Captive gentoo penguin vocal variation: A comparison within family groups and between the sexes

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Amali Himashini Thrimawithana

Supervisors: Dr Emma Marks and Louis Ranjard

Summary

This study was undertaken to analyse the acoustic system of the gentoo penguin, *Pygoscelis papua*. To carry out this analysis, recorded calls of the captive gentoo population at Kelly Tarlton's Underwater World and Antarctic Adventure were sampled between 1999 and 2003. The calls were extracted from tape recordings and a call pair-wise distance matrix was computed. In addition, each individual penguin's information such as gender, weight and relatedness were used to build further distance matrices for use in a series of Mantel's tests. The results from the tests suggest that gender and weight have no effect on the acoustic system of the gentoo penguin. Additionally, the results suggest that variability in calls from individual to individual is likely with the possibility of the calls being affected by their inheritance as well as by a learning process. Furthermore, there is support for the possibility of the calls being stable over time, given that the mate of the individual typically remains unchanged between breeding seasons. As this species has been rarely studied, the results from this study will also contribute to an article in an international journal.

Introduction

Communication is an important factor in colonial sea birds such as penguins, where the aid of visual, vocal and chemical cues helps the interaction with other individuals (Slabbekorn 2004). However, due to the nature of noisy dense colonies, the use of acoustic signals as a way of communication dominates (Slabbekorn 2004). The specific features of sound, such as the ability of sound waves to travel over large distances makes it less affected by the obstacles in the landscape (Slabbekorn 2004). Therefore, in a densely populated colony of penguins, acoustic signals facilitate the crucial interactions between individuals, such as individual recognition and pair formation (Williams 1995).

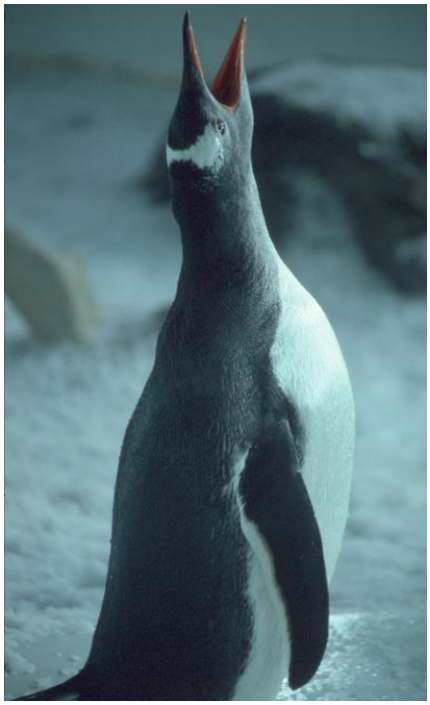

Figure 1: Gentoo penguin giving an ecstatic/mutual display call (photo by Caleb Staines)

The penguin acoustic system varies in complexity from a two voice system (as seen in the *Aptenodytes* penguins) to a more simple regular series of almost identical syllables (as seen in most nesting species) (Williams 1995). The acoustic system plays an important role in ensuring the breeding season is a success as the communication between parent and chick is mostly dependent on acoustic signals (Medvin & Beecher 1986). In this study we look at a rarely studied acoustic system of gentoo penguins, *Pygoscelis papua.* The gentoo species consists of two subspecies, *Pygoscelis papua papua* and *Pygoscelis papua ellsworthii*, and is sister species to the Adélie penguin, *Pygoscelis adeliae*, and chinstrap penguin, *Pygoscelis antarctica* (Jouventin 1982 & Williams 1995).

Gentoo penguins have a circumpolar distribution, with breeding sites on both the sub-Antarctic islands and Antarctic Peninsula (Williams 1995). The sexes are very similar, with the female being slightly smaller (Williams 1995). Gentoo penguins can be easily distinguished by their unique bright red-orange bill and the white eye patch (Williams 1995). Their weights vary throughout the year, with the molting period resulting the highest weight loss (Williams 1995). Gentoo penguins begin to breed after two

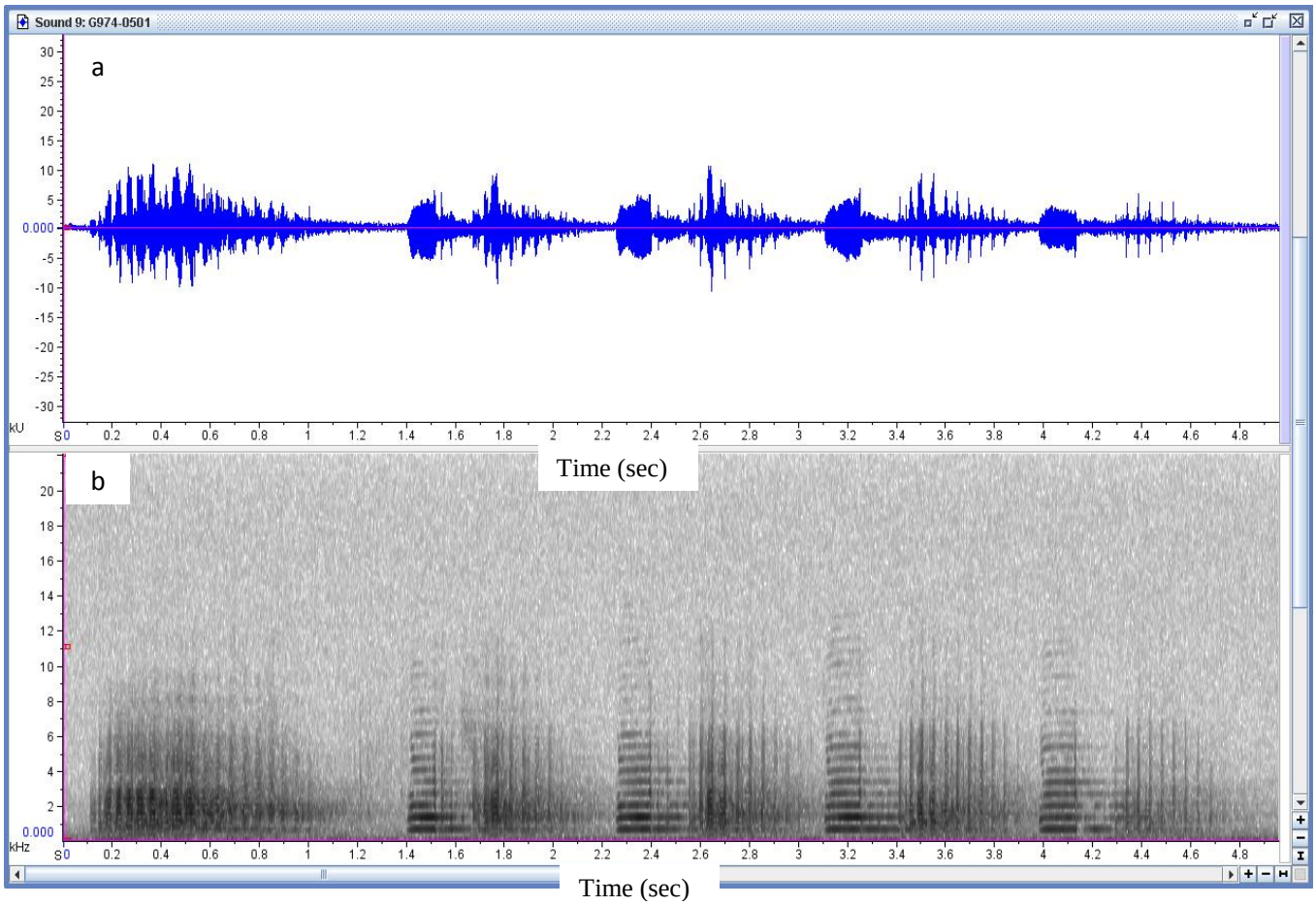

Figure 2: Ecstatic call structure of a Kelly Tarlton's gentoo penguin. a) is an illustration on the wave file and b) is an illustration of the calls spectrogram. The image is imported from the program Raven Lite 1.0.

years of age and are nesting species (Williams 1995). Their nest consists of a platform of stones up to 10-20cm high and 45cm across (Williams 1995). Although they are a nesting species, they rely mainly on acoustic signals as a method of communication (Jouventin & Aubin 2002).

They are known to be highly vocal on land, especially during pair formation, territory establishment and chick rearing (Williams 1995). There are three types of calls used by penguins; they are contact call, agnostic call and display/sexual calls (Jouventin 1982 & Williams 1995). The display calls can be further broken down to three types; they are ecstatic calls, mutual display calls and 'bowing' calls (Williams 1995). For this study, we will be looking at the ecstatic call. The ecstatic call is a loud trumpeting call, given with the head and neck stretched vertically as illustrated by Figure 1 (Williams 1995). It consists of a highly regular series of almost identical syllables produced by inhalation and

exhalation (Figure 2) (Jouventin 1982 & Williams 1995). The mutual display call is very similar to the ecstatic call, but can be shorter and less regular (Williams 1995).

The gentoo penguins' acoustic system has been rarely studied, with only the basic structure and function described (Jouventin 1982). Previous studies of gentoo penguin calls have shown that the inter-individual variation is greater than the intra-individual variation (Jouventin 1982 & Williams 1995). But there are many more aspects of the acoustic system that need to be explored, including the variation between genders, stability of the calls over time, individual recognition and the contribution of other factors such as weight to the variation in the calls.

Goal

The aim of this project is to examine whether gentoo penguin ecstatic call variation is correlated with five factors: individual, gender, weight, season and family group.

Results

Mantel's tests, a test of correlation, were used to carry out the analyses (Sokal & Rohlf 1995). To carry out the tests, a series of matrices were built e.g. a weight and relatedness matrix and were compared to the pair-wise distance matrix of the calls. The calls distance matrix was built by aligning each pair of calls encoded as a sequence of mel-frequency cepstrum coefficients (Ranjard et al 2008). In the relatedness matrix, coancestry coefficients were used to complete the matrix (Weir et al. 2006). The test for differences between the sexes showed no significant evidence (Table 1). Consequently, the rest of the tests had no separation of the data based on gender. However, there was weak evidence for weight having an effect on the acoustic system (Table 1).

The possibility of a difference between individuals was proven to be significant, as the Mantel's test provided extremely strong evidence against the null hypothesis that the calls are similar between individuals (Table 1).

Table 1: Table of P-values for the tests carried out for the study

Test	Number of calls used	P-value
Test for difference between the sexes	301	0.31
Test for vocals depend on the weight	344/271[1]	**0.047/0.056**[1]
Test for difference between individuals	334	**< 0.0001**
Test for stability of vocals overtime:		
Individual		
G138	15	0.251
G198	18	0.135
G137	12	0.198
G143	19	0.453
G170	10	**0.009**
G974	19	**< 0.0001**
G9814	20	0.572
Test for genetic relatedness	351	**0.002**
Test for biological parents	90	**0.002**
Test for fostered parents	90	**0.013**

[1] The first p-value refers to all the available weights, while the second p-value is the result of a re-test, where the ambiguous weights were removed. Also the number of calls used refers to the number of calls used for the test after removal of any ambiguity or unknown values.

For the test of the individual call stability overtime, only seven individuals could be used due to insufficient amount of replicates available for the other individuals. The individual penguins 138, 198, 137, 143 and 9814 provide no evidence against the null hypothesis that the calls remain stable overtime (Table 1). But this observation is contradicted by the significance from individuals 170 and 974 (Table 1). Note individuals 170 and 974 had more than one mate over the seasons recorded and thus there is the potential for calls to vary when a new mate is found. Whereas the five other individuals used in the test had the same mate over the seasons.

In addition, results from the Mantel's test provide very strong evidence for the possibility of genetic relatedness and the call similarity. Also there is evidence for the possibility that both the

biological and fostered parents are having an effect on the call development of the chick (Table 1).

Conclusion

This study illustrates some of the features of the acoustic system of gentoo penguins. The results from the study suggest that the gender of the penguin does not have an effect on the acoustic parameters and weight has little or no effect either. However, the results also shows that both biological and fostered parents have an effect on shaping the acoustic properties of a chicks call, suggesting that there is both an inherited component as well as a learned component. In addition, the results illustrate that there is a difference between individual penguin calls, supporting the observation of greater inter-individual variation from previous studies (Jouventin 1982 & Williams 1995). Furthermore, the results show that the calls of an individual remains stable over time provided the individual does not change its partner over the breeding seasons. This implies that the call of an individual changes slightly as the mate changes and is possibly a mechanism to overcome miscommunication or to assess the new mate (Levin 1996). However, the number of samples where the individuals changed their mate is small, so it would be appropriate if further analyses were carried out with more samples. In addition, it must be noted that these observations are based on a captive gentoo penguin population, which has a small colony size when compared to wild population, and each individual is likely to be related to each other by at least a small fraction. So to ensure that the result observed from the Kelly Tarltons' population is realistic further analyses must be carried out. Nevertheless, it must be noted that this study will provide the basis for further studies to be done on this rarely studied penguin vocal system.

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