Bat calls
of
New South Wales

Region based guide to the echolocation calls of microchiropteran bats

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Cover illustration of *Tadarida australis* by Michael Pennay.

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Acknowledgments

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Introduction

In February 2003 the Australasian Bat Society resolved to recommend minimum standards for bat detector surveys and reporting for fauna impact statements, fauna assessments, research papers and survey reports.

These standards require that each report include three features: a sample frequency vs time graph for each species identified during the survey; a description of the characteristics used to distinguish between species and a description of the reference library used (Reardon 2003).

This guide will assist consultants and bat researchers to improve their identifications by supporting their own reference libraries with a large library of bat calls collected from throughout the State. It may help consultants with areas and species they are less familiar with.

The guide will also assist people who use consultants to undertake ultrasonic identification. It will help them understand and monitor results provided to them as graphs without having to acquire an extensive detailed knowledge of how Anabat works.

The guide is not intended to be a replacement for reference libraries; it should support your own local library of calls. We highly recommend that any person undertaking ultrasonic bat identifications record as many reference calls from the area that they intend to work as possible.

Over 1200 reference calls recorded from individuals of known species throughout NSW were used to develop this guide. The guide and calls are available to download from http://www.nationalparks.nsw.gov.au/batcalls. Copies of the reference library may be obtained from Michael Pennay if access to the Internet is not possible or technical problems are experienced.

Background

This guide describes how bats can be identified from the 'echolocation' calls used for navigation. Echolocation calls are high frequency sounds made by the bat to assist with navigation, these are usually beyond the range of human hearing (i.e. ultrasonic).

In Australia, as with most other places in the world, only the small insect-eating bat species (known as michrochiropterans or microbats) echolocate. The fruit and blossom bats (known as megachiropterans or megabats) use their eyesight and sense of smell to navigate and to find their food of fruit and blossoms.

The echolocation calls of bats are often species specific within a region. By using one of a number of ultrasonic bat detectors (such as the Anabat system used in this guide, Titley Electronics Pty Ltd, Ballina, NSW) recordings of these calls can be made and used to identify bats.

This guide follows on from work done in 2000 to produce the *Key to the bat calls of south-east Queensland and north-east New South Wales* (Reinhold *et al.* 2001), which used reference calls collected from throughout that region. Bat calls from other parts of NSW have been much less intensely studied than the North Eastern corner. At present our data are not comprehensive enough to compile a definitive key of bat calls for the entire State. However, we have produced a guide to those calls we do know, which can be used to assist bat researchers with identifying calls from throughout the State.

Bat detectors have become one of the standard methods for surveying bats since the early 1990's. They have the benefit of being able to record free flying wild bats without having to capture them. Unfortunately there have been problems of subjectivity and reliability in the identification of the calls recorded (NPWS 1998, Reinhold *et al.* 2001). The reliability problems appear to have stemmed from two main causes, the underestimation of variation within bat calls, and overlapping call characteristics between some species in certain regions (Reinhold *et al.* 2001, Reardon 2003).

It has only recently become apparent that the range of call types and call characteristics produced by some Australian bat species can vary considerably even within specific geographic areas. Call characteristics have also been found to vary significantly within a species over its geographic range (Reinhold *et al.* 2001, Law *et al.* 2002). Realisation of the extent of variation and potential overlap has increased our awareness of the importance of collecting reference calls from the areas where calls will be analysed. With this has come the development of regional based reference call libraries.

The Australasian Bat Society recently proposed certain standards in bat detector based surveys be adopted as a universally applied protocol throughout Australasia (Reardon 2003). The Australasian Bat Society standards recommend a call analyst to be in possession of, have access to, or be able to produce a reference library of calls for each species from the region where the bat calls are being analysed.

The regions used in this guide

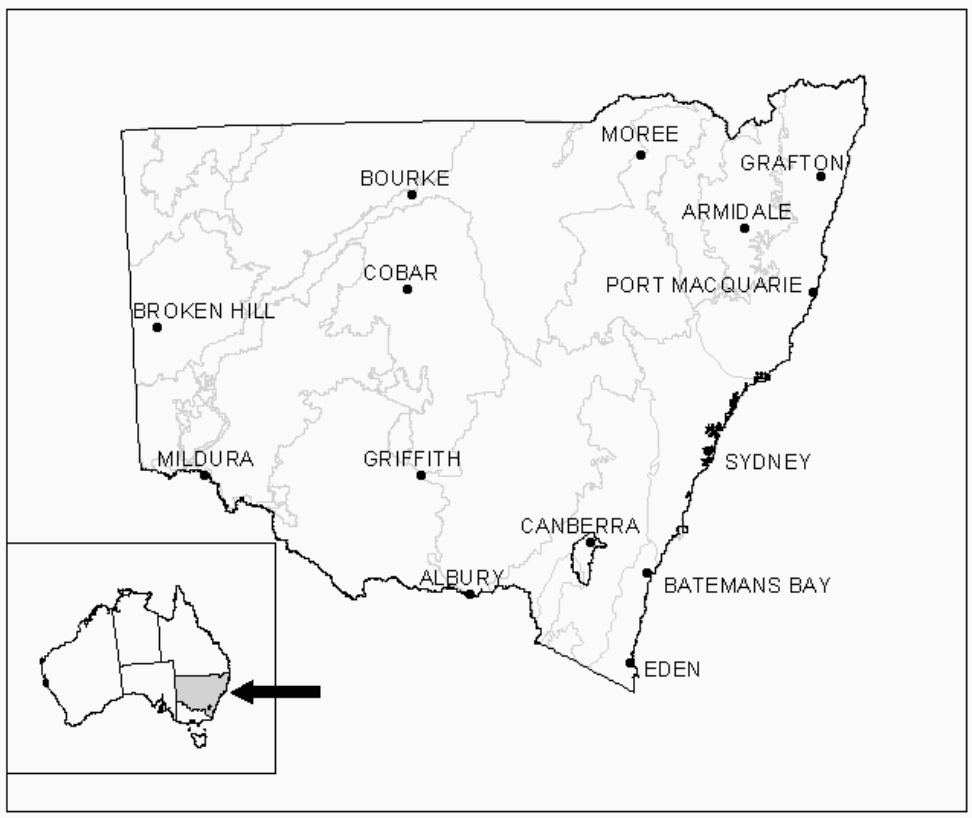
This guide covers bat calls from the State of New South Wales (NSW) in the south east of Australia. NSW has a diverse range of habitats including major transitional zones between subtropical, temperate, alpine and arid climates. This results in variation both between and within species in many aspects of their biology.

To designate different regions, we have attempted to use the boundaries where regional call variation is believed to occur based on the work of Law *et al.* (2002). Our knowledge of intraspecific call variation is currently limited to the *Vespadelus* genus. The boundaries of call types within this genus are not yet clearly defined, but tend to be specific to individual species rather than common to every species.

In the absence of additional knowledge, we have adopted a combined approach, with the six regions roughly following the boundaries of the two species found to have the greatest variation (*Vespadelus vulturnus* and *V. regulus)*. Where there is no information on call variation the boundaries loosely follow the recognised biogeographic regional boundaries devised by Thackway and Cresswell (1995). These regions represent major changes in the vegetation, soils, topography, hydrology and other features of the landscape with which flora and fauna may respond (Figure 1).

Six regions are identified:

- **North East NSW**, comprises the New England Tableland and NSW North Coast bioregions.
- **The Sydney Basin,** comprises the Sydney Basin bioregion, the Liverpool Range and the northern parts of the Southeast Highlands bioregion.
- **Southern NSW** this region follows known call variation boundaries rather than bioregional boundaries. It covers the south eastern corner of the State including the Australian Alps, southern parts of the Southwest Slopes, Southeast Highlands and Southeast Corner bioregions.
- **Riverina** comprises the plains surrounding the Murray, Murrumbidgee and Lachlan rivers in the southern part of the State.
- **Western Slopes and Plains**, this area is characterised by the slopes and plains west of the great dividing range including the South West Slopes, Cobar Peneplain, Darling Riverine Plains and the Nandewar and Brigalow Belt South bioregions.
- **Far West NSW** incorporates the western most bioregions of the Murray Darling Depression, Broken Hill Complex, Mulga Lands, Simpson Strezlecki Dunefields and the lower Darling floodplain. This region represents the most poorly known area of NSW and may need to be to be broken into more detailed regions as knowledge improves.



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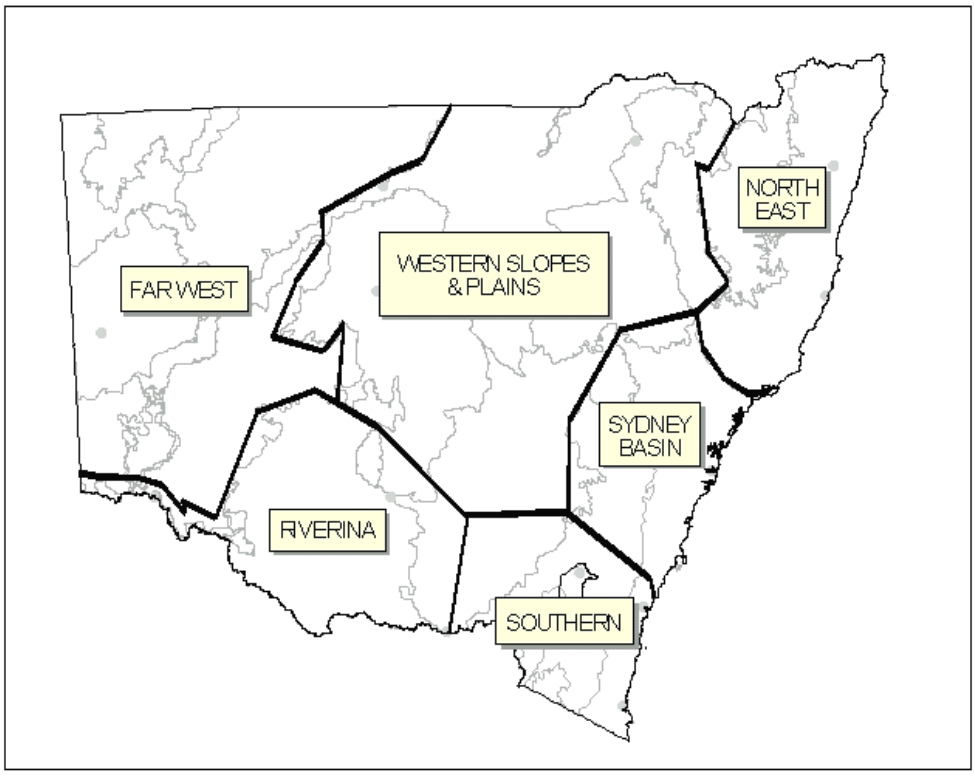

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Figure 1. a) New South Wales, b)The six regions of NSW used in this guide.

The bats of New South Wales

There are currently 29 species of microchiropteran bats recorded in New South Wales, plus an additional five taxa not formally described as species but widely recognised by bat biologists (Atlas of NSW Wildlife 2003, Churchill 1998). This number is likely to increase as the status of several taxa appear uncertain and they probably are represented by more than one species (H. Parnaby pers. comm.)

Table 1, Microchiropteran bats that have been captured in New South Wales.

Chalinolobus dwyeri
Chalinolobus gouldii
Chalinolobus morio
Chalinolobus nigrogriseus
Chalinolobus picatus
Falsistrellus tasmaniensis
Kerivoula papuensis
Miniopterus australis
Miniopterus schreibersii oceanensis
Mormopterus beccarii
Mormopterus norfolkensis
Mormopterus species 4 (large penis form)
Mormopterus species 3 (small penis form)
Mormopterus species 2
Mormopterus species 6
Myotis macropus
Nyctophilus bifax
Nyctophilus geoffroyi
Nyctophilus gouldi
Nyctophilus timoriensis
Rhinolophus megaphyllus
Saccolaimus flaviventris
Scoteanax rueppellii
Scotorepens balstoni
Scotorepens greyii
Scotorepens orion
Scotorepens species 1
Tadarida australis
Vespadelus baverstocki
Vespadelus darlingtoni
Vespadelus pumilus
Vespadelus regulus
Vespadelus troughtoni
Vespadelus vulturnus

The most commonly captured species in NSW is the little forest bat, *Vespadelus vulturnus.* It has been captured at more than 4500 locations across the State. The least captured species is *Mormopterus* species 6 , which has only been caught at three locations in NSW (Atlas of NSW Wildlife 2003).

Our knowledge of bats within the State is highly variable. Records of captures are mostly centred around areas of the highest population densities (Sydney and the coast) where the density of bat records may be as high as 2000 records in a single 25 square kilometre block. West of the Great Dividing Range there are many hundreds of square kilometres where a single bat species has yet to be recorded and survey work often reveals range extensions of hundreds of kilometres or species previously unrecorded in the State (Ellis 2001, RACD 2002). It may come as a surprise to some people that when viewed in 25km square blocks, more than half of the State has never had a single bat recorded.

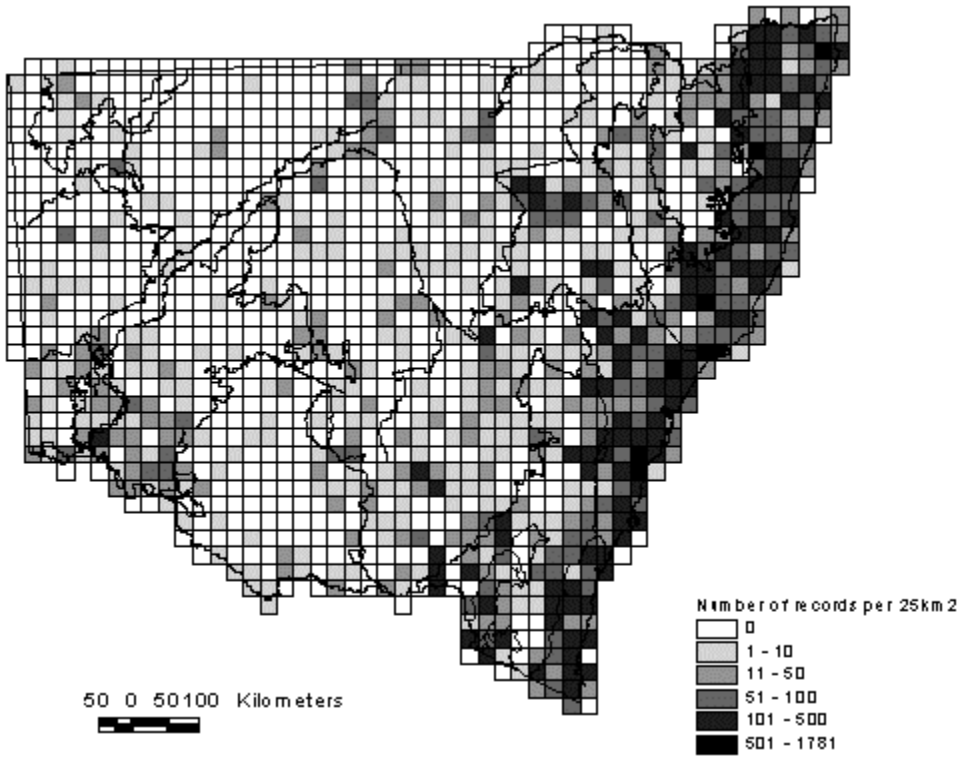

Figure 2. The density of microchiropteran records per 25km^2 cell in New South Wales

Hardware and software requirements

This guide describes bat calls recorded using the Anabat system (Corben 2000a). The system requires a computer and a number of items of specialised equipment:

- An Anabat II detector to record bat calls.
- A storage device. Several options are available for storage of bat calls, they can be recorded onto audio cassette (not recommended due to poor quality), directly into a computer using an Anabat zero crossings analysis interface module (various designs available), or onto compact flash memory cards using an Anabat CF reader (Titley Electronics).
- Software for recording calls. We used Anabat 6.3.e (Corben 2000a).
- Software for analysis of calls. We used Analook (Corben 2000b) to view calls as frequency vs time graphs.

More information on the Anabat system equipment is available from Titley Electronics (http://www.titley.com.au/). A detailed instruction manual on use of the equipment has been produced by Corben and O'Farrell (1999).

Definitions and features of pulses

A bat call usually consists of a series of sound pulses repeated at regular intervals. A consecutive string of pulses made by the same bat is referred to as a sequence (Corben and O'Farrell 1999, Reinhold *et al.* 2001). A pass is defined a continuous sequence of calls from a single bat from the time it is first detected until it has travelled beyond the range of detection (Corben and O'Farrell 1999). It is often not easy to define when one pass ends and another starts, but Law et al (1998) have suggested a gap of five seconds in an attempt at standardisation.

Bats produce a wide range of different shaped pulses which can all be broken down into standard components for comparison.

There are four main parts to a pulse:

- the initial section. This is the start of the pulse, which is often steeper than the rest of the pulse, and is ended at the knee, the point of greatest change in slope;
- the pre-characteristic section. This is the section between the knee and the flattest section of the pulse, its end being called the heel;
- the characteristic section. This is the flattest and often lowest frequency part of the pulse; and
- the tail. This begins at the end of the characteristic section (characteristic point) and runs to the end of the pulse. The tail may rise, drop or do both, they may vary within call sequences, but the majority of pulses usually have tails typical of the species when in "search phase" (Reinhold *et al.* 2001).

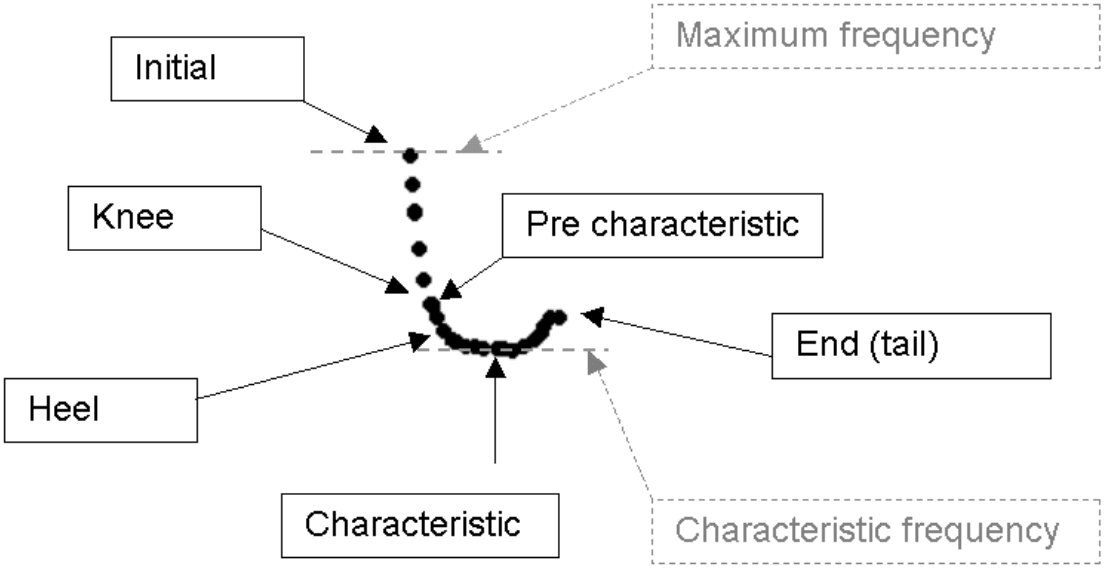

Figure 3. Features of a generic call pulse.

Call shape characteristics are also important in identifying bat calls. Descriptions in this guide follow Corben and O'Farrell (1999) and Reinhold *et al.* (2001) with four main categories of pulse shape; near vertical, flat, curved and alternating (Figure 4).

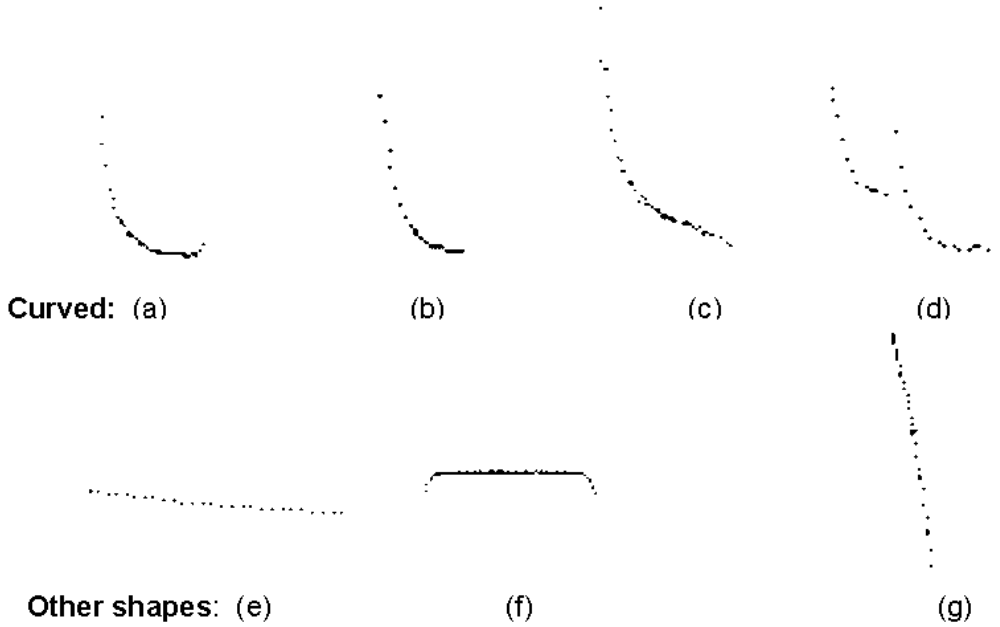

Figure 4. Typical call shapes referred to in this guide. (a) Up-sweeping tail, (b) Tail absent, (c) Down-sweeping tail, (d) Alternating, (e) Flat, (f) Flat, up-sweeping initial, (g) Near vertical.

Extraction of call parameters

Pulse shape (Figure 4) and characteristic frequency (Figure 3) are the main parameters required for discrimination. The measurement should be the average for a series of evenly-spaced, evenly-shaped pulses (Figure 6). It can either be taken using the horizontal frequency cursor in *Anabat6* (Corben 2000a) or by "Fc" in measurement mode of *Analook* (Corben 2000b). Use of the software is explained in Corben and O'Farrell (1999).

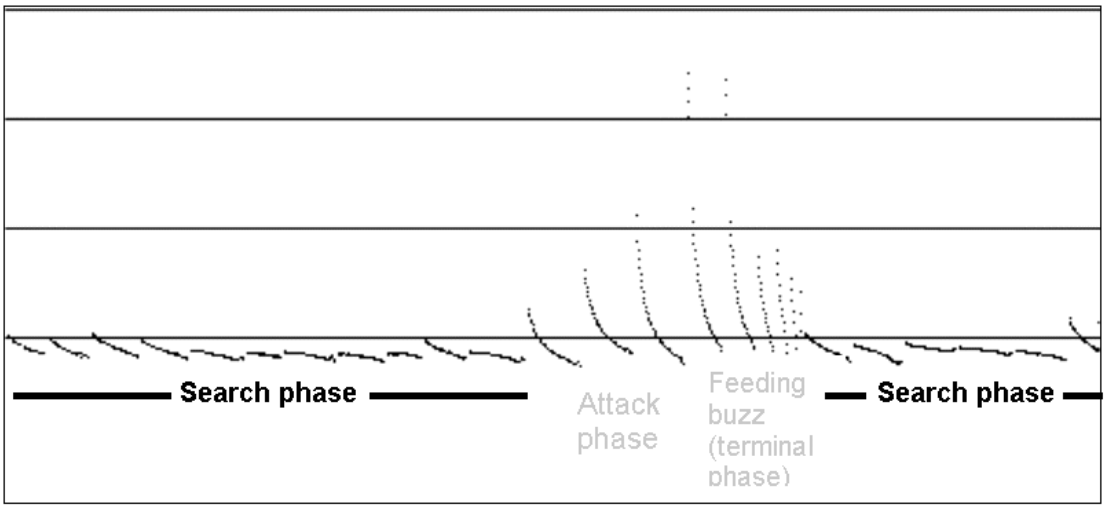

Figure 5. Phases of a *Mormopterus* species 4 call sequence, illustrating search phase pulses used for identification in this guide.

Selection of calls for analysis

It is essential for anybody attempting to identify bats by call recordings that they are aware of the range and variety of calls wild flying bats make. Only search phase calls are used in this guide. Search phase calls are relatively regular shaped pulses that bats emit as they navigate through the landscape searching for food (figure 5).

You will need to understand the main ways bat calls vary when you try to identify them otherwise you run the risk of making many serious errors in identification:

- Bats adjust their search phase calls when flying in different environments, giving steeper shorter calls in cluttered areas and flatter longer lower calls in open areas, which may make their calls appear like those of other species (Reinhold *et al.* 2001). This highlights the need to collect as many reference calls from as many situations possible to sample the full variation in calls for the area you are attempting to study.
- Bats alter their calls when feeding and sometimes drinking, producing a series of pulses increasing in slope, frequency and speed in what is known as "attack phase" culminating in a "feeding buzz" (Figure 5). Pulses emitted by bats during the attack phase and feeding buzz often resemble calls of other species with steep calls such as *Myotis* or *Nyctophilus* (Reinhold *et al.* 2001). It is therefore very important that calls being identified are long enough in duration that the possibility of the call being part of an attack phase or feeding buzz can be ruled out.
- Bats often produce an "excited" call just after release. Excited calls are generally higher and steeper than the normal search phase call and appear somewhat similar to the calls bats give in cluttered environments (Figure 6). Excited calls are not very useful for call identification, therefore it is important to record the bat as long as possible, to allow the bat to settle into its regular search phase call. Some bats settle into normal search phase call rapidly. Others such as *Chalinolobus morio* are difficult to obtain good reference calls from as they take a notoriously long time to calm down.

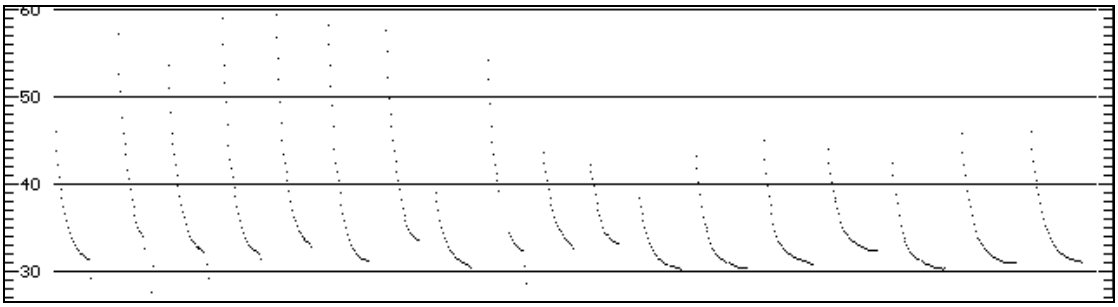

Figure 6. 'Excited' release call of *Chalinolobus gouldii*, showing several higher steeper pulses before producing normal pulses.

- The Doppler shift is a phenomena familiar to most people, the sound of a car or train coming towards you sounds higher in pitch as it approaches and lower as it retreats. The same principle applies to recording bats. As the bat flies towards the detector the soundwaves are compressed in front giving a higher frequency and as it flies away a lower frequency leaving expanded waves behind (Figure 7). The Doppler shift varies with the flying speed of the bat and can make up to 6% difference in characteristic frequency over the entire call (Corben and O'Farrell 1999). The pattern of characteristic frequency needs to be examined over the entire call sequence to assess the impact of the Doppler shift on a call and identify the actual characteristic frequency. Doppler patterns cannot be assessed in calls consisting of a few pulses making them much more difficult to distinguish from species with overlapping frequency ranges.

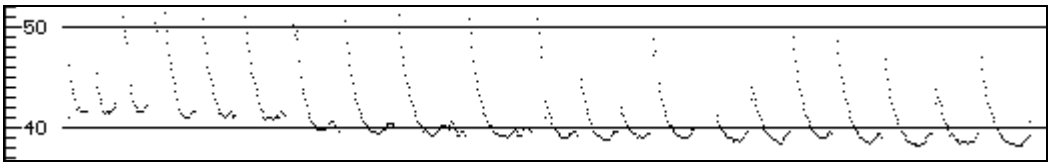

Figure 7. Doppler effect on *Scotorepens* sp. call showing a 3 kHz drop in characteristic frequency as the bat passes the detector.

- If more than one bat is recorded at the same time, the call file can appear like an alternating call of a single bat. This may be checked by the timing of the calls (more easily seen in truetime mode), the pulses from different bats calling at the same time will not be continually synchronised (Figure 8).

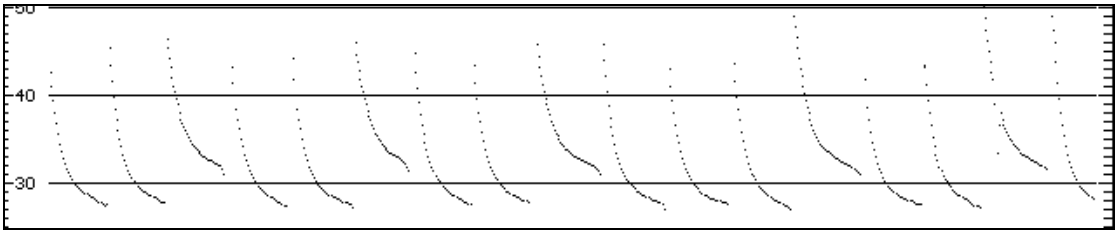

Figure 8. Two bats calling at the same time - note irregular synchronisation.

- Bats make a whole array of other calls. Some seem to be communicative; they frequently occur when bats interact and are commonly recorded at places of high bat activity such as cave exits and watering points. Odd or unusual calls are often referred to as "social calls", though their true purpose is generally unknown. Social calls are usually easily distinguished from search phase calls by erratic pulses often varying greatly in length and frequency, sometimes producing a series of very long pulses fluctuating in frequency which are called bat song (Figure 9). The existence of social calls again emphasises the need to only identify calls which have a good number of pulses so that search phase pulses can be selected. Recordings from cave exits, watering points and areas where there is a lot of bat interaction often have a high number of calls which cannot be identified due to the impact of social calls.

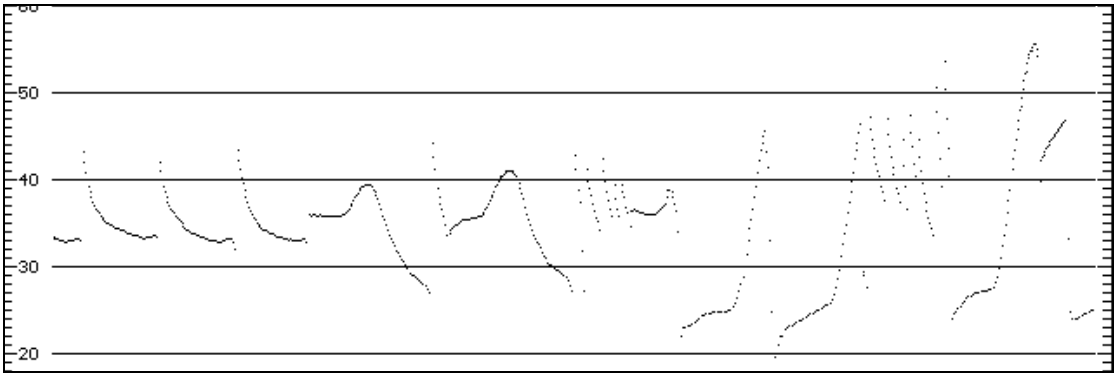

Figure 9. Social calls from *Scotorepens balstoni* over a wetland near the Macquarie Marshes.

- Some bat species produce calls in a range of harmonics. The zero crossings method of analysis used by Anabat can only display the dominant harmonic at which the bat is calling. Occasionally bats shift their energy to a different harmonic, and the detector records the call at the higher or lower frequency. For example, *Saccolaimus flaviventris* is usually recorded calling around 20 kHz. However, when foraging low to the canopy, or beneath the canopy in open woodlands it is sometimes recorded at about 30kHz. This shift is usually temporary and in longer calls pulses in the 20kHz range are obvious. In calls consisting of only a few pulses these may be absent, which could lead to misidentification with *Mormopterus* species 2 or 3.

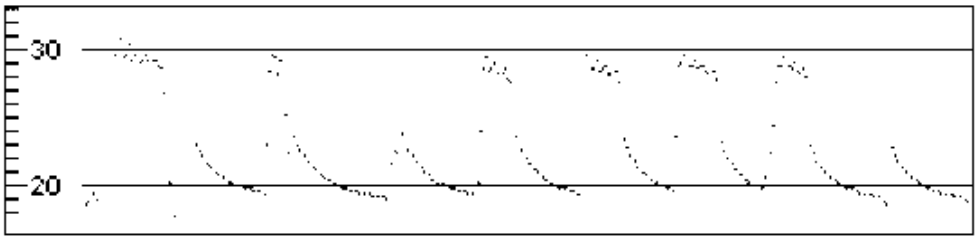

Figure 10. *Saccolaimus flaviventris* call showing fragments of an upper harmonic just below 30 kHz.

There are two general rules that should be applied to bat call analysis:

1. **Be very cautious of calls consisting of only a few pulses,**
2. **If you are unsure, or a call appears borderline do not try to identify it to species.**

Collecting reference calls

We strongly advise anybody undertaking bat call analysis to collect as many reference calls from the study area as possible. The reliability of your reference set is extremely important. Only use calls from bats where you have a positive identification. If you are unsure about the identity of the species do not use it.

Try to get calls from a variety of methods; release calls, pre capture calls, roost fly outs and free flight calls identified by spotlight.

If you are using release calls remember that many species emit steep excited calls for a long time after release. Try to anticipate the flight path of the bat (previously released bats of the same species may help here) and stand more than 20 metres from the bat. Some very good results have been obtained by attaching a small piece of coloured reflective tape to the belly hair of the bat. Different species can be colour coded with different pieces of tape. Often the released bats will fly by many times during the night so continue recording at the release location and if you spotlight the bat the coloured tag will allow you to identify the species while you record it in a more natural state. Be careful to note the time at which you saw the bat in the spotlight beam as the bat may alter its calling pattern once illuminated by the spotlight.

Feedback

This guide provides a substantial resource to support and assist people undertaking Anabat analysis within NSW and represents the efforts of several government agencies and individuals.

Whilst the authors have gathered together the largest collection of Anabat reference calls in NSW for public use, the resulting guide does not provide a complete library for each region. Some species calls have not yet been recorded within a region and many descriptions are based on a small sample of calls so are unlikely to cover the complete range of the species' repertoire.

In the spirit of collaboration we would like to invite continued feedback from bat researchers who have collected reference calls that contradict or add to species descriptions so that further editions can be updated. Corrections and supporting reference calls can be sent to:

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Summary of bat call frequencies

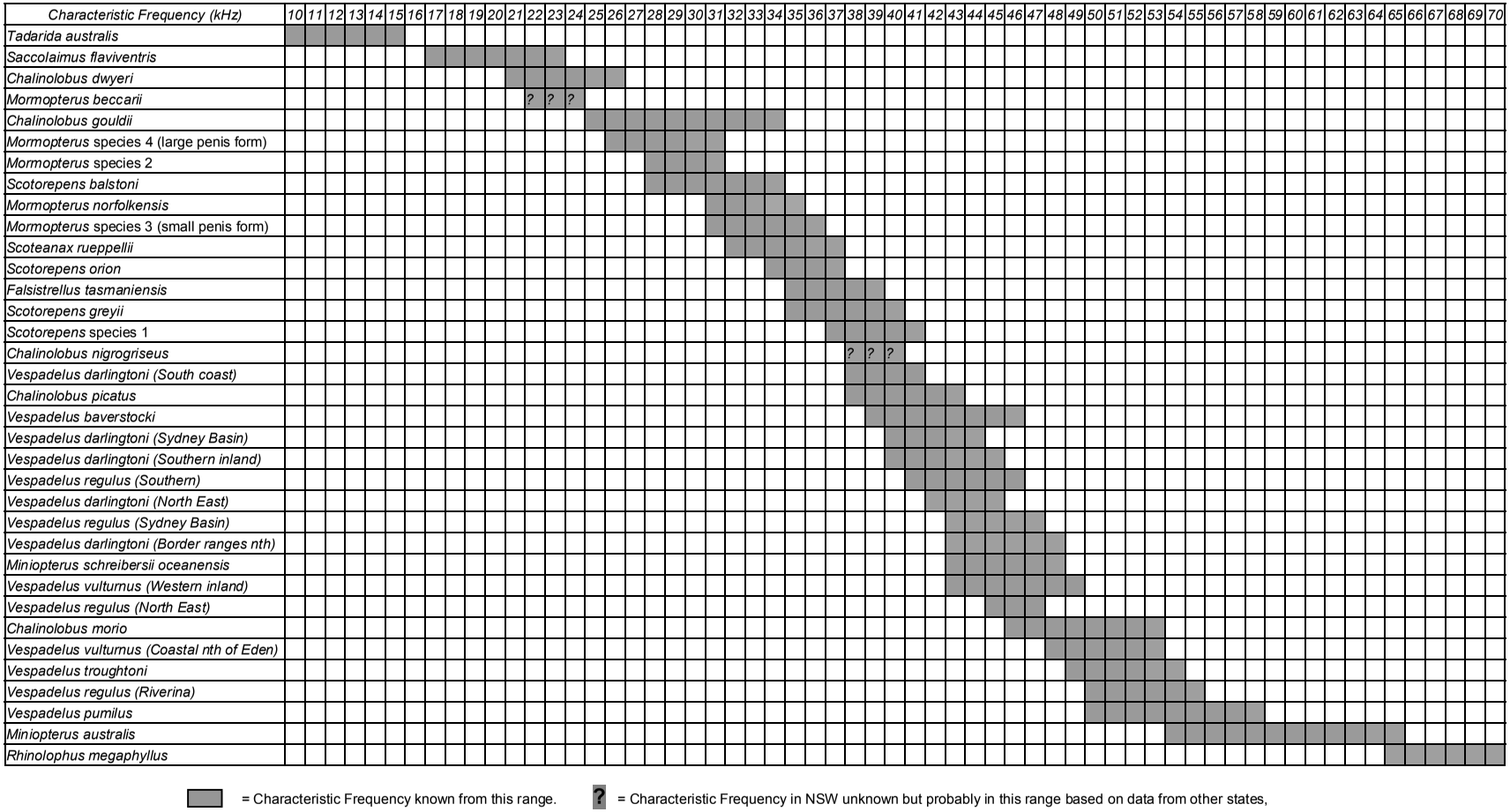


Figure 11, Summary of characteristic frequency range for bats with curved or flat shaped calls in NSW.

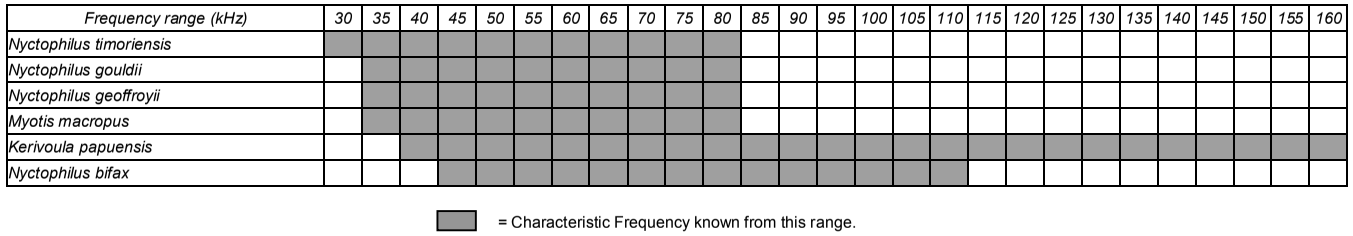


Figure 12, Summary of frequency range for bats with vertical shaped calls in NSW.

Note on characteristic frequency ranges

The upper and lower characteristic frequency values for each species includes Doppler affected pulses to give the reader an indication of the range of frequencies encountered from the species in flight. These upper and lower values mostly represent frequencies that may be recorded for a few pulses at the beginning or end of some sequences, rather than the 'norm' for an entire sequence. Care should be taken when identifying calls to view the characteristic frequency range over the entire sequence so the impact of the Doppler phenomena can be accounted for, particularly at frequencies where there is species overlap.

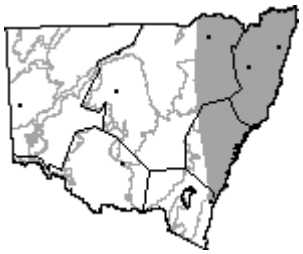
Species Descriptions

Note on calls displayed

All call graphics are displayed on a linear scale (with the exception of those with frequencies above 80 kHz) in compressed time between pulse mode with call expansion on F7.

Chalinolobus dwyeri

Characteristic frequency between 21.5 and 25.5 kHz (n = 14). Curved with up sweeping, down sweeping or no tail. Pulses alternate in frequency.



Can easily be distinguished from other species by the combination of the low frequencies and distinct pattern of alternation present in search phase calls.

Data indicates that this species does not noticeably vary its call throughout NSW.

Regional Information

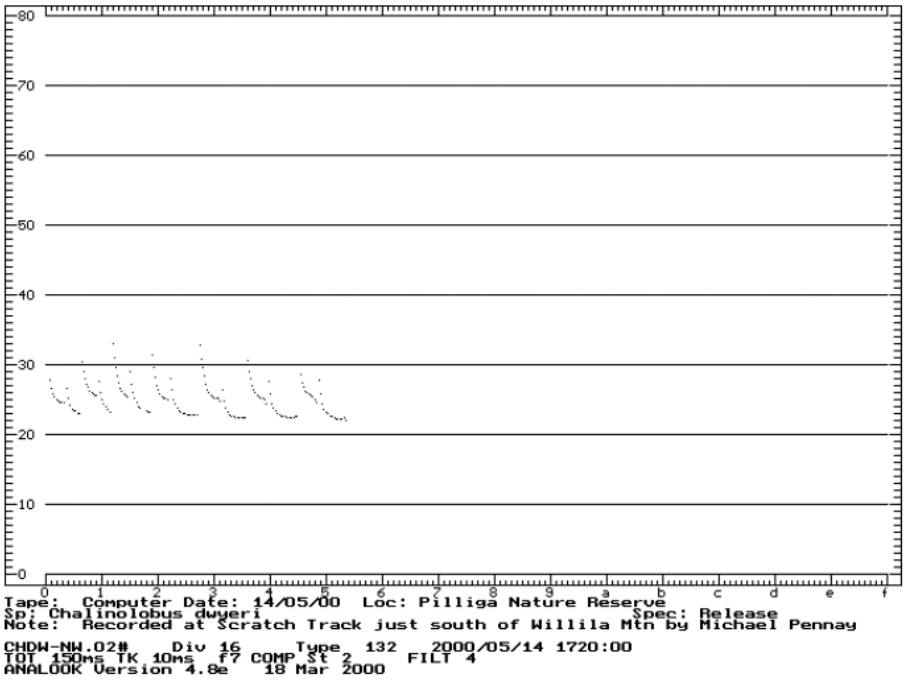
Western Slopes & Plains: Average characteristic frequency 23 to 24 kHz (n = 4). Curved with up sweeping, down sweeping or no tail. Pulses alternate in frequency, so that every second pulse is stepped-up by a couple of kHz. Lower pulses range from 22 to 23 kHz and higher pulses from 24.5 to 25.5 kHz.

Sydney Basin: Average characteristic frequency 22 to 23.5 kHz (n = 10). Curved. Pulses alternate in frequency, so that every second pulse is stepped-up by a couple of kHz. Lower pulses range from 21.5 to 23 kHz and higher pulses from 23.5 to 25 kHz.

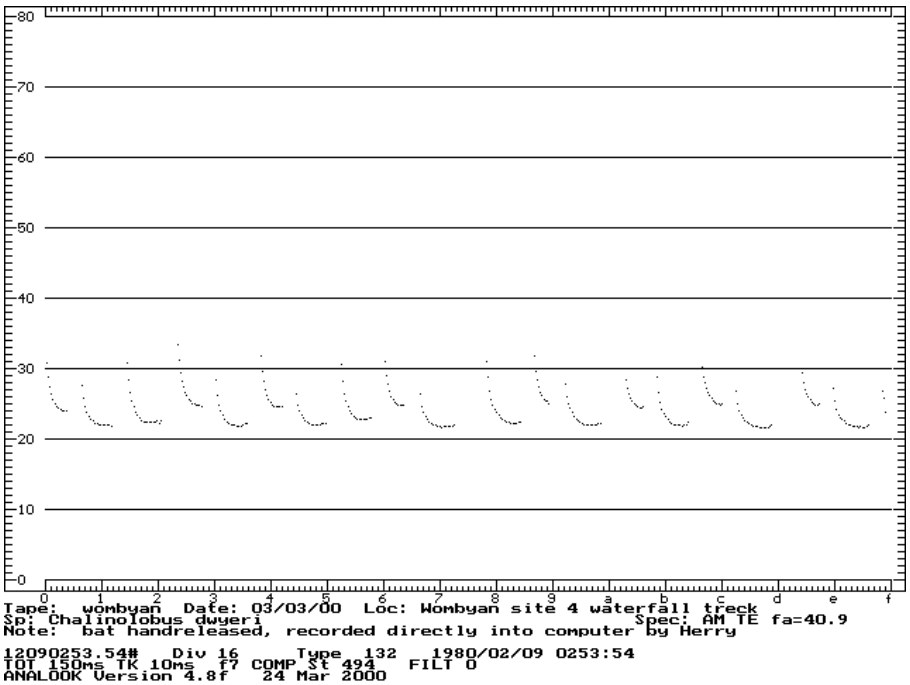
North East, Southern, Riverina and Far West: No reference calls from these regions.

Chalinolobus dwyeri: Representative regional calls

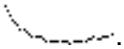
Western Slopes & Plains



Sydney Basin



Chalinolobus gouldii

Characteristic frequency between 25 and 34 kHz (n = 122). Usually curved, with a down-sweeping tail or no tail. Consecutive pulses alternate in frequency and sometimes shape when in "typical" search phase. The upper pulses may be shorter in duration with a maximum frequency that is often equal or lower than the lower pulses. Never exhibits harmonics. The upper pulses may drop out when "cruising" in open spaces leaving only the lower pulses  . Usually reverts to alternating pulses if long enough sequence is recorded. In forest the calls are steep and alternating. Good quality calls should not be confused with any other species.

In regions west of the Great Dividing Range the call may be confused with *Mormopterus* species 4 (large penis) and *Scotorepens balstoni*. Can be differentiated from *Mormopterus* species 4 (large penis) by curved call, lack of harmonics and alternation if long enough sequence is recorded. Can be differentiated from *Scotorepens balstoni*, when calling at higher than 30 kHz by the presence of alternation.

Data indicates that this species does not noticeably vary its call throughout NSW.

Regional Information

North East: Characteristic frequency 27 to 33 kHz (n = 13). Alternating, lower pulses range from 26.5 to 30 kHz, and higher pulses from 29.5 to 33kHz.

Western Slopes & Plains: Characteristic frequency 27.5 to 33 kHz (n = 28). Alternating, lower pulses range from 27.5 to 30.5 kHz, and higher pulses from 30 to 33 kHz.

Sydney Basin: Characteristic frequency 27.5 to 32.5 kHz. (n = 17). Curved, consecutive pulses alternate in frequency, lower pulses range from 27.5 to 30.5 kHz, and higher pulses from 28 to 32.5 kHz. The upper pulses may be shorter in duration with a maximum frequency that is often equal to or lower than the lower pulses.

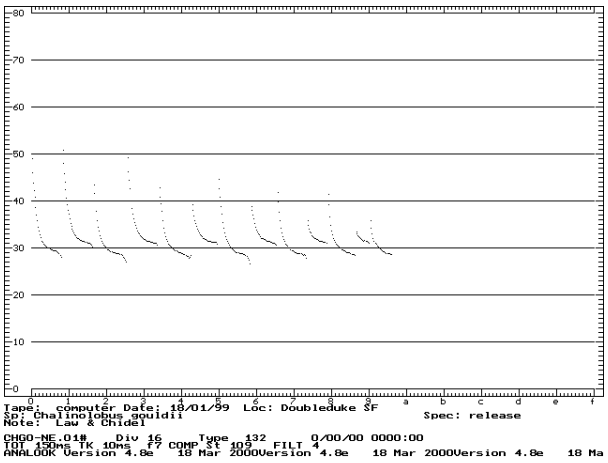
Southern: Characteristic frequency 28.5 to 32.5 kHz (n = 15). Curved, consecutive pulses alternate in frequency, lower pulses range from 28.5 to 30.5 kHz, and higher pulses from 30 to 32.5 kHz.

Riverina: Characteristic frequency 26.5 to 34 kHz (n = 12). Curved, consecutive pulses alternate in frequency, lower pulses range from 26.5 to 32 kHz, and higher pulses from 32 to 34.5 kHz. May drop upper pulses in open areas giving a call between 26.5 and 29.5 kHz.

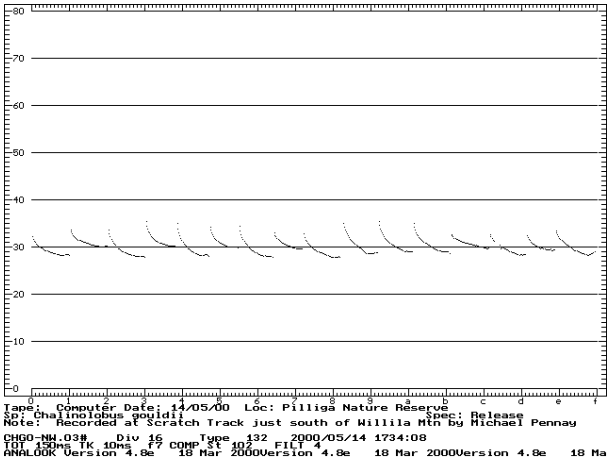
Far West: Characteristic frequency 25 to 32.5 kHz (n = 37). Curved, consecutive pulses alternate in frequency, lower pulses range from 25 to 30.5 kHz, and higher pulses from 28 to 32.5 kHz. May drop upper pulses in open areas giving a call between 25 and 29.5 kHz.

Chalinolobus gouldii: Representative regional calls

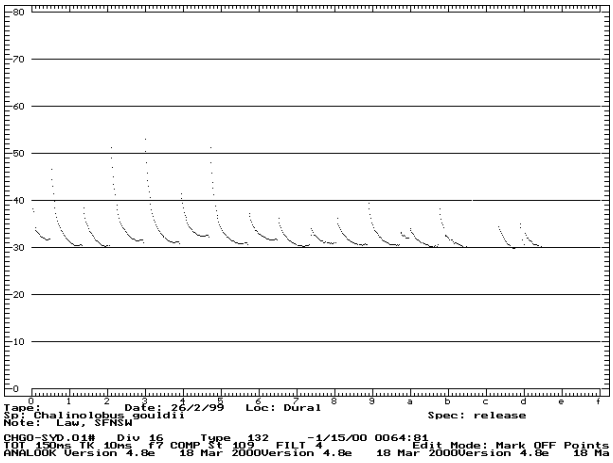
North East



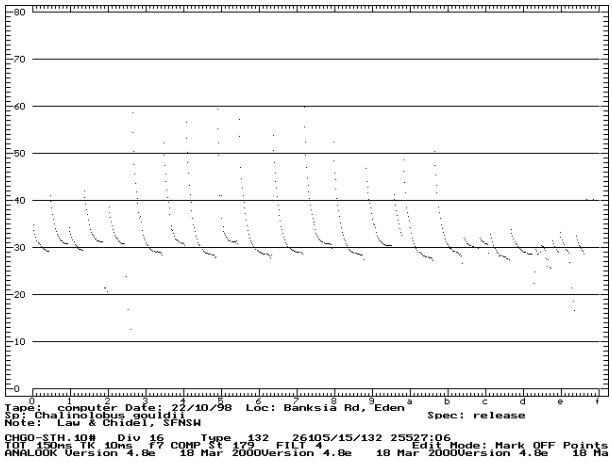
Western Slopes & Plains



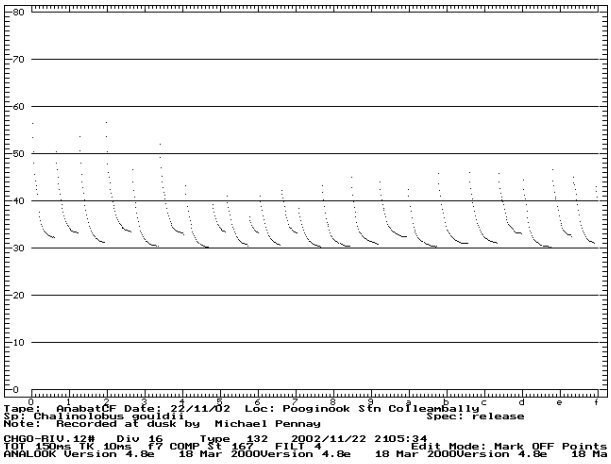
Sydney Basin



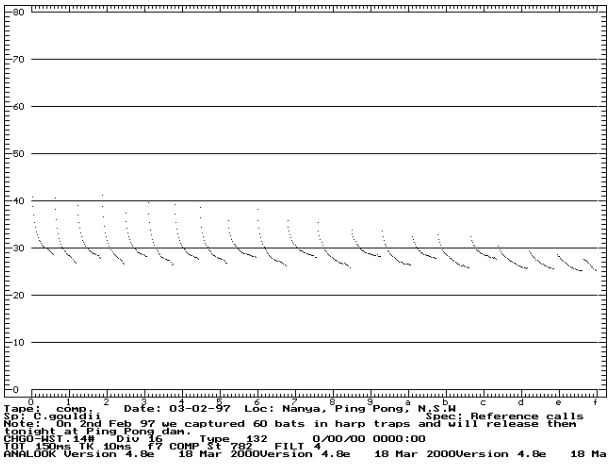
Southern



Riverina



Far west



Chalinolobus morio

Characteristic frequency between 46.5 and 53 kHz (n = 84). Curved with down sweeping tail. Consecutive pulses sometimes show slight alternation in shape  . Alternate pulses have lower maximum frequency or sometimes the frequency of knee appears to step up and down. Can generally be distinguished from other species calling at similar frequencies by a down sweeping tail which is often present in search phase calls.

Regional information

North East: Characteristic frequency 46.5 to 53 kHz (n = 14). Calls may overlap in frequency with *Vespadelus troughtoni*, *V.pumilus* and *V. vulturnus* but should be able to be identified by the down sweeping tail usually visible in calls from this species.

Western Slopes & Plains: Characteristic frequency 48.5 to 51.5 kHz (n = 13). Calls may overlap in frequency with *Vespadelus troughtoni* but should be able to be identified by the down sweeping tail. They are higher in frequency than *Vespadelus vulturnus* and *Miniopterus schreibersii oceanensis*.

Sydney Basin: Characteristic frequency of 49.5 to 52.5 kHz (n = 27). Similar frequency to *Vespadelus vulturnus. C. morio* has a down-sweeping tail, whereas *V. vulturnus* has an up-sweeping tail or no tail.

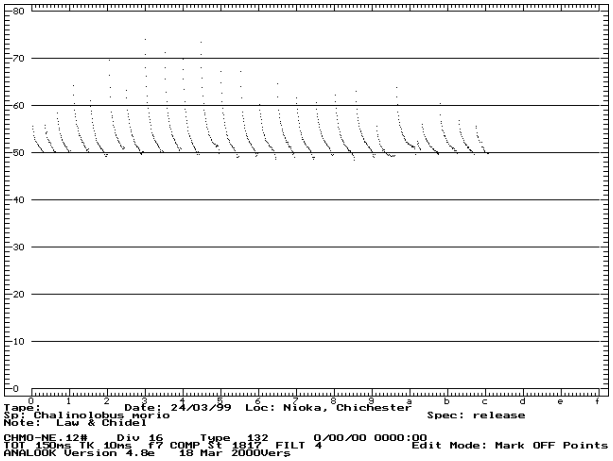
Southern: Characteristic frequency 48 to 52 kHz (n = 21). Characteristic frequency similar to high-frequency *Vespadelus vulturnus*, may be distinguished by having a down-sweeping tail that is not present in search phase *V. vulturnus*. In areas where *V. vulturnus* calls below 49 kHz, can be distinguished by being higher in frequency.

Riverina: Characteristic frequency 47.5 to 53 kHz (n = 9). Sometimes less steep, flatter call. Slightly higher frequency and down-sweeping tail end should differentiate from *Vespadelus vulturnus*. Likely to be confused with *Vespadelus regulus* with which it overlaps in frequency between 50 and 53kHz. *V. regulus* from this region have long down-sweeping tails and rarely call below 50 kHz, which may help differentiate.

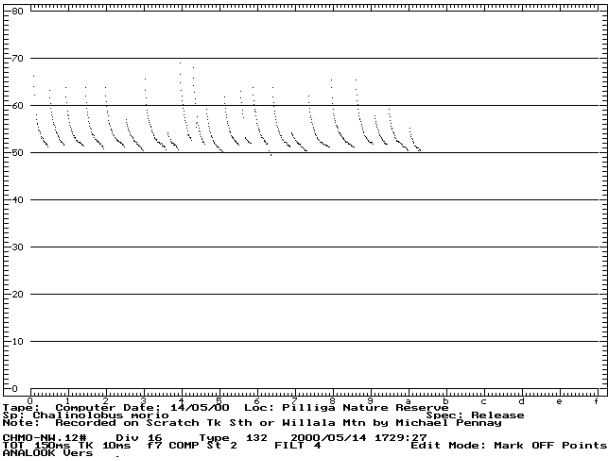
Far West: No reference calls from this region.

Chalinolobus morio: Representative regional calls

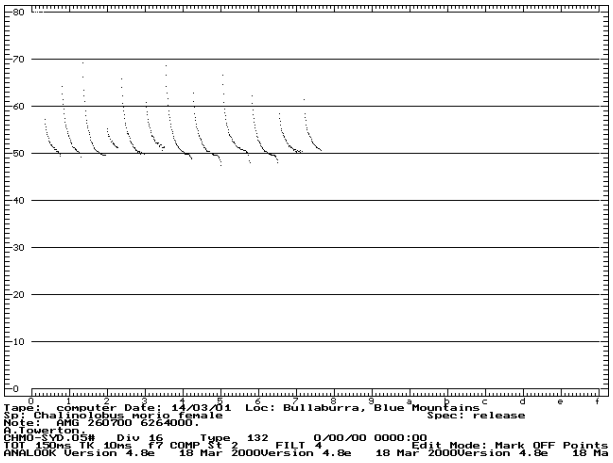
North East



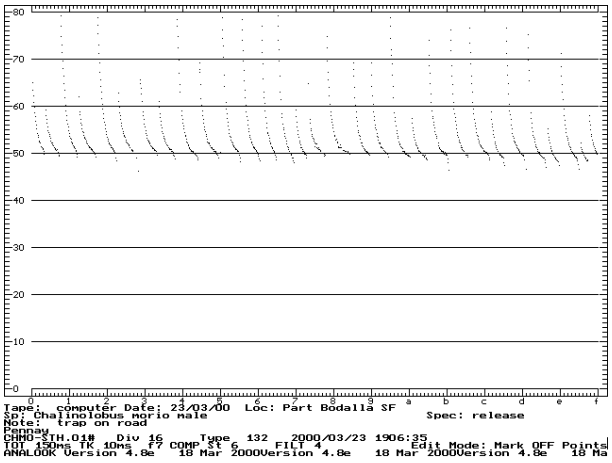
Western Slopes & Plains



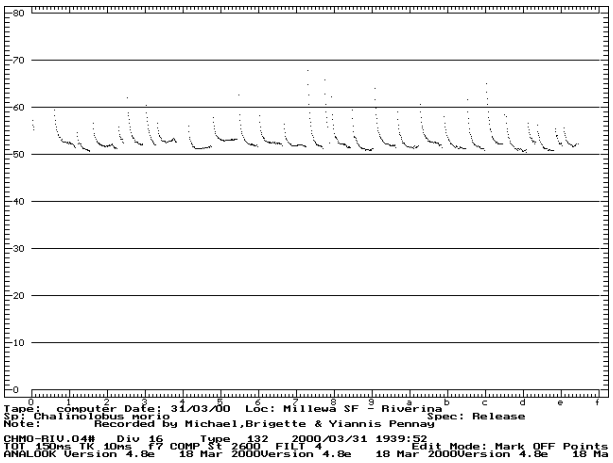
Sydney Basin



Southern



Riverina



Chalinolobus nigrogriseus

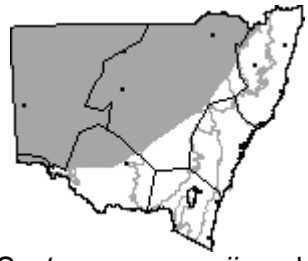
No reference calls from New South Wales for this species. In Queensland the call is curved. Characteristic frequency 37 to 40 kHz. Usually with no tail or occasionally up sweeping tail.

May be difficult to distinguish from *Scotorepens greyii* and *Scotorepens* sp. (Parnaby, 1992) where these species overlap in range. Reinhold *et al.* (2001) report that *C. nigrogriseus* have relatively longer characteristic and tail sections, usually 2/3 or more of the total pulse which, in conjunction with the lack of up-sweeping tail, may help to differentiate.

Regional information

None available for New South Wales.

Chalinolobus picatus



Characteristic frequency between 38.5 and 43 kHz (n = 9). Curved. Pulses alternate in frequency.

Good quality calls should not be confused with any other species. Characteristic frequency is usually higher than *Scotorepens greyii*, and lower than *Vespadelus vulturnus*. Non alternating calls below 40 kHz may be confused with *Scotorepens greyii*.

There is insufficient data to indicate if this species noticeably varies its call throughout NSW.

Regional Information

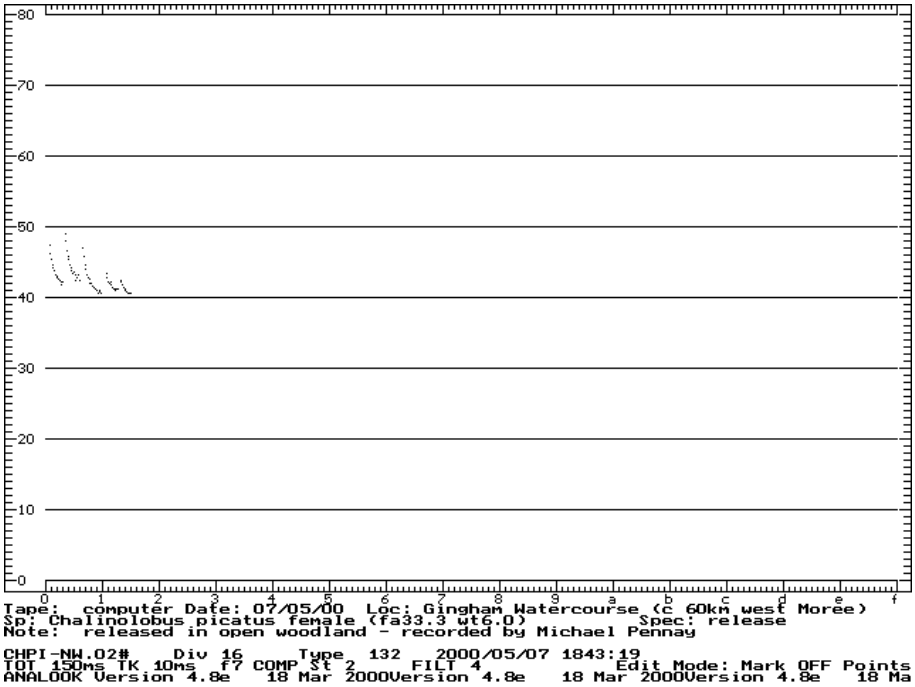
Far West: Characteristic frequency 38.5 to 43 kHz (n = 5). Alternating, lower pulses range from 38.5 to 41.5 kHz, and upper pulses usually approximately 2 kHz higher ranging from 40.5 to 43 kHz. May give flatter calls  with decreased alternation of about 1 kHz between upper and lower pulses when in 'cruise' mode.

Western Slopes & Plains: Characteristic frequency 42 to 44 kHz (n = 4). Alternating. Only poor quality calls from this region.

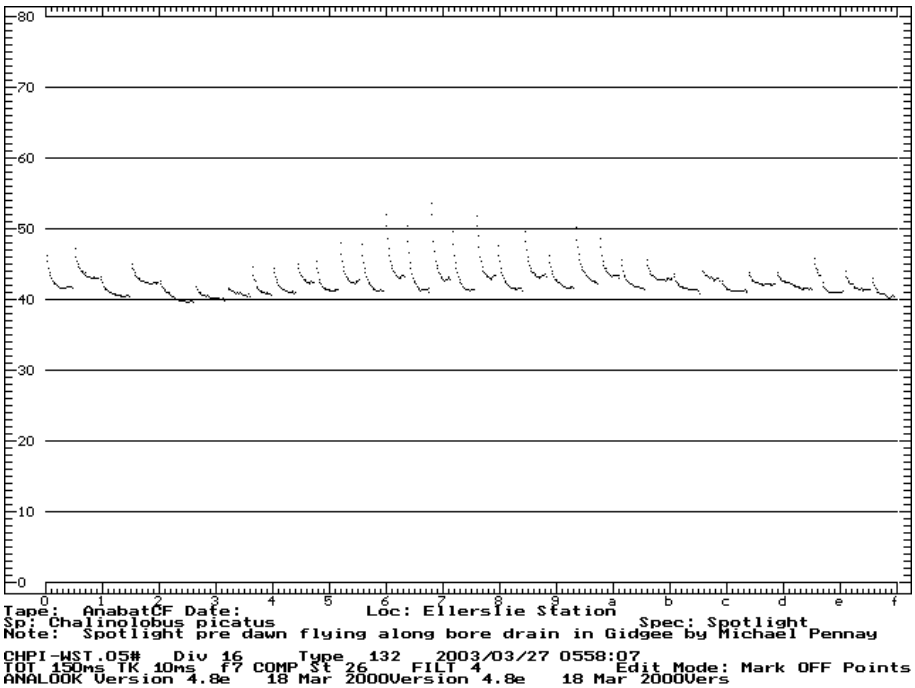
North East, Southern, Riverina and Sydney Basin: No reference calls from these regions.

Chalinolobus picatus: Representative regional calls

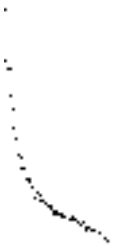
Western Slopes & Plains



Far west



Falsistrellus tasmaniensis



Characteristic frequency between 35 and 39 kHz (n = 32). Curved and often steep without an up-sweeping tail, occasionally tail down sweeping. Pre-characteristic section often long.

Can be separated from *Scotorepens greyii* and *Scotorepens* sp. (Parnaby, 1992) by the lack of up-sweeping tail on most pulses. Easily confused with *S. orion* and *Scoteanax rueppellii*, however may be differentiated on length of pre-characteristic section in some calls (Reinhold *et al.* 2001).

This species does not appear to vary its call throughout New South Wales, however most calls are of poor quality and the repertoire of this species is not well known.

Regional Information

North East: Characteristic frequency 35 to 39 kHz (n = 18). Pulse shape as described above.

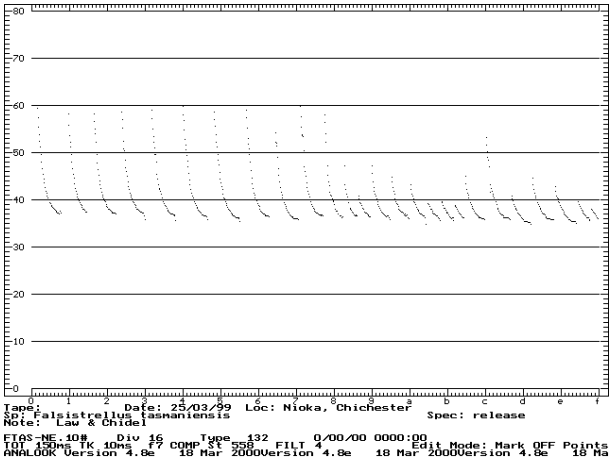
Sydney Basin: Characteristic frequency 35.5 to 39 kHz (n = 3). Pulse shape as described above.

Southern: Characteristic frequency 35.5 to 40.5 kHz (n = 11). Curved. Steep to curved with occasional down sweeping tail.

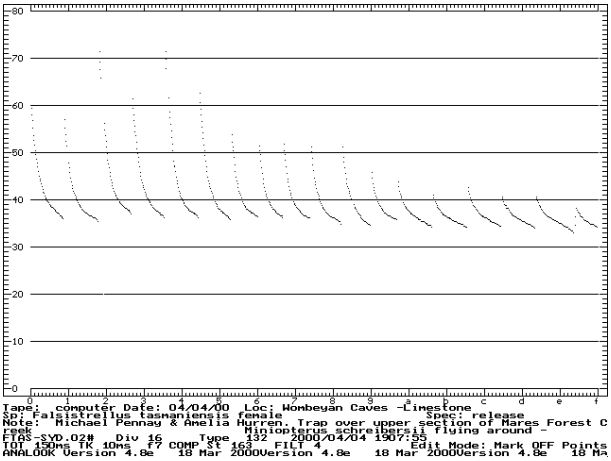
Riverina, Western Slopes & Plains, Far West: No reference calls from these regions.

Falsistrellus tasmaniensis: Representative regional calls

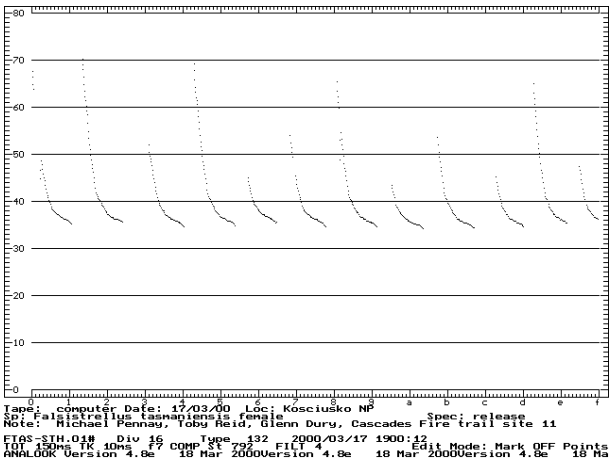
North East



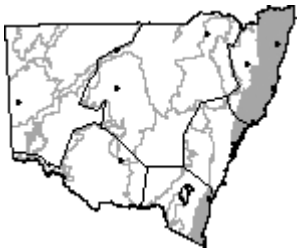
Sydney Basin



Southern



Kerivoula papuensis



Steep, near vertical, starting at between 160 and 80 kHz, usually around 120 kHz and dropping to as low as 40 kHz, usually between 55 and 85 kHz (n = 18). The call is very soft (low amplitude). Good quality calls have a distinctive shape. Two kinks are obvious. The first kink after a short vertical drop around 120 kHz. The characteristic section slopes steeply followed by the second kink around 70 to 80 kHz after which the long tail drops almost vertically. In poorer quality calls the initial kink is sometimes not apparent.

Some calls may be confused with *Nyctophilus* and *Myotis* due to similar shape, but *Kerivoula* are much higher in frequency.

Available data shows no indication of variation in call characteristics for this species throughout New South Wales.

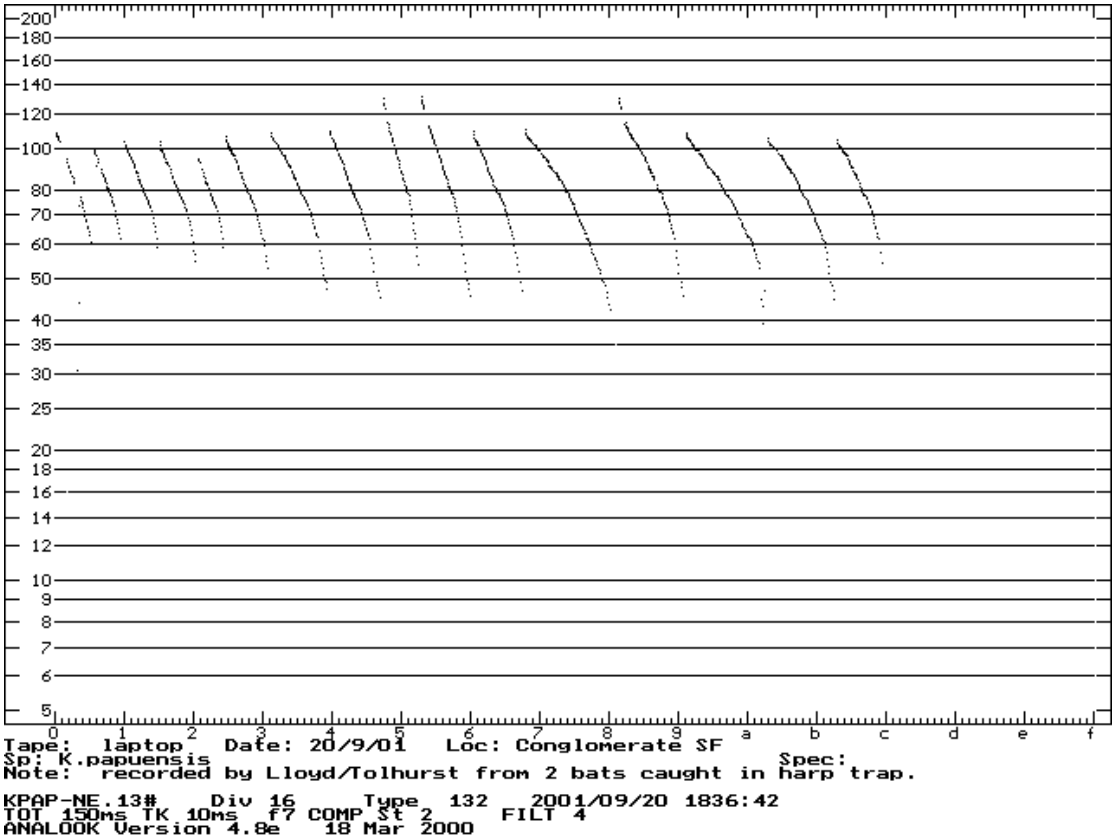
Regional Information

North East: As described above. Steep, near vertical, starting at between 160 and 80 kHz, usually around 120 kHz and dropping to between 85 and 55 kHz (n = 18).

Sydney Basin, Southern, Riverina, Western Slopes & Plains, Far West: No reference calls from these regions.

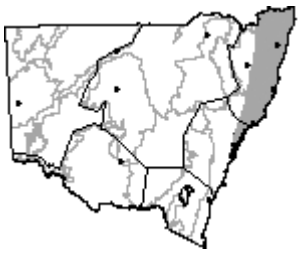
Kerivoula papuensis: Representative regional calls

North East



Miniopterus australis

Characteristic frequency 54.5 to 64.5 kHz (n = 53). Curved, usually with down-sweeping tail. Has a higher characteristic frequency than any other species with curved pulses.



Overlaps in frequency with *Vespadelus pumilus* at 57 to 58 kHz, but most good calls can be distinguished by the presence of a down-sweeping tail.

This species is known to exhibit some variation in call characteristics over its range, calling at lower frequencies (56 to 56.5 kHz) in north Queensland (Reinhold *et al*. 2001). Data from New South Wales occupies a wide range in characteristic frequencies (10 kHz), which may suggest some local variation.

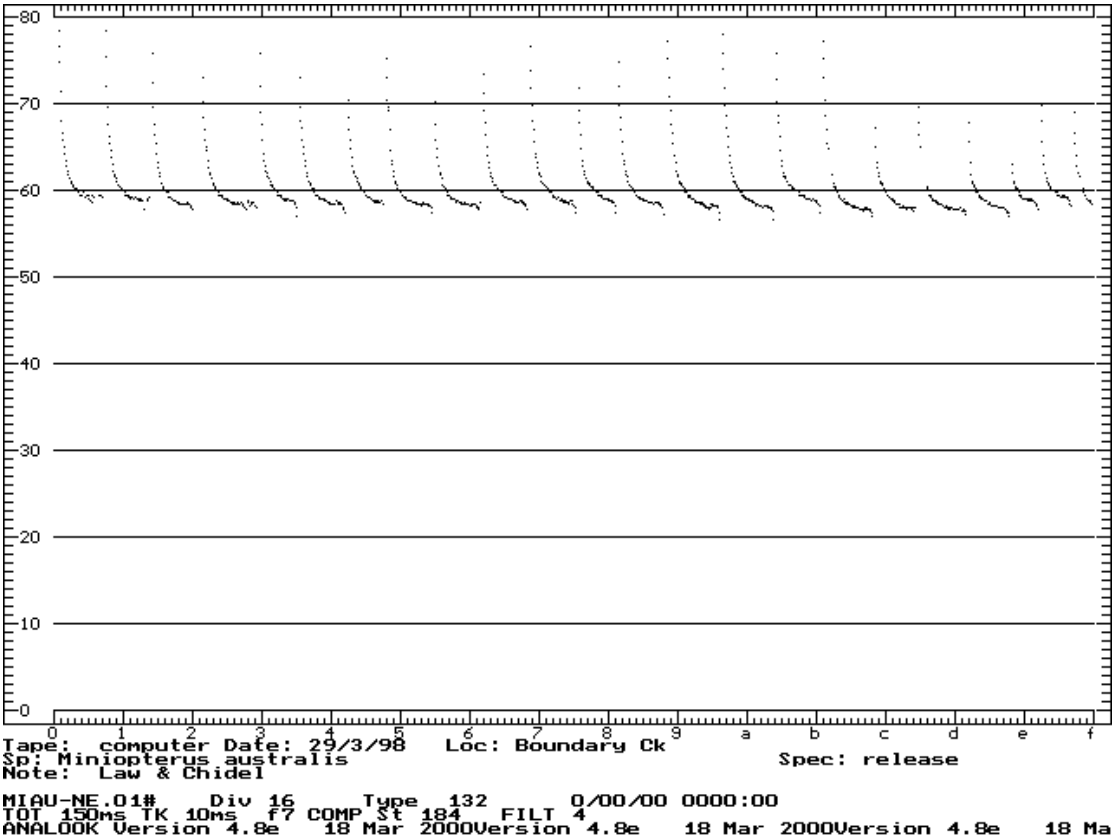
Regional Information

North East: As described above. 54.5 to 64.5 kHz (n = 53). The characteristic frequency of calls from most areas rarely drops below 58 kHz and is usually above 60 kHz, however calls from Unumgar and Washpool State Forests in the northern tablelands appear to have lower characteristic frequencies between 55 and 57 kHz.

Sydney Basin, Southern, Riverina, Western Slopes & Plains, Far West: No reference calls from these regions.

Miniopterus australis: Representative regional calls

North East



Miniopterus schreibersii oceanensis

Characteristic frequency 43 to 48 kHz (n = 72). Curved, often with down-sweeping tail. Characteristic section may be long in search phase. Pulse shape and time between calls usually variable within a sequence.

Overlaps in frequency with *Vespadelus darlingtoni, Vespadelus regulus* and *Vespadelus vulturnus* in various parts of New South Wales (see regional information). Calls may be distinguished from other species if distinctive characteristics are present, but these characteristics are not always obvious and some calls cannot be correctly identified.

Available data shows no indication of variation in call characteristics for this species throughout New South Wales.

Regional Information

North East: Characteristic frequency 44.5 to 48 kHz (n = 14).

Overlaps in frequency with *Vespadelus darlingtoni* between 44.5 and 46 kHz. Some calls can be distinguished by the presence of a down-sweeping tail and / or uneven time between call pulses and pulse shape within a sequence. If tail is absent or up-sweeping may not be distinguished from *V. darlingtoni* at the same frequency.

Overlaps in frequency with *Vespadelus regulus* between 45 and 47 kHz. Most calls can be distinguished by the presence of a down-sweeping tail, longer characteristic section and uneven consecutive pulses.

Western Slopes & Plains: Characteristic frequency 44 to 48.5 kHz (n = 33). Pulse shape as described above. Overlaps in frequency with *Vespadelus vulturnus* (43 to 49 kHz). Most calls can be distinguished by the absence of an up-sweeping tail, longer characteristic section and uneven consecutive pulses.

Sydney Basin: Characteristic frequency 44 to 47.5 kHz (n = 23). Pulse shape as above. Overlaps in frequency with *Vespadelus darlingtoni* at between 44 and 46 kHz, although most *V. darlingtoni* calls from this region are lower in frequency (40 to 45 kHz). Can be distinguished by the presence of a down-sweeping tail and uneven consecutive pulses.

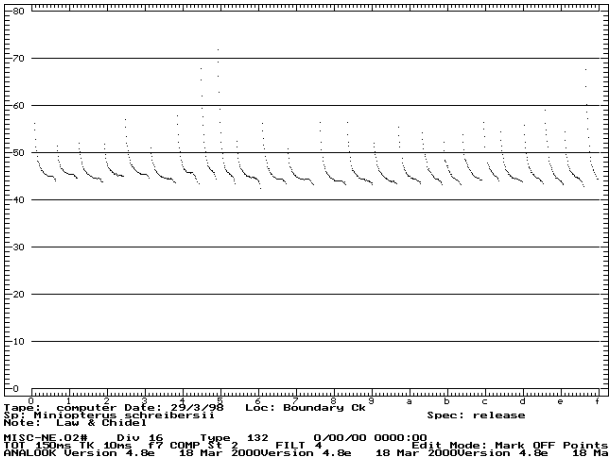
Overlaps in frequency with *Vespadelus regulus*. Most calls can be distinguished by the presence of a down-sweeping tail, longer characteristic section and uneven consecutive pulses.

Southern: Characteristic frequency 44 to 47 kHz (n = 2). Overlaps in frequency with *Vespadelus vulturnus* between 44.5 and 47 kHz on the far south coast and across the Snowy Mountains to the South West Slopes. Most calls can be distinguished by the presence of a down-sweeping tail, longer characteristic section and uneven consecutive pulses.

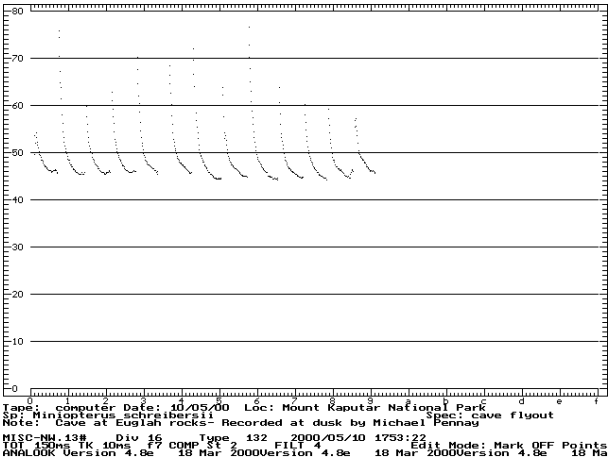
Riverina, Far West: No reference calls from these regions.

Miniopterus schreibersii oceanensis: Representative regional calls

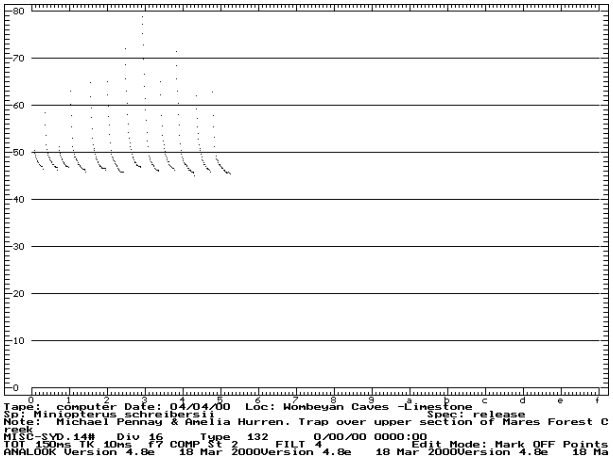
North East



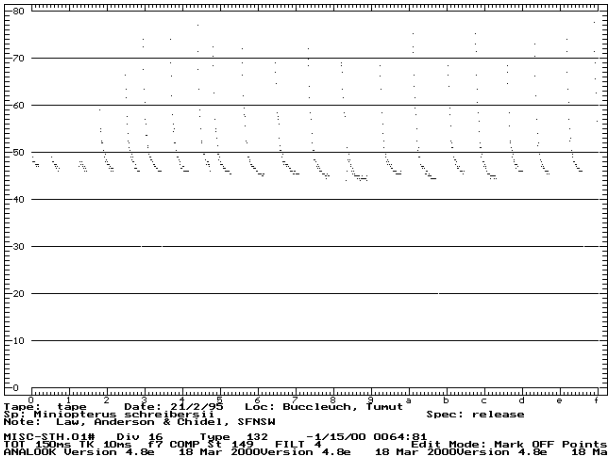
Western Slopes & Plains



Sydney Basin



Southern



Mormopterus beccarii

No reference calls from New South Wales for this species. In Queensland the call is flat to curved. Characteristic frequency 22 to 24 kHz (Reinhold *et al.* 2001).

Calls have occasionally been recorded from free flying bats around Gunnedah, Narrabri and Moree in north west NSW that match the characteristics of *M. beccarii* calls from Queensland but the identity of the species producing the calls has not been confirmed.

May be confused with *Saccolaimus flaviventris,* however *S. flaviventris* rarely call above 22 kHz.

Regional information

None available for New South Wales.

Mormopterus norfolkensis

Characteristic frequency 31 to 35 kHz (n = 5). May be flat, but sometimes with short initial and down-sweeping tail. Pulses alternate by about 2 kHz in frequency when in search phase, however may call for several pulses without alternating.

Regional Information

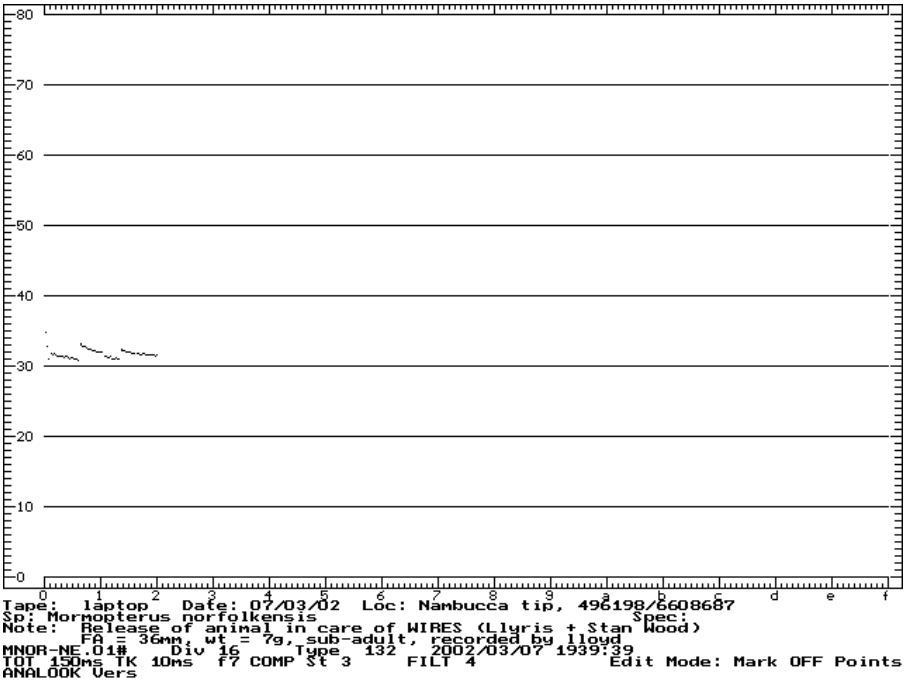
North East: Characteristic frequency 31 to 33.5 kHz (n = 3). Pulse shape as above. Overlaps in frequency with *Mormopterus* species 2, but unlikely to be confused due to alternating pattern and distinctive pulse shape.

Sydney Basin: Characteristic frequency 32 to 35 kHz (n = 2). Pulse shape as above. Lower pulses range from 32 to 33 kHz, and higher pulses from 34 to 35 kHz. Overlaps in frequency with *Mormopterus* species 2, but unlikely to be confused due to alternating pattern and distinctive pulse shape.

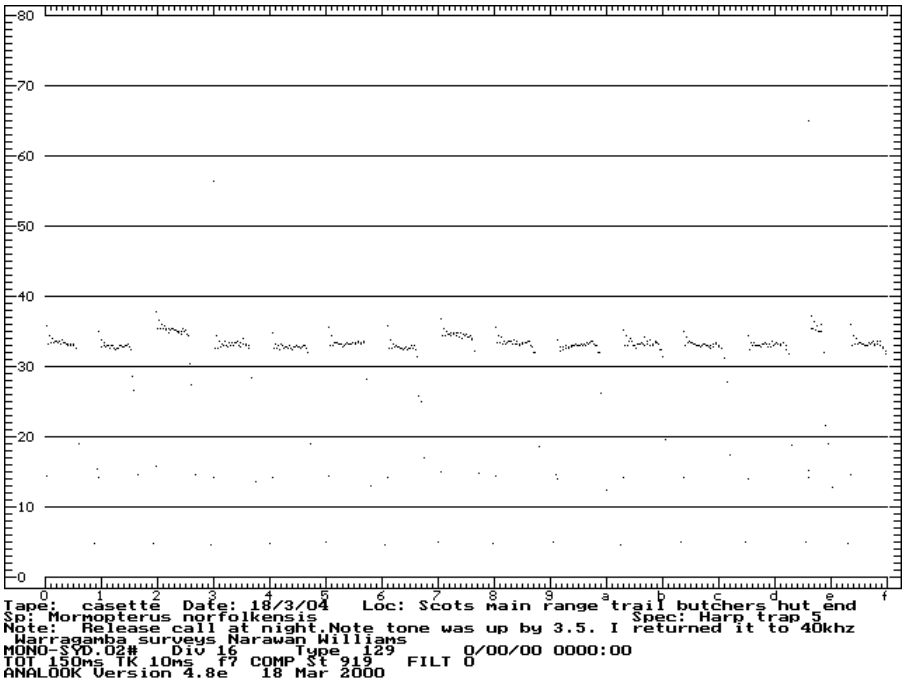
Southern, Riverina, Western Slopes & Plains, Far West: No reference calls from these regions.

Mormopterus norfolkensis: Representative regional calls

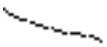
North East



Sydney Basin



Mormopterus species 4 (Long penis form) (Adams *et al.* 1988).



Characteristic frequency 26 to 30.5 kHz (n = 30). Flat or curved, sometimes with down-sweeping tail. Sometimes exhibits on upper harmonic around 53 to 60 kHz identical in shape.

Can easily be confused with *Chalinolobus gouldii* in cruise mode. Can be differentiated by lack of alternation in frequency or pulse shape, or the presence of harmonics which are never present in *C. gouldii* calls. May be confused in calls consisting of only a few pulses with *Saccolaimus flaviventris,* which often produces upper harmonic pulses around this frequency but only for short periods.

Calls indistinguishable from *Mormopterus* species 3 (short penis form) between 30 and 30.5 kHz where they overlap frequency.

Available data shows no indication of variation in call characteristics for this species throughout New South Wales.

Regional Information

Western Slopes & Plains: Characteristic frequency 26 to 29.5 kHz (n = 6). Pulse shape as described above, often with down-sweeping tail and harmonics visible.

Calls at 30kHz probably overlap in frequency and are indistinguishable from *Mormopterus* short penis form, however there is insufficient number calls at present to verify this. May also overlap with *Mormopterus* species 6 in this region whose call is unknown.

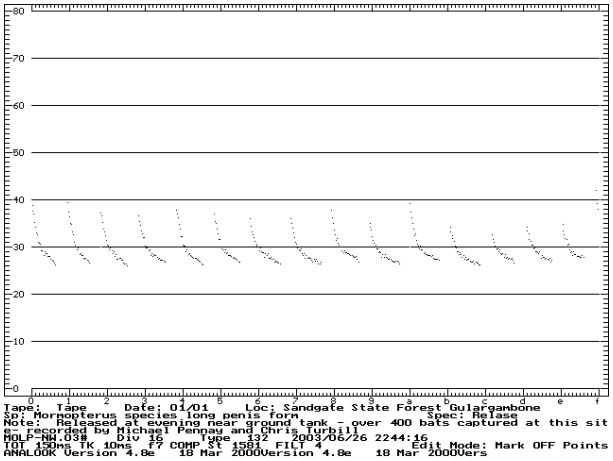
Riverina: Characteristic frequency 26.5 to 30.5 kHz (n = 13). Pulse shape as described above. Sometimes with odd pulses around 40 kHz in addition to harmonics.

Far West: Reference calls from this region were identified to the synonym '*Mormopterus planniceps*' prior to the species split from *M. planniceps* by Adams *et al.* (1988). The characteristics of the calls recorded suggest that the species recorded was *Mormopterus* species 4. Characteristic frequency 26 to 29.5 (n = 11). Pulse shape as described above. May also overlap in this region with *Mormopterus* species 6 whose call is unknown.

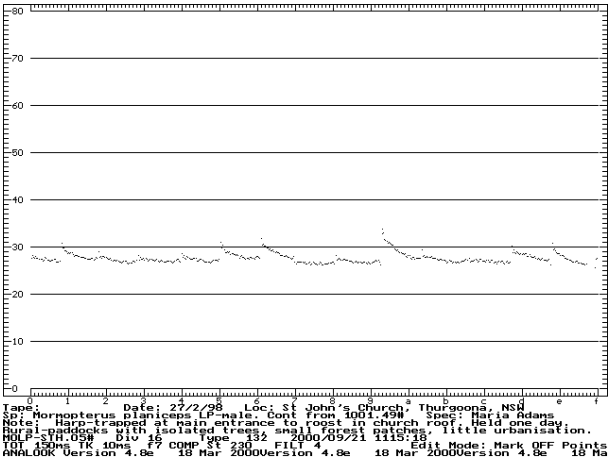
North East, Sydney Basin, Southern: No reference calls from these regions.

Mormopterus species 4 (Long penis form): Representative regional calls

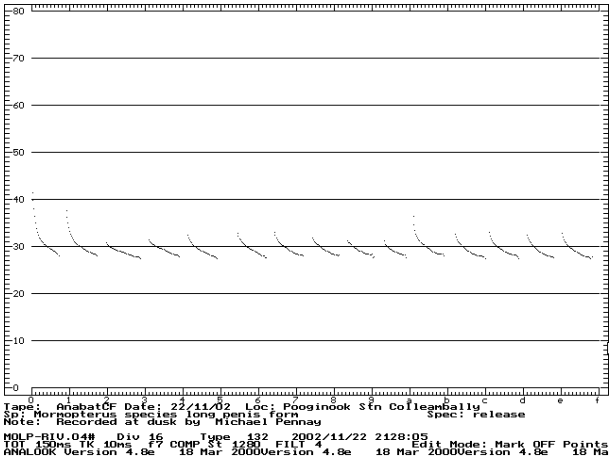
Western Slopes & Plains



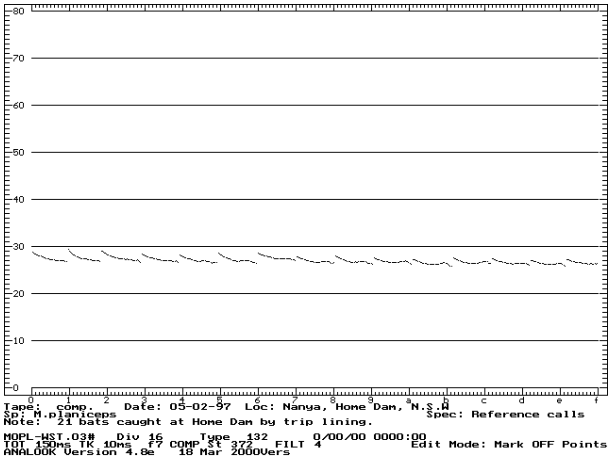
Southern



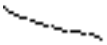
Riverina



Far west



Mormopterus species 3 (Short penis form) (Adams *et al.* 1988)



Characteristic frequency 31 to 36 kHz (n = 9). Call similar shape to *Mormopterus* species 4 except at higher frequencies. Tail variable. Good quality calls unlikely to be confused with any other species.

May be confused with *Chalinolobus gouldii*. Can be differentiated by lack of alternation which is usually present in *C.gouldii* calls at these frequencies. When in attack phase may appear similar to *Scotorepens balstoni*.

Calls around below 31 kHz are likely to be indistinguishable from *Mormopterus* species 4.

Available data shows no indication of variation in call characteristics for this species throughout New South Wales.

Regional Information

Western Slopes & Plains: Characteristic frequency 34.5 to 35 kHz (n = 5).

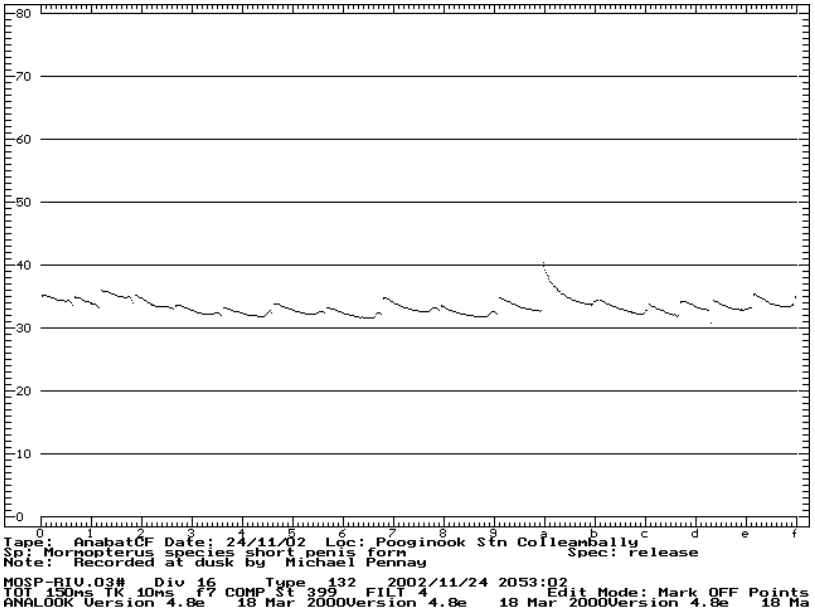
May overlap with *Mormopterus* species 6 whose call is unknown.

Riverina: Characteristic frequency 31 to 36 kHz (n = 4).

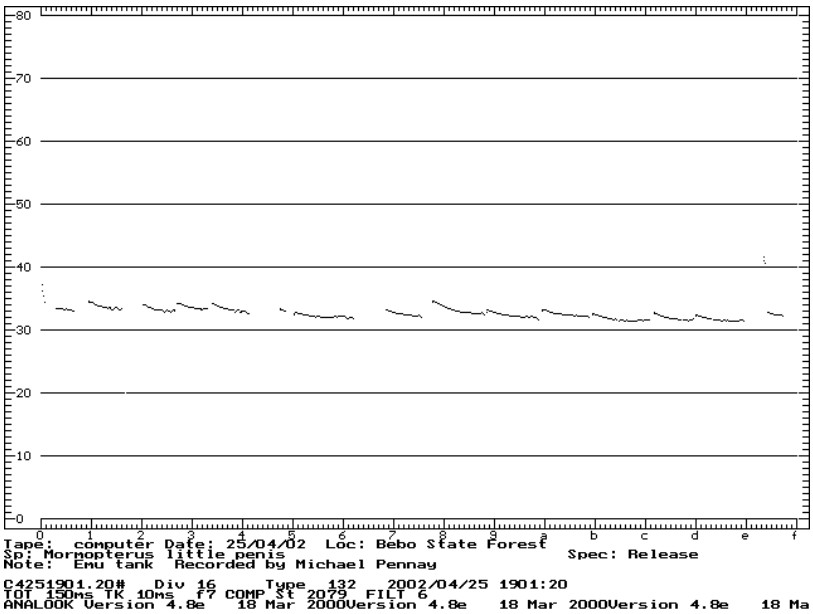
North East, Sydney Basin, Southern, Far West: No reference calls from these regions.

Mormopterus species 3 (Small penis form): Representative regional calls

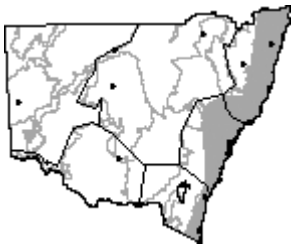
Riverina

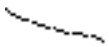


Western Slopes & Plains



Mormopterus species 2 (Adams *et al.* 1988)





Characteristic frequency 28.5 to 31 kHz (n = 2). Flat. Occasional pulses in a sequence may have a higher frequency but not in a regular up and down alternating pattern.

Overlaps in frequency with *Mormopterus norfolkensis,* however easily distinguished by lack of regular alternating pattern.

There are very few reference calls from this species in New South Wales.

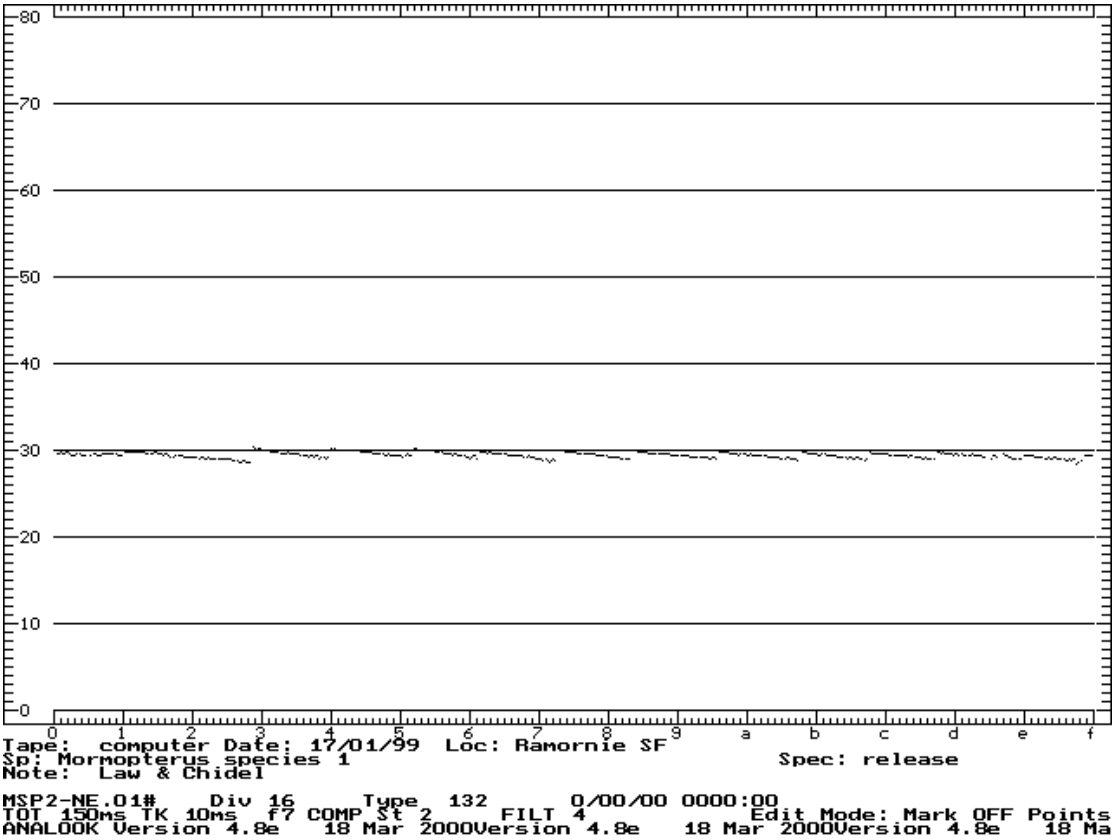
Regional Information

North East: As described above.

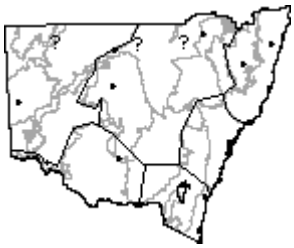
Western Slopes & Plains, Sydney Basin, Southern, Riverina, Far West: No reference calls from these regions.

Mormopterus species 2: Representative regional calls

North East



Mormopterus species 6 (Adams *et al.* 1988)



This species has been captured at three locations in north western New South Wales; Mt Gunderbooka near Bourke, Bebo State Forest near Yetman and near Bonshaw. These are the only locations where *Mormopterus* sp. 6 has been found in NSW. The call has not yet been recorded.

It may be possible that it produces a call similar to either *Mormopterus* species 3 or *Mormopterus* species 4 as no unusual calls were observed from recordings of free flying bats around the capture location in Bebo State Forest on several occasions.

Regional Information

Call currently unknown.

Myotis macropus

Steep, near vertical, starting at between 70 to 80 kHz, usually dropping to between 35 to 40 kHz (n = 21). Good quality calls have a central kink around 47 to 50 kHz and very occasionally another prior to the tail dropping off around 35 kHz. Appears very similar to calls of *Nyctophilus* and could be easily confused.

Good calls can be differentiated on by a number of features: Pulse interval <75 ms, an initial slope of greater than 400 octaves per second (OPS) and shape often with a central kink in slope, the second part of the call having a lesser slope than the first part. *Myotis* can be recorded up to a 20 metre range which usually results in longer sequences recorded than *Nyctophilus* (Reinhold *et al.* 2001). If interval is between 75 and 95 ms and slope between 300 and 400 OPS then call cannot be distinguished from *Nyctophilus.*

Available data shows no indication of variation in call characteristics for this species, however reference calls have not been recorded from throughout its known range.

Regional Information

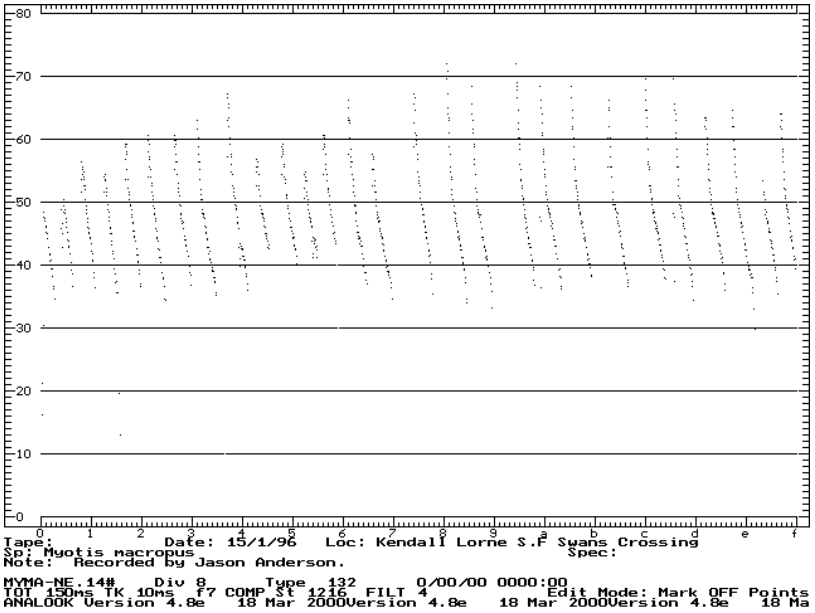
North East: As described above (n = 20).

Sydney Basin, As described above (n = 1)

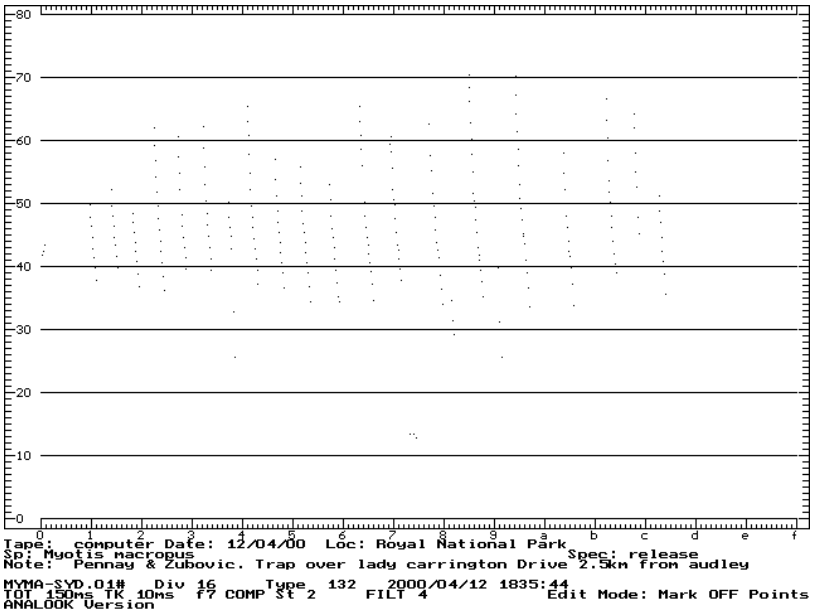
Western Slopes & Plains, Southern, Riverina, Far West: No reference calls from these regions.

Myotis macropus: Representative regional calls

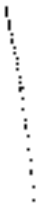
North East



Sydney Basin



Nyctophilus bifax



Steep, near vertical, starting at between 70 to 108 kHz, usually dropping to between 47 to 55 kHz (n = 10). Good quality calls usually have two changes in the slope in the middle or lower half. The first section is longest and steepest followed by a flatter section and then a steeper tail.

All *Nyctophilus* spp. are soft callers so short fragmentary calls are typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus gouldi, N. geoffroyii, and N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

On average *Nyctophilus bifax* appears to have a higher call than other *Nyctophilus* spp. Average maximum frequency is 89.1 kHz (other *Nyctophilus* spp. 65 to 77 kHz), average mean frequency 68 kHz (others 49 to 57 kHz) and average mean frequency of the knee is 78kHz (others 45-65). However, this is unlikely to be of use in identifying individual call sequences as the range between calls is highly variable and maximum frequency varies strongly with distance of the bat from the microphone.

Bullen and McKenzie (2002) have devised a method using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This method has not been used for this guide as most calls were recorded as zero crossings in time domain data rather than audio files.

Easily confused with *Myotis macropus*, but may be distinguished by several features. Pulse interval is usually greater than 95ms and initial slope less than 300 OPS. If interval is between 75 and 95 ms and slope between 300 and 400 OPS then cannot be distinguished from *Myotis.*

Superficially similar to *Kerivoula,* but much lower in frequency.

Available data shows no indication of variation in call characteristics for this species in New South Wales.

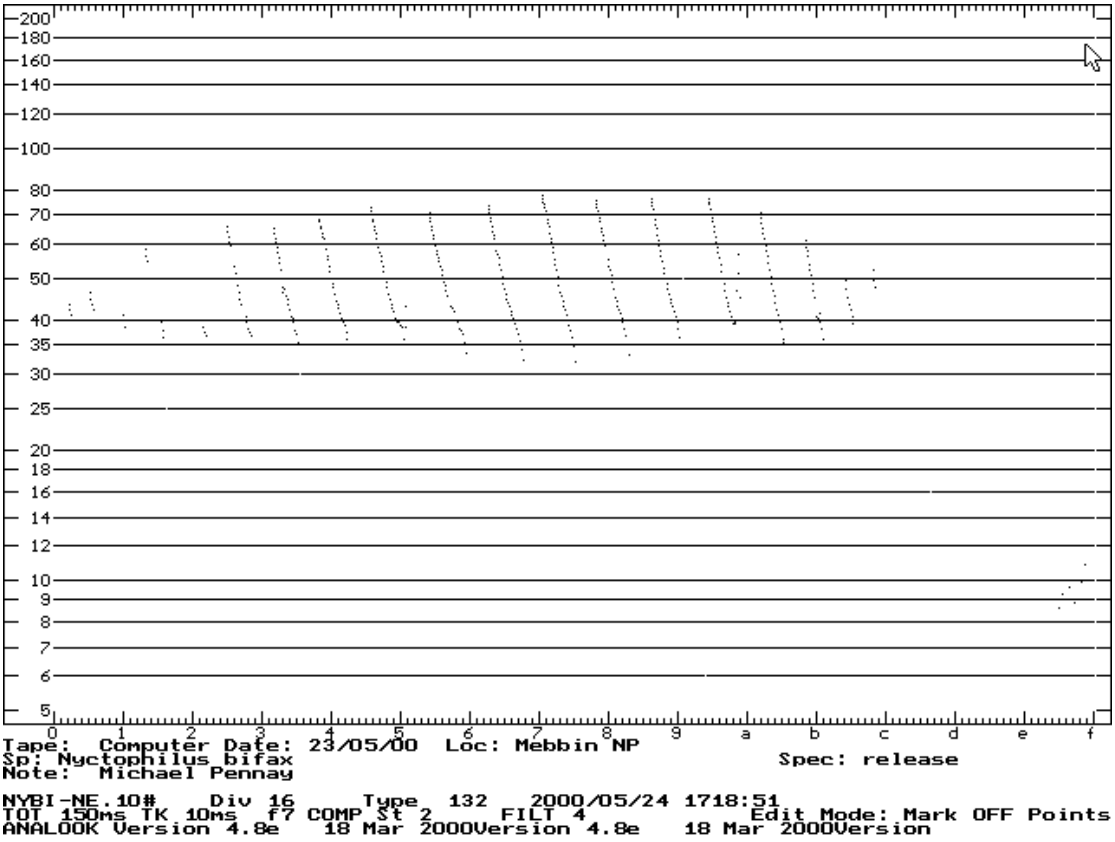
Regional Information

North East: As described above (n = 10).

Western Slopes & Plains, Sydney Basin, Southern, Riverina, Far West: No reference calls from these regions.

Nyctophilus bifax: Representative regional calls

North East



Nyctophilus geoffroyi

Steep, near vertical, starting at between 65 to 80 kHz, usually dropping to between 35 to 47 kHz (n = 51). Good quality calls usually have two changes in the slope in the middle or lower half. The first section is longest and steepest followed by a flatter section and then a steeper tail.

All *Nyctophilus* spp. are soft callers so short fragmentary calls are typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus gouldi, N. bifax, and N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

Bullen and McKenzie (2002) have devised a method to differentiate Western Australian *Nyctophilus* species using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This technique may help to differentiate these species.

Easily confused with *Myotis macropus*, but may be distinguished by several features. Pulse interval is usually greater than 95 ms and initial slope less than 300 OPS. If interval is between 75 and 95 ms and slope between 300 and 400 OPS then cannot be distinguished from *Myotis.*

Superficially similar to *Kerivoula,* but much lower in frequency.

Available data shows little indication of variation in call characteristics for this species in New South Wales. However, calls from west of the Great Dividing Range, particularly the Riverina and Far west regions are generally lower in frequency with longer durations.

Regional Information

North East: Average starting frequency 72 kHz dropping to 42 kHz, mean frequency 57 kHz (n = 2).

Western Slopes & Plains: Average starting frequency 66 kHz dropping to 46 kHz, mean frequency 53.5 kHz (n = 14).

Sydney Basin: Average starting frequency 71 kHz dropping to 39 kHz, mean frequency 47 kHz (n = 3).

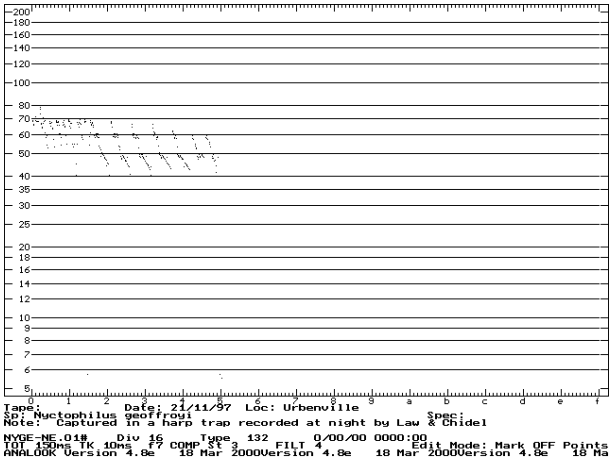
Southern: Average starting frequency 67 kHz dropping to 45 kHz, mean frequency 53.5 kHz (n = 10).

Riverina: Average starting frequency 65.5 kHz dropping to 39 kHz, mean frequency 49 kHz (n = 11). Occasionally calls display distinctive “social” non search pulses, long (> 10 ms), curved, dropping from 45 to 50 kHz to 20 to 25 kHz.

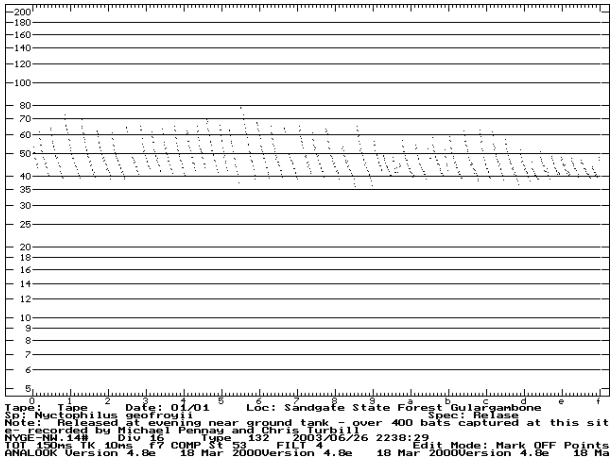
Far West: Average starting frequency 65 kHz dropping to 45 kHz, mean frequency 46 kHz (n = 11).

Nyctophilus geoffroyii: Representative regional calls

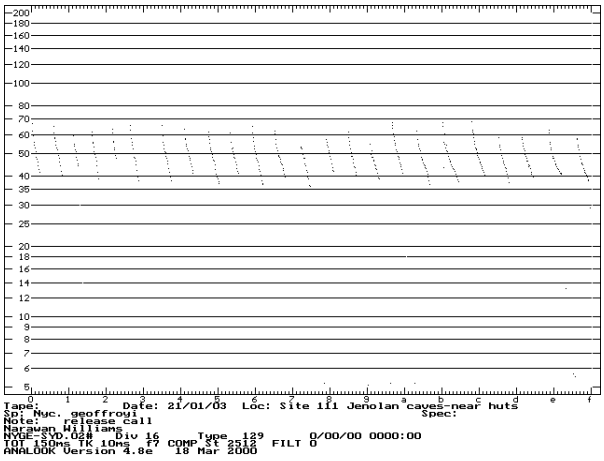
North East



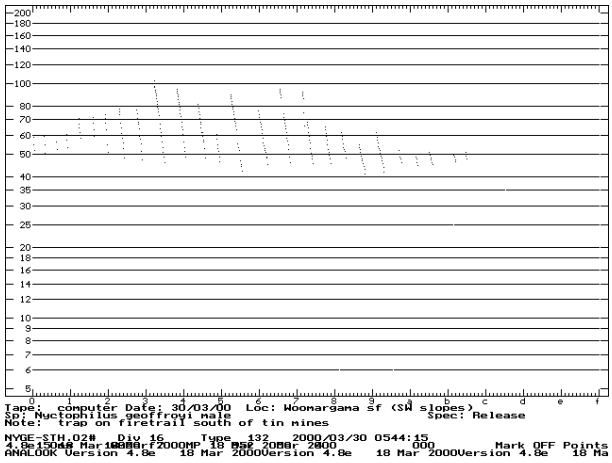
Western Slopes & Plains



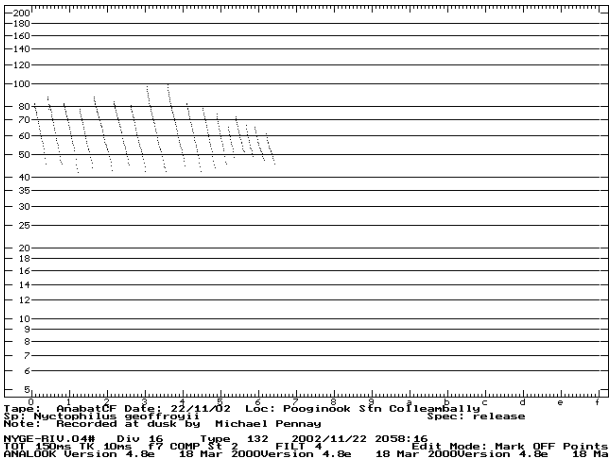
Sydney Basin



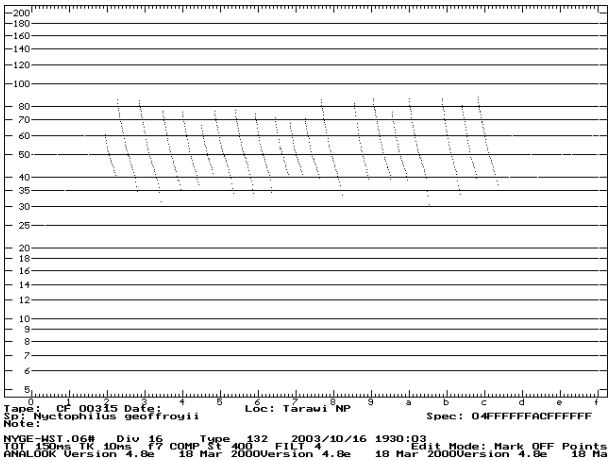
Southern



Riverina



Far west



Nyctophilus gouldi

Almost identical in shape and characteristics to *Nyctophilus geoffroyi* and other *Nyctophilus* species. Steep, near vertical, starting at between 65 and 80 kHz, usually dropping to between 35 to 43 kHz (n = 56). Soft callers, fragmentary calls typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus geoffroyi, N. bifax,* and *N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

Bullen and McKenzie (2002) have devised a method to differentiate Western Australian *Nyctophilus* species using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This technique may help to differentiate these species.

Easily confused with *Myotis macropus*, but may be distinguished by several features. Pulse interval is usually greater than 95ms and initial slope less than 300 OPS. If interval is between 75 and 95 ms and slope between 300 and 400 OPS then cannot be distinguished from *Myotis.*

Superficially similar to *Kerivoula* but much lower in frequency.

Available data shows little indication of variation in call characteristics for this species in New South Wales.

Regional Information

North East: Average starting frequency 78 kHz dropping to 41 kHz, mean frequency 56 kHz (n = 16).

Western Slopes & Plains: Average starting frequency 67 kHz dropping to 40 kHz, mean frequency 49.5 kHz (n = 5).

Southern: Average starting frequency 67 kHz dropping to 45 kHz, mean frequency 53.5 kHz (n = 10).

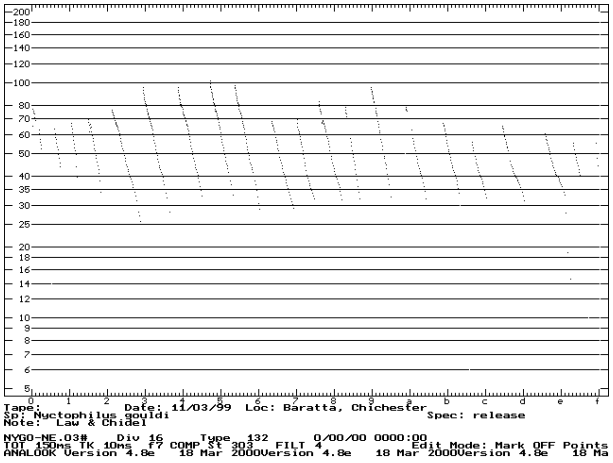
Riverina: Average starting frequency 68 kHz dropping to 42 kHz, mean frequency 53 kHz (n = 16).

Sydney Basin: Average starting frequency 65.5 kHz dropping to 37.5 kHz, mean frequency 50 kHz (n = 9).

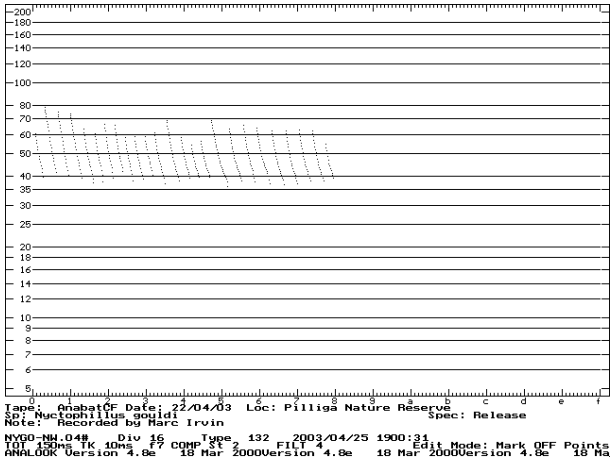
Far West: No reference calls from this region.

Nyctophilus gouldii: Representative regional calls

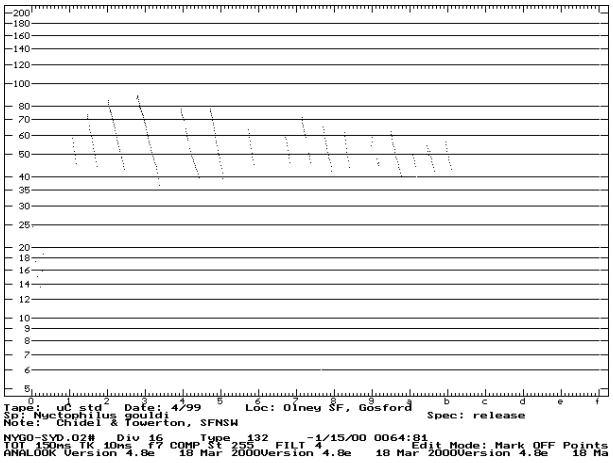
North East



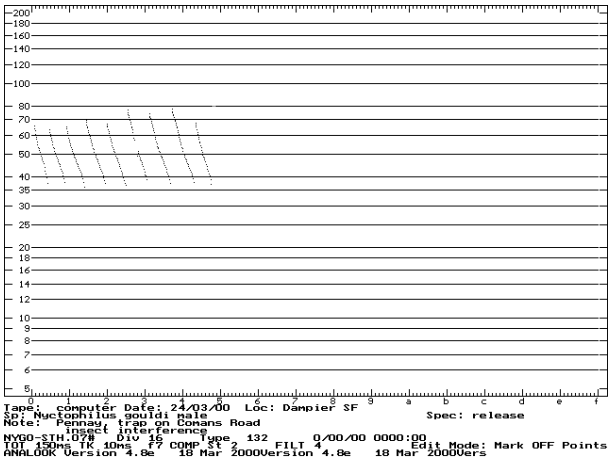
Western Slopes & Plains



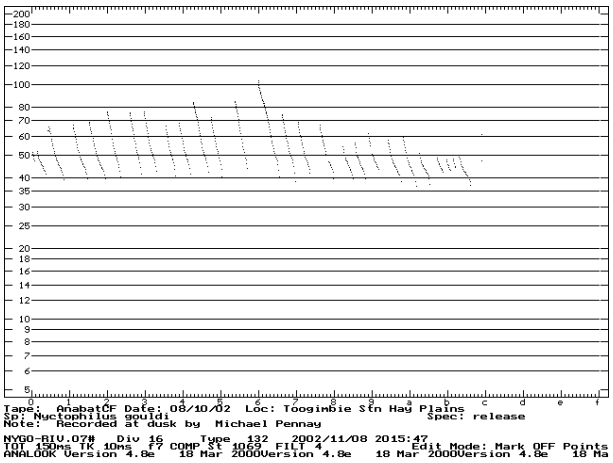
Sydney Basin



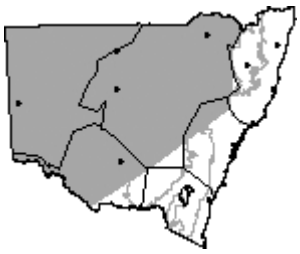
Southern



Riverina



Nyctophilus timoriensis



Almost identical in shape and characteristics to other *Nyctophilus* species. Steep, near vertical, starting at between 60 and 80 kHz, usually dropping to between 31 to 37 kHz (n = 16). Soft callers, fragmentary calls typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus geoffroyi, N. bifax, and N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

Bullen and McKenzie (2002) have devised a method to differentiate Western Australian *Nyctophilus* species using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This technique may help to differentiate these species.

Available data shows little indication of variation in call characteristics for this species in New South Wales.

Regional Information

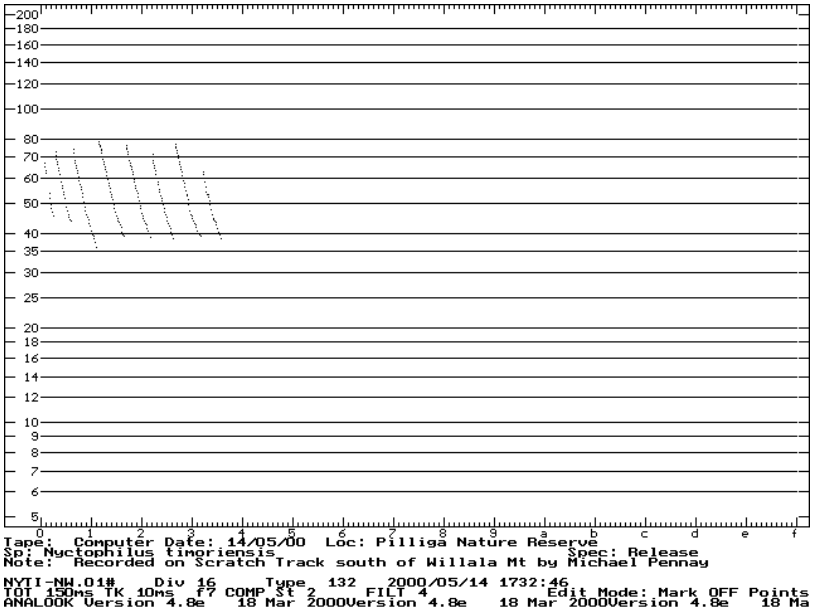
Western Slopes & Plains: Average starting frequency 71 kHz dropping to 43 kHz, mean frequency 53 kHz (n = 7).

Far West: Average starting frequency 70.5 kHz dropping to 42 kHz, mean frequency 53 kHz (n = 9).

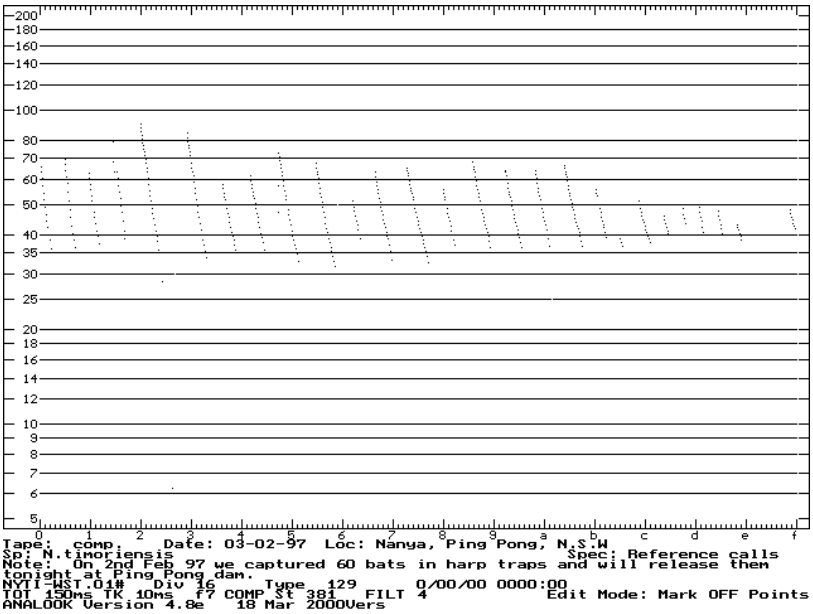
North East, Sydney Basin, Southern, Riverina: No reference calls from these regions.

Nyctophilus timoriensis: Representative regional calls

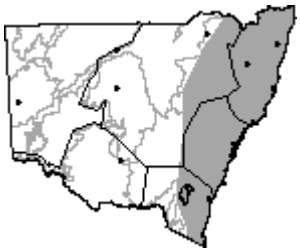
Western Slopes & Plains



Far west



Rhinolophus megaphyllus



Characteristic frequency 66 to 70 kHz (n = 36). Perfectly flat, except for up sweeping initial section, and down sweeping tail. Sometimes displaying identical shaped pulses at other harmonics.

Highly distinctive and cannot be confused with any other species in New South Wales.

Available data shows no indication of variation in call characteristics for this species.

Regional Information

North East: Characteristic frequency 66 to 70 kHz (n = 17).

Western Slopes & Plains: Characteristic frequency 66 kHz (n = 2).

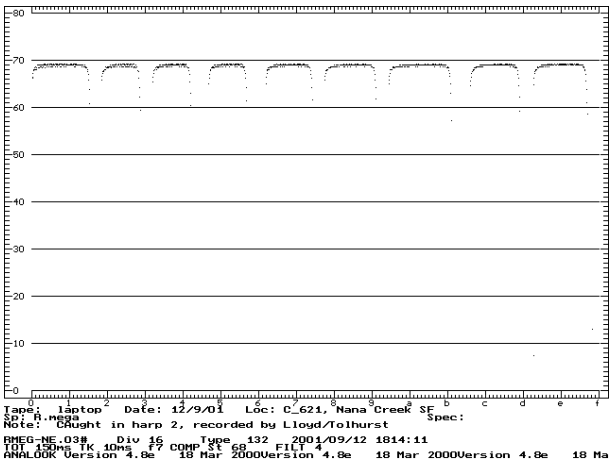
Southern: Characteristic frequency 66.5 to 70 kHz (n = 15).

Sydney Basin: Characteristic frequency 68 to 70 kHz (n = 2).

Riverina, Far West: No reference calls from these regions.

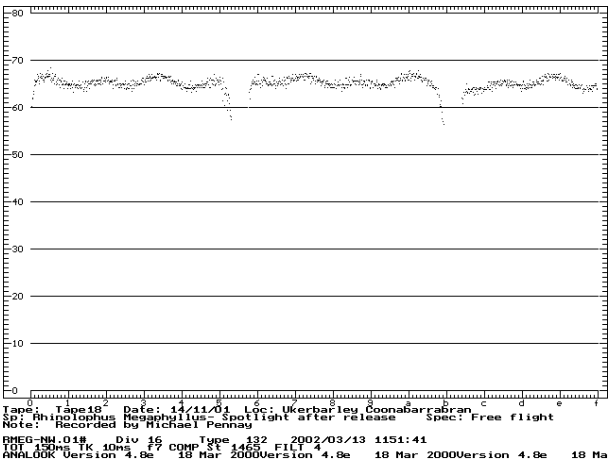
Rhinolophus megaphyllus: Representative regional calls

North East

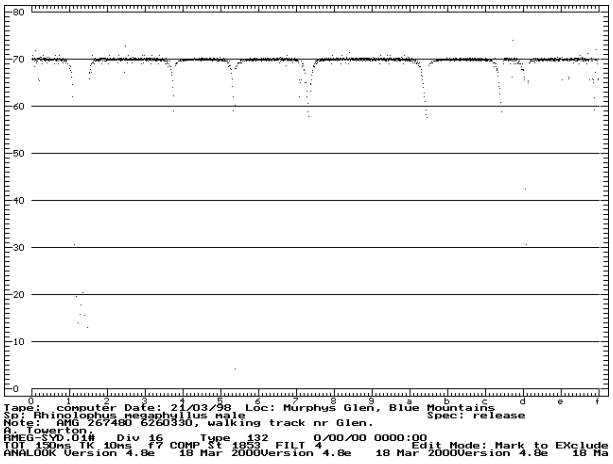


Western Slopes & Plains

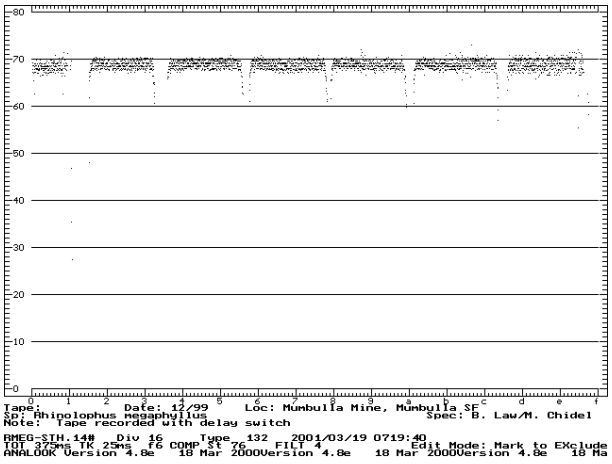
(affected by tape speed flutter)



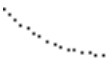
Sydney Basin



Southern



Saccolaimus flaviventris



Characteristic frequency of 17.5 to 22.5 kHz (n = 21). Usually curved in search phase, but may be flat. Often displays harmonics in the 28-33 kHz range and less commonly in the 9 to 13 kHz range. Occasional non-harmonic pulses within a sequence may have characteristic frequency as low as 15 kHz or as high as 24 kHz.

May be confused with *Mormopterus* species or *Tadarida australis* if only a few pulses are recorded when using an upper or lower harmonic. However, should be easily identified if using sequences longer than a few pulses as calls usually return to the dominant 18 to 20kHz harmonic. Traces of the 18 to 20 kHz harmonic call are often still visible when calling at a different frequency.

Overlaps in frequency with *Mormopterus beccarii* between 20 to 22.5 kHz. Most calls should be easily differentiated by the lower characteristic frequency and shape of attack phase calls. *S. flaviventris* attack phase calls do not greatly change in frequency from the search phase calls whereas *M. beccarii* attack pulses rise in frequency (Reinhold *et al.* 2001).

Available data shows no indication of variation in call characteristics for this species in New South Wales.

Regional Information

North East: Characteristic frequency 17.5 to 19 kHz (n = 1).

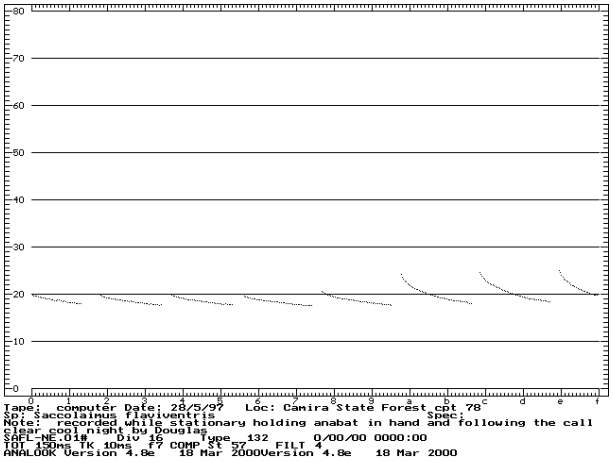
Western Slopes & Plains: Characteristic frequency 17.5 to 22.5 kHz (n = 13).

Far West: Characteristic frequency 17.5 to 20 kHz (n = 7).

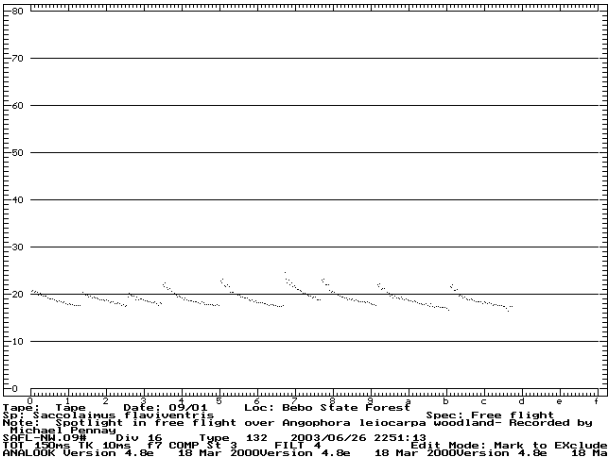
Sydney Basin, Southern, Riverina: No reference calls from these regions.

Saccolaimus flaviventris: Representative regional calls

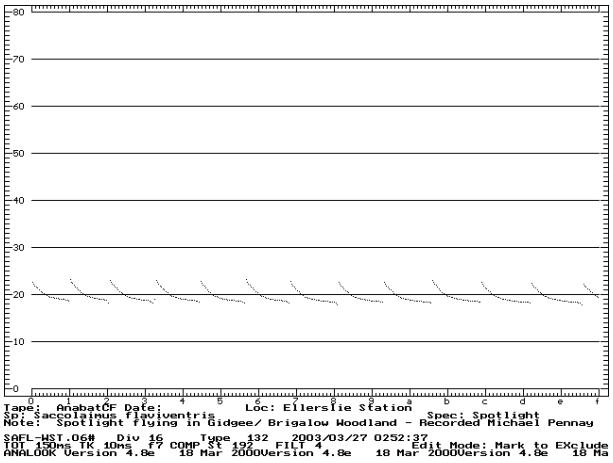
North East



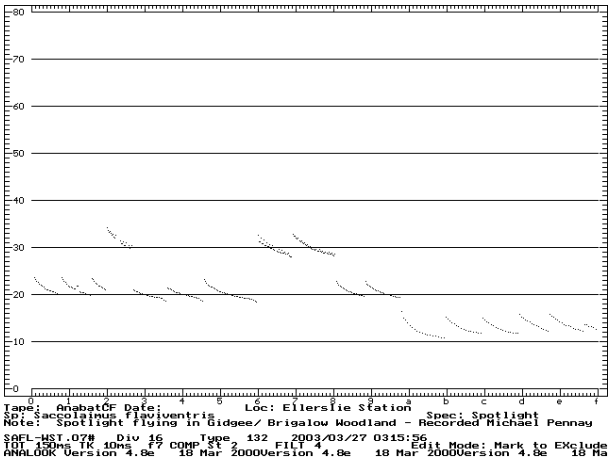
Western Slopes & Plains



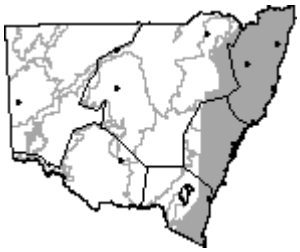
Far west



Far west (showing harmonics)



Scoteanax rueppellii



Characteristic frequency between 32 and 36.5 kHz (n = 12). Curved, most pulses lack tail, occasionally with short down-sweeping tail.

Overlaps in frequency and may be confused with *Falsistrellus tasmaniensis, Scotorepens orion,* and *Scotorepens balstoni*. Most calls can be separated from *S. orion* and *S. balstoni* by the frequency of the knee which is most often higher than 37 kHz and pre-characteristic section dropping by more than 3 kHz in *S. rueppellii.* Mostly differentiated from *F. tasmaniensis* by frequency, *F. tasmaniensis* calls below 36.5 kHz are difficult to separate, but the length of pre-characteristic section is longer in *S. rueppellii* (Reinhold *et al.* 2001).

The repertoire of this species is not well known.

Regional Information

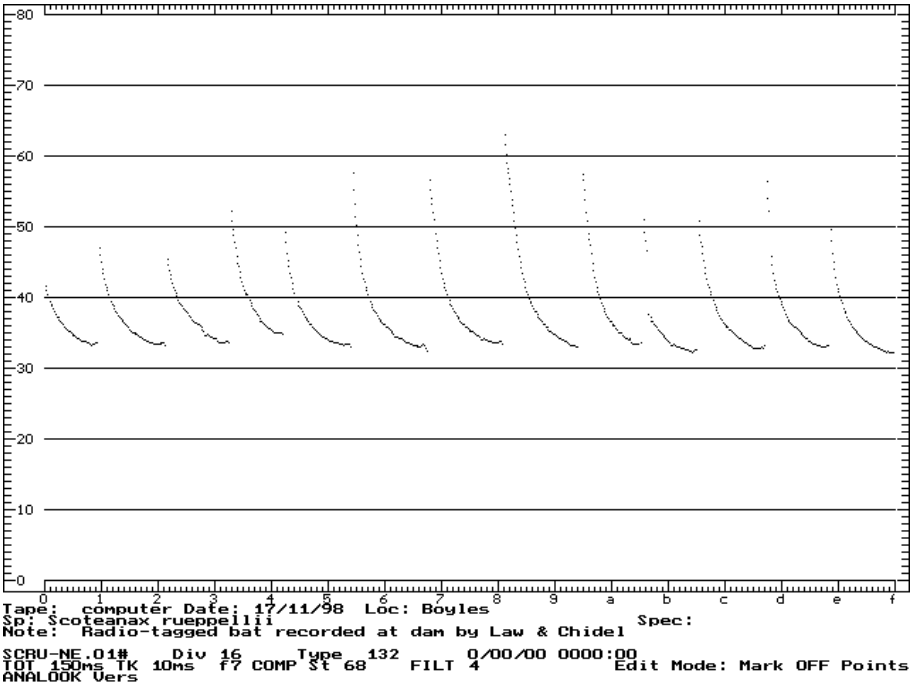
North East: Characteristic frequency 32 to 36 kHz (n = 9). Pulse shape as described above.

Southern: Characteristic frequency 33 to 36 kHz (n = 3).

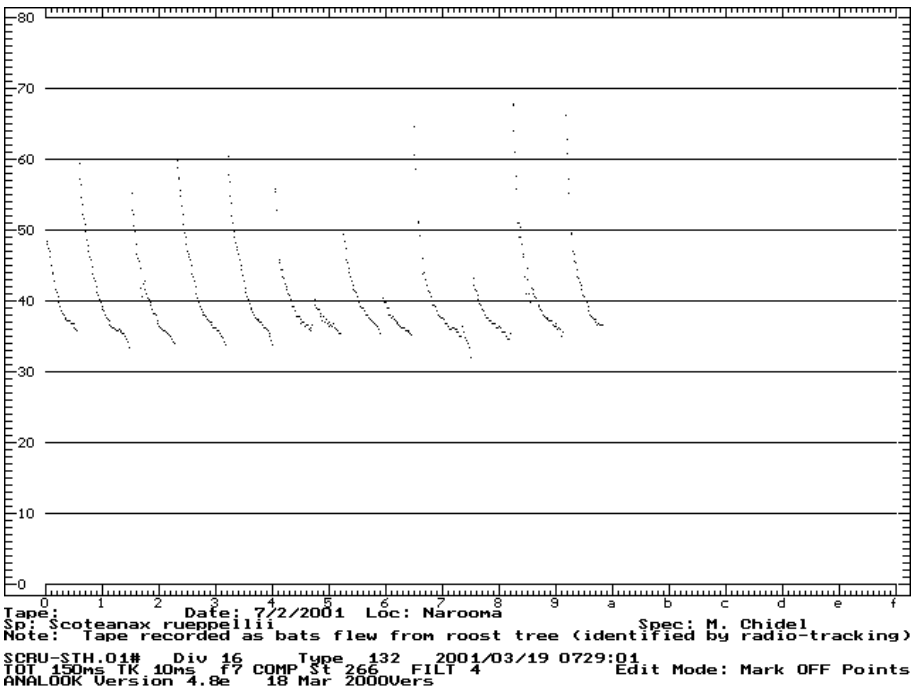
Sydney Basin, Riverina, Western Slopes & Plains, Far West: No reference calls from these regions.

Scoteanax rueppellii: Representative regional calls

North East



Southern



Scotorepens balstoni

Characteristic frequency between 28 and 34 kHz (n = 45). Curved, tail variable, usually down-sweeping or absent, occasionally up-sweeping. In open areas may go into cruise phase giving sloped pulses

, at about 28 kHz.

May be confused with *Chalinolobus gouldii*, but *C. gouldii* is generally lower in frequency and alternates. Very difficult to distinguish in cruise phase where both *C. gouldii* and *S. balstoni* call 28 to 29 kHz. However *C. gouldii* have pulse length of > 10 ms whereas *S. balstoni* pulses are always below 10 ms (usually 7 ms) when in cruise phase.

May be confused with *Mormopterus* species 3 which overlap in frequency between 31 to 34 kHz. However *Mormopterus* search phase pulses are flatter with a slope of less than 100 OPS, whereas *S. balstoni* calls are curved with a slope usually greater than 200 OPS.

May be differentiated from *Falsistrellus tasmaniensis*, *Scoteanax rueppellii* and *Scotorepens orion* which share similar shaped calls and frequencies by frequency of the knee which is lower than 37 kHz (usually 31 to 33 kHz)

Available data shows no indication of variation in call characteristics for this species over most of its range in New South Wales, cruise phase calls appear more common in open areas.

Regional Information

Western Slopes & Plains: Characteristic frequency 29 to 34 kHz (n = 20) Pulse shape as described above.

Far West: Characteristic frequency 28 to 33 kHz (n = 13) Pulse shape as described above.

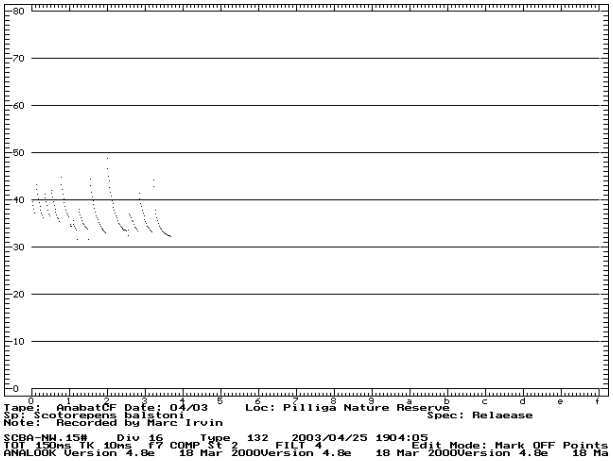
Riverina: Characteristic frequency 29 to 34 kHz (n = 11) Pulse shape as described above.

Southern: Characteristic frequency 36 kHz (n = 1). The only reference call from this region consists of an excited release call much higher in frequency than other areas. Additional reference calls are required from this region to confirm frequency.

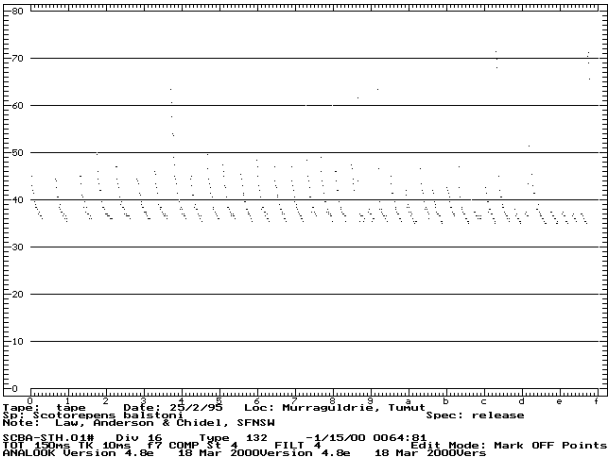
North East, Sydney Basin: No reference calls from these regions.

Scotorepens balstoni: Representative regional calls

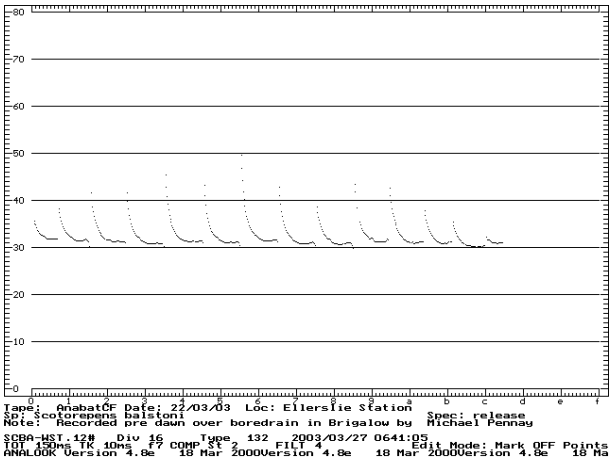
Western Slopes & Plains



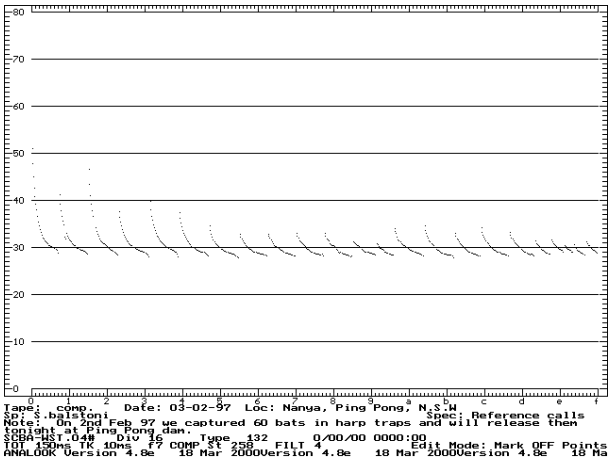
Southern ('excited')



Far west



Far west ('cruise')



Scotorepens greyii

Characteristic frequency between 35 and 40 kHz (n = 14). Curved, tail usually up-sweeping but may be down-sweeping or absent in some pulses. Sometimes gives flatter pulses.

Overlaps in frequency with *Chalinolobus picatus, C. nigrogriseus, Scotorepens* sp. (Parnaby, 1992), and *Falsistrellus tasmaniensis* in some regions.

Available data shows little variation in call characteristics for this species. Calls from North East NSW appear slightly higher in frequency than elsewhere, however the number of reference calls is low.

Regional Information

North East: Characteristic frequency 39 to 41 kHz (n = 4). Cannot be distinguished *Scotorepens*. sp (Parnaby, 1992) in this region where they are sympatric. May be difficult to distinguish from *C. nigrogriseus, S. greyii* have relatively shorter characteristic and tail sections usually ½ or less of the total pulse, *S. greyii* also usually have an up-sweeping tail absent in *C. nigrogriseus* calls (Reinhold *et al.* 2001).

Overlaps in characteristic frequency with *F. tasmaniensis* at 39 kHz, most calls can be separated by generally higher frequency and the presence of up-sweeping tails in most *S. greyii* pulses.

Western Slopes & Plains: Characteristic frequency 36.5 to 40 kHz (n = 4). Indistinguishable from *Scotorepens* sp (Parnaby, 1992) in the east of this region where they are sympatric. Overlaps in characteristic frequency with *Chalinolobus picatus* between 38.5 and 40 kHz. Can usually be distinguished by lower frequency and lack of alternation. *C. picatus* sometimes produce non alternating calls, in which case *S. greyii* have longer pulses, with time from the start of the call to end of the body (Tc) usually greater than 5 ms. Tc in *C. picatus* pulses is usually less than 5ms.

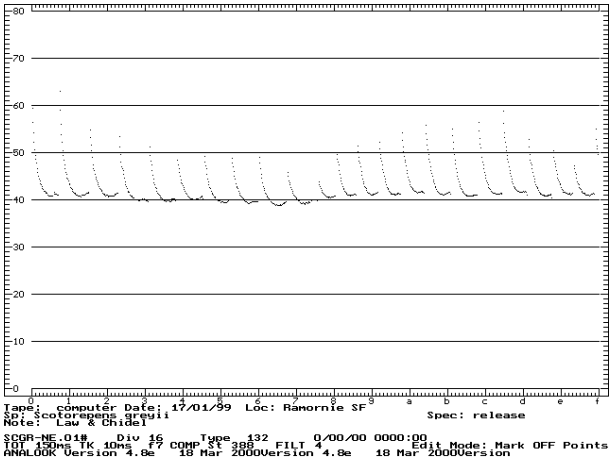
Overlaps in characteristic frequency with *F. tasmaniensis* at 39 kHz, most calls can be separated by higher frequency and up-sweeping tails.

Far West: Characteristic frequency 35 to 40 kHz (n = 6). Overlaps in characteristic frequency with *Chalinolobus picatus* between 38.5 and 40 kHz. Can usually be distinguished by lower frequency, lack of alternation and call pulses, with Tc greater than 5 ms.

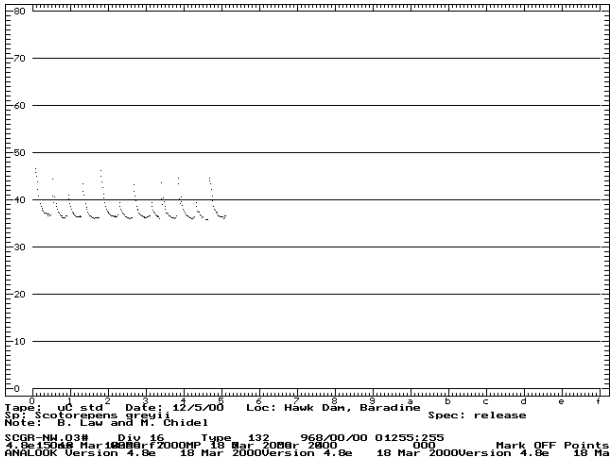
Sydney Basin, **Southern, Riverina:** No reference calls from these regions.

Scotorepens greyii: Representative regional calls

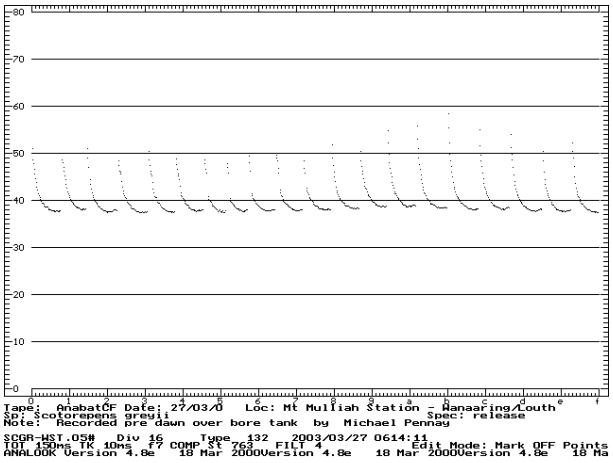
North East



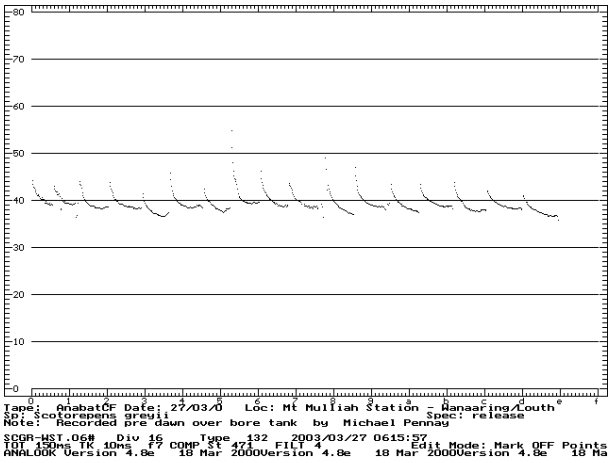
Western Slopes & Plains



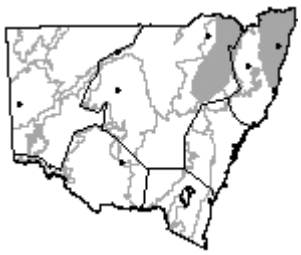
Far west

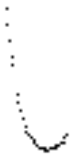


Far west (‘cruise’)



Scotorepens species (Parnaby 1992)





Characteristic frequency between 38 and 41 kHz (n = 22). Curved, tail usually up-sweeping.

May be confused with *C. nigrogriseus* and *Falsistrellus tasmaniensis* in some regions. Indistinguishable from *Scotorepens greyii* on recorded characteristics.

Available data shows little variation in call characteristics for this species.

Regional Information

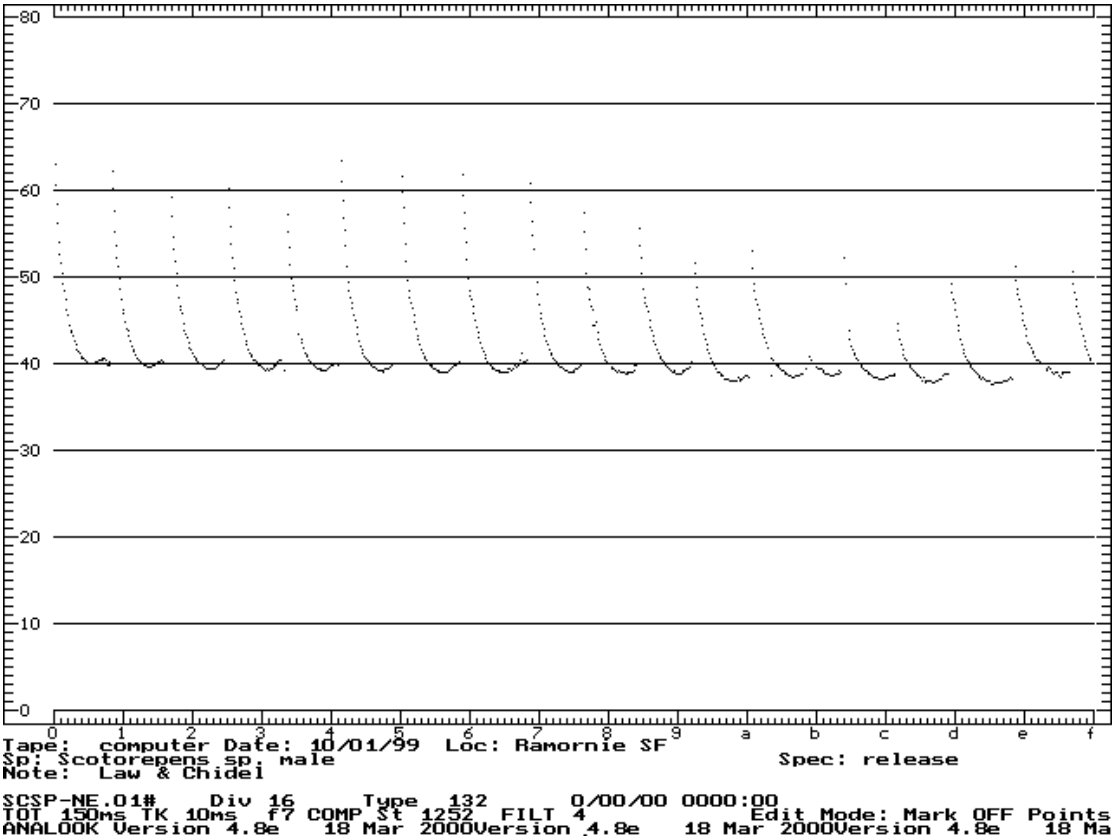
North East: As described above. May be difficult to distinguish from *C. nigrogriseus.* Some calls can be distinguished on the basis of shorter characteristic, tail sections usually ½ or less of the total pulse and the presence of an up sweeping tail. As in *S. greyii* (Reinhold *et al.* 2001).

Overlaps in characteristic frequency with *F. tasmaniensis* between 38 and 39 kHz. Most calls can be separated by generally higher frequency and the presence of up-sweeping tails in most pulses.

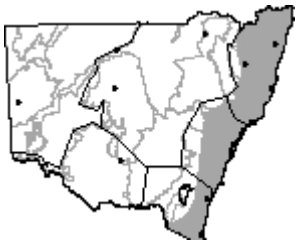
Western Slopes & Plains, Sydney Basin, **Southern, Riverina, Far West:** No reference calls from these regions.

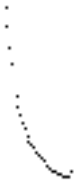
Scotorepens species: Representative regional calls

North East



Scotorepens orion





Characteristic frequency between 34.5 and 37.5 kHz (n = 21). Curved, tail absent sometimes down-sweeping. Frequency of the knee is usually > 38 kHz.

Overlaps in frequency and often indistinguishable from *Falsistrellus tasmaniensis* and *Scoteanax rueppellii*. Reinhold *et al.* (2001) report that *S. orion* may be differentiated on length of pre-characteristic section in some calls.

There are not enough reference calls from this species in New South Wales to assess variation in call characteristics.

Regional Information

North East: Characteristic frequency between 34.5 and 37 kHz (n = 12). Pulse shape as described above.

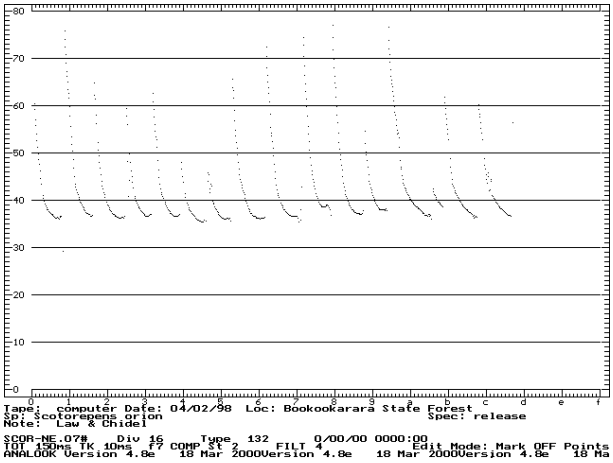
Sydney Basin: Characteristic frequency between 36 and 37.5 kHz (n = 3). Pulse shape as described above. Only poor quality audio taped calls from this region.

Southern: Characteristic frequency between 34.5 and 37 kHz (n = 6). Pulse shape as described above.

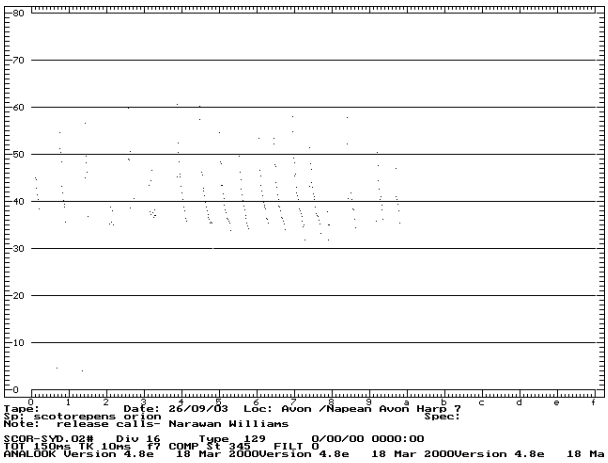
Western Slopes & Plains, Riverina, Far West: No reference calls from these regions.

Scotorepens orion: Representative regional calls

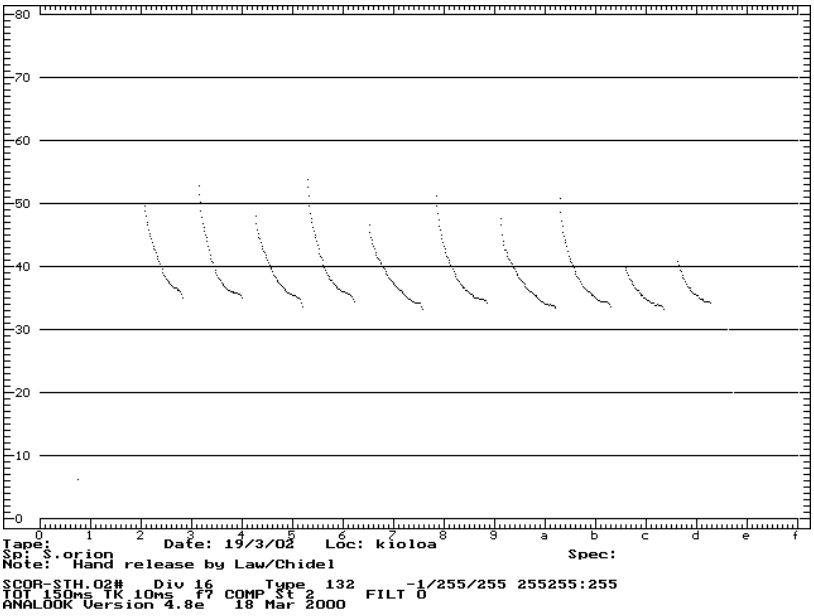
North East



Sydney Basin



Southern



Tadarida australis

Characteristic frequency 10 to 15 kHz (n = 8). Flat, but sloped. May become curved and increase slightly in frequency. Irregular pulses in a sequence may jump to around 15 kHz.

Short sequences may be confused with *Saccolaimus flaviventris* which produce harmonics in the 10-13kHz-frequency range. However *S. flaviventris* calls often show traces of the dominant harmonic and usually last only a few pulses.

Available data shows no indication of variation in call characteristics for this species in New South Wales.

Regional Information

North East: Characteristic frequency 12 to 14 kHz (n = 1).

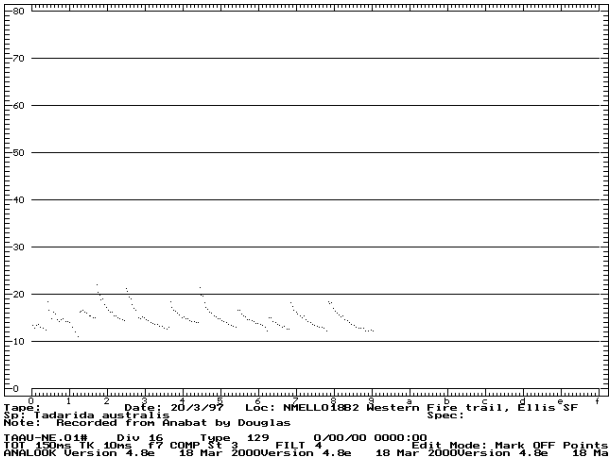
Western Slopes & Plains: Characteristic frequency 10 to 13 kHz (n = 4).

Far West: Characteristic frequency 10 to 13 kHz (n = 3).

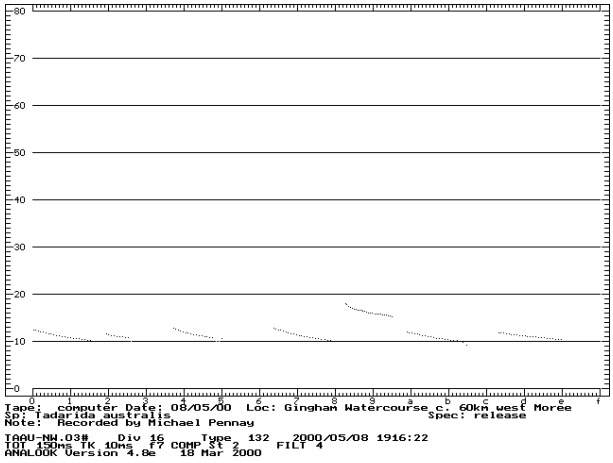
Sydney Basin, Southern, Riverina: No reference calls from these regions.

Tadarida australis: Representative regional calls

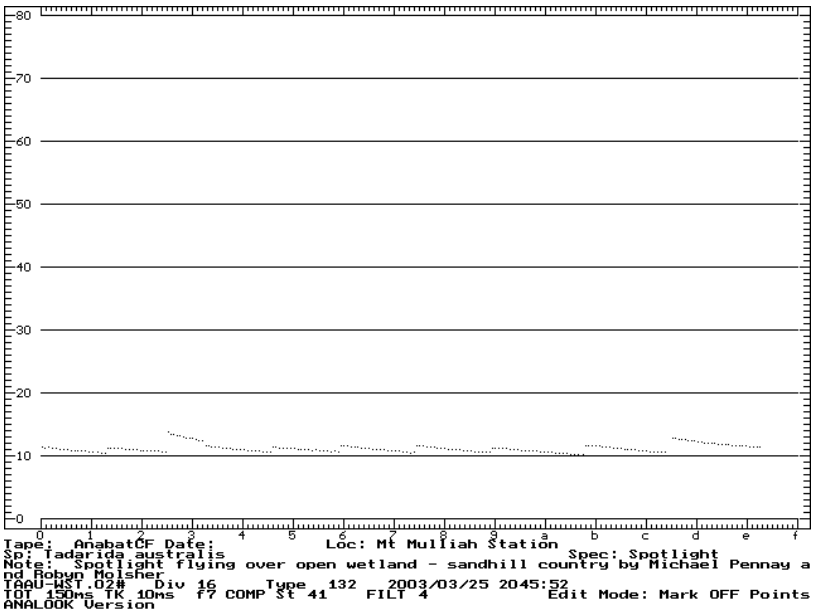
North East



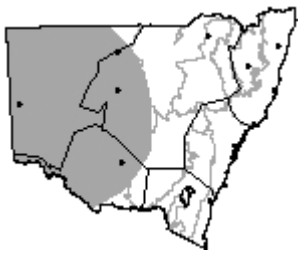
Western Slopes & Plains



Far west



Vespadelus baverstocki



Characteristic frequency 39 to 46 kHz (n = 23*) Curved, usually with up-sweeping tail. Consecutive pulses even. Similar in frequency to *Chalinolobus picatus*, but can be differentiated by lack of alternation. Similar in frequency to *Vespadelus vulturnus* in the north west (47 to 48 kHz) and in the Riverina (43 to 50 kHz).

*Identification of this species in the field is difficult. Species identification has only been confirmed with a museum specimen for the bats recorded in the Riverina (n = 2). The identity is unconfirmed for the calls of a Vespadelus species recorded by University of Ballarat at Nanya in the south west corner of NSW (n = 21). Calls were recorded as *V. baverstocki* but may be *V. vulturnus* or a mix of both species. Further trapping and reference call collection is required to confirm identification and characteristics for this species.

Regional Information

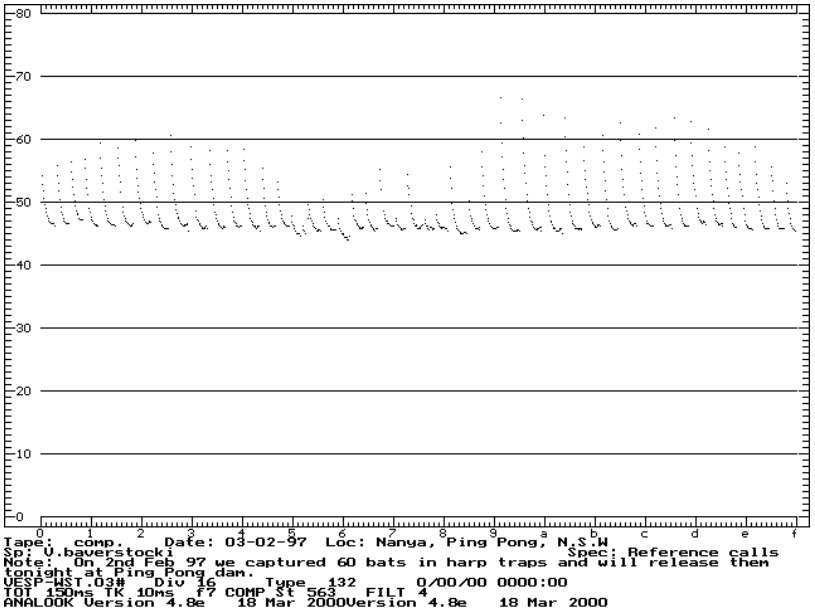
Far West: Characteristic frequency 39 to 46 kHz (n = 21) refer to notes about identification above.

Riverina: Characteristic frequency 44.5 to 45.5 kHz (n = 2).

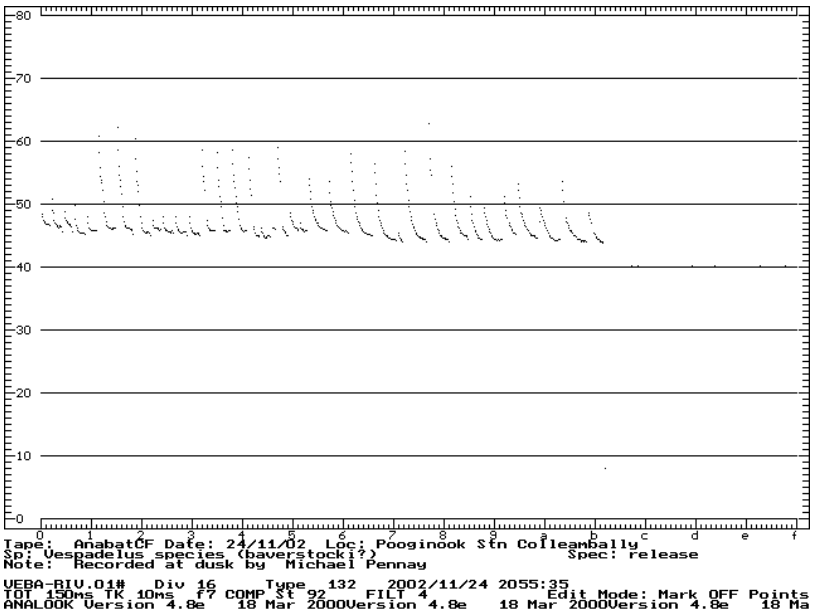
North East, Western Slopes & Plains, Sydney Basin, Southern, Riverina: No reference calls from these regions.

Vespadelus baverstocki: Representative regional calls

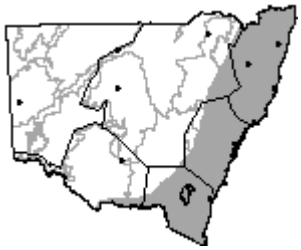
Far west

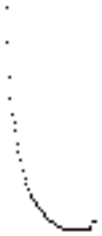


Riverina



Vespadelus darlingtoni





Characteristic frequency varies gradually over distribution from 38 to 46 kHz (n = 89). Curved, tail absent or up-sweeping, characteristic section often long. In general, characteristic frequency decreases from the north east to the south east, west of the south east the characteristic frequency increases.

Where sympatric, can sometimes be distinguished from *Miniopterus schreibersii oceanensis* by having even, consecutive pulses and lacking down-sweeping tail. In the southern part of its range, calls below 43 kHz can be distinguished from *M. schreibersii* on frequency.

Regional Information

North East: For most of the region characteristic frequency 41 to 44 kHz. From the border ranges north into southern Queensland from 43 to 48 kHz (n = 44).

Sydney Basin: Characteristic frequency 40 to 43 kHz (n = 23).

Southern: For most of the region characteristic frequency 40 to 44 kHz. South east corner calls are lower, characteristic frequency 38 – 40 kHz (n = 17). Calls above 40 kHz overlap in frequency with *Vespadelus regulus.*

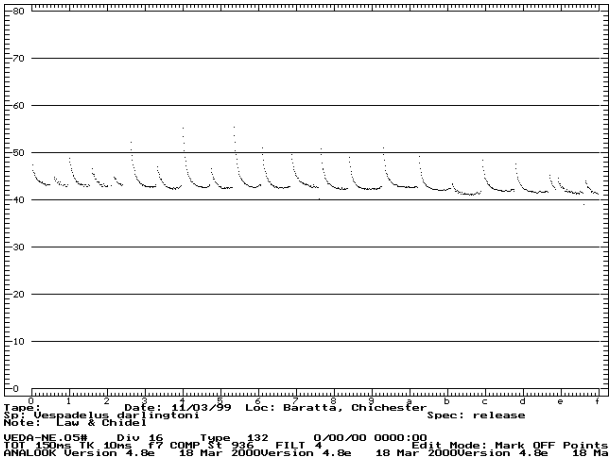
Riverina: Characteristic frequency 40 to 44 kHz (n = 5) there is gradual shift towards higher frequencies in the west. Some calls have down sweeping tails.

Most *Vespadelus vulturnus* calls are higher in frequency. However, calls between 43.5 and 44 kHz overlap and cannot be distinguished.

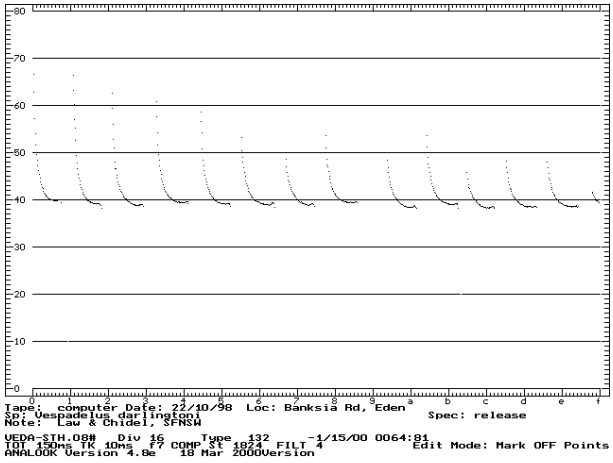
Western Slopes & Plains, Far West: No reference calls from these regions.

Vespadelus darlingtoni: Representative regional calls

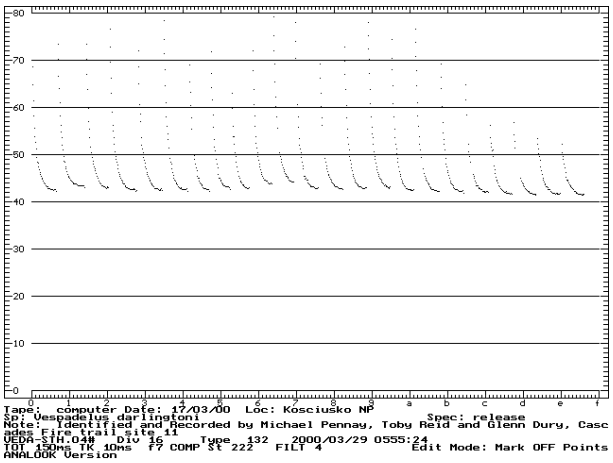
North East



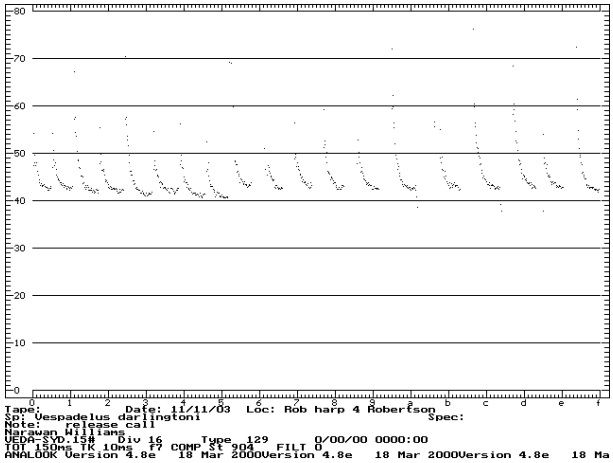
Southern coastal



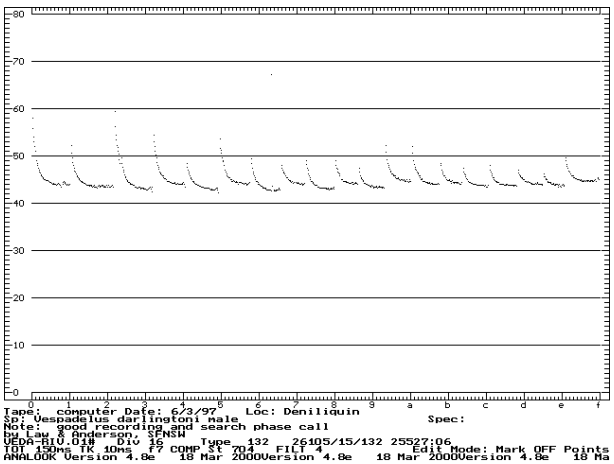
Southern inland



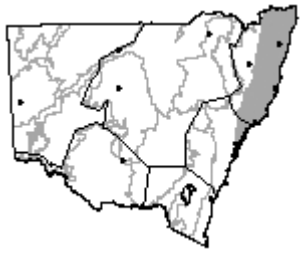
Sydney Basin



Riverina



Vespadelus pumilus



Characteristic frequency 50.5 to 58 kHz (n = 50). Curved often with prominent up-sweeping tail. Reinhold *et al.* (2001) report that calls overlap in frequency with *V. troughtoni*. If the end frequency is higher than 54.5 can be identified as *V. pumilus*, or if end frequency lower than 51 kHz, can be identified to *V. troughtoni*. Middle values cannot be identified to species, where these species are sympatric.

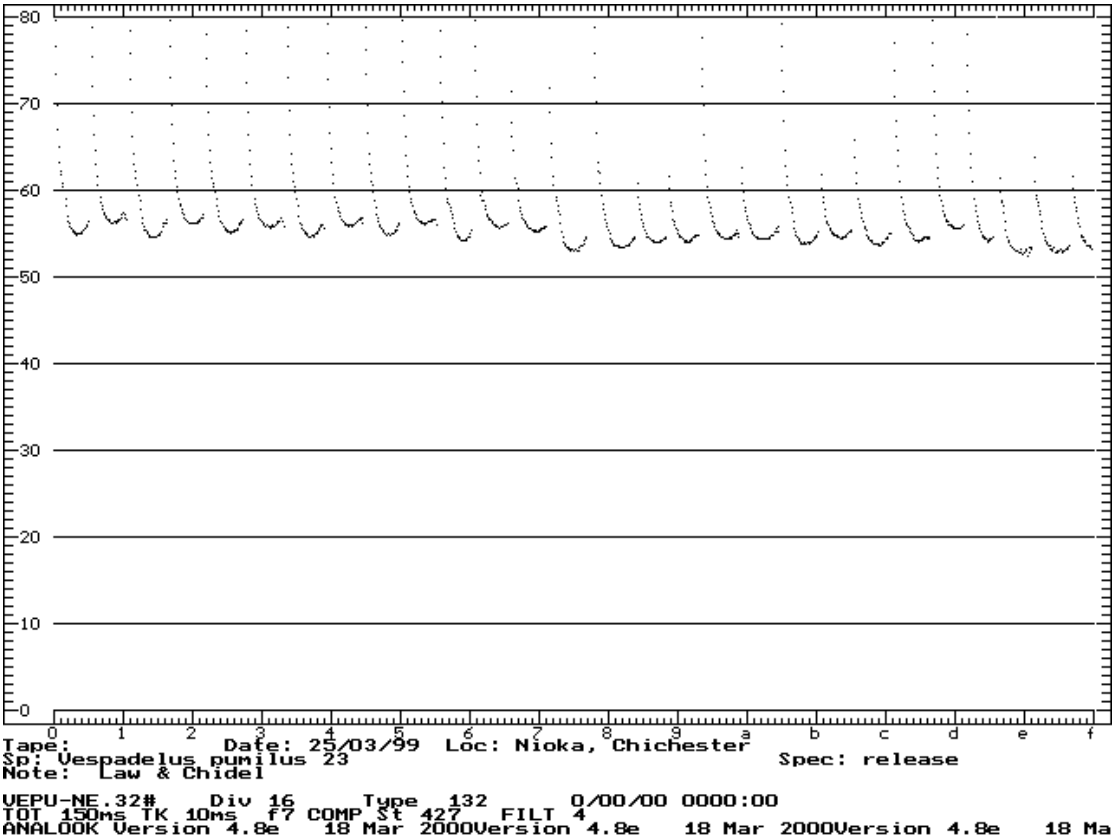
Regional Information

North East: As described above. Calls below 53 kHz cannot be distinguished from *V. vulturnus* in this region.

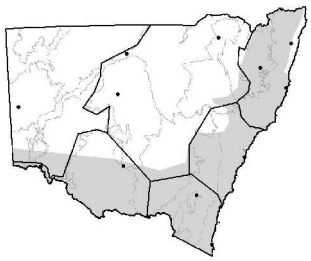
Western Slopes & Plains, Sydney Basin, Southern, Riverina, Far West: No reference calls from these regions.

Vespadelus pumilus: Representative regional calls

North East



Vespadelus regulus



Characteristic frequency varies significantly over distribution from 40 to 55 kHz (n = 95). Call shape also varies between regions (see regional information).

There is a major shift in characteristic frequency of about 10 kHz around Albury. Calls from Hume Dam and from Albury west into the Riverina are 50kHz and above, calls from Tabletop only 30km north of Albury, and Tumbarumba 100km north east of Albury are in the 40 to 44 kHz range.

Regional Information

North East: Characteristic frequency 45 to 47 kHz (n = 19). Curved with up-sweeping tail. Overlaps entirely in frequency with *Miniopterus schreibersii*, some calls may be identified by even consecutive pulses and up-sweeping tail. May also overlap with *Vespadelus darlingtoni* calling above 45kHz from the border ranges if sympatric.

Sydney Basin: Characteristic frequency 43.5 to 46 (n = 9). Curved, tail usually up-sweeping but occasionally down-sweeping. Overlaps entirely in frequency with *Miniopterus schreibersii*, some calls may be identified by even consecutive pulses and up-sweeping tail. Calls around 43 kHz may also overlap with *Vespadelus darlingtoni*. Only poor quality audio taped calls from this region.

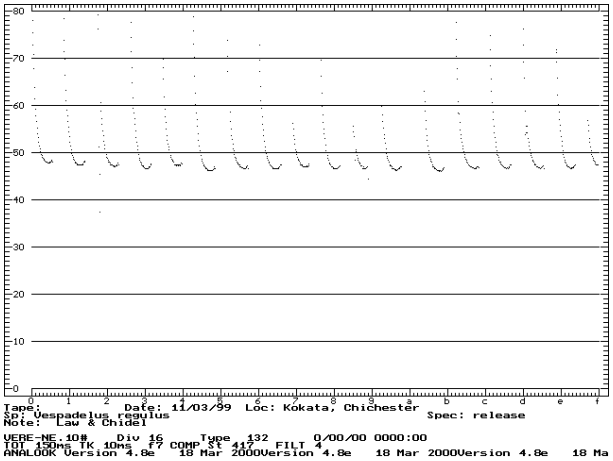
Southern: Characteristic frequency 40 to 44.5 kHz (n = 29). Curved, tail variable. Easily confused with *V. darlingtoni* where frequency overlaps, but duration of characteristic section generally shorter (<1.8 ms) in *V. regulus* (however, *V. darlingtoni* can also have a short characteristic section.) Higher calls may overlap with *Miniopterus schreibersii oceanensis*. *V. regulus* can sometimes be distinguished by even consecutive pulses. There is a major shift in characteristic frequency around Albury (see notes).

Riverina: Characteristic frequency 50 to 55 kHz (n = 38). Curved often with downs-weeping tail. Likely to be confused with *Chalinolobus morio* with which it overlaps in frequency between 50 and 53kHz. *Chalinolobus morio* tends to alternate pulse shape so that every second pulse is steeper or shorter which may help differentiate some calls.

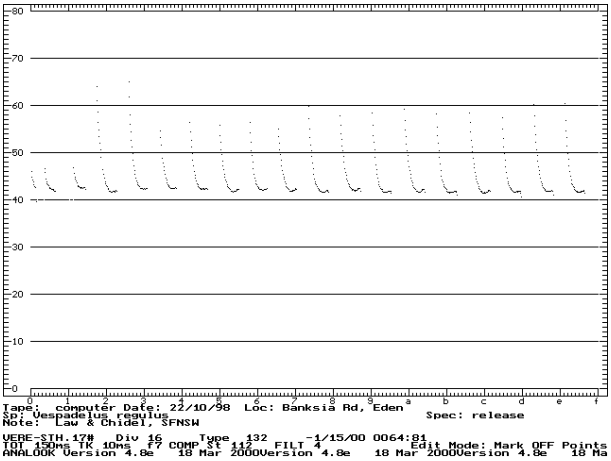
Western Slopes & Plains, Far West: No reference calls from these regions.

Vespadelus regulus: Representative regional calls

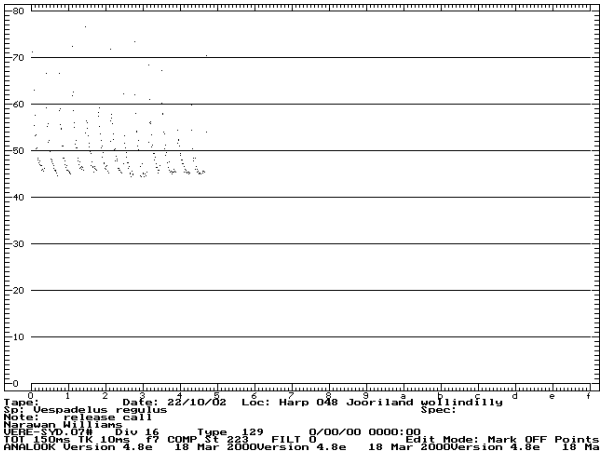
North East



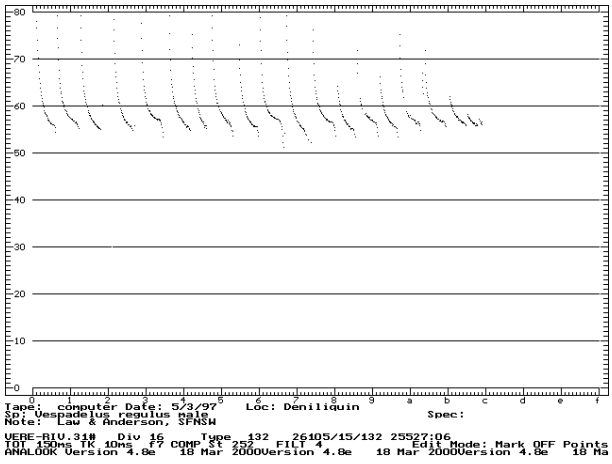
Southern



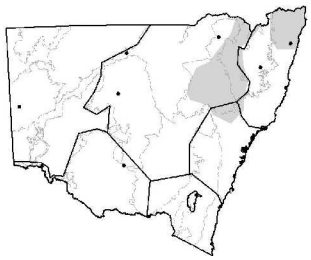
Sydney Basin

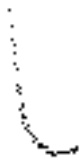


Riverina



Vespadelus troughtoni





Characteristic frequency 49 to 53.5 kHz (n = 50). Curved with up-sweeping tail. Overlaps in frequency with *Chalinolobus morio*, *V. pumilus* and eastern *V. vulturnus*.

Available data shows no indication of variation in call characteristics for this species in New South Wales.

Regional Information

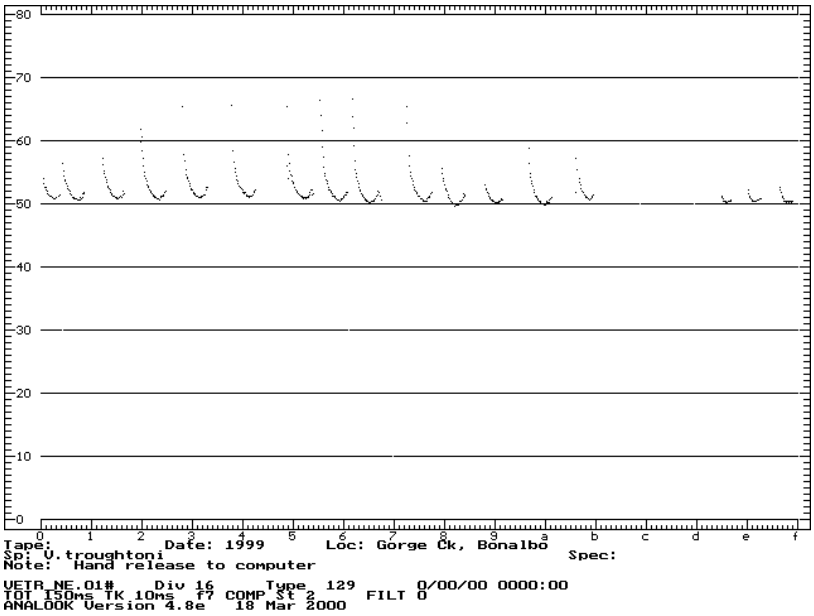
Western Slopes & Plains: Characteristic frequency 49 to 53.5 kHz (n = 35). Overlaps in frequency with *Chalinolobus morio,* but is easily distinguished by the up-sweeping tail present in most pulses of good quality calls.

North East: Characteristic frequency 49 to 52 kHz (n = 15). Overlaps in frequency with *Chalinolobus morio*, *V. pumilus* and *V. vulturnus*. May be distinguished from *C. morio* by an up-sweeping tail present in most pulses. Can be distinguished from *V. pumilus* only if end frequency lower than 51 kHz (can be identified as *V. troughtoni*), or if the end frequency is higher than 54.5 (can be identified as *V. pumilus*). Middle values cannot be identified to species, where these species are sympatric. Can not be differentiated from *V. vulturnus* where sympatric.

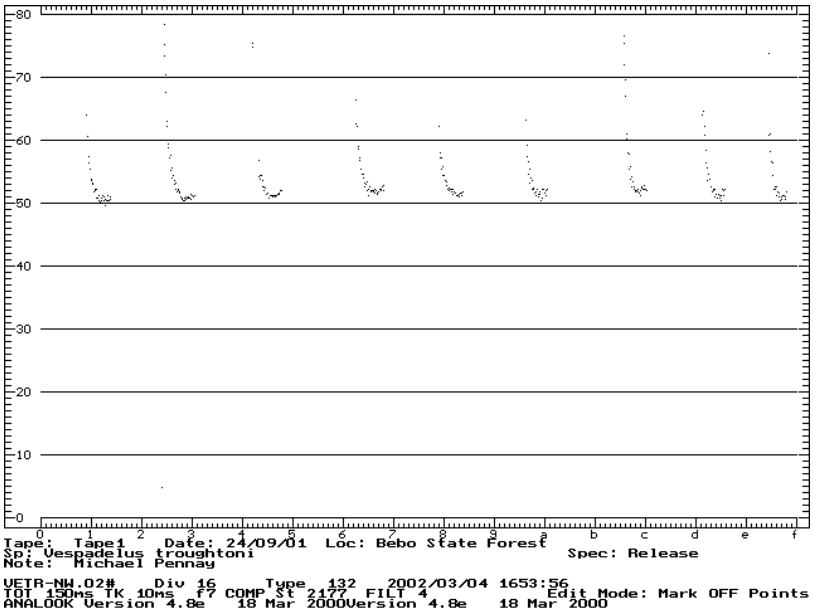
Sydney Basin, Southern, Riverina, Far West: No reference calls from these regions.

Vespadelus troughtoni: Representative regional calls

North East

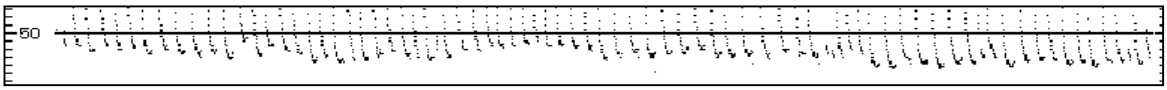


Western Slopes & Plains



Vespadelus vulturnus

Characteristic frequency varies significantly over distribution from 42.5 to 53 kHz (n = 189). Curved, almost always with a prominent up-sweeping tail. In open areas can give flatter calls. Characteristic frequency often varies highly within a single call sequence, wandering over a range of up to 4 or 5 kHz. Probably a product of the Doppler effect resulting from this species tight circling behaviour when foraging.



East of the Great Dividing Range calls are higher ranging from 49 to 53 kHz, with the exception of the far south. Inland calls range from 43 to 49 kHz with calls from the northern inland slightly lower than those from the southern inland. The far south has similar frequencies to the southern inland extending from the coast across the Great Dividing Range (Law *et al.* 2002).

Regional Information

North East: Characteristic frequency 48.5 to 53 kHz (n = 6). May not be able to distinguish from *V. troughtoni.* Cannot be separated from *V. pumilus* between 50.5 and 53 kHz where they overlap in frequency.

Western Slopes & Plains: Characteristic frequency 42.5 to 48 kHz (n = 47). May not be able to distinguish from *V. troughtoni* between 47 and 53 kHz where they overlap in frequency in locations where they are sympatric. Overlaps with *Miniopterus schreibersii* between 44 and 48 kHz. Most calls can be identified by up-sweeping tail and even consecutive pulses.

Sydney Basin, Characteristic frequency 48.5 to 53 kHz (n = 66). Overlaps in frequency with *Chalinolobus morio,* but has an up-sweeping tail or no tail whereas *C. morio* has a down-sweeping tail.

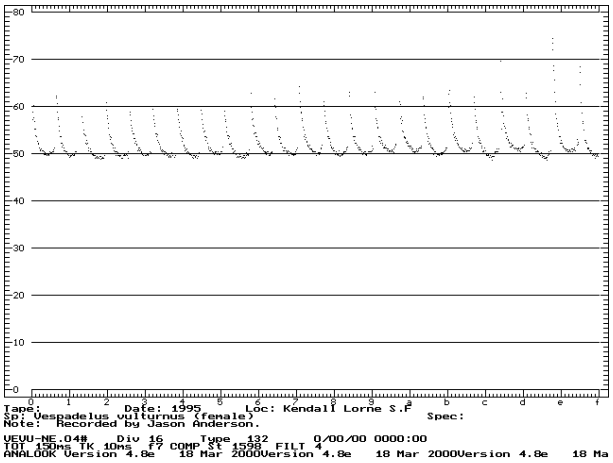
Southern: There is an abrupt change of characteristic frequency in this region somewhere between Narooma and Eden. Characteristic frequency from Narooma north is 49 to 53.5 kHz. From Eden across the Great Dividing Range to the South West Slopes the characteristic frequency is 44 to 47 kHz (n=31). Narooma north, overlaps in frequency with *Chalinolobus morio,* but can be identified by up-sweeping tail. Eden west, overlaps in frequency with *Miniopterus schreibersii,* but can be identified by up-sweeping tail and even consecutive pulses. Calls below 44 kHz may overlap with *V. darlingtoni* away from the coast.

Riverina: Characteristic frequency 44.5 to 51 kHz (n = 38). Calls cover a large range in frequencies. May give much flatter looking calls in open areas. Overlaps in frequency with *Chalinolobus morio* between 47 and 51 kHz, but can be identified by up-sweeping tail. Overlaps with *Vespadelus regulus* at 51 kHz, but should be distinguished by up-sweeping tail. May overlap with *V. baverstocki* where they are sympatric.

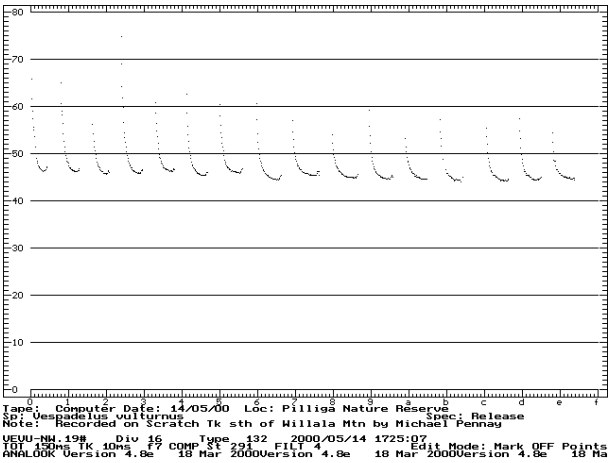
Far West: Characteristic frequency 46 to 47 kHz (n = 1). May overlap with *V. baverstocki* where they are sympatric.

Vespadelus vulturnus: Representative regional calls

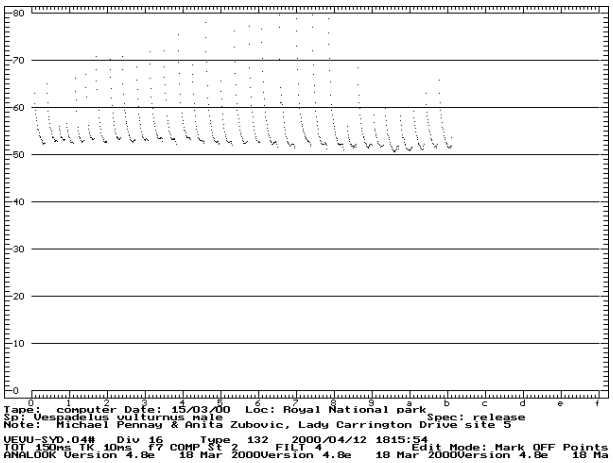
North East



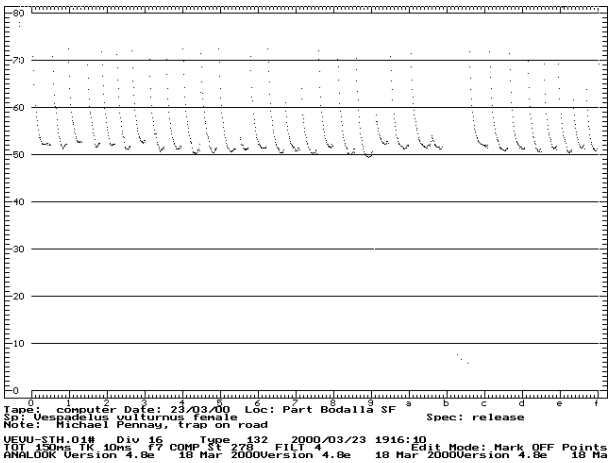
Western Slopes & Plains



Sydney Basin

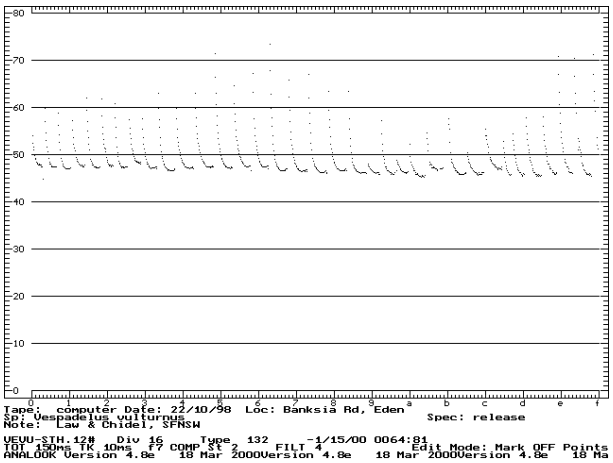


Southern (coastal north of Eden)

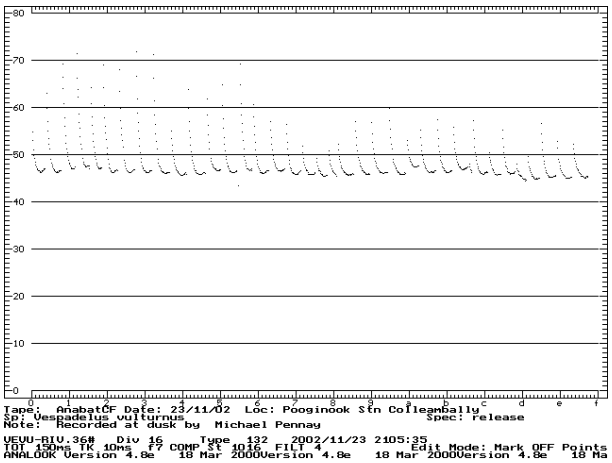


Vespadelus vulturnus: Representative regional calls

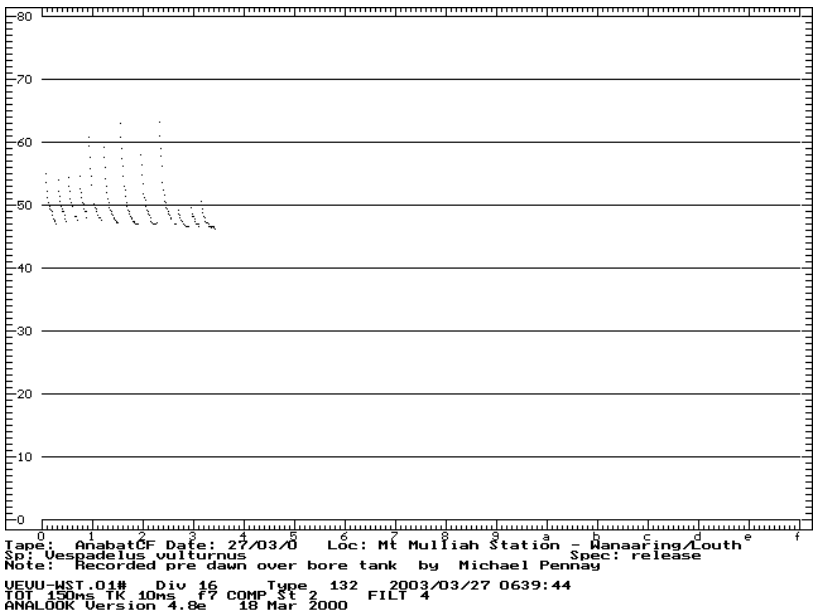
Southern (far south coast and inland)



Riverina



Far west



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