Sound Analysis

Frog calls were recorded to produce a popular guide to the frogs of the island. All frogs on Polillo can be recognised simply by ear and are not easily confused with the other species on the island. Brief analyses of the calls are provided, for use by other students working on frog calls of the amphibians in the Philippines. All analyses are based upon a very small sample size, in most cases only one, however some species have a repertoire of different types of calls which may not be reflected in analysis. For most species frogs were heard calling frequently and sounded the same. Therefore the calls recorded provide a useful guide for reference, but are not comprehensive. Copies of all recordings have been deposited at the British library of Wildlife Sounds, The National Sound Archive, The British Library of wildlife sounds.

Sound analysis was conducted using the Canary 1.2 package for the Macintosh computer to produce spectrograms (frequency versus time, amplitude represented by shades of grey), Fast Fourier Transform (FFT) spectra (amplitude/ pressure in arbitrary units versus frequency), and oscillograms (amplitude versus time). Reticule measurement cursors were used to give precise measurements. The advertisement calls are described together with numerical data about the temporal and spectral features of the calls. The calls are compared with other species of relevance. Call repetition rate is not such a useful feature as it can increase dramatically for species that call in a chorus, and can be affected by temperature.

To avoid confusion in the description of the calls, definitions for descriptive terms are given below:
The *call* is '…a discrete unit of vocalisation composed of one or more separate bursts of sound and temporally distinct from similar units…'(Zweifel 1985, p.272).

Fig 1.1 A 'call' (of the white frog) made up of 23 chirps

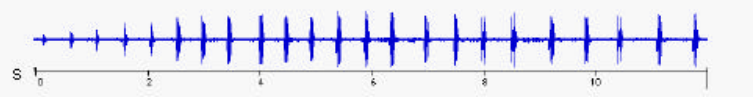


Fig.1.2

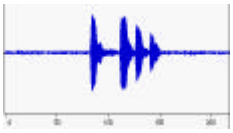


Fig. 1.3

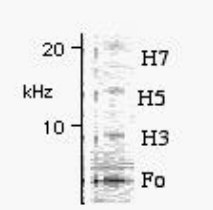
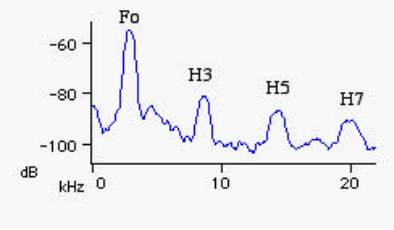


Fig. 1.4



A *pulse* is a physical unit of sound energy, comprising of a number of *waveform cycles* in a simple undivided wave train, rising to a single peak in amplitude and then falling. (P.Olding 1998) Figure 1.2 illustrates a chirp composed of four pulses. Pulses may be produced singly, as groups or as an extended series. Both a single pulse or a brief finite series is termed a chirp (Bennet-Clark, 1989). The envelope shape of the chirp is compared with relevant species.
The *fundamental frequency* is the lowest frequency of vibration, and the *dominant frequency* is that spectral band with the greatest energy output. *Harmonics* are frequency bands that are integer multiples of the fundamental frequency, generated by

different modes of vibration, generally forming a harmonic series, with the fundamental frequency as the first harmonic (Fletcher 1992). Usually the fundamental frequency is the dominant frequency. Cases where the harmonics are of the dominant frequency and not the fundamental are labeled as such. By convention the fundamental frequency is labeled Fo, and the harmonics as H2, H3, etc depending upon their multiple. Figure 1.4 illustrates an FFT spectrum of a single chirp with the associated spectrogram (figure 1.3) showing H3, H5 and H7 each with decreasing amplitude from the dominant frequency.

1.2 The White frog

A white frog was located by its call during a visit to the north of Polillo on 9/9/99 near Panukulan. The frog was calling from ferns approximately 2.7m above the ground overhanging a small stream. Four of its calls were recorded (2140 hours, 25°C), the frog was collected for morphometric measurements (0.5g, SV 22mm) and returned to the same site the following morning. On the 11/9/99 in the same location another white frog was found calling (0.55g SV 22m), possibly the same individual as found on the 9/11/99. (Refer to detailed description of frog).

Each call consisted of a train of chirps illustrated in Figure 1.2.1

Fig 1.2.1 The second call recorded from the white frog

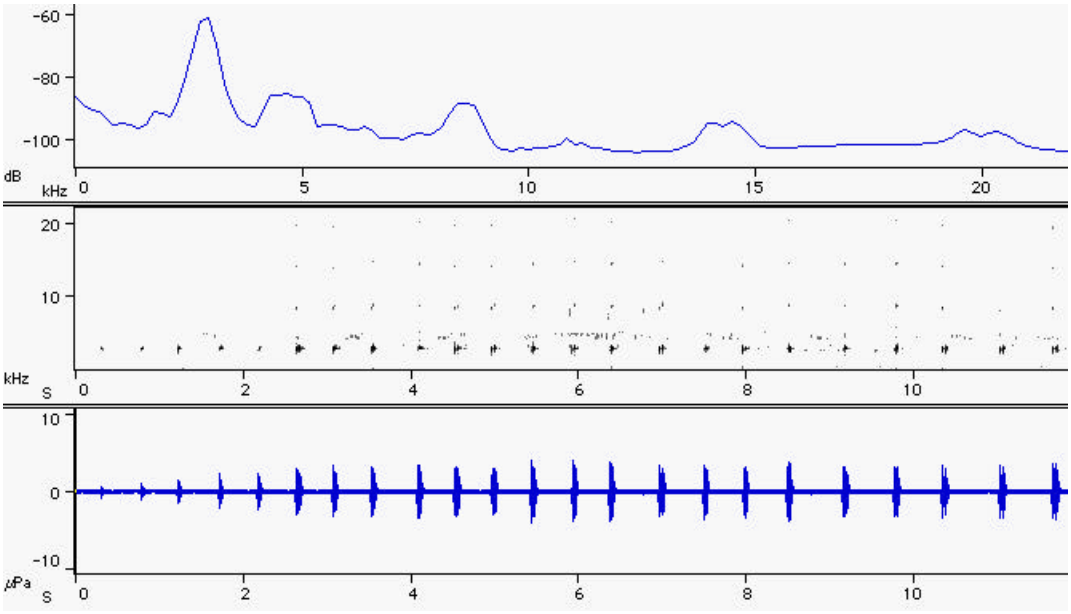


Table 1.2.1

Call	1	2	3	4
Number of chirps/call	12	23	24	23
Call Duration (s)	6.29	11.47	12.25	11.49
Time to next call (s)	82	82	84	-
Dominant frequency kHz	2.8	2.85	2.87	2.89
3H kHz	8.2	8.68	8.57	8.75
5H kHz	13.6	14.05	14.24	14.5
7H kHz	19.1	19.7	19.6	20.04

Table 1.2.1 describes the characteristics of the call pattern from each call in the recording and the dominant frequencies and harmonics from the FFT spectrum. (see fig 1.2.1).

Table 1.2.2 summarises the characteristics of the finer call structure.

The White frog	*Chirp duration (s)*	*Interval (s)*	*Chirp and interval (s)*	*Dominant frequency (kHz)*
Mean	0.069	0.46	0.52	2.77
Standard Error	0.0013	0.0086	0.0109	0.007
Standard Deviation	0.012	0.075	0.096	0.066
Count	82	78	79	82
Confidence Level(95.0%)	0.0027	0.017	0.022	0.0146

The call is repeated at regular intervals approximately every 80-90 seconds, in call groups of approximately 12 to 24 trills. The call rate is 0.65 per min, and the chirp rate is 2.0 per second. Each chirp is composed of a dominant frequency at about 2.8 kHz plus H3, H5, and H7. The 3rd harmonic is approximately 30 dB lower than the dominant frequency, the 5th about 6 dB less than the 3rd and the 7th is 2 dB lower again. It is sometimes not possible to distinguish H5, and H7 depending upon background noise levels. The call takes between 3 and 6 chirps to reach the maximum amplitude and correspondingly similar envelope shape, after which amplitude is relatively constant. The first few chirps have correspondingly different envelope shapes as the call builds up. See figure 1.2.2 for the typical envelope shape of the chirps. Chirps are made up of usually three or four pulses.

Table 1.2.3 summarises the call structure and pattern for a recording of *Platymantis sierramadrensis* donated by Arvin Diesmos.

Table 1.2.3

P.sierramadrensis	Pulse duration (s)	interval duration (s)	Pulse + interval (s)	Dominant frequency (kHz)	H3 (kHz)	H5 (kHz)	H7 (kHz)
Mean	0.057	0.76	0.82	2.8	8.34	13.96	19.5
Standard Error	0.0017	0.04	0.040	0.021	0.034	0.048	0.049
Standard Deviation	0.0059	0.133	0.136	0.074	0.12	0.17	0.17
Count	12	11	11	12	12	12	12
Confidence Level(95.0%)	0.0038	0.090	0.091	0.047	0.074	0.107	0.108

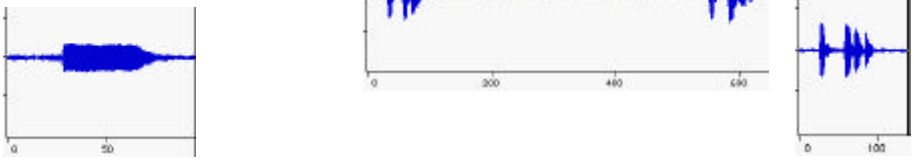
Table 1.2.4

	Pulse duration (s)	interval duration (s)	Pulse + interval (s)	Dominant frequency (kHz)	H3 (kHz)	H5 (kHz)	H7 (kHz)
White frog	0.069	0.46	0.52	2.77	8.5	13.9	19.8
P.sierramadrensis	0.057	0.76	0.82	2.8	8.34	13.96	19.5

The call of *P.sierramadrensis* consists of the same dominant frequencies and harmonics as the white frog. However the pattern of the chirps is very different. The call of the white frog is made up of a regular pattern, of trains containing 12 to 30 chirps separated by large intervals of between one and two minutes. Chirps are shorter in the white frog than *P.sierramadrensis* and are separated by a smaller interval. The recording of *P.sierramadrensis* is not long enough to determine the number of chirps to a call if such a chirp train exists. The description of *P.sierramadrensis* (Brown, Alcala, Ong, and Diesmos. 1999) states 'the call of this frog sounds like "pek-pek-pek" produced in a forceful manner. Each note ranges from 2500 to 3250 Hz with a duration of 0.05 to 0.06 of a second. The time interval between notes is about 0.53 to 0.64 seconds.' This corresponds to the analysis of *P.sierramadrensis* above except for

the time interval, which differs slightly. No pattern to the chirps is described by Brown *et al.* (1999). Each chirp made by the white frog is composed of 3 or 4 short pulses (figures 1.2.2) whereas for *P.sierramadrensis* each chirp is a single pulse (figure 1.2.3), with a longer duration than the white frog pulses. This feature of the frog call is unmistakable and separates the two recordings very distinctly.

Figure 1.2.3 Figures 1.2.2



1.1 *Platymantis* sp

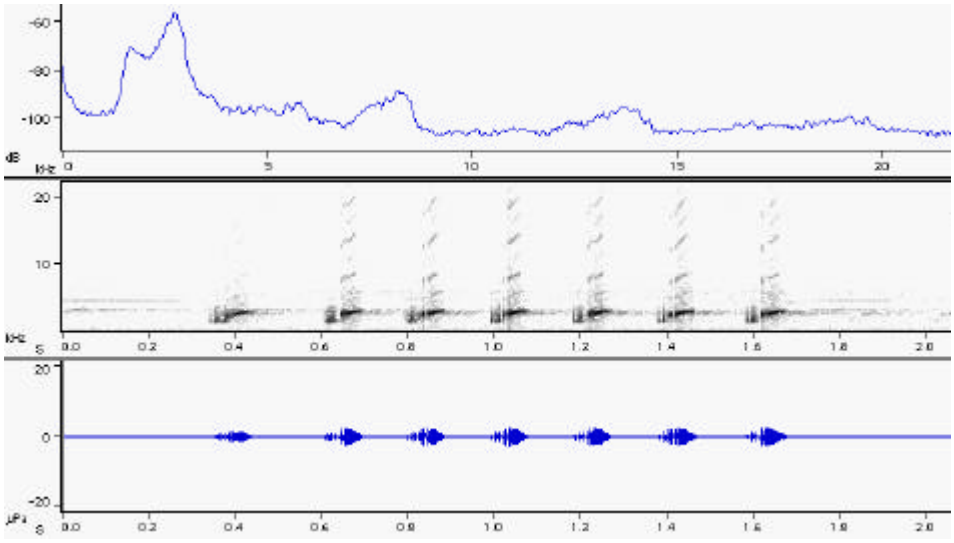
Platymantis sp calls from usually 2m or more above ground. Notes about its distribution and habitat are in the section 'species accounts'.

The call analysis was conducted on two samples of recordings (one from 20/8/99, Sibulan watershed reserve, Polillo Island, 20.30hours, 26°C, the second from 9/9/99, Near Panukulan, north Polillo, 2030hours, 24.8°C). This frog calls at irregular intervals from 11 seconds to a minute apart. The call interval details are given in the table below. The average is 34.8 seconds apart (n=13), but, because of its irregularity call interval is not a useful descriptive characteristic for this frog. On average the call is composed of 6 chirps, see table 1.3.1. Occasionally a single chirp is emitted, but these have been omitted from the calculations of number of chirps per call, because they are not typical. The spectrogram, spectrum and waveform are shown in figure 1.3.1

Table 1.3.3

Platymantis *sp*	No. of chirps per call	Average call length (s)	Call interval (s)
Mean	6.1	1.2	34.8
Standard Error	0.3	0.049	3.86
Standard Deviation	1.27	0.20	13.9
Count	17	17	13

Figure 1.3.3



The FFT spectrums show the call is two tone with two dominant frequencies. The first part of the call has a dominant frequency at approximately 1.7 kHz. The second part of the call has a dominant frequency at approximately 2.7 kHz (13dB louder than the first dominant frequency) with H3 at 7.7 kHz (30 dB lower than the dominant frequency) and weaker H5 and H7 (a further 8 dB lower than H3).

Table 1.3.2 summarises the call characteristics

P.sp	Dominant frequency Hz	Dominant frequency Hz	Chirp duration (s)	Interval Duration (s)	Call period (s)
Mean	1870	2699	0.088	0.13	0.220
Standard Error	22.68	11.15	0.00078	0.0066	0.0065
Standard Deviation	232.4	114.2	0.008	0.061	0.06
Count	105	105	105	88	88

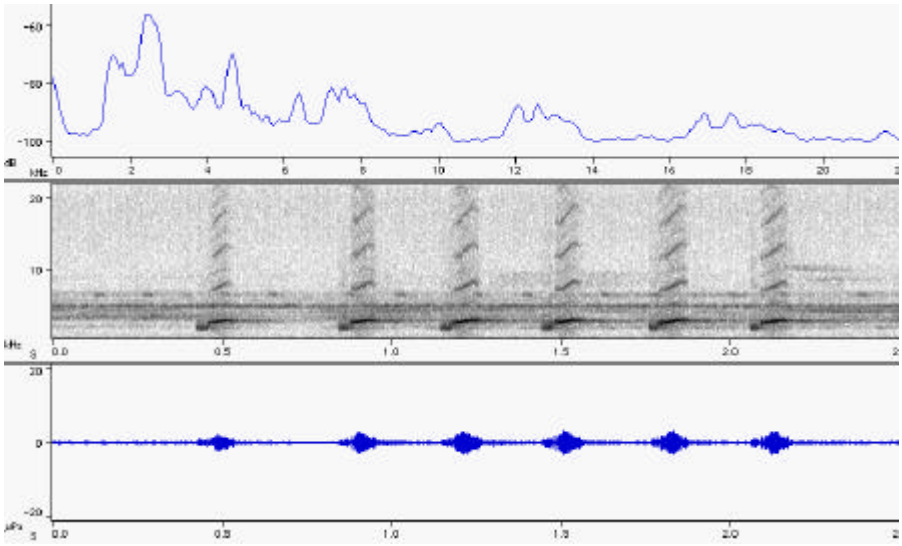
1.4 *Platymantis luzonensis*

This frog calls from heights at least 2m above the ground. The analysis is from two recorded individuals (one donated by Arvin Diesmos, a second recorded on 18/9/99 from Mount Makiling, near Mudsprings, Los Banos, Luzon 25.4°C). The average time between calls is very variable (12-108 seconds, mean 47, n = 11). It is not possible to draw meaningful conclusions for comparisons between call rates.

Table 1.4.1

P.luzonensis	No. chirps per call
Mean	4.7
Standard Error	0.3
Standard Deviation	0.58
Count	3

Figure 1.4.1



There are not enough calls recorded to analyse call length (n=3)

The call of *P.luzonensis* has two tones the first part of the call has a dominant frequency at 1.6 kHz. The second part of the call has a dominant frequency of approximately 2.57 kHz, with a strong H3 (25 dB below the dominant frequency) and weaker H5 and H7. There is a lot noise from the recording between the dominant frequency and 3rd harmonic, which corresponds to the extra peaks on the FFT spectrum.

Table 1.4.2

P.luzonensis	Fundamental frequency (kHz)	Dominant frequency (kHz)	Chirp duration (s)	Interval duration (s)	Call period (s)
Mean	1.626	2.572	0.112	0.20	0.315
Standard Error	0.027	0.019	0.002	0.015	0.015
Standard Deviation	0.107	0.078	0.008	0.05	0.052
Count	16	16	16	12	12

Comparison of *Platymantis* sp to *P.luzonensis*

	Fundamental frequency (kHz)	Dominant frequency (kHz)	Chirp duration (s)	Interval duration (s)
Platymantis sp	1.870	2.699	0.088	0.13
P.luzonensis	1.626	2.572	0.112	0.20

The two groups have essentially the same dominant and fundamental frequencies, those of *Platymantis* sp are perhaps slightly higher. However the chirp length and interval between chirps within the call are shorter for *Platymantis* sp than for *P.luzonensis*. This can be detected whilst listening to the call. The calls of *Platymantis* sp. Were recorded at temperatures above and below the *P.luzonensis* recording therefore differences do not reflect temperature related trends. The number of chirps per call is higher for *Platymantis* sp than for *P.luzonensis*. (mean 6.1 versus 4.7).

Figure 1.4.2

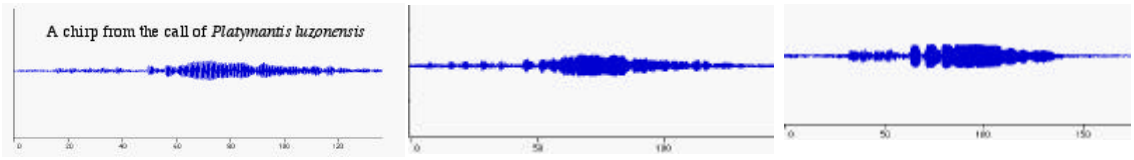
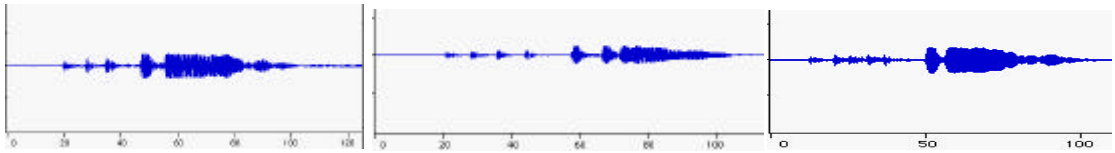


Figure 1.4.3



P.luzonensis (fig 1.4.2) and *Platymantis* sp (fig 1.4.3) both have similar envelope shapes. Each chirp within the call is made up of several pulses. For both species the first half of the chirp is at one dominant frequency and the second half of the chirp at another with harmonics that form a clear upward sweep. For *Platymantis* sp the first half of the call consists of distinct pulses (3, 4, or 5). The second half of the call consists of less distinct, overlapping pulses. The same is true for *P.luzonensis* although the pulses within the first part of the call are less clearly defined.

1.5 *Platymantis dorsalis*

The analyses are based upon the combined characteristics of 4 different recordings

Table 1.5.1

	chirp duration mS	chirp interval mS
Mean	83.4	480.8
Standard Error	2.4	27.7
Standard Deviation	12.21	135.84
Count	26	24

Frogs call during the night and often begin calling in the afternoon stationed on the ground or from low bushes and shrubs, rarely higher than 1.5m from the ground. The call (fig 1.5.2) is composed of short (mean duration 83.4 mS) repetitive (intervals of 480mS) chirps. Sometimes a very quiet click can be heard before the call and occasionally a few chirps are emitted all together as illustrated by figure 1.5.1.
The call starts at approximately 0.5 kHz and rises rapidly in a sharp upward sweep. The main body of the call is concentrated within 2.3 and 3.6 kHz. The dominant frequency is 3.2kHz with H3 (at 9.8 kHz) and a weaker H5. This corresponds closely to the call description given by Brown, Alcala and Diesmos (1997). There is a mistake in their Figure 2, A should correspond to *P.dorsalis* as it is described in the paper, and B to *P.mimulus.*
Figure 1.5.1

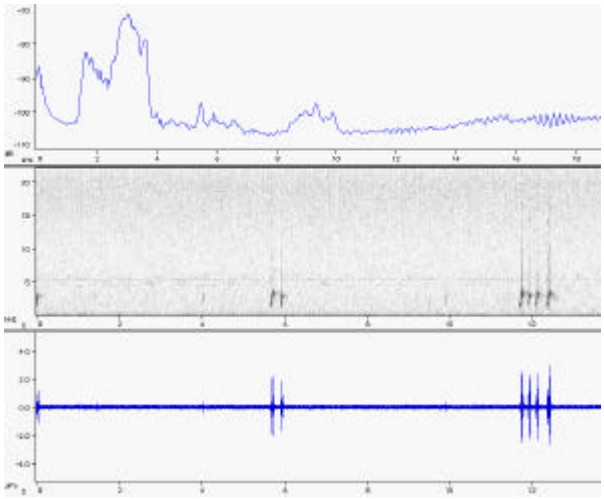
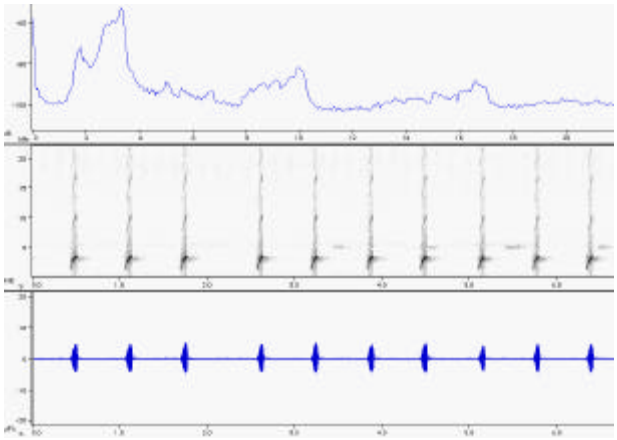


Figure 1.5.2



1.6.1 *Platymantis corrugatus.*
The rate at which this frog called was variable. This species did not call as part of a chorus, however calls recorded early on where repeated at much longer intervals than later on seemingly dependant on the activity of other frogs in the vicinity. When the call reached the maximum calling rate and amplitude the envelope shape was standard. Each call starts at a low frequency of 0.7 kHz and increases in a rapid upward sweep to the dominant frequency of 2.2 kHz. The call is concentrated within 1.6 to 2.9 kHz. There are very weak H3, H5, H7 and H9. The call duration is then approximately 0.25 seconds with intervals between 0.3 and 0.5 seconds

Figure 1.6.1

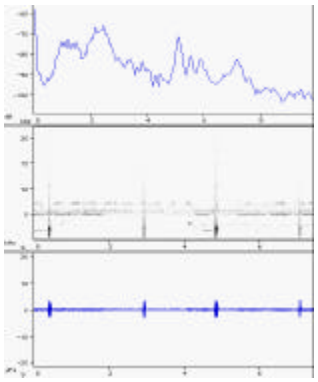


Figure 1.6.2

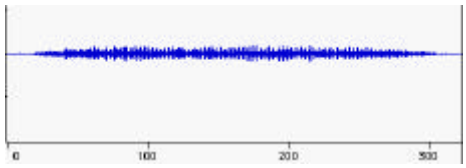
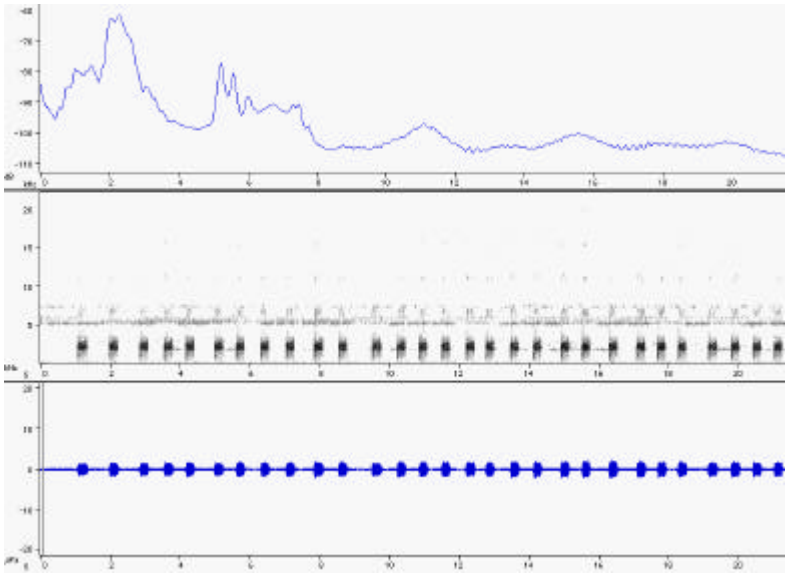


Figure 1.6.3



1.7 *Rhacophorus appendiculatus*

This species was recorded on Luzon, since only a single individual was found on Polillo and none were found calling. The call is concentrated within the frequencies 1.4 kHz to 3 kHz. In figure 1.7.1 there is a lot of background noise between 3 and 5 kHz. The call consists of several rapidly repeated chirps. Within each chirp there are usually two or three pulses, often the first is by far the weakest as illustrated in Figure 1.7.2.

Figure 1.7.1

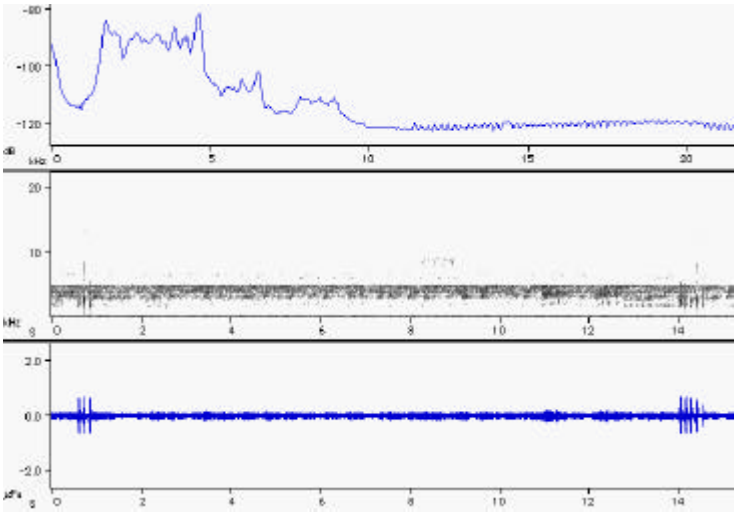
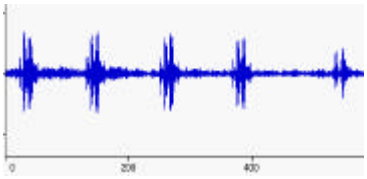


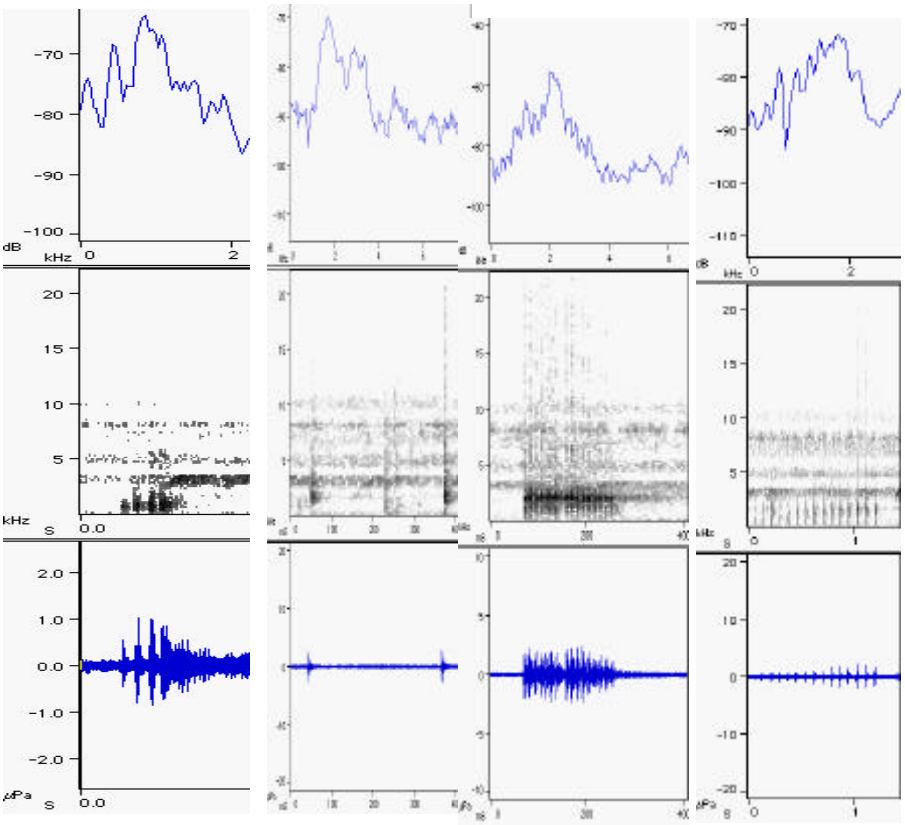
Figure 1.7.2



1.8 *Rhacophorus pardalis*

This frog has a very variable call made up of clicks, rattles, trills and gurgling sounds. The call is also very quiet. This frog would not call in our presence so the microphone was set up while recorders waited remotely. Therefore the recording is relatively poor and quiet, and must be separated from the background of other calling frogs, such as *P.dorsalis* and *O.laevis*. I have therefore selected different recognisable call types illustrated below.

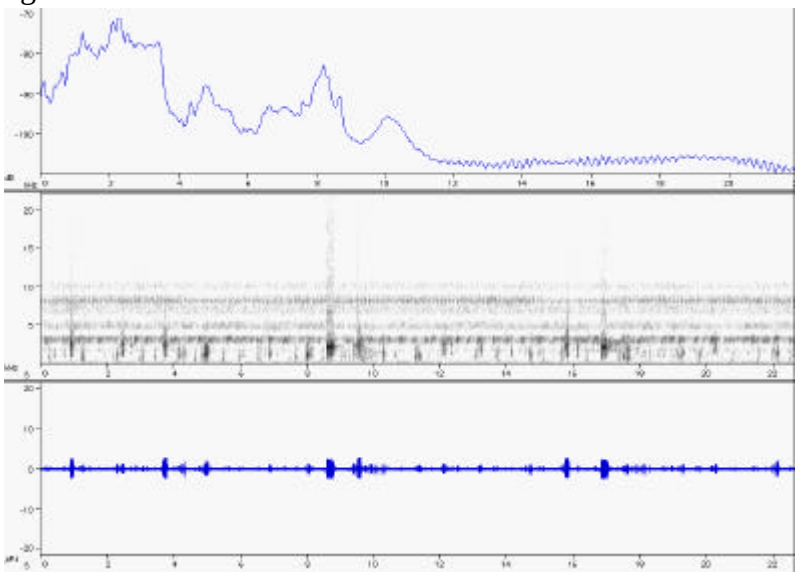
Trill click croak rattle



The above diagrams illustrate distinctive aspects of the call repertoire of *R.pardalis*. The call is basically concentrated between 0.5 to 3 kHz, with each of the different

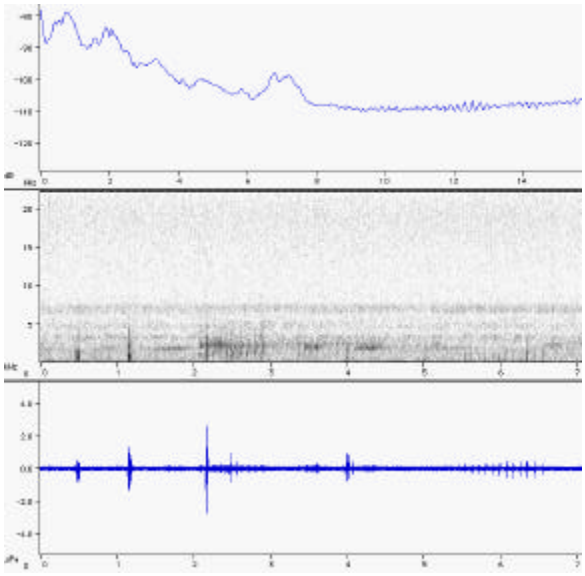
noises having their own separate peaks. Figure 1.8.1 illustrates an example of how some of the calls are included in a calling sequence.

Figure 1.8.1



1.9 *Polypedates leucomystax*

The call of *P. leucomystax* is very variable, with a variety of clicks, gurgles and croaks, similar to *R.pardalis*. The dominant frequency for the croaks is approximately 0.75 kHz and all call types are concentrated between 0.3 to 2.7 kHz, which is very similar to *R.pardalis*. For more information on the call of *P.leucomystax* refer to Brzoska, Joermann and Alcala (1986).

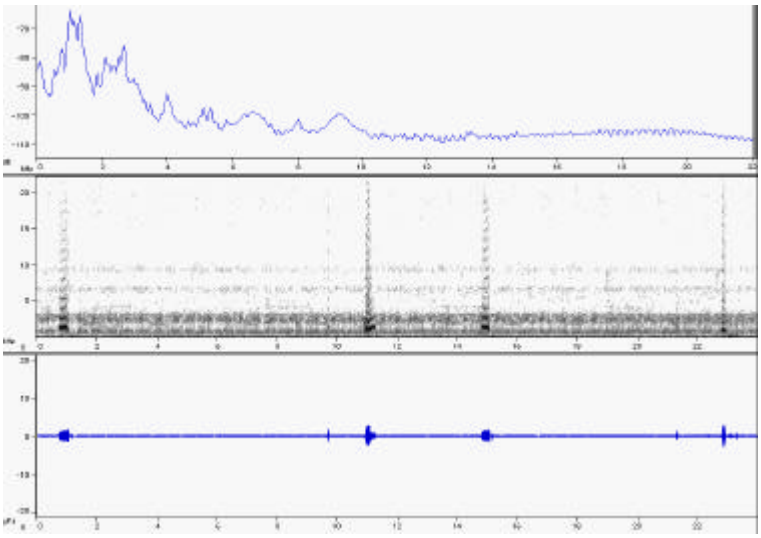


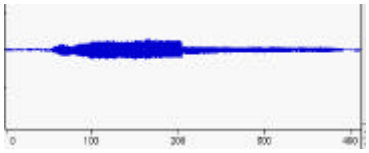
1.9 *Rana luzonensis*

A pair were found in amplexus on 14/8/99 (at site H) and brought back to base camp. During the night squeaking was heard from the bag within which the frogs were being stored. The sound was recorded (23.7-24 C). Both animals were released the next day.

The dominant frequency of the call is approximately 1.1 kHz and there is H2 (2.2 kHz) and decreasingly weaker H3, H4, H5, H6, and beyond, visible on the spectrogram. The chirp length can vary from 0.05 seconds to over 0.5 seconds. The call of this frog

might not be true to the call under natural conditions, therefore recording this species in the wild should be a priority. The envelope shape shows one long changing pulse





1.10 *Rana woodworthi*

The call of *Rana woodworthi* is composed of a train of chirps, sometimes up to 25 chirps in one call. Each chirp is made up of a variable number of pulses, either 1, 2 or 3. The dominant frequency is approximately 2.45 kHz with strong H2 and H3 (both about 20 db lower than the dominant frequency) and weak H4 and H5. The fundamental frequency is approximately 0.97 kHz which can be seen as the lower frequency waves within a single chirp.

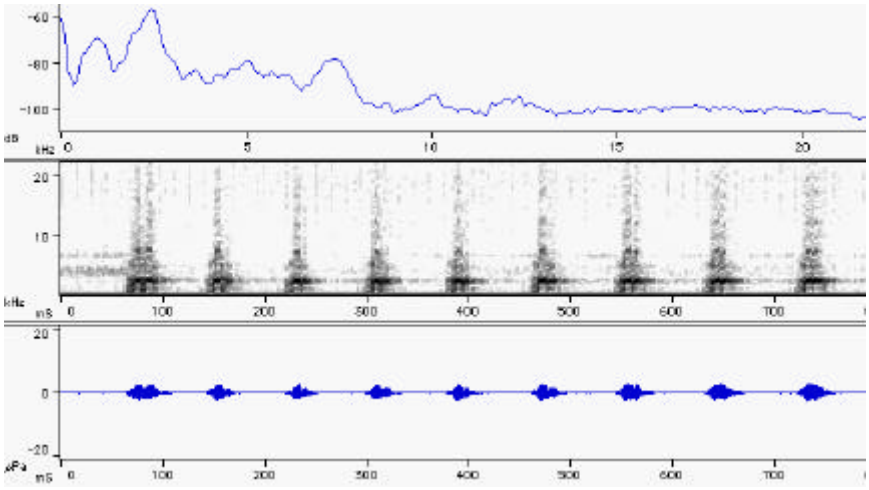


Table 1.10.1

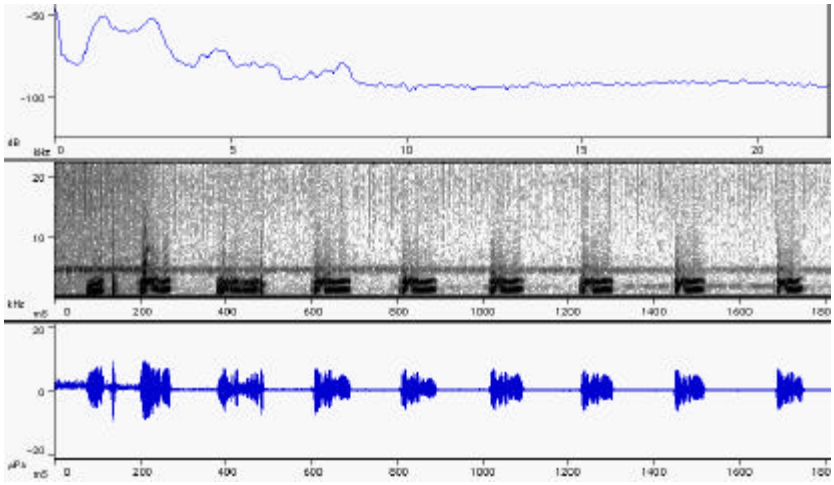
	Chirp duration (s)	Interval duration (s)
Mean	0.03	0.05
Standard Error	0.0011	0.0015
Standard Deviation	0.006	0.008
Count	29	26

1.11.1 *Rana similis*

The call of *Rana similis* is variable consisting of sometimes a single chirp, to a call composed of several chirps (figure 1.11.1). The dominant frequency is 1.35kHz with a strong H2 at approximately 2.7kHz. In this recording chirps were between 0.04 to 0.08 mS long with intervals between chirps of about 0.1mS. However because this frog has

a variable repertoire more recordings are needed to quantify the call pattern. The individual chirps do not have a simple structure but are made up of a number (between 1 and 8) overlapping pulses. For more information refer to Alcala, Joermann, and Brzoska (1986).

Figure 1.11.1



1.12 *Rana vittigerra*

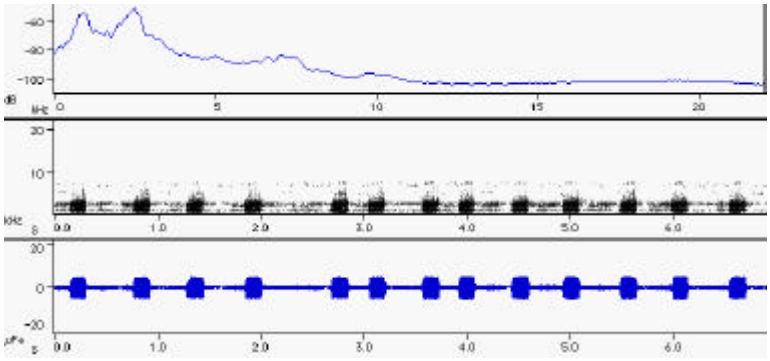
This species was frequently found calling in paddyfields, sympatrically with the marine toad. Its call is also loud. Recorded on 13/7/99, 10.30 pm, in a paddy field, water temperature 27.4°C, air temperature 26.3°C.

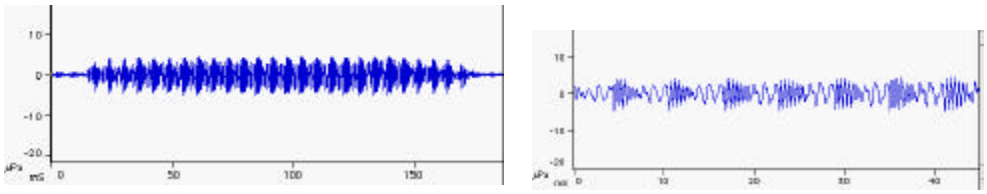
The call duration is typically 0.16 seconds with a varying interval. When in a group these frogs call in a chorus, often calling more regularly and rapidly.

Table 1.12.1

	Call duration(s)	Call interval (s)	Dominant frequency (Hz)	H2 (Hz)
Mean	0.161	0.437	798	2342
Standard Error	0.00058	0.070	8.44	7.17
Standard Deviation	0.0022	0.255	31.59	26.83
Count	14	13	14	14

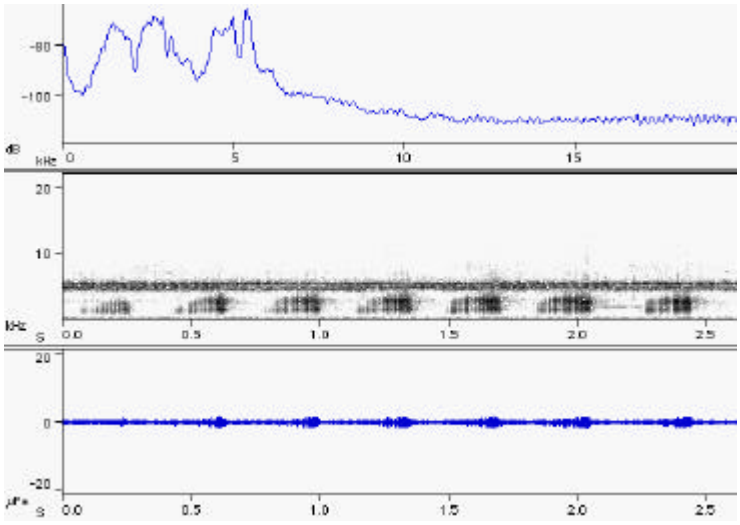
Figure 1.12.1





Each call is made up of 20 to 30 high (2.47KHz) frequency pulses that are separated by 3 wave cycles at a lower frequency (0.88KHz). see above

1.13 *Occidozyga laevis*



The call of *O.laevis* is quiet, with a fundamental frequency at 1.43 kHz and a dominant frequency (approximately 3dB louder) at 2.7 kHz. The third peak on the FFT spectrum is from the constant background noise visible in the spectrogram. The pattern of calling is variable, sometimes a single chirp and sometimes the chirps are repeated usually dependant on the activity of surrounding frogs. Often there are between 4 and 8 chirps to a call. This frog often calls in a chorus, which increases the frequency of call repetition.

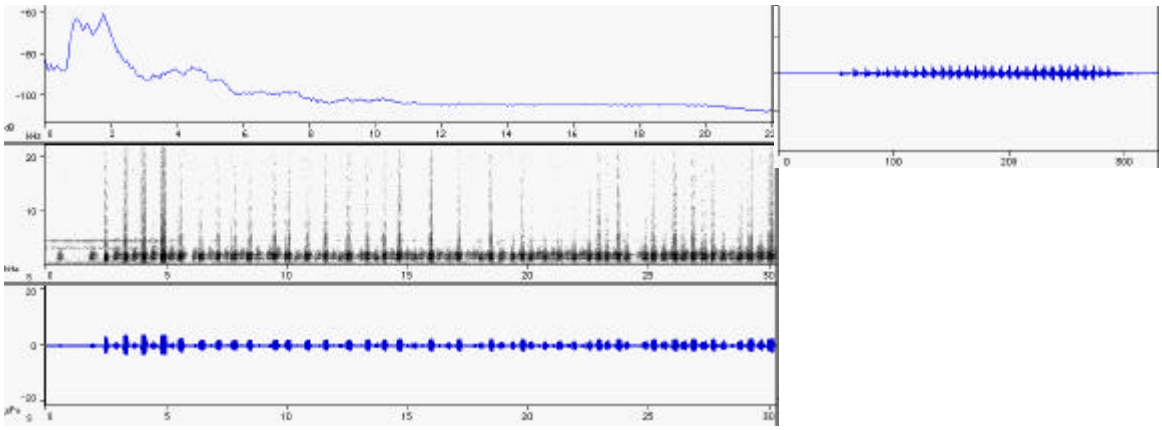
Table 1.13.1

	Chirp duration (s)	Interval duration (s)
Mean	0.137	0.226
Standard Error	0.0076	0.012
Standard Deviation	0.0186	0.027
Count	6	5

1.14 *Kaloula picta*

This species was found on Polillo, but the only recording made was on Luzon. The call of this species can be almost deafening in large numbers. The sound analysis is provided as a comparison for future recordings necessary for Polillo specimens.

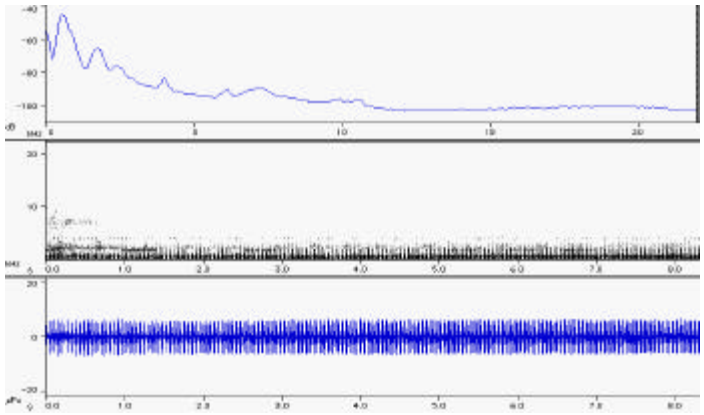
Figure 1.14.1



The chorus (figure 1.14.1 depicts clearly the constant frequencies used by different individuals). More than one frog is calling. Calls of individuals further from the microphone have a lower amplitude and therefore are lighter on the spectrogram. But all have identical frequencies. The fundamental frequency is approximately 0.9 kHz with an H2. The call repetition rate of this frog can increase dramatically in a chorus. However call duration varies between 0.2 to 0.25 Seconds long. Each call consists of a large number of repeated pulses. See above.

Bufo marinus

The call of this toad is loud and resounding. These frogs were most frequently seen calling in paddy fields often in large numbers. The diagram below illustrates a section of call lasting about 8.2 seconds. Recorded on 13/7/99, 9.30pm, in a paddy field, Water Temperature 27.3°C, Air temperature fluctuating between 26.2°C and 27°C because of a breeze. The toad was in shallow water approximately 3cm deep. In the background are other *B. marinus* and *Rana vittigerra*.)



The call duration of *B. marinus* is often more than 16 seconds. The call has a generally constant amplitude. The dominant frequency is approximately 0.5kHz with a second weaker harmonic at approximately 1.7 kHz evident later in the call. The number of pulses per second is 17.8 (143 pulses in 8.04 seconds n = 143).