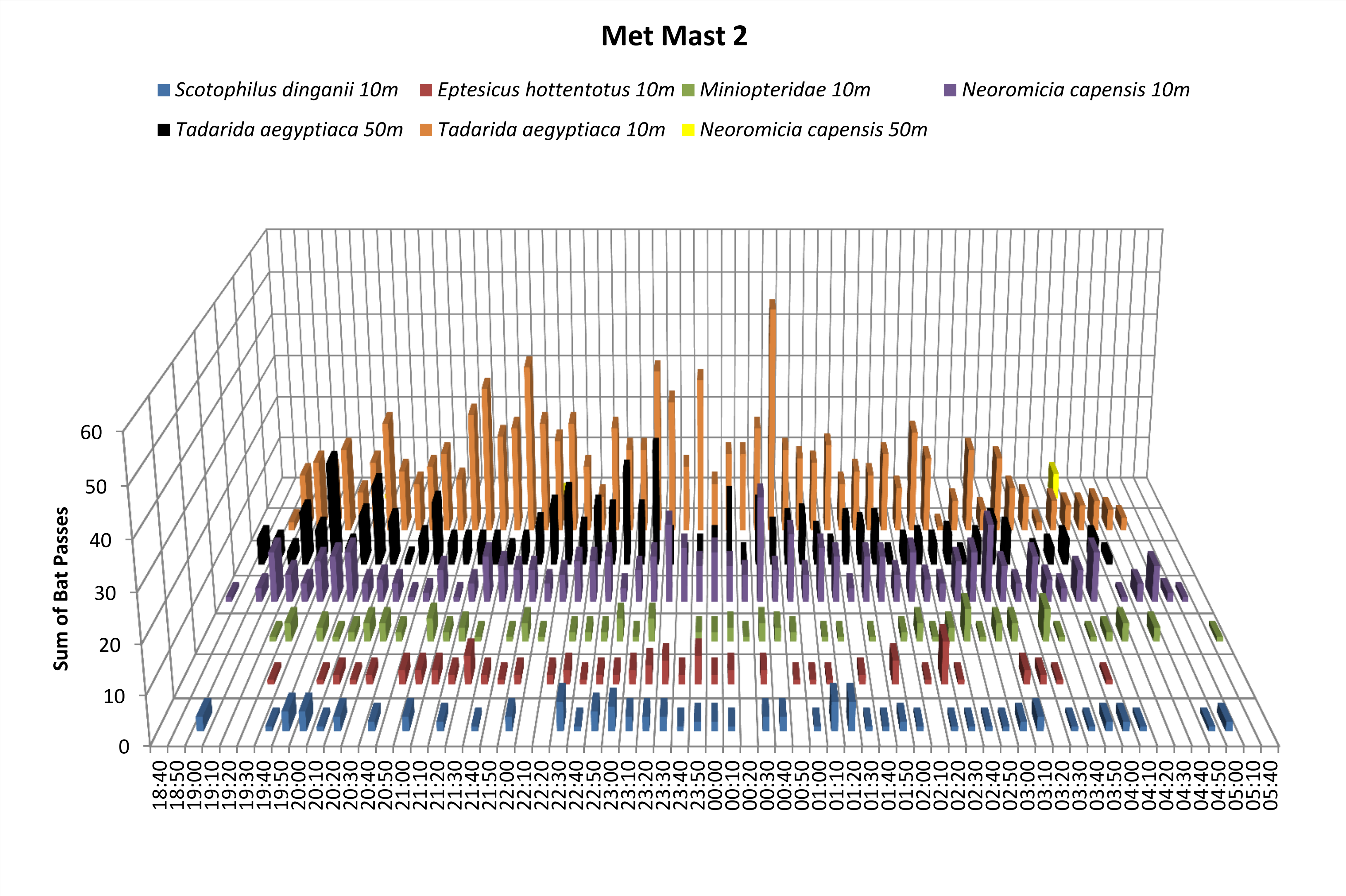



**Figure 39:** Temporal distribution of bat passes over November 2014 – March 2015 for the Lattice Mast monitoring system.

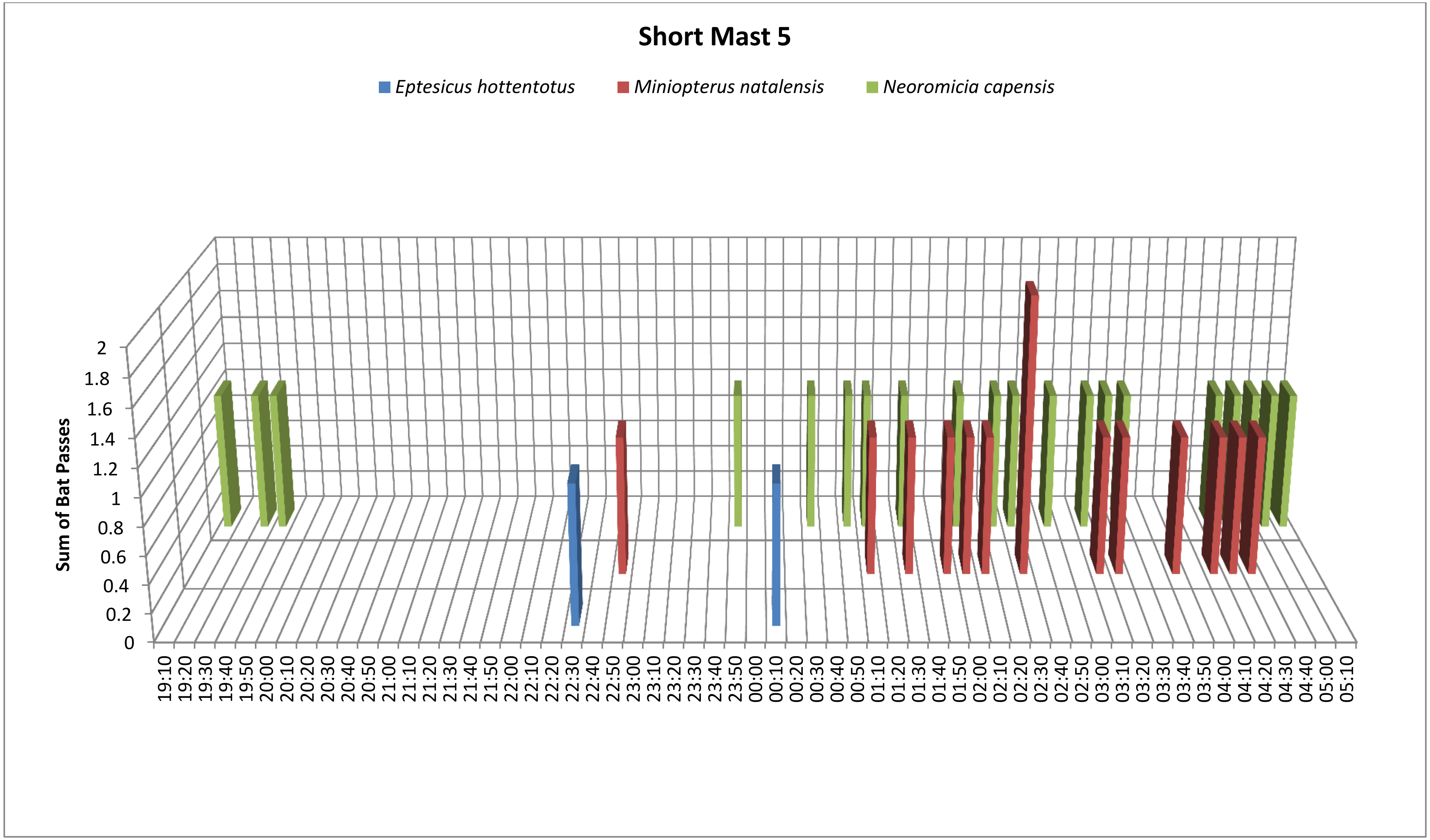



**Figure 40:** Temporal distribution of bat passes over February - May 2014 for the Short Mast 5 monitoring system

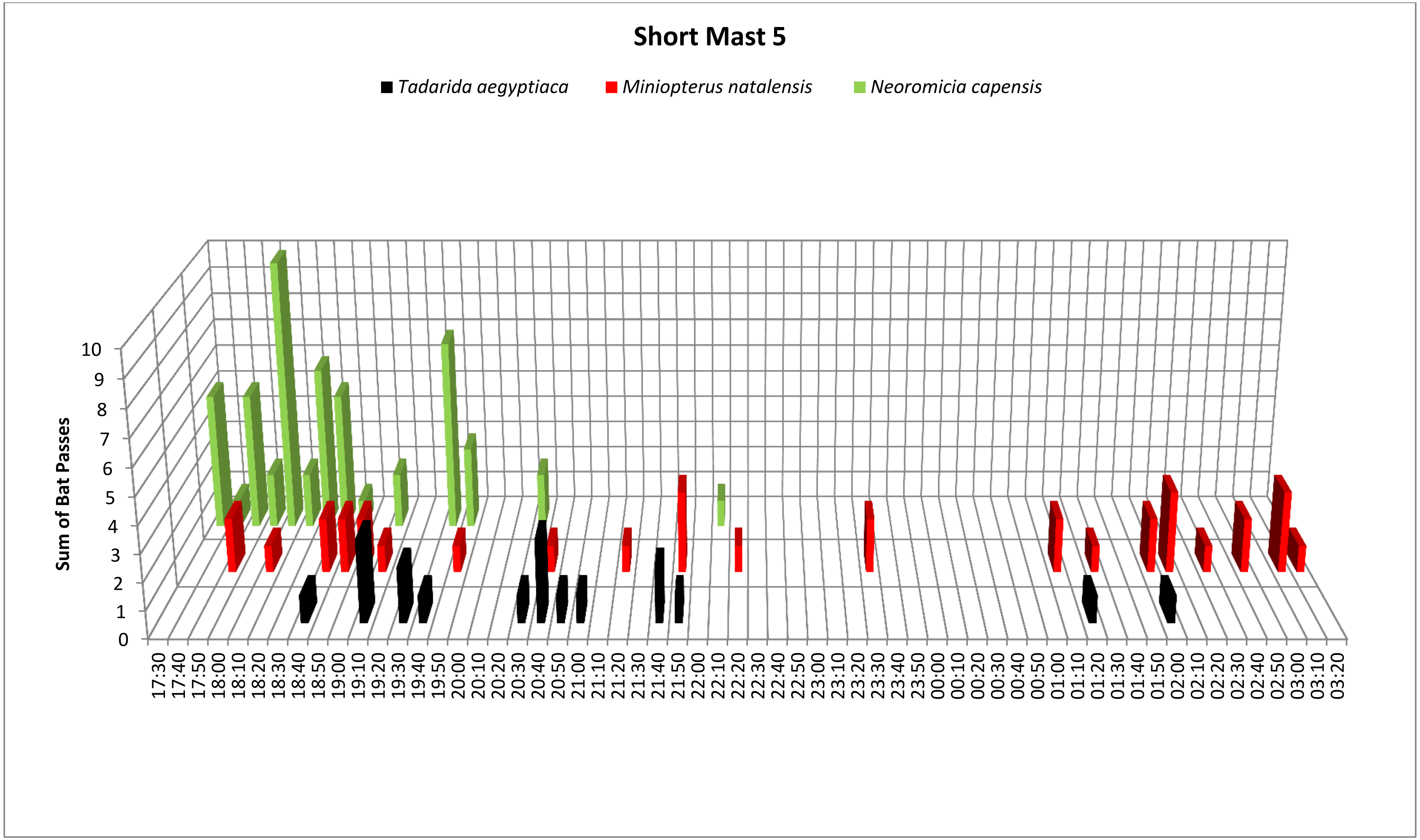



**Figure 41:** Temporal distribution of bat passes over May - August 2014 for the Short Mast 5 monitoring system

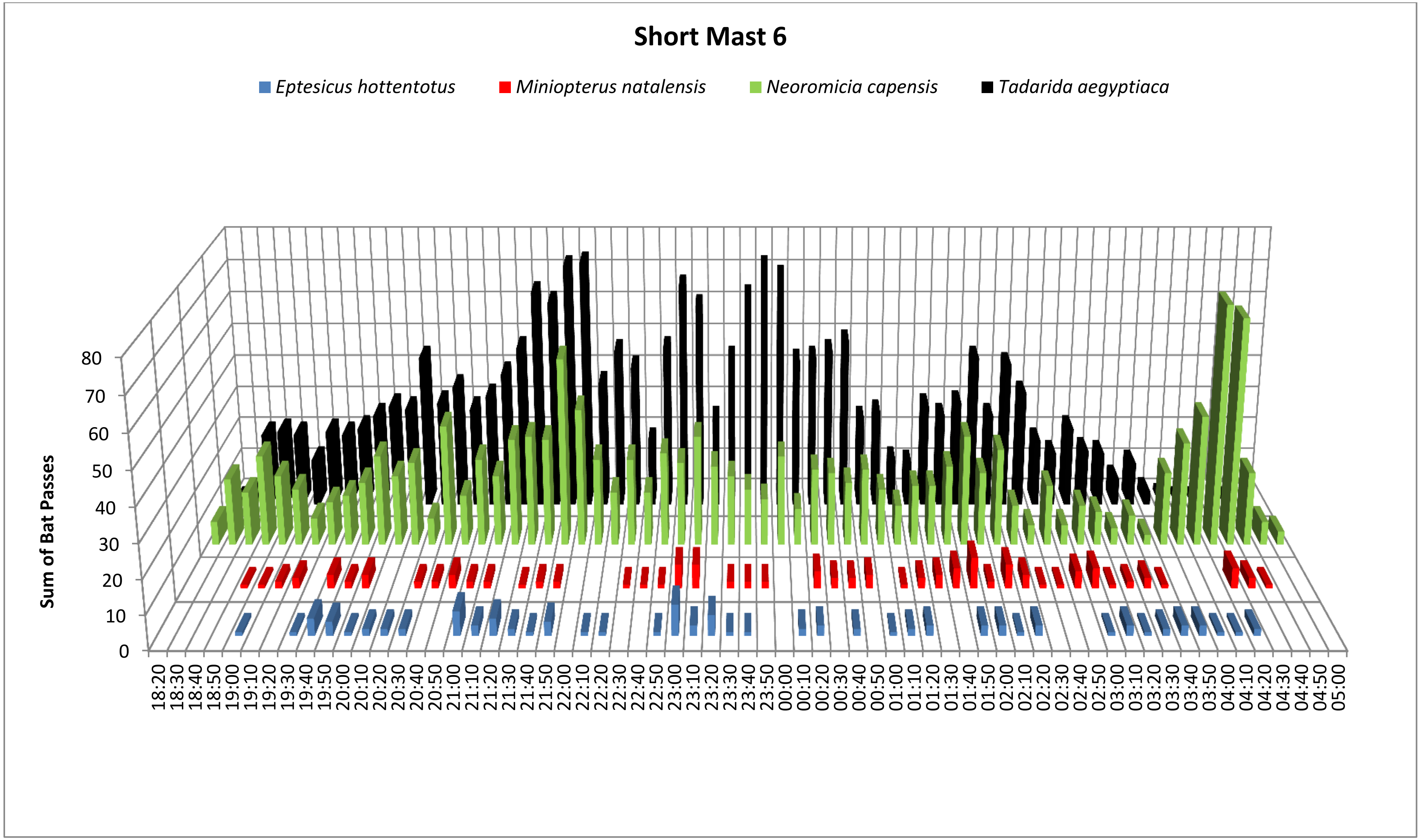



**Figure 42:** Temporal distribution of bat passes over October 2013 -February 2014 for the Short Mast 6 monitoring system

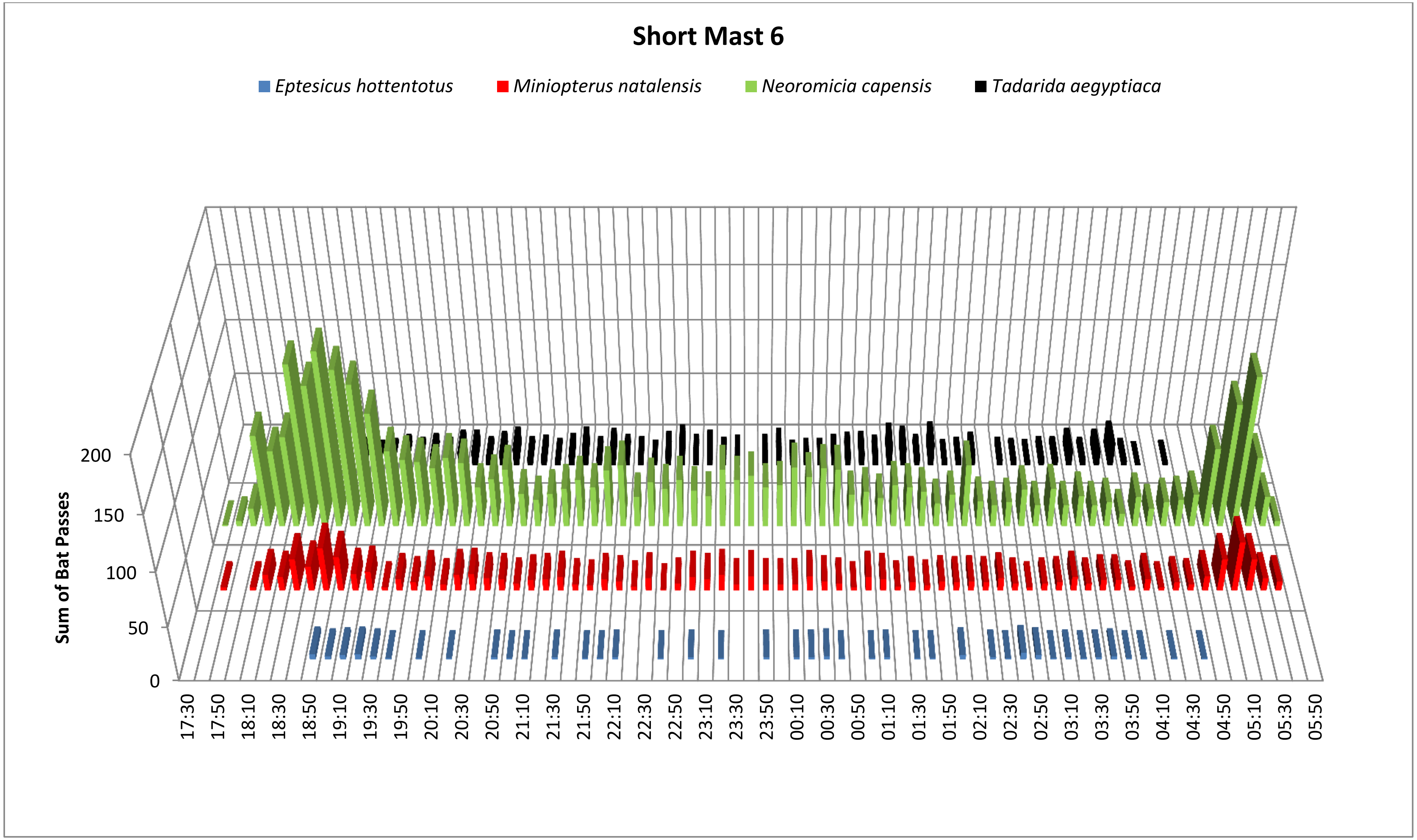



**Figure 43:** Temporal distribution of bat passes over February – May 2014 for the Short Mast 6 monitoring system

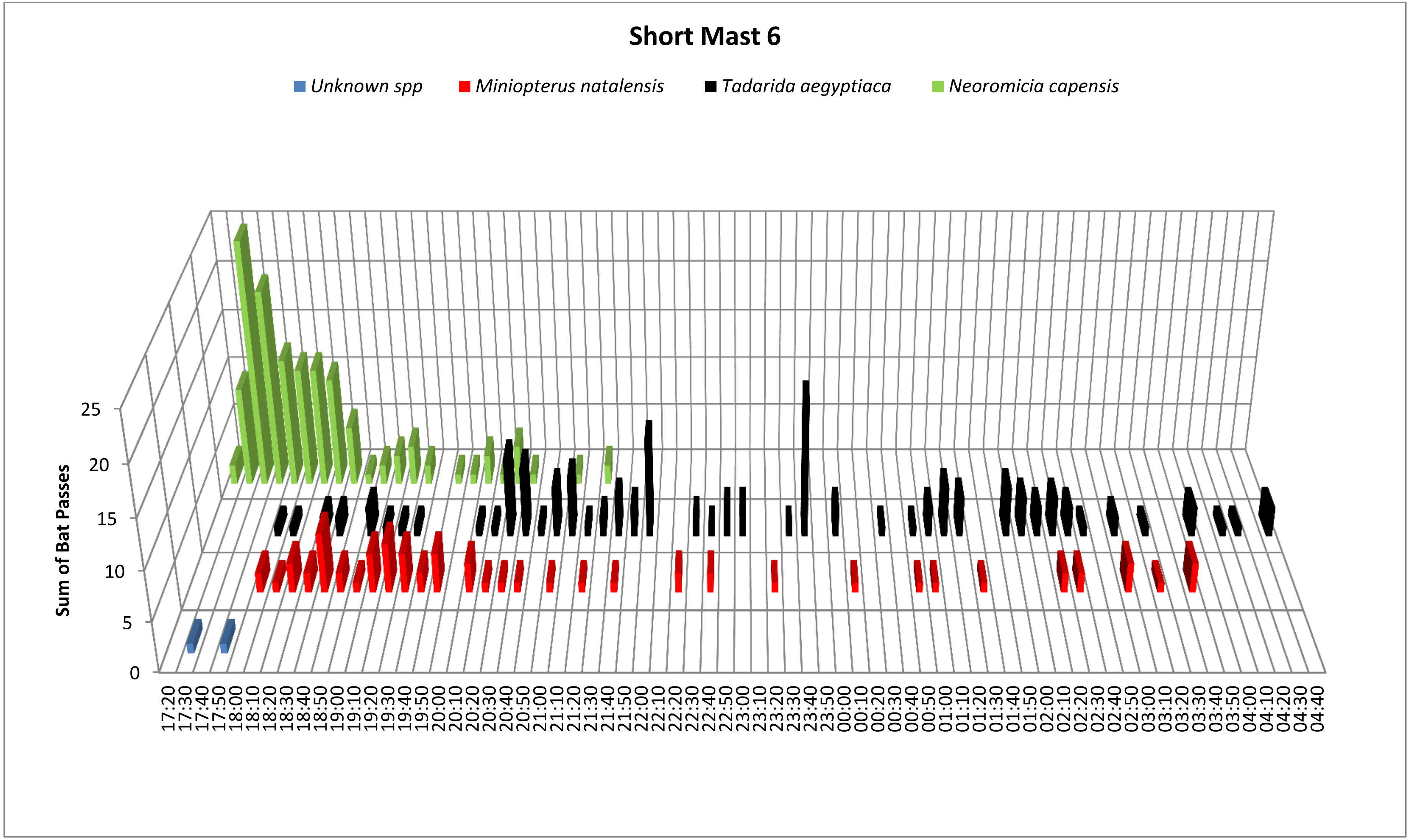



**Figure 44:** Temporal distribution of bat passes over May - August 2014 for the Short Mast 6 monitoring system

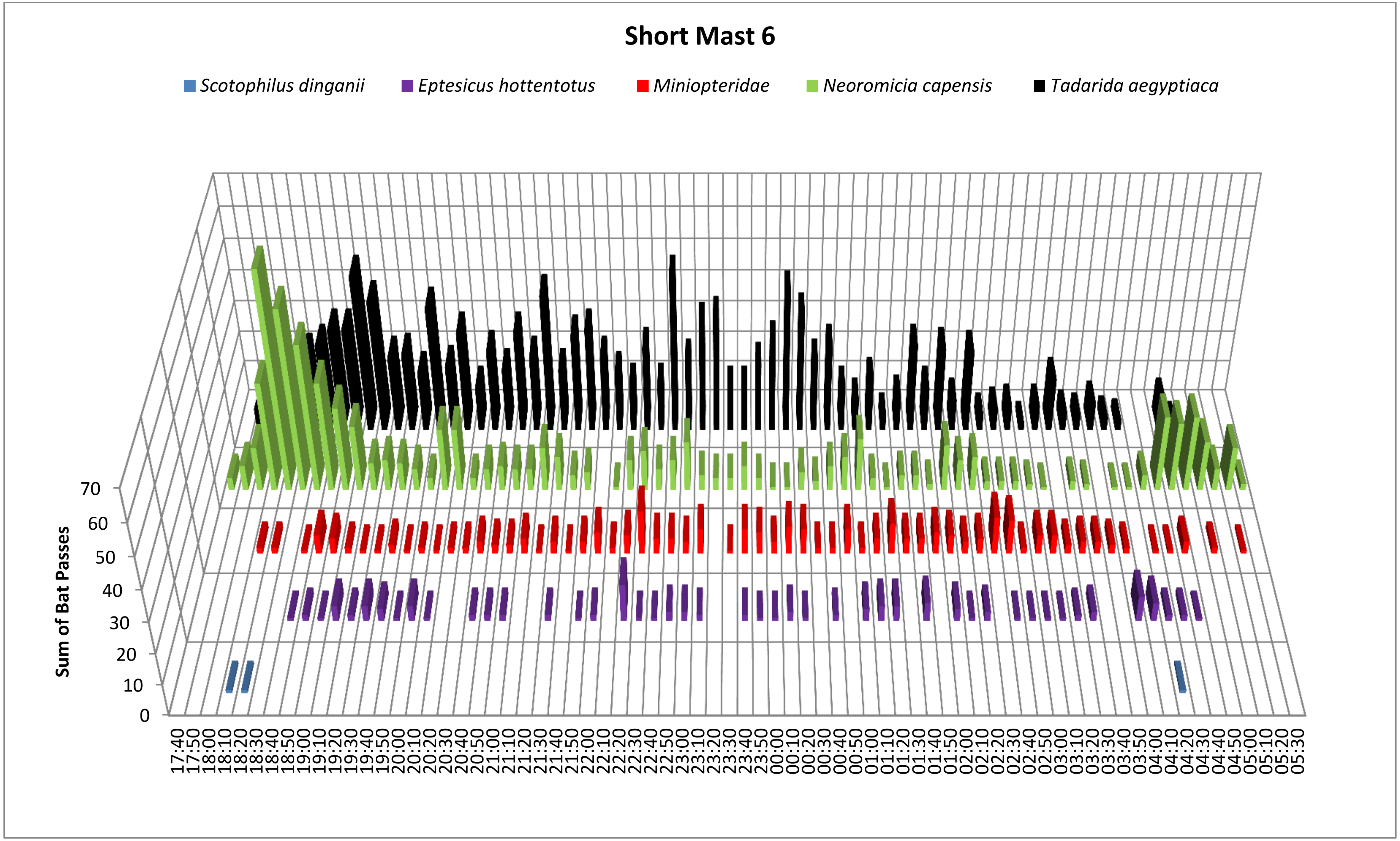



**Figure 45:** Temporal distribution of bat passes over August - November 2014 for the Short Mast 6 monitoring system

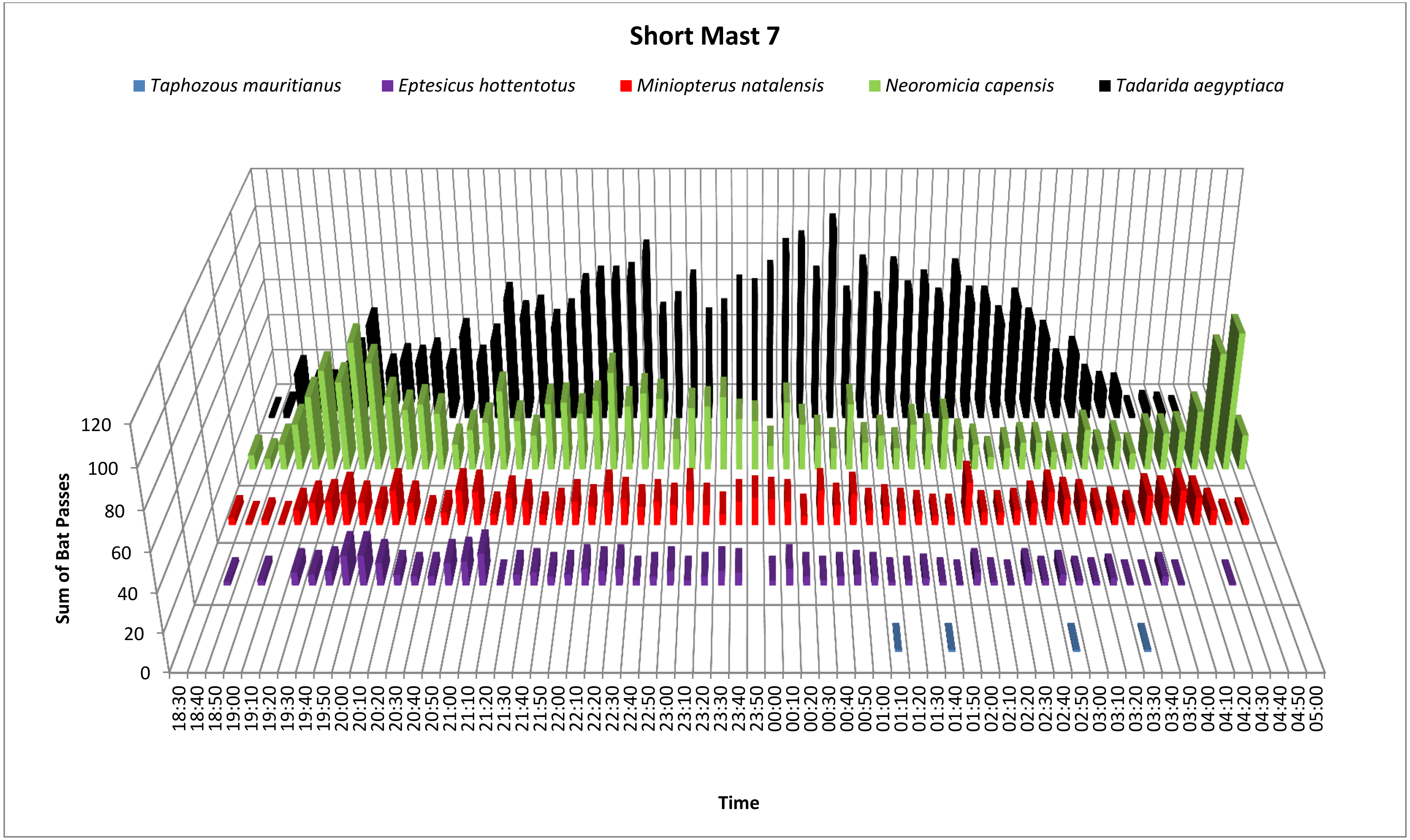



**Figure 46:** Temporal distribution of bat passes over October 2013 – February 2014 for the Short Mast 7 monitoring system

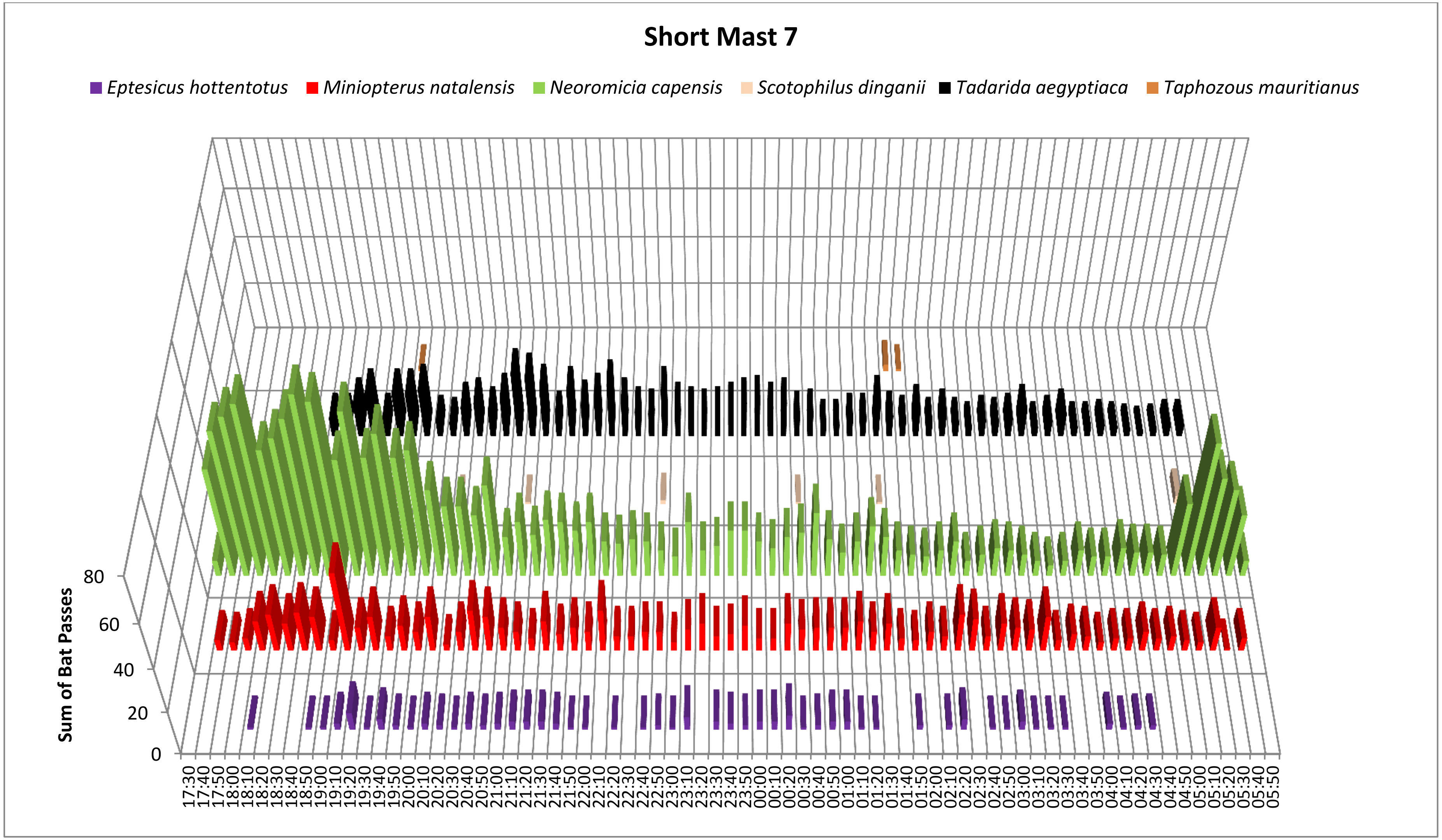



**Figure 47:** Temporal distribution of bat passes over February – May 2014 for the Short Mast 7 monitoring system

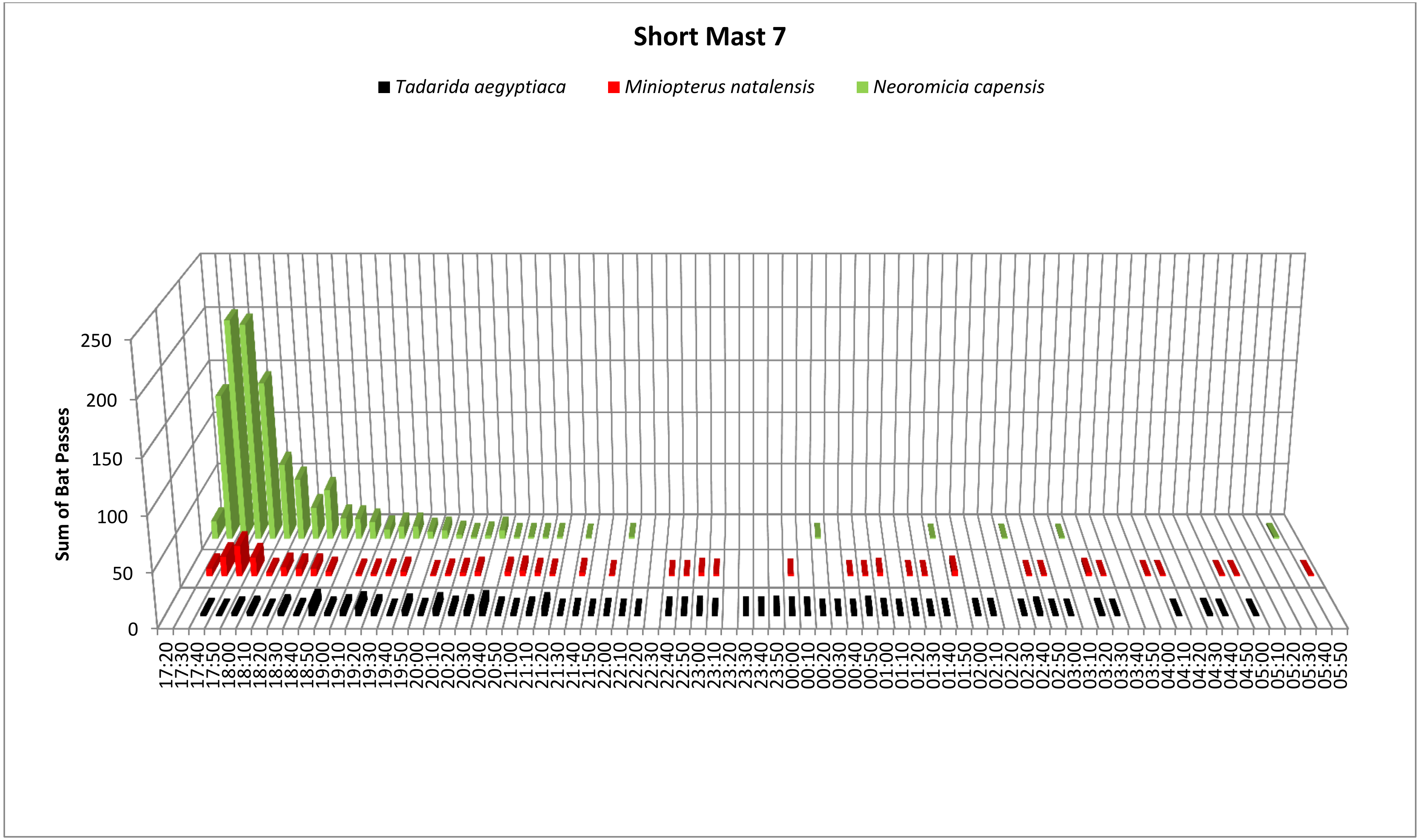



**Figure 48:** Temporal distribution of bat passes over May – August 2014 for the Short Mast 7 monitoring system

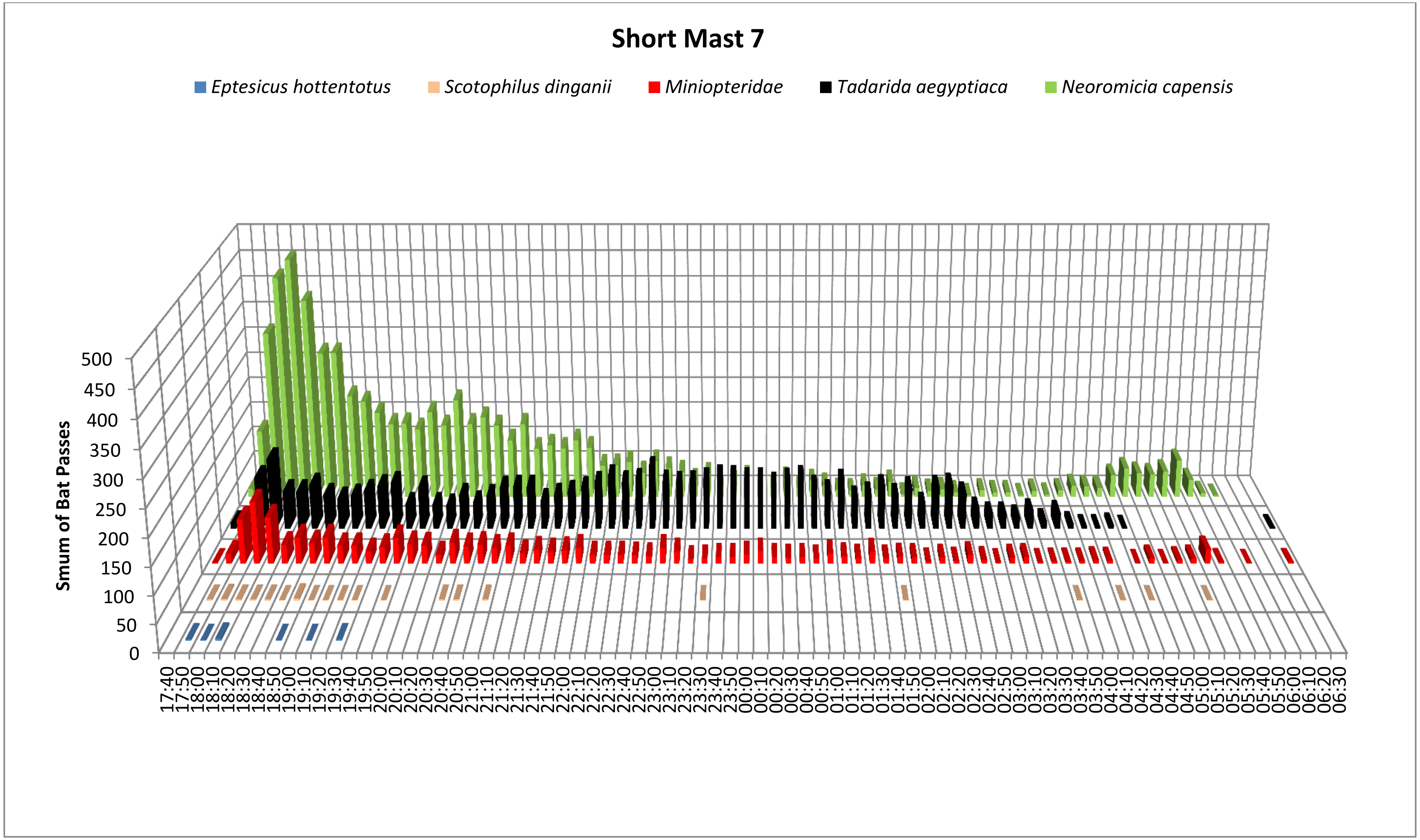



**Figure 49:** Temporal distribution of bat passes over August - November 2014 for the Short Mast 7 monitoring system

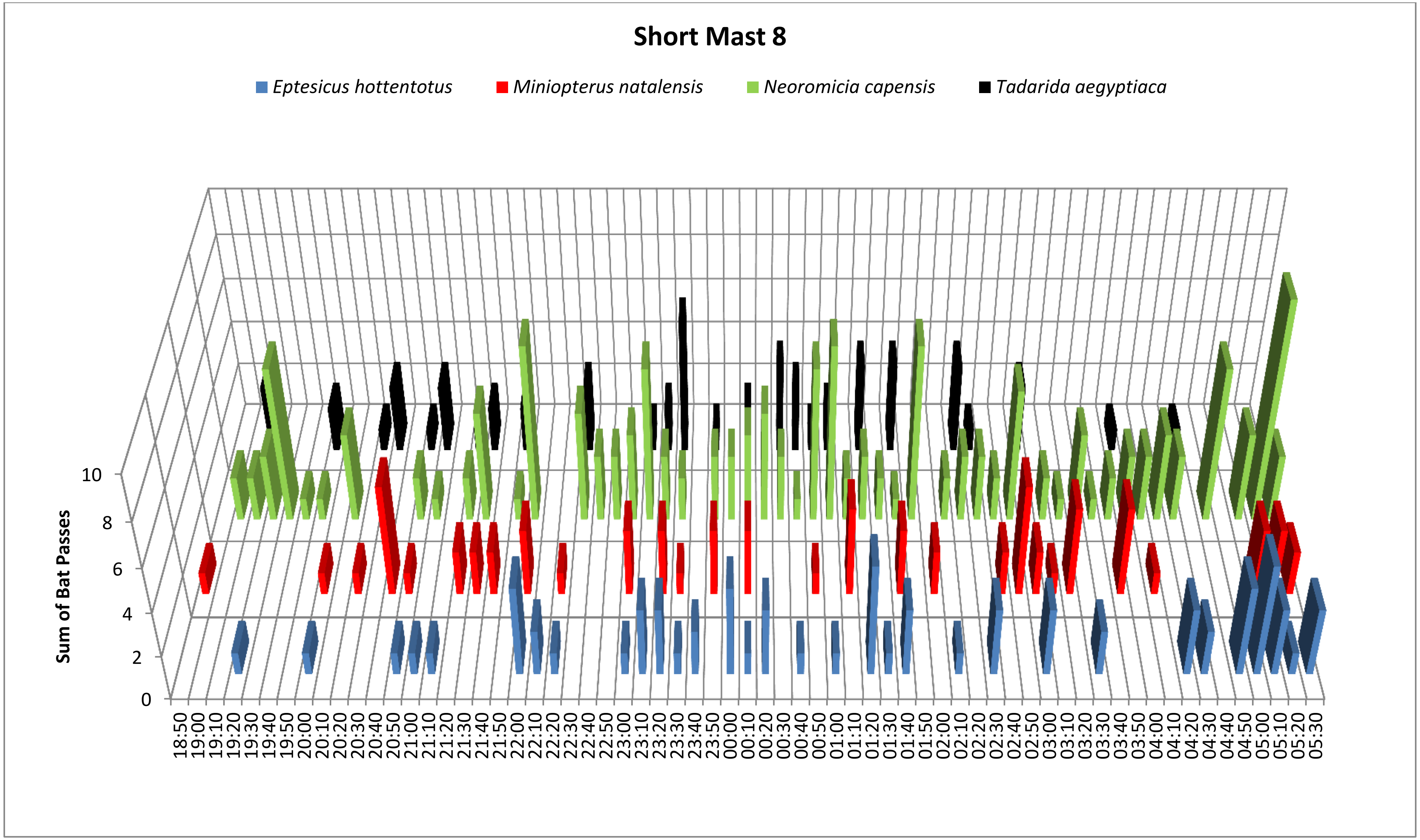



**Figure 50:** Temporal distribution of bat passes over February – May 2014 for short mast 8 monitoring system

### 4.6.3 Relations 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 realize 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 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. 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.

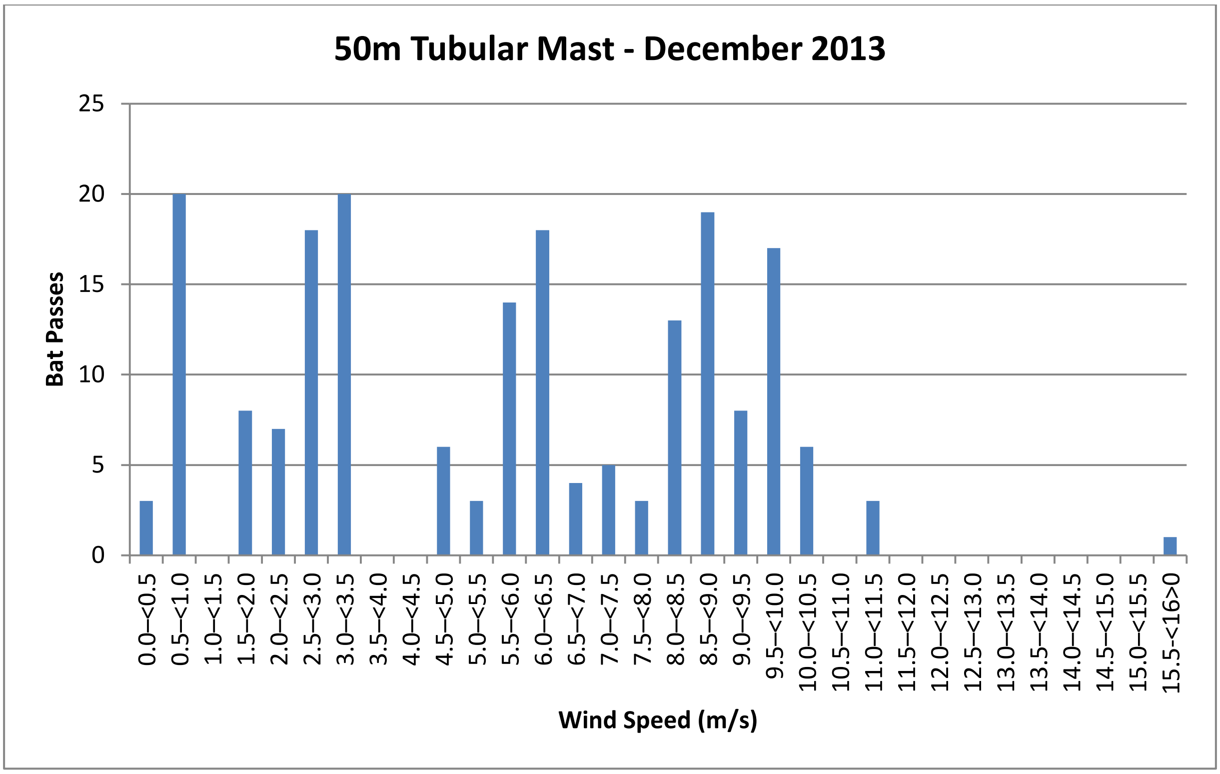
**Analysis**

An analysis of the bat passes detected within specific wind speed and temperature categories has been performed and will be supplemented at a later stage with further data collections, particularly from the lattice mast 50m microphone. The cumulative percentages of the sum of bat passes per wind speed and temperature categories are presented. The aim of this analysis is to determine the wind speed and temperature range within which 80% of bat passes were detected. Ultimately these values of wind speed and temperature will be used to mitigate turbine operation 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.

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) will then be used to inform mitigation where needed.

**Figures 51 - 66** displays the relationship of bat activity with wind speed and temperature values as detected by the meteorological masts on site. Due to temperature sensors faults on the lattice mast, the temperature readings from the 5.5m sensor on the tubular mast have been used for all the below analysis.

Wind speeds at 60m have been used for correlation with bat activity detected by the 50m microphone on the lattice mast. Wind speeds from 50m has been used for bat activity detected by the 50m microphone on the tubular mast prior to May 2014, and after May 2014 wind speeds from 30m were used for correlation with bat activity at 25m on the tubular mast.



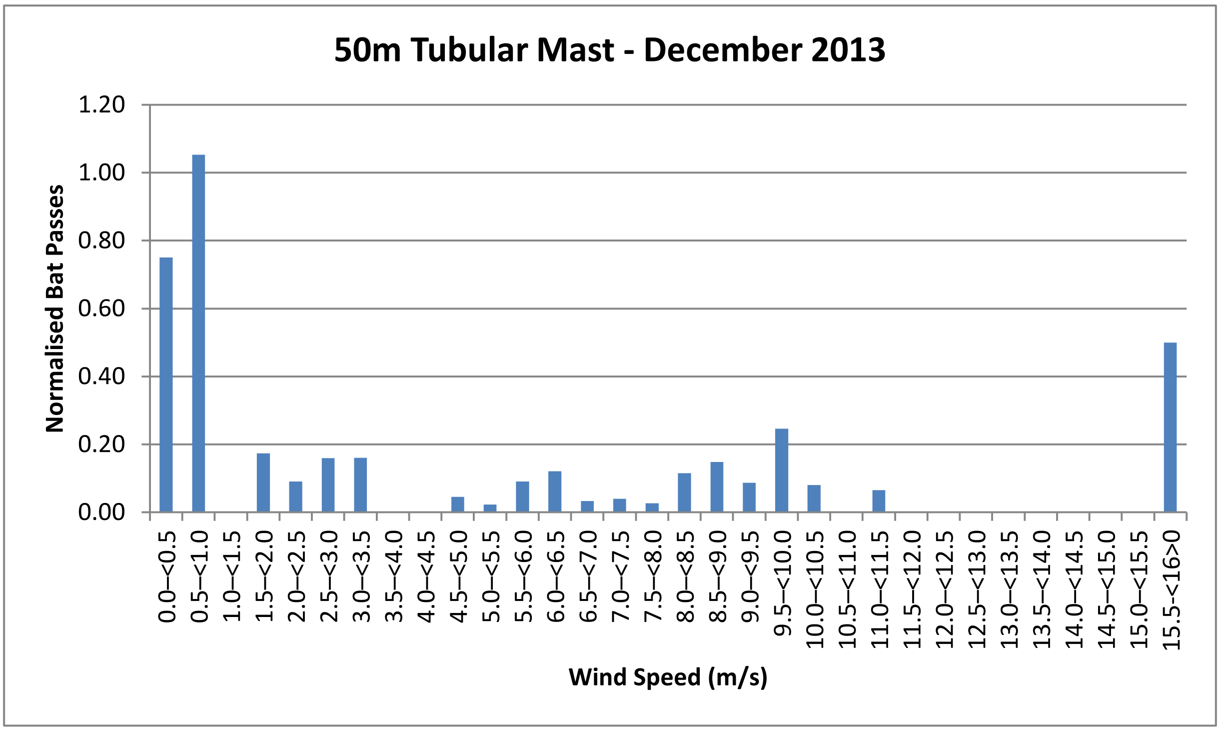




**Figure 51:** Sum of bat passes (top) and normalised passes (bottom) per wind speed category

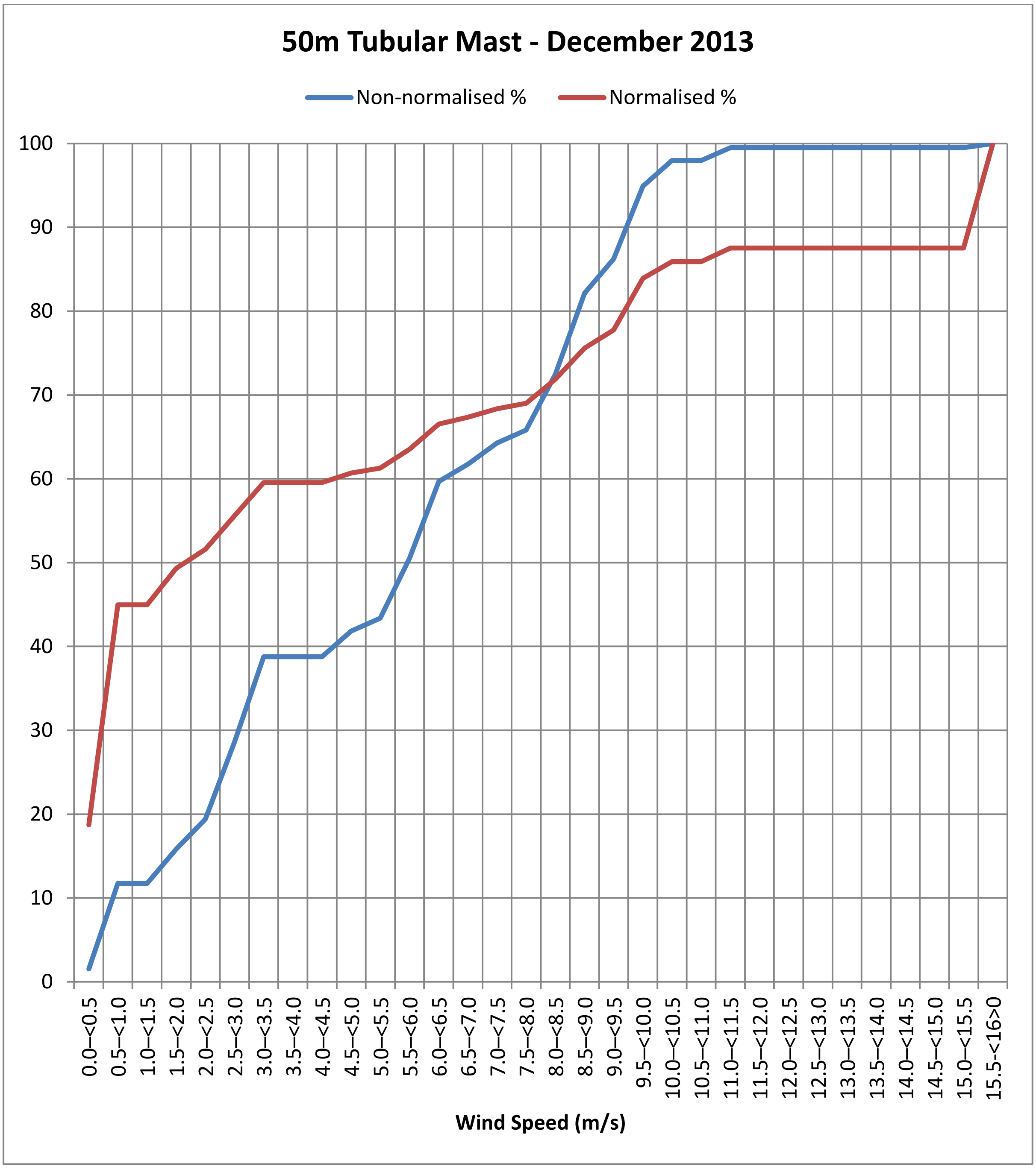
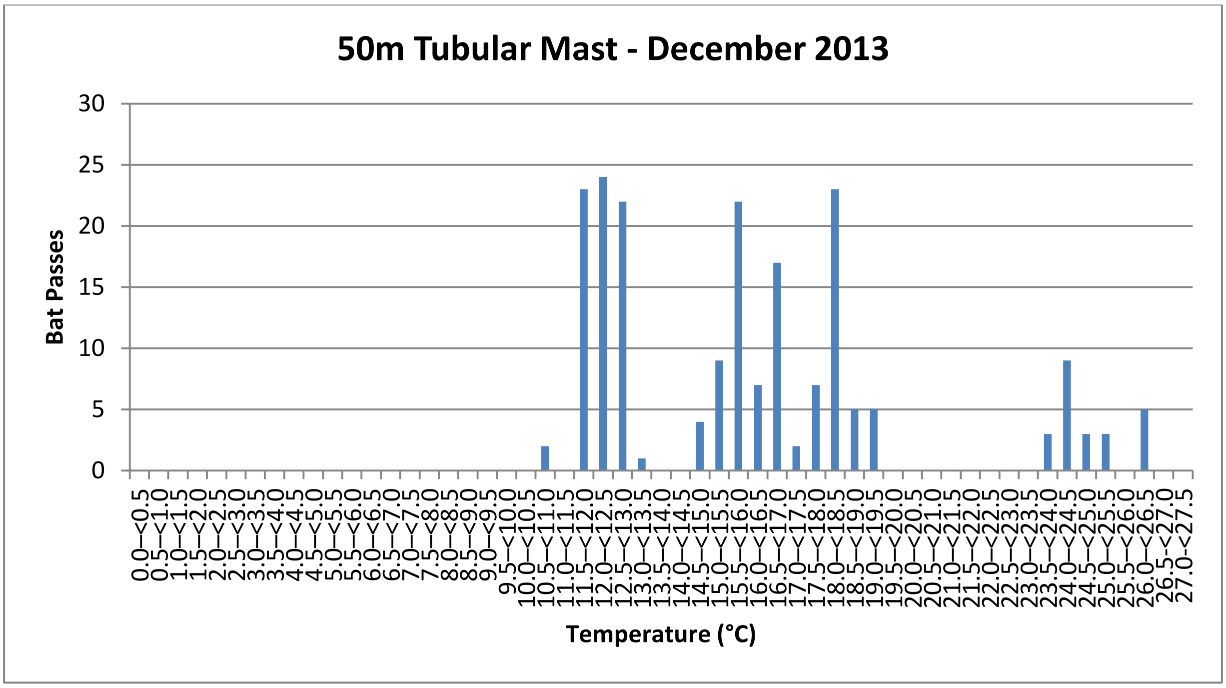



**Figure 52:** Cumulative percentage of normalised and non-normalised bat passes per wind speed category.



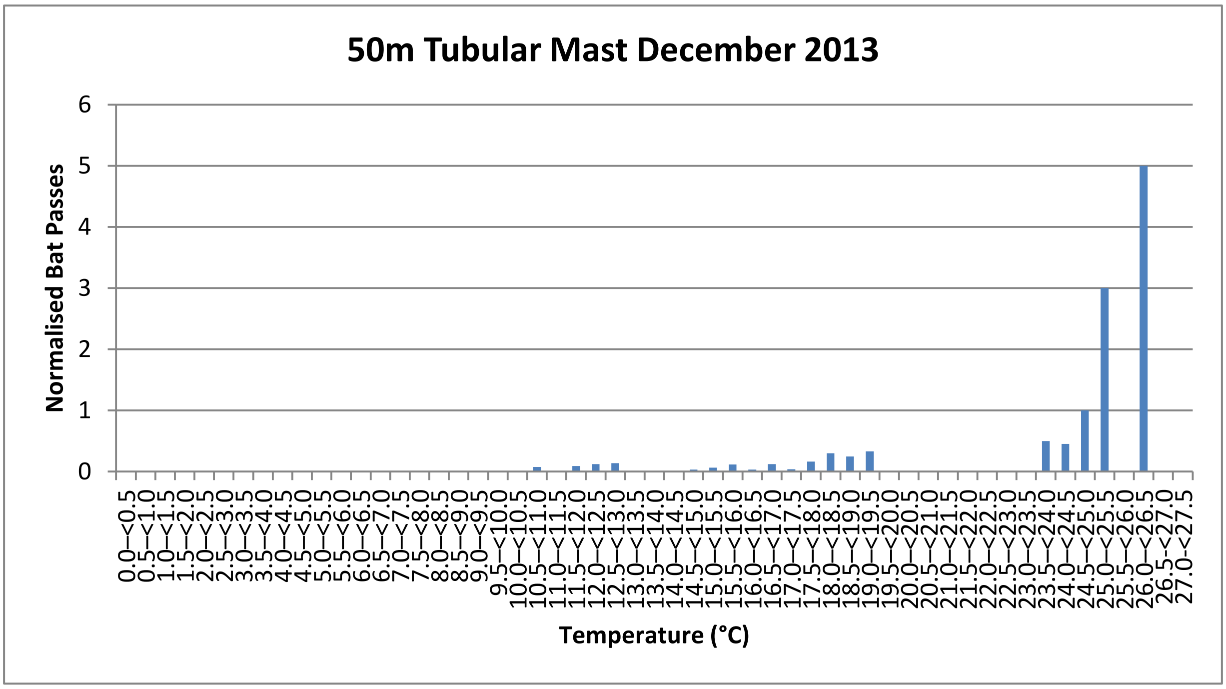




**Figure 53:** Sum of bat passes (top) and normalised passes (bottom) per temperature category

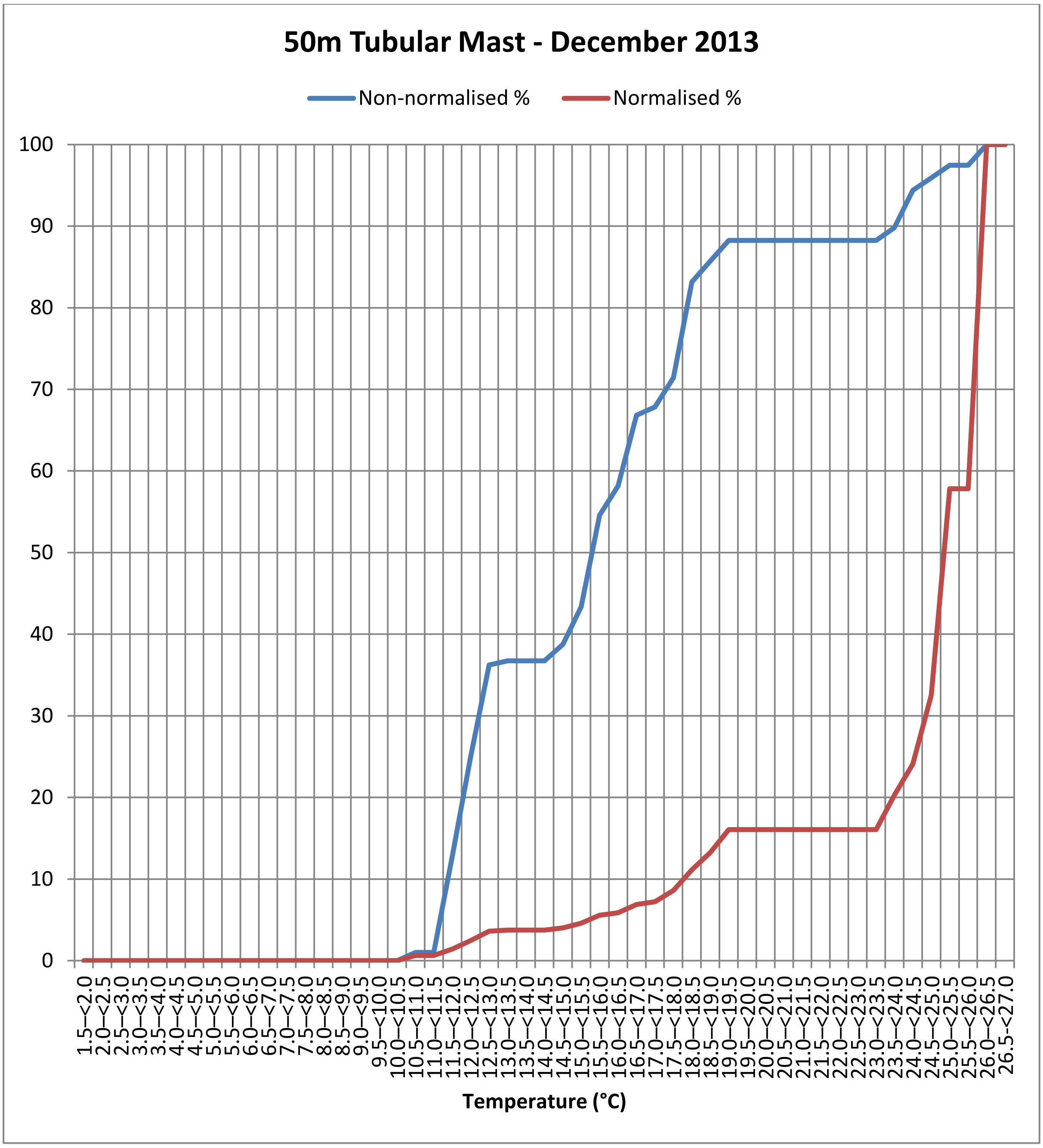
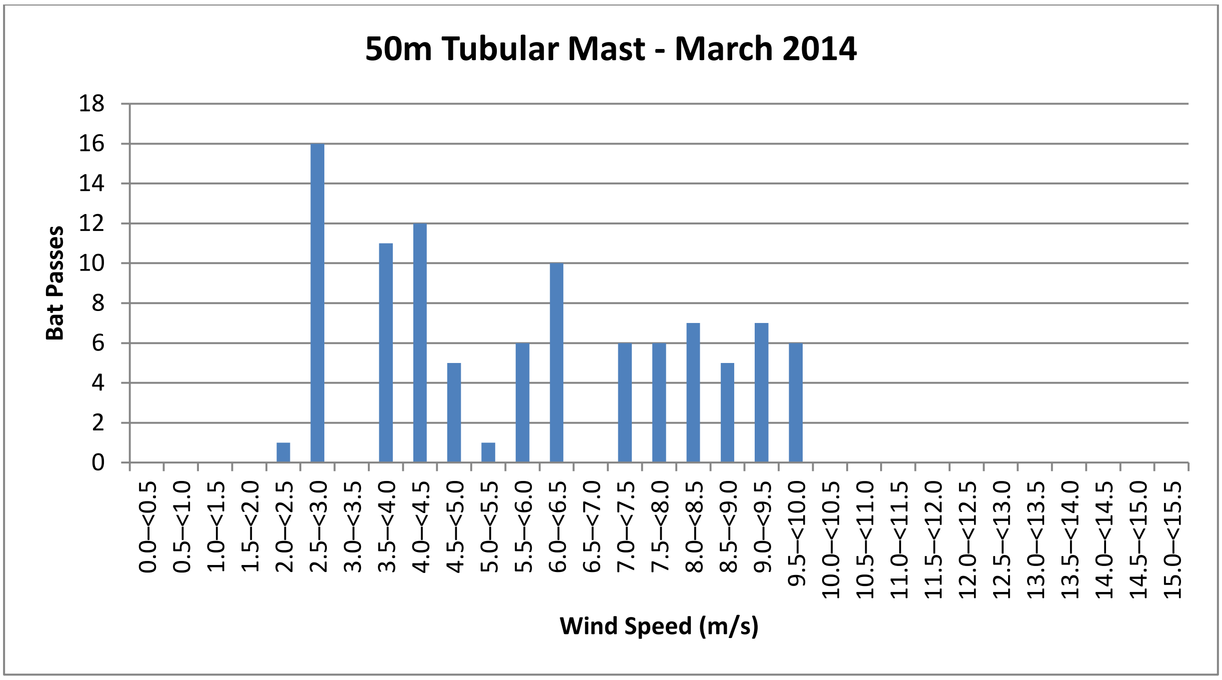



**Figure 54:** Cumulative percentage of normalised and non-normalised bat passes per temperature category



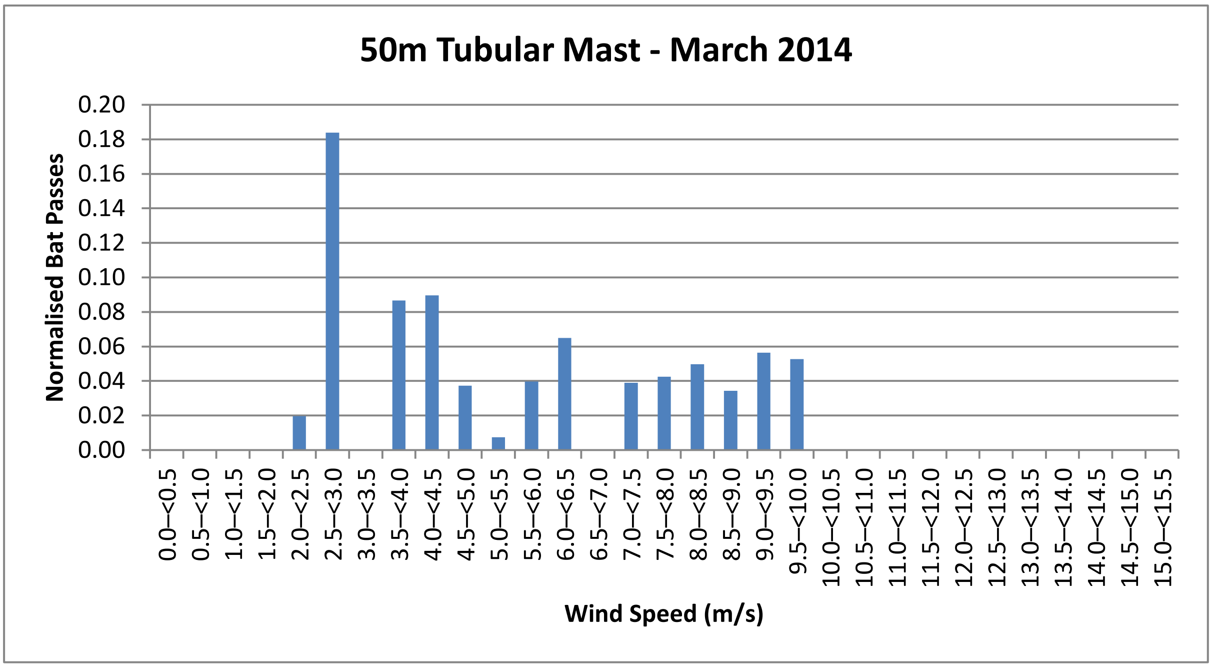




**Figure 55:** Sum of bat passes (top) and normalised passes (bottom) per wind speed category

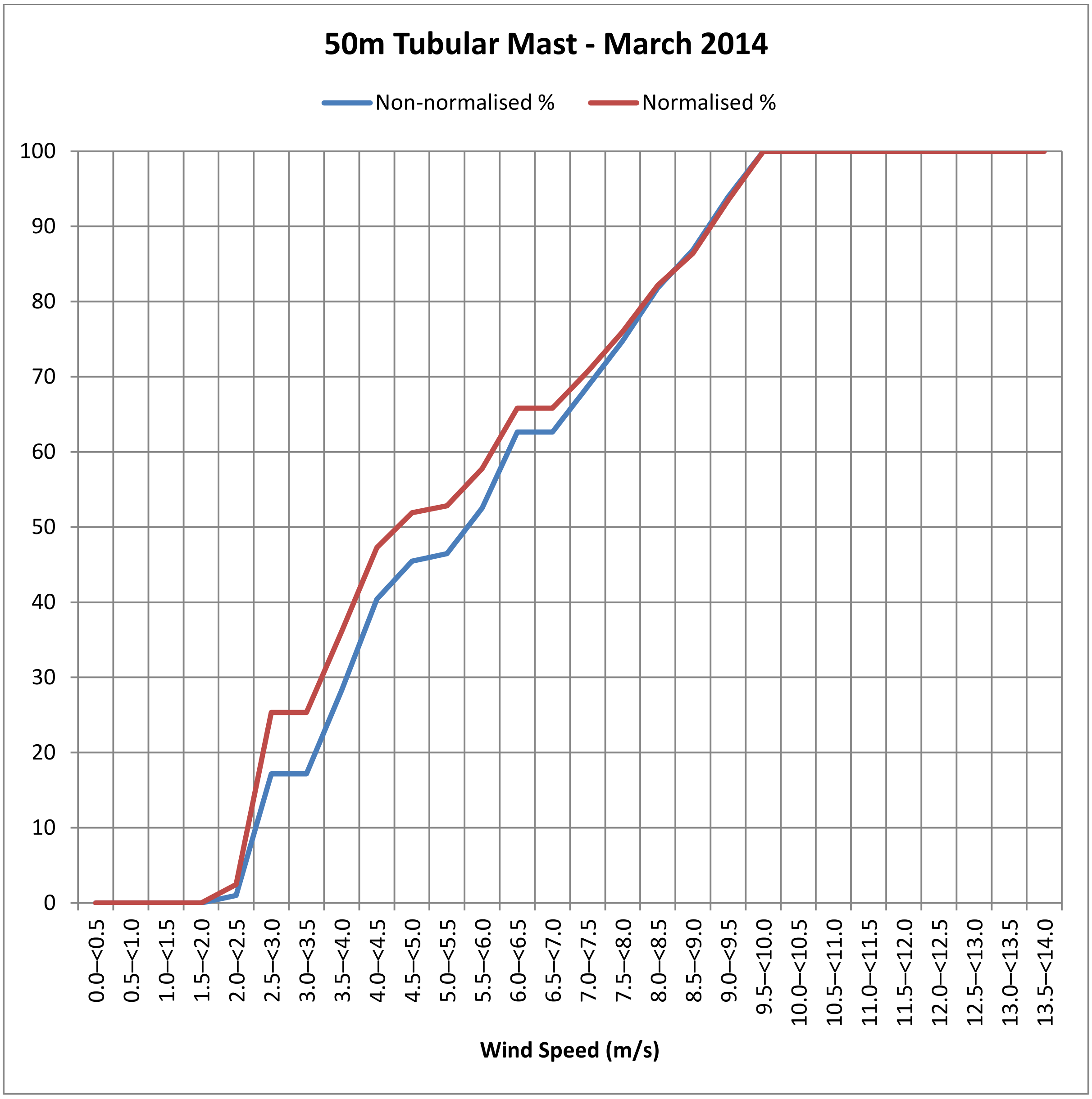
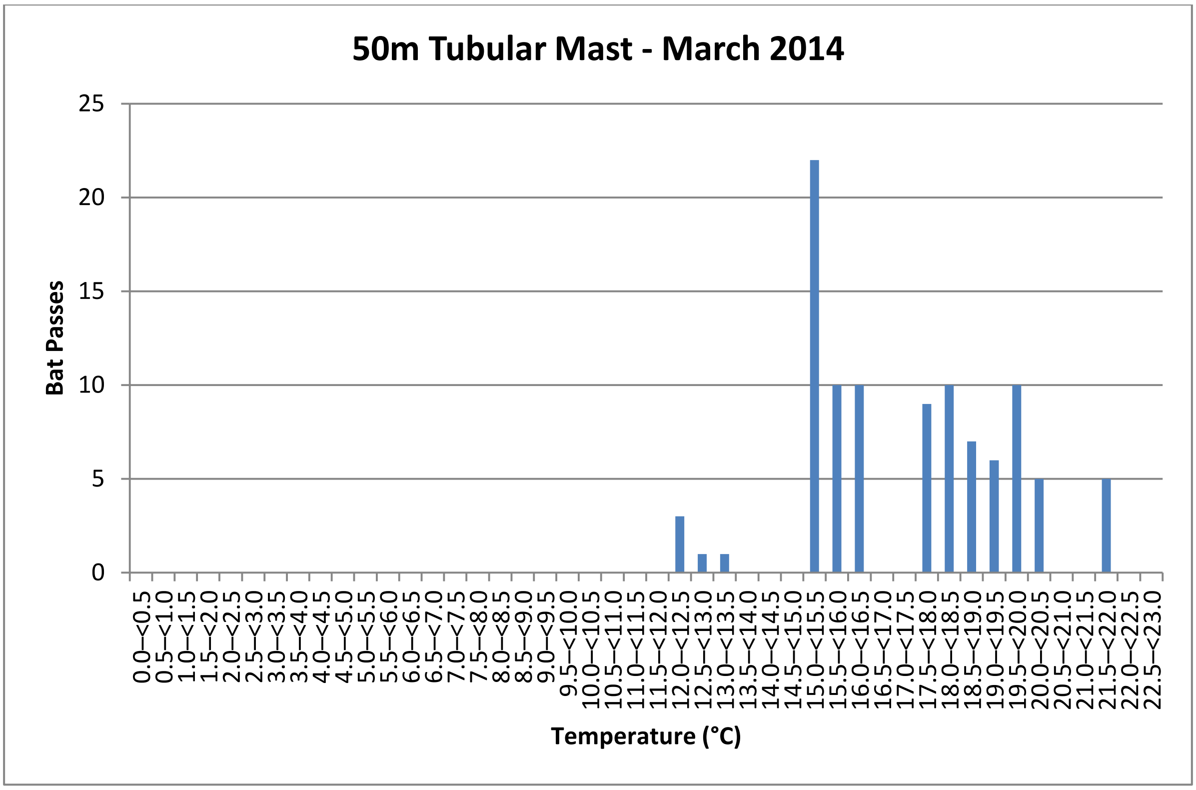



**Figure 56:** Cumulative percentage of normalised and non-normalised bat passes per wind speed category



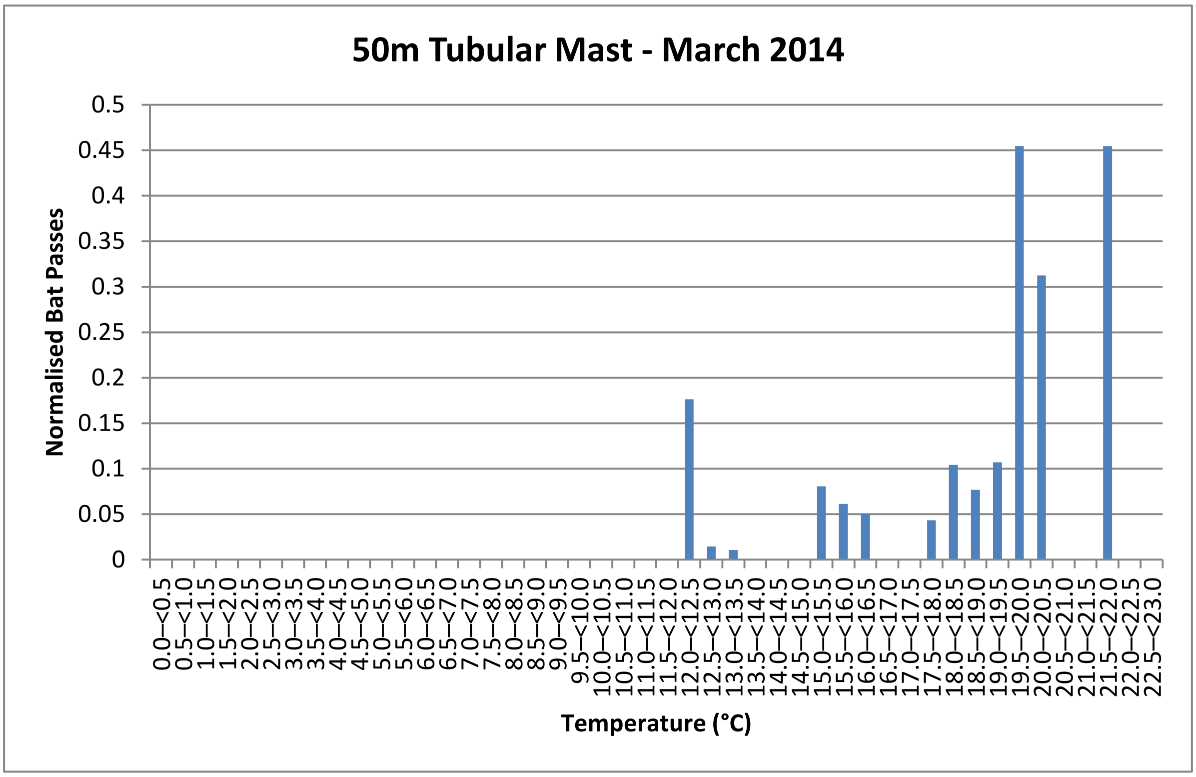




**Figure 57:** Sum of bat passes (top) and normalised passes (bottom) per temperature category

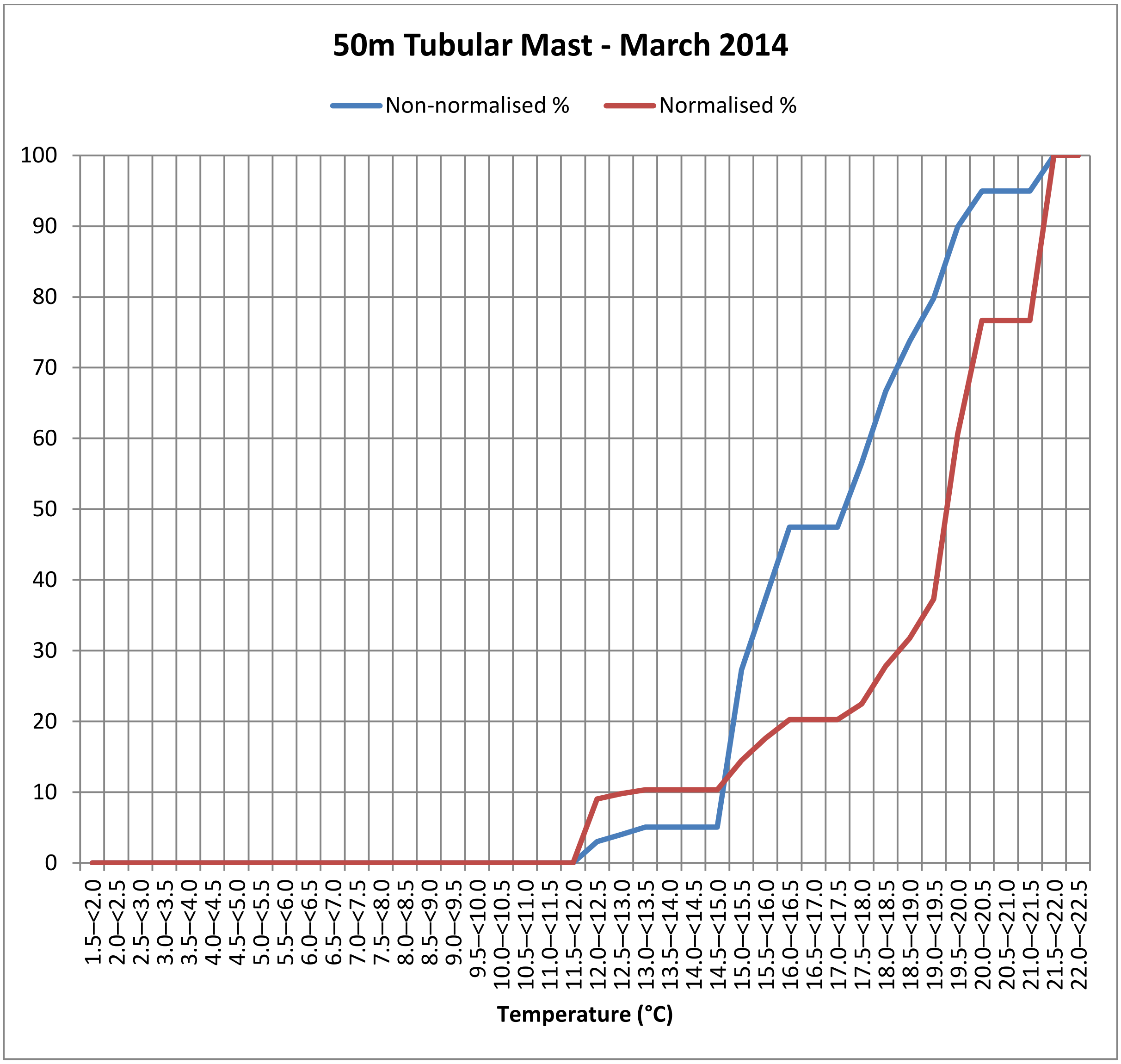
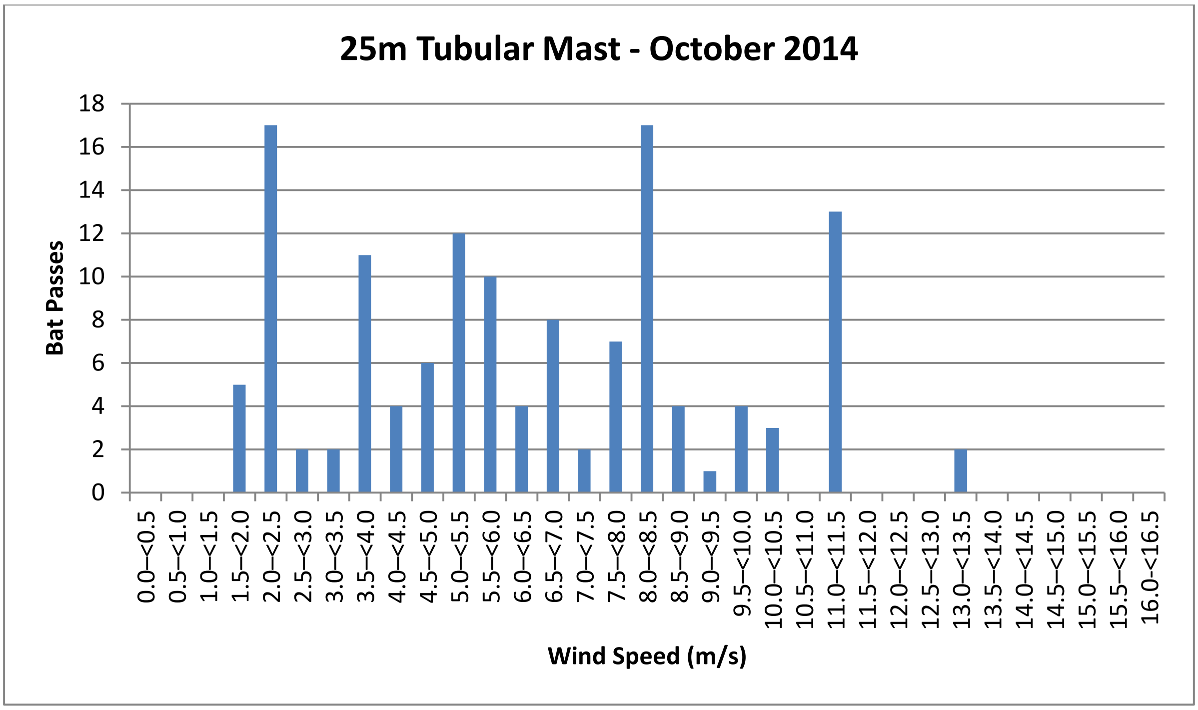



**Figure 58:** Cumulative percentage of normalised and non-normalised bat passes per temperature category



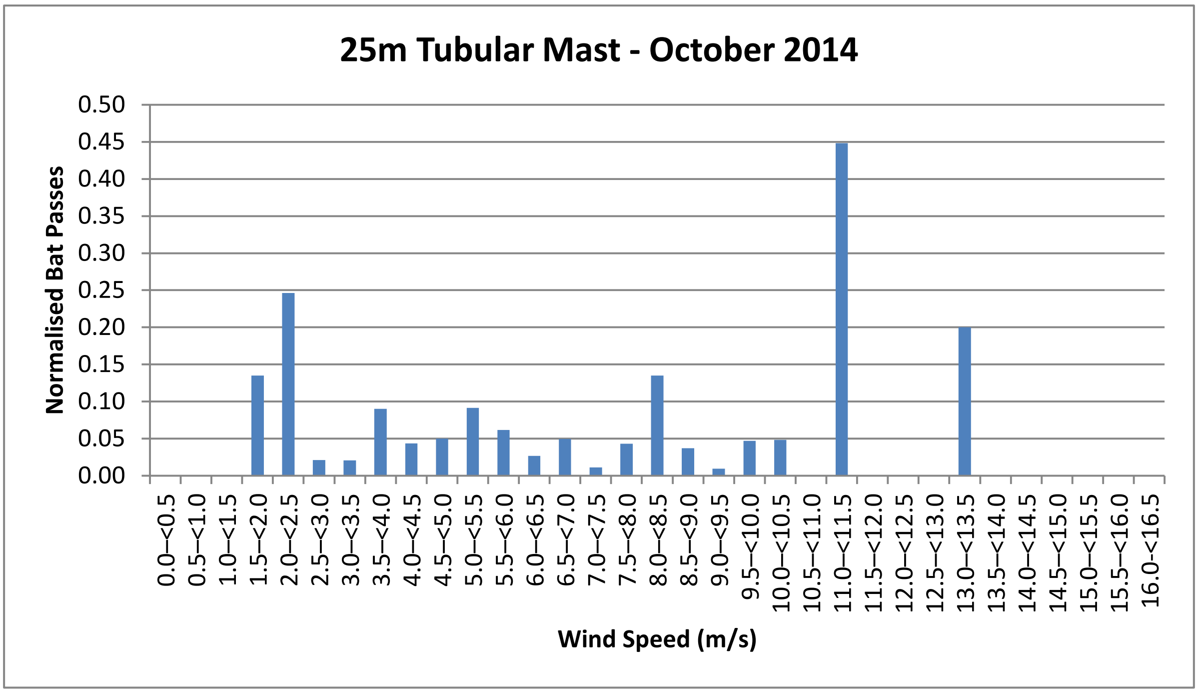




**Figure 59:** Sum of bat passes (top) and normalised passes (bottom) per wind speed category

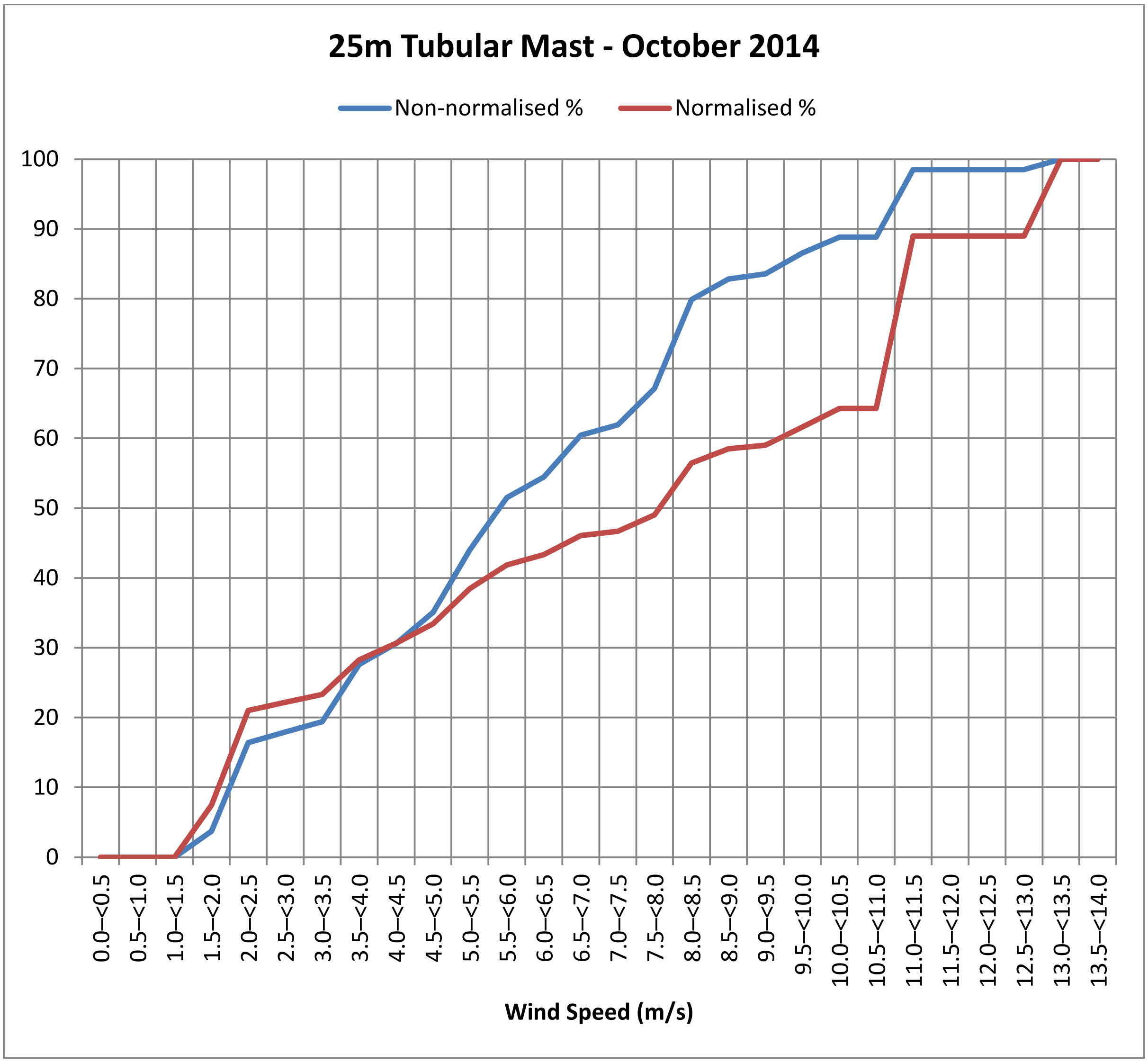
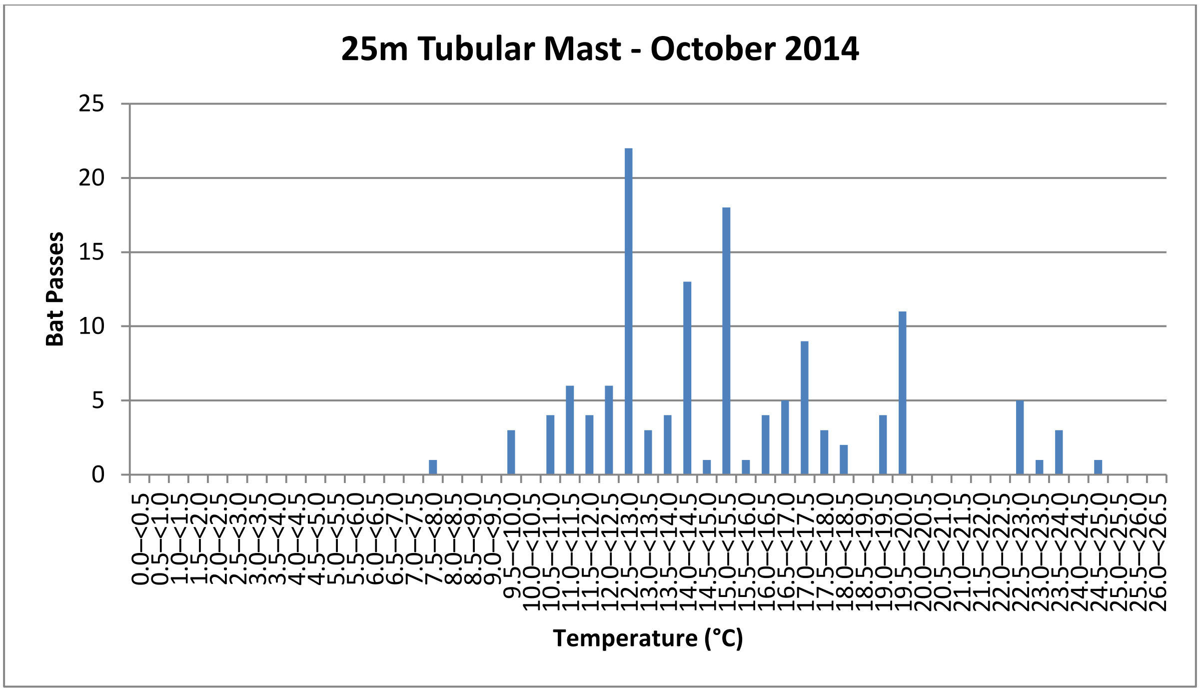



**Figure 60:** Cumulative percentage of normalised and non-normalised bat passes per wind speed category



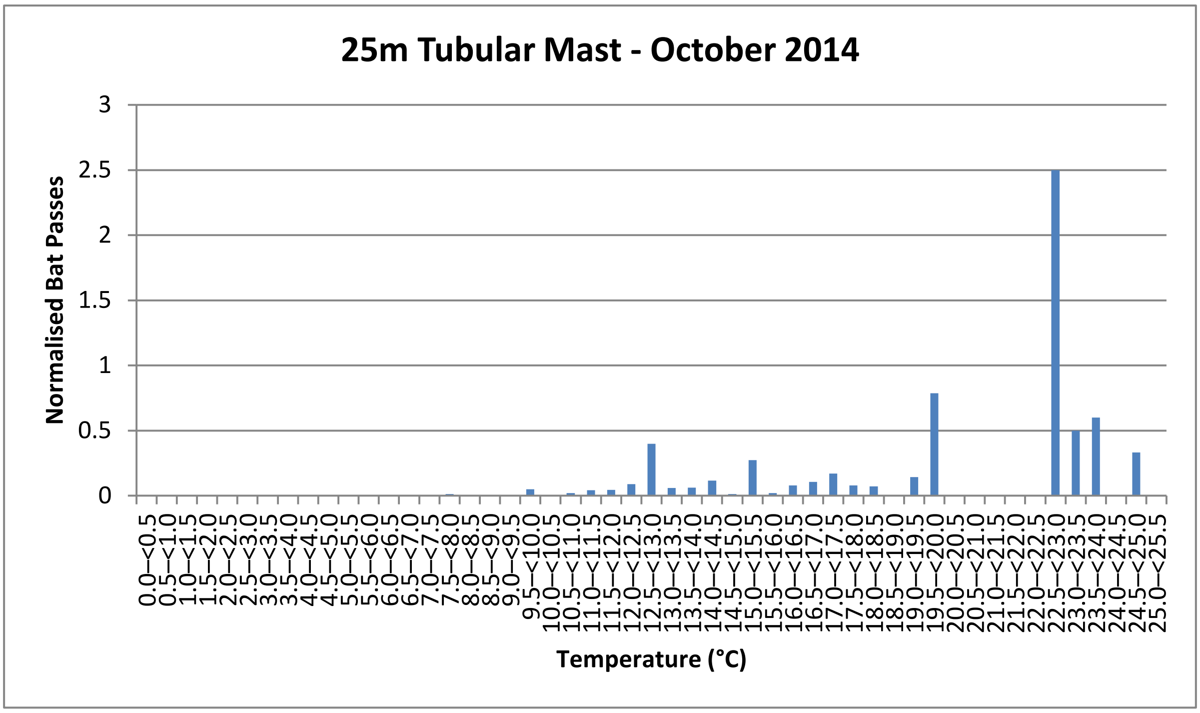




**Figure 61:** Sum of bat passes (top) and normalised passes (bottom) per temperature category

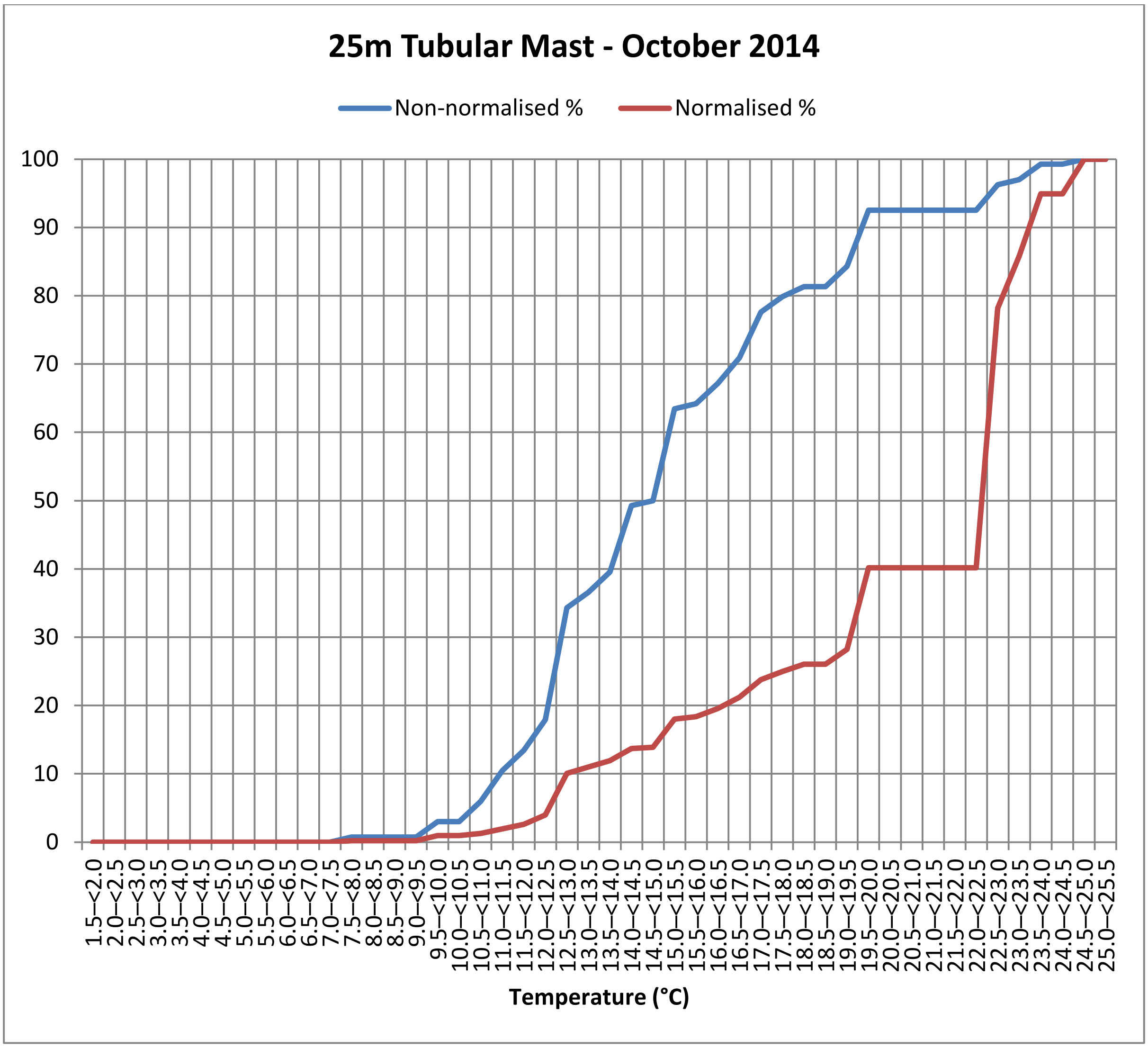
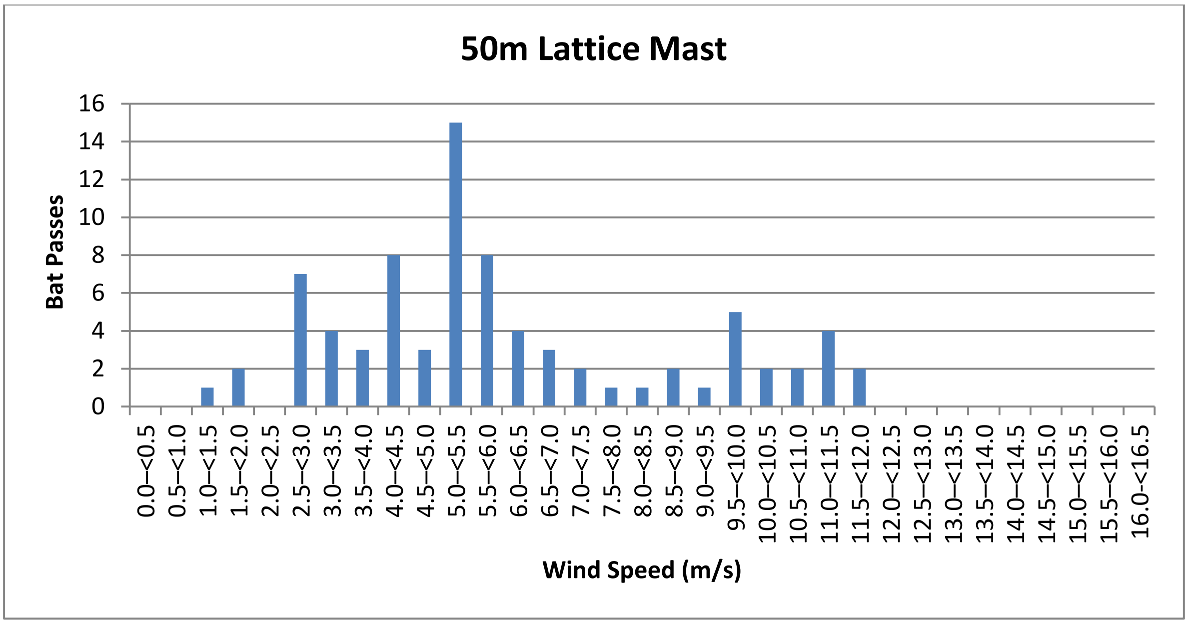



**Figure 62:** Cumulative percentage of normalised and non-normalised bat passes per temperature category



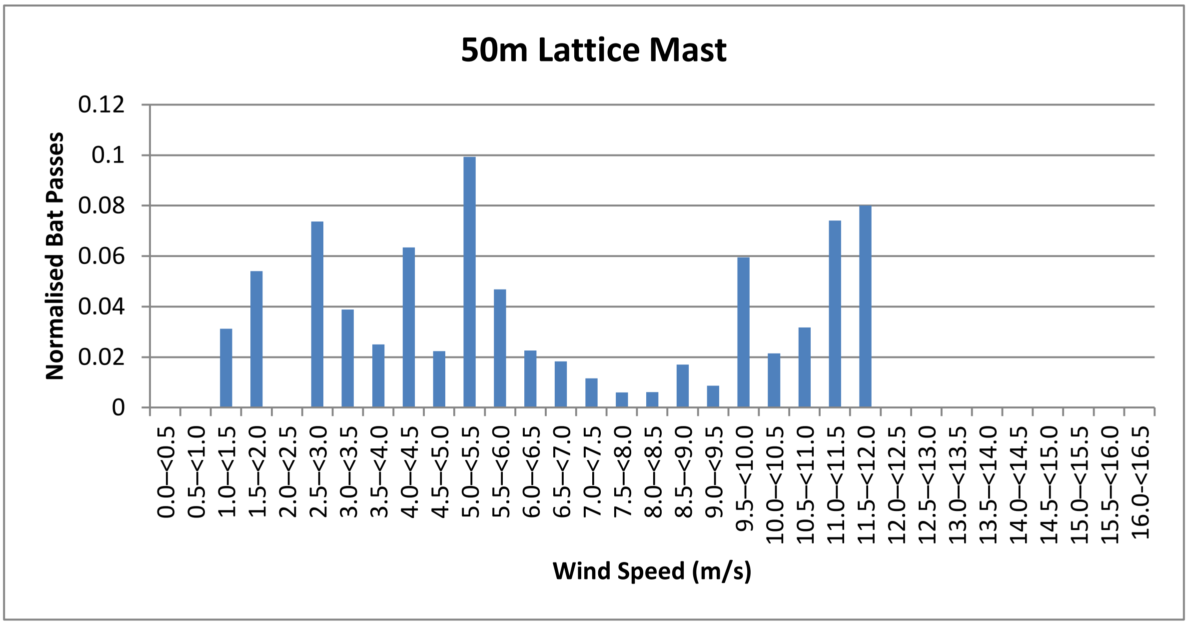




**Figure 63:** Sum of bat passes (top) and normalised passes (bottom) per wind speed category

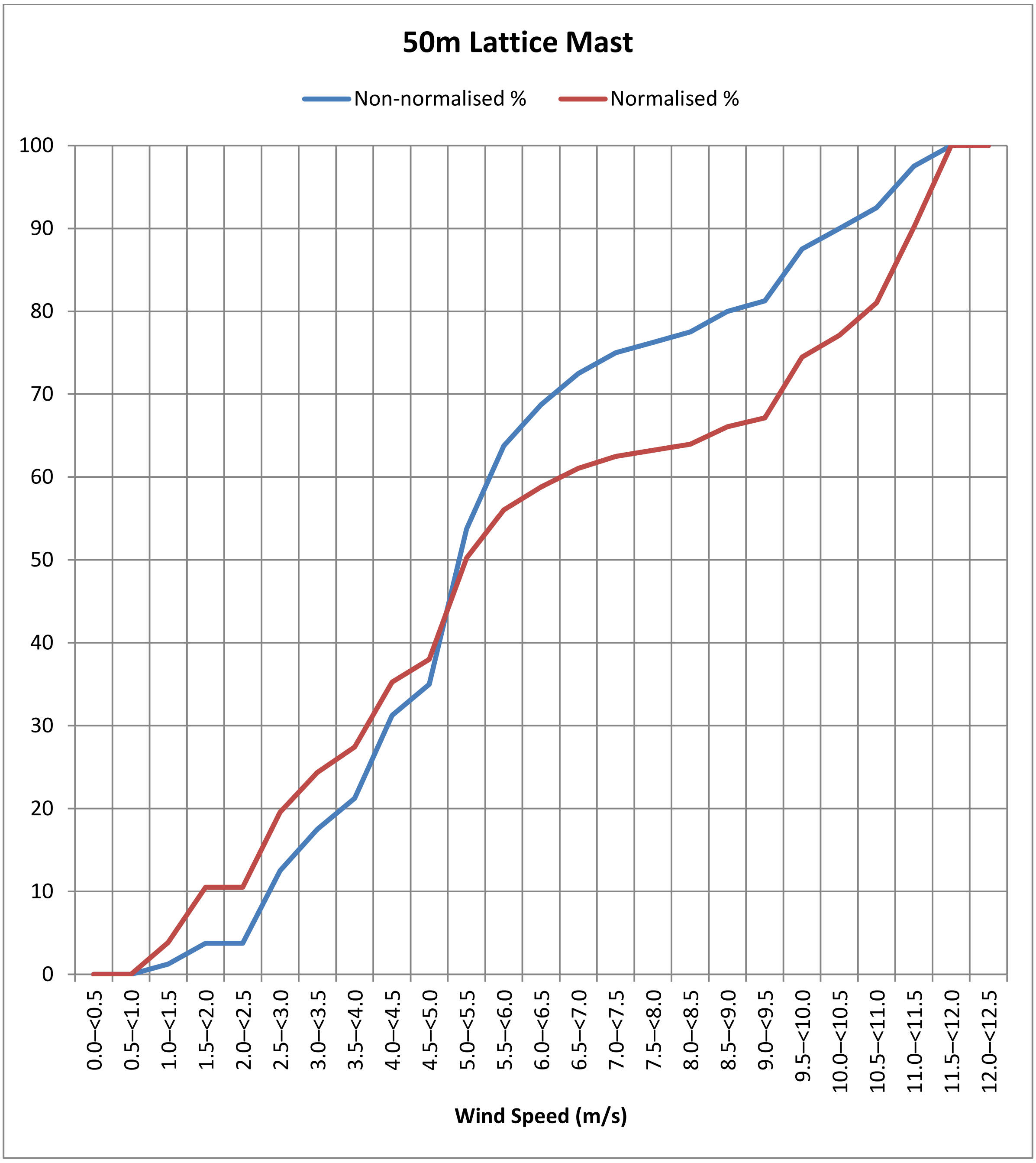
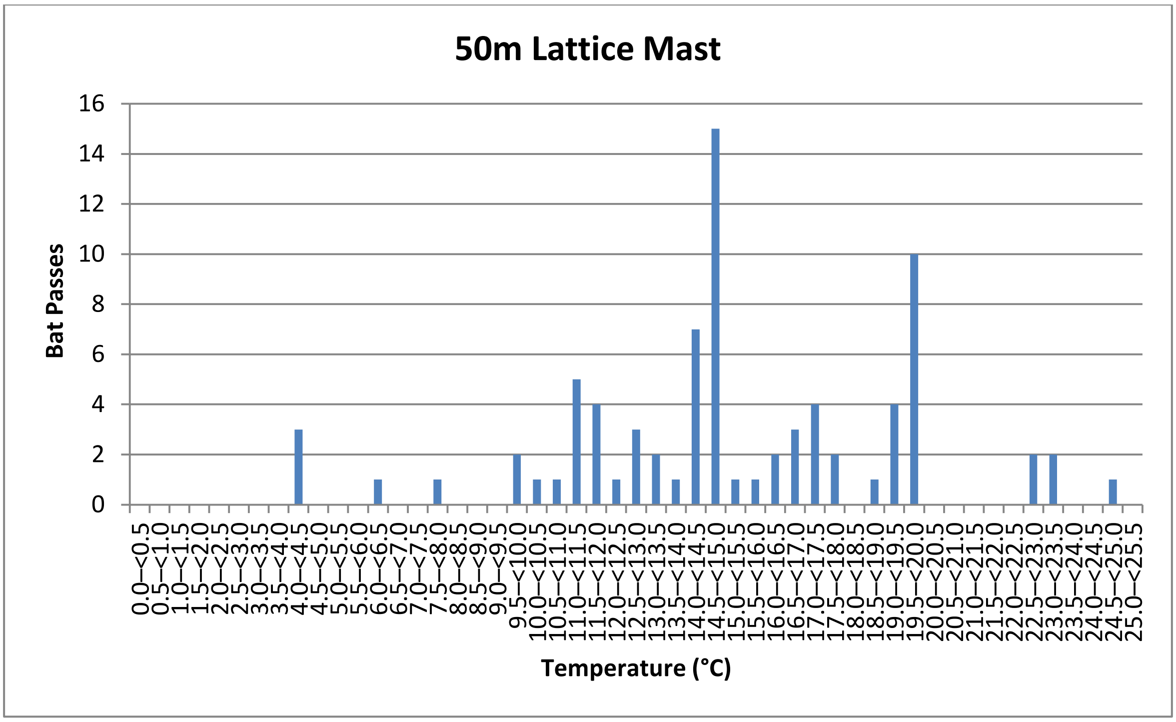



**Figure 64:** Cumulative percentage of normalised and non-normalised bat passes per wind speed category



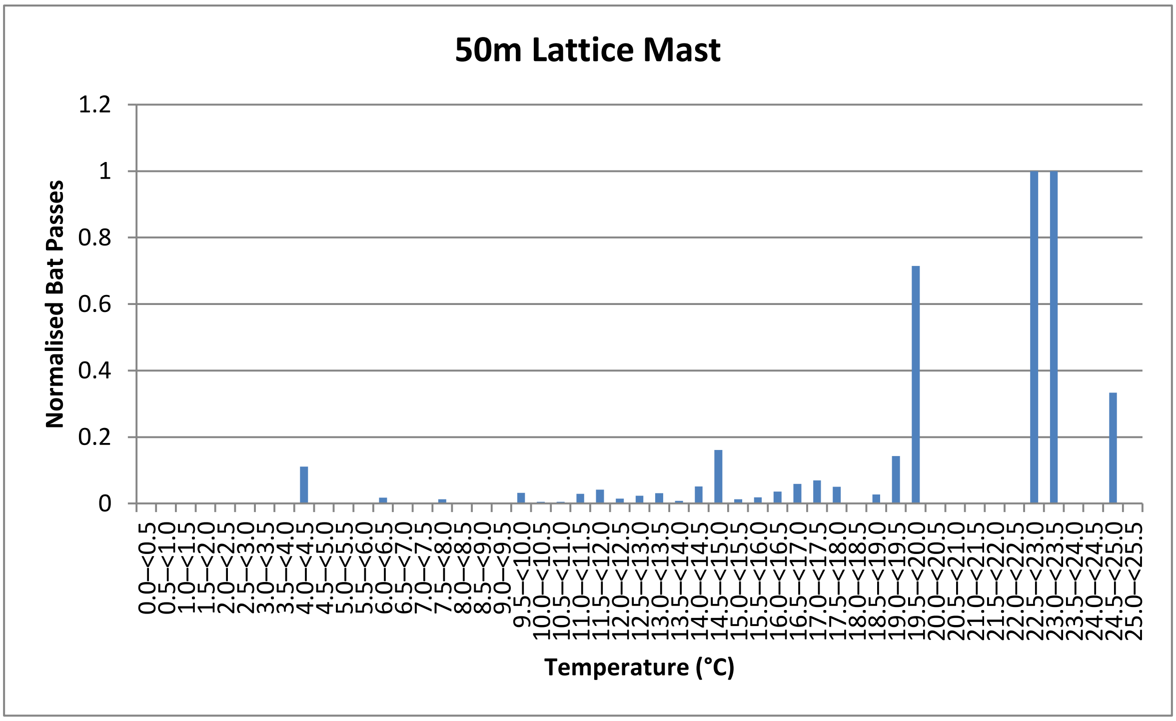




**Figure 65:** Sum of bat passes (top) and normalised passes (bottom) per temperature category

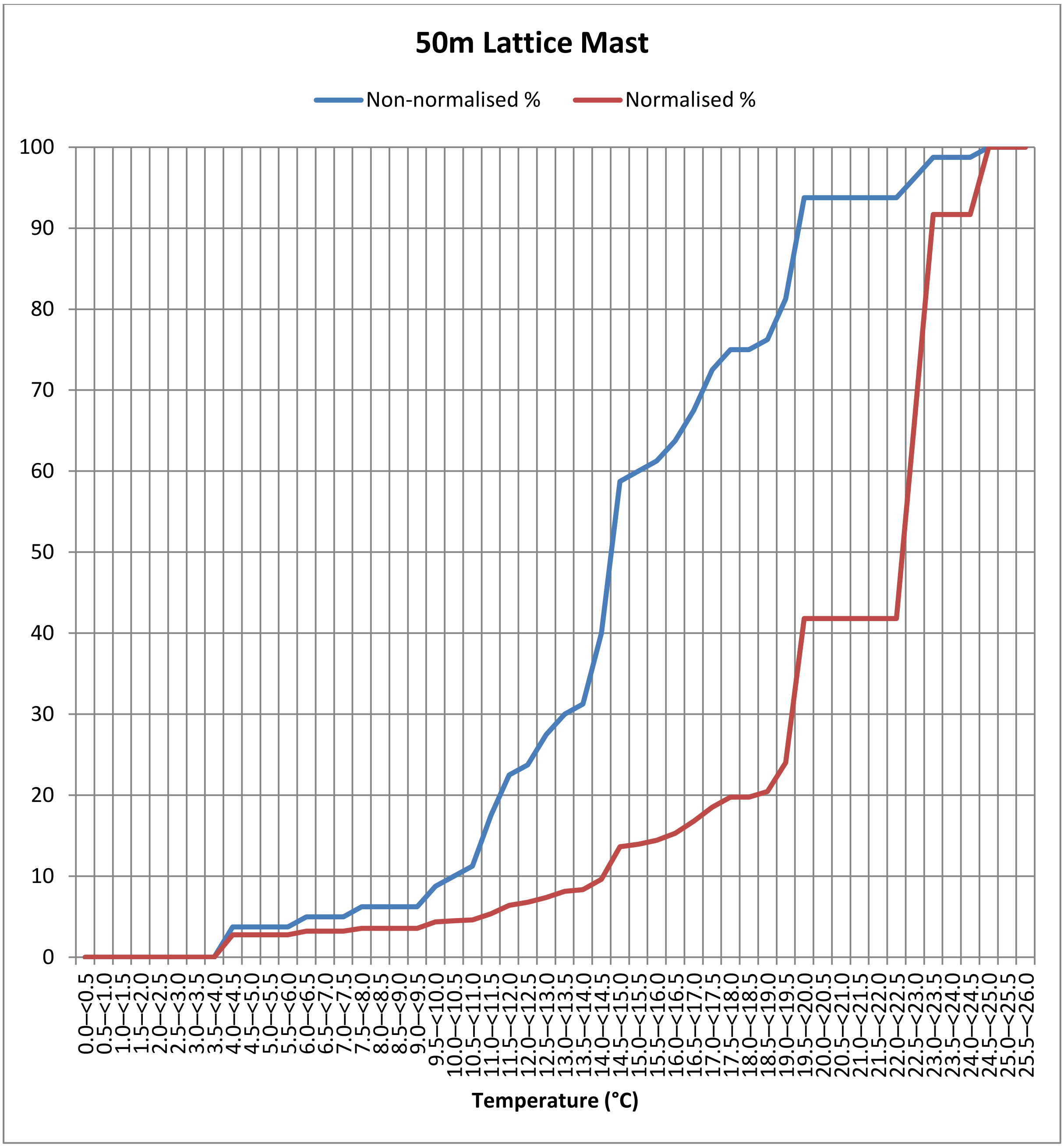



**Figure 66:** Cumulative percentage of normalised and non-normalised bat passes per temperature category

# 5 PROPOSED INITIAL MITIGATION MEASURES

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). Proposed mitigation pertaining to the Lattice mast in **Table 13** below, will be updated once the corrupted data from this mast has been recovered. However, according to **Figure 23** it is expected that the seasonal peak was within the uncorrupted data range.

The following turbines are linked to the passive systems below (informed by moderate sensitivity, and comparable habitat/terrain) and are thus affected by the below mitigation schedule. **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. Thus the below parameters is preliminary and pertains to turbines in the proximity of each met mast.**

Lattice mast: Turbines within Moderate sensitivity buffers, North of the blue line in **Figure 67.**

Tubular mast: Turbines within Moderate sensitivity buffers, South of the blue line in **Figure 67.**

**Table 13:** The times of implementation of mitigation measures is preliminarily recommended (considering more than 80% bat activity, normalised data) as follows:

| **Preliminary** times to implement curtailment/ mitigation | **Lattice mast**<br>1 October - 4 November<br>Sunset – 19:30; 23:30 – 00:30; 03:30 – 4:00 |
|---|---|
| Environmental conditions in which to implement curtailment/ mitigation at start of operational phase (**preliminary**) | Below 10m/s measured at 60m<br>Above 19°C |

| | | | |
|---|---|---|---|
| **Preliminary** times to implement curtailment/ mitigation | **Tubular mast**<br>1 – 31 March<br><br>Sunset – 20:30;<br><br>22:30 – 00:00 | **Tubular mast**<br>1 – 31 October<br><br>Sunset – 22:30;<br>02:00 – 03:30 | **Tubular mast**<br>1 -31 December<br><br>Sunset – 01:00 |
| Environmental conditions in which to implement curtailment/ mitigation at start of operational phase (**preliminary**) | Below 8.5m/s measured at 50m<br><br>Above 17.5°C | Below 10m/s measured at 30m<br><br>Above 16.5°C | Below 9.5m/s measured at 50m<br><br>Above 24°C measured at 5.5m |

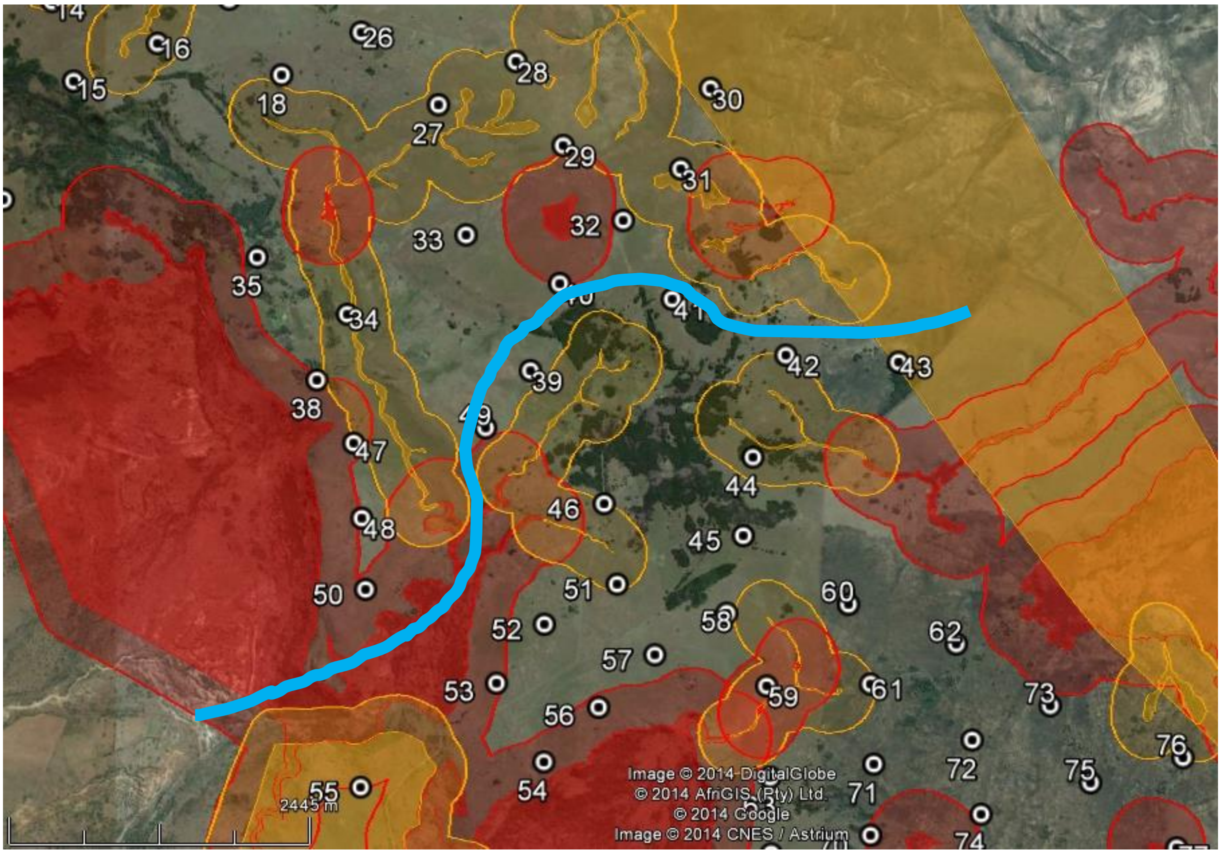



**Figure 67:** Indication of turbines to be associated with each met mast, refer to **Table 13** above.

***Please note:** The turbine layout used in Figure 67 is the November 2014 layout and has since been amended. Please see amended WEF EIR.

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. 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/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.

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 "5 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. 90 Degree feathering of blades below manufacturers cut-in speed so it is exactly parallel to the wind direction as to minimise free-wheeling blade rotation as much as possible without locking the blades.

3. 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.

4. 90 Degree feathering of blades below mitigation cut in conditions.

5. 90 Degree feathering throughout the entire night.

It is recommended that curtailment be applied **initially at the start of operation** at **Level 2** during the climatic conditions and time frames outlined in **Table 13**. **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).**

**Acoustic deterrents:**

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:**

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:**

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.

# 6 CONCLUSION

A relatively high number of bat passes were recorded by the two controls, Short Mast 6 and Short Mast 7, compared to the Tubular and Lattice met masts. This indicates bat activity to be lower in the open terrain further away from open water and farm buildings.

Probabilities of terrain that may be utilised by fruit bats (especially *Epomophorus wahlbergi*) for foraging, roosting and commuting have been considered in the sensitivity map based on current available data. An additional spring site visit, completely devoted to fruit bats, will be carried out in order to inform the study design of the operational monitoring and the associated mitigations that may apply. It is not practical to identify all roosts of insectivorous or fruit bats on site, therefore terrain and habitat probable of providing such roosting spaces have been identified and demarcated in the sensitivity map as a High sensitivity.

The clumps of Black Wattle invader trees on the plateau indicated elevated levels of bat activity, especially *Neoromicia capensis* and *Miniopterus natalensis* bats. Since these are artificial colonies of aggressive invasive tree species, it is recommended that the black wattle trees be kept cleared in a radius of 300m around any turbine for the lifetime of the WEF. This would be in order to avoid significant bat mortalities close to these trees and therefore designating such areas as no-go High bat sensitivity zones. This is the only acceptable proposed mitigation that involves habitat modification.

Peak bat activity periods and climatic conditions were identified from Section 4.6. These periods and weather conditions have been used to inform proposed initial mitigation measures that may be applicable (initially) to selected turbines identified during the operational monitoring study design. These initial mitigation measures will be adjusted during the operational monitoring phase, according to available bat mortality data gathered during the operational phase.

The revised proposed turbine layout, dated 26 August 2015, is respective of the bat sensitivity map and considerable amendments to the layout have been made in order to achieve this. No turbines are proposed within High bat sensitivities or their buffers, as well as Moderate bat sensitivities.

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# 7 APPENDIX A (completely unedited as provided to Animalia)

**Sapsford and Bats KZN list of trees associated with *Epomophorus* species in KwaZulu-Natal**

- Figs (*Ficus sur, F. trichopoda, F. natalensis*)
- Wild frangipani (*Voaconga thouarsii*)
- Forest toad tree (*Tabernaemontana ventricosa*)
- Water pear (*Syzigium cordatum*)
- Coastal goldenleaf (*Bridelia mucrantha*)
- Natal ebony (*Euclea natalensis*)
- Dune myrtle (*Eugenia capensis*)
- Cape ash (*Ekebergia capensis*)
- Wild custard-apple (*Annona senegalensis*)
- Yellowoods (*Podocarpus latifolius, P. falcatus*)
- White milkwood (*Sideroxylon inerme*)
- Quinine tree (*Rauvolfia caffra*)
- Tree fuschia (*Halleria lucida*)
- Marula (*Sclerocarya caffra*)
- Natal mahogany (*Trichelia emetica*)
- Wild plum (*Harpephyllum caffrum*)
- Red milkwood (*Mimusops caffra*)

- **Coast:** *Strelitzia (Strelitzia nicolai)*

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