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

- For the proposed Graskoppies Wind Energy Facility, Northern Cape

Compiled by: Daleen Burger

Reviewed by: Monika Moir

January 2017

PREPARED FOR:

MAINSTREAM RENEWABLE POWER

4th Floor Mariendahl House
Newlands on Main
Corner Main & Campground Roads
Claremont, 7708, Cape Town

+27 (0)21 657 4040

Info-southafrica@mainstreamrp.com

by

ANiMALiA
zoological & ecological consultation

CK 2015/364493/07

Heldervue
Somerset West
Cape Town
7130
☎+27 78 190 3316

✉werner@animalia-consult.co.za

www.animalia-consult.co.za

Ref: R-1701-10

Appointment of Specialist

Specialist Company:	Animalia Zoological & Ecological Consultation (Pty) Ltd
Fieldwork conducted by:	Daleen Burger
Report done by:	Daleen Burger
Overseen/reviewed by:	Monika Moir and Werner Marais
Appointed by:	Mainstream Renewable Power
For:	12 Month pre-construction bat activity monitoring

Independence:

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

Applicable Legislation:

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

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

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

TABLE OF CONTENTS

1 OBJECTIVES AND TERMS OF REFERENCE FOR PRECONSTRUCTION STUDY 8

2 INTRODUCTION 8

2.1 The Bats of South Africa 9

2.2 Bats and Wind Turbines 10

3 METHODOLOGY 12

3.1 Site Visits Information 14

3.2 Assumptions and Limitations 16

3.3 Assessment of Impacts 17

3.3.1 Determination of Significance of Impacts 17

3.3.2 Impact Rating System 17

4 RESULTS AND DISCUSSION 21

4.1 Land Use, Vegetation, Climate and Topography 21

4.2 Literature Based Species Probability of Occurrence 23

4.3 Ecology of bat species that may be largely impacted by the Graskoppies WEF.... 25

4.4 Transects 27

4.4.1 First Site Visit 27

4.4.2 Second Site Visit 28

4.4.3 Third Site Visit 30

4.4.4 Fourth Site Visit 33

4.4.5 Fifth Site Visit 33

4.5 Sensitivity Map 36

4.6 Passive Data 39

4.6.1 Abundances and Composition of Bat Assemblages 39

4.6.2 Temporal Distribution ... 49

4.6.3 Distribution of bat activity across the night per season ... 57

4.6.4 Relation between Bat Activity and Weather Conditions ... 82

5 IMPACT ASSESSMENT OF PROPOSED WEF ON BAT FAUNA ... 120

5.1 Construction phase ... 120

5.1.1 Impact: Destruction of bat roosts due to earthworks and blasting ... 120

5.1.2 Impact: Loss of foraging habitat ... 121

5.2 Operational phase ... 122

5.2.1 Impact: Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration) ... 122

5.2.2 Impact: Artificial lighting ... 123

5.3 Decommissioning phase ... 125

5.3.1 Impact: Loss of foraging habitat ... 125

6 CUMULATIVE IMPACT ASSESSMENT ... 126

6.1 Cumulative Impact Assessment Rating ... 127

6.1.1 Impact: Cumulative bat mortalities due to direct blade impact or barotrauma during foraging (resident and migrating bats affected). ... 127

7 ASSESSMENT OF ALTERNATIVES ... 131

8 PROPOSED INITIAL MITIGATION MEASURES AND DETAILS ... 132

9 CONCLUSION ... 137

10 REFERENCES ... 139

Figure 1: Map overview of the proposed Graskoppies WEF.

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

1 OBJECTIVES AND TERMS OF REFERENCE FOR PRECONSTRUCTION STUDY

- Study bat species assemblage and abundance on the site.
- Study temporal distribution of bat activity across the night as well as the four seasons of the year in order to detect peaks and troughs in activity.
- Determine 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 identify if any turbines occur in sensitive areas and need to be shifted into less sensitive areas or removed from the layout.
- Detail the types of mitigation measures that are possible if bat mortality rates are found to be unacceptable, including the potential times/circumstances which may result in high mortality rates.

2 INTRODUCTION

This is the fifth and final progress report for a twelve-month bat monitoring study at the proposed Graskoppies Wind Energy Facility near Loeriesfontein, Northern Cape.

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. The importance of these factors can vary greatly between bat species, their respective behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above-mentioned factors.

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

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

2.1 The Bats of South Africa

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

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

Many bat species roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities within the same population (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum. Moreover, according to O'Shea *et al*. (2003), bats may live for up to 30 years thereby limiting the number of pups born due to this increased life expectancy. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity and the relatively low predation of bats when compared to other small mammals. However, in contrast the relatively low reproduction rates of bats results in populations having a low recovery rate from mass mortalities and major roost disturbances.

2.2 Bats and Wind Turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesized that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, numerous bat fatalities 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 to exceed bird fatalities by up to three-fold.

Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water; in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (e.g. Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure to investigate perceived potential 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 of disorientation for 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 scavenging, the rate of which differs from site to site as a result of habitat type, species of scavenger 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, 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 was done through site visits with transects made throughout the site with a vehicle-mounted bat detector. Passive detection was carried out with the mounting of passive bat monitoring systems placed on six monitoring masts on site. Specifically, five short 10m masts (**Figure 3**) and one meteorological mast.

The monitoring systems consisted of SM2BAT+ time expansion bat detectors that were powered by 12V, 18Ah, sealed lead acid batteries and 20W solar panels that provided recharging power to the batteries (**Figure 4**). Each system also had an 8-amp low voltage protection regulator and SM3PWR step down transformer. Four SD memory cards, class 10 speed, with a capacity of 32GB each were utilized within each SM2BAT+ detector; this was to ensure substantial memory space with high quality recordings even under conditions of multiple false wind triggers.

One weatherproof ultrasound microphone was mounted at a height of 10 meters on the short masts, while two microphones were mounted at 10m and 80m on the meteorological mast. These microphones were then connected to the SM2BAT+ bat detectors.

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


Figure 3: Short mast monitoring system


Figure 4: SM2BAT+ detector and supporting hardware

3.1 Site Visits Information

<table>
<tr><td colspan="2" rowspan="5">Site visit dates</td><td>First Visit</td><td>30 November – 5 December 2015</td></tr>
<tr><td>Second Visit</td><td>14 – 18 February 2016</td></tr>
<tr><td>Third Visit</td><td>25 April – 4 May 2016</td></tr>
<tr><td>Fourth Visit</td><td>29 August – 3 September 2016</td></tr>
<tr><td>Fifth Visit</td><td>28 November – 02 December 2016</td></tr>
<tr><td rowspan="3">Met mast passive bat detection systems</td><td>Quantity on site</td><td colspan="2">1</td></tr>
<tr><td>Microphone heights</td><td colspan="2">10m; 80m</td></tr>
<tr><td>Coordinates</td><td colspan="2">Met Mast 1: 30°18'49.56"S 19°19'0.01"E</td></tr>
<tr><td rowspan="3">Short mast passive bat detection systems</td><td>Quantity on site</td><td colspan="2">5</td></tr>
<tr><td>Microphone height</td><td colspan="2">10m</td></tr>
<tr><td>Coordinates</td><td colspan="2">SM1: 30°13'9.21"S 19°23'18.12"E

SM2: 30°16'56.03"S 19°15'20.45"E

SM3: 30°18'16.16"S 19°21'34.84"E

SM4: 30°21'7.55"S 19°16'29.17"E

SM5: 30°21'34.44"S 19°18'55.03"E</td></tr>
<tr><td colspan="2">Replacements/ Repairs/ Comments</td><td colspan="2"></td></tr>
<tr><td colspan="2">First Visit</td><td colspan="2">The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Crows have been found to peck at microphones and subsequently destroying them. Hence, measures were taken for protection against birds, without noticeably compromising effectiveness.

The bat detectors were installed within their weatherproof containers and all peripherals attached.

Monitoring at 80m height will provide an assessment of the bat activity occurring within rotor-sweep height.</td></tr>
<tr><td colspan="2">Second Visit</td><td colspan="2">All the systems were functioning correctly apart from Short Mast 2 which had a software malfunction causing the detector to freeze resulting in the low bat activity recorded. A software update was loaded and the system is functional again.</td></tr>
</table>

Third Visit	Short Mast 1 bat detector had frozen and a firmware update was applied. Short Mast 2 bat detector had no power and after inspection it was found that the wire connection on the regulator was faulty and was reconnected. Short Mast 3 solar panel had turned slightly towards north east and was turned to north west. All the other systems were functional.
Fourth Visit	Short Mast 1 bat detector was not powered, due to a discharged battery. The battery was charged, and solar panel was re-aligned. Short Mast 2 had collapsed, after which it was erected again and solar panel re-aligned. Firmware update was applied to Short Masts 3 - 5 and the Met Mast. Short Mast 1 and 3 decibel settings were updated to 12db.
Fifth Visit	All the systems were functioning correctly.
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 in relation to latitude, longitude and season).
Trigger threshold	>16KHz, -18dB
Trigger window (time of recording after trigger ceased)	500 ms
Microphone gain setting	36dB
Compression	WAC0
Single memory card size (each system uses 4 cards)	32GB
Battery size	18Ah; 12V
Solar panel output	20 Watts
Solar charge regulator	6 - 8 Amp with low voltage/deep discharge protection
Other methods	Terrain was investigated during the day for signs of roosting and foraging habitat.

All site visits were conducted following the same methodology as mentioned above, over the course of the 12-month preconstruction monitoring period.

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

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

3.2 Assumptions and Limitations

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

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

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

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

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

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

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

3.3 Assessment of Impacts

The EIA Methodology assists in evaluating the overall effect of a proposed activity on the environment. The determination of the effect of an environmental impact on an environmental parameter is determined through a systematic analysis of the various components of the impact. This is undertaken using information that is available to the environmental practitioner through the process of the environmental impact assessment. The impact evaluation of predicted impacts was undertaken through an assessment of the significance of the impacts.

3.3.1 Determination of Significance of Impacts

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale i.e. site, local, national or global whereas Intensity is defined by the severity of the impact e.g. the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated as shown in **Table 1**.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

3.3.2 Impact Rating System

Impact assessment must take account of the nature, scale and duration of effects on the environment whether such effects are positive (beneficial) or negative (detrimental). Each issue / impact is also assessed according to the project stages:

- planning
- construction
- operation
- decommissioning

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

3.3.2.1 Rating System Used to Classify Impacts

The rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the mitigation of the impact. Impacts have been consolidated into one rating. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

Table 1: Description of terms

NATURE		
Include a brief description of the impact of environmental parameter being assessed in the context of the project. This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity.		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
1	Site	The impact will only affect the site
2	Local/district	Will affect the local area or district
3	Province/region	Will affect the entire province or region
4	International and National	Will affect the entire country
PROBABILITY		
This describes the chance of occurrence of an impact		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
REVERSIBILITY		
This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource.	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.

DURATION		
This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity		
1	Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts on the environmental parameter. A cumulative effect/impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible Cumulative Impact	The impact would result in negligible to no cumulative effects
2	Low Cumulative Impact	The impact would result in insignificant cumulative effects
3	Medium Cumulative impact	The impact would result in minor cumulative effects
4	High Cumulative Impact	The impact would result in significant cumulative effects
INTENSITY / MAGNITUDE		
Describes the severity of an impact		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).

3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.

SIGNIFICANCE

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula:

(Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.

The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Points	**Impact Significance Rating**	**Description**
6 to 28	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive Low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive Medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive High impact	The anticipated impact will have significant positive effects.
74 to 96	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive Very high impact	The anticipated impact will have highly significant positive effects.

4 RESULTS AND DISCUSSION

4.1 Land Use, Vegetation, Climate and Topography

The site is located over two different vegetation units, namely Bushmanland Basin Shrubland and Western Bushmanland Klipveld. The folowing vegetation units are found in the surrounding area: Namaqualand Blomveld, Bushmanland Arid Grassland and Bushmanland Vloere (**Figure 5**).

The site mostly falls in the Bushmanland Basin Shrubland vegetation unit which consists of slightly irregular plains with dwarf shrubland dominated by a mixture of low sturdy and spiny shrubs as well as 'white' grasses and abundant annuals in years of high rainfall. This unit is found at an altitude of 800 m – 1200 m. Mudstones and shales of Ecca Group and Dwyka tillites, both of early Karoo age, dominate the unit. About 20% of rock outcrop is formed by Jurassic intrusive dolerite sheets and dykes. Soils are shallow Glenrosa and Mispah forms with lime generally present in the entire landscape. To a lesser extent, red-yellow apedal, freely drained soils with a high base status and usually less than 15% clay are also found. These soils have a high salt content. Rainfall occurs mainly in late summer and early autumn with MAP ranging from 100 mm - 200 mm. Mean maximum and minimum temperatures are 39.6°C and -2.2°C for January and July, respectively. This biome is Least Threatened with a target of 21%. None of the unit is statutorily conserved and is without signs of serious transformation. Erosion is moderate (56%) and low (34%) (Mucina and Rutherford 2006).

The Western Bushmanland Klipveld vegetation unit is mostly present in the western parts of the site. The unit consists of very sparsely populated plains with a desert appearance supporting succulent dwarf shrubs with microphyllous non succulent shrubs and draught tolerant grasses. There are occasional mass displays of spring flora. Geology consists of Hutton and Mispah soils over Karoo Sequance sediments. The rocky pavement of rounded boulders, which characterise this area, are palaeo-river terraces of the palaeo-Orange river, which is presumed to have flowed south through this area (approximately 22 mya). Rainfall shows slight peak in winter, hardly any rain falls in December and January, thus this unit is in winter-rainfall regime. Mean maximum and minimum temperatures are 36°C and -2°C for January and July, respectively. Incidence of frost is relatively high due to its land-locked position and high altitude. The biome is Least threatened with a target of 18%. No portion of the vegetation unit is statutorily conserved. There are no signs of serious large scale transformation or invasion of alien species (Mucina and Rutherford 2006).

Vegetation units and geology are of great importance as these may serve as suitable sites for the roosting of bats and support of their foraging habits (Monadjem *et al.* 2010). Houses and buildings may also serve as suitable roosting spaces (Taylor 2000; Monadjem *et al.*

2010). The importance of the vegetation units and associated geomorphology serving as potential roosting and foraging sites have been described in **Table 3**.

Table 3: Potential of the vegetation to serve as suitable roosting and foraging spaces for bats.

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Namaqualand Blomveld	Low - Moderate	Moderate - High	Scattered and few rocky outcrops as well as little to no large flora result in low roosting potential. The flowering flora results in higher concentrations of insects and thus increasing foraging.
Bushmanland Arid Grassland	Low - Moderate	Low - Moderate	Roosting potential is almost entirely determined by sparse rocky outcrops resulting in low roosting potential. The lack of diverse flora results in a lower diversity of insect species resulting in lowered foraging potential.
Bushmanland Basin Shrubland	Low - Moderate	Moderate	Rocky outcrops provide roosting areas and scrubland provides potential foraging space.
Western Bushmanland Klipveld	Moderate - High	Moderate - High	The presence of large boulders and rock outcrops provide roost sites. The presence of drought tolerant grasses as well as a variety of shrubs make for adequate foraging area.
Bushmanland Vloere	Low	Moderate -High	This biome possesses salt pans and dry riverbeds which does not provide adequate roosting place. The sprouting of flora may infer a higher foraging capacity for the unit.

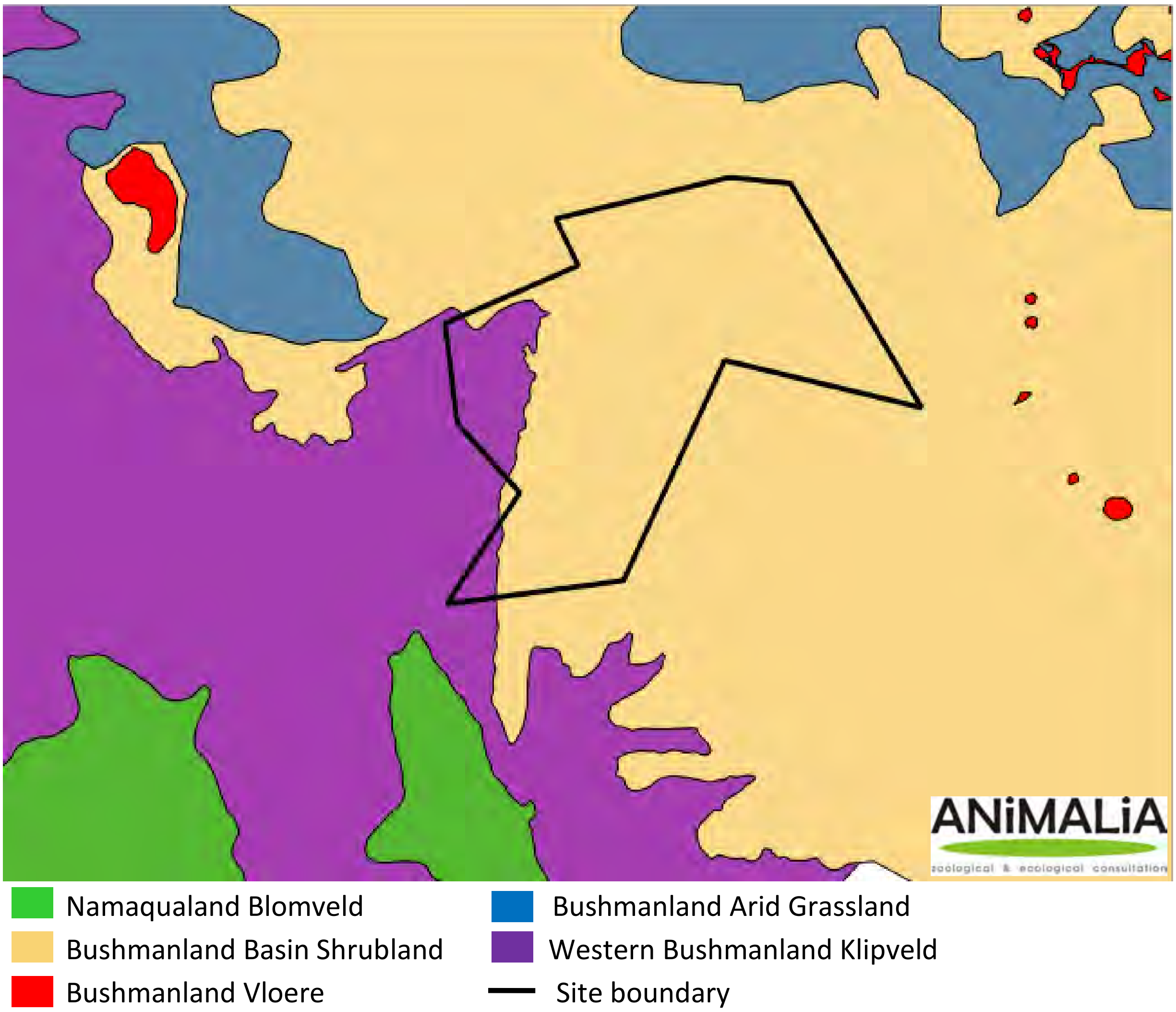


Figure 5: Vegetation units present on the study area (Mucina and Rutherford 2006).

4.2 Literature Based Species Probability of Occurrence

"Probability of Occurrence" is assigned based on consideration of the presence of roosting sites and foraging habitats on the site, compared to literature described preferences. The probability of occurrence is described by a percentage indicative of the expected numbers of individuals present on site and the frequency with which the site will be visited by the species (in other words the likelihood of encountering the bat species).

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

Table 4: Table of species that may be roosting or foraging on the study area, the possible site specific roosts, and their probability of occurrence based on literature (Monadjem *et al.* 2010).

Species name	Common name	Probability of Occurrence (%)	Conservation Status	Possible roosting sites occupied on site	Foraging habits (indicative of possible foraging areas on site)	Likely Risk of Impact (Sowler & Stoffberg 2014)
Miniopterus natalensis	Natal long-fingered bat	10 - 20	Near Threatened	Cave-dependent. No known caves in vicinity of site, however mountainous terrain within the larger area can possibly provide caves. Also being observed to forage singly or in small groups in small hollows and culverts or bridges.	Clutter-edge forager. Feeds on a variety of aerial prey including Diptera, Hemiptera, Coleoptera, Lepidoptera and Isoptera.	Medium - High
Neoromicia capensis	Cape serotine	90 - 100	Least Concern	Possibly large trees around farm buildings livestock kraal and shade areas. Limited farm building roofs	Clutter-edge forager feeding mainly on Coleoptera, Hemiptera, Lepidoptera and Neuroptera.	Medium - High
Tadarida aegyptiaca	Egyptian free-tailed bat	90 - 100	Least concern	Limited farm buildings and tall farm structures. Crevice dweller that will take refuge in almost any suitably sized crevice raised above ground.	Open-air forager with a diet consisting mainly of Diptera, Hemiptera, Coleoptera and to some extent Lepidoptera. Vegetation below has little influence on foraging habitat, and can forage large distances.	High
Eptesicus hottentotus	Long-tailed serotine	90 - 100	Least Concern	It is a crevice dweller roosting in rock crevices, expansion joints in bridges and road culverts	It seems to prefer woodland habitats, and has been caught in granitic hills and near rocky outcrops	Medium

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

There are three bat species recorded in the vicinity of the site that occurs commonly in the area due to their probably 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 et al. 2016). 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 *Miniopterus natalensis* in South Africa with migration distances exceeding 150 kilometres. If the site is located within a migratory path the bat detection systems should detect high numbers and activity of the Natal long-fingered bat.

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

Sowler and co-workers (2016) advise that *Miniopterus 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 *Neoromicia 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 et al., 2016).

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. *Tadarida 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 et al., 2016). 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.

4.4 Transects

4.4.1 First Site Visit

Transects were not carried out over the first site visit due to time constraints as a result from the installation of the monitoring systems. Further transects will be carried out over the following site visits.

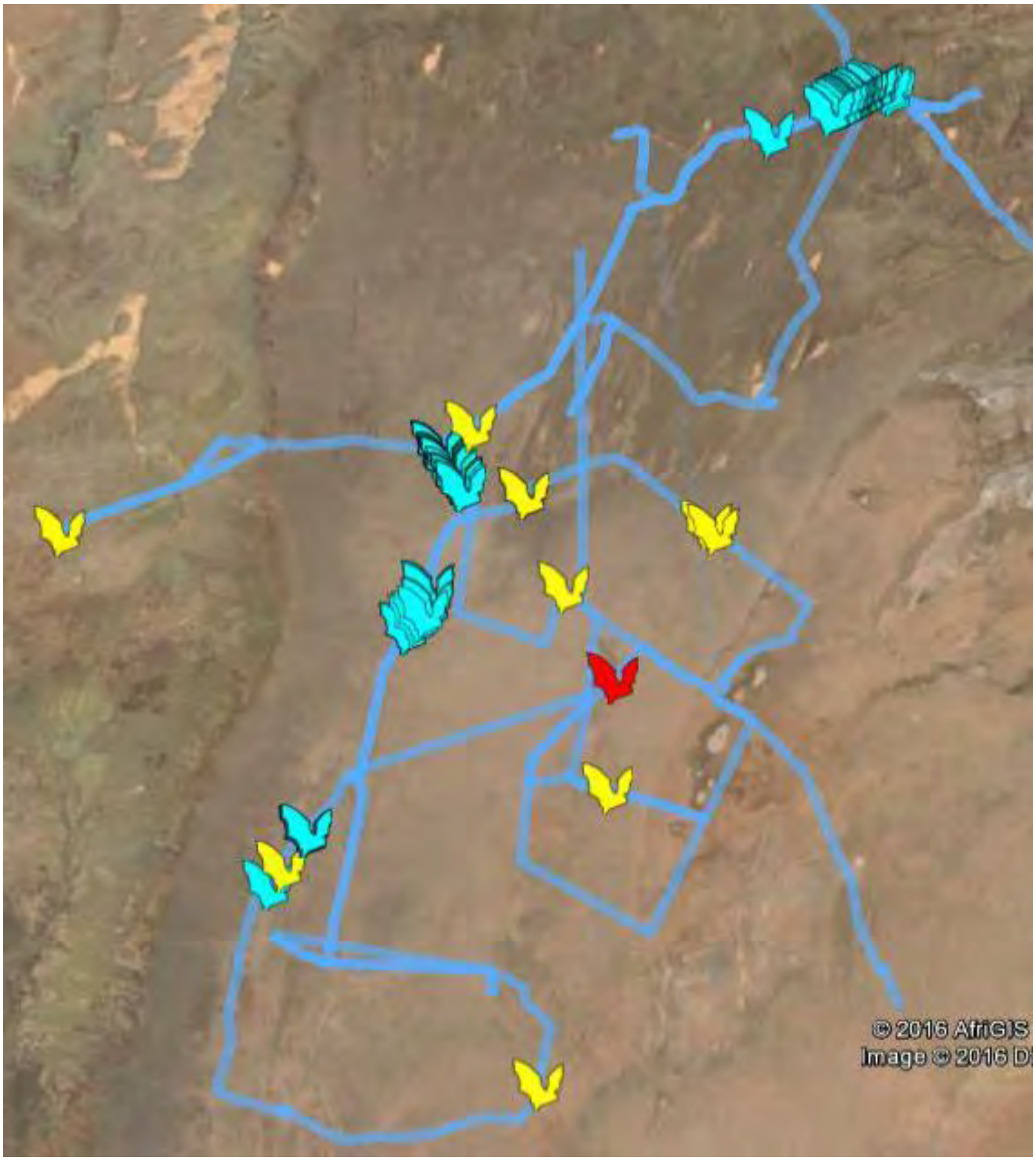
4.4.2 Second Site Visit

Transect data was used to analyse the accuracy of the bat sensitivity map. Large amounts of bat activity were recorded in the north and west of the site.

Figure 6 below indicates the transect routes during the second site visit. Transect routes were not calculated and were carried out randomly based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 5** displays the sampling effort and weather conditions prevalent during transect surveys.

Table 5: Transect distance, duration and average weather conditions experienced during the second site visit transect

Date	**Distance (km)**	**Duration (hours and minutes)**	**Temperature (˚C)**	**Rain (mm)**	**Wind speed (km/h)**
14 February 2016	22.7	1hr 40min	20	0	14.5
15 February 2016	28.2	1hr 55 min	23	0	14.5
16 February 2016	24.9	2hr 15min	28	0	9.7
17 February 2016	25.5	2hr 0min	29	0	19.3



Tadarida aegyptiaca *Miniopterus natalensis* *Neoromicia capensis*

Transect track

Figure 6: Transect routes and bat passes detected across the site over the second site visit

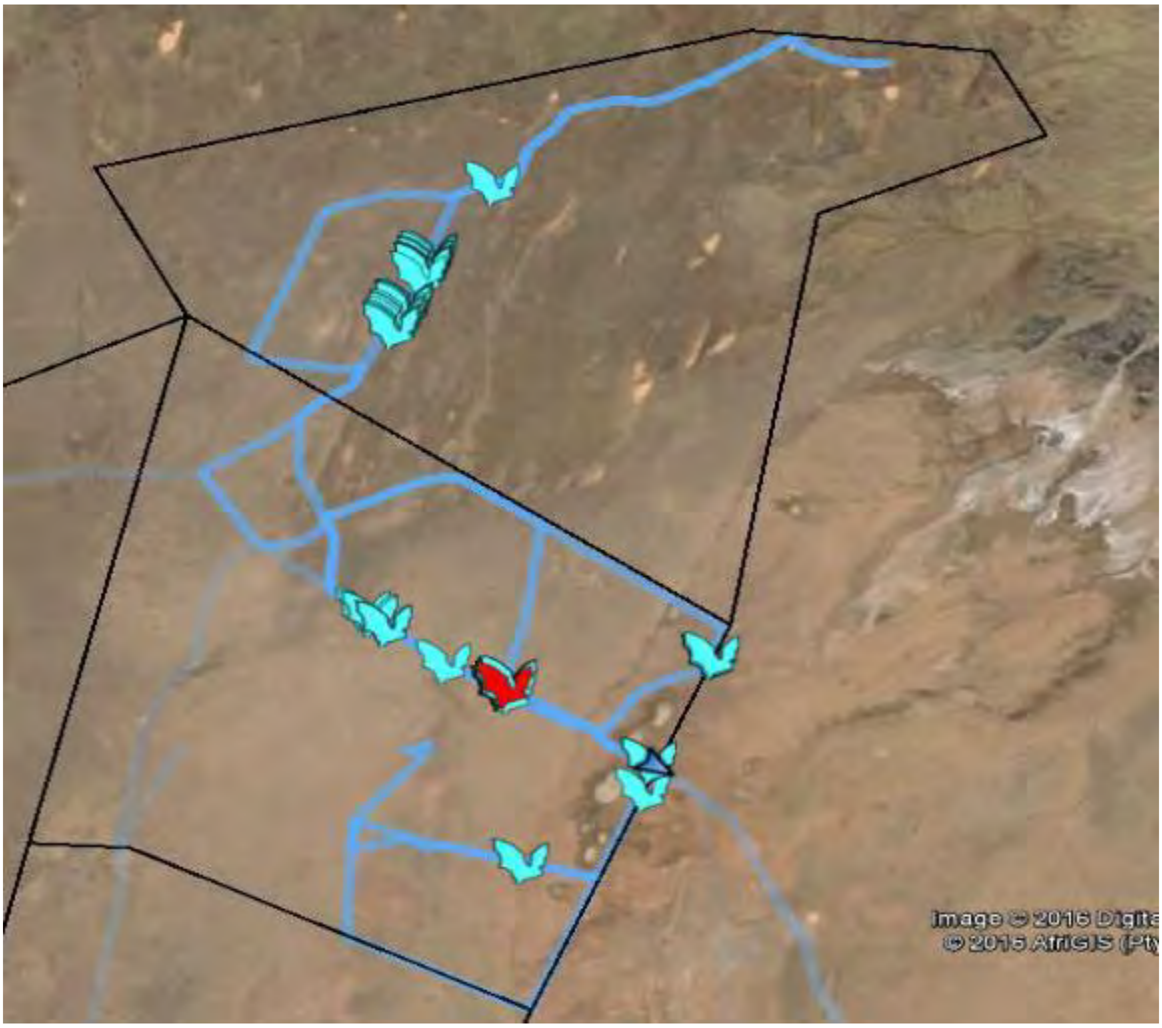
4.4.3 Third Site Visit

Figure 7 below displays the results of the transects carried out over the April 2016 site visit. A high number of bat passes, specifically *Tadarida aegyptiaca*, was detected in the north and centre of the site. **Figure 8** displays the congregation of bats detected near the farm dams, indicating these water sources to be bat sensitive features. Only one night of transect data was collected due to problems with monitoring equipment and rain preventing site work.

Figure 7 below indicates the transect routes during the third site visit. Transect routes were not calculated and were carried out randomly based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 6** displays the sampling effort and weather conditions prevalent during transect survey.

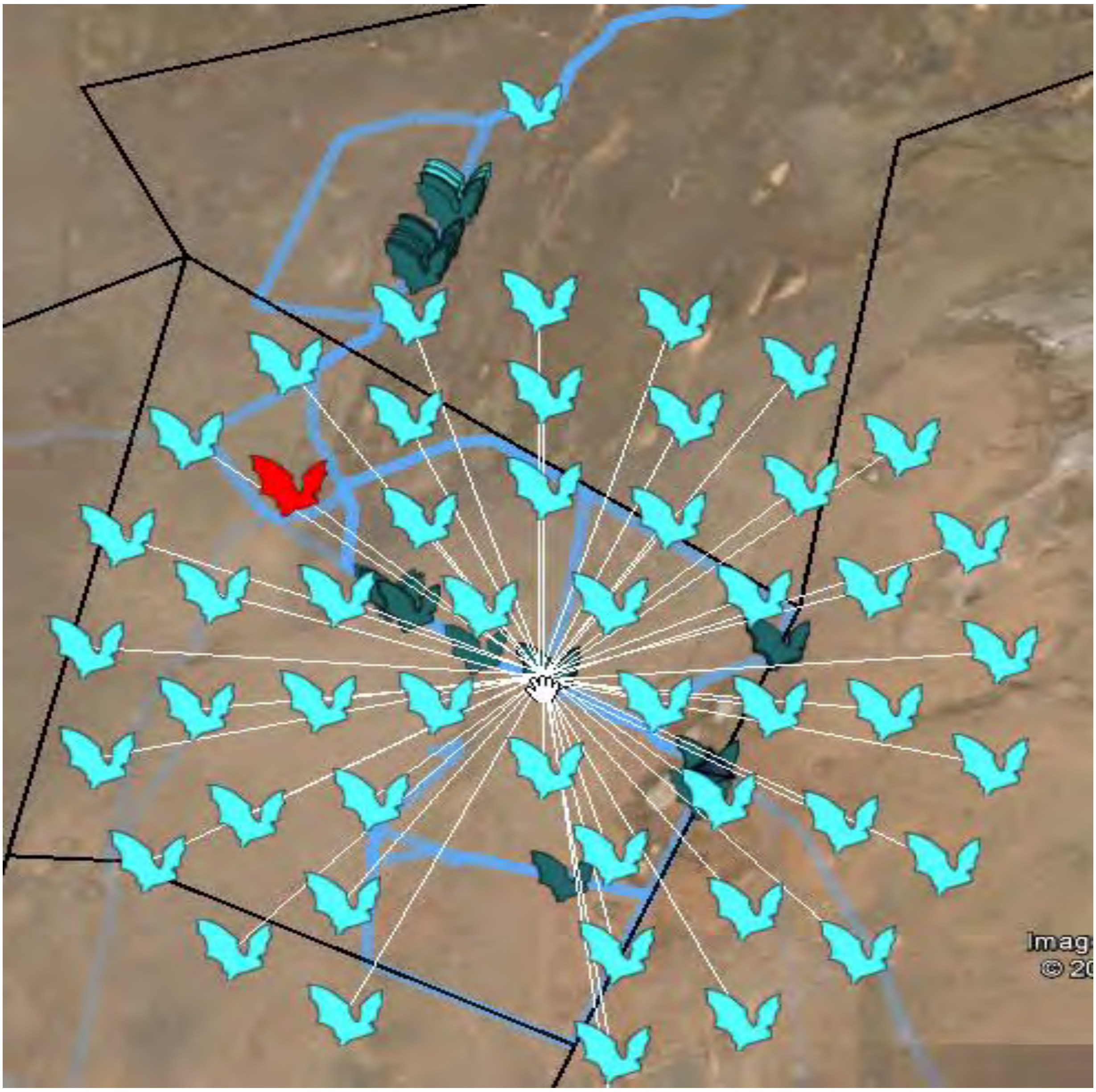
Table 6: Transect distance, duration and average weather conditions experienced during the third site visit transect

Date	**Distance (km)**	**Duration (hours and minutes)**	**Temperature (˚C)**	**Rain (mm)**	**Wind speed (km/h)**
27 April 2016	73.58	3hr 50min	21	0	4.82



Tadarida aegyptiaca *Miniopterus natalensis* *Neoromicia capensis*

Figure 7: Transect routes and bat passes detected across the site over the third site visit



Tadarida aegyptiaca *Miniopterus natalensis* *Neoromicia capensis*

Figure 8: Large cluster of bats found during transects near the centre of the study area

4.4.4 Fourth Site Visit

Figure 9 below displays the results of the transects carried out over August - September 2016 site visit. A lower number of bat passes was detected throughout the site, with *Tadarida aegyptiaca* being the only species within the site. The low number could be due to the fact that the site visit occurred during the winter months.

Figure 9 below indicates the transect routes during the fourth site visit. **Table 7** displays the sampling effort and weather conditions prevalent during transect survey.

Table 7: Transect distance, duration and average weather conditions experienced during the fourth site visit transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
31 Augustus 2016	74.6	5h 09min	17	0	8.85
01 September 2016	93.9	5h 01min	10	0	6.4
02 September 2016	65.3	3h 20min	18.5	0	9.65

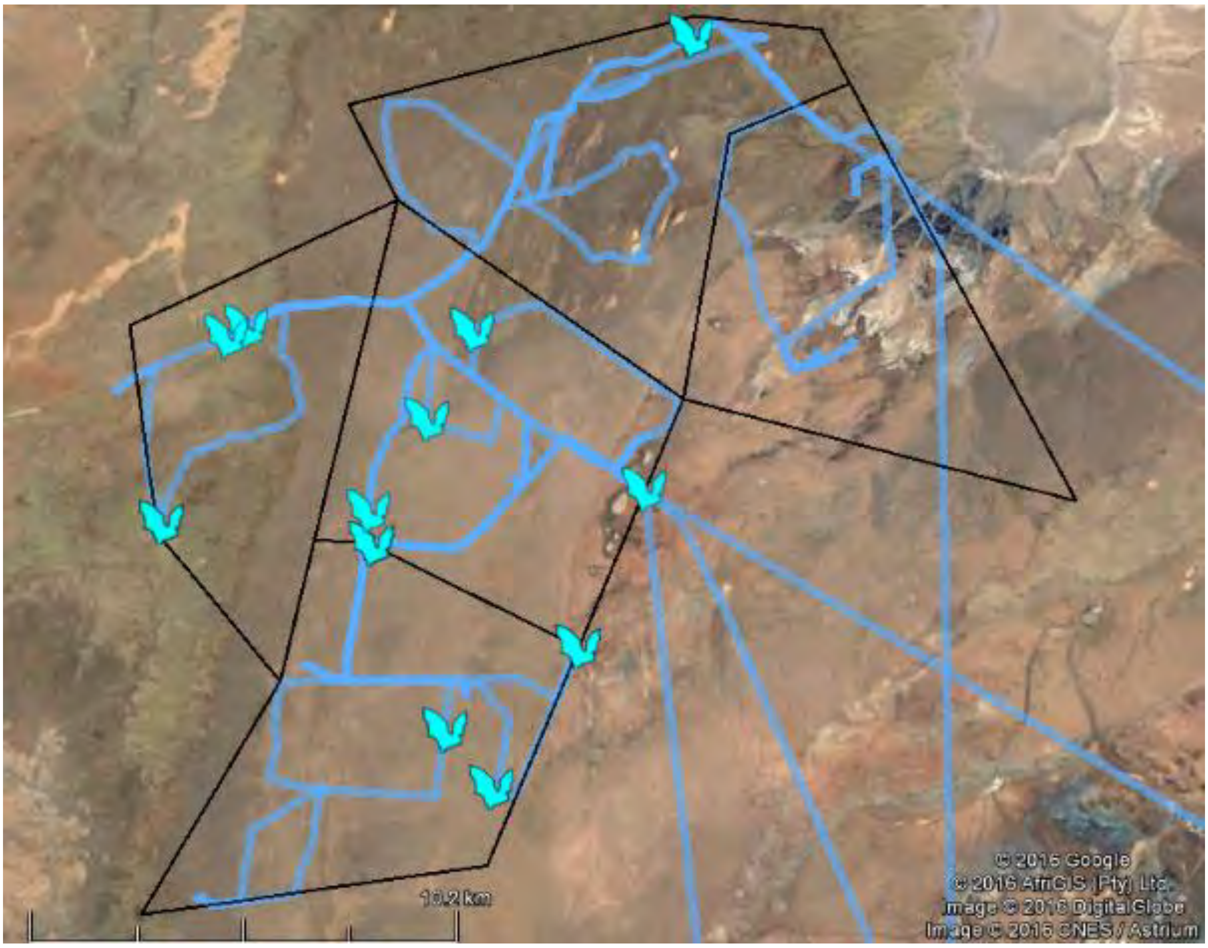
4.4.5 Fifth Site Visit

Figure 10 below displays the results of the transects carried out over November – December 2016 site visit. An increase in the number of bat passes was detected on the northern section of the site, with *Tadarida aegyptiaca* being the only species within the site. The increase in the number of bat passes could be due to the fact that the site visit occurred during the spring and summer months of the year. Unfortunately, due to unforeseeable circumstances only half of the site was driven during the transects.

Figure 10 below indicates the transect routes during the fifth site visit. Transect routes were not calculated and were carried out randomly based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 8** displays the sampling effort and weather conditions prevalent during transect survey.

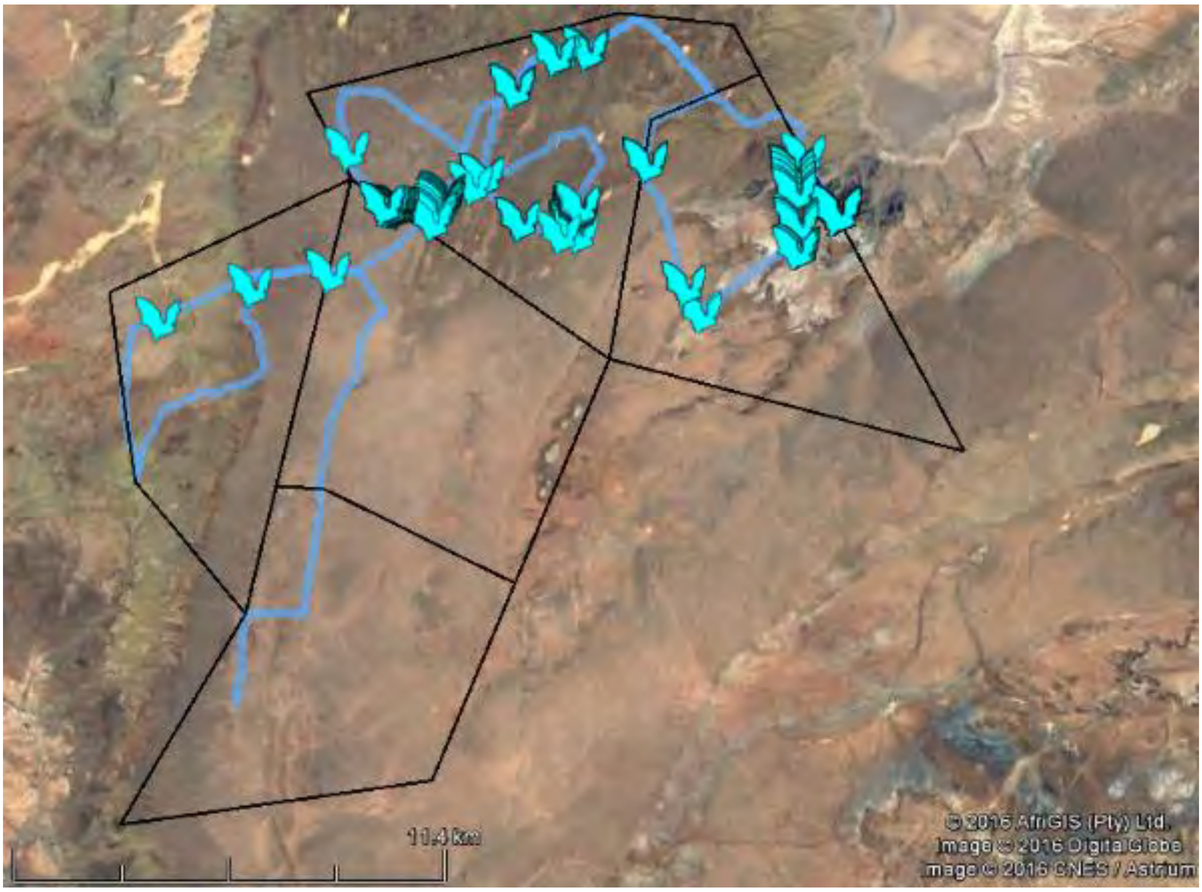
Table 8: Transect distance, duration and average weather conditions experienced during the fifth site visit transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
29 November 2016	59.8	2h 46min	28.5	0	13.7
01 December 2016	37.0	1h 48min	27.0	0	13.7



● *Tadarida aegyptiaca*

Figure 9: Transect routes and bat passes detected across the site over the fourth site visit



Tadarida aegyptiaca

Figure 10: Transect routes and bat passes detected across the site over the fifth site visit

4.5 Sensitivity Map

Figures 11 - 12 depict the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are confirmed and most probable to occur on site. Thus the sensitivity map is based on species ecology and habitat preferences. This map can be used as a pre-construction mitigation in terms of improving turbine placement with regards to bat preferred habitats on site.

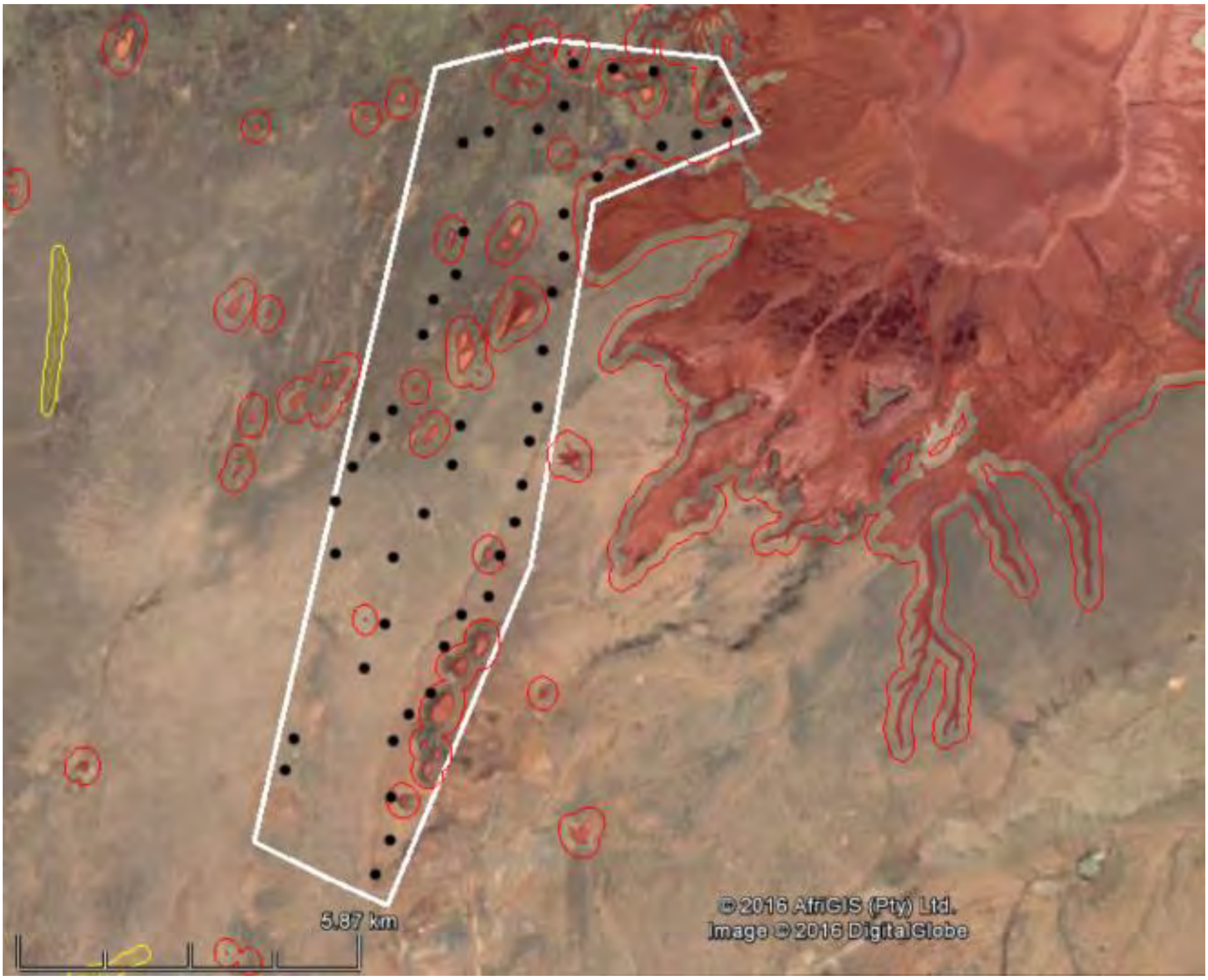
Last iteration	January 2016
High sensitivity buffer	200m
Moderate sensitivity buffer	100m
Features used to develop the sensitivity map	Manmade structures, such as farm houses, barns, sheds, road culverts and mine adits, these structures provide easily accessible roosting sites.
	The presence of caves, rock faces, areas of exfoliating rock and clumps of larger woody plants. These features provide natural roosting spaces and tend to attract insect prey.
	The different vegetation types and presence of riparian/water drainage habitat is used as indicators of probable foraging areas.
	Open water sources, be it man-made farm dams or natural streams and wetlands, are important sources of drinking water and provide habitat that host insect prey.

The areas designated as having a High Bat Sensitivity **(Table 9)** implicates that no turbines should be placed in these areas and their respective buffer zones, due to the elevated impacts it can have on bat mortalities. Turbines located within high sensitivity areas and their buffers are identified in **Figure 12** below. These turbines must be moved out of high bat sensitivities or removed from the turbine layout. If turbines are located within the Moderate Bat Sensitivity zone or buffer zone, they must receive special attention and preference for post-construction monitoring and implementation of mitigations during the operational phase.

Table 9: Description of sensitivity categories utilized in the sensitivity map

Sensitivity	Description
Moderate Sensitivity	Areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within or close to these areas must acquire priority (not excluding all other turbines) during pre/post-construction studies and mitigation measures, if any is needed.

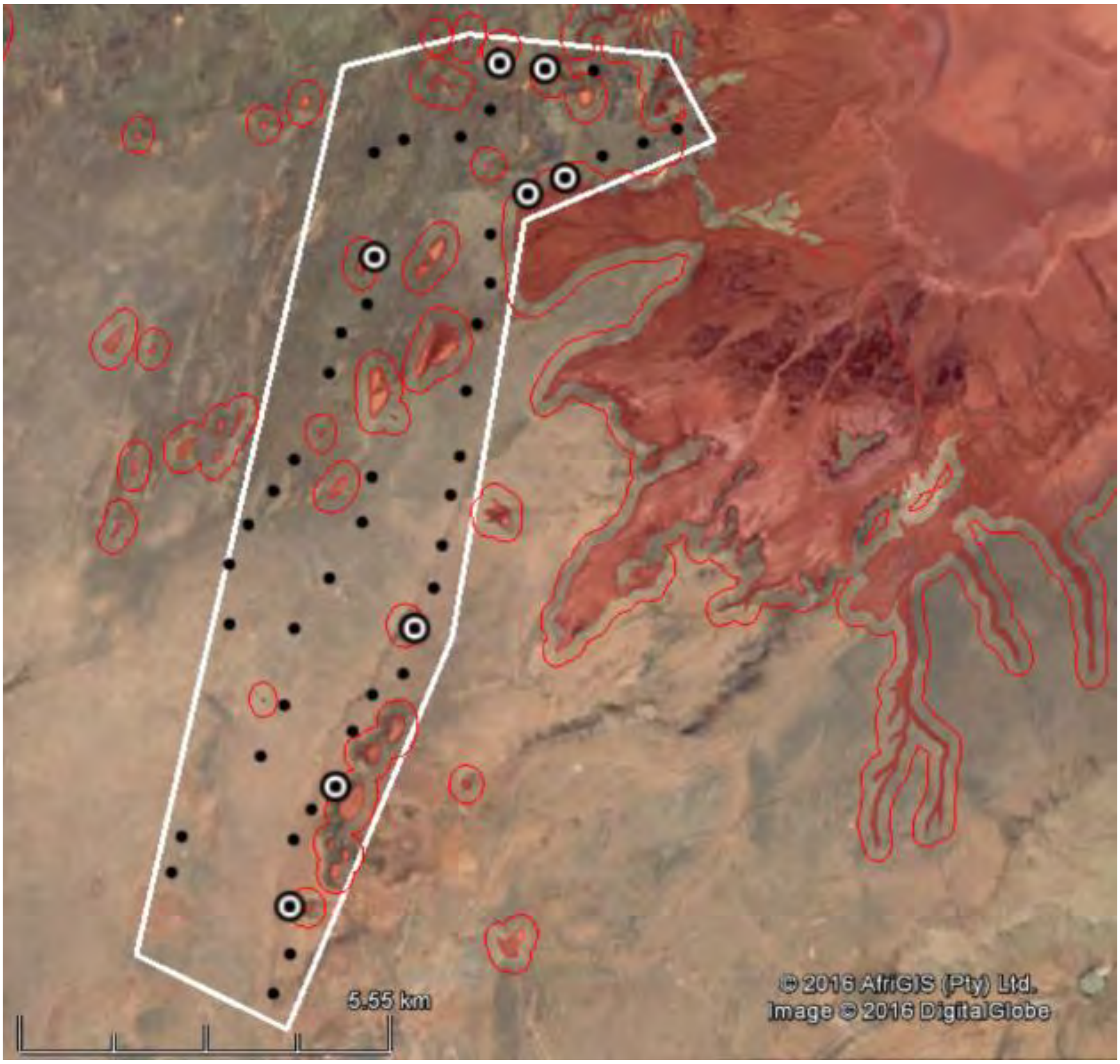
High Sensitivity	Areas that are deemed critical for resident bat populations, capable of elevated levels of bat activity and support greater bat diversity than the rest of the site. These areas are 'no-go' areas and turbines must not be placed in these areas.



High bat sensitivity area — High bat sensitivity buffer

Moderate bat sensitivity area — Moderate bat sensitivity buffer

Figure 11: Bat sensitivity map of the study area.



High bat sensitivity area | High bat sensitivity buffer

Moderate bat sensitivity area | Moderate bat sensitivity buffer

Figure 12: Turbines (white icons) located within high bat sensitivity areas and their buffers

4.6 Passive Data

4.6.1 Abundances and Composition of Bat Assemblages

Average bat passes detected per bat detector night (nights on which detectors recorded correctly) and total number of bat passes detected over the monitoring period by all systems are displayed in **Figures 14 - 25**. Three bat species were detected by the passive monitoring systems, namely, *Miniopterus natalensis, Neoromicia capensis,* and *Tadarida aegyptiaca.*

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

Miniopterus natalensis is the only migratory species detected on site. It was detected by all the monitoring systems, with Short Mast 3 detecting the highest number of passes. The relative abundance of this species, as detected by the Short Mast 3 monitoring system, was over the months of January, March - April 2016, with it being highest in March 2016 (**Figure 23**). The results of the full 12 months monitoring study were analysed for the presence of a migratory event in order to determine whether the site is located within a migratory route. There is no indication of a migration event from any of the six monitoring systems. The operational phase bat monitoring study must be designed such that it continues to monitor for any evidence of a migration in order to effectively mitigate if such an event occurs in years to come.

Met Mast monitoring system indicates the highest amount of bat passes, followed by Short Mast 3 **(Figure 14 and 17)**.

Short Mast 2 shows a low sum of bat passes over the first three-month monitoring period due to a fault with the detector software causing the system to freeze and not record for the full monitoring period (**Figure 22**). Short Mast 1 had no data for the months of April, June, and July 2016 due to system failures (**Figure 21**).

The average nightly bat passes per month is used to show the general trend in bat activity across the different month of the year. All the masts show higher bat activity from January to April with predominant peaks for the month of March, except for Short Mast 4 which has a peak in January 2016 (**Figures 20 – 25**), except for Short Mast 2 which was not recording during January as explained above. Bat activity decreased as the seasons changed into winter. An increase in bat activity, for all the monitoring systems, occurred again from August to November as the seasons changed from winter to spring.

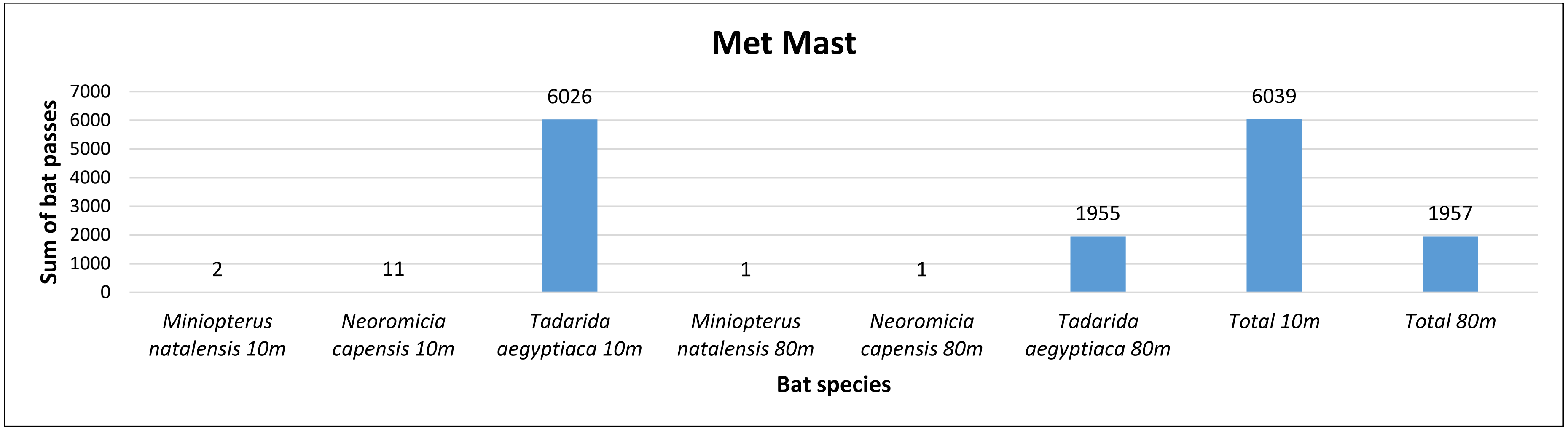


Figure 14: Total bat passes recorded over the monitoring period by the detector mounted on the Met Mast.

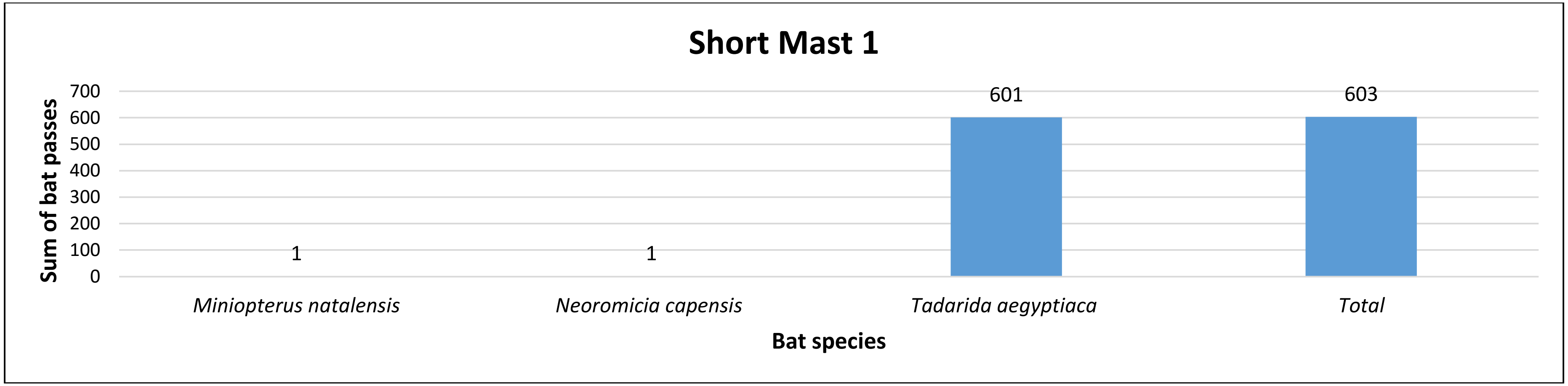


Figure 15: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 1.

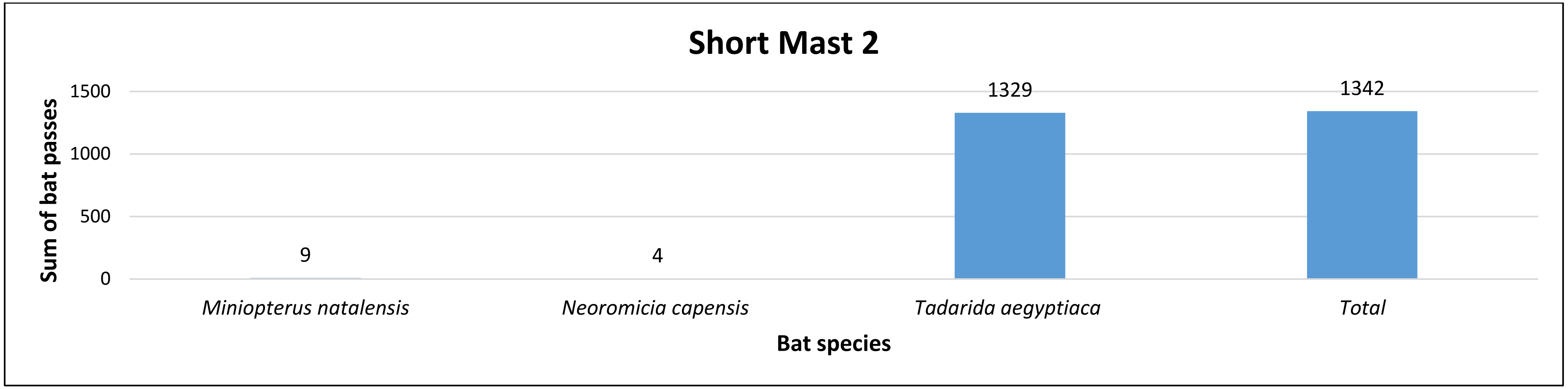


Figure 16: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 2.

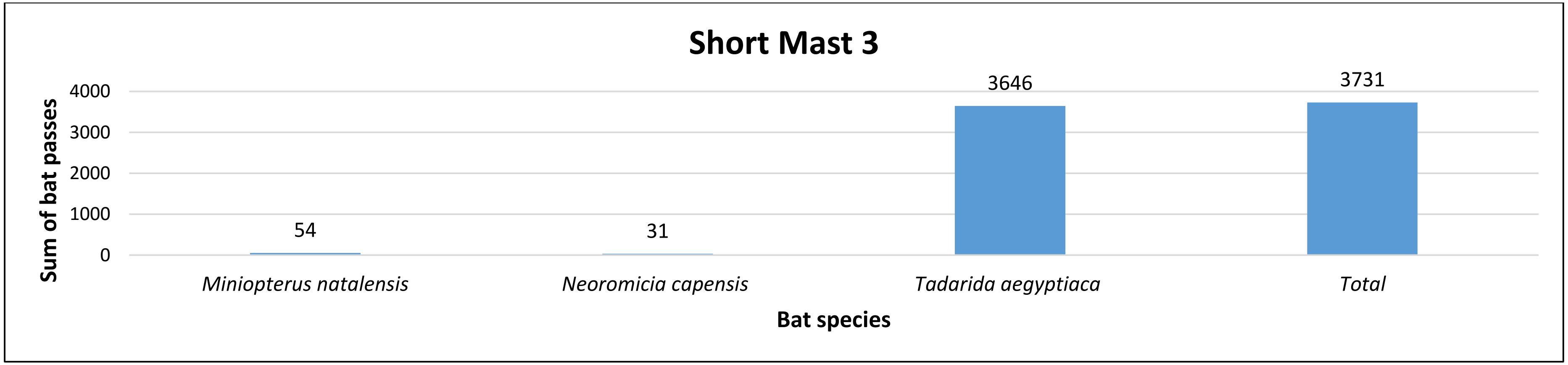


Figure 17: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 3.

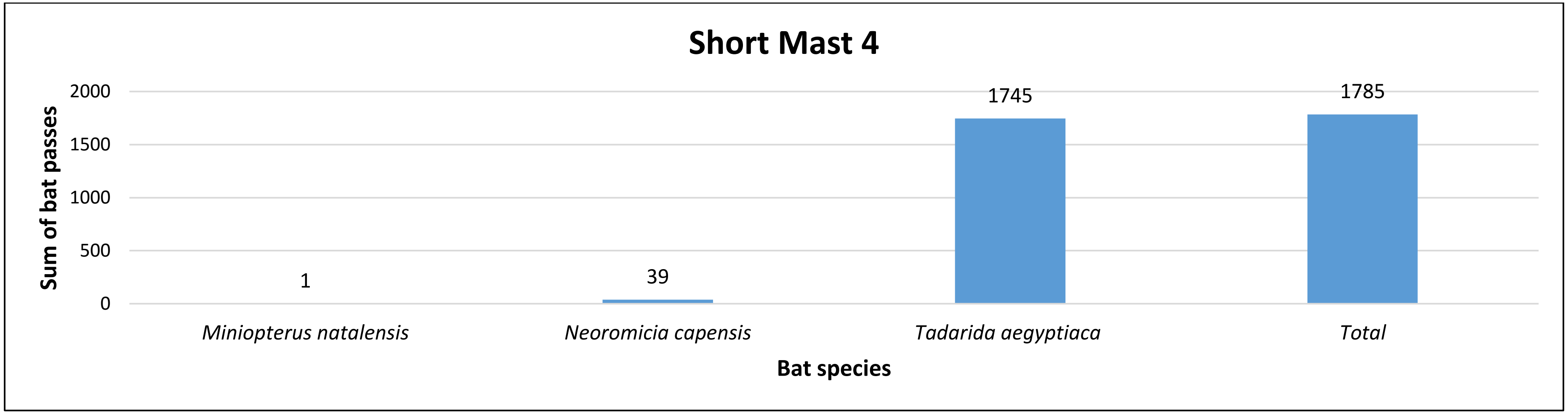


Figure 18: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 4.

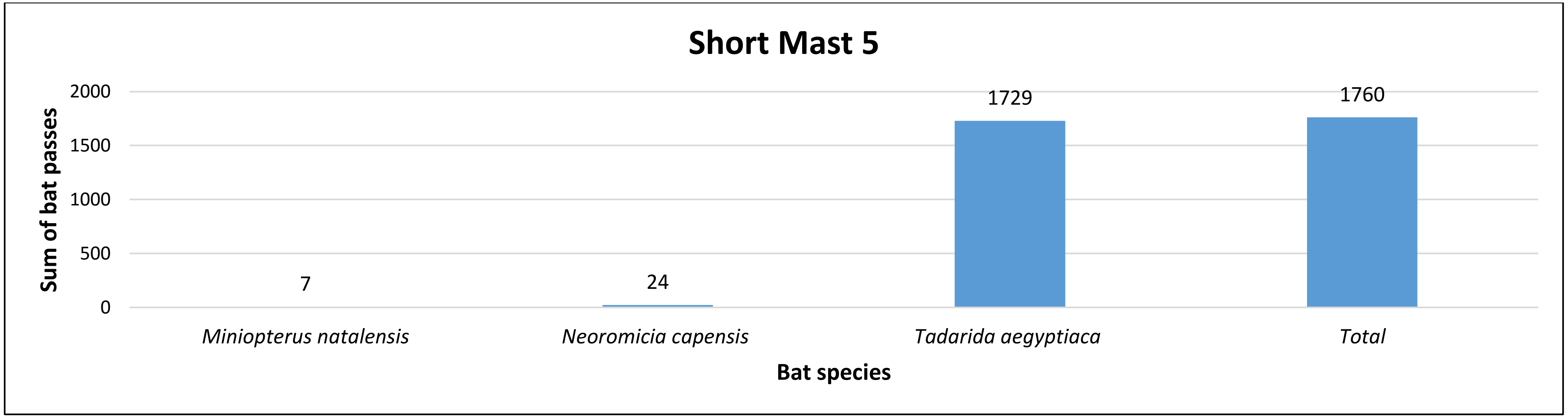


Figure 19: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 5.

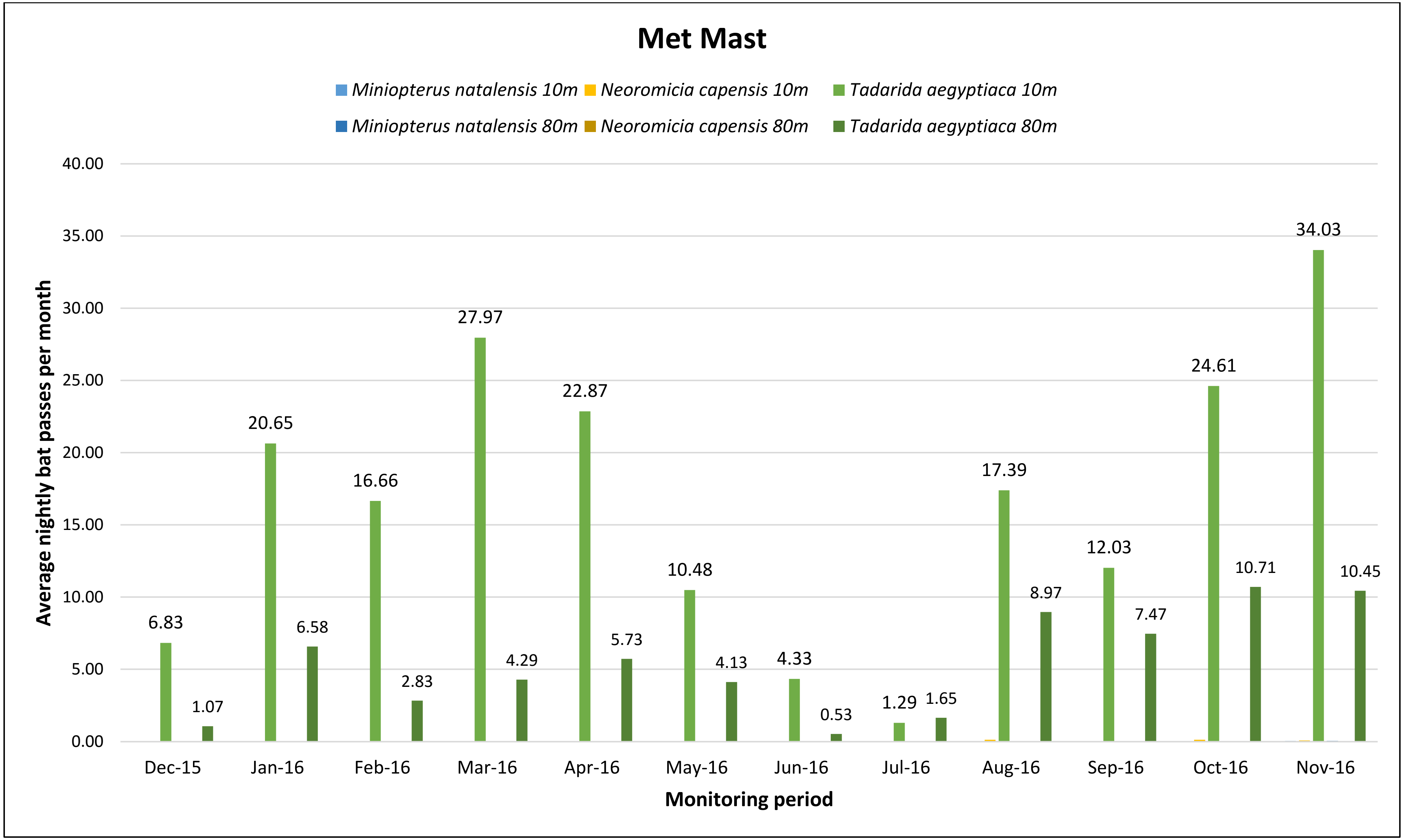


Figure 20: Average bat passes recorded per month by the detector mounted on the Met Mast.

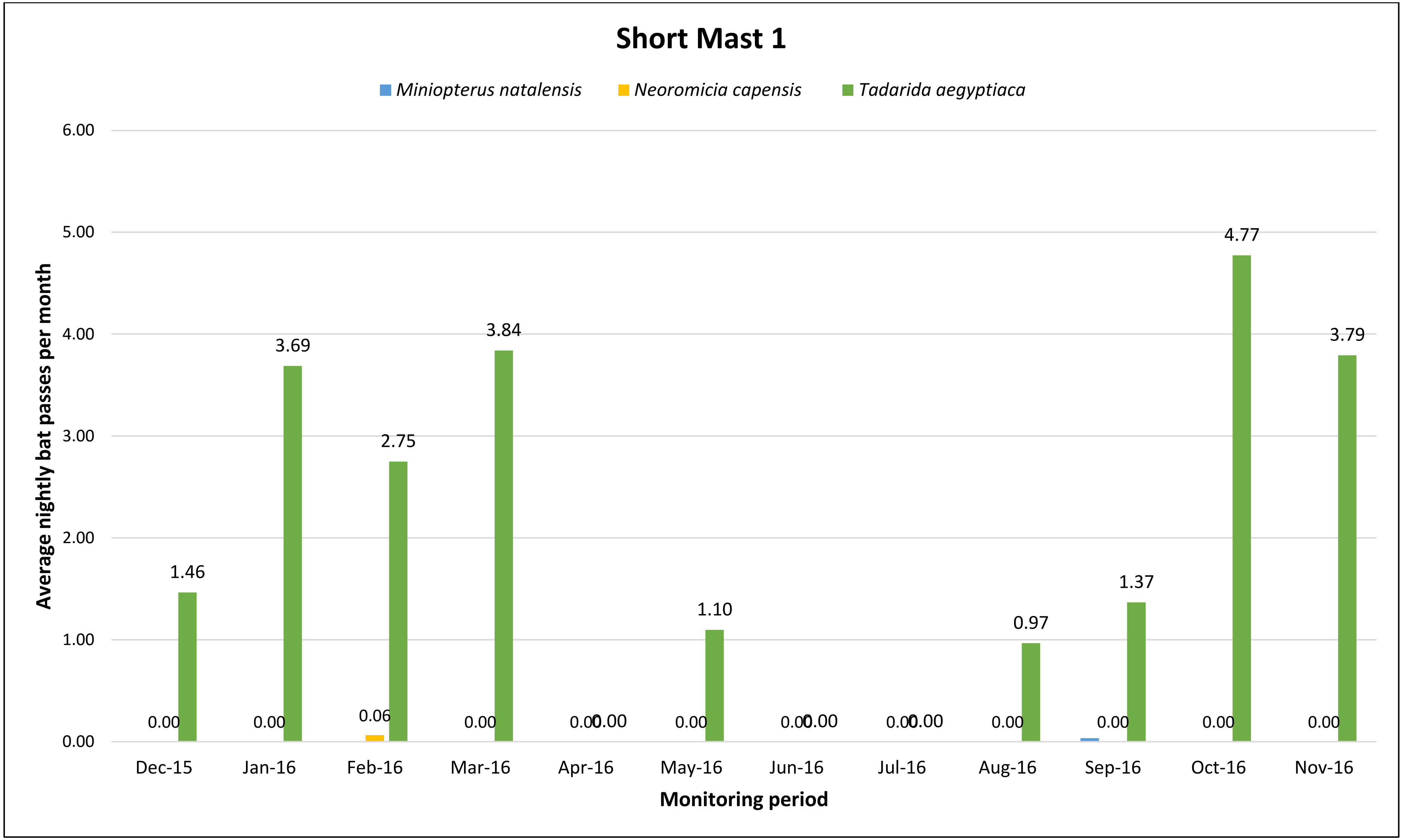


Figure 21: Average bat passes recorded per month by the detector mounted on Short Mast 1.

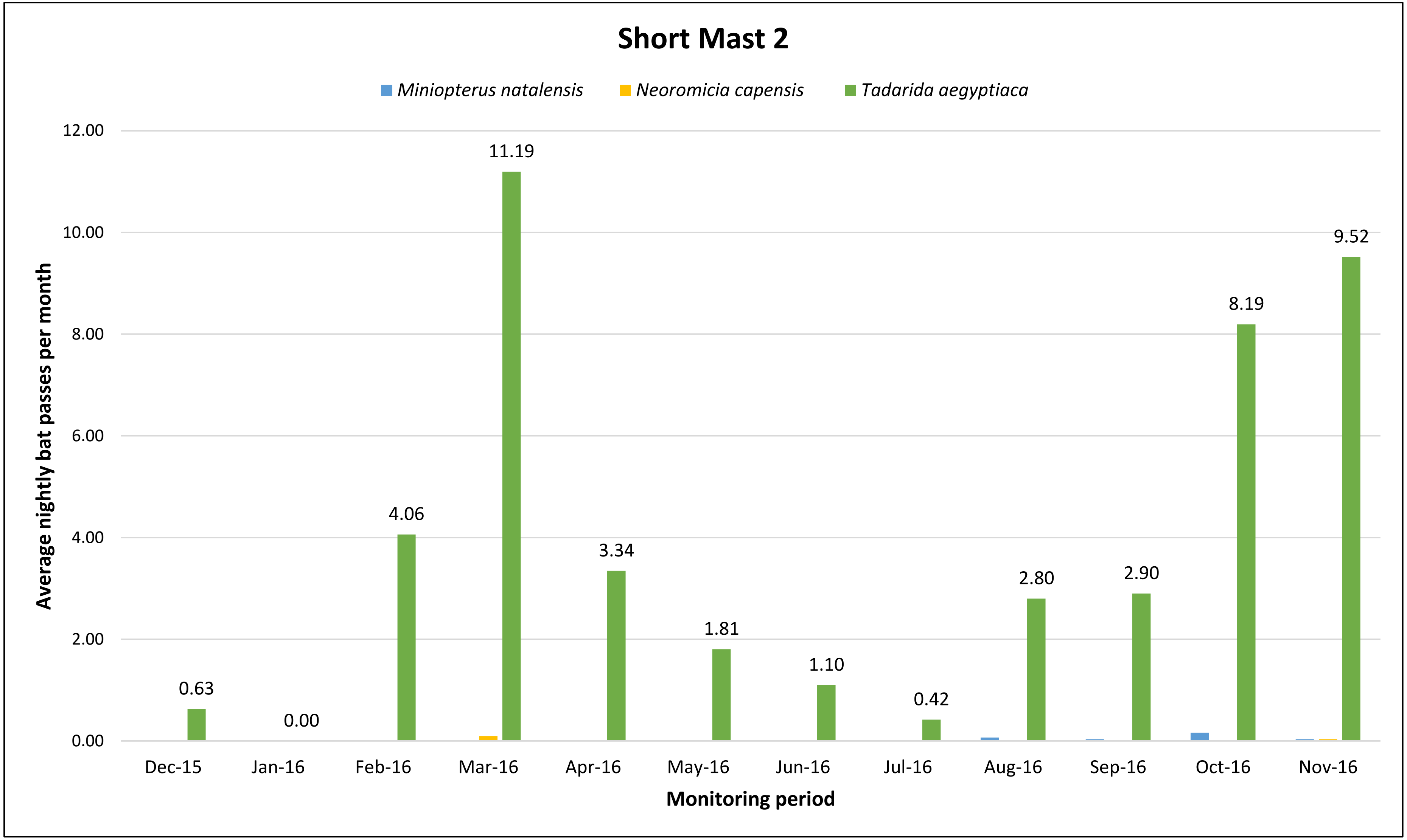


Figure 22: Average bat passes recorded per month by the detector mounted on Short Mast 2.

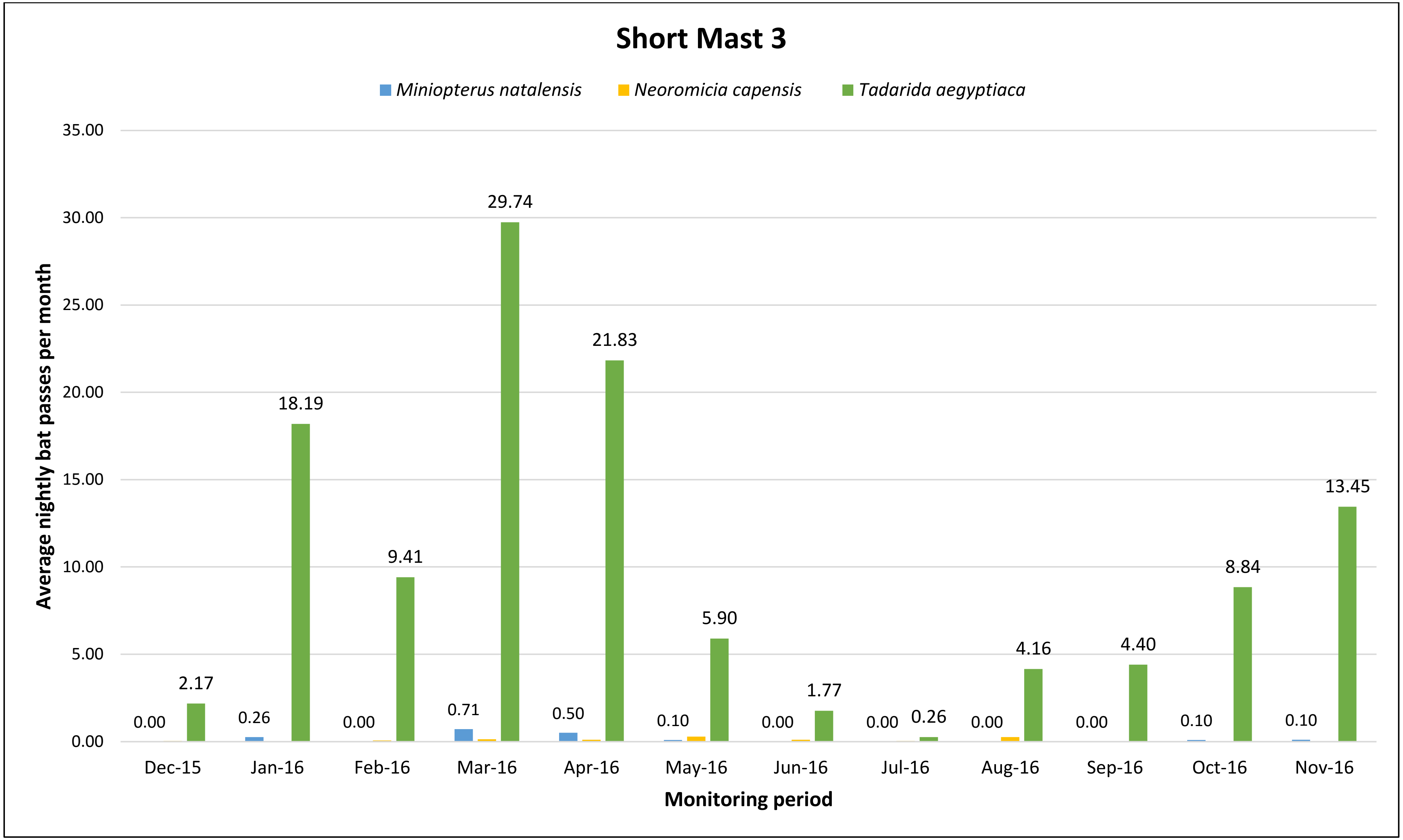


Figure 23: Average bat passes recorded per month by the detector mounted on Short Mast 3.

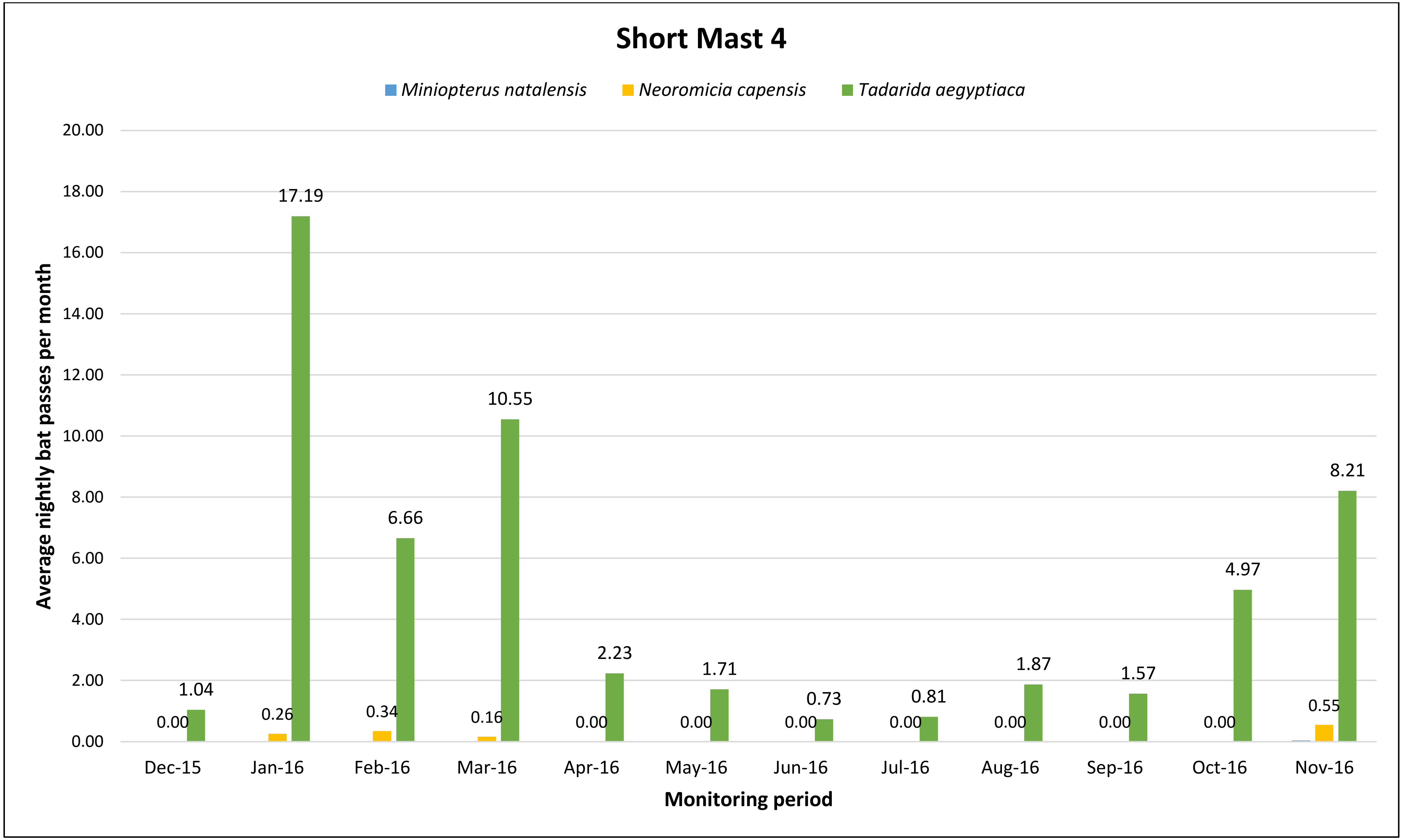


Figure 24: Average bat passes recorded per month by the detector mounted on Short Mast 4.

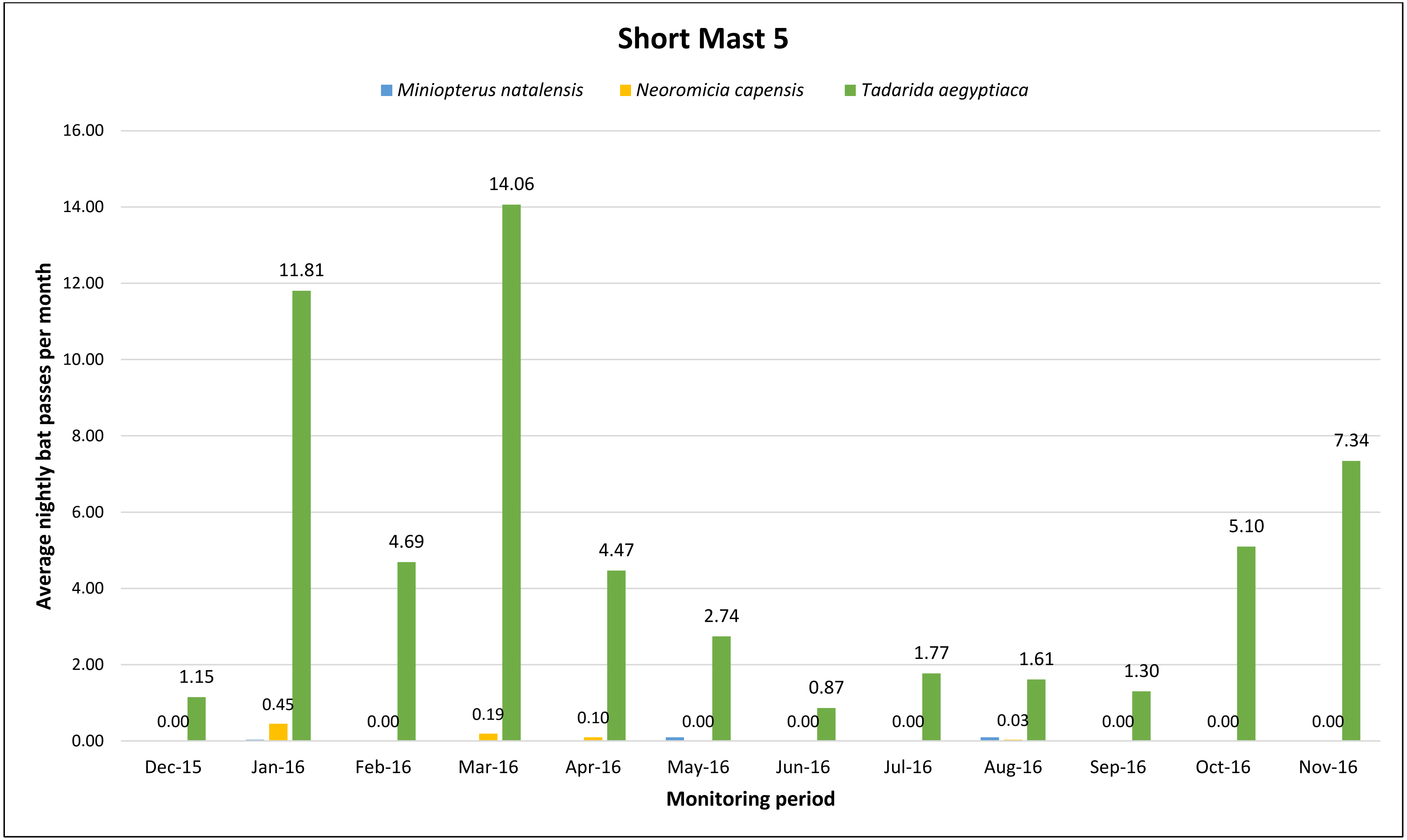


Figure 25: Average bat passes recorded per month by the detector mounted on Short Mast 5.

4.6.2 Temporal Distribution

The sum of all bat passes recorded by the monitoring systems of the particular species are displayed per night over the entire monitoring period (**Figures 26 - 31**). The peak activity times identified are mostly of the temporal distribution of *Tadarida aegyptiaca* as they were the species detected more often by a substantial margin. This data is used to inform the peak times that may inform mitigation, if needed.

The periods of elevated bat activity as depicted in **Figures 26 - 31** are as follows:

Met Mast

- Mid to late January 2016
- Early February to early April 2016
- Mid-April 2016
- Early May to early June 2016
- End August to end November 2016 **(Highest peak occurred in August 2016)**

Short Mast 1

- End December 2015 to early January 2016 **(Highest peak occurred in January 2016)**
- End February to end March 2016
- Mid-September to end November 2016

Short Mast 2

- Mid-February to late March 2016
- Early April to end March 2016
- End August 2016
- End September to end November 2016 **(Highest peak occurred in November 2016)**

Short Mast 3

- End December 2015
- Mid-January to early February 2016 **(Highest peak occurred in January 2016)**
- Mid-February to mid-May 2016
- Mid-August 2016
- End August to early September 2016
- End September 2016
- Mid-October to end November 2016

Short Mast 4

- Mid to end January 2016 **(Highest peak occurred in January 2016)**
- Mid-February to end March 2016
- End August 2016
- Mid-October to end November 2016

Short Mast 5

- Mid to end January 2016 **(Highest peak occurred in January 2016)**
- Mid-February to mid-April 2016
- Early to end May 2016
- Mid-July 2016
- End August to end November 2016

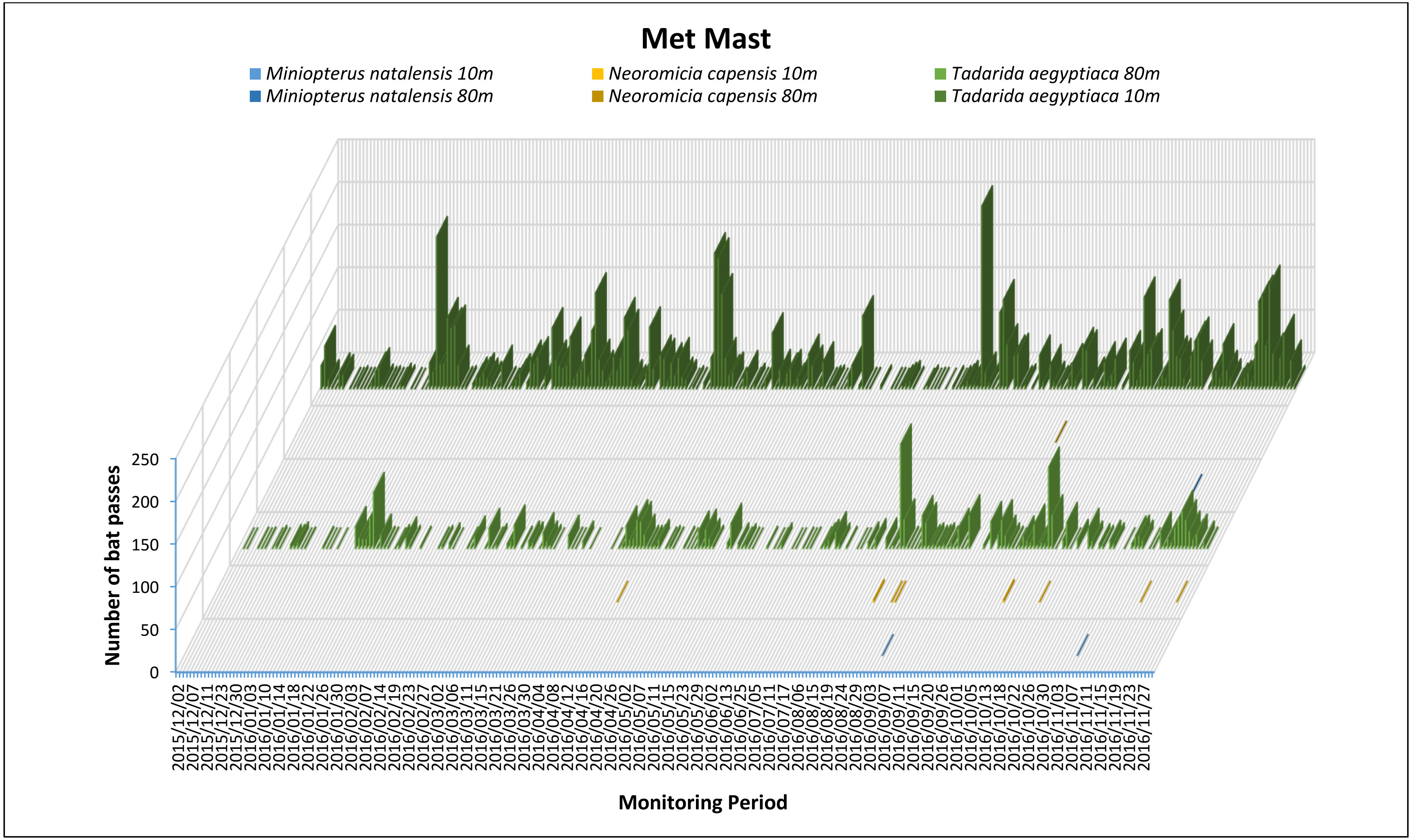


Figure 26: Temporal distribution of bats detected by the Met Mast.

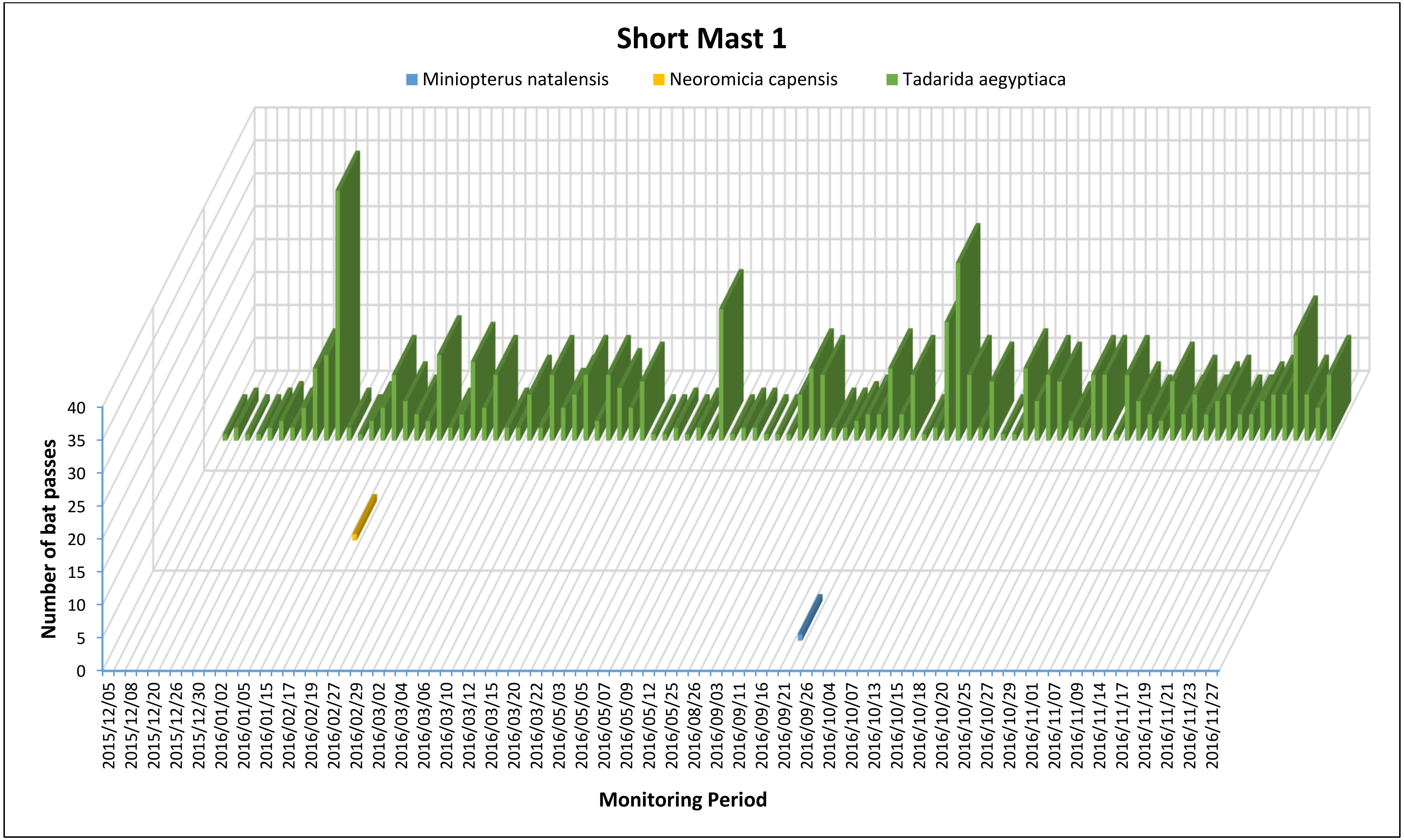


Figure 27: Temporal distribution of bats detected by Short Mast 1.

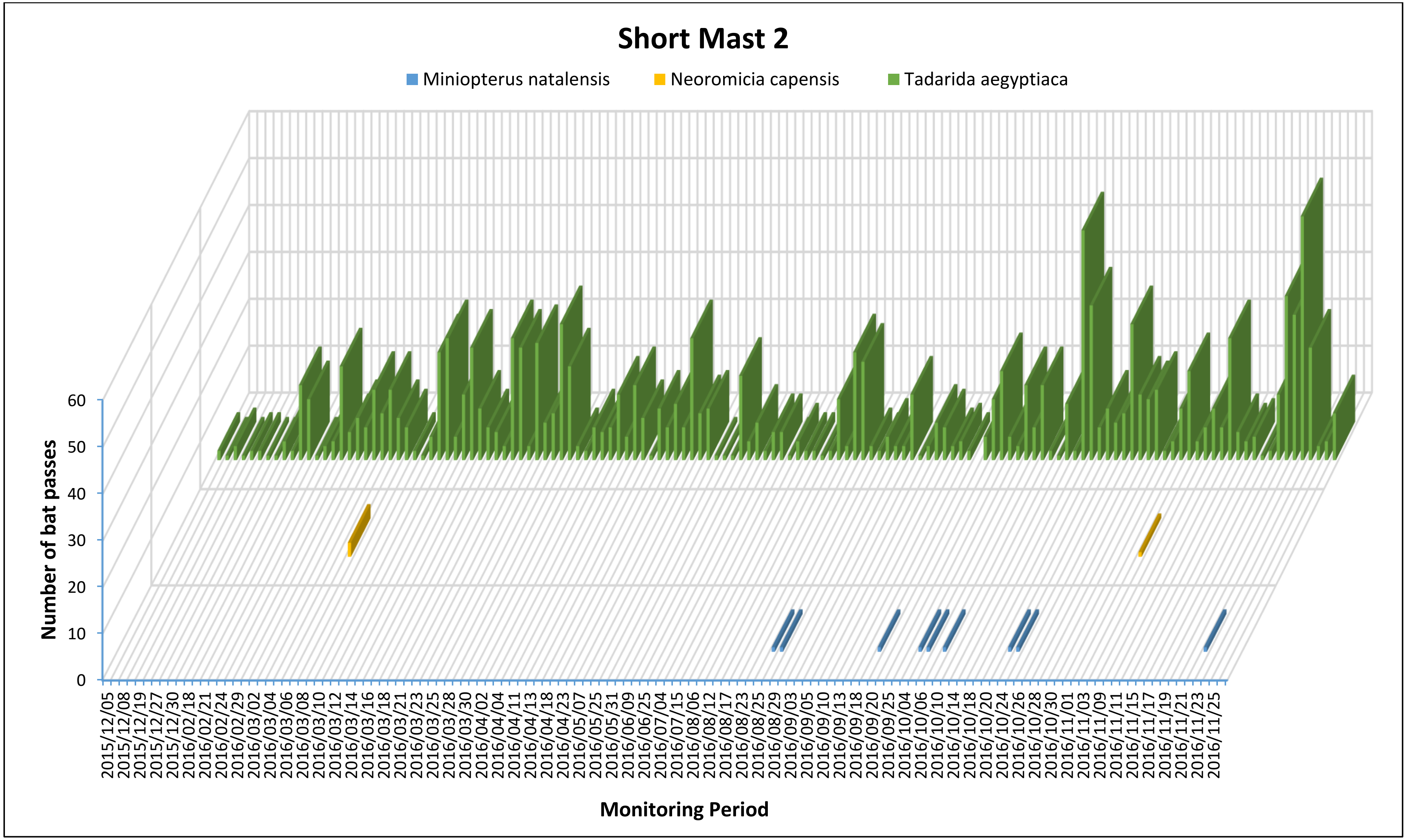


Figure 28: Temporal distribution of bats detected by Short Mast 2.

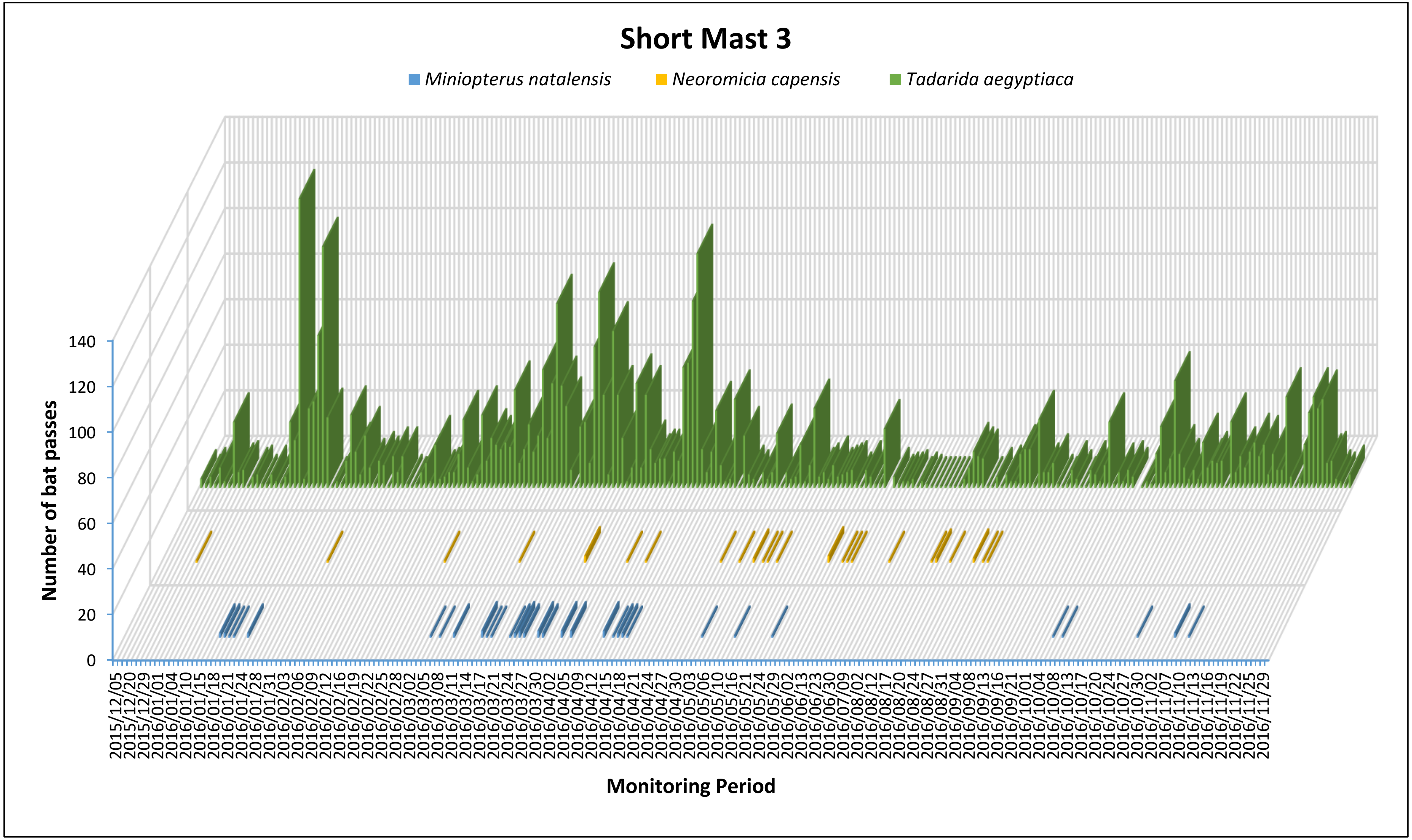


Figure 29: Temporal distribution of bats detected by Short Mast 3.

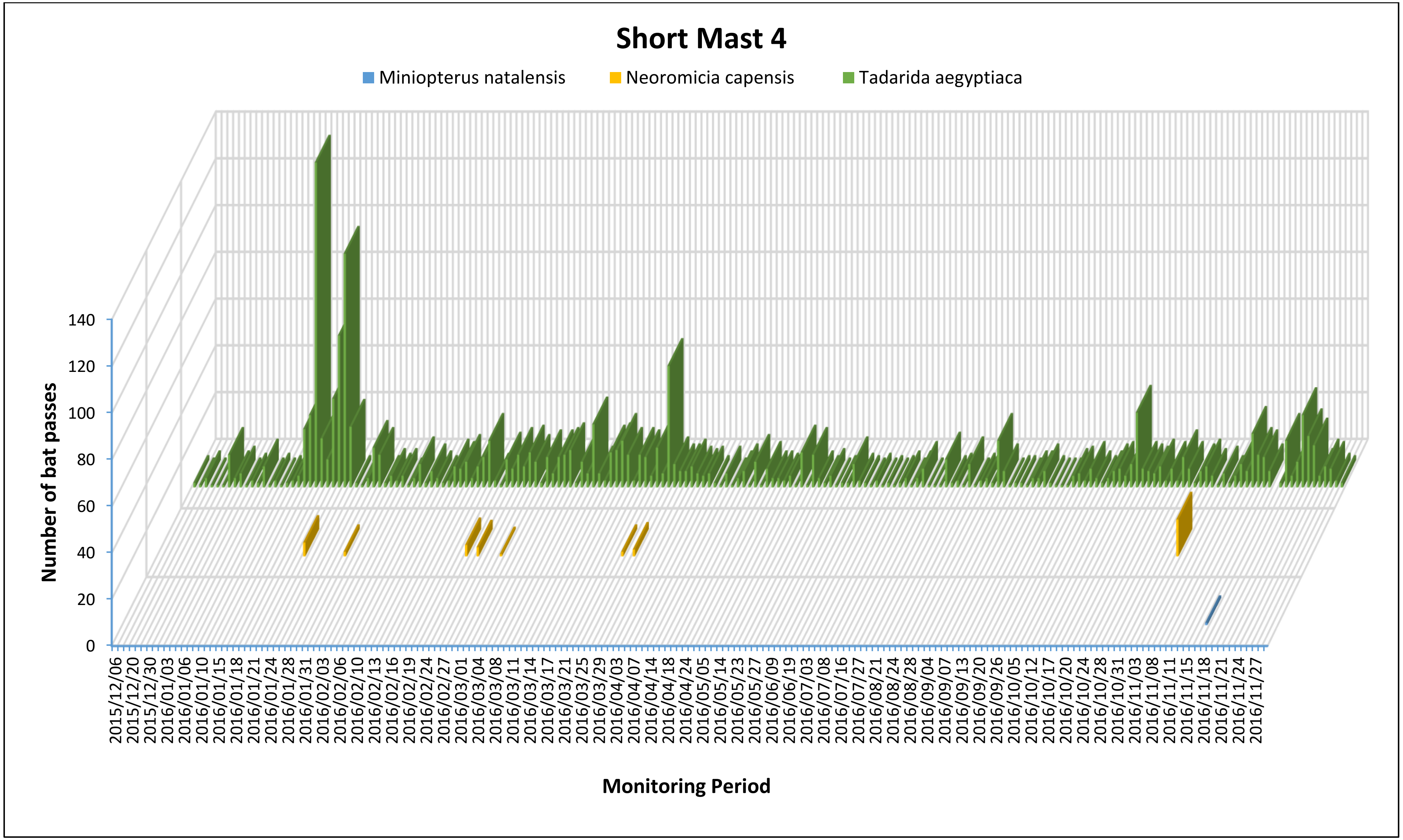


Figure 30: Temporal distribution of bats detected by Short Mast 4.

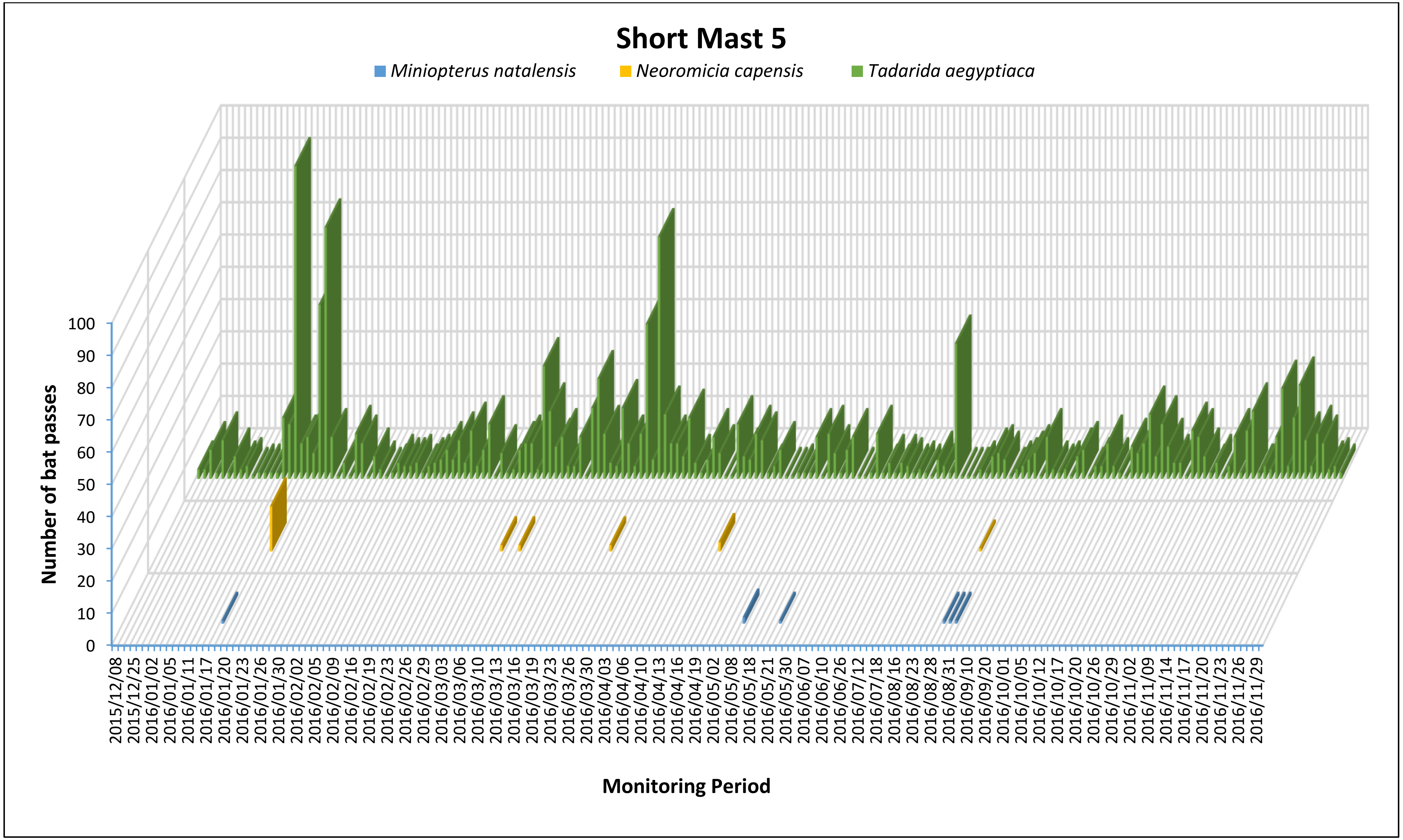


Figure 31: Temporal distribution of bats detected by Short Mast 5.

4.6.3 Distribution of bat activity across the night per season

The distribution of bat activity across the night, per season, has been analysed in this section **(Figure 32 – 55)**. The 12-month monitoring period was divided based on generic calendar seasons outlined **Table 10**.

Table 10: Time frame of each season

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

The number of bat passes per 10-minute interval over the seasonal monitoring periods were summed to generate the figures of bat activity over the time of night. Higher levels of activity indicate preference for activity over a particular period of the night. These periods will then be used to inform mitigation implementation when and where needed.

Once again, peak activity times are mostly an amalgamation of the activity of *Tadarida aegyptiaca* especially at 10m height. The figures show that there are seldom cases of other species being highly active in the absence of high activity levels of this abundant species.

Miniopterus natalensis was active during spring near all the monitoring systems, except for short mast 5. They were also active during winter near short mast 2, and during winter, summer and autumn near short mast 5. Short Mast 3 had higher amount of activity of *Miniopterus natalensis* during summer, which increased into autumn (**Figure 32 - 55**).

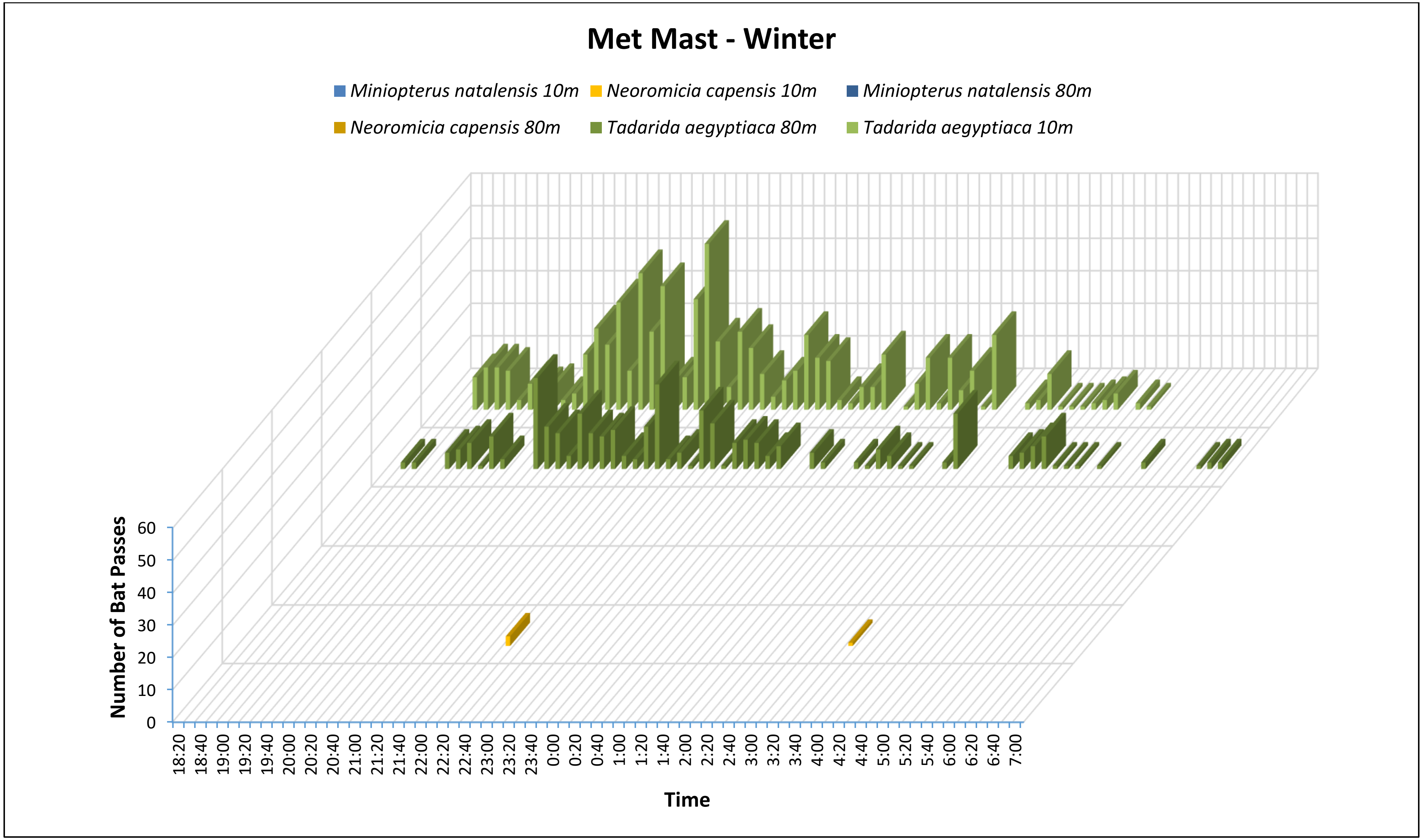


Figure 32: Temporal distribution of activity across the night as detected by Met Mast in winter.

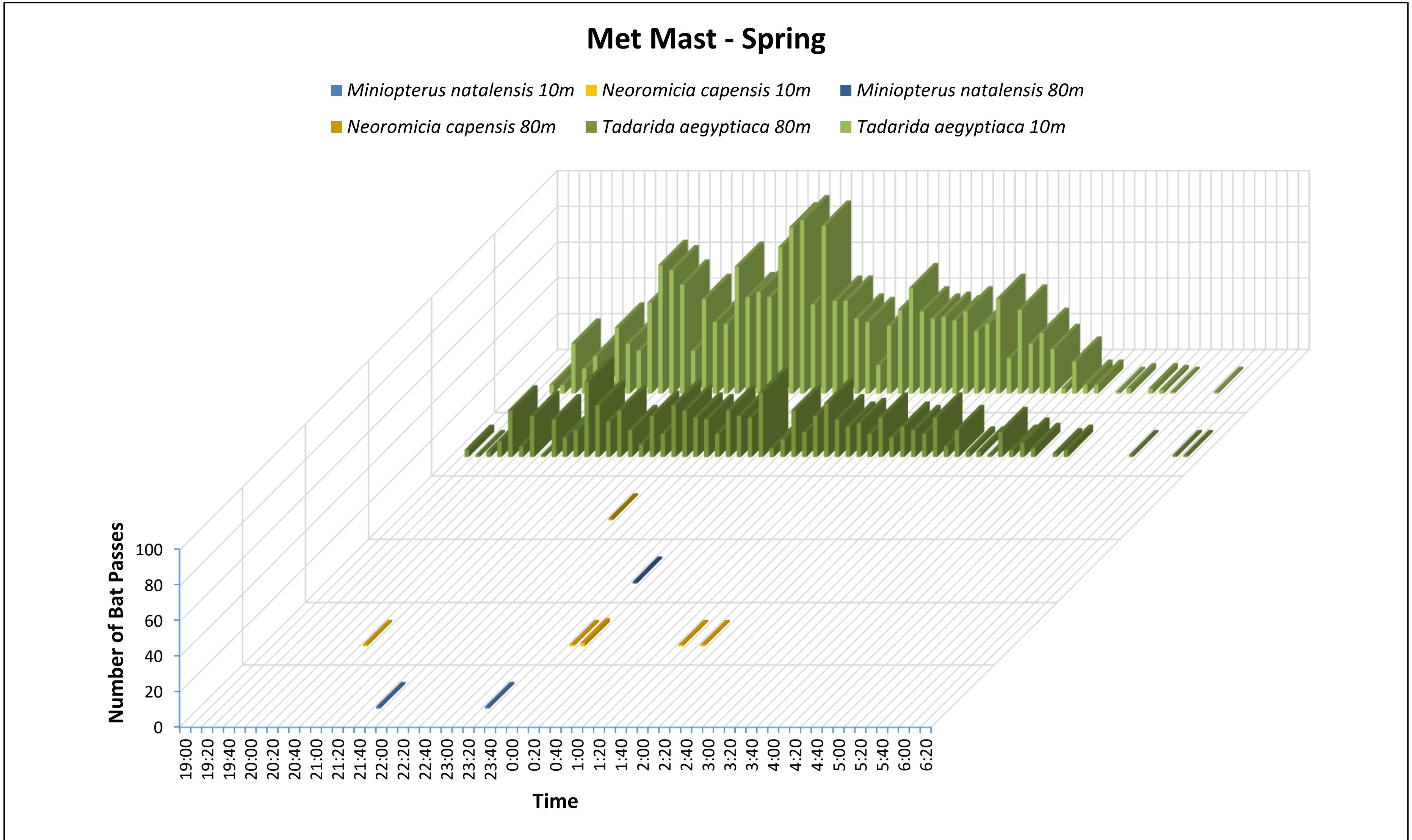


Figure 33: Temporal distribution of activity across the night as detected by Met Mast in spring.

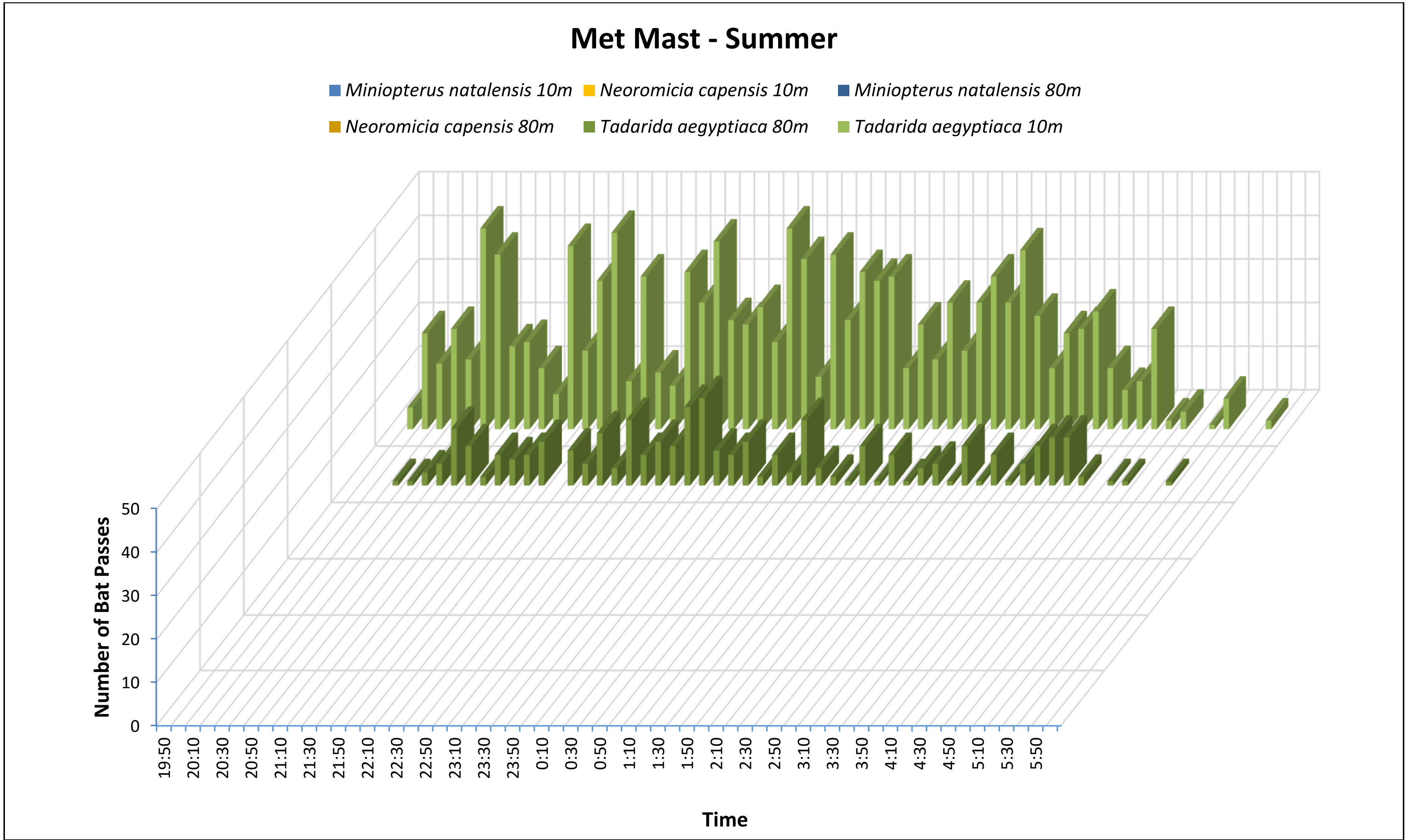


Figure 34: Temporal distribution of activity across the night as detected by Met Mast in summer.

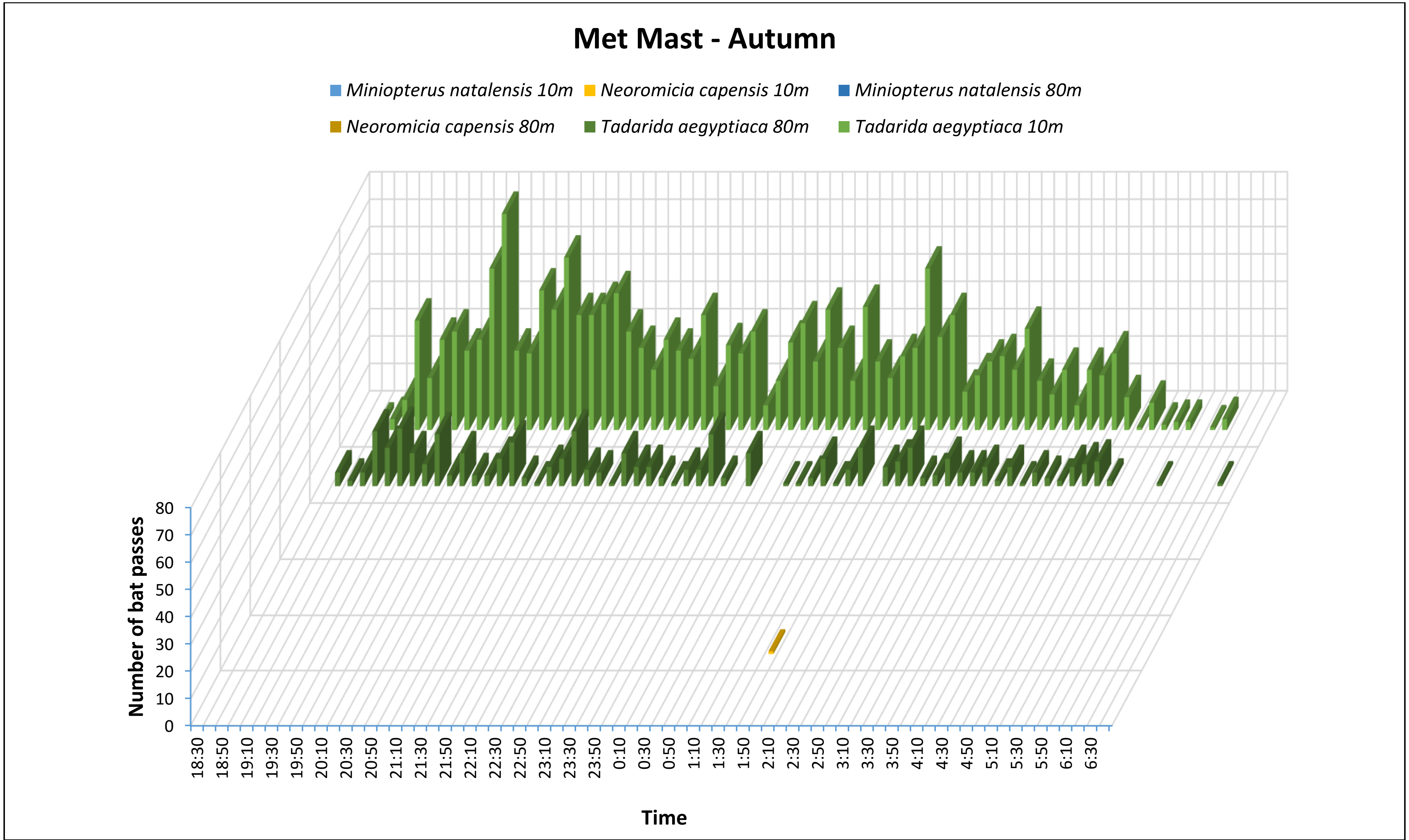


Figure 35: Temporal distribution of activity across the night as detected by Met Mast in autumn.

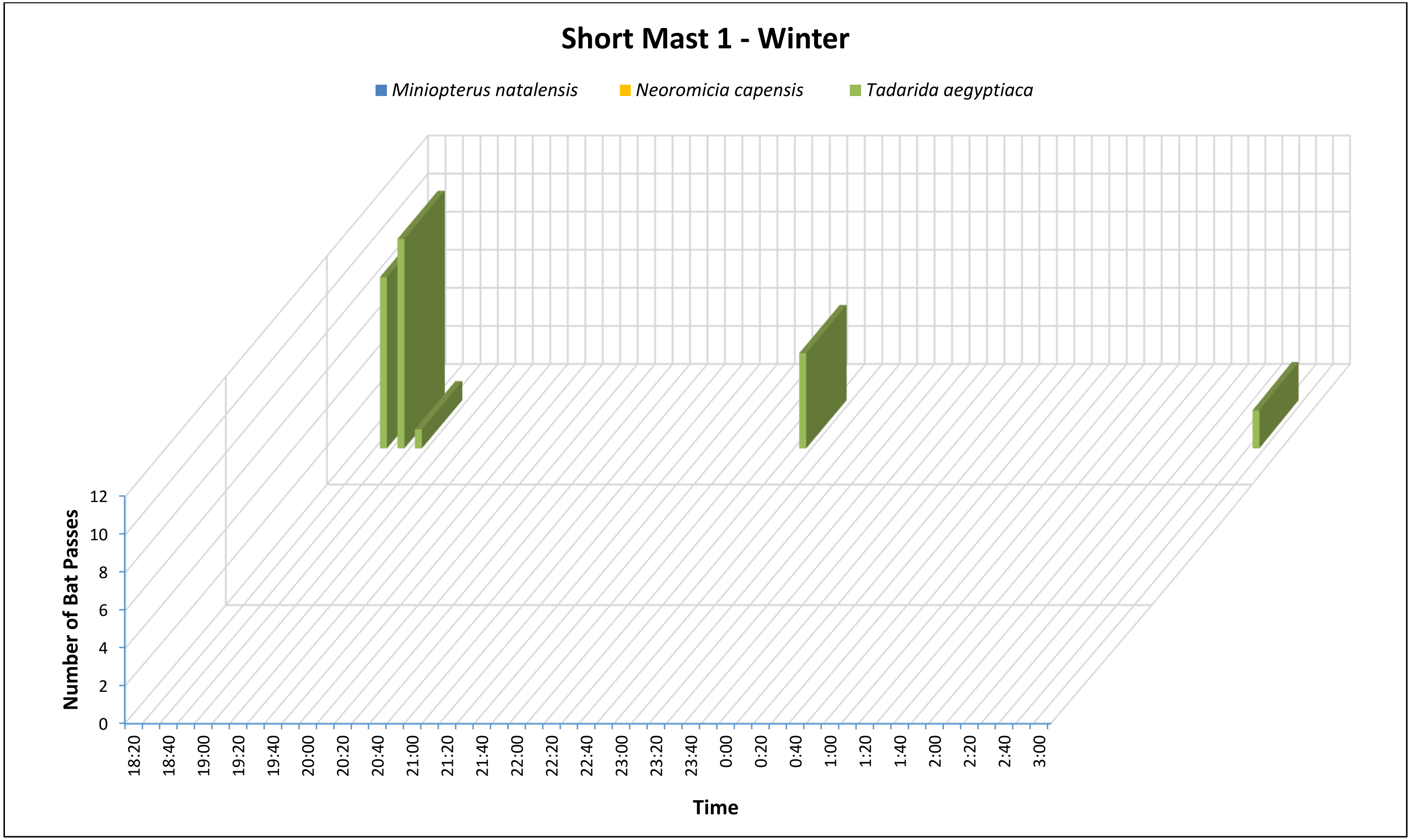


Figure 36: Temporal distribution of activity across the night as detected by Short Mast 1 in winter.

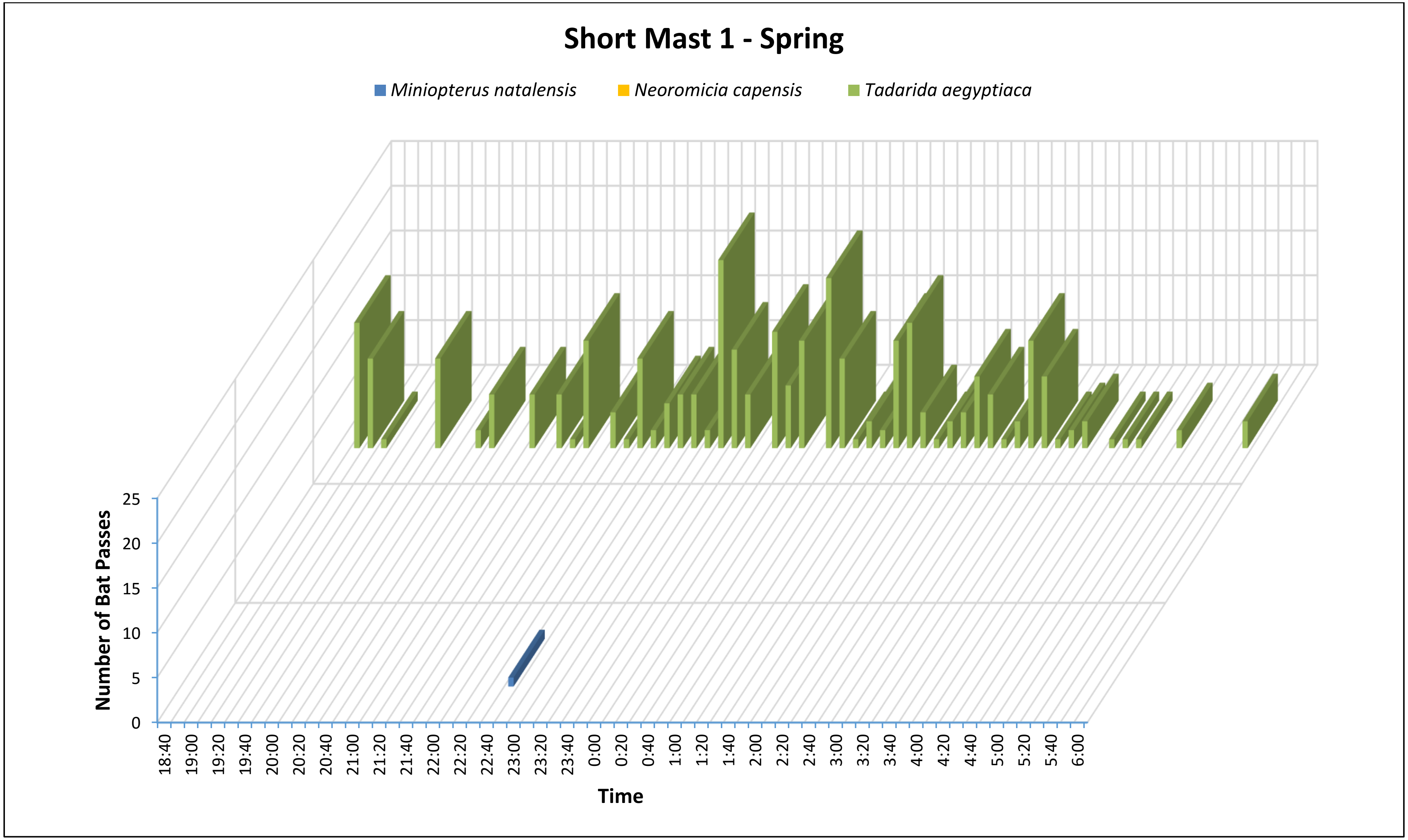


Figure 37: Temporal distribution of activity across the night as detected by Short Mast 1 in spring.

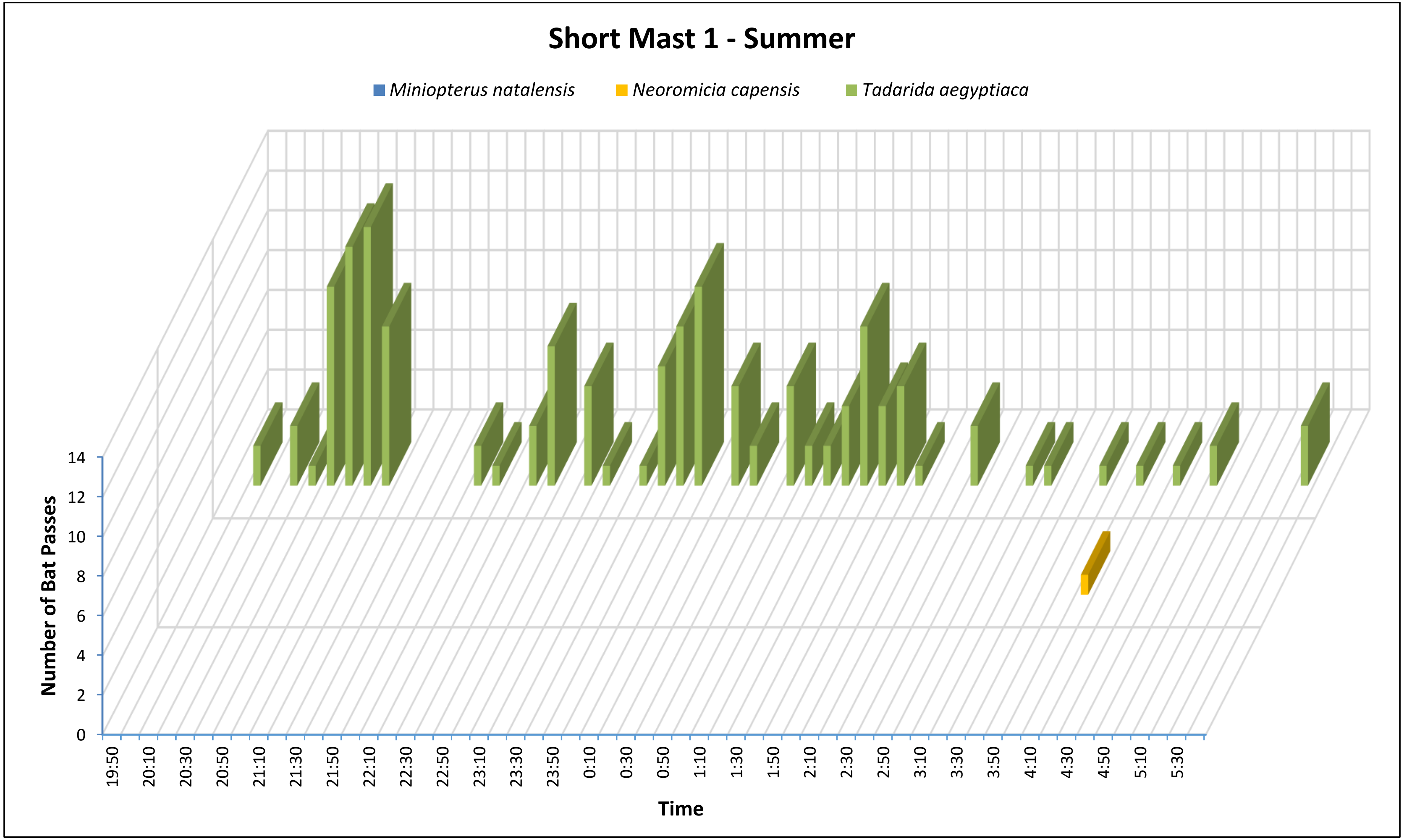


Figure 38: Temporal distribution of activity across the night as detected by Short Mast 1 in summer.

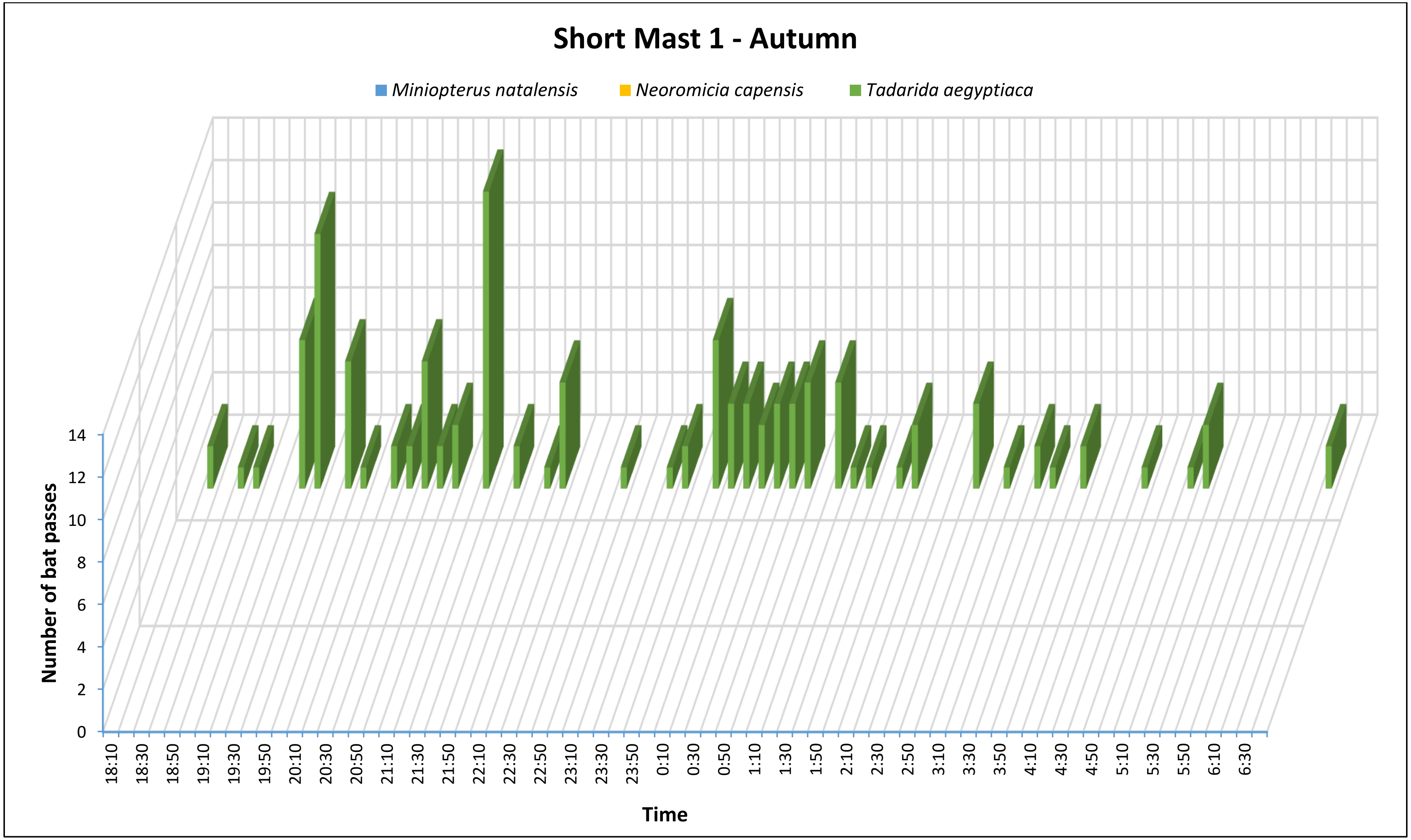


Figure 39: Temporal distribution of activity across the night as detected by Short Mast 1 in autumn.

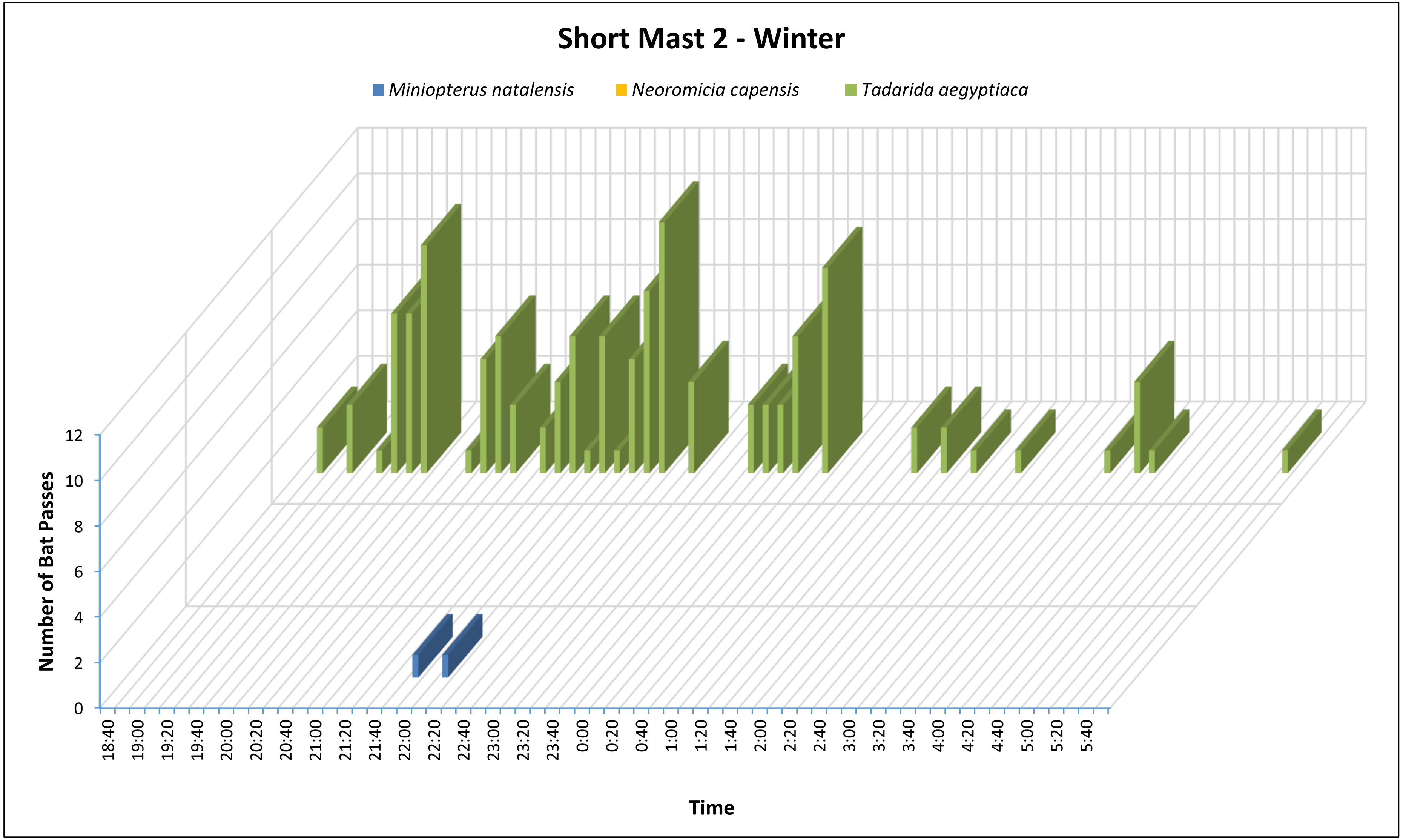


Figure 40: Temporal distribution of activity across the night as detected by Short Mast 2 in winter.

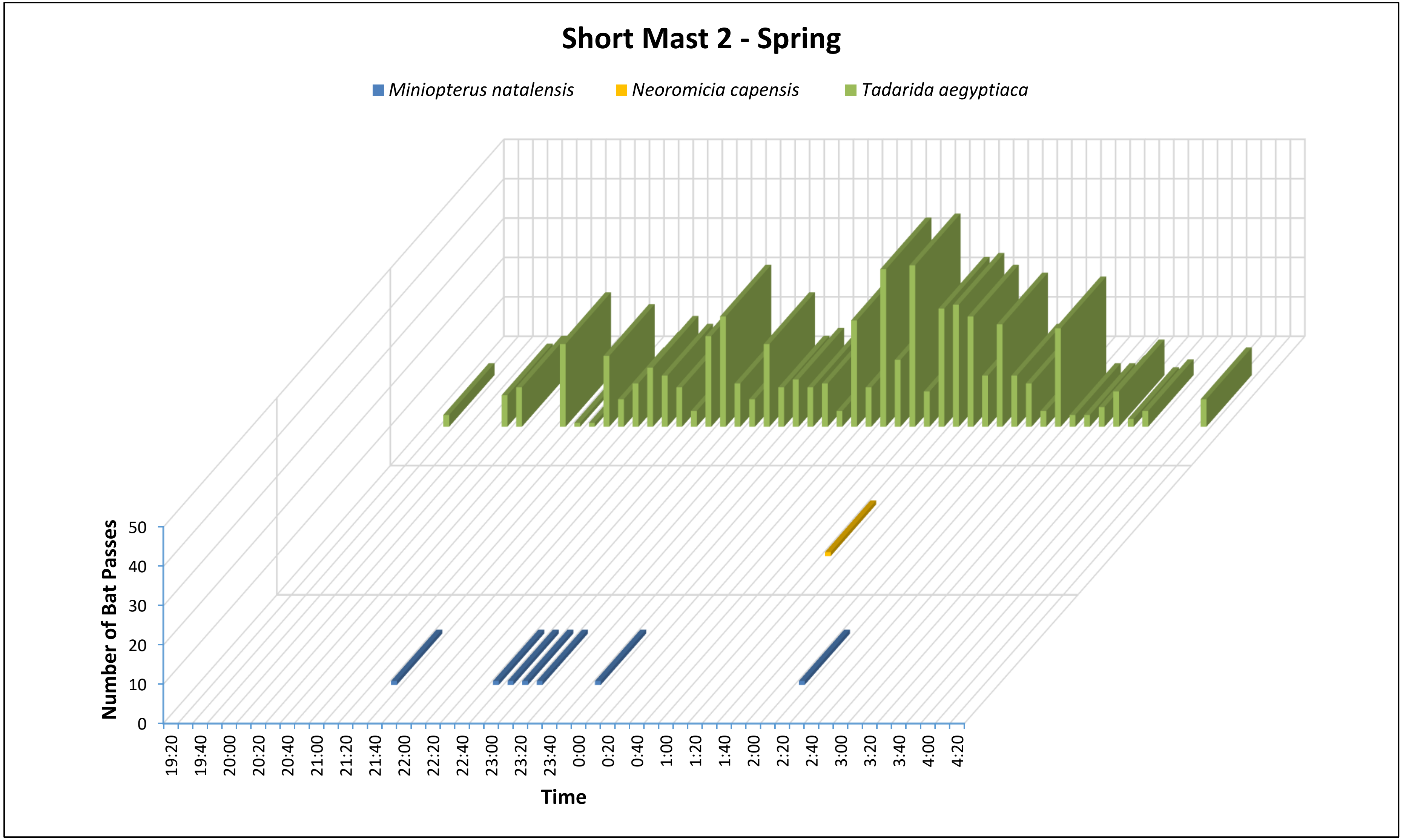


Figure 41: Temporal distribution of activity across the night as detected by Short Mast 2 in spring.

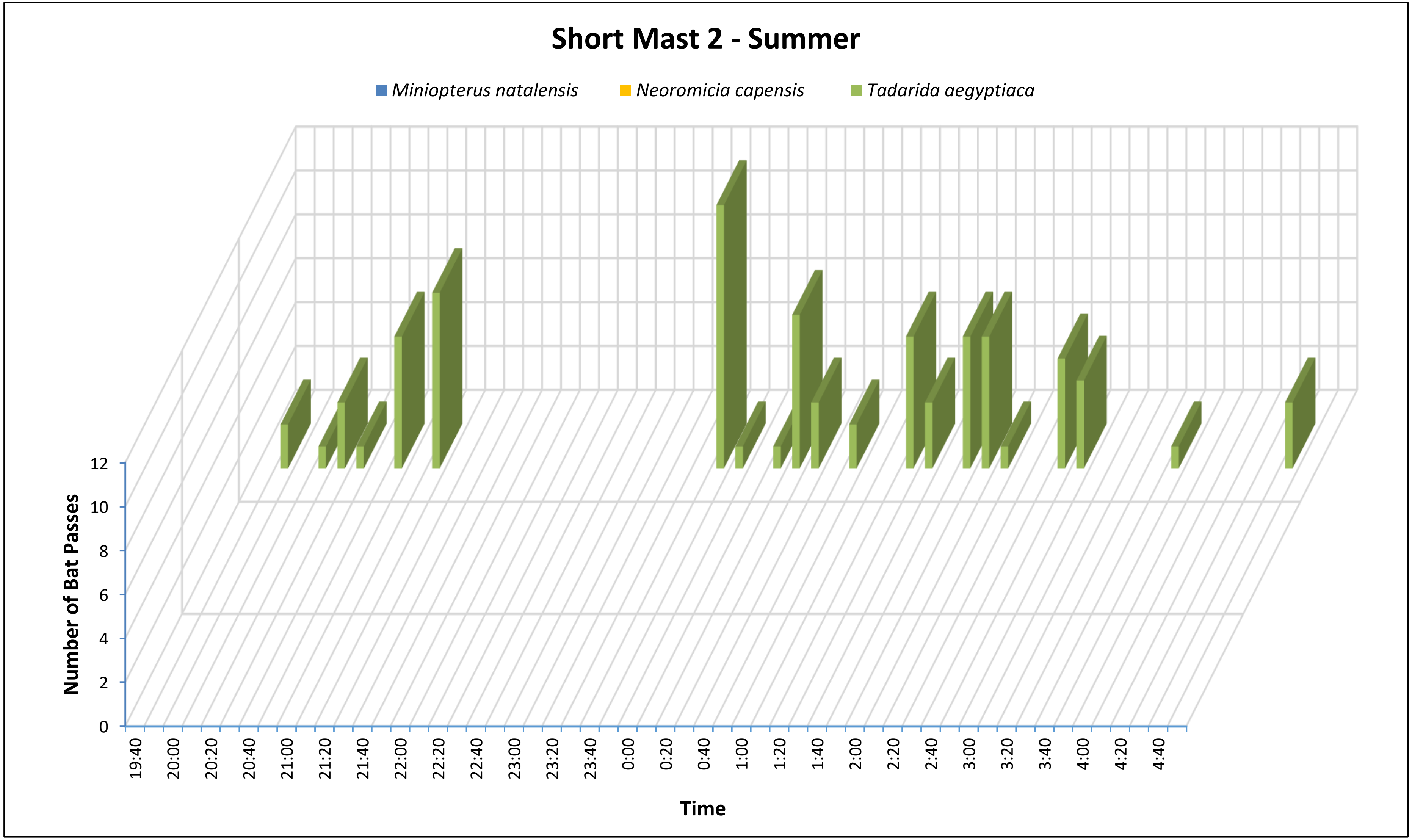


Figure 42: Temporal distribution of activity across the night as detected by Short Mast 2 in summer.

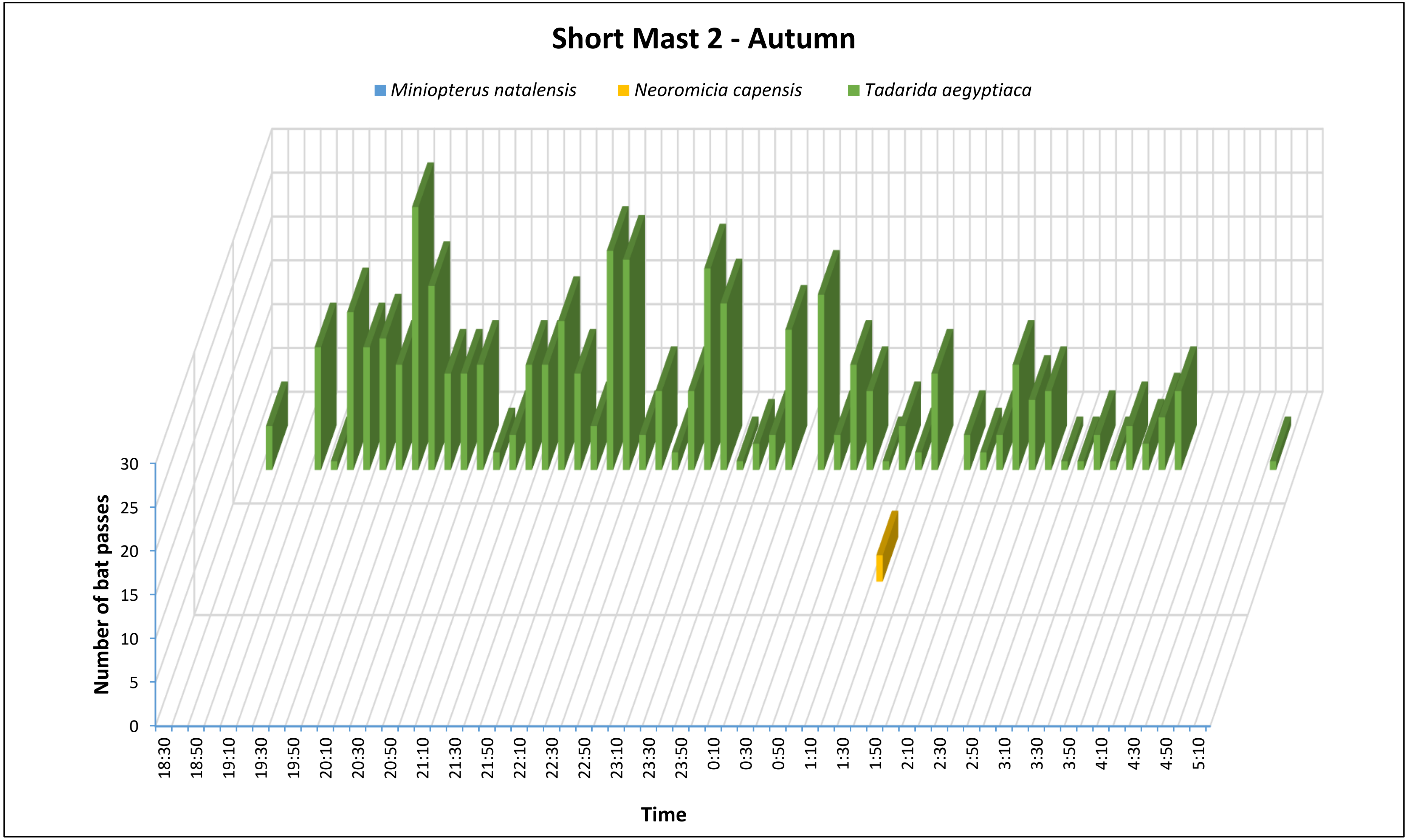


Figure 43: Temporal distribution of activity across the night as detected by Short Mast 2 in autumn.

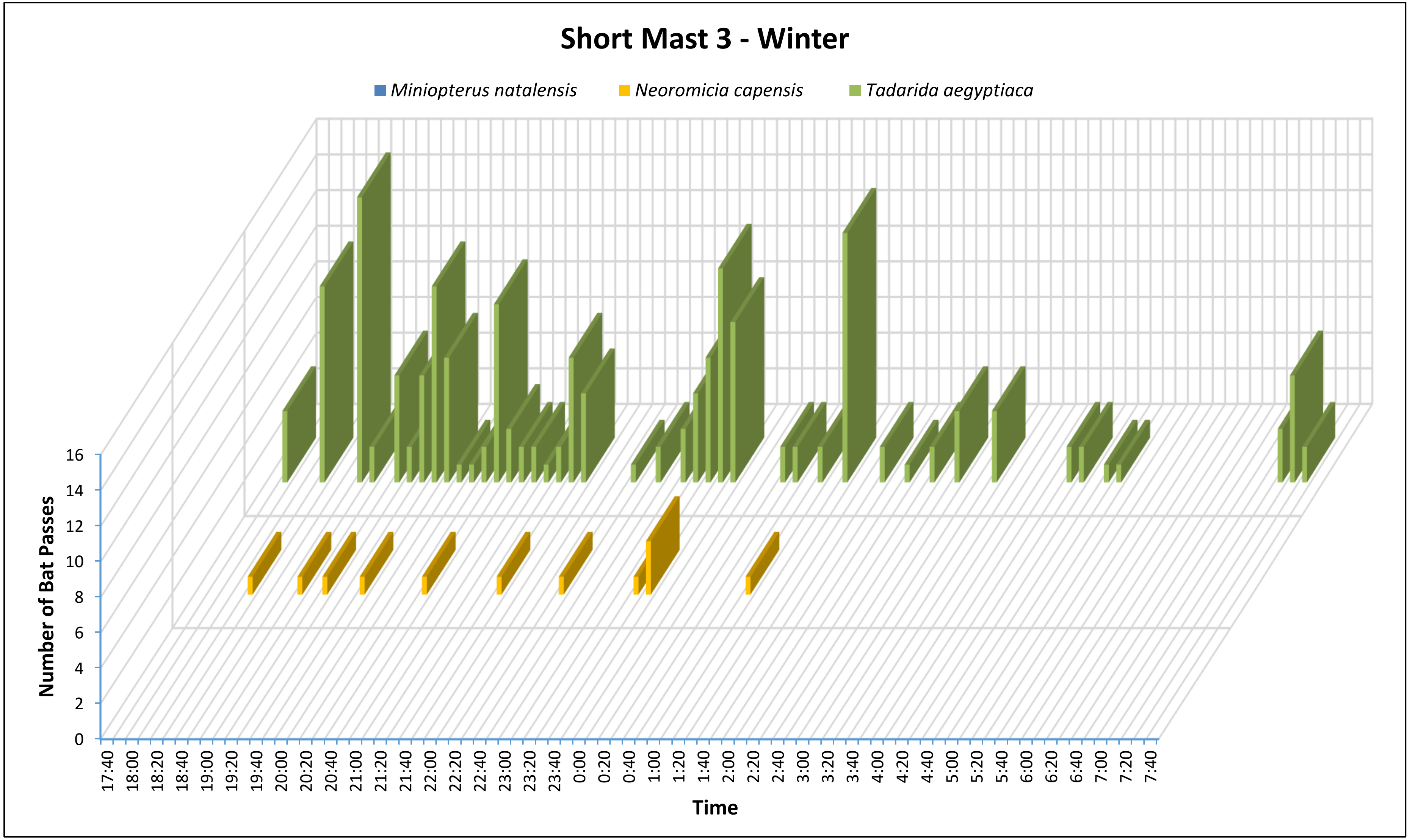


Figure 44: Temporal distribution of activity across the night as detected by Short Mast 3 in winter.

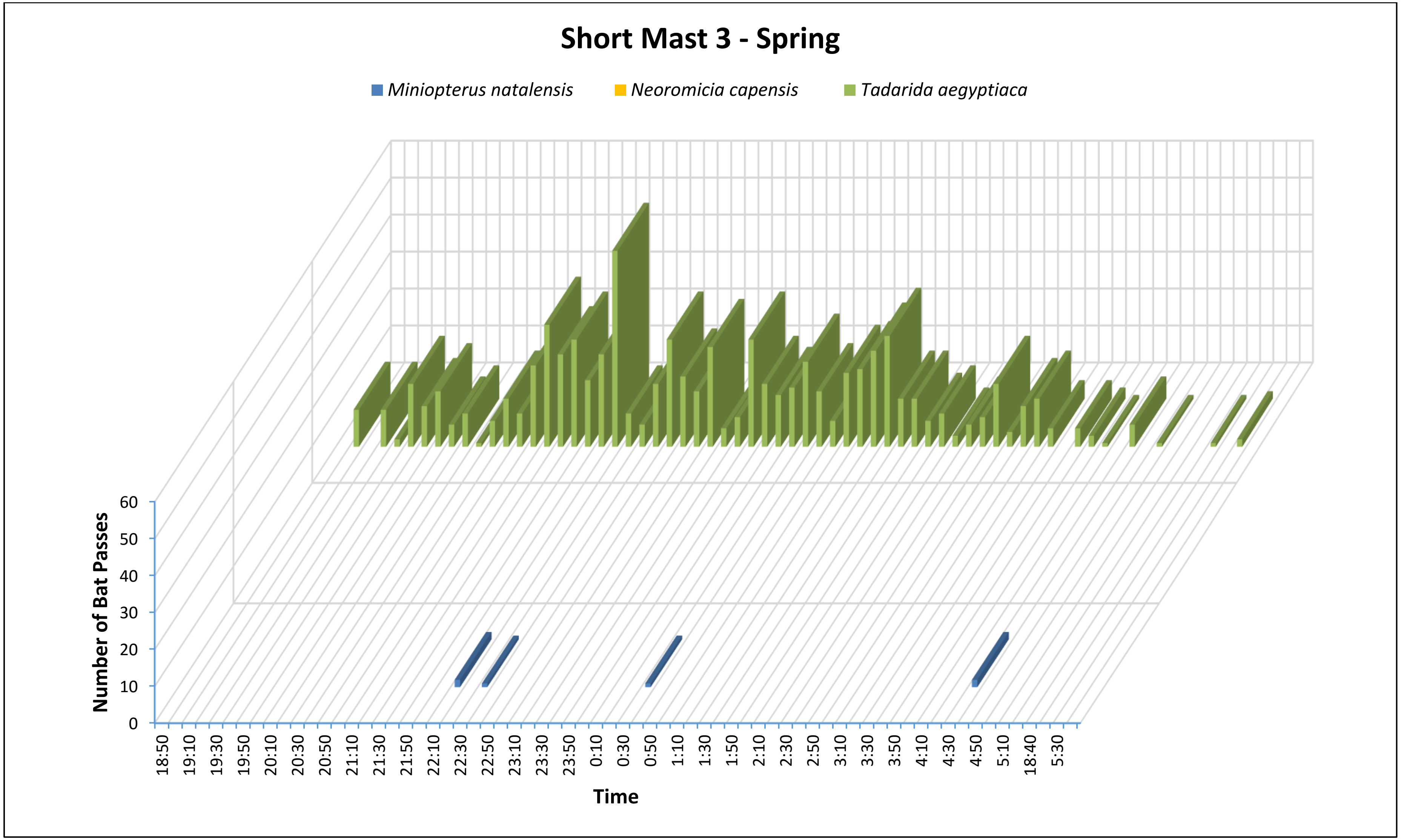


Figure 45: Temporal distribution of activity across the night as detected by Short Mast 3 in spring.

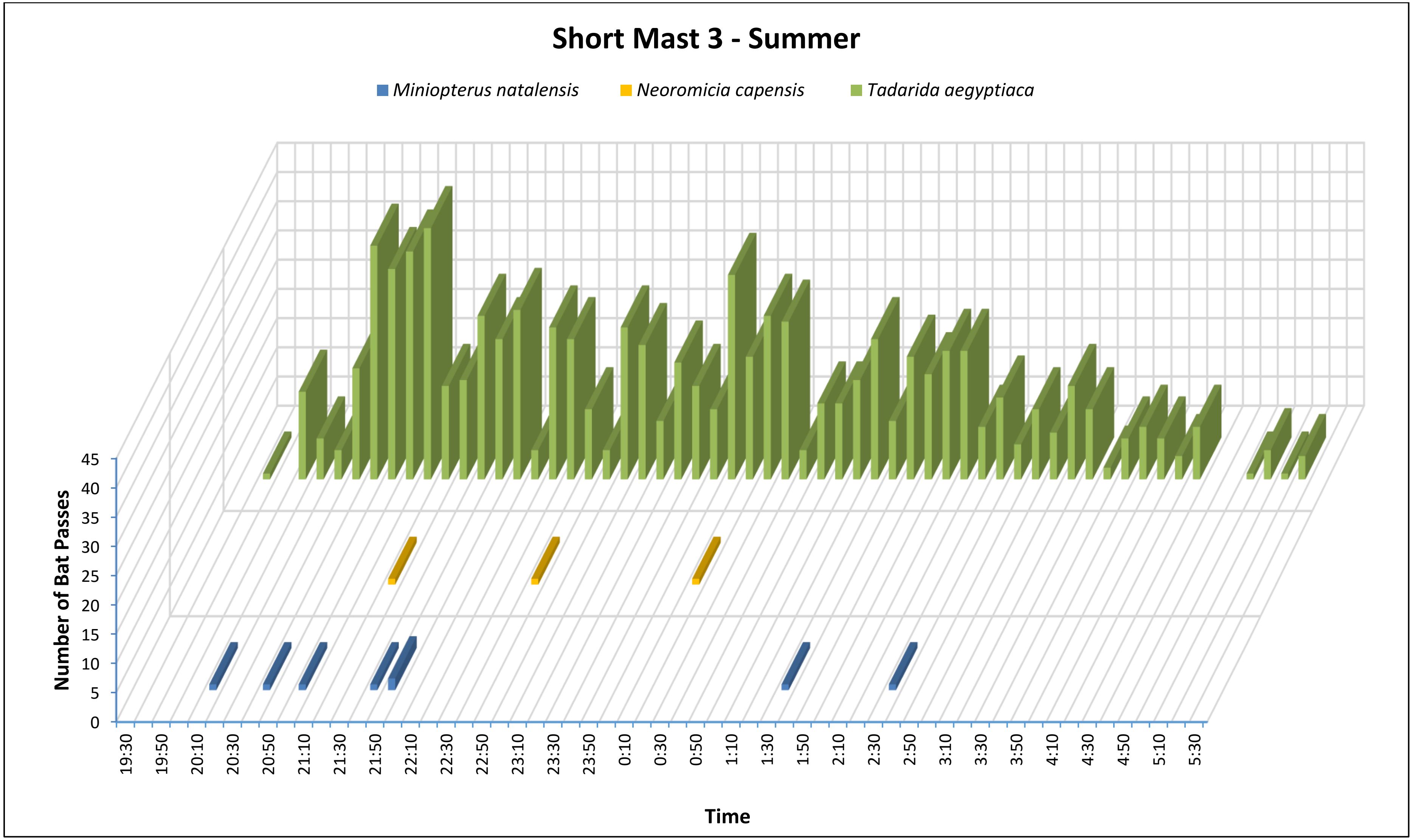


Figure 46: Temporal distribution of activity across the night as detected by Short Mast 3 in summer.

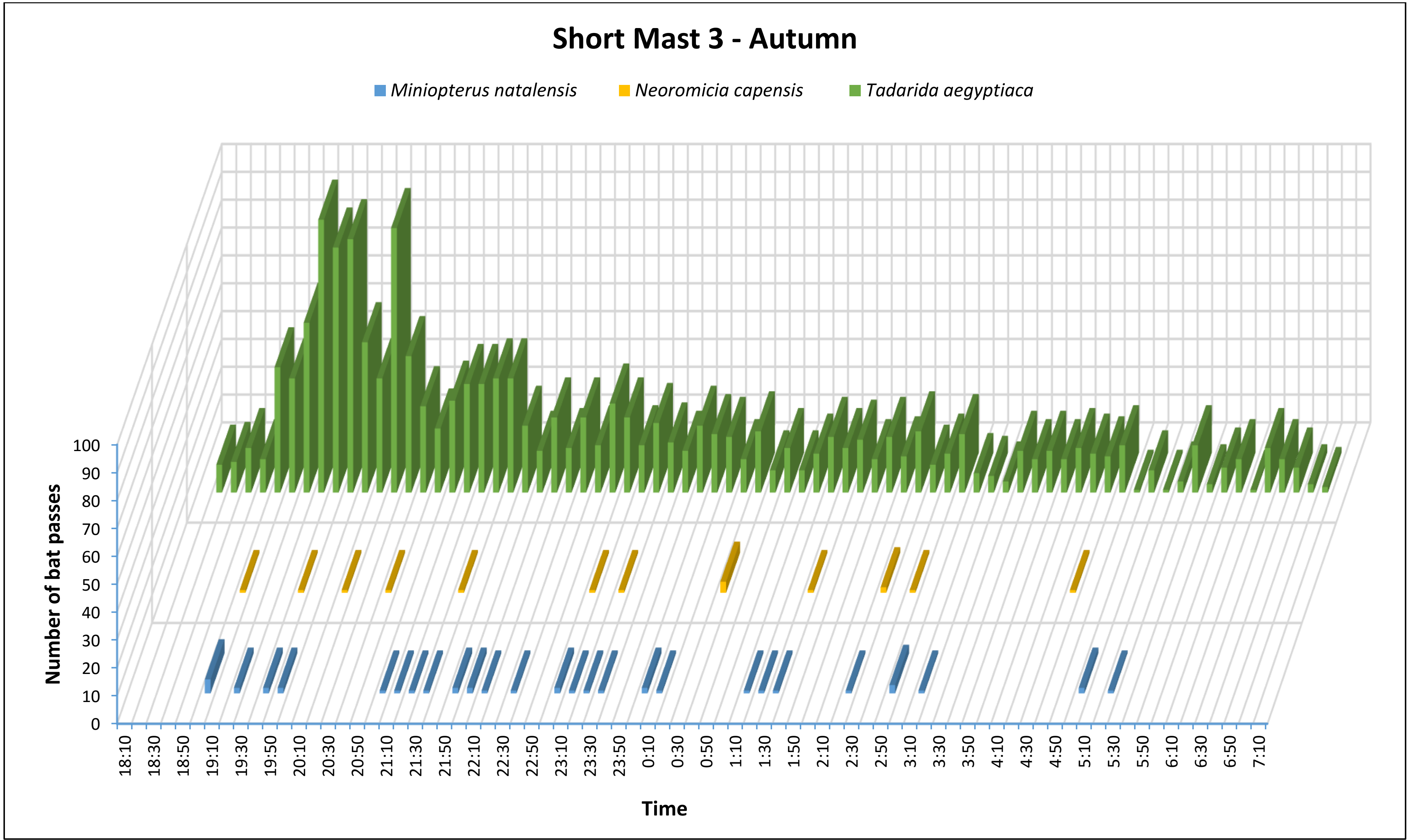


Figure 47: Temporal distribution of activity across the night as detected by Short Mast 3 in autumn.

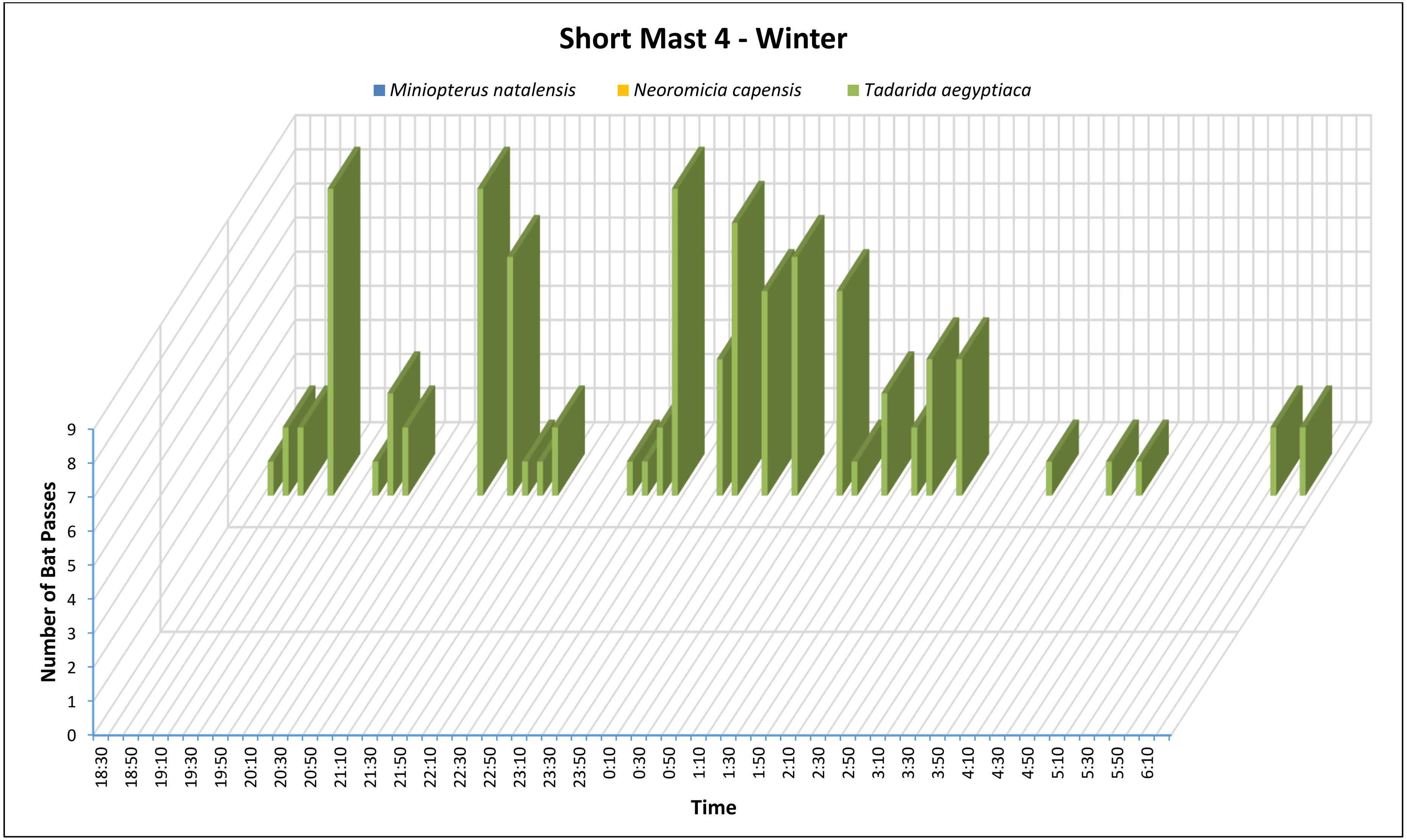


Figure 48: Temporal distribution of activity across the night as detected by Short Mast 4 in winter.

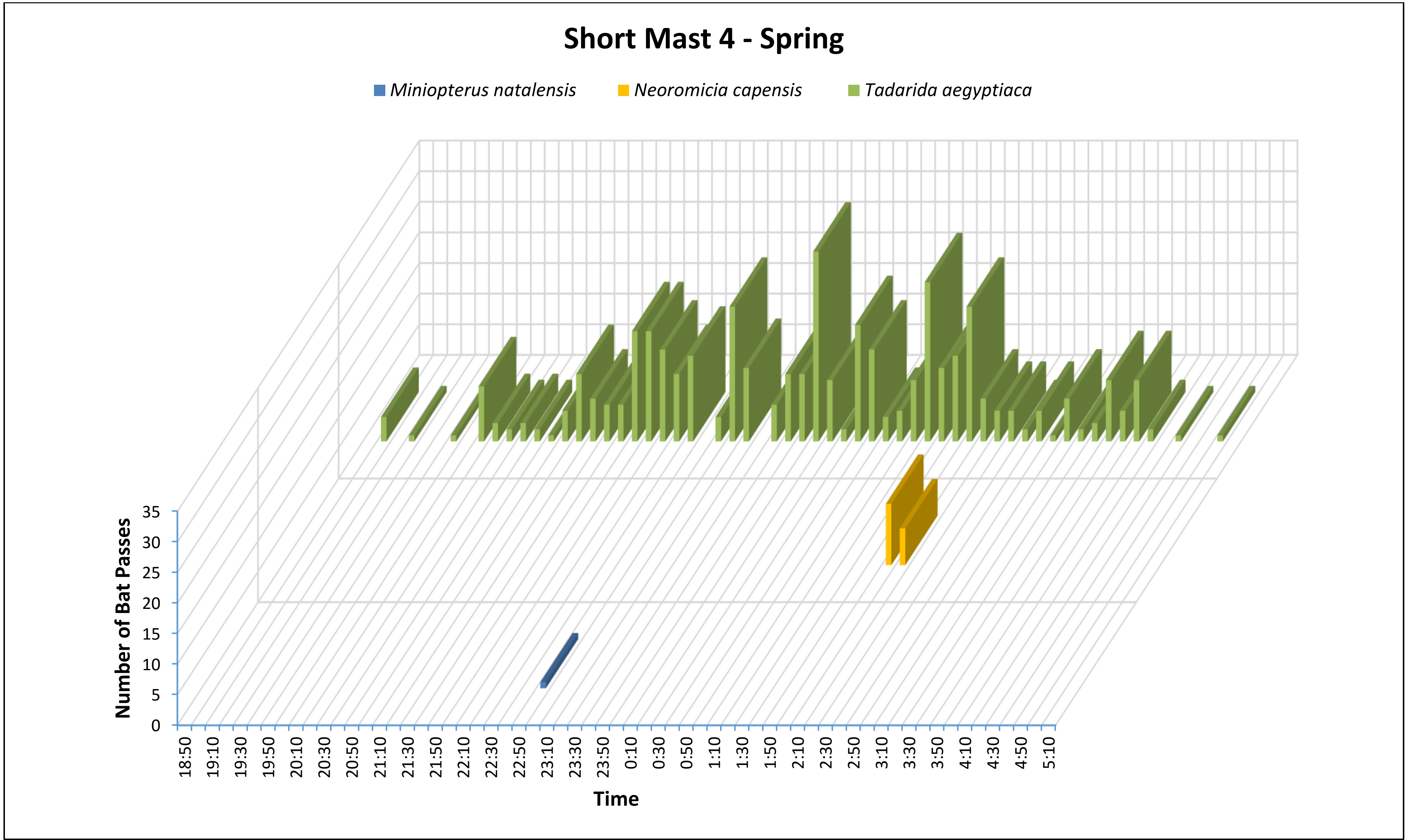


Figure 49: Temporal distribution of activity across the night as detected by Short Mast 4 in spring.

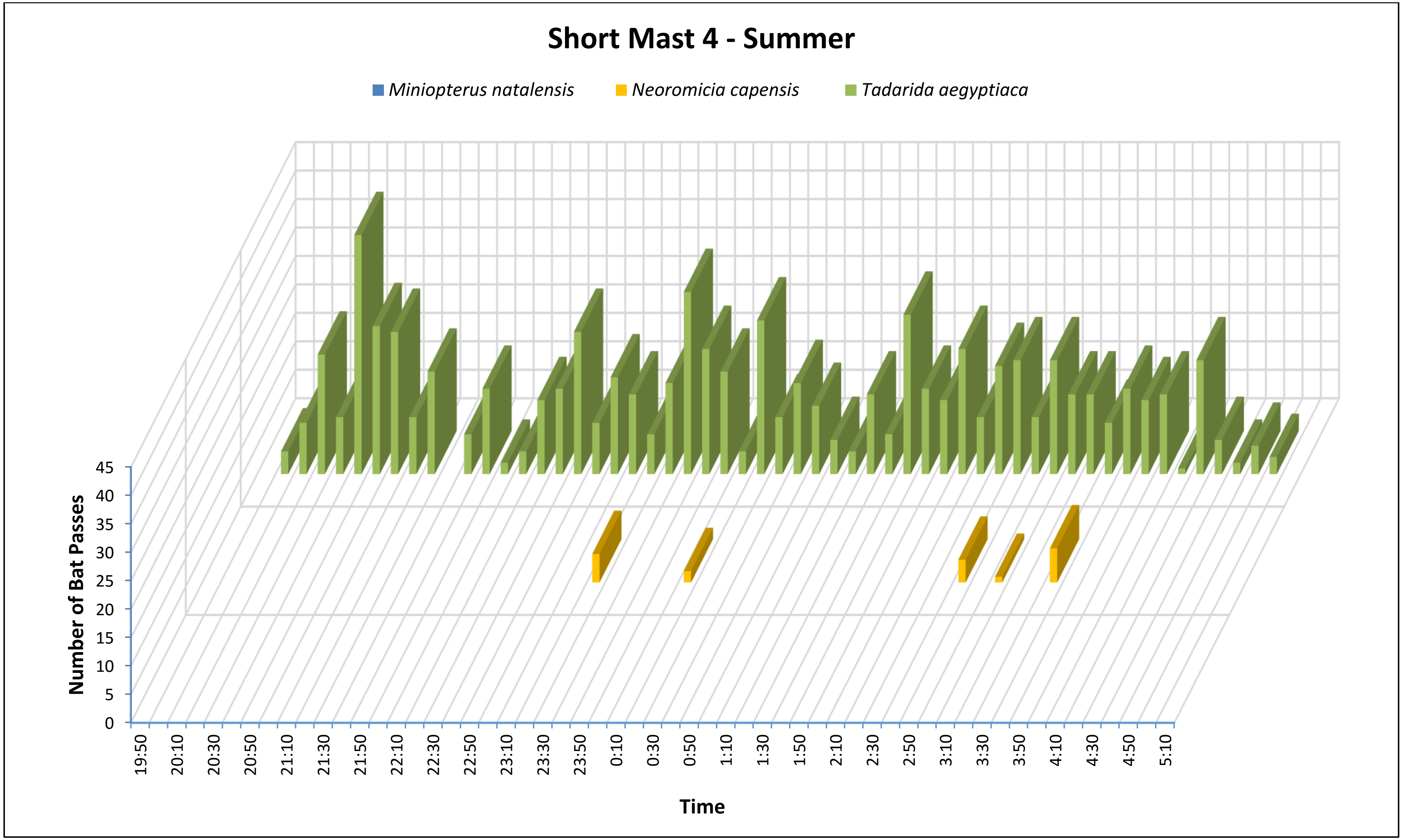


Figure 50: Temporal distribution of activity across the night as detected by Short Mast 4 in summer.

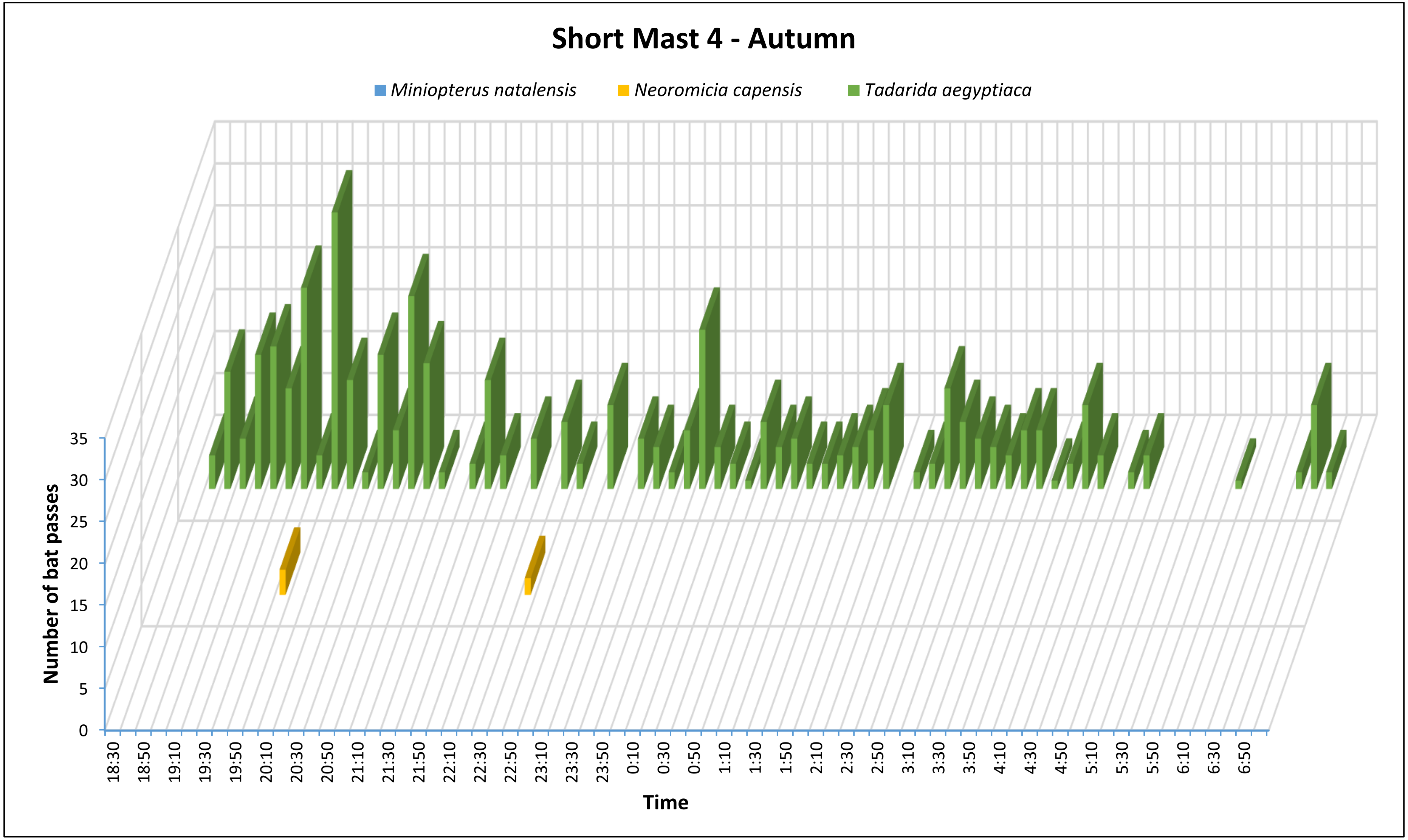


Figure 51: Temporal distribution of activity across the night as detected by Short Mast 4 in autumn.

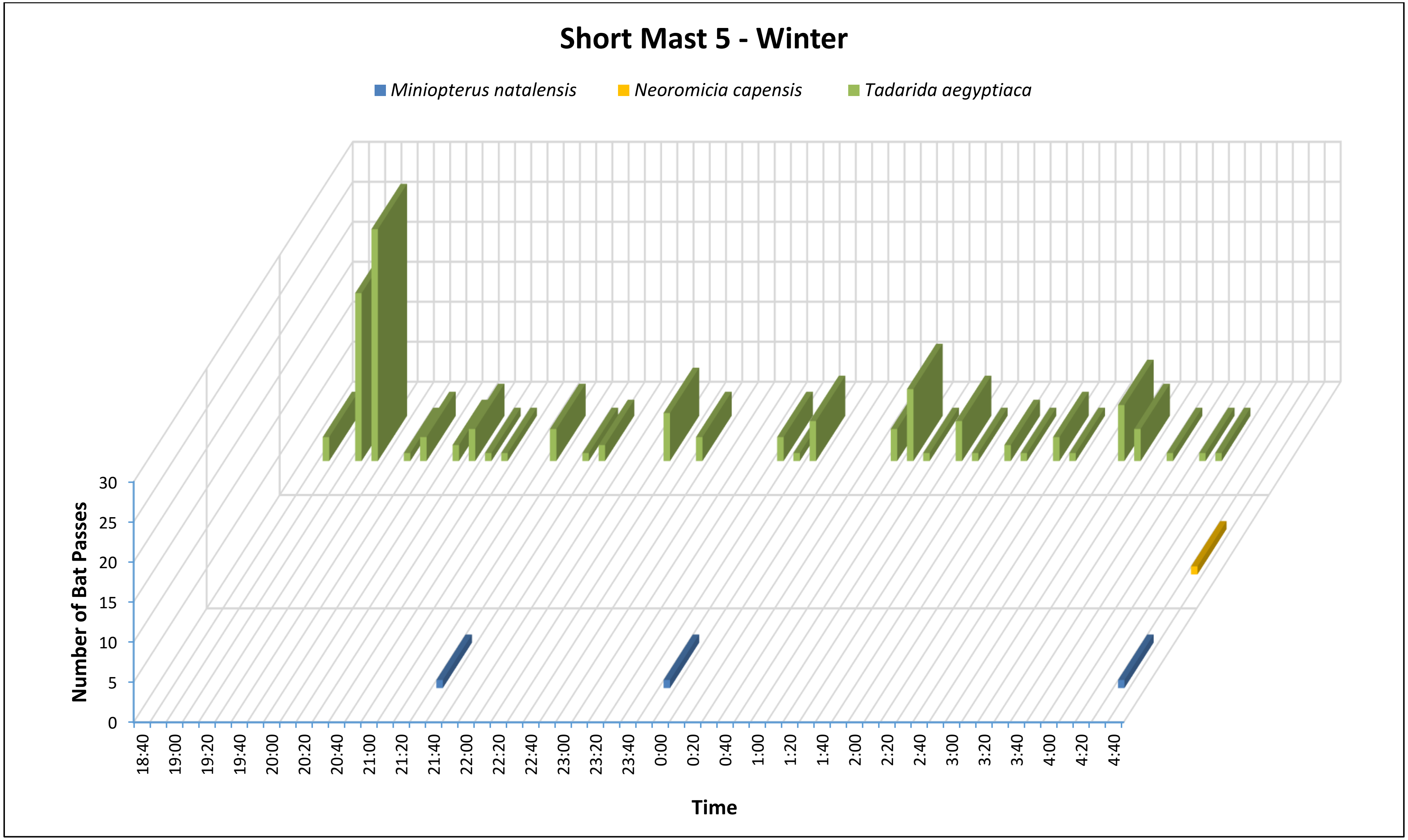


Figure 52: Temporal distribution of activity across the night as detected by Short Mast 5 in winter.

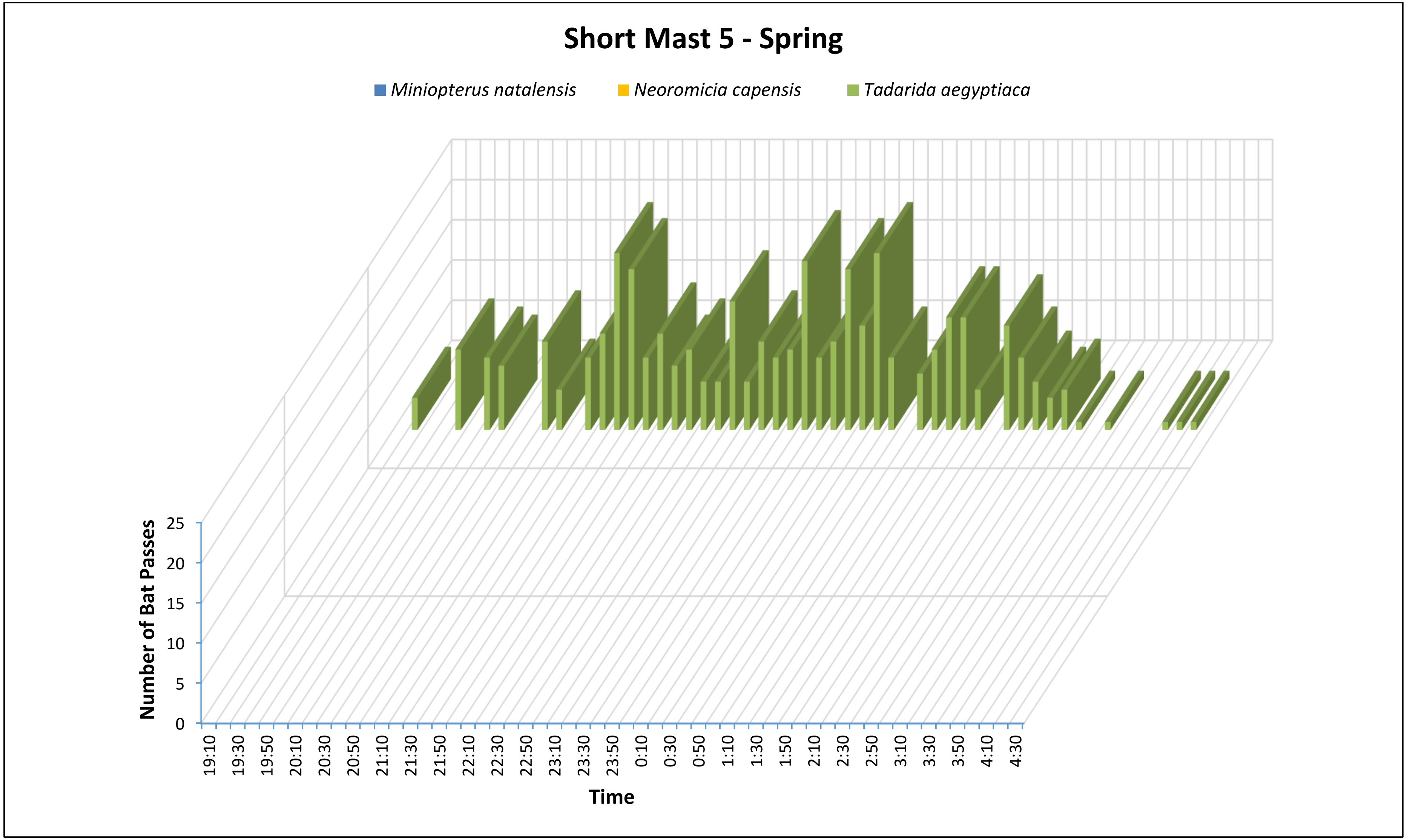


Figure 53: Temporal distribution of activity across the night as detected by Short Mast 5 in spring.

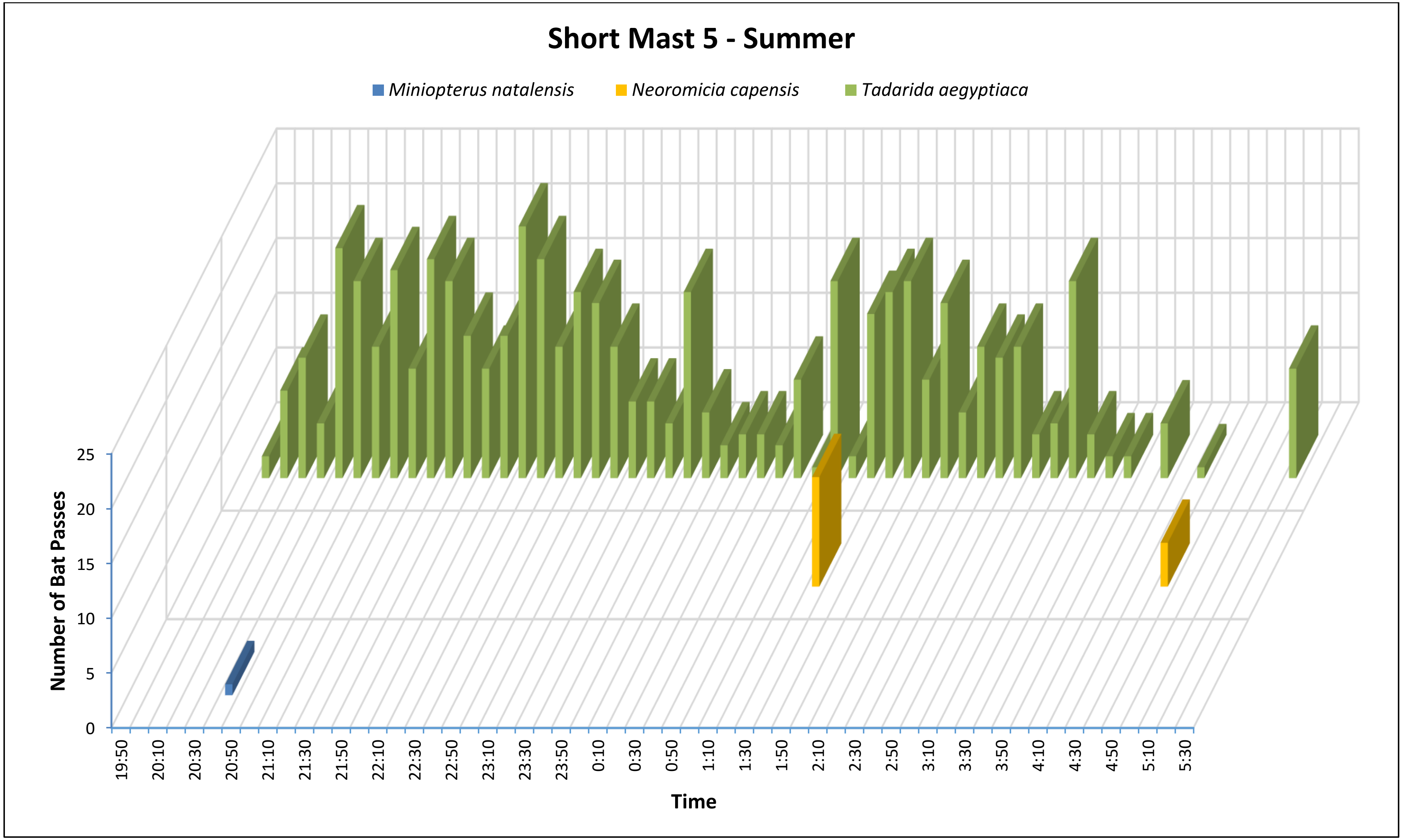


Figure 54: Temporal distribution of activity across the night as detected by Short Mast 5 in summer.

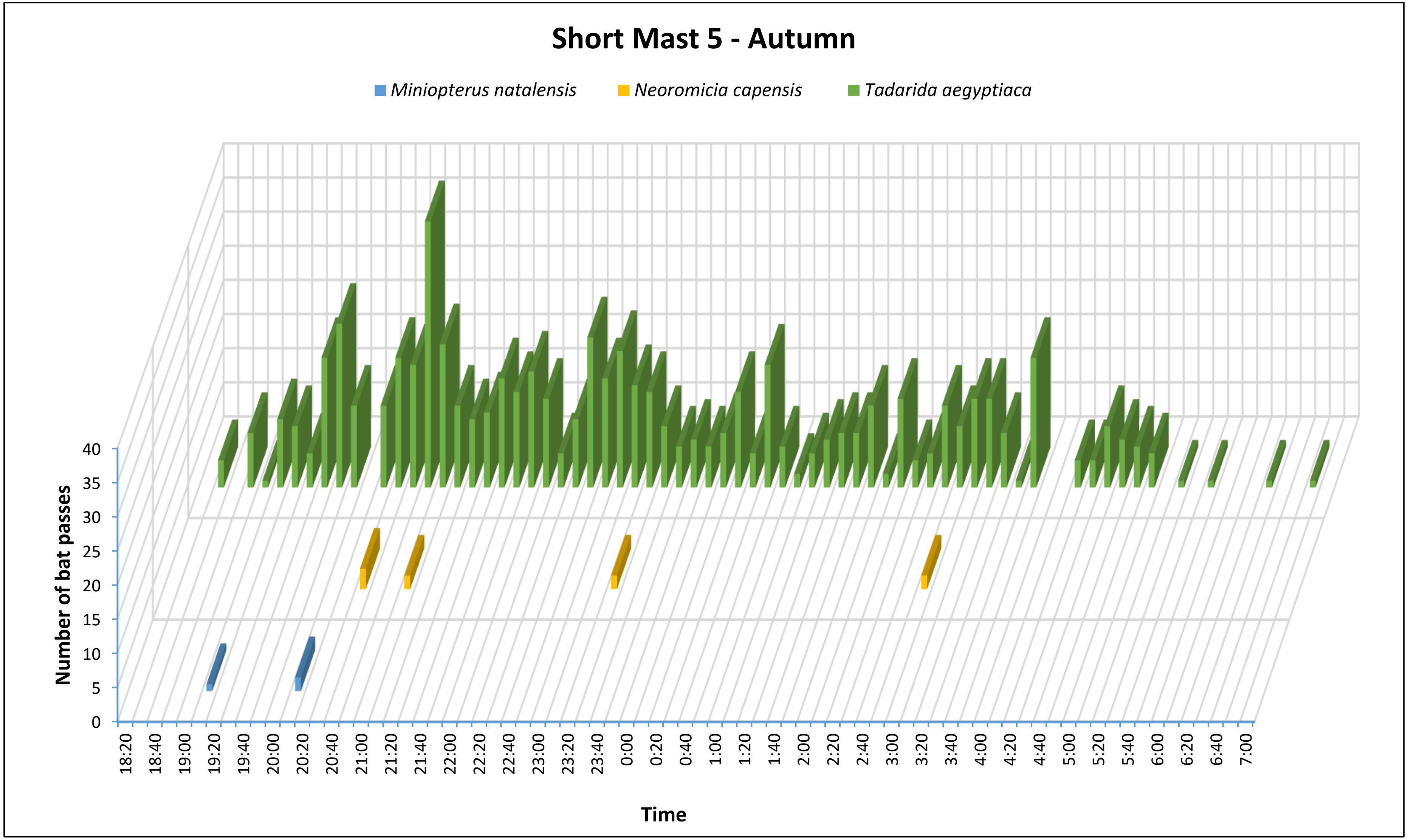


Figure 55: Temporal distribution of activity across the night as detected by Short Mast 5 in autumn.

4.6.4 Relation between Bat Activity and Weather Conditions

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

Wind speed

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

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

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

Time periods used in the analysis below for each monitoring system were identified in Sections 4.6.2 and 4.6.3 as periods of elevated activity. The analysis was only performed for time frames of the highest activity levels. The time periods used in the analysis below corresponds with the time periods and systems used to inform mitigation in Section 6. Wind speed measured at a height of 61m and temperature measured at a height of 40m were used for the analysis.

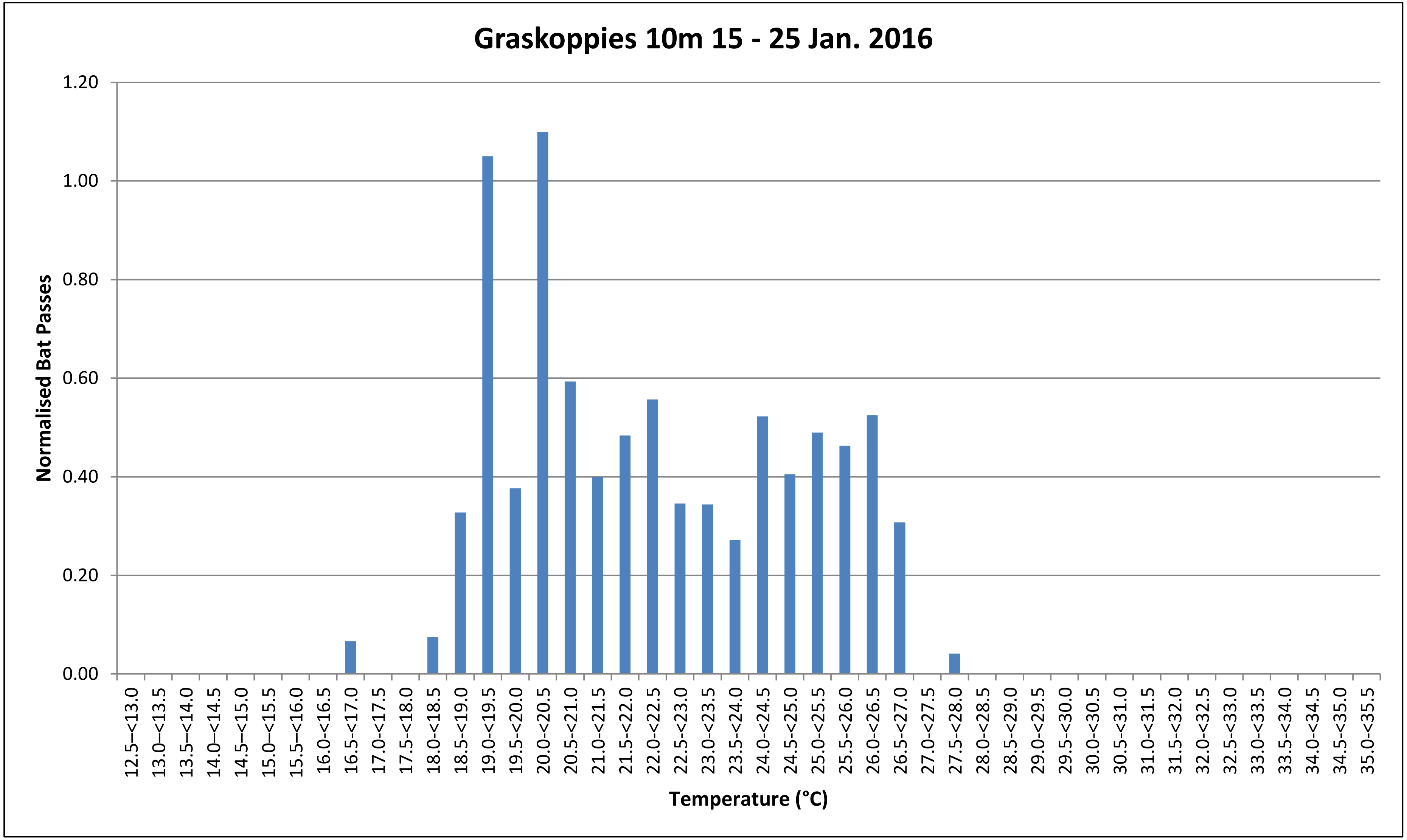


Figure 56: Sum of bat passes (Normalised) per Temperature category for Graskoppies 10m (15 – 25 January 2016).

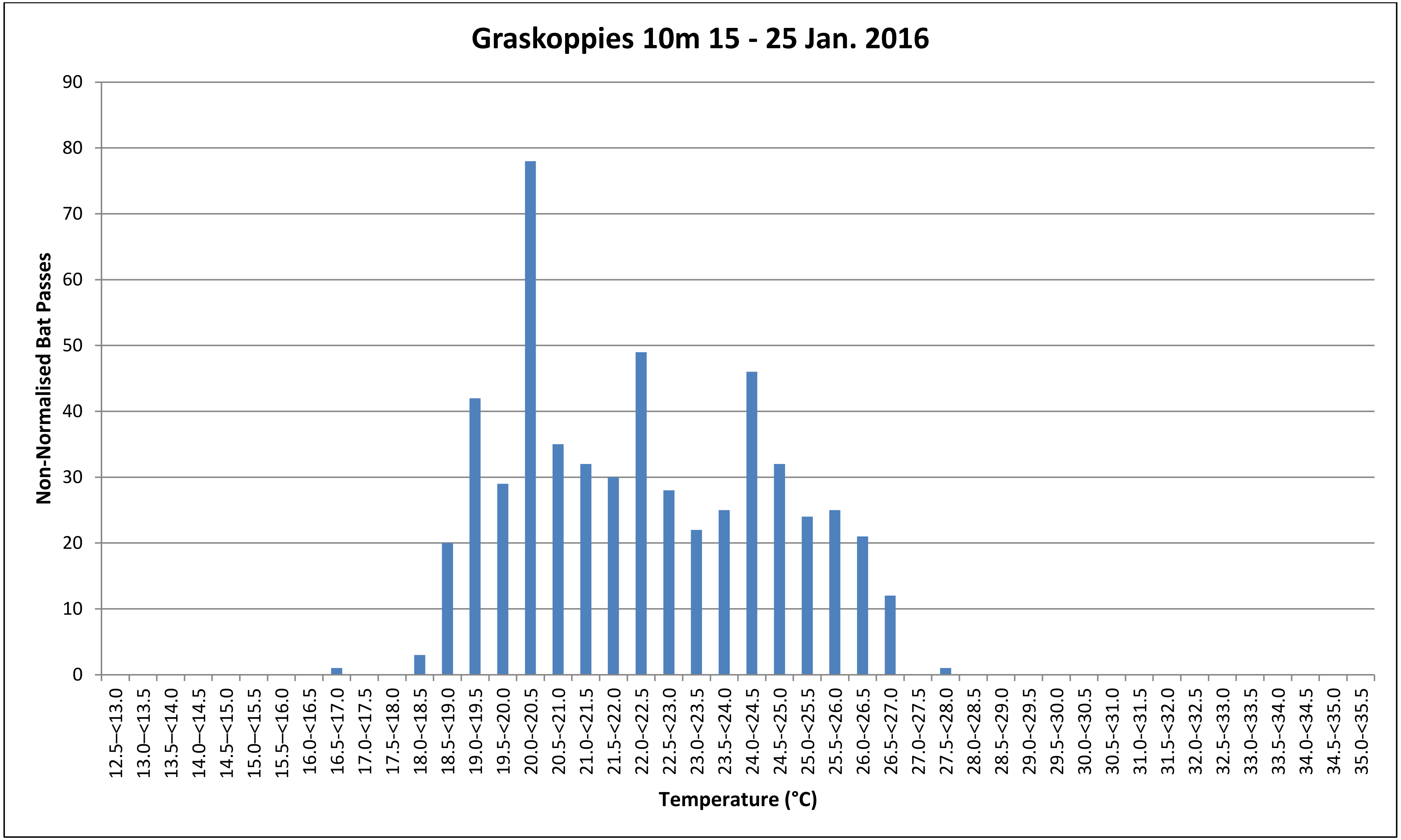


Figure 57: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 10m (15 – 25 January 2016).

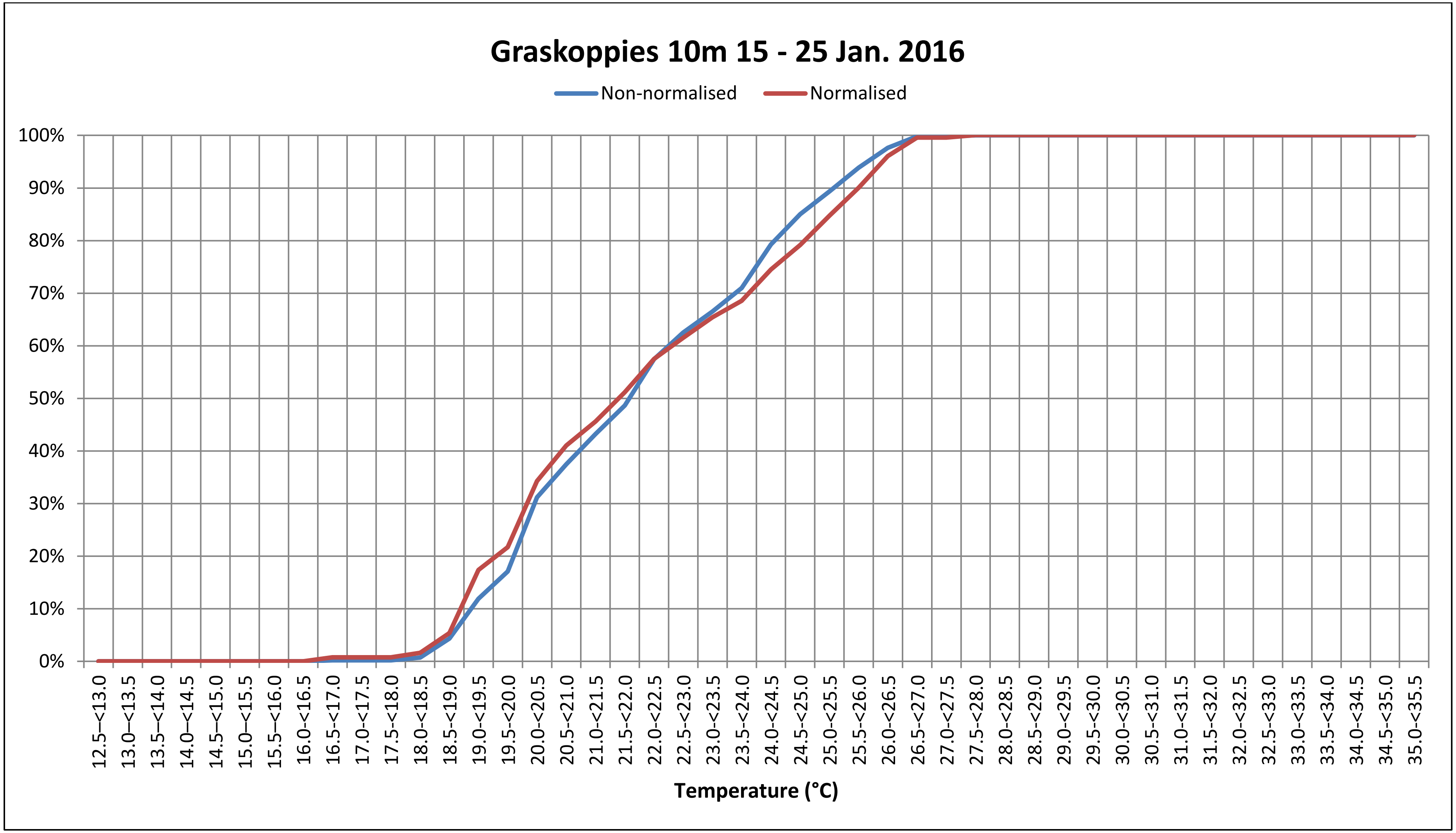


Figure 58: Cumulative percentage of normalised and non-normalised bat passes per temperature category for Graskoppies 10m (15 – 25 January 2016).

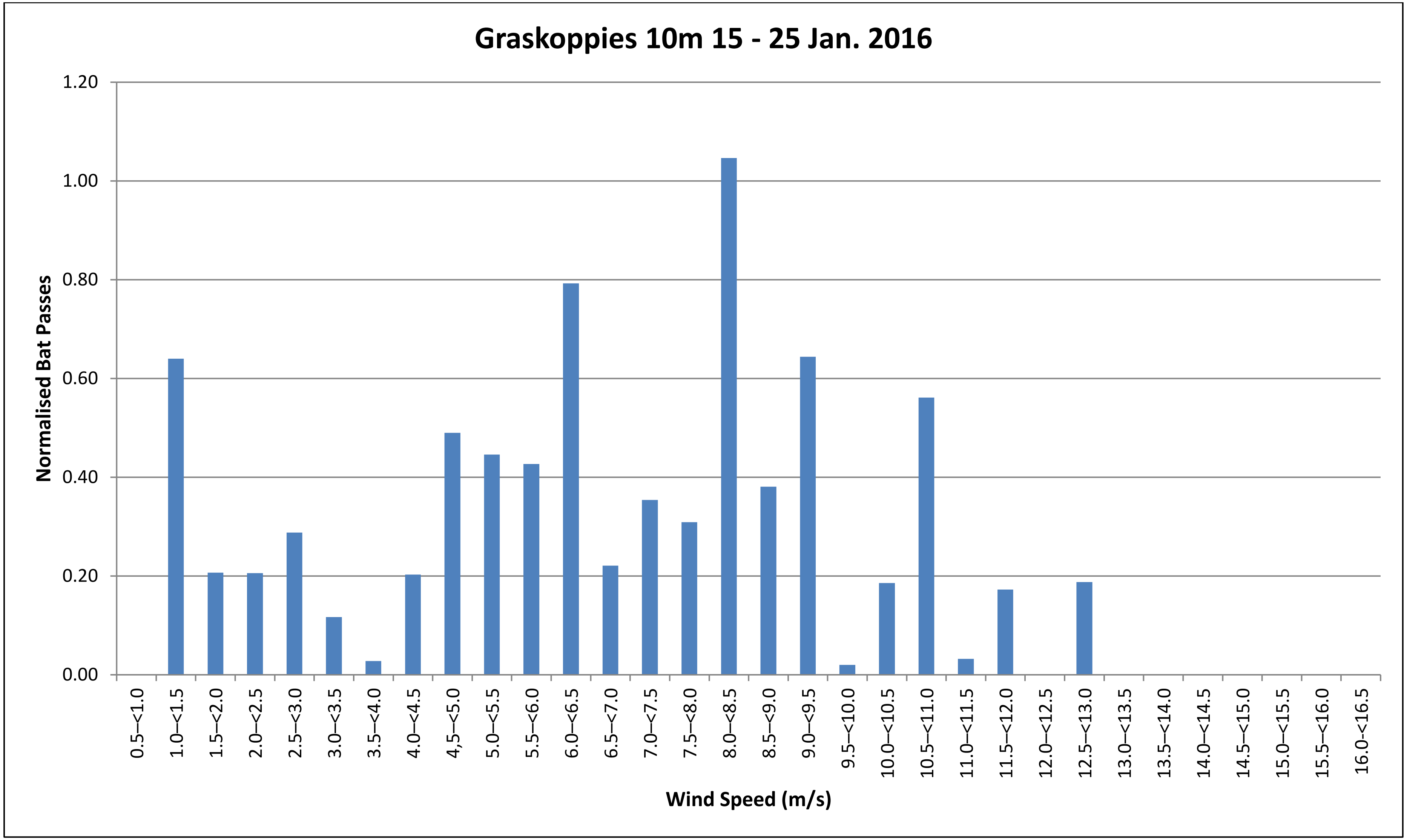


Figure 59: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 10m (15 – 25 January 2016).

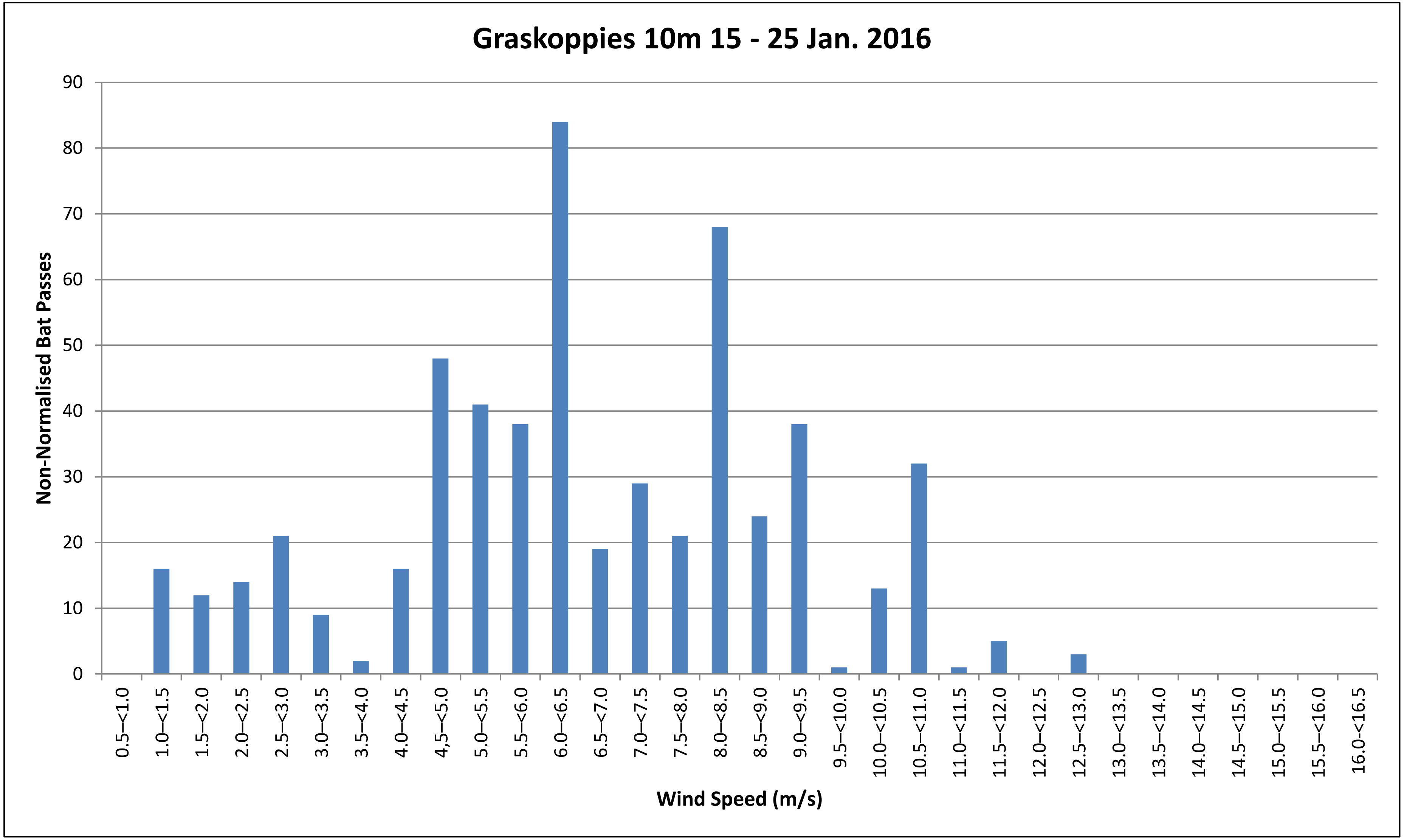


Figure 60: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 10m (15 – 25 January 2016).

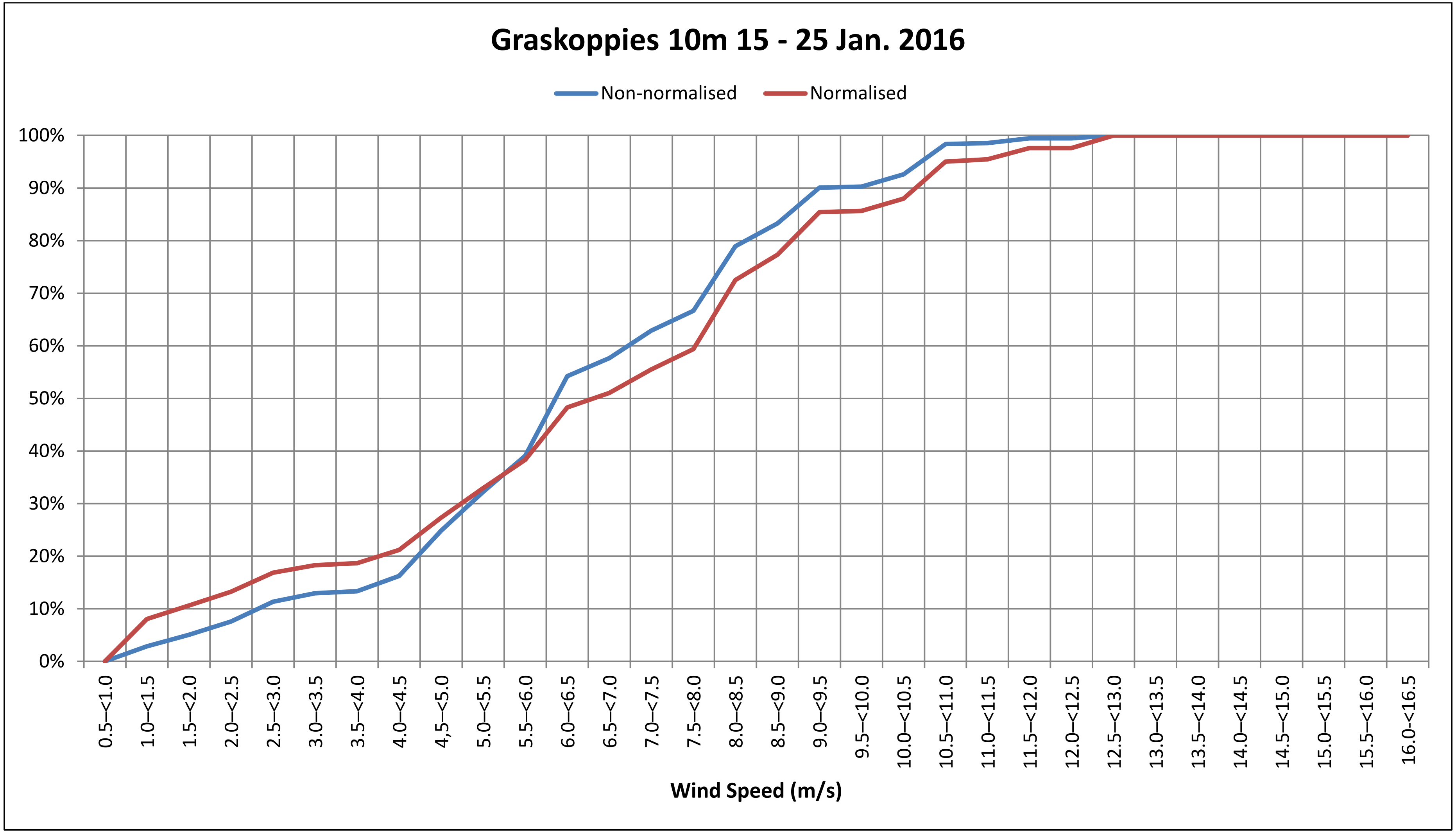


Figure 61: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 10m (15 – 25 January 2016).

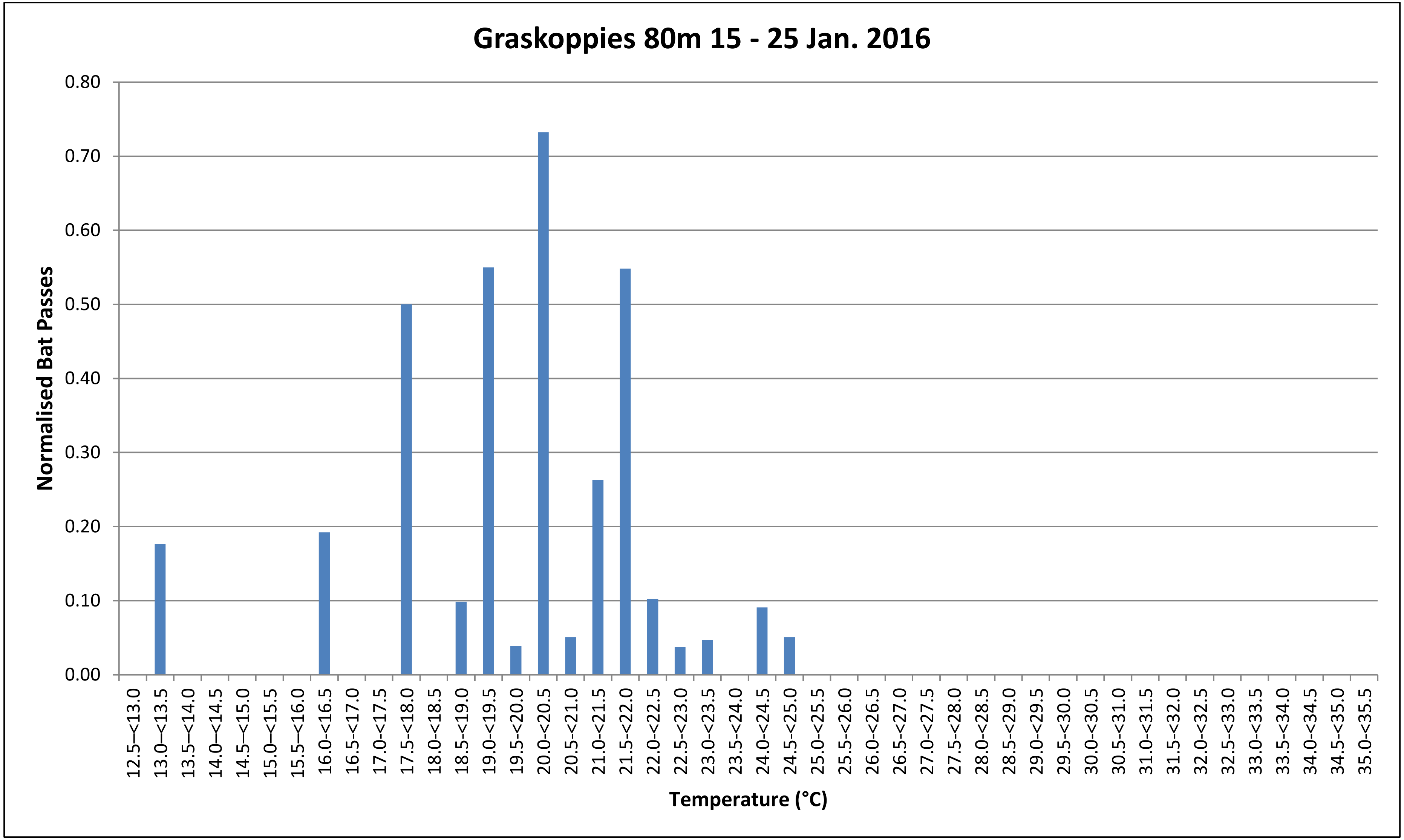


Figure 62: Sum of bat passes (Normalised) per Temperature category for Graskoppies 80m (15 – 25 January 2016).

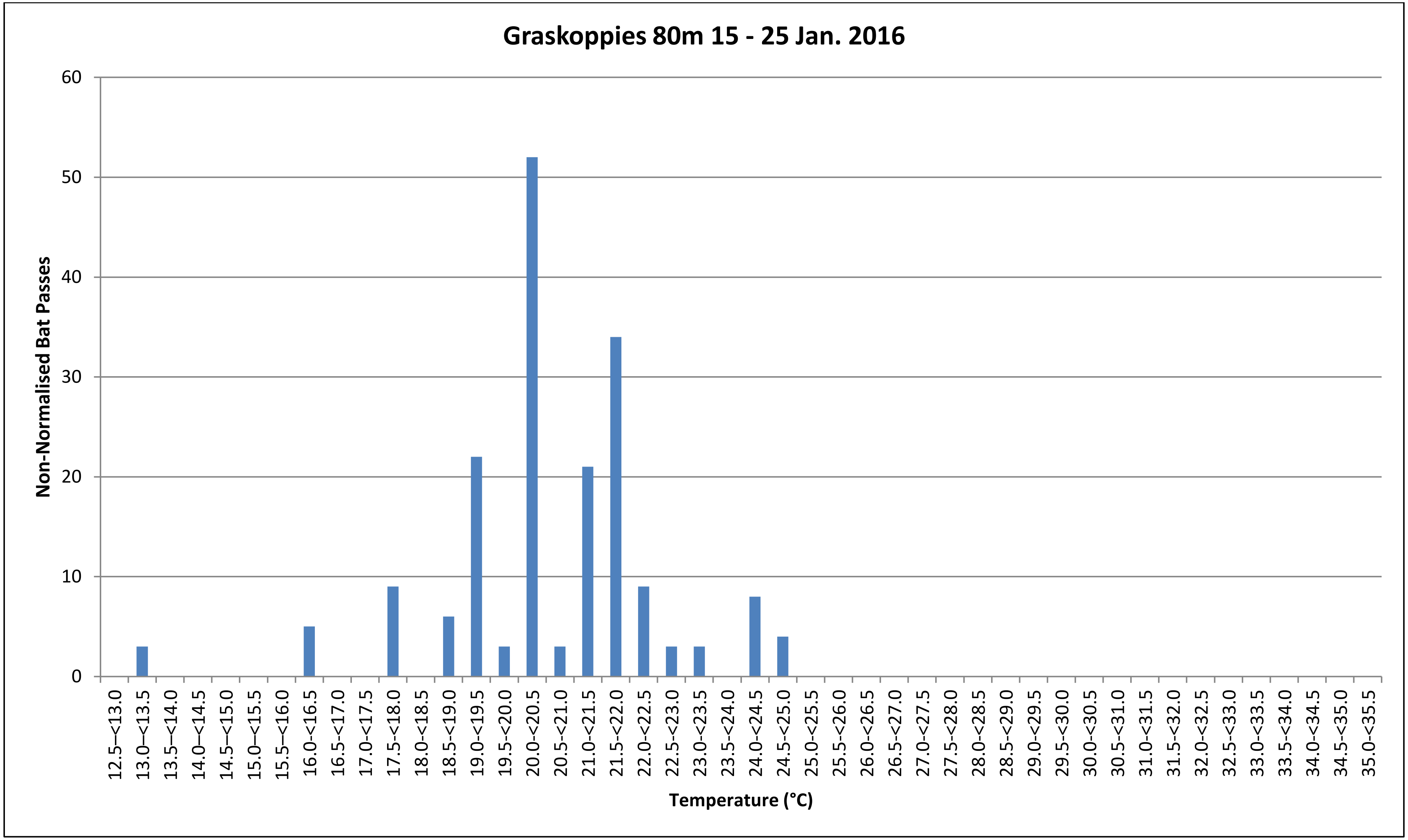


Figure 63: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 80m (15 – 25 January 2016).

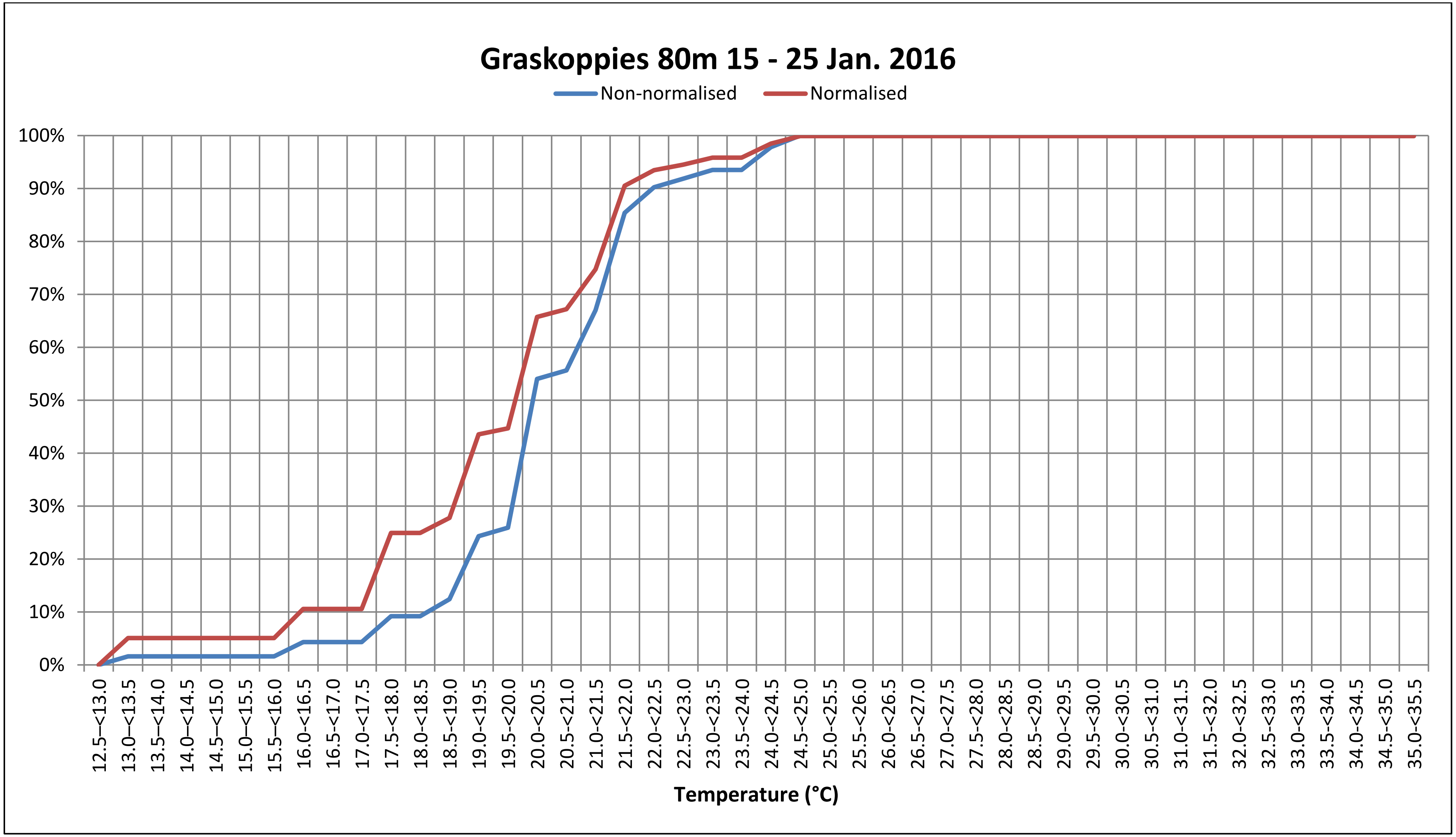


Figure 64: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Graskoppies 80m (15 – 25 January 2016).

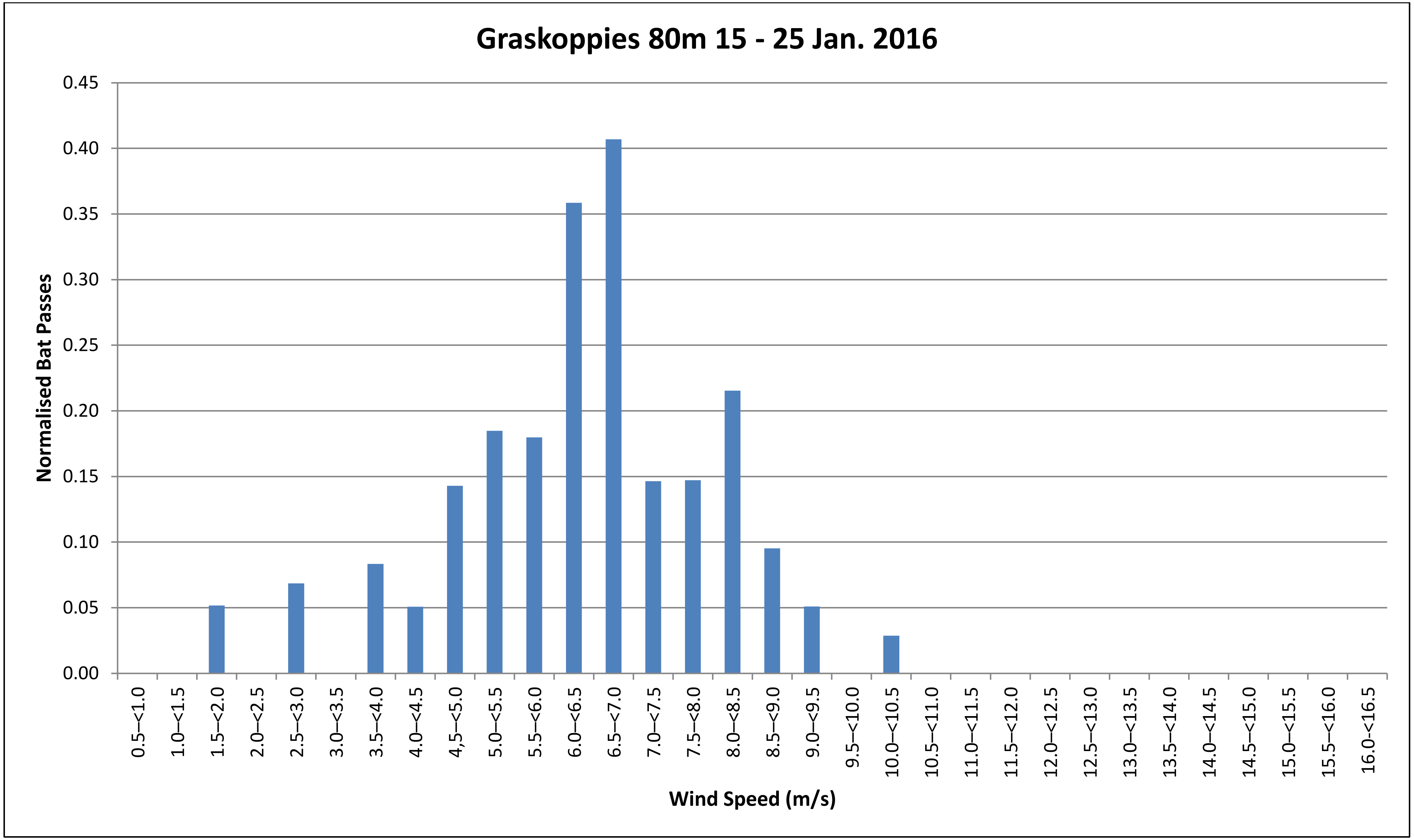


Figure 65: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 80m (15 – 25 January 2016).

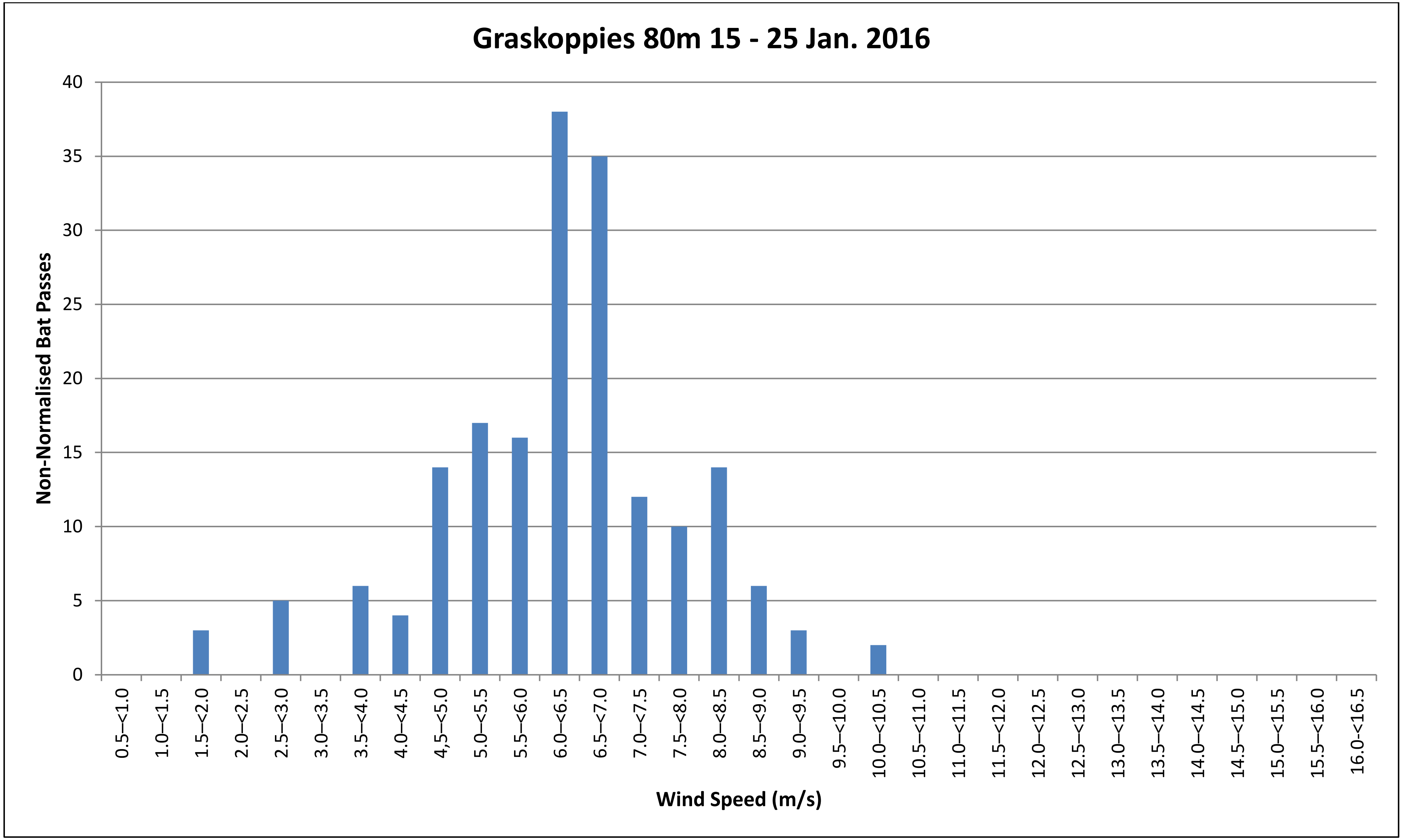


Figure 66: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 80m (15 – 25 January 2016).

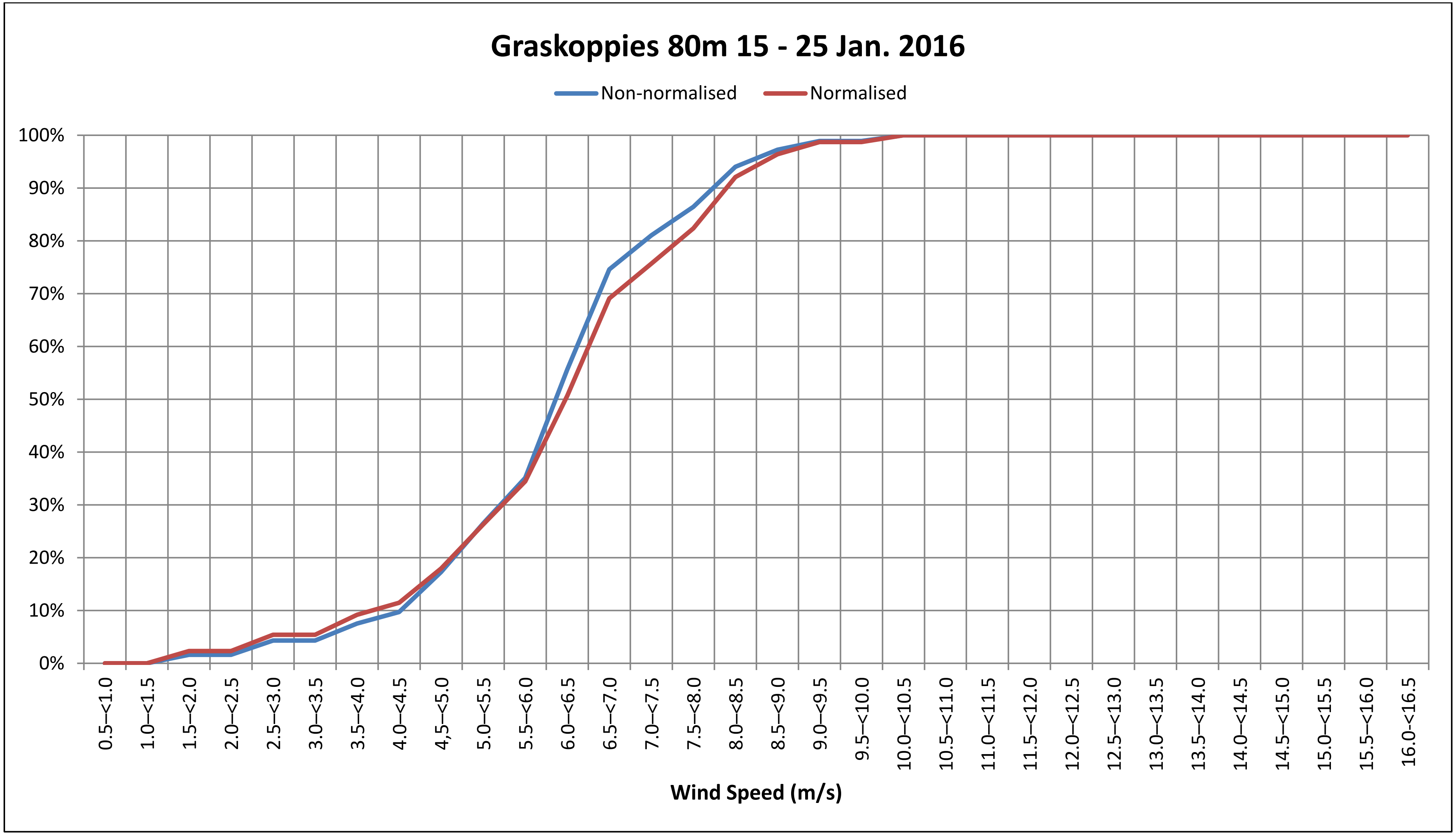


Figure 67: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 80m (15 – 25 January 2016).

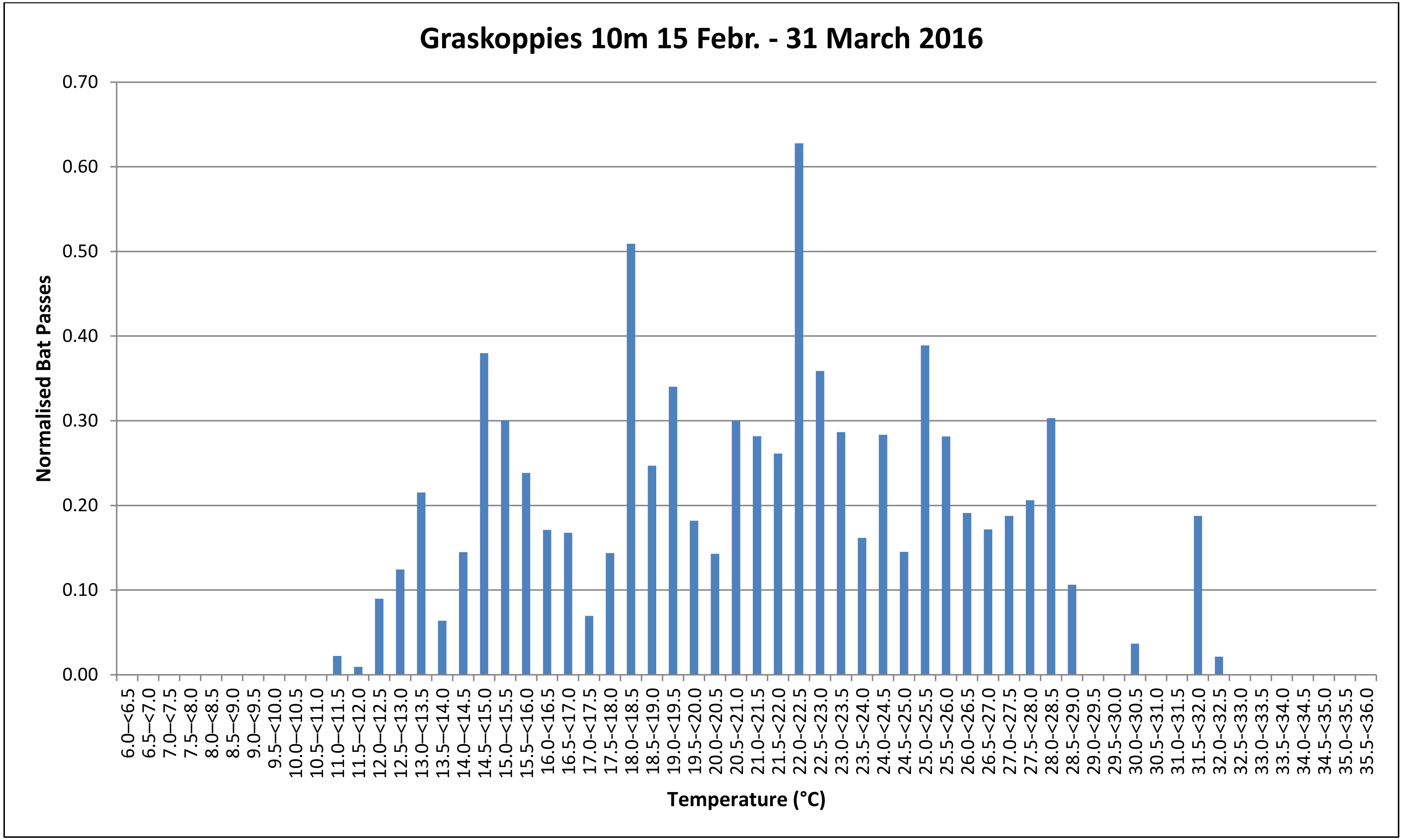


Figure 68: Sum of bat passes (Normalised) per Temperature category for Graskoppies 10m (15 February – 31 March 2016).

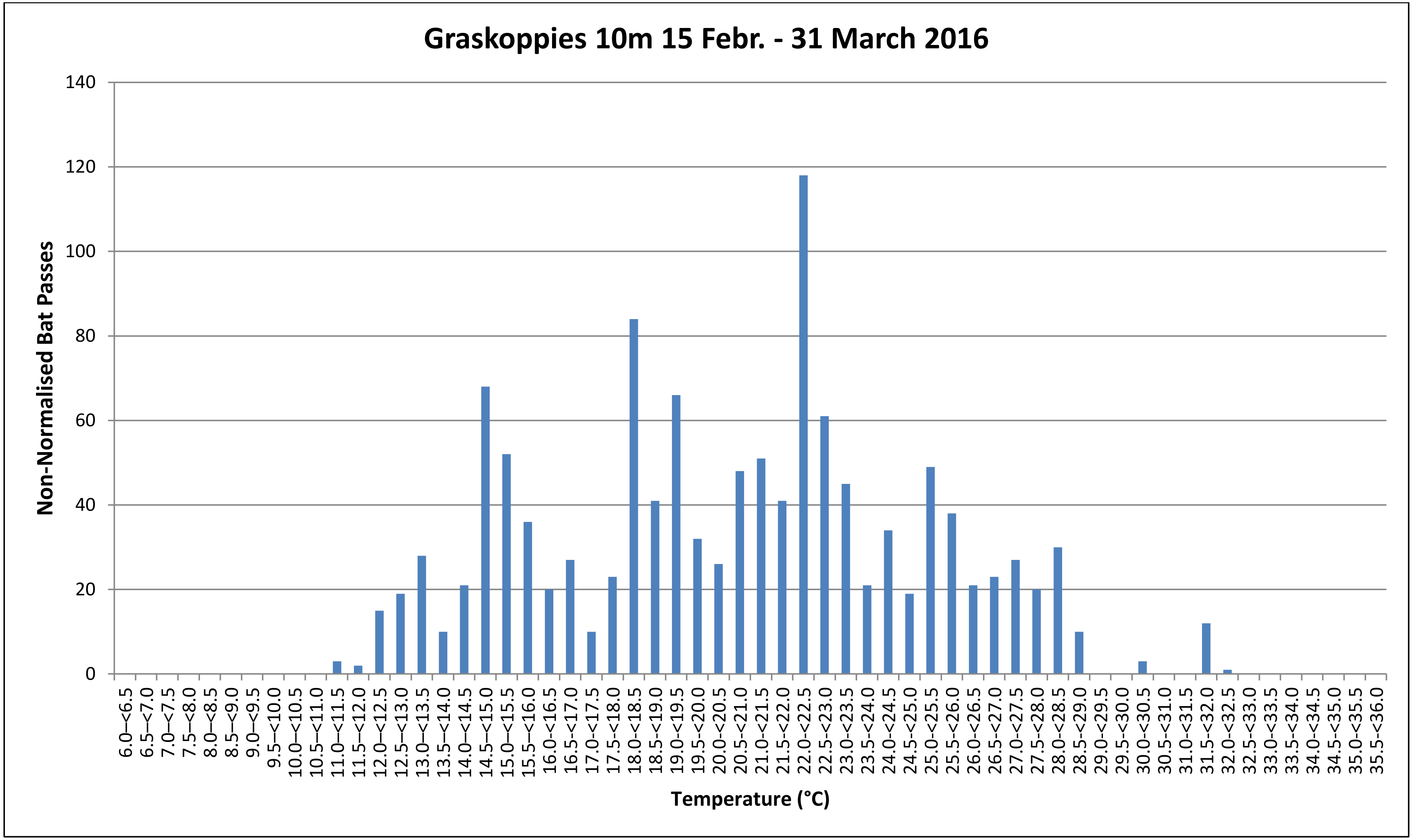


Figure 69: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 10m (15 February – 31 March 2016).

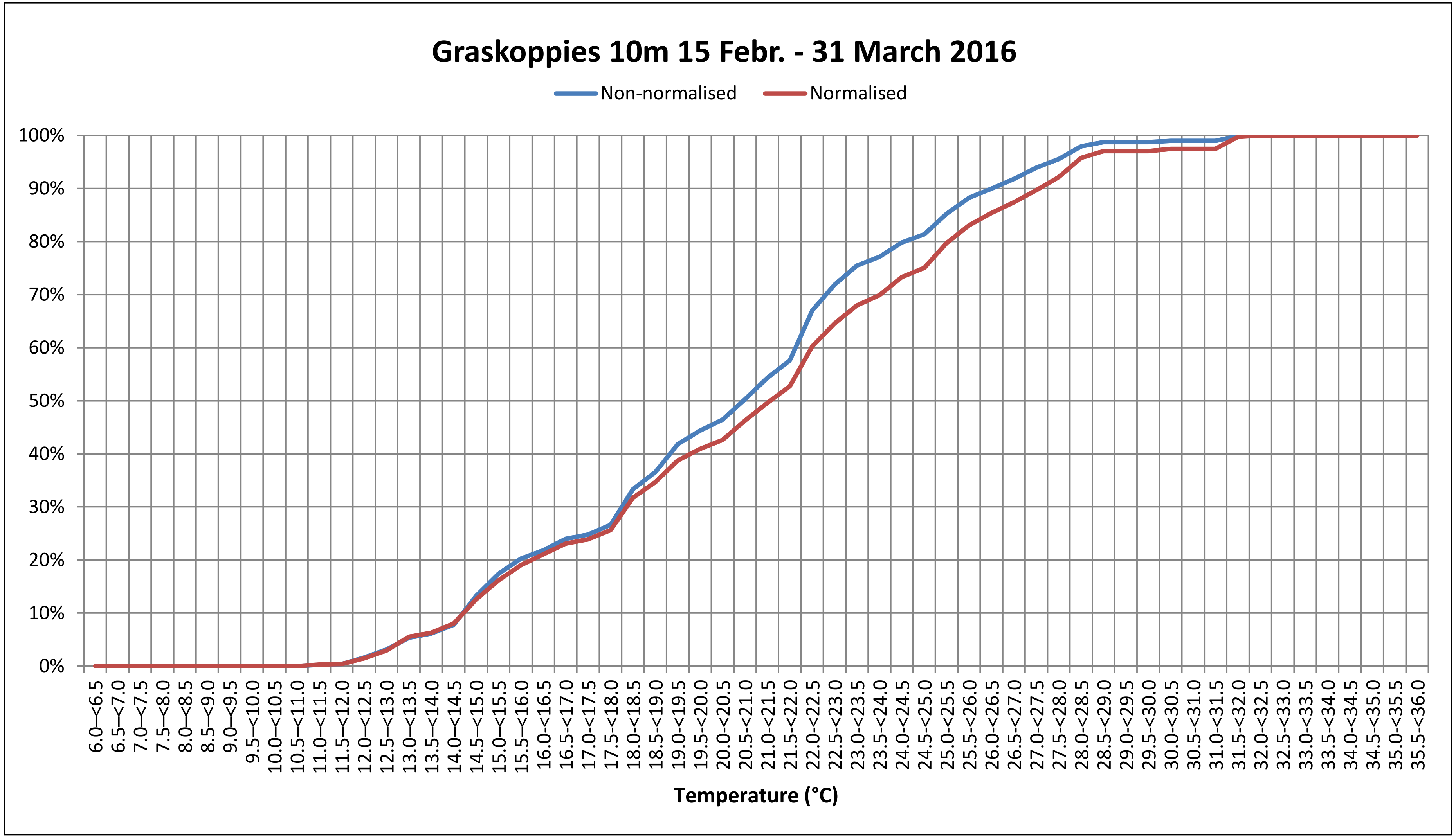


Figure 70: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Graskoppies 10m (15 February – 31 March 2016).

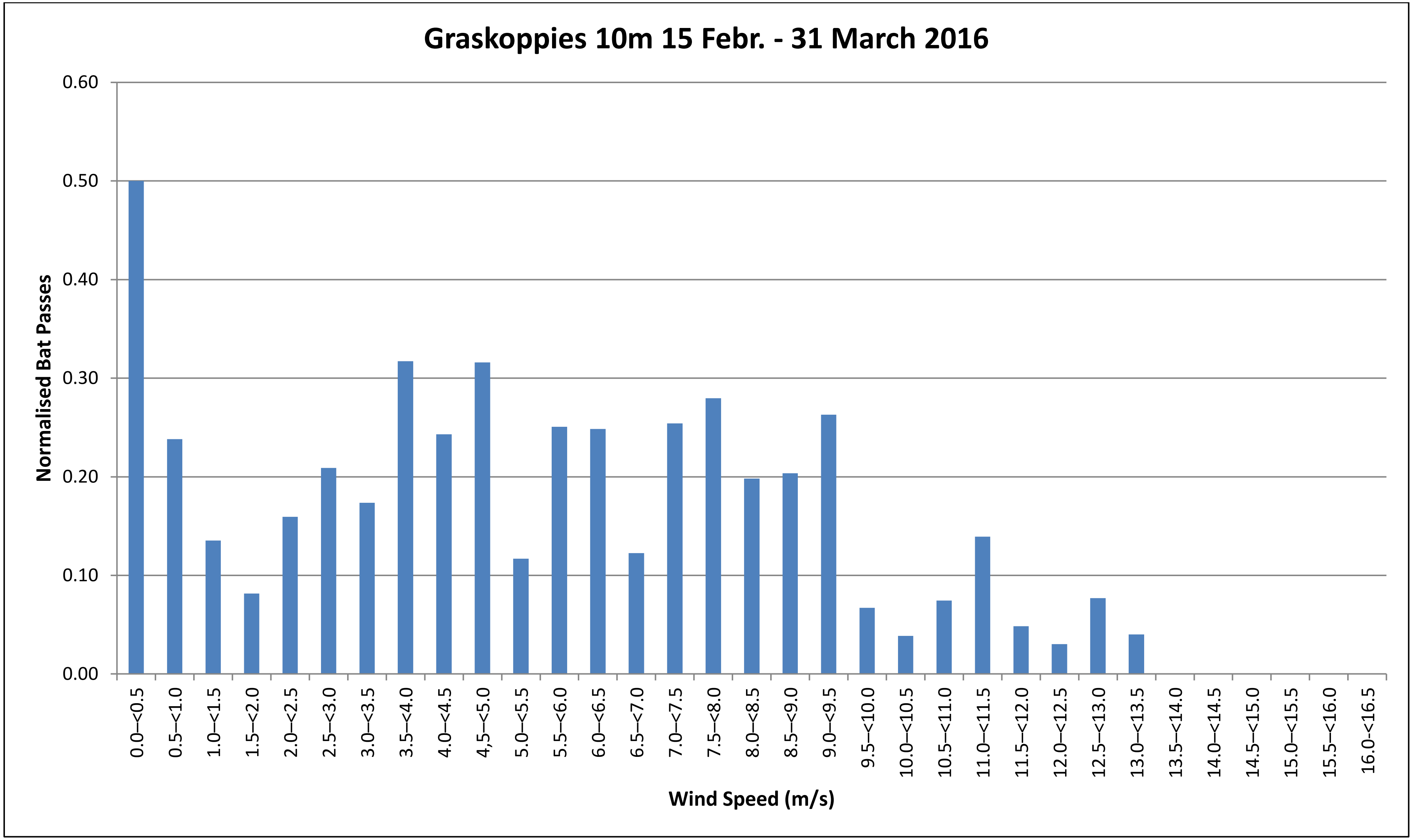


Figure 71: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 10m (15 February – 31 March 2016).

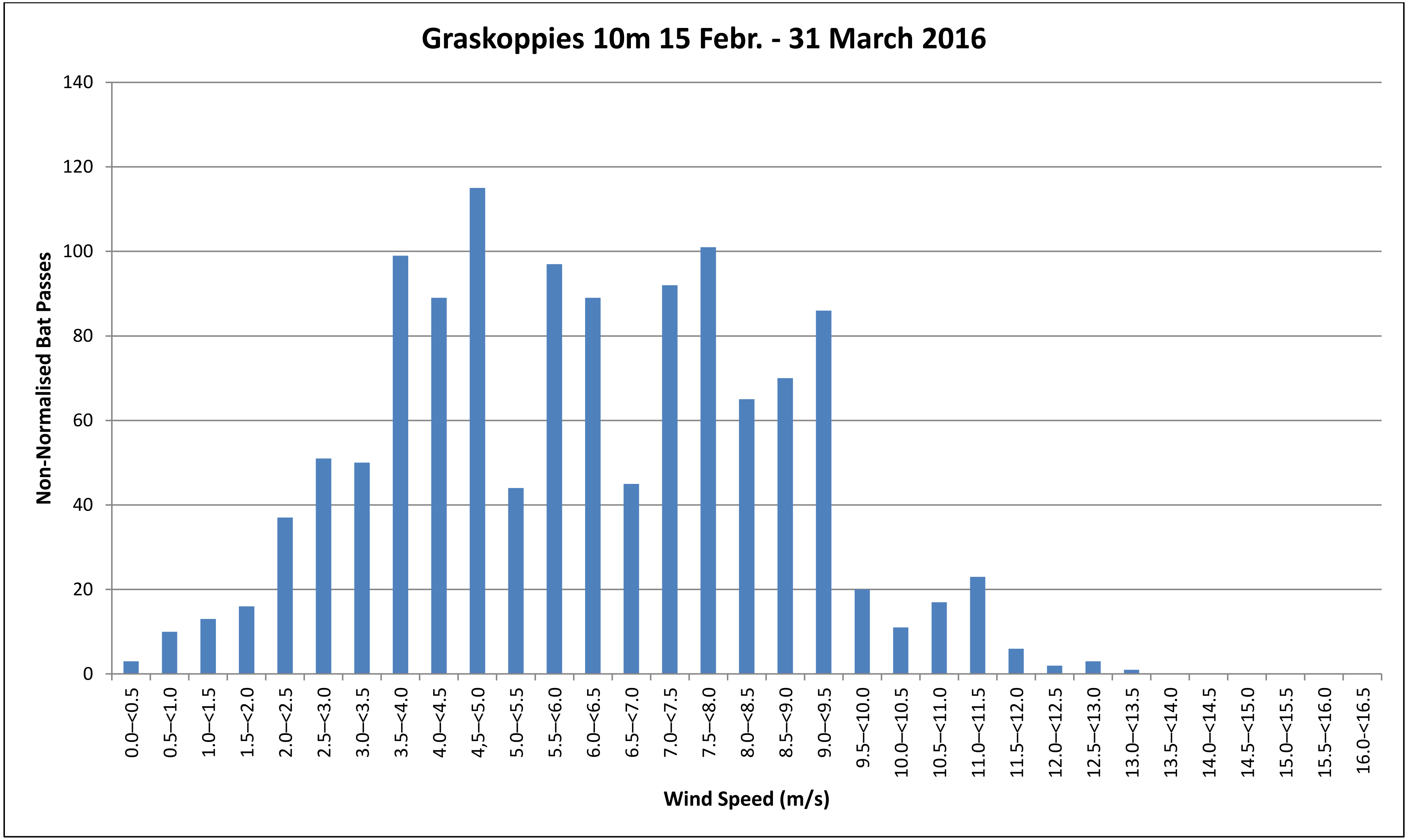


Figure 72: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 10m (15 February – 31 March 2016).

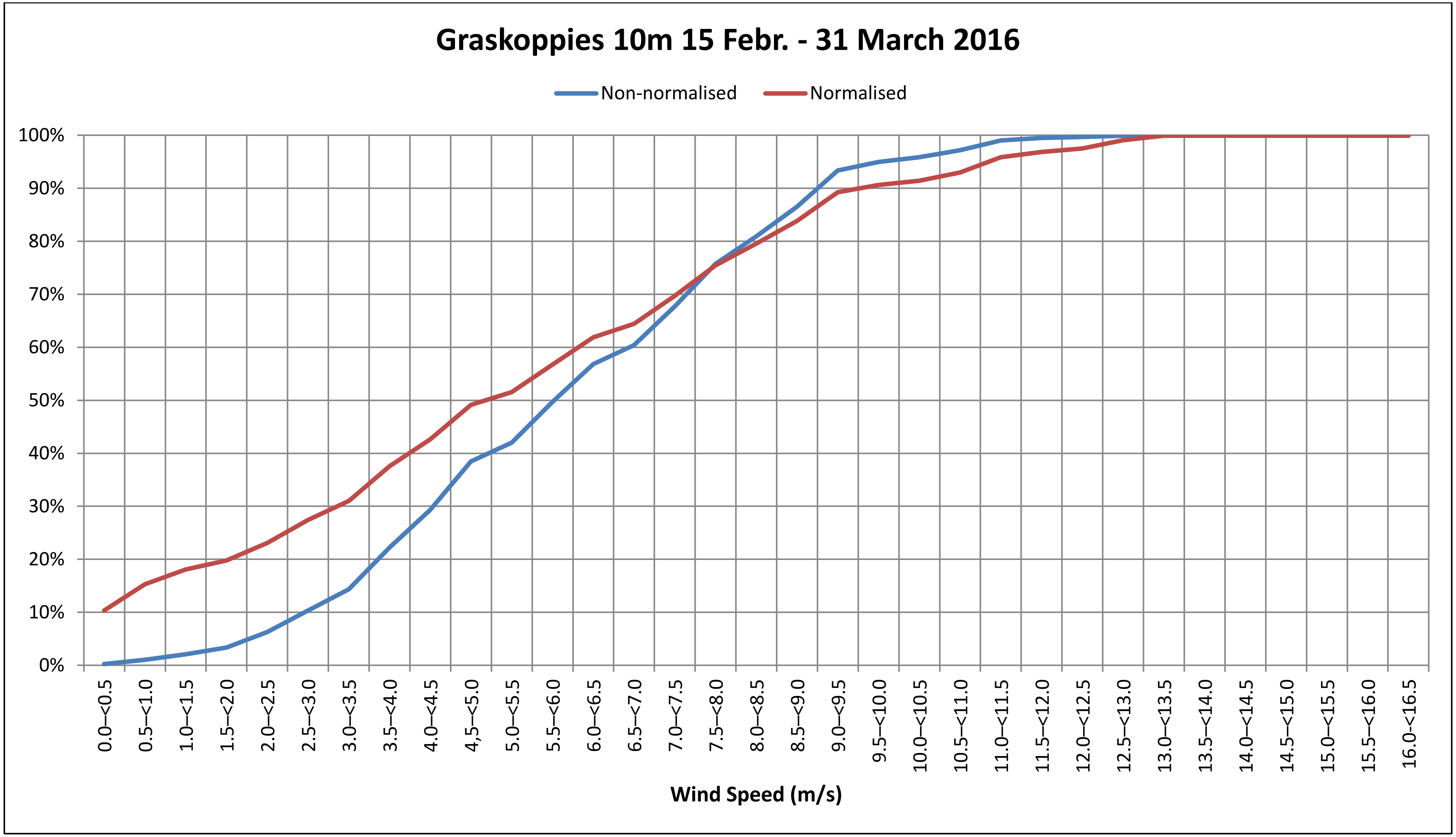


Figure 73: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 10m (15 February – 31 March 2016).

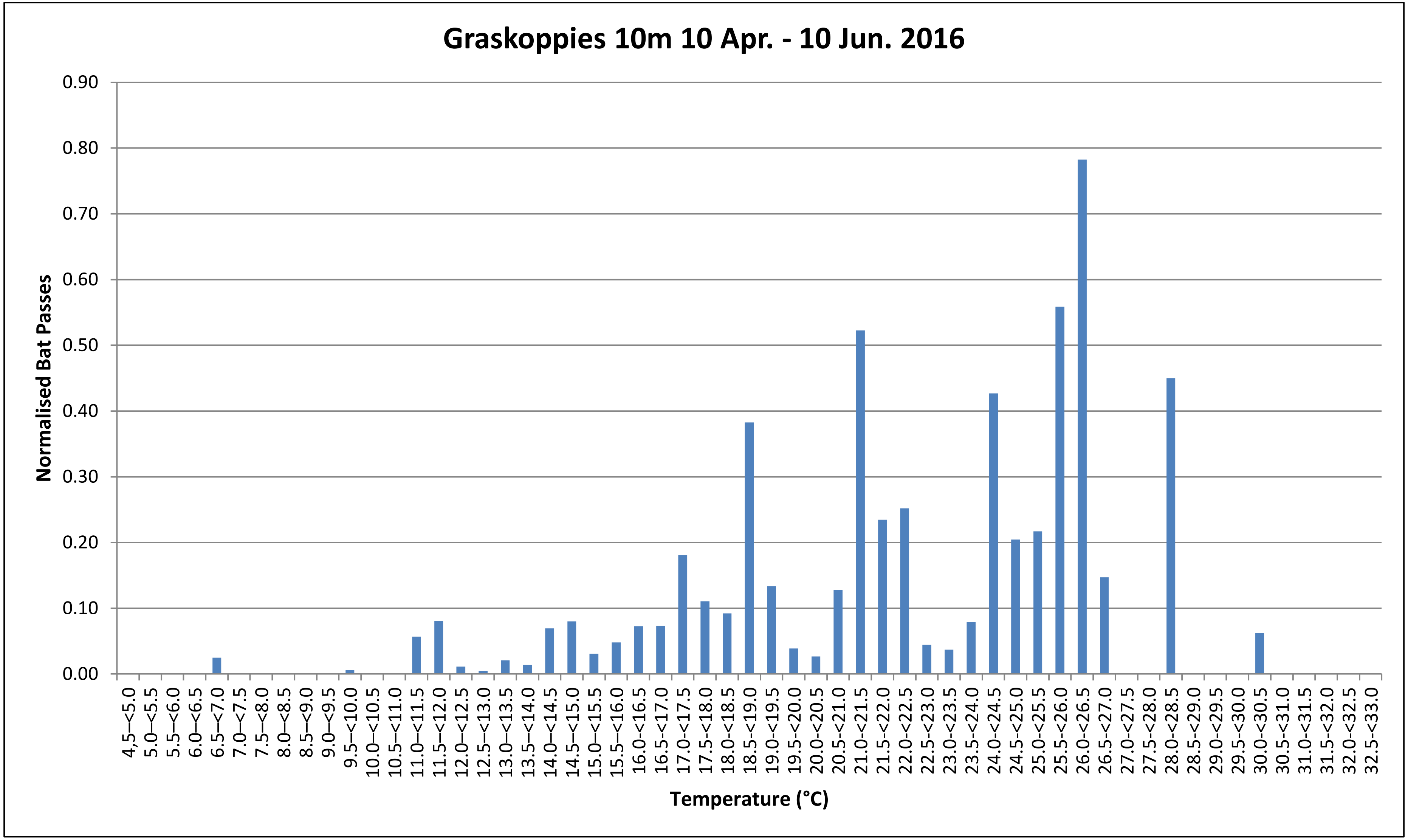


Figure 74: Sum of bat passes (Normalised) per Temperature category for Graskoppies 10m (10 April – 10 June 2016).

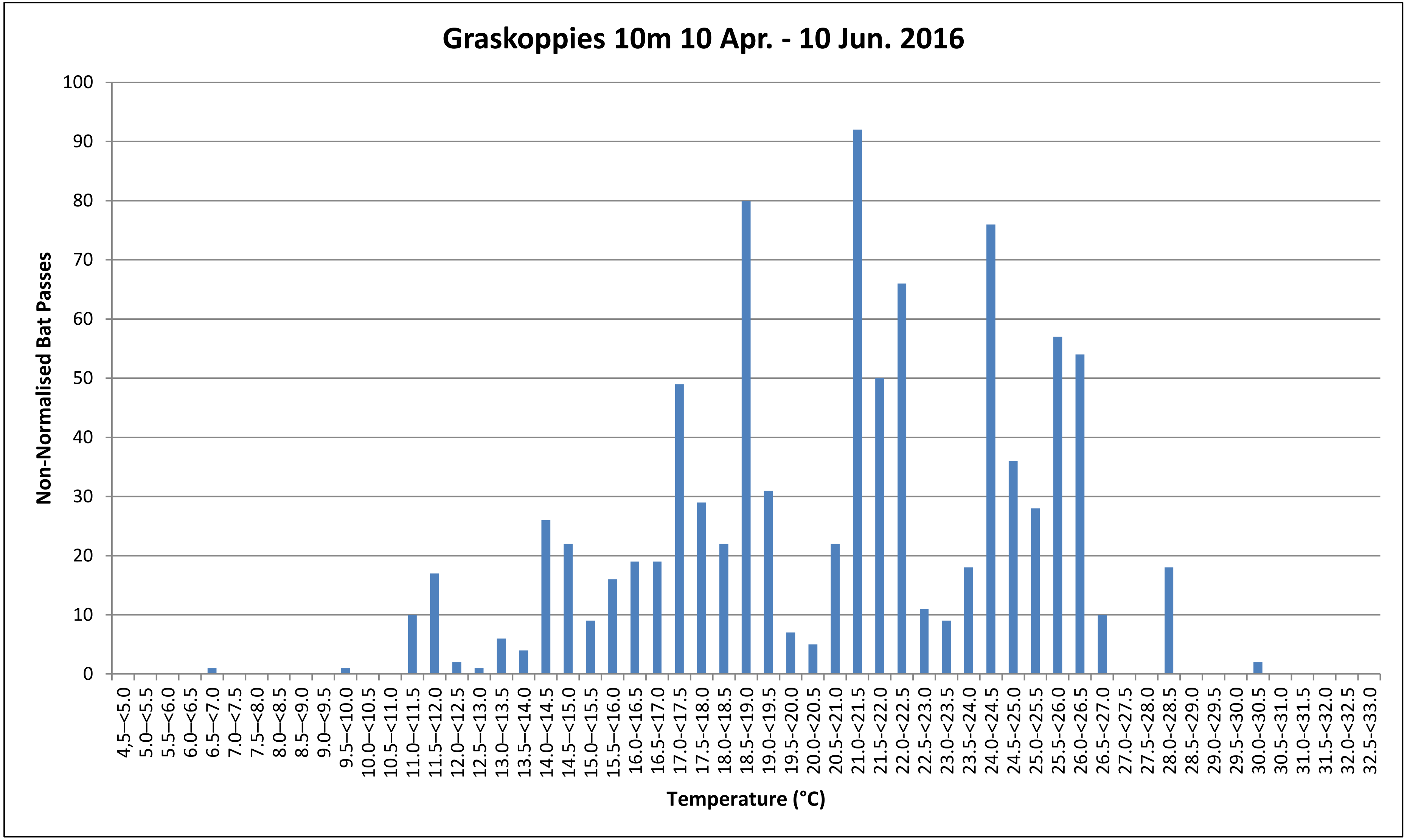


Figure 75: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 10m (10 April – 10 June 2016).

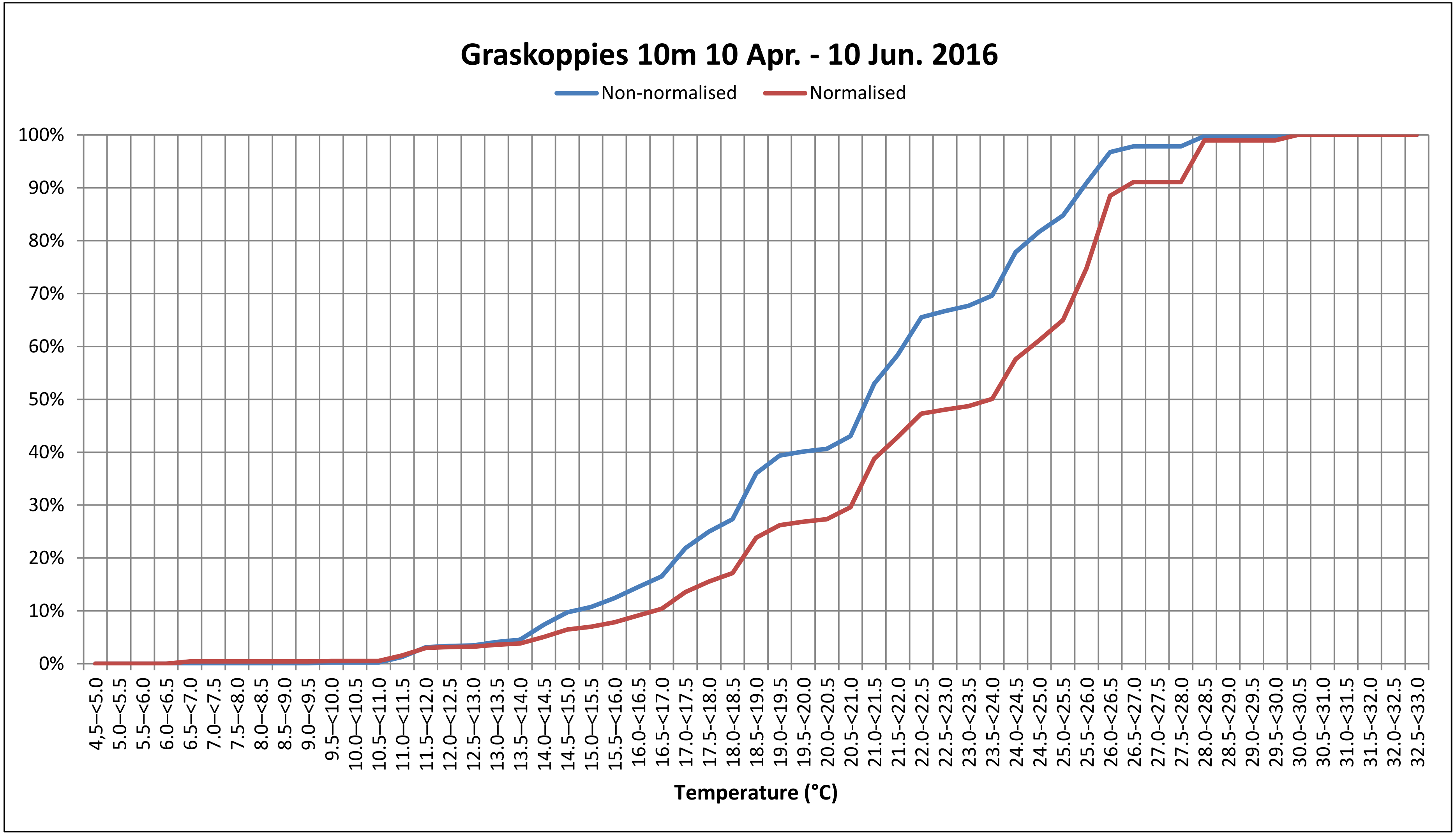


Figure 76: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Graskoppies 10m (10 April – 10 June 2016).

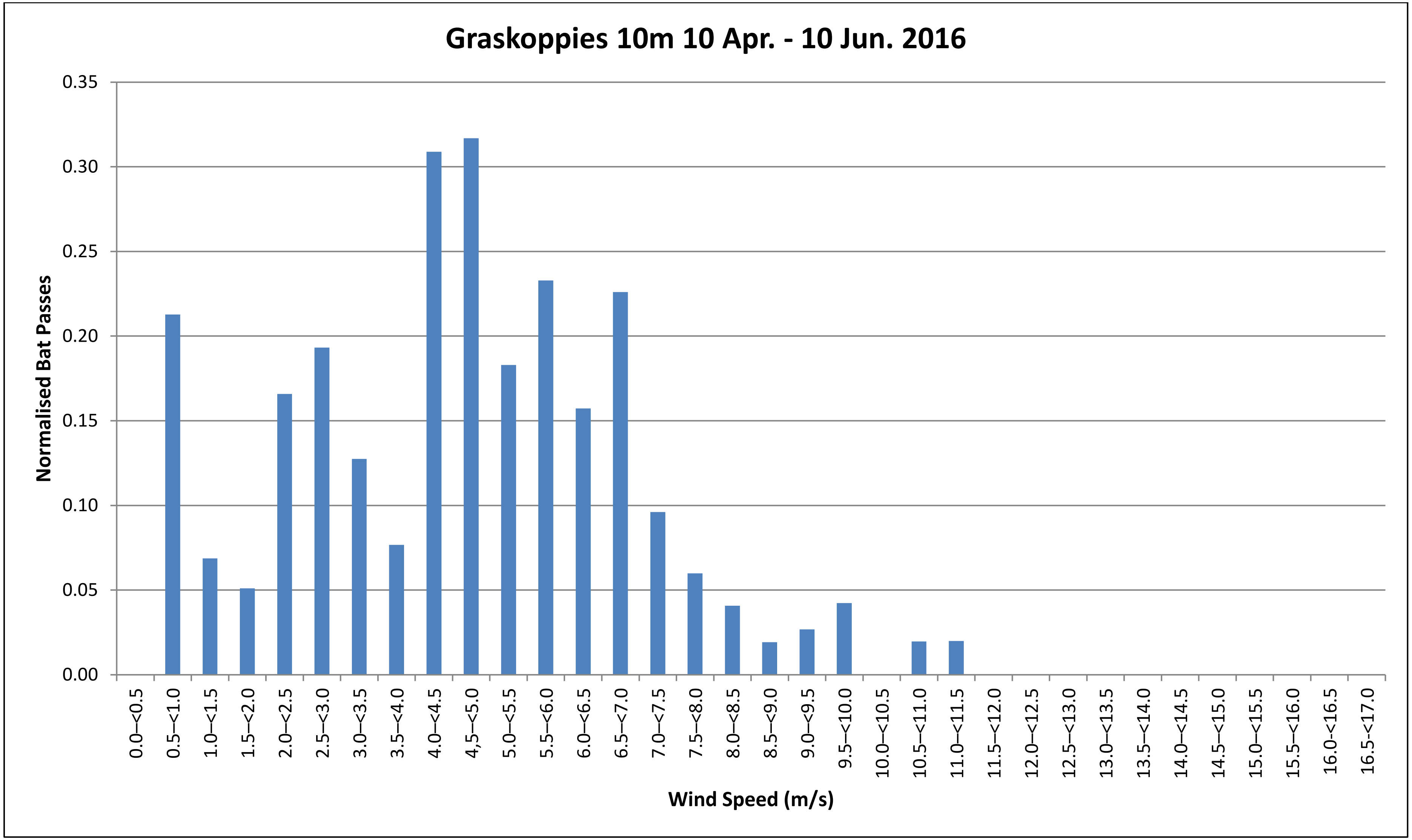


Figure 77: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 10m (10 April – 10 June 2016).

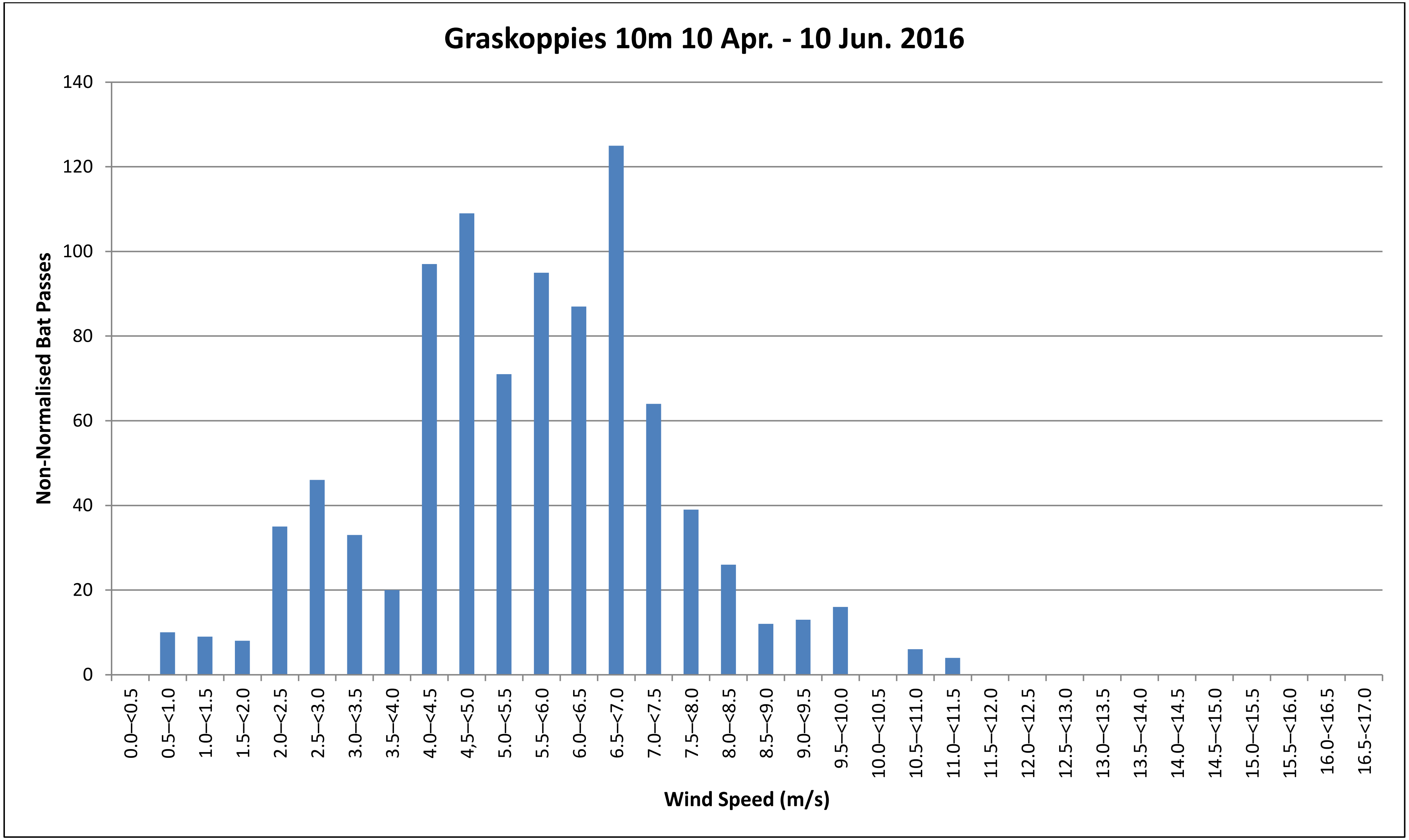


Figure 78: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 10m (10 April – 10 June 2016).

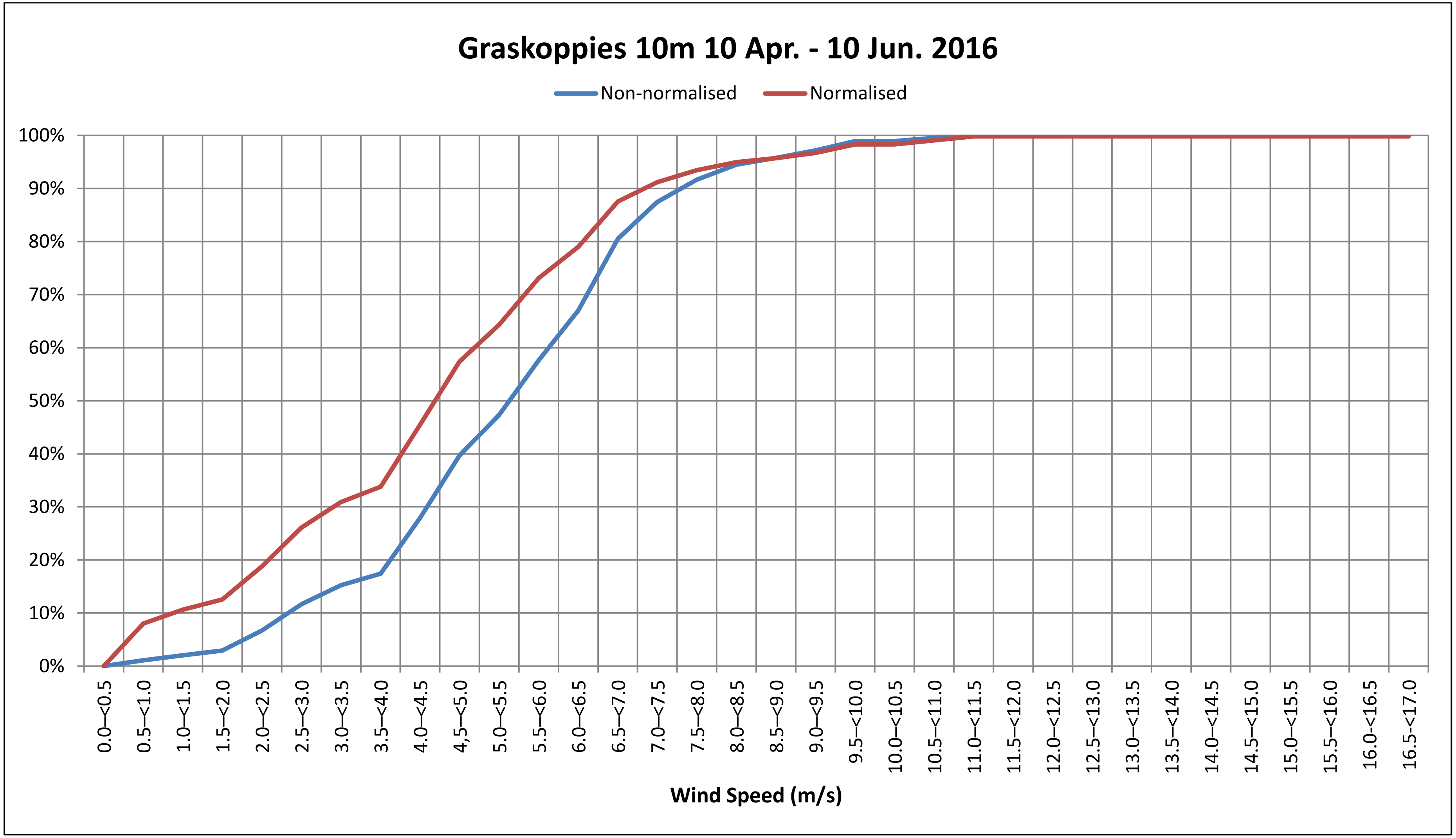


Figure 79: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 10m (10 April – 10 June 2016).

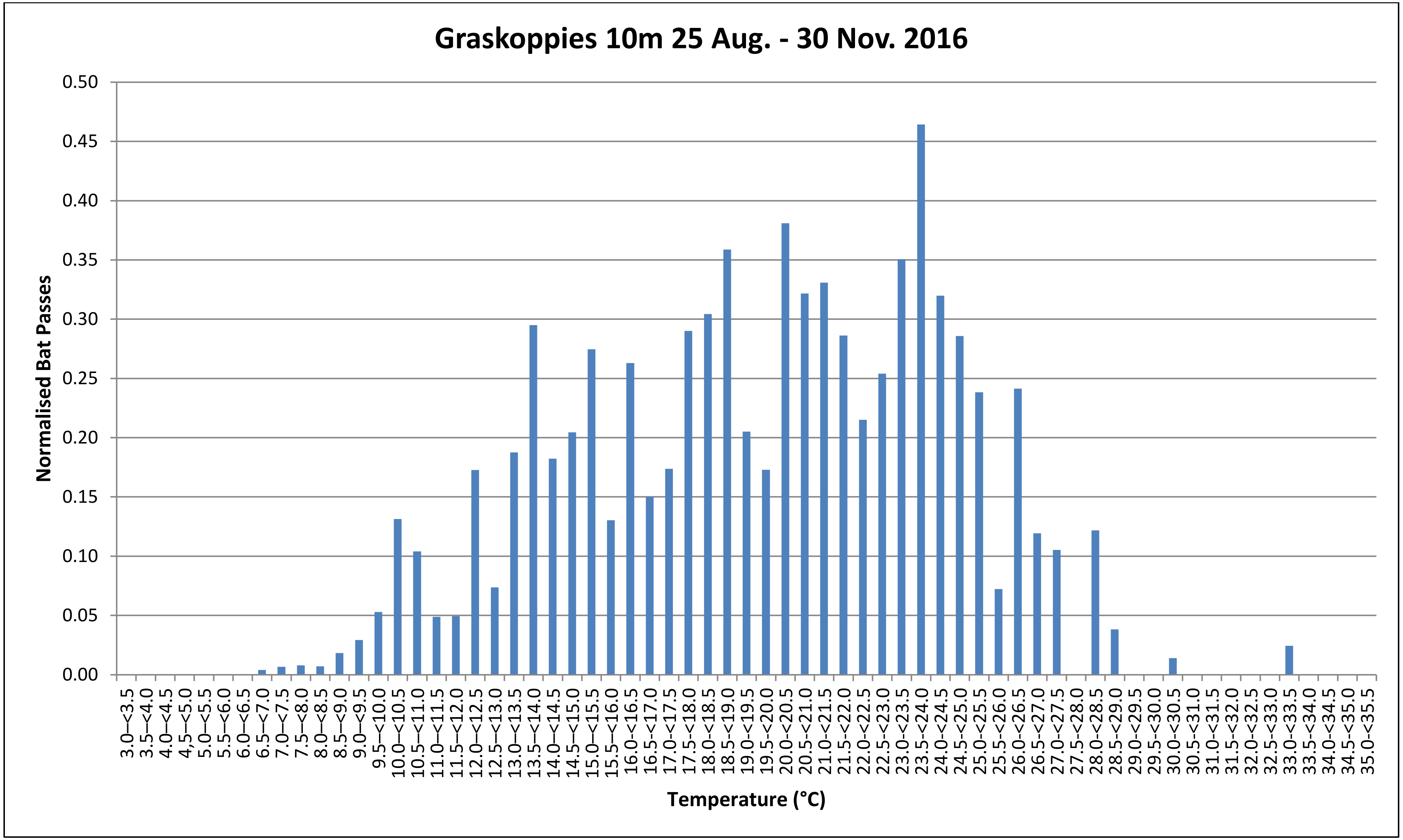


Figure 80: Sum of bat passes (Normalised) per Temperature category for Graskoppies 10m (25 August – 30 November 2016).

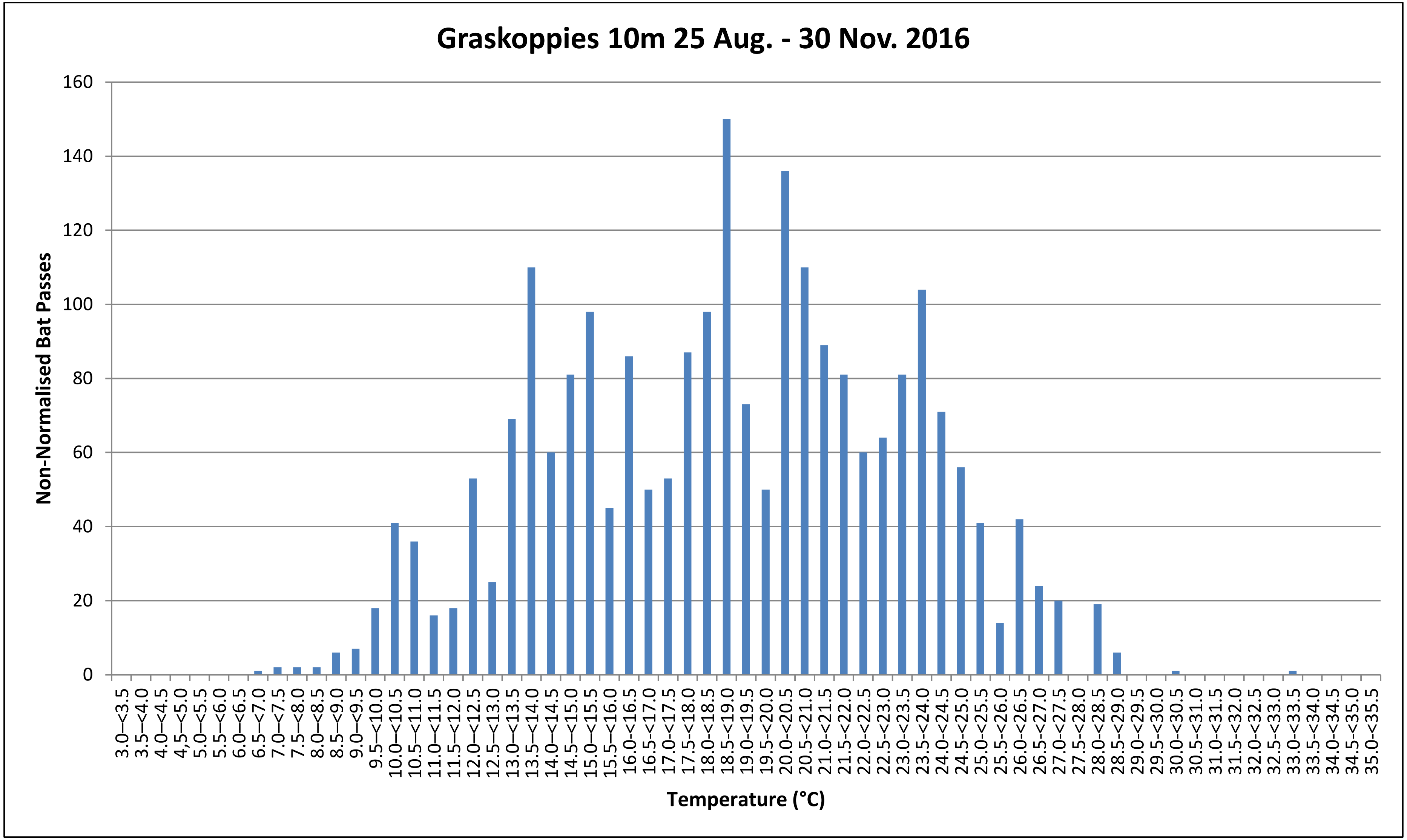


Figure 81: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 10m (25 August – 30 November 2016).

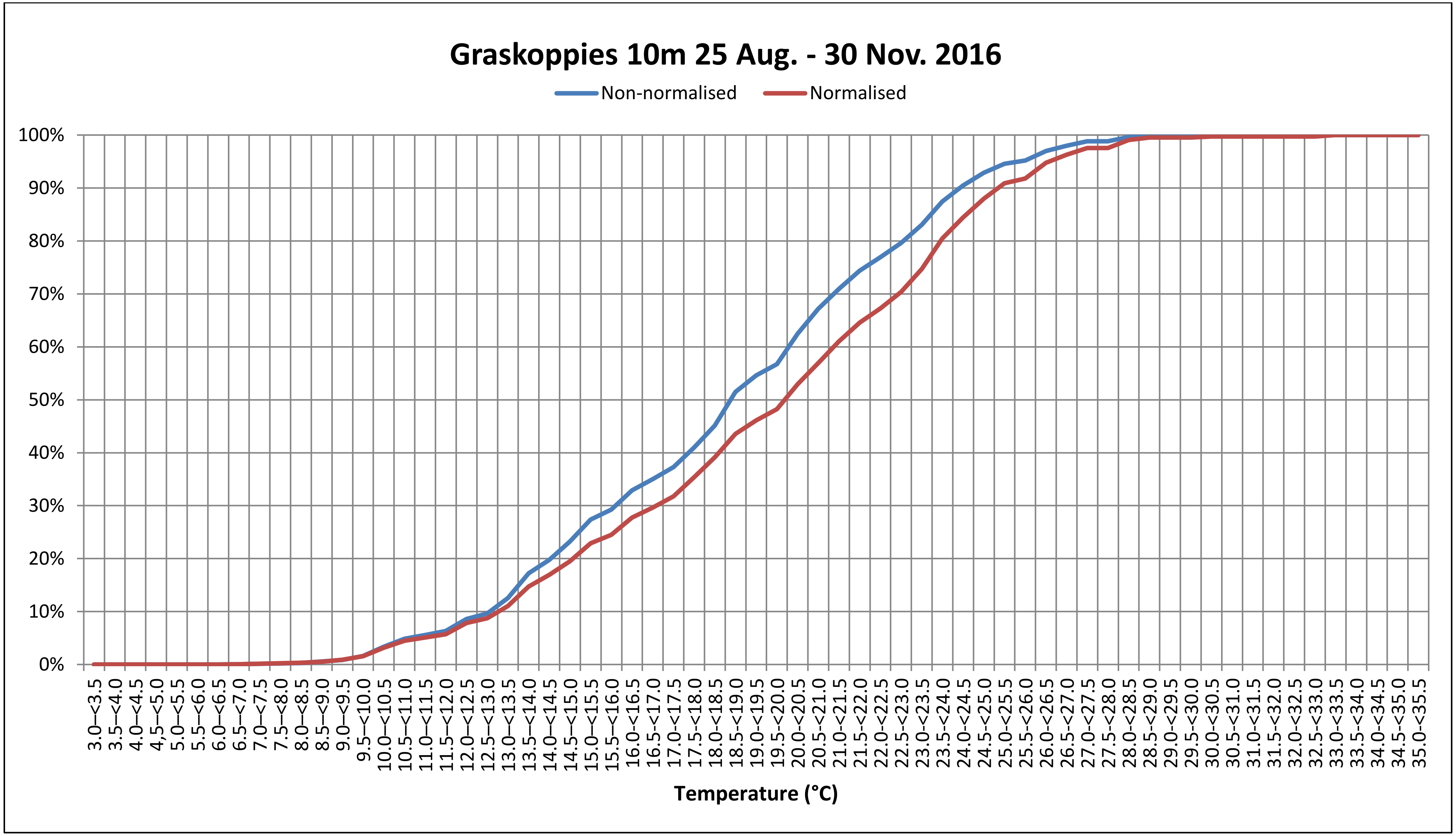


Figure 82: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Graskoppies 10m (25 August – 30 November 2016).

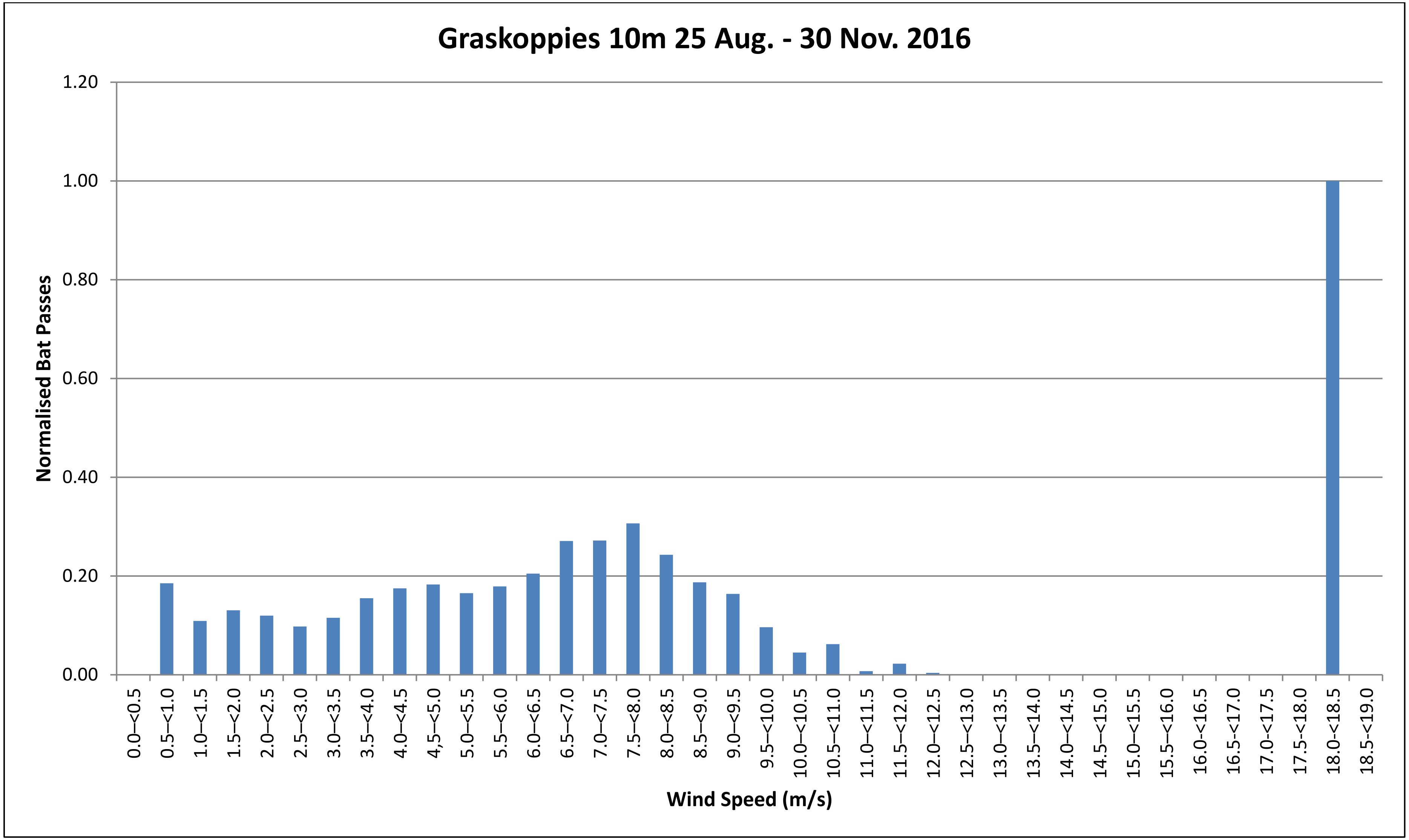


Figure 83: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 10m (25 August – 30 November 2016).

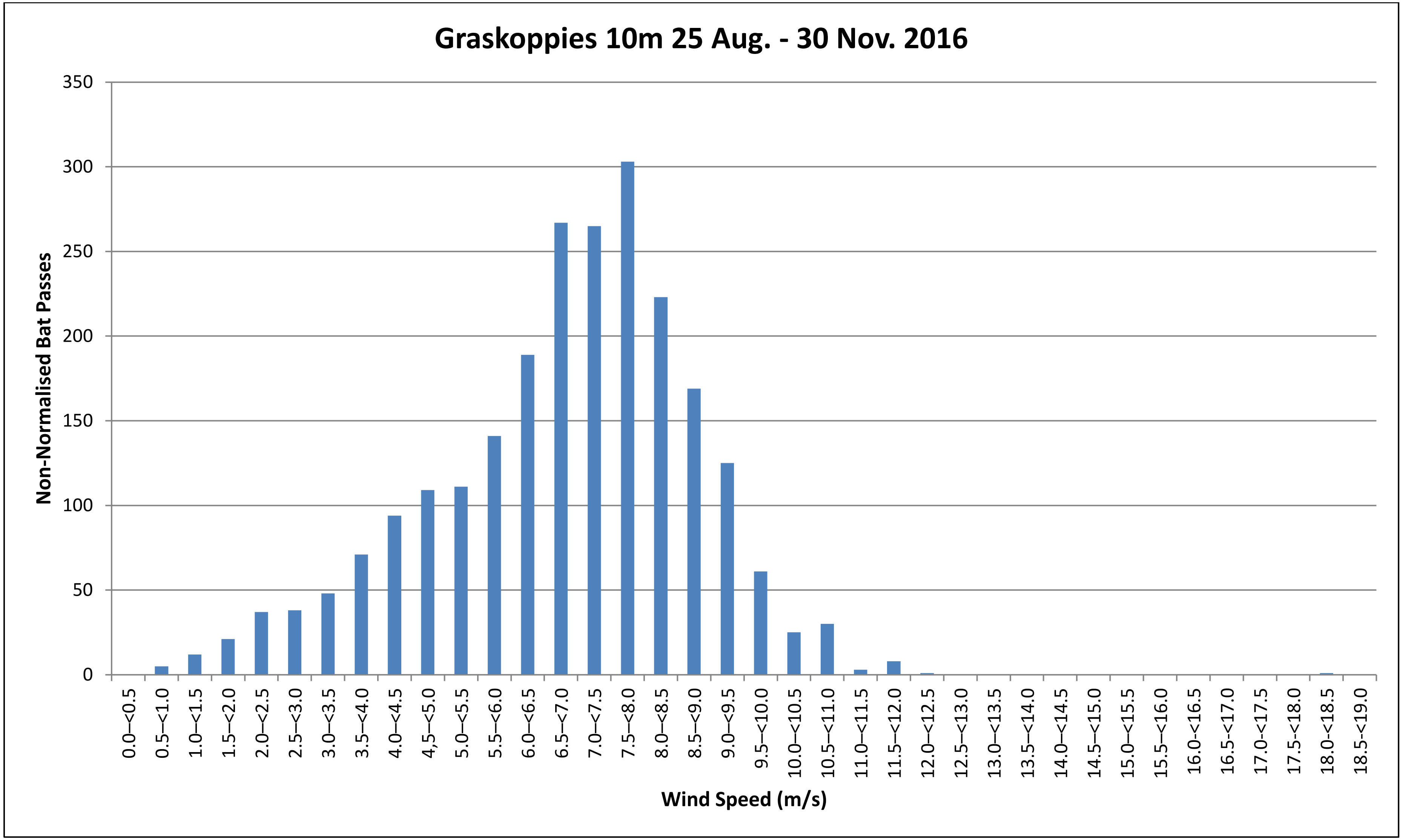


Figure 84: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 10m (25 August – 30 November 2016).

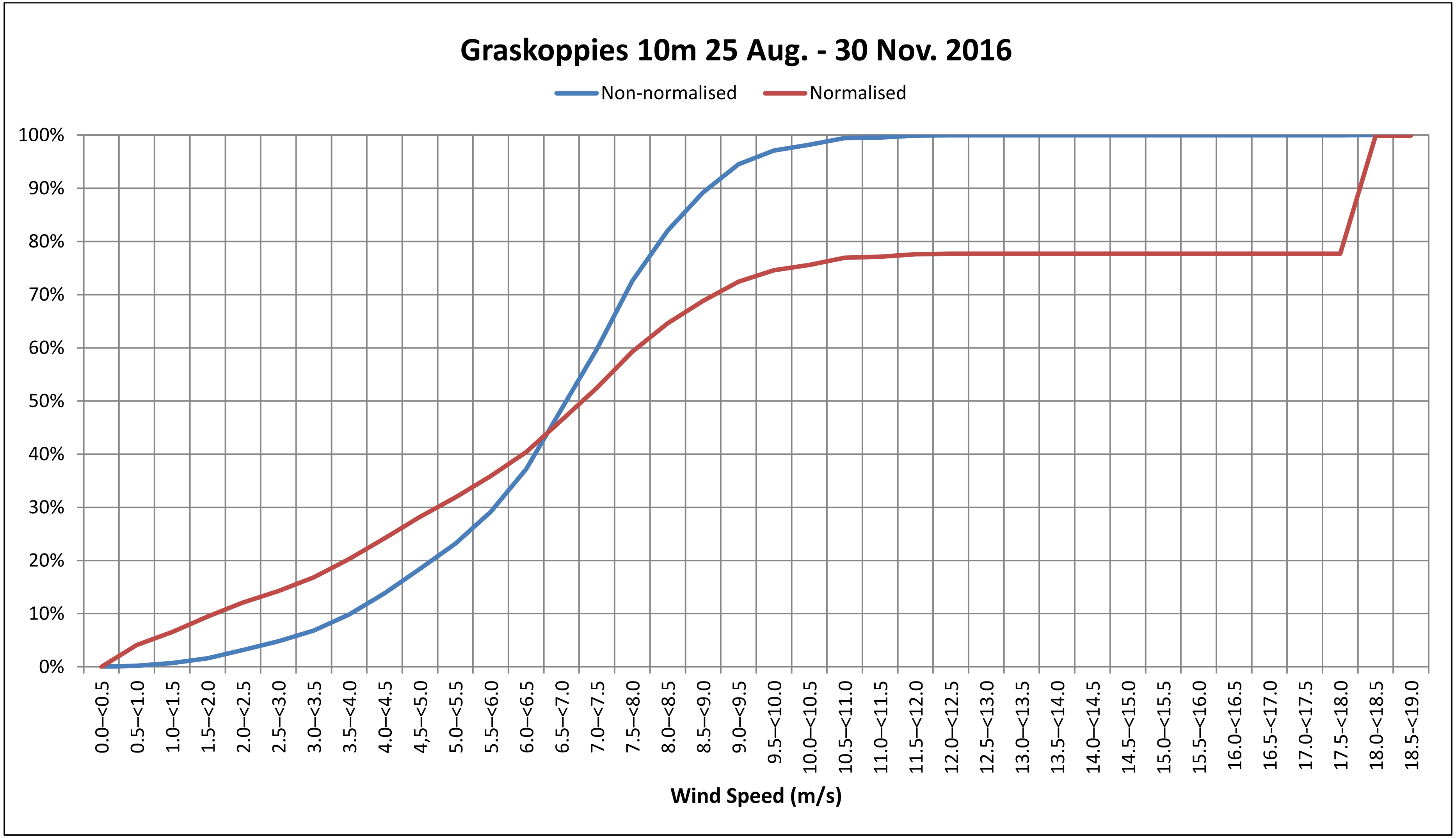


Figure 85: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 10m (25 August – 30 November 2016).

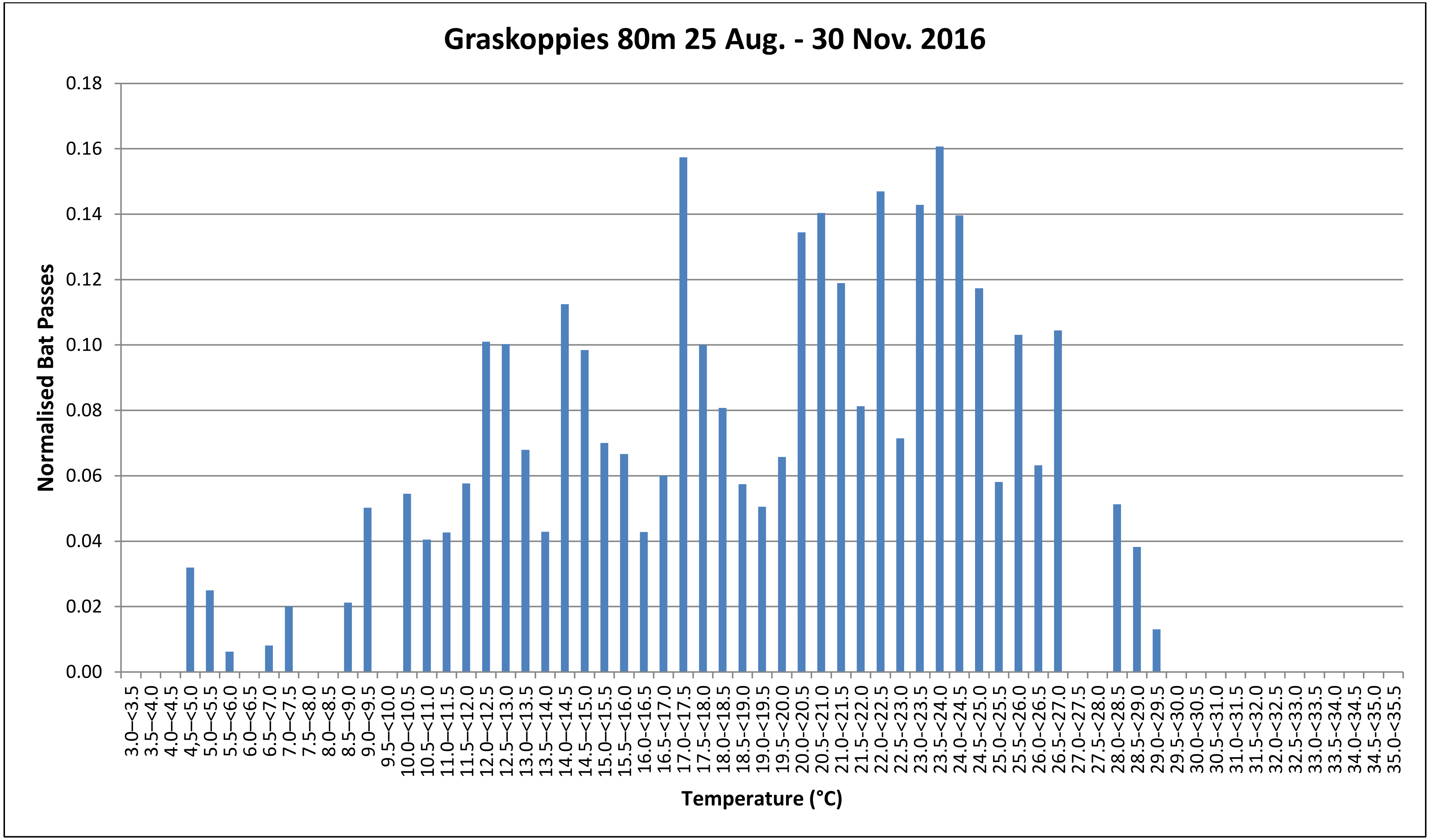


Figure 86: Sum of bat passes (Normalised) per Temperature category for Graskoppies 80m (25 August – 30 November 2016).

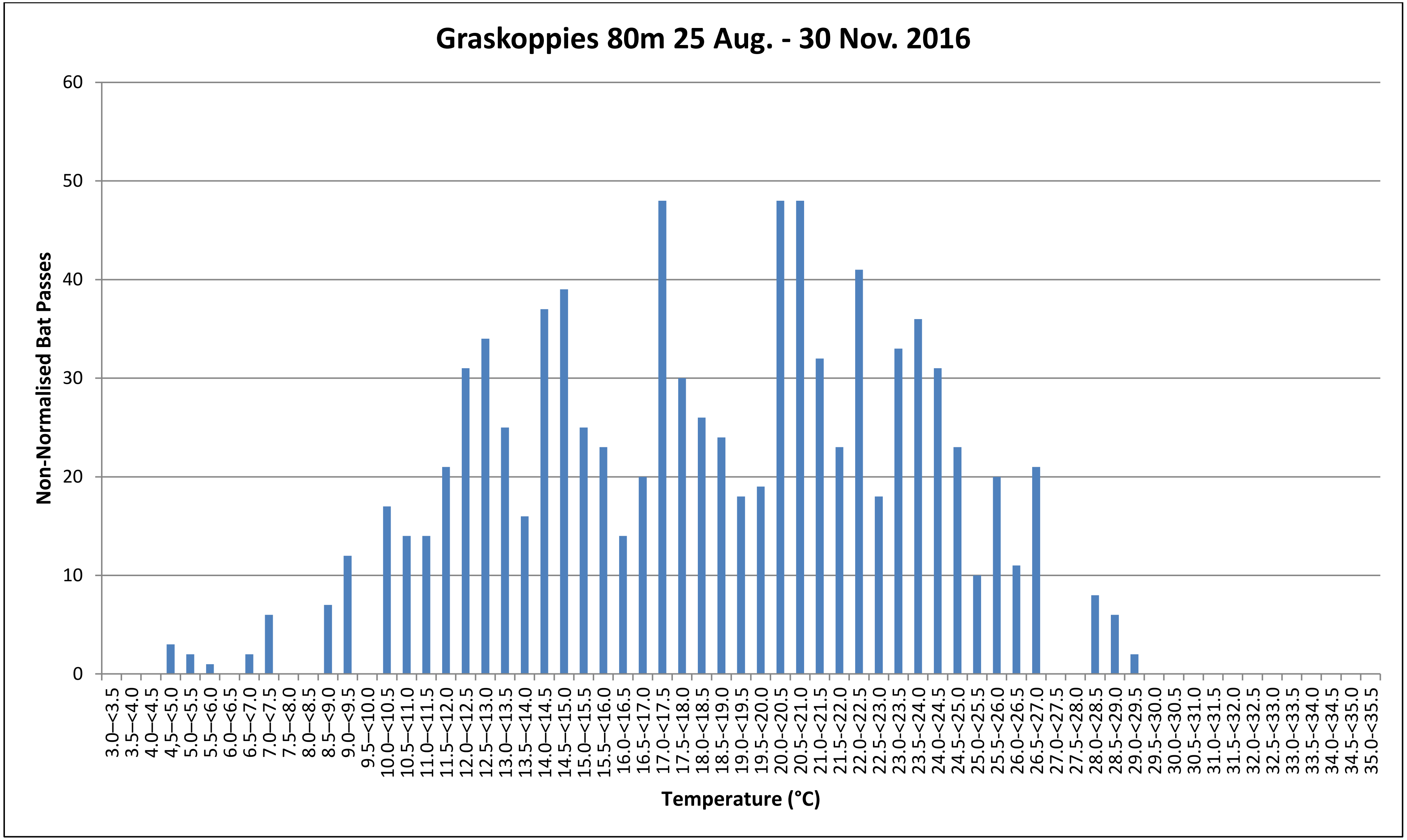


Figure 87: Sum of bat passes (Non-normalised) per Temperature category for Graskoppies 80m (25 August – 30 November 2016).

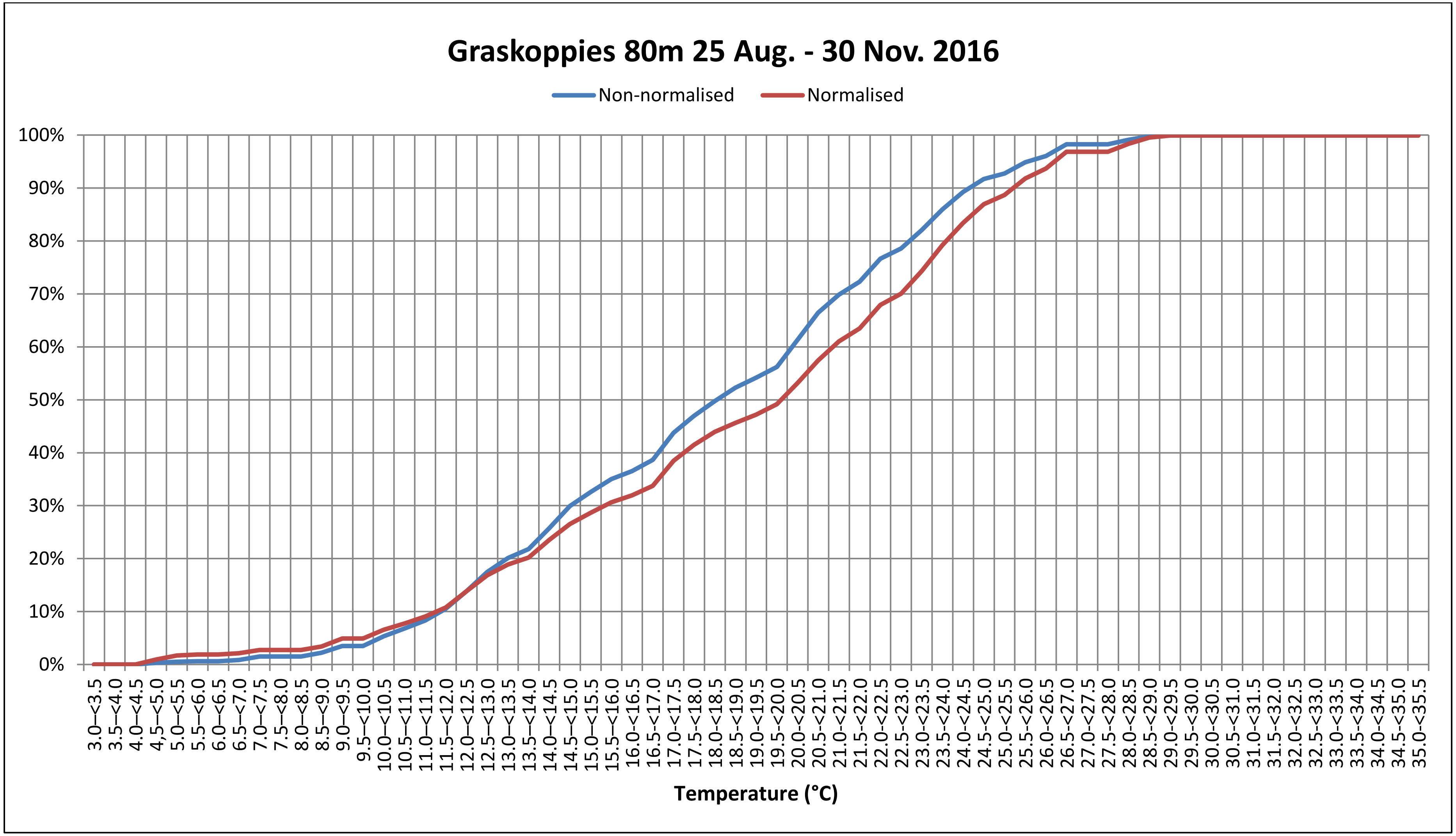


Figure 88: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Graskoppies 80m (25 August – 30 November 2016).

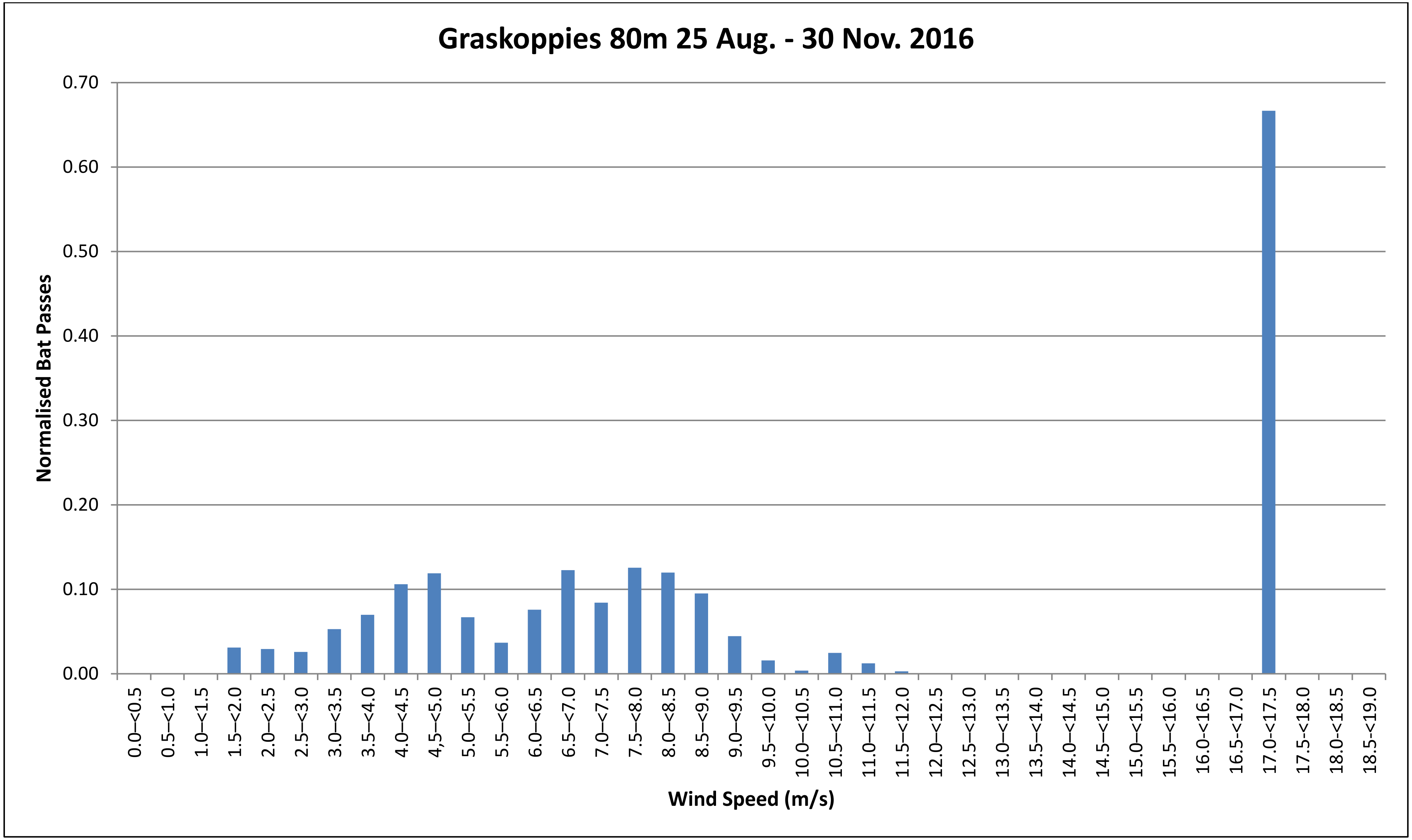


Figure 89: Sum of bat passes (Normalised) per Wind Speed category for Graskoppies 80m (25 August – 30 November 2016).

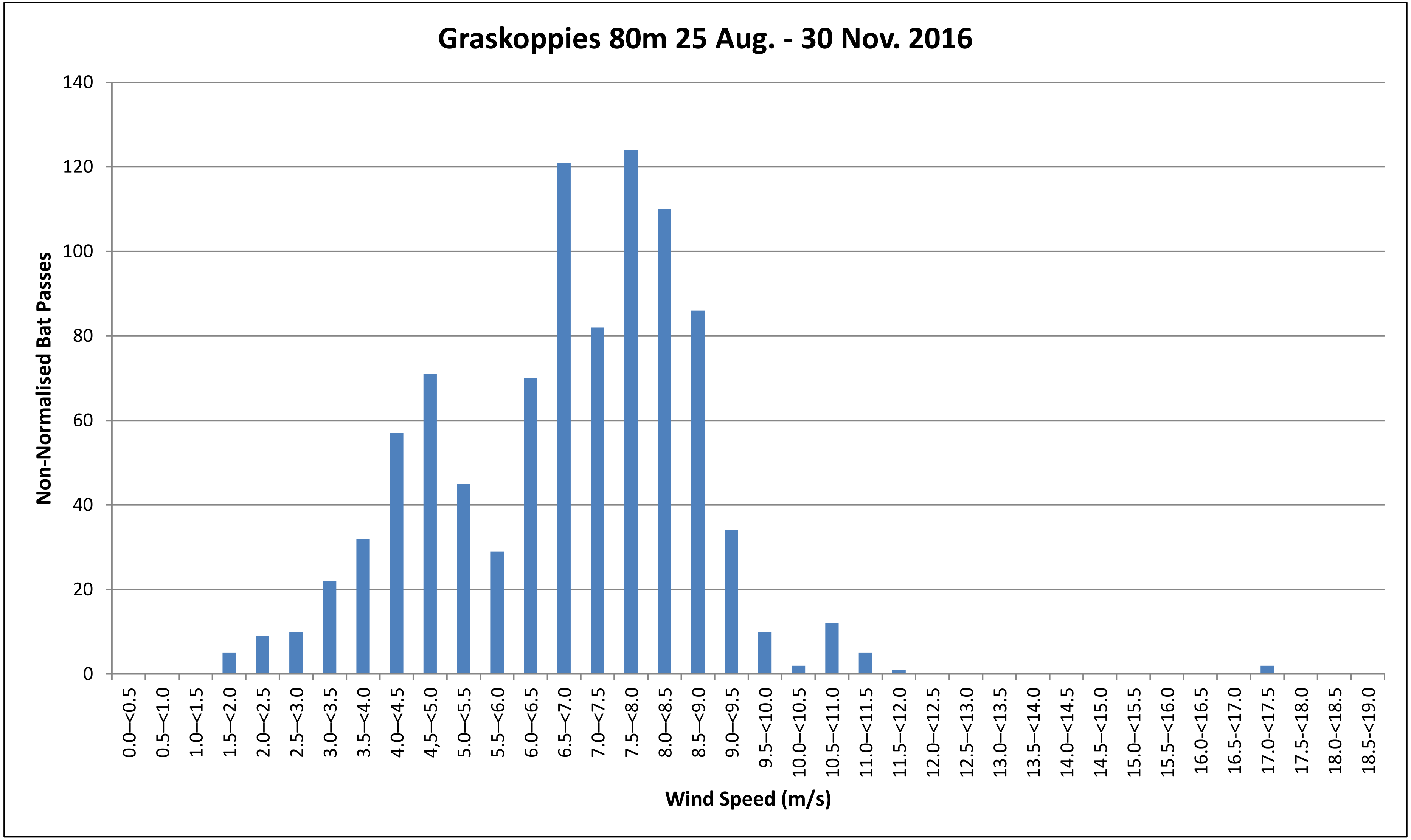


Figure 90: Sum of bat passes (Non-normalised) per Wind Speed category for Graskoppies 80m (25 August – 30 November 2016).

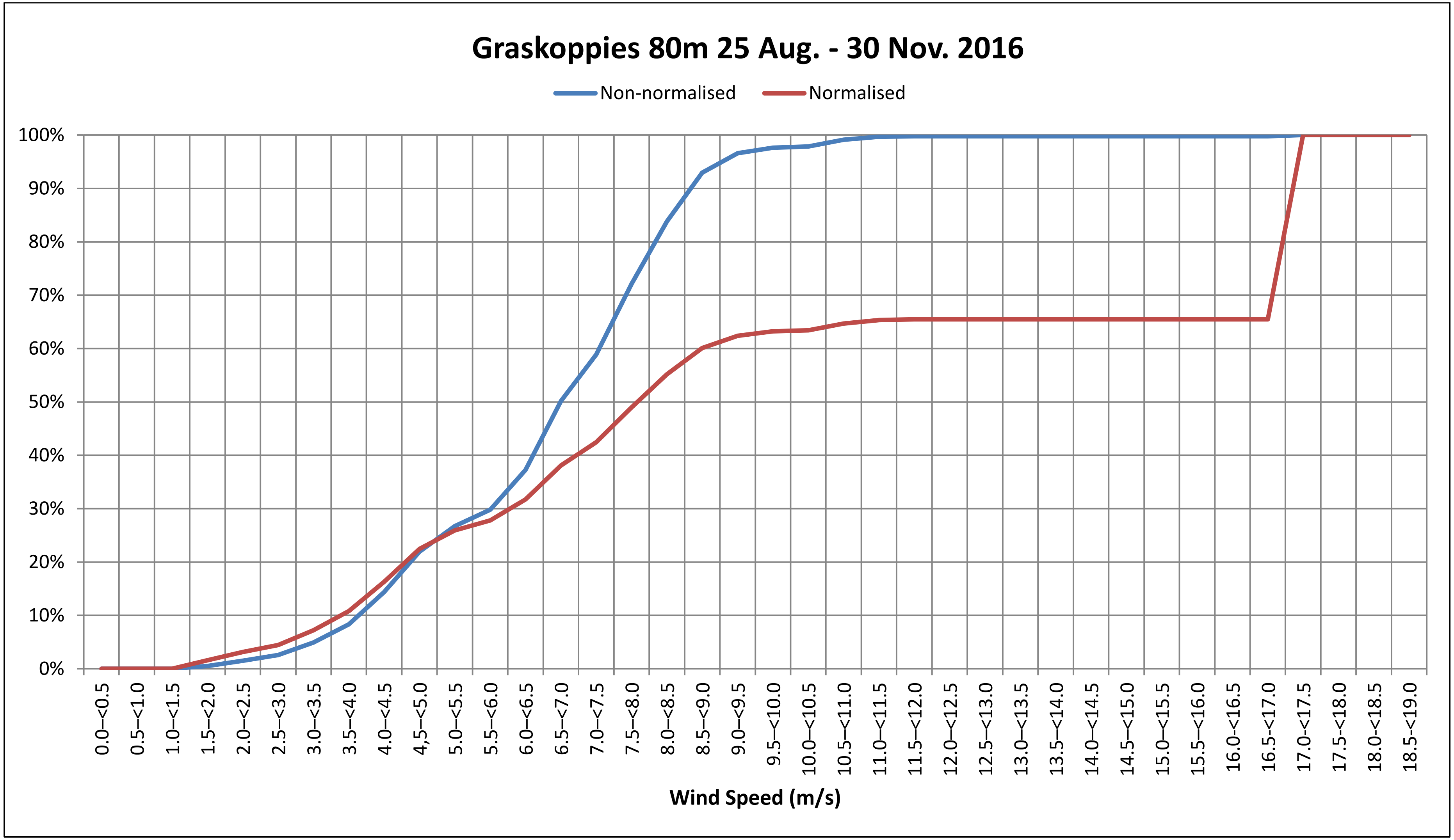


Figure 91: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Graskoppies 80m (25 August – 30 November 2016).

5 IMPACT ASSESSMENT OF PROPOSED WEF ON BAT FAUNA

5.1 Construction phase

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

IMPACT ASSESSMENT TABLE		
Environmental Parameter	Bat populations will be impacted upon through earthworks and blasting close to bat roosts.	
Issue/Impact/Environmental Effect/Nature	Earthworks and blasting close to bat roosts will negatively affect bat populations through high mortality, which in effect will cause a decrease in bat population numbers.	
Extent	If bat roosts are found to be within the site, blasting will have a negative effect on the bat populations in the local area.	
Probability	There is a probable chance of the impact occurring.	
Reversibility	Blasting occurring at bat roosts will cause damage to the bat population in the area. Depending on the extent, the impact is reversible however, recovery of the roost numbers would take place over several generations and many years.	
Irreplaceable loss of resources	If blasting and earthworks occurs close to a bat roost, it will be destroyed and lost.	
Duration	The impact will be of short duration, as blasting and earthworks will only occur during construction phase.	
Cumulative effect	Moderate effect, as the destruction of the bat roosts impact the population numbers within the area which in effect may impact the insect numbers.	
Intensity/magnitude	Blasting of bat roosts will cause mortality to the bats inhabiting the roosts, and will negatively impact the population and system.	
Significance Rating	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.	
	Pre-mitigation impact rating	**Post mitigation impact rating**
Extent	2	1
Probability	3	1
Reversibility	4	2
Irreplaceable loss	3	2
Duration	1	1
Cumulative effect	3	1
Intensity/magnitude	4	2
Significance rating	- 64 (high negative)	- 16 (low negative)

IMPACT ASSESSMENT TABLE	
Mitigation measures	Adhere to the sensitivity map during turbine placement. Blasting should be minimised and used only when necessary. A Bat Specialist should be consulted before blasting of a rocky cliff face or rocky cavernous area. The mitigation measures will reduce the impact blasting and earthworks will have on the environmental parameter, through avoiding sensitive areas.

5.1.2 Impact: Loss of foraging habitat

IMPACT ASSESSMENT TABLE		
Environmental Parameter	Loss of foraging habitat within the site boundaries.	
Issue/Impact/Environmental Effect/Nature	Loss of foraging habitat. Some minimal foraging habitat will be permanently lost by construction of turbines and access roads. Temporary foraging habitat loss will occur during construction due to storage areas and movement of heavy vehicles.	
Extent	Loss of foraging habitat will be contained within the boundaries of the development site.	
Probability	The impact will definitely occur.	
Reversibility	Depending on the degree of habitat loss, it will be partly reversed with some mitigation measures, especially in more sensitive areas. Minimal foraging habitat will be permanently lost.	
Irreplaceable loss of resources	In areas where vegetation is removed for roads and turbines, there will be a loss of habitat resources, but the scale is small.	
Duration	The impact will be of a long duration, past the operational phase of the development.	
Cumulative effect	Low effect, the removal of habitat will cause a decrease in the number of bat numbers and insect numbers within the site boundaries.	
Intensity/magnitude	Removal of foraging grounds may negatively impact the population and system, but most likely on a small scale since foraging distances are usually large for insectivorous bat species.	
Significance Rating	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.	
	Pre-mitigation impact rating	**Post mitigation impact rating**
Extent	1	1

IMPACT ASSESSMENT TABLE		
Probability	4	1
Reversibility	3	1
Irreplaceable loss	3	2
Duration	3	2
Cumulative effect	2	1
Intensity/magnitude	2	1
Significance rating	- 32 (medium negative)	- 8 (low negative)
Mitigation measures	Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or construction vehicles and keep to designated roads with all construction vehicles. Damaged areas not required after construction should be rehabilitated by an experienced vegetation succession specialist. The mitigation measures will reduce the degree of habitat loss.	

5.2 Operational phase

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

IMPACT ASSESSMENT TABLE	
Environmental Parameter	Impact on bat population numbers.
Issue/Impact/Environmental Effect/Nature	Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration). The concerns of foraging bats in relation to wind turbines is discussed in Section 2.2. If the impact is too severe (e.g. in the case of no mitigation) local bat populations may not recover from mortalities.
Extent	The impact will be contained within the boundaries of the development site.
Probability	There is a definite chance of the impact occurring.
Reversibility	The impact will occur throughout the lifespan of the wind facility. Population numbers may take very long to recover. Population and diversity genetics may be permanently altered.
Irreplaceable loss of resources	Bat population numbers will decrease in the area.

IMPACT ASSESSMENT TABLE		
Duration	The impact will be of long duration, past the operational phase of the development. It will take some time for the population to achieve its previous numbers after the impact is removed.	
Cumulative effect	High effect, as the decrease in bat numbers will in effect cause an increase in the number of insects in the area which changes the system of the area.	
Intensity/magnitude	Very high intensity impact on the bat population numbers in the area.	
Significance Rating	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".	
	Pre-mitigation impact rating	**Post mitigation impact rating**
Extent	1	1
Probability	4	2
Reversibility	4	2
Irreplaceable loss	3	2
Duration	3	3
Cumulative effect	4	3
Intensity/magnitude	4	2
Significance rating	- 76 (very high negative)	- 26 (low negative)
Mitigation measures	Adhere to the sensitivity maps, avoid areas of high bat sensitivity and their buffers as well as preferably avoid areas of Moderate bat sensitivity and their buffers. Adhere to operational mitigation measures described in Section 7 of this report. An operational phase bat monitoring study must be implemented as soon as the facility has been constructed.	

5.2.2 Impact: Artificial lighting

IMPACT ASSESSMENT TABLE	
Environmental Parameter	Impact on bat populations and diversity.
Issue/Impact/Environmental Effect/Nature	During operation, strong artificial lights that may be used at the turbine base or immediate surrounding infrastructure will attract insects and thereby also bats. This will significantly increase the likelihood of impact to

IMPACT ASSESSMENT TABLE	
	bats foraging around such lights. Additionally, only certain species of bats will readily forage around strong lights, whereas others avoid such lights even if there is insect prey available, which can draw insect prey away from other natural areas and thereby artificially favor only certain species.
Extent	Artificial lighting will be contained within the boundaries of the development site.
Probability	There is a probable chance of the impact occurring.
Reversibility	On completion of the operational phase, the artificial lighting will be removed, whereby certain bat species won't be favoured in the area.
Irreplaceable loss of resources	No
Duration	The impact will be of a long-term duration, the lifespan of the development. It will take some time to reverse the impact.
Cumulative effect	During operational phase, strong artificial lights used at the work environment during night time will attract insects and thereby also bats. However only certain species of bats will readily forage around strong lights, whereas others avoid such lights even if there is insect prey available. This can draw insect prey away from other natural areas and thereby artificially favour certain species, affecting bat diversity in the area.
Intensity/magnitude	Artificial lighting in the area will change the diversity of the bat species in the area. This will negatively affect the system.
Significance Rating	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.

	Pre-mitigation impact rating	**Post mitigation impact rating**
Extent	1	1
Probability	4	1
Reversibility	2	1
Irreplaceable loss	2	1
Duration	3	2
Cumulative effect	3	2

IMPACT ASSESSMENT TABLE		
Intensity/magnitude	2	1
Significance rating	- 30 (medium negative)	- 8 (low negative)
Mitigation measures	Utilize lights with wavelengths that attract less insects (low thermal/infrared signature). If not required for safety or security purposes, lights should be switched off when not in use or equipped with passive motion sensors. The mitigation measures will reduce the likelihood of certain bat species being favored.	

5.3 Decommissioning phase

5.3.1 Impact: Loss of foraging habitat

IMPACT ASSESSMENT TABLE		
Environmental Parameter	Loss of foraging habitat within the site boundaries.	
Issue/Impact/Environmental Effect/Nature	Loss of foraging habitat. Some minimal foraging habitat will be permanently lost by decommissioning of the facility.	
Extent	Loss of foraging habitat will be contained within the boundaries of the facility site.	
Probability	There is a probable chance of the impact occurring.	
Reversibility	Depending on the degree of habitat loss, it will be partly reversed with some mitigation measures, especially in more sensitive areas.	
Irreplaceable loss of resources	In areas where vegetation is removed there will be a loss of habitat resources.	
Duration	The impact will be of a long duration	
Cumulative effect	Low effect, as the removal of habitat will cause a decrease in the number of bat numbers and insect numbers within the site boundaries.	
Intensity/magnitude	Removal of foraging grounds may negatively impact the population and system, but most likely on a small scale since foraging distances are usually large for insectivorous bat species.	
Significance Rating	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.	
	Pre-mitigation impact	**Post mitigation impact**

IMPACT ASSESSMENT TABLE		
	rating	**rating**
Extent	1	1
Probability	3	1
Reversibility	3	1
Irreplaceable loss	3	2
Duration	3	2
Cumulative effect	2	1
Intensity/magnitude	2	1
Significance rating	- 30 (medium negative)	- 8 (low negative)
Mitigation measures	Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or large vehicles and keep to designated roads with all large vehicles. Damaged areas not required after decommissioning should be rehabilitated by an experienced vegetation succession specialist. The mitigation measures will reduce the degree of habitat loss.	

6 CUMULATIVE IMPACT ASSESSMENT

Several renewable energy development applications have been submitted and/or authorized within the immediate area of the proposed Graskoppies WEF. **Figure 92** below displays these areas and **Table 11** lists the neighbouring renewable energy projects. The impact of the Graskoppies wind energy facility was assessed in **Section 5** above; this section assesses the cumulative impact of all renewable energy developments within the area.

Table 11: Neighbouring renewable energy developments

Development	Current status of EIA/development	Proponent	Capacity	Farm details
Khobab Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 2 of Farm Sous 226
Loeriesfontein 2 Wind Farm	Under Construction	Mainstream Renewable Power	140MW	Pt 1 & 2 of Farm Aan de Karree Doorn Pan 213
Wind farm	Environmental Authorisation issued	Mainstream Renewable Power	50MW	Pt 1 of Farm Aan de Karree Doorn Pan 213
PV Solar Energy Facility	Environmental Authorisation issued	Mainstream Renewable Power	100MW	Portion 2 of Farm Aan de Karree

				Doorn Pan 213
Hantam PV Solar Energy Facility	Environmental Authorisation issued / Approved under RE IPPPP	Solar Capital (Pty) Ltd	Up to 525MW	RE of Farm Narosies 228
PV Solar Power Plant	Environmental Authorisation issued	BioTherm Energy	70MW	Pt 5 of Farm Kleine Rooiberg 227
Dwarsrug Wind Farm	Environmental Authorisation issued	Mainstream Renewable Power	140MW	Remainder of Brak Pan 212 Stinkputs 229

The impacts of the neighbouring wind farms are considered in this section as the impacts of solar developments are not easily comparable. The bat sensitivity assessment reports and bat sensitivity maps could not be obtained for all of the neighbouring wind energy developments. The final pre-construction bat sensitivity information for the below listed wind energy facilities were used where applicable:

- Loeriesfontein 2 Wind Farm
- Dwarsrug Wind Farm

6.1 Cumulative Impact Assessment Rating

The table below lists and summarises the impact assessment for Graskoppies WEF taking into account the information from available Specialist reports of the neighbouring wind energy projects.

The main impact on bats that raises concern from a cumulative impact assessment point of view is the bat mortalities due to direct turbine blade collision or barotrauma during operation. There is potential for mass loss of locally active bats and migratory bats from the area due to cumulative mortality from wind turbines of several neighbouring wind farms. This impact is assessed below.

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

IMPACT ASSESSMENT TABLE	
Environmental Parameter	Impact on bat population numbers.
Issue/Impact/Environmental Effect/Nature	Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration). The concerns of

IMPACT ASSESSMENT TABLE	
	foraging bats in relation to wind turbines is discussed in Section 2.2. If the impact is too severe (e.g. in the case of no mitigation) migrating bat populations may not recover from mortalities.
Extent	The impact will occur nationally.
Probability	There is a high probability of the impact occurring.
Reversibility	The impact will occur throughout the lifespan of the wind facility as well as other facilities in the area, therefore population numbers may take very long to recover. There is a higher probability for population and diversity genetics to be permanently altered in cumulative impacts.
Irreplaceable loss of resources	Bat population numbers will decrease in the area.
Duration	The impact will be of long duration, over the operational phase of the facility. It will take many years for the population to achieve its previous numbers after the impact is removed.
Cumulative effect	High cumulative effects. Mortalities of bats due to wind turbines during foraging and migration can have significant ecological consequences as the bat species at risk are insectivorous and thereby contribute significantly to the control of nocturnal flying insects. On a project specific level insect numbers in a certain habitat can increase if significant numbers of bats are killed off. But if such an impact is present on multiple projects in close vicinity of each other, insect numbers can increase regionally and possibly cause outbreaks of colonies of certain insect species. If migrating bats are killed off it can have detrimental effects on the cave ecology of the caves that a specific colony utilises. This is due to the fact that bat guano is the primary form of energy input into a cave ecology system.
Intensity/magnitude	Very high intensity impact on the bat population numbers in the area.
Significance Rating	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately.

IMPACT ASSESSMENT TABLE		
	Pre-mitigation impact rating	**Post mitigation impact rating**
Extent	4	4
Probability	3	3
Reversibility	4	2
Irreplaceable loss	3	2
Duration	3	2
Cumulative effect	4	3
Intensity/magnitude	4	2
Significance rating	- 84 (very high negative)	- 32 (medium negative)
Mitigation measures	The high sensitivity valley areas can serve as commuting corridors for bats in the larger area, potentially lowering the cumulative effects of several WEF's in an area. Adhere to recommended mitigation measures for this project as described in Section 8 of this report. It is essential that project specific mitigations be applied and adhered to for each project, as there is no overarching mitigation that can be recommended on a regional level due to habitat and ecological differences between project sites. Adhere to the sensitivity map during any further turbine layout revisions.	

Figure 92: Renewable energy facilities neighbouring the proposed Graskoppies WEF

7 ASSESSMENT OF ALTERNATIVES

The Graskoppies WEF has two options for the on-site substation location which have been assessed to determine which option is most suitable for lowered bat fauna impacts.

Table 12: Key to determine the preference of the on-site substation.

PREFERRED	The alternative will result in a low impact / reduce the impact
FAVOURABLE	The impact will be relatively insignificant
NOT PREFERRED	The alternative will result in a high impact / increase the impact
NO PREFERENCE	The alternative will result in equal impacts

Table 13: On-site substation alternatives and preference

Alternative	Preference	Reasons (incl. potential issues)
SUBSTATION ALTERNATIVES		
On-site Substation Option 1 (East)	No Preference	The alternative will result in equal impacts
On-site Substation Option 2 (West)	No Preference	The alternative will result in equal impacts

Figure 93: On-site substation alternatives for the Graskoppies WEF.

8 PROPOSED INITIAL MITIGATION MEASURES AND DETAILS

The correct placement of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area, and should be considered as the initial method of 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). Wind speed measured at a height of 61m and temperature measured at a height of 40m were used for the analysis.

All turbines of the Graskoppies WEF must be curtailed below cut in speed and not allow for free-wheeling from the start of operation. Bat activity is markedly higher over low wind speed periods. Preventing free-wheeling should not affect energy production significantly and will be a significant bat conservation mitigation measure.

Table 14: The times and weather conditions during which to implement mitigation

Terms of mitigation implementation	
Peak activity (times to implement curtailment/ mitigation)	Met Mast (10m): 15 – 25 January from the time of sunset to 04:00
Environmental conditions in which to implement curtailment/ mitigation	Met Mast (10m): Wind speed below 8.5m/s *and* Temperature above 20°C
Peak activity (times to implement curtailment/ mitigation)	Met Mast (80m): 15 – 25 January over the time of sunset – 01:00
Environmental conditions in which to implement curtailment/ mitigation	Met Mast (80m): Wind speed below 7m/s *and* Temperature above 18°C

Peak activity (times to implement curtailment/ mitigation)	Met Mast (10m): 15 February – 31 March over the time of sunset – 04:00
Environmental conditions in which to implement curtailment/ mitigation -	Met Mast (10m): Wind speed below 8.0m/s *and* Temperature above 16.0°C
Peak activity (times to implement curtailment/ mitigation)	Met Mast (10m): 10 April – 10 June over the time of sunset – 04:00
Environmental conditions in which to implement curtailment/ mitigation	Met Mast (10m): Wind speed below 6m/s *and* Temperature above 17°C
Peak activity (times to implement curtailment/ mitigation)	Met Mast (10m): 25 August – 30 November over the time of sunset – 03:00
Environmental conditions in which to implement curtailment/ mitigation	Met Mast (10m): Wind speed below 8m/s *and* Temperature above 14°C
Peak activity (times to implement curtailment/ mitigation)	Met Mast (80m): 25 August – 30 November over the time of sunset – 00:00
Environmental conditions in which to implement curtailment/ mitigation	Met Mast (80m): Wind speed below 8m/s *and* Temperature above 13°C

Mitigation options include curtailment, blade feathering, blade lock, acoustic deterrents or light lures. The following terminology applies:

Curtailment:

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

Cut-in speed:

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

Feathering or Feathered:

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

Free-wheeling:

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

Increasing cut-in speed:

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

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

Acoustic deterrents:

Are a developing technology and will need further investigation closer to time of wind farm operation, opportunities to test such devices may be available during operation of the facility.

Light lures:

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

Habitat modification:

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

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

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

1. No curtailment (free-wheeling is unhindered below manufacturer's cut in speed so all momentum is retained, thus normal operation).

2. Partial feathering (45 degree angle) of blades below manufacturer's cut-in speed in order to allow the free-wheeling blades half the speed it would have had without feathering (some momentum is retained below the cut in speed).

3. Ninety degree feathering of blades below manufacturer's cut-in speed so it is exactly parallel to the wind direction as to minimize free-wheeling blade rotation as much as possible without locking the blades.

4. Ninety degree feathering of blades below manufacturer's cut-in speed, with partial feathering (45 degree angle) between the manufacturer's cut-in speed and mitigation cut-in conditions.

5. Ninety degree feathering of blades below mitigation cut in conditions.

6. Ninety degree feathering throughout the entire night.

It is recommended that curtailment be applied initially to all turbines at the start of operation at Level 3 of the mitigation scale. Mitigation at level 5 must be applied during the climatic conditions and time frames outlined in **Table 14** to the turbines highlighted in yellow in **Figure 94** below. The impacts of this mitigation schedule will then be monitored during the operational phase bat study, 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 changes, suggested by the appointed Bat Specialist, 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).

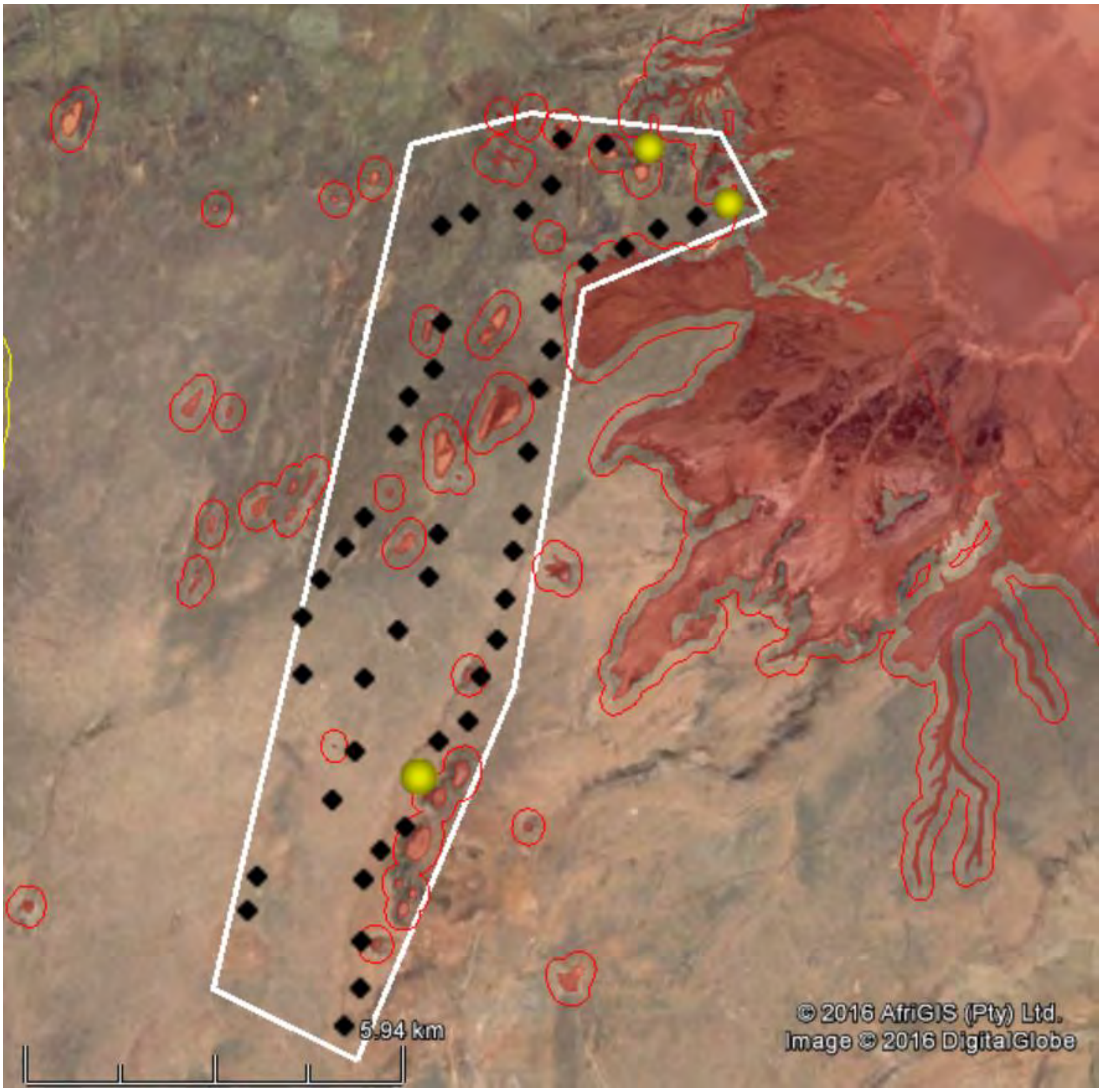


Figure 94: Turbines (yellow icons) identified for mitigation application as they are higher risk for direct bat mortality

9 CONCLUSION

The site was visited over the period of November 2015 to December 2016 wherein data was collected from the five 10m mast and one meteorological mast, where after the systems were decommissioned**.** The long-term data was analysed by means of identifying the bat species detected by the monitoring systems and the periods of high bat activity.

A number of technical failures occurred with the monitoring systems. The failures should not compromise the study since an adequate amount of data was recorded during the 12 months.

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

Miniopterus natalensis is the only migratory species detected on site. It was detected by all the monitoring systems, with Short Mast 3 detecting the highest number of passes. The results of the full 12 months monitoring study were analysed for the presence of a migratory event in order to determine whether the site is located within a migratory route. There were no signs and activity levels indicative of a migratory event however, an event may occur in the future and the Operational Phase Bat Monitoring Study must be designed such that a migratory event would be detected if it occurred.

Met Mast monitoring system indicates the highest amount of bat passes, followed by Short Mast 3 **(Figure 14 and 17)**.

The average nightly bat passes per month is used to show the general trend in bat activity across the different month of the year. All the masts show higher bat activity from January to April with predominant peaks for the month of March, except for Short Mast 4 which has a peak in January 2016 (**Figures 20 – 25**), except for Short Mast 2 which was not recording during January as explained above. Bat activity decreased as the seasons changed into winter. An increase in bat activity, for all the monitoring systems, occurred again from August to November as the seasons changed from winter to spring.

A sensitivity map was drawn up indicating potential roosting and foraging habitat (**Figure 11**). The Moderate bat sensitivity areas and associated buffer zones must be prioritised during operational monitoring and preferably be avoided during turbine placement, if another feasible option is available. The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity. High Bat Sensitivity areas are 'no – go' areas due to expected elevated rates of bat fatalities due to wind turbines. Turbines located within high sensitivity areas and their buffers are identified in **Figure 12**.

These turbines must be moved out of high sensitivity areas and buffers or removed from the layout. There were no turbines located within moderate sensitivity areas.

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

It is recommended that curtailment be applied initially to all turbines at the start of operation at Level 3 of the mitigation scale. Mitigation at level 5 must be applied during the climatic conditions and time frames outlined in **Table 14** to the turbines highlighted in yellow in **Figure 94**. The impacts of this mitigation schedule will then be monitored during the operational phase bat study, 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 changes, suggested by the appointed Bat Specialist, 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).

10 REFERENCES

ACR. 2010. *African Chiroptera Report, 2010*. African Bats, Pretoria.

Arnett, E. B., Huso, M. M. P., Schirmacher, M. R and Hayes, J. P. 2009. Patterns of bat fatality at the Casselman Wind Project in south-central Pennsylvania. An annual report of the Bats and Wind Energy Cooperative and the Pennsylvania Game Commission. Bat Conservation International. Austin, Texas, USA.

Arnett, E. B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Baerwald, E. F., D'Amours, G. H., Klug, B.J. and Barclay, R. M. R. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. *Current Biology* 18: 695-695.

Barclay, R. M. R., Baerwald, E. F., and Gruver, J. C. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85: 381-387.

Bernard, R. T. F. and Tsita, J. N. 1995. Seasonally monoestrous reproduction in the molossid bat, *Tadarida aegyptiaca,* from low temperature latitudes (35^{o}S) in South Africa. *South African Journal of Zoology* 30: 18-22.

Cryan, P. M. and Barclay, R. M. R. 2009. Causes of bat fatalities at wind turbines: Hypotheses and predictions. *Journal of Mammalogy* 90: 1330-1340.

Herselman, J. C. 1980. The distribution and status of bats in the Cape Province. International Report. Cape Department of Nature and Environmental Conservation.

Hester, S. G. and Grenier, M.B. 2005. *A conservation plan for bats in Wyoming*. Lander, WY: Wyoming Game and Fish Department, Nongame Program.

Horn, J. W., Arnett, E. B. and Kunz, T.H. 2008. Behavioural responses of bats to operating wind turbines. *Journal of Wildlife Management* 72: 123-132.

Howe, R. H., Evans, W. and Wolf, A. T. 2002. Effects of wind turbines on Birds and Bats on Northeastern Wisconsin. Report submitted to *Wisconsin Public Service Corporation and Madison Gas and Electric Company*.

Johnson, G. D., Erickson, W. P., Stickland, M. D., Shepherd, M. F., Shepherd, D. A. and Sarappo, S. A. 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. *The American Midland Naturalist Journal* 150: 332-342.

Kunz, T. H., Arnett, E. B., Erickson, W. P., Hoar, A. R., Johnson, G. D., Larkin, R. P., Strickland, M. D., Thresher, R. W., Tuttle, M. D. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypothesis. *Frontiers in Ecology and the Environment* 5: 315-324.

Lynch, C. D. 1989. The mammals of the north-eastern Cape Province. *Mem. Nas. Mus. Bloemfontein* 25: 1-116.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. & Schoeman, M.C. (2010). Bats of southern and central Africa – A biogeographic and taxonomic synthesis, Ultra Litho (Pty) Ltd, Johannesburg.

Mucina, L. and Rutherford, M. C. 2006. The Vegetation of South Africa, Lesotho and Swaziland- *Strelitzia 19,* South African National Biodiversity Institute, Pretoria.

Neuweiler, G. 2000. *The Biology of Bats*. Oxford University Press.

O'Shea, T. J., Bogan, M. A. and Ellison, L. E. (2003). *Monitoring trends in bat populations of the United States and territories: Status of the science and recommendations for the future*. Wildlife Society Bulletin, 31: 16-29.

Rautenbach, I.L. 1982. *Mammals of the Transvaal*. Pretoria: Ecoplan.

Sowler, S., Stoffberg, S., MacEwan, K., Aronson, J., Ramalho, R., Potgieter, K., Lötter, C. 2016. *South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: 4th Edition*. South African Bat Assessment Association.

Taylor, P. J. 2000. Bats of southern Africa, University of Natal Press, Pietermaritzburg.

Tuttle, M. D. and Hensley, D. L. 2001. *The Bat House Builder's Handbook*. (BCI) Bat Conservation International.

van der Merwe, M. 1979. Growth of ovarian follicles in the Natal clinging bat. *South African Journal of Zoology* 14: 111-117.

van der Merwe, M. 1994. Reproductive biology of the Cape serotine bat, *Eptesicus capensis,* in the Transvaal, South Africa. *South African Journal of Zoology* 29: 36-39.

Vincent, S., Nemoz, M. and Aulagnier, S. 2011. Activity and foraging habitats of *Miniopterus schreibersii* (Chiroptera: Miniopteridae) in southern France: implications for its conservation. *The Italian Journal of Mammalogy* 22: 57-72.

Reviewed and signed off by:

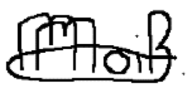
Monika Moir

Zoologist and Ecologist

MSc (Biodiversity & Conservation, UJ)

Pr.Sci.Nat. – SACNASP

(Zoological Science)



DISCLAIMER

The services carried out and reported in this document have been done as accurately and scientifically as allowed by the resources and knowledge available to Animalia Zoological & Ecological Consultation (Pty) Ltd at the time on which the requested services were provided to the client. Animalia Zoological & Ecological Consultation (Pty) Ltd reserves the right to modify aspects of the document including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

Although great care and pride have been taken to carry out the requested services accurately and professionally, and to represent the relevant data in a clear and concise manner; no responsibility or liability will be accepted by Animalia Zoological & Ecological Consultation (Pty) Ltd. And the client, by receiving this document, indemnifies Animalia Zoological & Ecological Consultation (Pty) Ltd and its staff against all claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by Animalia Zoological & Ecological Consultation (Pty) Ltd; and by the use of the information contained in this document. The primary goal of Animalia's services is to provide professionalism that is to the benefit of the environment as well as the community.