Johannes N.J. Post
Diergaarde Blijdorp

Biometrics of 35 specimens of the Leach's storm-petrel *Oceanodroma leucorhoa* from a wreck in southern Portugal

Post, J.N.J., 1998 - Biometrics of 35 specimens of the Leach's storm-petrel *Oceanodroma leucorhoa* from a wreck in southern Portugal - DEINSEA 4: 77 - 89 [ISSN 0923-9308]. Published 30 August 1998.

From a sample of 35 Leach's storm-petrels *Oeanodroma leucorhoa* washed ashore on some beaches in southern Portugal during the period 24 December 1996 - 5 January 1997 both external and internal (skeleton and skull) measurements were taken. 45.7% of the specimens could be sexed anatomically: 62,5 % were males. In addition, the feet were checked for abnormalities and the stomach contents were investigated. Of almost all specimens the skull and in most cases also the complete post-cranial skeleton was preserved. The biometrical data were compared with data from the literature and from the measurements taken from a specimen of the Madeiran storm-petrel *Oceanodroma castro* which was collected during the same period and at the same locality. As for biometry, the wing length of the Leach's storm-petrels was 1-5 mm longer than the range given in literature. To the best of our knowledge, the measurements of the skull and skeletons listed in this paper are the first published for the species. It is concluded that the specimens were from a wreck that also occurred along the (northern) coast of Morocco.

Biometrie van 35 exemplaren van het vale stormvogeltje Oceanodroma leucorhoa *afkomstig van een massa-aanspoeling in Zuid-Portugal* - Van 35 vale stormvogeltjes, gevonden op vier stranden in Zuid-Portugal tijdens de periode 24 december 1996 - 5 januari 1997, werden zowel uitwendige lichaamsmaten als skelet- en schedelmaten genomen. Bij 45.7% van de vogels kon het geslacht inwendig vastgesteld worden: 62,5% was van het mannelijk geslacht. Daarnaast werden pootafwijkingen geïnventariseerd en beschreven en werd de maaginhoud van de vogels bekeken. Van nagenoeg alle vogels werd tenminste de schedel en in de meeste gevallen ook de rest van het skelet geconserveerd. De gevonden biometrische gegevens werden vergeleken met gegevens uit de literatuur en met de maten van een Madeira stormvogeltje *Oceanodroma castro* dat in dezelfde periode op dezelfde locatie gevonden werd. De vleugellengte van de onderzochte vale stormvogeltjes bleek 1-5 mm langer te zijn dan de reeks van maten die in de literatuur staat. De schedel- en skeletmaten konden niet vergeleken worden aangezien de in dit artikel gepresenteerde maten, voor zover bekend, de eerste zijn die van de soorten worden gepubliceerd. Geconcludeerd wordt dat de stormvogeltjes afkomstig zijn van een massa-aanspoeling die ook langs de noordkust van Marokko is opgetreden.

Correspondence: J.N.J. Post, Diergaarde Blijdorp (Rotterdam Zoo), P.O. Box 532, NL- 3000 AM Rotterdam, The Netherlands

Keywords: Hydrobatidae, *Oceanodroma leucorhoa*, Leach's storm-petrel, *Oceanodroma castro*, Madeiran storm-petrel, wreck, biometrics, Algarve, Portugal

INTRODUCTION

The vast majority (estimations of a few million birds) of the nominate race of the Leach's storm-petrel *Oceanodroma leucorhoa leucorhoa* (VIEILLOT, 1817) belongs to the West-Atlantic population. Only a relatively small number of birds (approximately 10,000 pairs) make up the East-Atlantic population. The nesting areas of the East-Atlantic population are primarily located on islands off the coast of Great-Britain, Iceland, Faeroes, and Norway (Cramp & Simmons 1977; Harrison 1985, 1987). During migration the birds from

the West-Atlantic population mix with the East-Atlantic birds. Their joint route runs southwards along the southwestern coast of Great-Britain, the Bay of Biscay, and the western and southwestern coastline of Portugal before they enter the waters along the African coast. Records of dead Leach's storm-petrels on the beaches of West- and South-Portugal are rare: during monthly beach surveys in the period October - March in 1990/1991 and 1991/1992 only one specimen was found (Granadeiro & de Silva 1992, 1993). During the winter of 1995/1996 the number of birds washed ashore was much higher: 22 Leach's storm-petrels and 1 Madeiran Storm-petrel *Oceanodroma castro* (HARCOURT, 1851) (J.P. Granadeiro pers. comm. February 1997).

In December 1996 / January 1997 the author collected a total of 35 dead Leach's storm-petrels and one Madeiran storm-petrel on four beaches in Southern Portugal. As this number seemed exeptionally high, all birds were biometrically and anatomically examined and the skeletons were preserved. Here the biometrical data (of both the body and the skeleton) are presented and compared with data in the literature (Murphy 1936; Bauer & Glutz von Blotzheim 1966; Cramp & Simmons 1977) and with the measurements of a Madeiran storm-petrel that was collected during the same occasion. Besides, the cause of the occurrence of this high number of storm-petrels is discussed.

MATERIAL AND METHODS

On 24 December 1996, the author visited Praia de Falésia, a long, extended sandy beach, approximately 5 km south of Albufeira in the Algarve in southern Portugal (Fig. 1). A stretch of 1500m beach along the storm tideline (which was a few days old) was examined in a westerly direction from Albufeira. In total, 27 Leach's storm-petrels and one Madeira storm-petrel were found. This is about one specimen on every stretch of 54m of beach. All birds had already started to decay, but - in most cases - were still intact, including the internal organs. One specimen was incomplete: only two wings attached to the sternum (with the feet and tail missing) were present.

On 29 December 1996 three dead Leach's storm-petrels were collected near Armação de Pêra on a stretch of 500m of beach. The storm line was almost all covered by sand. This situation made it difficult to find the carcasses. The actual number of birds washed ashore near Armação de Pêra must have been much higher.

On 4 January 1997 four dead Leach's storm-petrels were found on one of the beaches near Lagos, Meia Praia, on a stretch of 1500m and on 5 January 1997 one specimen was collected along a 100 meter stretch of beach near Alvor. This totalled the number at 35 Leach's storm-petrels and one Madeira storm-petrel along 3600m of examined beach, on average about one bird washed ashore on every 100m of

Figure 1 Map of the Algarve, South Portugal, showing the four locations where the Leach's storm-petrels washed ashore [illustration: J.N.J. Post]

beach. As this number seemed unusually high, all the carcasses were collected. An attempt to determine the sex of each specimen was made immediately at the site by gonadal inspection. Of the 35 birds, 16 (45.7%) could be trustworthy sexed: 62.5% appeared to be males. The gonads of the other specimens were in such a bad condition that it was impossible to determine the sex. The age of the birds was not established. Not a single specimen was fresh enough to make it into a study skin. So after having taken 15 external body measurements (see below), the size of the gonads and after inspection of the stomach contents, of all specimens the (unmounted) skeleton was preserved.

Material

All complete, unmounted skeletons, unless noted otherwise. The following data are listed successively: location; collection date; col-lection and number (between brackets): sex (♂ = male, ♀ = female, ? = sex unknown), complete/incomplete skeleton. All material is temporarily kept in the private collection of the author (JNJP, Schiedam, The Netherlands) and will eventually be stored in the Natural History Museum Rotterdam (NMR).

Oceanodroma leucorhoa

Portugal, Albufeira, Praia de Falésia:

24-XII-1996 (JNJP 1997.1) ♂ complete
24-XII-1996 (JNJP 1997.2) ♀ complete
24-XII-1996 (JNJP 1997.3) ♀ complete
24-XII-1996 (JNJP 1997.4) ♀ complete
24-XII-1996 (JNJP 1997.5) ? complete
24-XII-1996 (JNJP 1997.6) ? complete
24-XII-1996 (JNJP 1997.7) ♂ complete
24-XII-1996 (JNJP 1997.8) ♀ complete
24-XII-1996 (JNJP 1997 9) ♂ complete
24-XII-1996 (JNJP 1997.10) ♂ complete
24-XII-1996 (JNJP 1997.11) ♂ complete
24-XII-1996 (JNJP 1997.12) ♂ complete
24-XII-1996 (JNJP 1997.13) ♂ complete
24-XII-1996 (JNJP 1997.14) ? complete
24-XII-1996 (JNJP 1997.15) ? complete
24-XII-1996 (JNJP 1997.16) ? complete
24-XII-1996 (JNJP 1997.18) ♀ complete
24-XII-1996 (JNJP 1997.19) ? complete
24-XII-1996 (JNJP 1997.20) ? complete
24-XII-1996 (JNJP 1997.21) ? complete
24-XII-1996 (JNJP 1997.22) ? complete
24-XII-1996 (JNJP 1997.23) ? complete
24-XII-1996 (JNJP 1997.24) ? complete
24-XII-1996 (JNJP 1997.25) ♂ complete
24-XII-1996 (JNJP 1997.26) ? incomplete
24-XII-1996 (JNJP 1997.27) ? complete
24-XII-1996 (JNJP 1997.28) ? complete

Portugal, Armação de Pêra, Praia Armação de Pêra:

29-XII-1996 (JNJP 1997.29) ? complete
29-XII-1996 (JNJP 1997.30) ♂ complete
29-XII-1996 (JNJP 1997.31) ♂ complete

Portugal, Lagos, Meia Praia:

04-I-1997 (JNJP 1997.33) ♀ complete
04-I-1997 (JNJP 1997.34) ? complete
04-I-1997 (JNJP 1997.35) ? incomplete
04-I-1997 (JNJP 1997.36) ? incomplete

Portugal, Alvor, Praia de Alvor:

05.I.1997 (JNJP 1997.37) ? incomplete

Oceanodroma castro

Portugal, Praia de Falésia:

-24-XII-1996 (JNJP 1997.17) ♂ complete

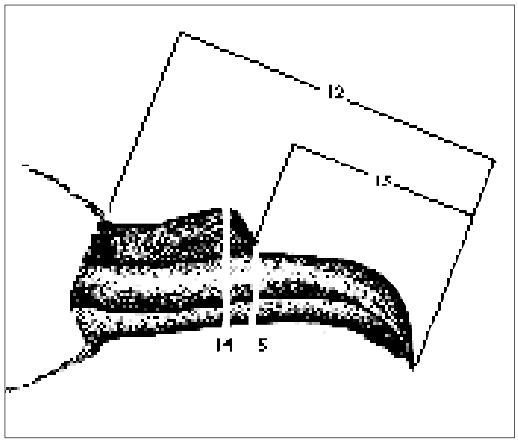
Measurements

External measurements (1-15) and measurements of the gonads (16 or 17) were taken during dissections in the field. The other measurements on the skull and skeletton (18-26) were taken after the carcass was cleaned. When applicable, all measurements were taken on both sides. When only one side was measured, it was always the right side. Wing lengths and tail lengths were measured with a measuring tape. All other measurements were taken with vernier callipers (Figs. 2, 3a, 3b).

External

1 TOTAL LENGTH: straigth line between the most distal point of the bill and the tip of the longest tail feather.
2 WING LENGTH RIGHT: wing stretched and flattened. The maximum length was taken from the carpal joint to the tip of the longest primary.
3 WING LENGTH LEFT: wing stretched and flattened. The maximum length was taken from the carpal joint to the tip of the longest primary.
4 TAIL LENGTH: measuring tape placed under the tail gland to the tip of the longest tail feather.
5 TARSAL LENGTH RIGHT: measured from the external groove between the tibia and tarsus to the joint between the tarso-metatarsus and the most proximal margin of the phalanx of the middle toe.
6 TARSAL LENGTH LEFT: measured from the external groove between the tibia and tarsus to the joint between the tarso-metatarsus and the most proximal margin of the phalanx of the middle toe.
7 MIDDLE TOE LENGTH WITHOUT NAIL RIGHT: measured from the joint between the tarsus and the most proximal margin of the phalanx of the middle toe to the most proximal margin of the nail.
8 MIDDLE TOE LENGTH WITHOUT NAIL LEFT: measured from the joint between the tarsus and the most proximal margin of the phalanx of the middle toe to the most proximal margin of the nail.
9 MIDDLE TOE LENGTH WITH NAIL RIGHT: measured as in 7, but to the most distal margin of the nail.
10 MIDDLE TOE LENGTH WITH NAIL LEFT: measured as in 8, but to the most distal margin of the nail.
11 HEAD LENGTH: measured from the tip of the bill to the most proximal point of the occiput.
12 BILL LENGTH INCLUDING TUBE: measured from the tip of the bill to the implantation of the feathers (Fig. 2).
13 BILL LENGTH EXCLUDING TUBE: measured from the tip of the bill to de most distal point of the tube (Fig. 2).
14 BILL HEIGHT ON TUBE: measured on the highest point of the tube (Fig. 2).
15 BILL HEIGHT IN FRONT OF TUBE: measured just before the tube (Fig. 2).

Figure 2 Lateral view of the bill of the Leach's storm-petrel *Oceanodroma leucorhoa* with measurement points used in this study: 12 = BILL LENGTH INCLUDING TUBE; 13 = BILL LENGTH EXCLUDING TUBE; 14 = BILL HEIGHT AT THE TUBE; 15 = BILL HEIGHT IN FRONT OF THE TUBE.
[illustration: J.N.J. Post]



Internal: gonads

16 TESTES RIGHT: the length is measured.
17 OVARIUM: the length is measured.

Internal: skeleton and skull

18 HUMERUS: measured is the maximal length.
19 ULNA: measured is the maximal length.
20 RADIUS: measured is the maximal length.
21 FEMUR: measured is the maximal length.
22 TIBIA: measured is the maximal length.
23 TARSUS: measured is the maximal length.
24 SKULL LENGTH: measured is the maximal length, including the bill sheath (Fig. 3a).
25 POSTORBITAL PROCESS BREADTH: the distance between the two postorbital processes (Fig. 3b).
26 LACRIMAL BREADTH: the distance between the two most lateral points of the lacrimals (Fig. 3b).

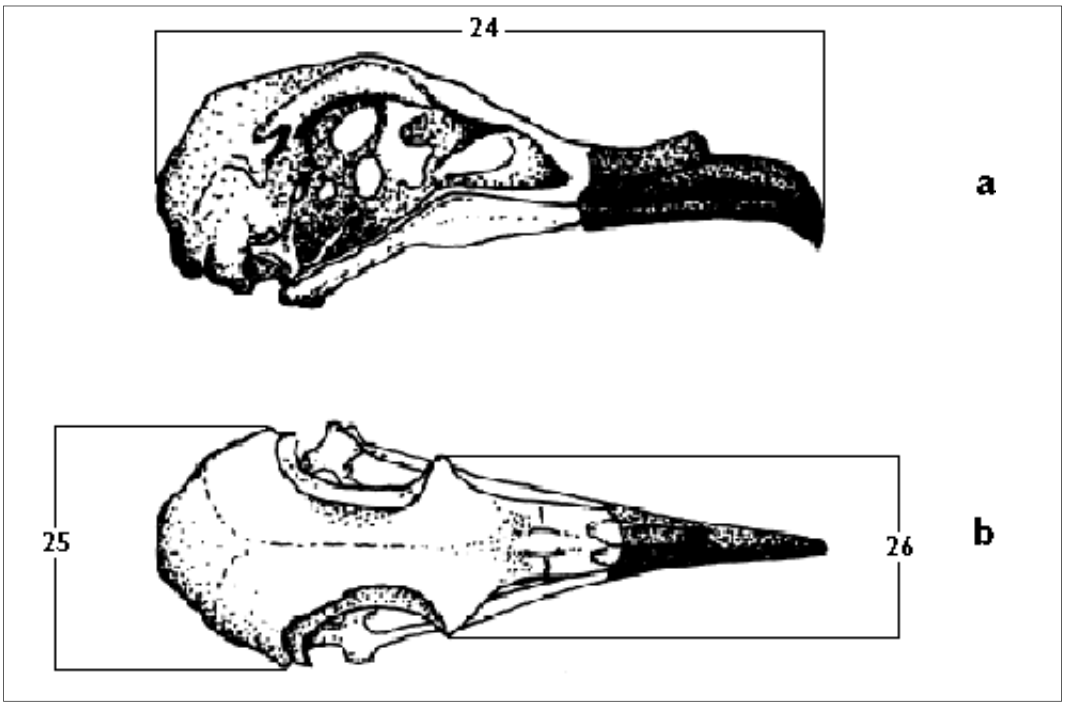


Figure 3 Skull of the Leach's storm-petrel *Oceanodroma leucorhoa;* **a** lateral view (24 = SKULL LENGTH); **b** dorsal view (25 = POSTORBITAL PROCESS BREADTH; 26 = LACRIMAL BREADTH). [illustration: J.N.J. Post]

RESULTS

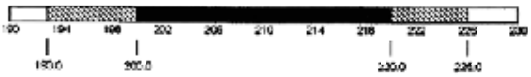
Anatomy and morphology

Post mortem examination did not shed any light on possible causes of death. In almost all the birds, fat tissue was lacking around the sternum and around the internal organs. The pectoralis muscle had a normal thickness in most of the birds. So - in general - the wrecked storm-petrels appeared to be in good condition. The stomachs of four specimens were opened as a random sampling: all were empty, except for some plastic pellets of several millimetres in size, that were present in two stomachs. The feet and webs between the toes of all the birds were examined. Special attention was paid to broken bones, amputations and other wounds. Of a total of 33 birds, 6 had foot abnormalities (18.2%). Two specimens (5.6%) had amputated feet. Five birds (15.2%) had damaged toes, varying from one or more amputated phalanxes to damaged webs (Fig. 4).

Biometry

The diagrams give separated maximum ranges of size of each measured part of the body/skeleton (in mm) of male and female specimens. Black areas indicate overlap in size. A full listing of results (in mm), including ranges, averages and sample sizes are given right below the diagrams. For the gonadal sizes no diagrams are given.

1 TOTAL LENGTH



male:range 193.0- 226.0, average 207.6 (n=10)
female:range 200.0- 220.0, average 211.8 (n= 6)
unsexed:range 201.0- 220.0, average 207.1 (n= 9)
all combined:range 193.0- 226.0, average 208.4 (n=25)

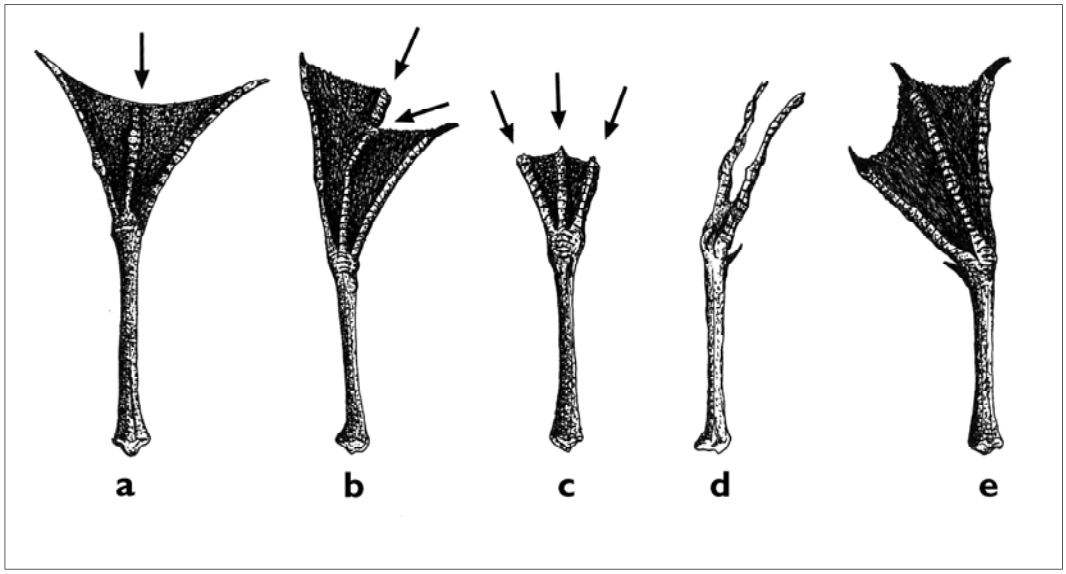
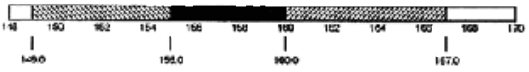


Figure 4 Abnormalities of the toes of the Leach's storm-petrel *Oceanodroma leucorhoa*; **a** (JNJP 1997.14): of left foot last phalanxe and nail of middle toe missing; **b** (JNJP 1997.29): of left foot middle toe broken and healed incorrectly, nail missing, web deformed; **c** (JNJP 1997.29): of right foot all distal phalanxes missing; **d** (JNJP 1997.20): of left foot one toe and both webs missing; **e** (JNJP 561): example of healthy foot. [illustration: J.N.J. Post]

2 WING LENGTH RIGHT:



male: range 149.0- 160.0, average 153.4 (n=10)
female: range 155.0- 167.0, average 159.2 (n= 6)
unsexed: range 151.0- 162.0, average 156.5 (n=15)
all combined:range 149.0- 167.0, average 156.0 (n=31)

3 WING LENGTH LEFT:

male: range 150.0- 161.0, average 155.2 (n=10)
female: range 155.0- 171.0, average 160.5 (n= 6)
unsexed: range 147.0- 168.0, average 157.4 (n=16)
all combined: range 147.0- 171.0, average 157.3 (n=32)

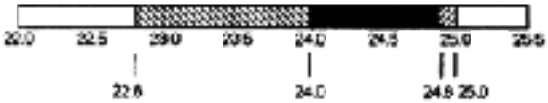
4 TAIL LENGTH

male: range 78.0- 88.0, average 81.9 (n=10)
female: range 80.0- 89.0, average 83.0 (n= 6)
unsexed: range 78.0- 90.0, average 83.1 (n=10)
all combined: range 78.0- 90.0, average 82.6 (n=26)

5 TARSAL LENGTH RIGHT

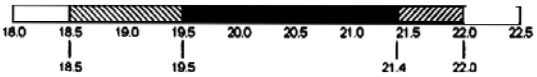
male: range 22.7- 24.8, average 23.9 (n=10)
female: range 23.7- 25.1, average 24.5 (n= 6)
unsexed: range 23.2- 25.7, average 24.5 (n=15)
all combined: range 23.2- 25.7, average 24.3 (n=31)

6 Tarsal length left



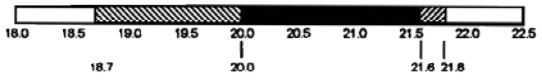
male: range 22.8- 24.8, average 23.8 (n= 9)
female: range 24.0- 25.0, average 24.6 (n= 5)
unsexed: range 23.7- 25.7, average 24.6 (n=15)
all combined: range 22.8- 25.7, average 24.4 (n=29)

7 Middle toe length without nail right



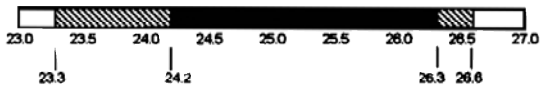
male: range 18.5- 21.4, average 19.6 (n=10)
female: range 19.5- 22.0, average 20.6 (n= 6)
unsexed: range 19.7- 21.9, average 20.4 (n=14)
all combined: range 18.5- 22.0, average 20.2 (n=30)

8 Middle toe length without nail left



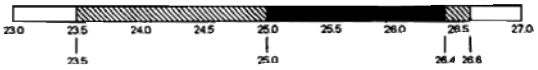
male: range 18.7- 21.6, average 19.6 (n= 9)
female: range 20.0- 21.8, average 20.9 (n= 5)
unsexed: range 19.3- 21.1, average 20.4 (n=12)
all combined: range 18.7- 21.8, average 20.2 (n=26)

9 Middle toe length with nail right



male: range 23.3- 26.6, average 24.7 (n=10)
female: range 24.2- 26.3, average 25.4 (n= 6)
unsexed: range 24.0- 26.4, average 25.4 (n=14)
all combined: range 23.3- 26.6, average 25.2 (n=30)

10 Middle toe length with nail left

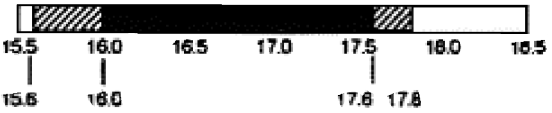


male: range 23.5- 26.6, average 24.7 (n= 9)
female:range 25.0- 26.4, average 25.8 (n= 5)
unsexed: range 24.0- 26.4, average 25.3 (n=12)
all combined: range 23.5- 26.4, average 25.2 (n=26)

11 Head length

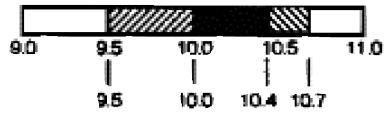
male: range 40.0- 42.0, average 41.0 (n=10)
female: range 40.8- 42.9, average 41.4 (n= 6)
unsexed: range 41.0- 43.0, average 41.7 (n=14)
all combined: range 40.0- 43.0, average 41.4 (n=30)

12 Bill length including tube



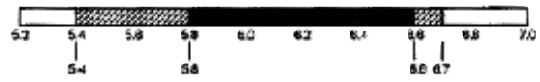
male: range 16.0- 17.6, average 16.8 (n=10)
female: range 15.6- 17.8, average 16.7 (n= 6)
unsexed: range 15.4- 18.7, average 16.8 (n=15)
all combined: range 15.4- 18.7, average 16.8 (n=31)

13 Bill length excluding tube



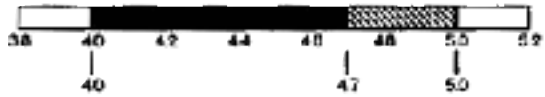
male: range 10.0- 10.7, average 10.2 (n=10)
female: range 9.5- 10.4, average 10.0 (n= 6)
unsexed: range 9.6- 10.7, average 10.2 (n=15)
all combined: range 9.0- 10.7, average 10.1 (n=31)

14 Bill height on tube



male: range 5.8- 6.6, average 6.2 (n=10)
female: range 5.4- 6.7, average 6.2 (n= 6)
unsexed: range 5.9- 7.0, average 6.5 (n=15)
all combined: range 5.4- 7.0, average 6.3 (n=31)

15 Bill height in front of tube



male: range 4.0- 5.0, average 4.5 (n=10)
female: range 4.0- 4.7, average 4.4 (n= 6)
unsexed: range 4.1- 5.3, average 4.6 (n=15)
all combined: range 4.0- 5.3, average 4.5 (n=31)

16 TESTES RIGHT:
male: range 1.5 x 0.8- 3 x 1.1 (n=11)

17 OVARIUM
female:range 2.2 x 2.2- 5.0 x 2.4 (n=5)

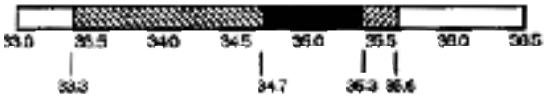
18 HUMERUS

male: range 35.0- 36.5, average 35.8 (n=10)
female: range 36.0- 36.8, average 36.4 (n= 6)
unsexed: range 34.6- 38.4, average 36.8 (n=15)
all combined: range 34.6- 38.4, average 36.4 (n=31)

19 ULNA

male: range 34.1- 37.6, average 35.7 (n=10)
female: range 36.0- 36.6, average 36.3 (n= 6)
unsexed: range 35.0- 39.6, average 36.6 (n=16)
all combined:range 34.1- 39.6, average 36.2 (n=32)

20 RADIUS

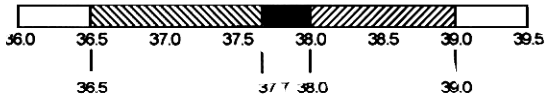


male: range 33.3- 35.3, average 34.2 (n=10)
female: range 34.7- 35.6, average 35.1 (n= 6)
unsexed: range 34.0- 38.7, average 35.5 (n=16)
all combined: range 33.3- 38.7, average 35.0 (n=32)

21 FEMUR

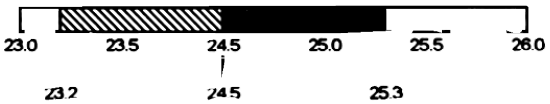
male: range 15.2- 16.2, average 15.8 (n=10)
female: range 15.6- 16.4, average 16.1 (n= 5)
unsexed: range 15.6- 16.9, average 16.3 (n=16)
all combined: range 15.2- 16.9, average 16.1 (n=31)

22 TIBIA



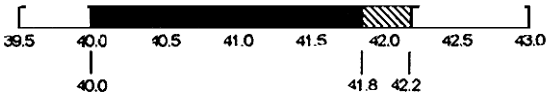
male:range 36.5- 38.0, average 37.4 (n=10)
female: range 37.7- 39.0, average 38.3 (n= 6)
unsexed: range 37.1- 40.1, average 38.5 (n=16)
all combined: range 36.5- 40.1, average 38.1 (n=32)

23 TARSUS



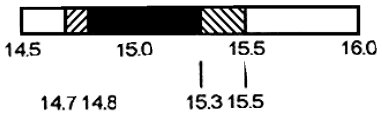
male: range 23.2- 25.3, average 24.4 (n=10)
female: range 24.5- 25.3, average 24.9 (n= 6)
unsexed: range 23.9- 26.2, average 25.1 (n=16)
all combined: range 23.2- 26.2, average 24.8 (n=32)

24 SKULL LENGTH



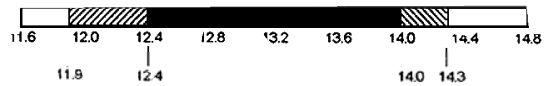
male: range 40.0- 42.2, average 41.3 (n=10)
female: range 40.0- 41.8, average 40.8 (n= 6)
unsexed: range 40.1- 43.0, average 42.0 (n=15)
all combined: range 40.0- 43.0, average 41.5 (n=31)

25 POSTORBITAL PROCESS BREADTH



male: range 14.8- 15.5, average 15.1 (n=10)
female: range 14.7- 15.3, average 15.0 (n= 6)
unsexed: range 14.3- 15.6, average 15.2 (n=16)
all combined: range 14.3- 15.6, average 15.2 (n=32)

26 LACRIMAL BREADTH



male: range 12.4- 14.3, average 13.2 (n=10)
female: range 11.9- 14.0, average 13.3 (n= 6)
unsexed: range 12.5- 14.4, average 13.4 (n=13)
all combined: range 11.9- 14.4, average 13.3 (n=29)

CONCLUSIONS AND DISCUSSION

A wreck?

The cause of death could not be explained after the post mortem examination. Some of the birds had oil on their feathers. It is unclear whether this occurred after death or that the birds came into contact with the oil while they were still alive. Possibly a sudden change in weather conditions, especially strong onshore wind, caused this massive occurrence of dead storm-petrels on the southern shores of Portugal. Leach's storm-petrel are, however, known to be excellent bad weather fliers, so weather conditions must have been extremely bad. The carcasses could have been pushed on the beach just by strong, onshore wind as was argued by Granadeiro & de Silva (1993) in an earlier case of large numbers of storm-petrels on the Portugese coast. In that case, what were possibly 'normal' casualties appeared to be an unusual situation caused by weather conditions that favoured the dead storm-petrels to be washed ashore.

It was not till J.P. Granadeiro (pers. comm. February 1997) reported a similar case of a relatively large number (32) of Leach's storm-petrels found in southern Portugal in the winter of 1996/1997, that it was clear that there had been a real wreck in that period.

Starting from the 36 specimens on 3600m of beach found during this study (1 petrel/100 m), a rough calculation shows that between Lagos in the west and Faro in the east on 36 km of sany beach about 360 petrels could, theoretically, be found. When add to this figure the number of petrels that were covered by the sand, that were consumed by predators, and the petrels that did not wash ashore anyhow (Keijl & Camphuysen 1992), between 1000 and 9000 Leach's storm-petrels, including a few Madeiran storm-petrels, were involved in the wreck off the coast of the Algarve. The accuracy of this estimate depends on the acceptance of the percentage of birds that actually wash ashore. Drifting experiments with other bird species demonstrated that this percentage could be between 0% and 59% (Keijl & Camphuysen 1992). Unfortunately, the sandy beaches east of Faro were not examined. This probably would have increased the estimated number of dead Leach's storm-petrels greatly. Anyhow, in conclusion, the unusual number of dead storm-petrels along the southern Portugese coast can safely be called a 'wreck'.

Cramp & Simmons (1977) described two wrecks of Leach's storm-petrels on European coasts within the past 100 years. Both were mainly in Great Britain and Ireland, but also further southwards. The first took place in 1891, between September 26 and October 10, and the second in 1952, between October 31 and November. The only known wreck of Leach's storm-petrels on the Portugese coast dates back to 1983 (Teixeira 1987).

Additional observations in Morocco

In the same period, Marc van Leeuwen (pers. comm. July 1997) came across dead Leach's storm-petrels on two beaches in Morocco. He was there from the end of January till the end of March 1997 and noticed the first remains on 22 January 1997: a Leach's storm-petrel lay upstream along the mouth of a river that enters the ocean near Larach (35°.15'N - 06°.14'W.). In total, a stretch of 1000m of beach was searched here. The two, already decayed, specimens were collected. On the beach south of Moulay Bousselham (34°.55'N- 06°.20'W), Marc van Leeuwen found remains of at least 10 specimens between 10 and 30 March, on a stretch of two kilometres that was regularly examined. The total number of Leach's storm-petrels found was 12 on 3000 m of beach (1 petrel / 250m beach). In each case, the specimens were completely dried out so it is most likely that the 'Moroccan wreck' happened more than a month before the specimens were found, probably in the period of the wreck in Portugal. Reports of unusually large numbers

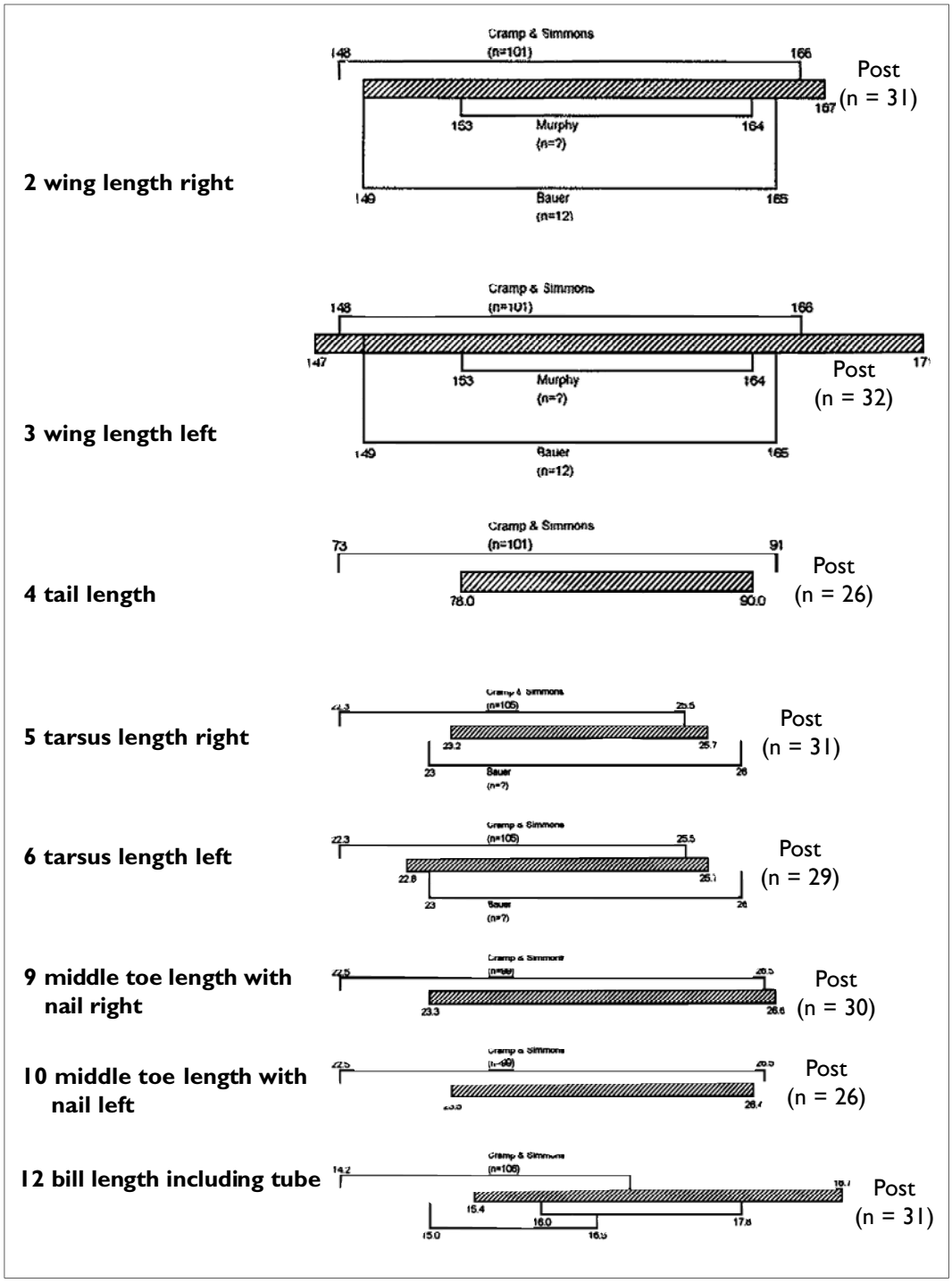


Figure 5 External measurements (in mm) of the Leach's storm-petrels used in this study (shaded bars) compared with measurements listed by Cramp & Simmons (1977) [upper lines], Murphy (1936) [middle lines], and Bauer & Glutz (1966) [lower lines]. Maximum ranges of all JNJP specimens (sexes combined) are given.

of Leach's storm-petrels along the north Atlantic coast of Morocco in late December 1996, including 1454 individuals flying northwest during 2.5 hours ['European News', British Birds 91(1998): 39] indicate that both wrecks are related to some large scale movements of storm-petrels on the border of European and African waters.

Biometry: external measurements

The values found for some measurements deviate from those reported in the literature (Murphy 1936; Bauer & Glutz von Blotzheim 1966; Cramp & Simmons 1977).This is shown in Figure 5. The wing length of specimens used in this study was 1 mm (right) and 5 mm (left) longer than the longest wing described in literature. The tail length fell completely within the range as described in the literature. This also goes for the tarsus length and the length of the middle toe (the insignificant deviation of the middle toe is 0.1 mm). The bill length was up to 0.9 mm longer than the lengths given in literature (Murphy 1936) (Fig. 5). Males and females show overlap in size of all the measurements. Indeed, Cramp & Simmons (1977), reported that biometrical differences between the sexes in *Oceanodroma leucorhoa* are not significant. This can be confirmed by this study. Concerning the discrimination of the sexes using biometrical data, some remarks have to be made. In general, males have a lesser total length, have shorter wings, have smaller tarsi, a shorter middle toe and a shorter head length than the females. The opposite applied to bill size (length with and without the tube and the height on as well as in front of the tube): bills are larger in the males than in the fe-males.

Biometry: skeleton and skull

In the literature no measurements of the skeleton and the skull of the Leach's storm-petrel were found. As far as we know, the measurements reported here (see above) are the first for the species. Their significance for sexing is briefly discussed here. The most suitable measurements for sexing are the humerus length, the length of the radius, the length of the femur and, especially, the tibia. However, in all cases, there is an overlap (sometimes small) between the sexes. The size of the ulna, tarsus and skull are not suitable for determining the sex: postorbital process breadth and lacrimal breadth are equally unsuitable. It is remarkable that the measurements of the female skulls (postorbital process breadth and lacrimal breadth) are on average smaller than those of the males. In all other measurements this is exactly the opposite.

Morphological notes

Six of 33 storm petrels (18.2%) showed foot abnormalities (Table 1). These range from missing of webs to amputated feet. In all cases, these were old injuries, the wounds had all completely healed (Fig. 4). The abnormalities could be caused by predatory fish as storm-petrels sometimes patter with their feet on the surface. Also during exavation of the nest, feet might get damaged.

Table 1 Description of abnormalities of the feet and toes of Leach's storm-petrels *Oceanodroma leucorhoa* collected in southern Portugal (see also Figure 4).

Abnormality	Collection number
- amputated half-way up the tarsus, left	1997.13
- middle toe left missing	1997.14
- amputation of the tarsus, left	1997.18
- amputation of one toe and web left	1997.20
- toes with webs missing left except for hind toe	1997.26
- right foot all distal phalanxes missing Left middle toe broken and healed incorrectly. Web mis-formed	1997.29

Notes on *Oceanodroma castro*

Special effort was made to find Madeiran storm-petrels, *Oceanodroma castro*, but only one male specimen was found on the beach of Praia de Falésia on 24 December 1996 (JNJP 1997.17). It was possible to identify this specimen by comparing the measurements with those of *Oceanodroma leucorhoa* (Table 2). Wing lengths shorter than 148 mm belonged to *O. castro*. The size of the wing of the specimen (both 146 mm) was within the range of the male of *O. castro* as given by Cramp & Simmons (1977). A tarsus length shorter than 23.0 mm should belong to a male *O. castro* (right tarsus 22.0 mm; left tarsus 21.6 mm). A bill length shorter than 15.5 mm should belong to a male *O. castro* (bill length was 14.3 mm). The middle toe length with claw resulted in an insignificant difference with *O. leucorhoa*.

Possible confusion with the storm petrel *Hydrobates pelagicus* could also be eliminated. This species is significantly smaller than *O. leucorhoa* and *O. castro*. Three other species of storm-petrel were examined because of possible confusion: Wilson's storm-petrel *Oceanites oceanicus*, white-faced storm-petrel *Pelagodroma marina*, and Swinhoe's storm-petrel *Oceanodroma monorhis*. Biometrically, these species differ significantly from *Oceanodroma castro*. The only confusing element can be an exceptionally small specimen of *O. leucorhoa*. Based on the measurements listed in Table 2, this possiblity can be regarded as highly unlikely.

Table 2 Biometrical data of a male specimen of the Madeiran storm-petrel *Oceanodroma castro* collected on the beach of Praia de Falésia, Algarve, Portugal on 24 December 1996 (JNJP 1997.17), compared with data of *O. castro* from BWP (Cramp & Simmons 1977) and the averages from the 35 *Oceanodroma leucorhoa* as given in this study [* indicates that left and right sides are not separately measured]

biometrical character	JNJP 1997.17	BWP	*O. leu*
Total length	--		
Wing length right	146.0	148*	153.4
Wing length left	146.0	148*	155.2
Tail length	--		
Tarsus length right	22.0	22.2*	23.9
Tarsus length left	21.6	22.2*	23.8
Middle toe without claw right	18.4		19.6
Middle toe without claw left	17.8		19.6
Middle toe with claw right	23.7	21.9*	24.7
Middle toe with claw left	23.2	21.9*	24.7
Head length	40.0		41.0
Bill length including tube	14.3		16.8
Bill length excluding tube	9.0		10.2
Bill height on the tube	6.0		6.2
Bill height before the tube	4.3		4.5
Skull length	39.6		41.3
Postorbital process breadth	14.9		15.1
Lacrimal Breadth	--		
Femur	15.3		15.8
Tibia	34.6		37.4
Tarsus (bone)	22.0		24.4
Humerus	35.1		35.8
Ulna	34.0		35.7
Radius	32.5		34.2

ACKNOWLEDGEMENTS

I would like to thank my travelling companions, Marja, Linda en Karin Post for their carefulness during the collection trips to the different beaches of southern Portugal. I would also like to thank Erwin Kompanje (Natuurmuseum Rotterdam) for critically reading the manuscript and for his help with measuring the skeletal material. Thank is also owed to Marc van Leeuwen (Foundation for Spoonbill Research Nederland), who supplied supplemental data on a wreck of the Leach's storm-petrel in Morocco. Finally, Susan Vermeulen, Rotterdam, for taking care of the DTP work on the various figures and Gayle Hoffman, in Delft, for the English translation of the manuscript. J.P. Granadeiro kindly supplied additional data on the wreck.

REFERENCES

Bauer, K.M. & Glutz von Blotzheim, U.N., 1966 - Handbuch der Vögel Mitteleuropas Band 1 Gaviiformes bis Phoenicopteriformes -Akademische Verlaggesellschaft, Frankfurt am Main

Cramp, S. & Simmons, K.E.L., (eds.) 1977 - Handbook of the Birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic Vol. 1 Ostrich to Ducks - Oxford University Press, Oxford

Granadeiro, J.P. & Silva, M.A., 1992 - Beached Bird Surveys in Portugal 1990/91- Sula 6(1): 22-27

Granadeiro, J.P. & Silva, M.A., 1993 - Beached Bird Surveys in Portugal 1991/92 - Sula 7(1): 1-8

Harrison, P., 1985 - Seabirds, an identification guide - Croom Helm, London & Sydney

Harrison, P., 1987 - Seabirds of the world, a photographic guide - Christopher Helm, London

Keijl, G.O., & Camphuysen, C.J., 1992 - Results of a corpse drift experiment off the Netherlands' coast, February 1991- Sula 6(2): 41-50

Murphy, R.C., 1936 - Oceanic Birds of South America Bd. 2 - Am. Mus. Nat. Hist., New York: 734-738

Teixeira, A., 1987 - The wreck of Leach's storm petrels on the Portugese coast in Autumn of 1983 - Ringing & migration, 8: 27-28

received 25 August1997
revised 17 February 1998
accepted 24 February 1998

DEINSEA - ANNUAL OF THE NATURAL HISTORY MUSEUM ROTTERDAM
P.O.Box 23452, NL-3001 KL Rotterdam The Netherlands