

THE HOMING BEHAVIOUR OF CORY'S SHEARWATERS (*CALONECTRIS DIOMEDEA*) STUDIED BY MEANS OF A DIRECTION RECORDER

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Summary

A direction recorder, which can be carried by a flying bird on its back, has been used for the first time on a wild species. The device can detect and record the direction in which a bird is heading during flight. Cory's shearwaters (*Calonectris diomedea*) were moved from their nesting colony to five different sites and fitted with direction recorders, and four homing flight paths were obtained.

Our data show that the displaced birds were able to

assume and maintain a homeward course soon after release over large areas of open sea, completely devoid of guiding features; topographical elements are, therefore, not necessary for correct orientation.

Key words: Cory's shearwater, *Calonectris diomedea*, homing, direction recorder, data-logger.

Introduction

A few years ago, Bramanti *et al.* (1988) developed a device which, when transported by a bird on its back, allows the reconstruction of the route followed during flight. This instrument was specifically devised to provide additional information on the homing strategies of pigeons, which cannot be obtained using traditional methods (Papi *et al.* 1991).

Experiments have recently been carried out in an attempt to extend the use of the direction recorder to a wild bird: the Cory's shearwater (*Calonectris diomedea*). This bird species was chosen for its excellent homing ability and the site tenacity shown by the results of previous investigations (Matthews, 1953; Kenyon and Rice, 1958; Massa *et al.* 1991); moreover, Cory's shearwaters can be easily captured and subsequently recovered in their nest burrows after experimental manipulations. This is an important prerequisite for this kind of study because the direction recorder is a data-logger and not a transmitter; thus, the experimenter needs to recover it to obtain the data stored in its memory.

Materials and methods

Experimental animals

The 11 Cory's shearwaters (*Calonectris d. diomedea* Scopoli) used in our experiments were captured on the islet of Linosa in the Mediterranean Sea (Pelagian Isles: 35°52' N,

12°52' E, 5.4 km²), where a breeding colony of 10 000 or more pairs was surveyed by Massa and Lo Valvo (1986). Our manipulation of the birds did not affect their breeding success, given that our tests were carried out with shearwaters which were not incubating a true egg but a chalk one (Benvenuti *et al.* 1993). Indeed, local people, following an illegal tradition, collect eggs from the shearwaters' nests. This regrettable practise does not prevent the birds from remaining faithful to the empty nest for 15–30 days, as we observed several times. However, we strengthened their nest fidelity by providing them with chalk eggs, in size and shape similar to the natural ones. The birds were captured early in the morning by pulling them out of their nest burrows and placing them in individual cloth bags.

The direction recorder

The device utilised in these releases is the one described by Dall'Antonia *et al.* (1992). This recent model can memorize 32×10^3 samples and it therefore allows about 6 days of recording at a sampling interval of 16 s. The direction recorder, including the materials for protection and waterproofing of the tag components, measured 87 mm × 24 mm × 15 mm and weighed 29 g. Since the mean masses of the Cory's shearwater of Linosa are 607 g for females and 734 g for males (Massa and Lo Valvo, 1986), the device represented less than 5% of the

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mean body mass of the bird, as widely recommended by many authors (Cochran, 1980; Nowak and Berthold, 1991).

In the present experiments, the periods between successive recordings of the orientation of the main axis of the birds' body with respect to magnetic North were 8 s for releases 1 and 4, and 16 s for releases 2, 3 and 5.

In order to distinguish between data recorded during flight and those recorded during the time when the birds were resting over the water, we used a seawater-sensitive recorder. It consisted of two electric wires which had one end connected to the direction recorder and the other glued to the feathers of the bird's abdomen. At this end, the two electric wires constituted a pair of electrodes which, when the Cory's shearwater was resting on the sea, were plunged into the water; during this period, the liquid shorted the two electrodes and hence closed a loop in the circuit which gave the same value (zero) at each recording interval.

Experimental protocol

To calculate the effect of wind drift in the reconstruction of the bird's flight paths, we used data on wind direction and strength (collected every hour) from five weather stations in Sicily, supplied by Servizio Meteorologico dell'Aeronautica Italiana.

In order to reconstruct the birds' routes, a flight speed of 30 km h^{-1} was assumed; this is comparable to the minimum power speed (the flight speed at which energy is used most slowly) estimated by Massa and Lo Valvo (1986) to be approximately 27 km h^{-1} for Cory's shearwaters from Pennycuik (1969). For the flight paths of releases 1, 2, 3 and 4, graph rotations of 10.2° , 8.7° , 3.8° and 3.1° , respectively, were necessary to eliminate the difference between the arrival point of the bird resulting from the reconstructed route and the real home (see Bramanti *et al.* 1988).

The experiments were carried out in June 1992 and 1993. All the release sites were reached by ferry and by car within 16 h of the capture of the birds. The Cory's shearwaters were released on the sea shore or (release 4) from the boat. The releases took place in the morning (site 1: four birds), in the early afternoon (site 4: two birds), 2 h before sunset (site 2: two birds) and at sunset (sites 3 and 5: two birds and one bird, respectively). Fig. 1 shows the positions of the five release sites; home distances and directions for sites 1–4 are reported in Table 1.

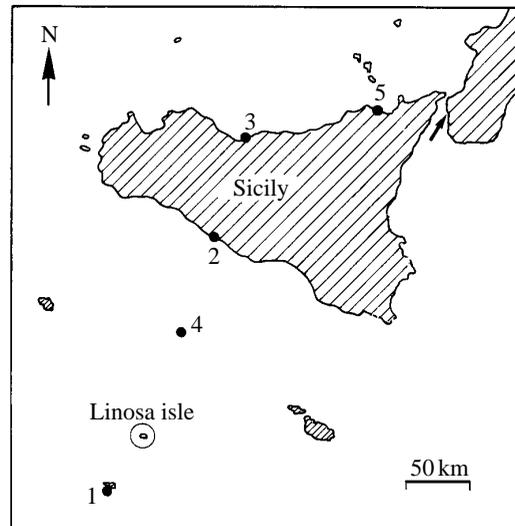


Fig. 1. Map of Sicily and surrounding areas. Each dot (with the nearby number) represents one release site. The arrow indicates the place where the Cory's shearwater released from site 5 was recovered. The islet of Linosa (where the nesting colony is situated) is surrounded by a circle.

Results

Four complete routes, out of 11 birds, were reconstructed (one for each release site, excluding site 5). Fig. 2 shows each homing flight in detail and Table 1 gives numerical data relevant to the four releases.

In all the experiments, Cory's shearwaters showed a tendency to stop over the sea some minutes after the release; when the releases are performed from land, they fly offshore in a course almost perpendicular to the coastline for a short time (Fig. 2A,B,C). At releases 1, 2 and 4 (Fig. 2A,B,D), the birds followed a fairly direct course towards home and they were correctly oriented towards the nesting colony soon after release. This was not the case for release 3 (Fig. 2C), where Sicily was interposed between the release site and Linosa. The reconstructed paths show that the birds travelled both during the day and at night, and that they often alternated long flights with periods characterised by short flights and frequent stops over the sea. The birds used in releases 1 and 4 (Fig. 2A,D) reached their nests during the night soon after the release, and

Table 1. Table showing distance, direction and information on flight data relevant to the homing routes of four Cory's shearwaters

Release site	Home distance (km)	Home direction (degrees)	Homing time (min)	Flight time (min)	Landing time (min)	Landing number	Flight length (km)
1	46	028	796	307	489	24	123.0
2	168	202	3345	669	2676	9	358.6
3	248	204	3116	1236	1880	21	801.4
4	Approx. 80	200	471	307	164	9	201.9

The direction recorder used in the fifth release did not provide data for analysis, and the bird that carried it did not home, but was recovered in the Strait of Messina (see Fig. 1 and text).

those of releases 2 and 3 during the night of the second day after release (Cory's shearwaters are strictly nocturnal in their activity at the breeding colony; see Benvenuti *et al.* 1993).

Of the seven birds whose flight paths had not been obtained, in some cases the direction recorders did not work correctly, while in other cases the birds failed to return home or returned many days after the release, so that the reconstruction of the homing flights was impossible. One bird released from site 5 did not reach home but was recovered some days later in the Straits of Messina (see Fig. 1).

Discussion

It is unfortunate that these homing experiments provided information on only four routes; in spite of this limitation, the results yielded so far show interesting aspects of the homing behaviour of Cory's shearwaters that have not been assessed in previous investigations (Massa *et al.* 1991).

The main feature of our results is that the direction of the birds' routes appears to be homeward-oriented soon after release, showing that the homing process, within distances of 50–300 km from the breeding colony, is not based on a random search for familiar landmarks, but on an efficient method in which the geographical position of the release site is assessed with respect to the goal. Large deviations from the homeward route, for example in release 3 (Fig. 2C) and release 5, appear to be the expression of a strategy intended to enable the birds to circumnavigate large land masses interposing between the release site and the home colony (shearwaters are strictly marine birds, except when at the breeding colony). It is worthwhile noting that the two birds that circumnavigated Sicily (experiments 3 and 5; see Figs 1, 2C) chose the shortest way, westward and eastward, respectively, for each to get around this land mass. Future studies will investigate whether this was by pure chance, or if it represents a strategy aimed at minimizing the length of the trip.

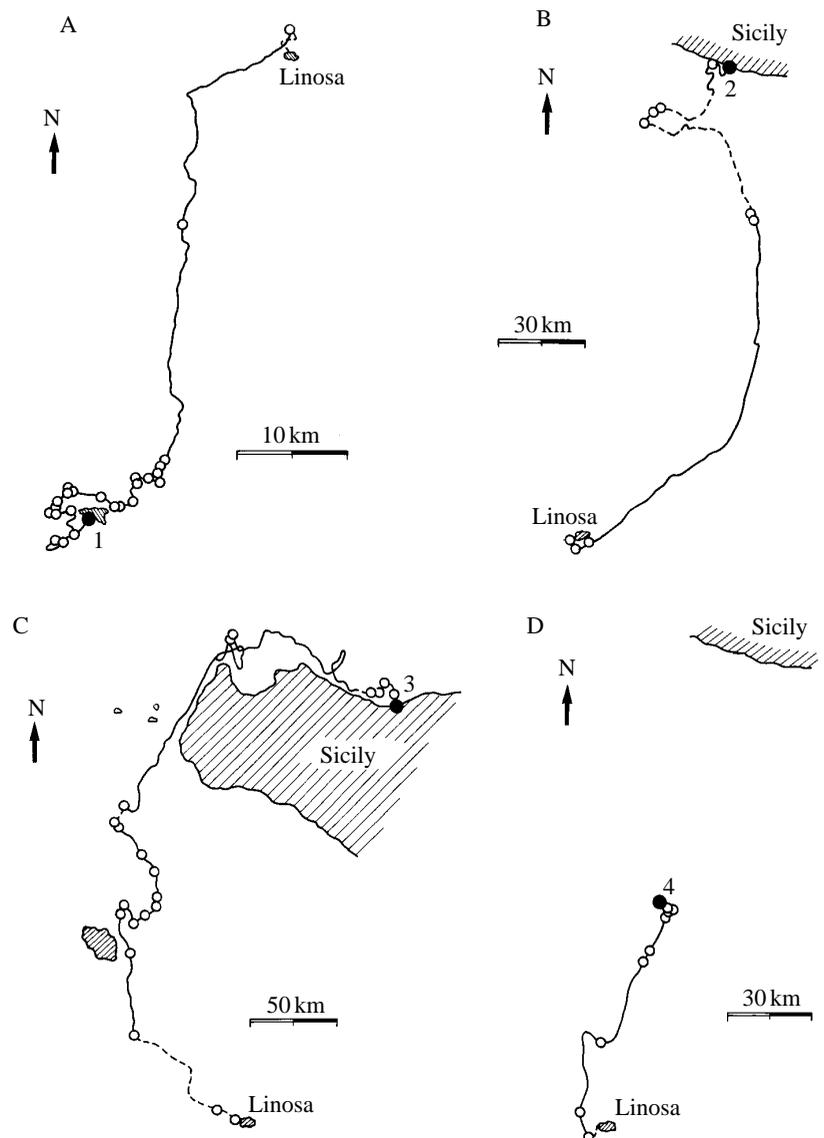


Fig. 2. Flight-path reconstructions of released birds. Each panel is for a different bird. The filled dots represent the release sites and each open dot indicates a bird alighting onto the sea surface. The solid line represents the route flown during the day and the dashed line the one flown during the night. (A) Flight-path reconstruction of release 1. (B) Flight-path reconstruction of release 2. (C) Flight-path reconstruction of release 3. (D) Flight-path reconstruction of release 4.

With regard to the mechanism of orientation, we cannot exclude the possibility that our releases were carried out in familiar areas, i.e. within the normal range of feeding activity; thus, the direction of the goal could have been assessed on the basis of a piloting mechanism guided by familiar landmarks (land masses) when available. However, one bird flew straight home from release site 4 (Fig. 2D: route 4), where land masses were not visible to the human eye and so, presumably, were not visible to the shearwaters either, given that these birds tend to fly close to the sea surface (both Linosa and Sicily were about 80 km from the release site; see Fig. 2D). In addition, the experimental birds were able to maintain constant homeward courses over large areas of open sea, completely devoid of guiding features. This ability, which was exhibited both during the day and at night, is interesting for its obvious implications for orientation mechanisms. This investigation, however, was neither aimed at nor suited to the investigation of possible compass mechanisms (see Massa *et al.* 1991).

Analysis of the birds' routes reveals that homing shearwaters alternate long flights with periods characterized by short flights and frequent stops on the sea surface. Our data do not allow us to verify whether short flights and frequent stops were associated with feeding activity or were induced by unfavourable winds or by the absence of wind, as reported by Jouventin and Weimerskirch (1990) for wandering albatrosses. Frequent stops could also be the result of non-specific disturbances caused by the weight or shape of the instrument carried on the birds' back; although this disturbance would have only influenced the time length of the trip, not the mechanism of orientation.

Our results show that the direction recorder can be used profitably in investigations on the homing strategies of wild bird species. The use of this effective instrument could be extended to other aspects of the biology of Cory's shearwaters, such as identification of foraging sites, and also to other birds.

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