EXISTENCE OF TWO *OCEANODROMA CASTRO* (HARCOURT, 1851) POPULATIONS ON THE ISLAND OF SELVAGEM GRANDE, PORTUGAL

By B.F. FARIA [1]

With 1 figure, 3 tables and 1 graphic

ABSTRACT. This work consisted of the statistical comparison of two samples of *Oceanodroma castro* (Madeira's storm petrel), ringed on the island of Selvagem Grande in September 1990 and June 1991, with the purpose of studying the population structure of this colony.

The study consisted of the application of the t test, and of the principal components analysis method, between some biometrics variables of rigid morphological structures of the birds, referred to the two samples, composed of 71 and 92 birds, respectively.

Both tests presented a heterogeneity in the results between the two samples, leading us to conclude that the colony of *Oceanodroma castro* of the island of Selvagem Grande is, most probably, composed of two populations with consecutive nest building periods.

INTRODUCTION

The Madeiran Storm-Petrel, *Oceanodroma castro*, is a marine bird found in tropical, subtropical and warm ocean waters. It belongs to the family Hydrobatidae, composed of the smaller Procellariiformes (CRAMP & SIMMONS, 1977). This species is widely distributed in the Atlantic and Pacific oceans and many aspects of its biology remain unknown. This is greatly due to the strangeness of its habits which makes in depth studies of these birds difficult.

The Madeira's storm petrel is a pelagic species, whose nesting areas seem to be limited to the Atlantic archipelagos of Cabo Verde, Canary Islands, Madeira and the Azores,

[1] Parque Natural da Madeira, Quinta do Bom Sucesso, Caminho do Meio - 9050 PORTUGAL

Ascencion Island and St. Helena Islands also in the Atlantic ocean, and some Japanese islands, Hawaii and the Galapagos in the Pacific (MARTIN, 1987). Their presence was also verified in the Berlengas, on the small island of Farilhão Grande, off the West coast of Portugal, by TEIXEIRA & MOORE (1981). The capture of some birds in places far away from their usual habitat, like the USA, Brazil, Mexico Gulf, Canada, Spain and England (PALMER, 1962; WATSON, 1966; GARRIDO & MONTANÃ, 1968; BAXTER, 1970) suggests a more extensive pelagic distribution in the Atlantic.

The movements of *Oceanodroma castro* are disperse and not well known. This is due to the difficulty of identification at sea, as they are similar to other petrels (BOURNE, 1967 *in* CRAMP & SIMMONS, 1977) and do not have the habit of following vessels (HARRISON, 1983). No real migrations are known; however, some variation in the concentration of birds on the Atlantic have been registered in places close to the geographic nesting areas (CRAMP & SIMMONS, 1977).

As far as reproduction is concerned, it is known that in tropical regions the laying of eggs occurs all year round and on some islands, like the Galapagos, that have two populations , each one of them has a very extensive annual laying season, with a six month difference between them (HARRIS, 1969). According to the same author, the Japanese population probably returns to the nesting areas in May, and laying starts in June. There is not much confirmed data on the laying season in colonies of the Atlantic ocean located in warm areas, as eggs are found there all year round except in May, in two concentrated periods (June - September and October - December) in Madeira (BANNERMAN, 1954 *in* CRAMP & SIMMONS, 1977); and, on the other hand because there is a laying period in Selvagens extending from the end of June until September (BANNERMAN, 1963).

Analysing the above information, we can postulate that the number of laying periods in the colonies of *Oceanodroma castro* is probably directly related to the number of populations that make up each colony. This is quite evident in the case of the Galapagos, but there are still doubts as far as the warm area colonies are concerned. They do not have well defined laying seasons and there is not much information concerning the population structure of the colonies. Thus, for the purpose of contributing to a better knowledge of the biology of the species in the field, we set out to define the global characteristics of this species colony on the island of Selvagem Grande. There, according to F. ZINO (personal communication, 1991), eggs can be found almost all year round, and there are doubts as to whether the colony is composed of one or two populations.

This study consists of the statistical comparison of some biometrics variables of rigid morphological structures between two samples captured and ringed on the island, in September 1990 and June 1991, using the "Student" t test and the principal components analysis method, with the purpose of discriminating both samples, thus underlining the existence of two nesting populations on the island.

MATERIAL AND METHODS

Area of study

Field-work took place on the island of Selvagem Grande, belonging to the small Portuguese archipelago of the Selvagens, in the Atlantic, between the archipelagos of Madeira and the Canary Islands, 280 Km and 165 km away from each, respectively. This volcanic island, with an area of 2,5 km x 2,2 km, is the biggest in the archipelago and its main feature is a plateau of about 140 hectares, entirely surrounded by cliffs.

According to MONOD (1990), the flora of this island is the poorest of all the surrounding archipelagos. Terrestrial vertebrates are limited to the rabbit (*Oryctolagus cuniculus*), the mouse (*Mus musculus*), the lizard (*Podarcis dugesii*) and the geckho (*Tarentola bischoffi*). These uninhabited islands are also a privileged nesting area for several species of marine birds, such as Cory's shearwater (*Calonectris diomedea*), Bulwer's petrel (*Bulweria bulwerii*), Frigate petrel (*Pelagodroma marina hypoleuca*), Little shearwater (*Puffinus assimilis*) and the Yellow legged Gull (*Larus cachinnans*). The archipelago is now a nature reserve under the protection of the Parque Natural da Madeira.

Ringing the birds

- 16 and 17 September 1990, near Furna das Galinhas: an area above Enseada das Galinhas.
- 18 September 1990, at Chão dos Caramujos: on the North-East of the Selvagem Grande plateau, at Corgo da Areia, Ponta da Espinha and the base of Pico dos Tornozelos; composed of sand and fossilised snail shells.
- 19 September 1990, Barracão Militar: area above the bay of Enseada das Cagarras, close to the ruins of the old military hut.
- 4, 5, 6, 8, 9 and 12 June 1991 at Barracão Militar.
- 16, 17 and 23 June 1991 in the nests.

The birds were ringed, weighed and measured [both wings length, total length of the bird, longest and shortest tail length, size of the white strip above the tail, tarsus length, middle toe length of the right leg, bill length, bill height close to the insertion with the head, bill thickness above the nostrils, bill thickness on the extremity and bill thickness close to the nostrils (see Figure1)].

Statistical comparison of the samples of September 1990 and June 1991

1 - For this study, using the data from the ringing of September 1990 and June 1991, only the biometrics variables of rigid morphological structures were used (tarsus length, middle toe length of the right leg, bill length, bill height close to the insertion with the head,

bill thickness above the nostrils, bill thickness on the extremity and bill thickness close to the nostrils), since these variables do not change during the year. Measurements were always carried out by the same person and only adult birds (breeders and non breeders) were measured so as to eliminate possible differences between the two samples, caused by sampler error.

2 - To compere the two samples, we used a t Student test.

The test consisted of testing the null hypothesis (uniformity between the averages of the two samples for each variable) with a significance level of 0,05.

3 - The use of the Principal Components Analysis method, through a covariance's matrix described by HOTELLING (1933 *in* JACKSON, 1991), aimed at the discrimination of the samples from September 1990 and June 1991.

The selection of the four variables used in this test was carried out through a stepwise, which consists in the application of a F test to the matrices of the variable covariances with a = 0,15 (methodology described by the SAS INSTITUTE, 1988). Generally speaking, this method selected the quantitative variables which revealed the differences between the two samples more effectively.

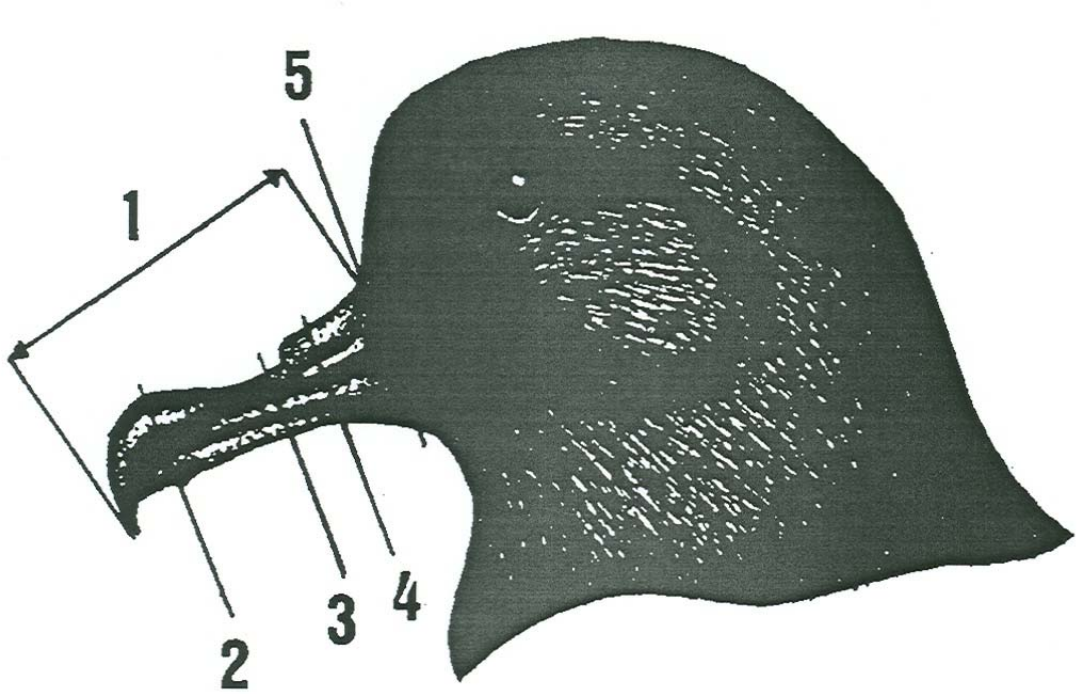

Fig. 1 - Biometrics variables of the bill. 1 - Bill length; 2 - Bill thickness on the extremity; 3 - Bill thickness above the nostrils; 4 - Bill thickness over the nostrils; 5 - Bill thickness close to the insertion with the head.

RESULTS

The results of the t Student test are presented on table 1 which shows that the variables tarsus, bill length, insertion of the beak, point and nostril measures have a t value inferior to the correspondent critic t value. In other words, for these variables there are no differences between the averages of both samples (there is no rejection of the null hypothesis). The remaining variables, middle toe and nostrils, on the contrary, have a t value superior to the critic t value, corresponding to the existence of a significant difference between the average of both samples (rejection of the null hypothesis).

With the Principal Components Analysis Method, the selected four variables data (middle toe length, bill thickness close to the insertion with the head, measured above and close to the nostrils through a stepwise - see table I in annexe) were transformed into four components. As can be seen on table II (in annexe), the two first components explain 93 % of the variation of the transformed values of the variables in relation to the axis.

From the observation of the above graphic, we can see, alongside the axis formed by component 1 and 2, three different areas:

1 - One formed by the points belonging only to the 1990 sample.
2 - One formed by a mixed area with points belonging to both samples.
3 - One formed by the points belonging only to the 1991 sample.

DISCUSSION AND CONCLUSION

The results obtained from t test support the hypothesis of the existence of two nesting populations on the island of Selvagem Grande, most specifically due to the rejection of the null hypothesis (similar averages between the samples from September 1990 and June 1991) and to the variables from the middle toe and bill thickness close to the nostrils, being those variables measurements of the rigid morphological structure of the bird, which remain unchanged all year long. If there were only one nesting population, the averages of both variables for each sample would have been considered by t test as belonging to the interval corresponding to the normal distribution, with a 95 % probability that the sample averages belonged to a same average (population average). But what the t test shows is exactly the opposite; it concludes that the averages of both variables under analysis for each sample belong to different distributions of population averages.

Applying the Principal Components Analysis (normally used to define different populations) to the samples from September 1990 and June 1991, it was possible to define them as in graphic 1; this fact is an unquestionable argument supporting the existence of two nesting *Oceanodroma castro* populations on the island of Selvagem Grande. The overlapping area may be justified by the fact that both populations have consecutive nesting seasons, with a 5 months interval. Each one of them has a laying period, from June to September and

from September to December respectively, a fact that is similar to the one registered in Madeira by BANNERMAN (1963).

The objective of the statistical comparison of both *Oceanodroma castro* samples that were studied was achieved, contributing to a better knowledge of this species. Both tests presented results which coincided, allowing us to conclude that the Selvagem Grande colony is most probably composed of two populations, with overlapping consecutive nesting periods.

It is however, advisable to carry out a ringing program to obtain a more representative annual sample, in order to be able to really characterize this colony and prove the unquestionable existence of two nesting populations on this island.

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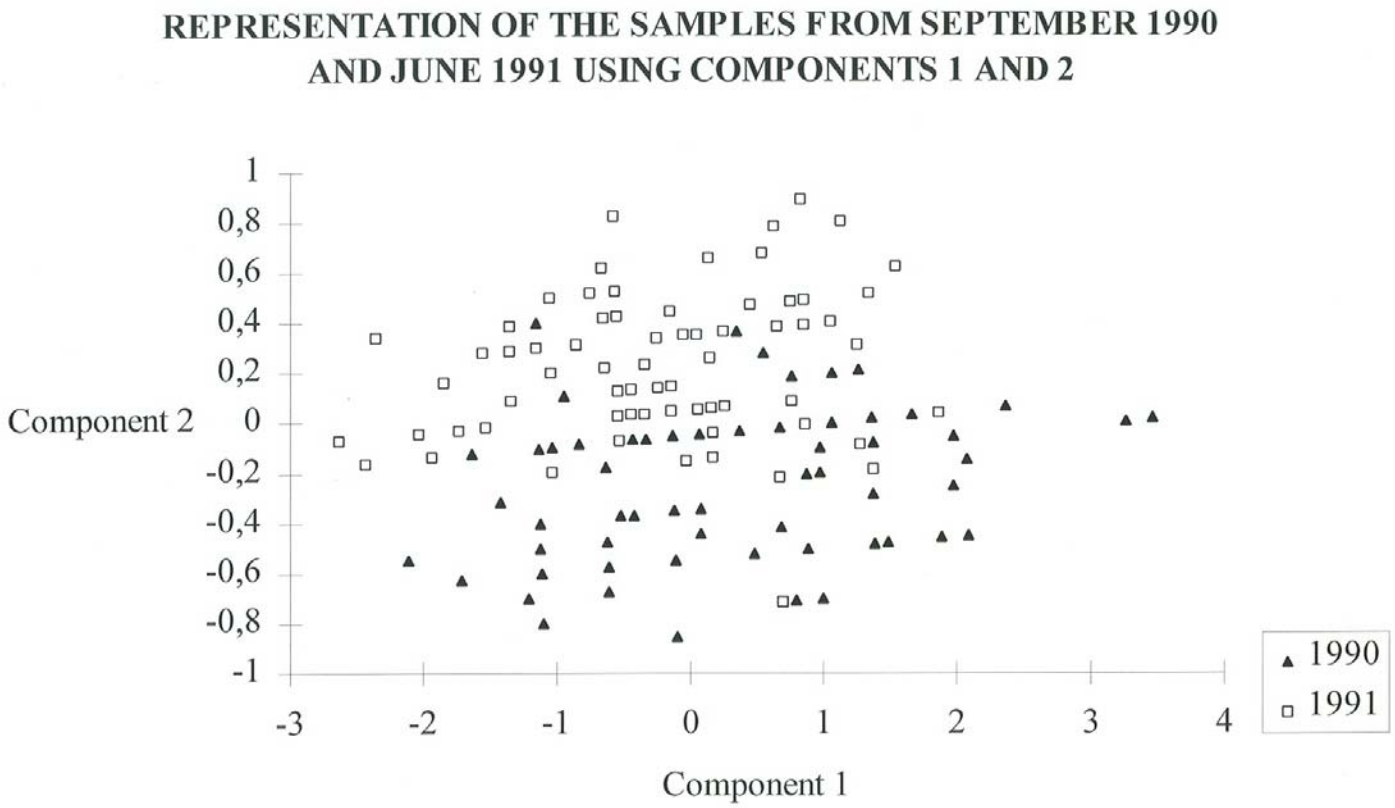
TABLE 1 - t TEST - bilateral, with $\alpha = 0,05$ and different variances														
	Tarsus		Middle Toe		Bill Length		Bill Insertion		Nostrils		Point		Close to Nost.	
Sample	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Average	24,713	24,461	21,438	20,866	14,211	14,157	6,435	6,424	6,285	6,783	5,152	5,221	4,828	4,815
Variance	0,908	2,348	1,398	1,100	0,693	0,586	0,115	0,065	0,0092	0,079	0,071	0,071	0,037	0,074
n	71	82	71	77	71	82	71	82	71	82	71	82	71	82
d. f.	137,713		140,362		143,517		128,533		144,290		147,857		145,227	
t	1,237		3,102		0,415		0,221		-10,486		-1,585		0,360	
Critic t	1,977		1,977		1,977		1,979		1,977		1,976		1,976	

TABLE I: STEPWISE SELECTION - SUMMARY $\alpha = 0,15$					
Variable Step Entered	Number Removed	Partial In	F	R^2	Prob, > Statistic F
1 Nostrils	1	0,4244	107,633		0,0001
2 Bill Ins.	2	0,1088	17,704		0,0001
3 Finger	3	0,0343	5,119		0,0252
4 Close Nost.	4	0,0273	4,013		0,047
Average Squared					
Variable Step Entered	Number Removed	Wilks' In	Prob, < Lambda	Canonical Lambda	Prob, > Correlation ASCC
1 Nostrils	1	0,57563554	0,0001	0,42436446	0,0001
2 Bill Ins.	2	0,51299925	0,0001	0,8700075	0,0001
3 Finger	3	0,49538902	0,0001	0,50461098	0,0001
4 Close Nost.	4	0,48186561	0,0001	0,51813439	0,0001

TABLE II: PRINCIPAL COMPONENT ANALYSIS - 148 Observation, 4 Variables				
Covariance Matrix				
	Finger	**Bill Insertion**	**Nostrils**	**Close Nostrils**
Finger	1,312452197	0,030725777	-0,056109119	0,013238187
Bill Insertion	0,030725777	0,088797113	0,038818257	0,022910921
Nostrils	0,056109119	0,038818257	0,148752988	0,01978075
Close Nostrils	0,013238187	0,022910921	0,01978075	0,056331587
Total Variance = 1,6063338849				
Eigenvalues of the Covariance Matrix				
	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
Prin 1	1,31596	1,14233	0,819232	0,81923
Prin 2	0,17363	0,10136	0,108088	0,92732
Prin 3	0,07227	0,02779	0,04499	0,97231
Prin 4	0,04448		0,02769	1
Eigenvectors				
	Prin 1	**Prin 2**	**Prin 3**	**Prin 4**
Finger	0,99856	0,026739	-0,046457	0,002301
Bill Insertion	0,023704	0,46413	0,753621	-0,464841
Nostrils	-0,047041	0,852911	0,519895	0,006331
Close Nostrils	0,010187	0,237512	0,399508	0,885369



Graphic 1 - Discrimination of two *Oceanodroma castro* samples using the main components analysis method.

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