SEXING OF ADULT ADELIE PENGUINS BY DISCRIMINANT ANALYSIS OF MORPHOMETRIC MEASUREMENTS

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Abstract

Discriminant analysis of eight morphometric measurements was used to determine the sex of Adélie penguins. A sample of 46 adult birds was taken for measurement from the breeding population at Stranger Point (King George/25 de Mayo Is., South Shetland Islands). The sex of each bird had been determined earlier by means of observing the birds' breeding behaviour (first incubation shift). It was found that the combination of flipper breadth, bill depth and length of the middle toe gave the most accurate sex discrimination (87% correct). Using measurements of flipper breadth and bill depth only also gave good results (80% correct).

Résumé

Une analyse discriminante de huit mensurations morphométriques a servi à identifier le sexe des manchots Adélie. Un échantillon de 46 adultes provenant des stocks reproducteurs de Stranger Point (île du Roi George / île 25 de Mayo, îles Shetland du Sud) a été mesuré. Le sexe de chaque oiseau a été précédemment déterminé par l'observation du comportement reproducteur (premier tour d'incubation). La combinaison de la largeur de l'aileron, de la hauteur du culmen et de la longueur du doigt médian a donné le facteur de discrimination du sexe le plus précis (correct à 87%). Si seules sont utilisées la largeur de l'aileron et la hauteur du culmen, la discrimination s'est également montrée satisfaisante (correcte à 80%).

Резюме

Для определения половой принадлежности пингвинов Адели использовался дискриминантный анализ результатов восьми морфометрических замеров. Измерялась выборка, состоящая из 46 половозрелых особей, взятая из размножающейся популяции, обитающей на мысу Стрейнджер-Пойнт острова Кинг-Джордж (острове 25-го Мая), Южные Шетландские острова. Половая принадлеж-ность каждой особи была предварительно установлена в результате наблюдений за поведением воспроизводства (первая инкубационная смена). Было установлено, что половую принадлежность птиц можно наиболее точно определить по комбинации замеров ширины крыла, высоты клюва и длины среднего пальца (87-процентная точность). При использовании только замеров ширины крыла и высоты клюва также были получены хорошие результаты (80-процентная точность).

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Resumen

Se utilizó un análisis discriminante de ocho medidas morfométricas para identificar el sexo de los pingüinos adelia. Se escogió una muestra de 46 aves adultas de las poblaciones reproductoras de Stranger Point (King George / isla 25 de Mayo, Islas Shetlands del Sur). El sexo de cada ave había sido determinado anteriormente mediante la observación del comportamiento reproductivo (primer turno de incubación). El conjunto de las mediciones del largo del dedo medio de la pata, la anchura de la aleta y el grosor del pico proporcionaron la determinación del sexo más precisa (87% certeza). Al utilizar solamente las mediciones de anchura de la aleta y del grosor del pico, también proporcionó buenos resultados (80% certeza).

1.   INTRODUCTION

Penguins do not have any clear sexual dimorphism. Determination of penguin sex has been performed by using several techniques.

- Observation of birds' behaviour - Sladen, 1958 (Adélie penguins, *Pygoscelis adeliae*).

- External cloacal examination and observation of copulatory behaviour - Richdale, 1957 (yellow-eyed penguins, *Megadypted anitpodes*).

- Internal cloacal examination - Ainley *et al.*, 1983 (Adélie penguins), Samour *et al.*, 1983 (five species of penguins).

In Adélie penguins significant differences between sexes was also found in bill size (Ainley *et al.*, 1983).

The techniques listed above are very useful but during the breeding season they can be applied only after egg-laying. In many studies it would be necessary to know the sex of penguins on their arrival at the breeding colony.

A technique of sex determination in adult, fledgling and yearling Megellanic penguins, *Spheniscus magellanicus*, using discriminant analysis of morphometric measurements, was described by Scolaro, Hall and Ximenez (1983) and Scolaro (1987). In this paper the technique is extended to cover sex determination in adult Adélie penguins.

2.   DESCRIPTION OF THE TECHNIQUE

A sample of 46 adult birds was used for the selection of appropriate morphometric variables for discriminant analysis. A sample was taken from a colony of Adélie penguins at Stranger Point (62°14'S, 58°40'W, King George/25 de Mayo Is., South Shetland Islands). The sex of birds (28 males and 18 females) was determined earlier by observing their breeding behaviour (first incubation shift).

For each individual, eight measurements were taken following the "Standard of Birds' Measurements" proposed by Baldwin *et al.* (1931) with some modifications suggested by Warham (1975). They were: flipper length of open wing (FL), flipper breadth at the widest point near the cubito-carpal joint (FB), length of the middle toe including nail (LM), arc between

eyes from upper edges of eyes over the crown (AE), forehead arc between front of both eyes over the forehead at the base of the bill (FA), bill length equivalent to length of exposed culmen (LC), bill depth measured vertically at the nostrils (BD), bill width measured transversely at the nostrils (Figure 1).

Most variables were selected by their power to discriminate on a single canonical axis between two groups, males and females.

To obtain the discriminant function and the discriminant score between sexes the BMDP computer program (Dixon, 1981) was used for discriminant analysis.

BD (bill depth) was found to be the most significant discriminant variable followed by FB (flipper breadth) and LM (length of the middle toe). These three variables are uncorrelated and all have higher values for males. They could be related to behavioural differences between the sexes during the breeding season (Ainley *et al.*, 1983). In order to improve sex determination in the field and to eliminate non-relevant variables, a stepwise method was used for obtaining the smallest possible subset of significant variables for discriminating between sexes.

In practice, this means that the sex of an individual Adélie penguin can be determined simply by taking two or three standard measurements, combining them in a simple formula, and comparing the results with the constants shown in Table 1.

To verify the validity of this analysis, all the data were grouped and checked against the individual measurements of the sexed birds. This validation showed that 89.3% of the males and 83.3% of the females were classified correctly. Chi-square tests comparing predicted and observed results of sex identification gave highly significant estimates for all subsets considered ($P < 0.0001$).

In gentoo penguins, *Pygoscelis papua*, discriminant analysis of bill measurements gave 95.5% accuracy of correct determination (Williams, 1990). In Adélie penguins bill dimensions are not as useful as in gentoo penguins, and the discriminant analysis indicated that the best measurements for sex identification are flipper breadth (FB) and length of middle toe (LM).

Males can be distinguished from the females by bill, flipper and middle toe measurements. The larger bill size of males is doubtless related to its role in attack, defense and nest construction as it was found in other penguins (Stonehouse, 1971; Warham, 1975 and Scolaro, 1987).

ACKNOWLEDGEMENTS

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Table 1: Results of sex determination in adult Adélie penguins by means of discriminant analysis.

Variables	FB (Flipper Breadth) BD (Bill Depth)	FB (Flipper Breadth) BD (Bill Depth) LM (Length Middle Toe)
Discriminant function	W = 0.428 FB + 1.40 BD	W = 0.348 FB + 1.46 BD + + 0.311 LM
Discriminant function score	C = 49.64	C = 70.52
% of correctly classified birds	80.4%	87.0%

If W > C the sex is male
If W < C the sex is female
If W = C the sex is indeterminate
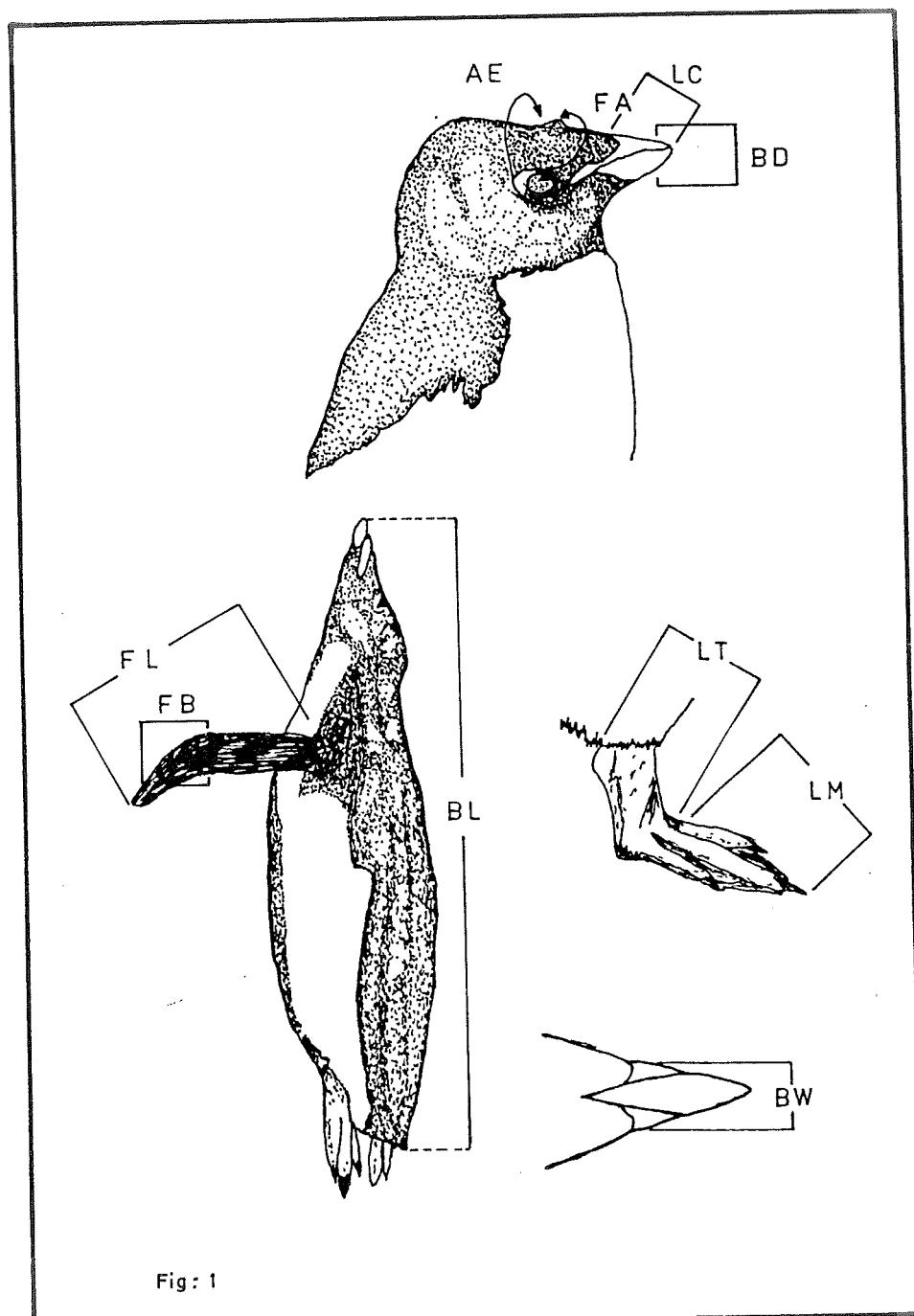
Figure 1:   Adélie penguin, schematic illustration of variables measured to differentiate sex.
BL - body length, FL - flipper length, FB - flipper breadth, LT - tarsus length,
LM - length of middle toe, AE - arc between eyes, FA - forehead arc, LC - bill
length, BD - bill depth, BW - bill width.