Bird Study (2013) **60**, 270–274
http://dx.doi.org/10.1080/00063657.2013.778226

SHORT REPORT

Satellite tracking of Bulwer's Petrels *Bulweria bulwerii* in the Canary Islands

BENEHARO RODRÍGUEZ[1]*, JUAN BÉCARES[1], JUAN MANUEL MARTÍNEZ[1], AIRAM RODRÍGUEZ[2], ASUNCIÓN RUIZ[1] and JOSÉ MANUEL ARCOS[1]
[1]*SEO/BirdLife, C/ Libertad no. 22 (Pueblo Sabanda), 38296 La Laguna, Tenerife, Canary Islands, Spain;*
[2]*Department of Evolutionary Ecology, Estación Biológica de Doñana (CSIC), Avda. Américo Vespucio s/n, 41092 Seville, Spain*

Capsule The breeding foraging and post-breeding dispersal movements of five satellite-tagged Bulwer's Petrels from the Canary Islands were recorded. Foraging trips lasted 5.6 days in average ($n = 3$), while the mean distance covered was 1261 km, and foraging areas were located over the continental slope and the adjacent pelagic waters, around 1200–2000 m depth and up to 350 km from the colony. After the chick-rearing period, birds dispersed southwestwards to the tropical waters of the central Atlantic.

The continued improvement and deployment of remote tracking systems has revolutionized the understanding of the distribution patterns and at sea behaviour of several pelagic seabird species over the last two decades (Burger & Shaffer 2008). These improvements have been key for the conservation of Procellariiforms at sea, e.g. by contributing to the identification of hotspots that could be designated as Marine Protected Areas (MPAs) (BirdLife International 2004, Ropert-Coudert & Wilson 2005, Phillips *et al.* 2007). However, the weight of the devices has constrained their use to medium–large species (Phillips, Xavier & Croxall 2003).

Here, we present novel data for one of the smallest seabird species ever tracked using satellite devices (Platform Terminal Transmitters, PTT), the Bulwer's Petrel *Bulweria bulwerii*. This is a tropical and subtropical Procellariiform that breeds in the Atlantic and the Pacific oceans. In the Canary Islands, its breeding population is mainly localized to small marine rocks and inaccessible seacliffs (Arcos *et al.* 2009). The limited existing evidence suggests that the population has declined over the last few decades (Rodríguez, Rodríguez & Lucas 2012). Reasons for this presumed decline include threats at the breeding grounds, particularly predation by introduced mammals and attraction to artificial lights (Madroño, González & Atienza 2004). Threats at sea could also play a role, but studies on the species' behaviour and ecology at sea are scarce (Mougin & Mougin 2000), with only isolated observations (van Oordt & Kruijt 1953, Bourne 1995), or indirect information such as dietary data (Zonfrillo 1986, Martín & Lorenzo 2001, Cheng, Spear & Ainley *et al.* 2010).

We tracked five adult Bulwer's Petrels from Alegranza (29°29′N–13°29′W), an inhabited islet off N Lanzarote, Canary Islands (Fig. 1), where over 150 pairs breed (Rodríguez *et al.* 2003). Tagging was conducted in mid–late August 2010, coinciding with the latest stages of the breeding period, as fledglings start leaving the nest from the first fortnight of September onwards (Martín & Lorenzo 2001). Birds were captured by hand at their nests, whenever possible after delivering food to their chicks, and then ringed, weighed and PTT-tagged. We used ~5 g solar-powered PTTs (Microwave Telemetry, Inc.) fitted to the back feathers of the birds using TESA tape (Wilson *et al.* 2002). The weight of the birds ranged from 85 to 100 g, which means that the devices (including the tape) represented about 6% of the body mass, slightly passing the maximum recommended limit of 3–5% of the total bird mass (Wilson *et al.* 2002, Phillips *et al.* 2003). This implies that slight detrimental effects could not be ruled out, although the PTTs were attached to the back feathers, and using as few feathers as possible, thus ensuring that they would be lost in a relatively short period. In addition, tagging was conducted when chicks were almost ready to fledge, to reduce the risk of breeding failure.

*Correspondence author. Email: benerguez@terra.es

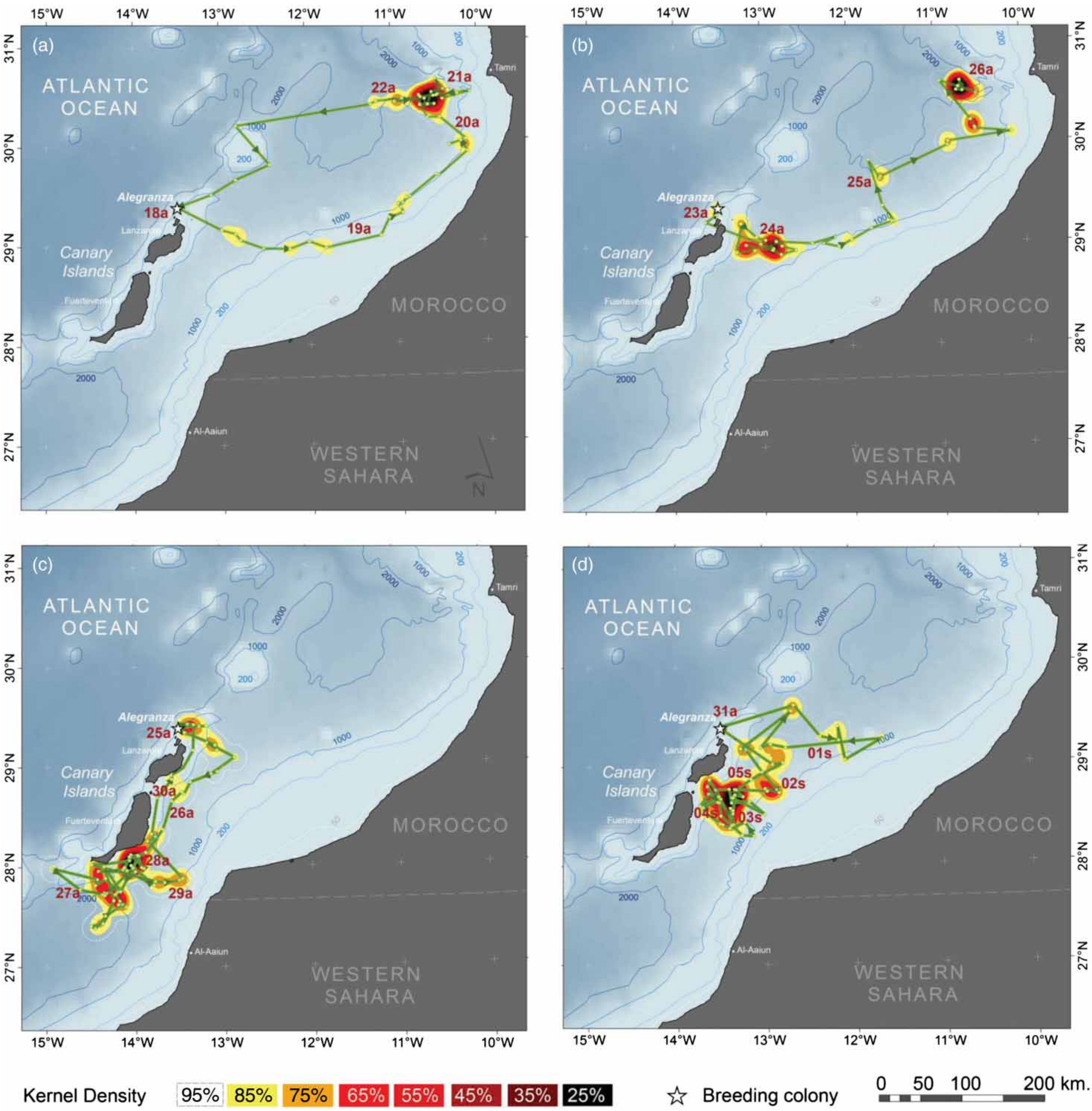

Figure 1. Foraging trips (green lines) of two Bulwer's Petrels *Bulweria bulwerii* from Alegranza, Canary Islands, tracked by satellite. Kernel density distribution maps are shown encompassing 25–85% of the locations. Dates are also shown (day number plus first letter of month, a = August, s = September). **a** and **b** = first and second trip of bird 2 (second trip is incomplete). **c** and **d** = first and second trip of bird 3.

Geographical locations of petrels were downloaded from the ARGOS website (http://www.argos-system.org). In a first step we retained all locations (LC 3, 2, 1, 0, A, B), and later these were filtered to remove incorrect or impossible positions. For every pair of subsequent locations we removed the lowest quality one when speed between them was greater than 100 km/h, and positions over land were also removed. We assigned all filtered locations to two stages: breeding (foraging trips during the chick-rearing period) and post-breeding dispersal (migratory movements just after the chick-rearing period). For each foraging trip, we calculated the duration, total distance covered and maximum distance from the

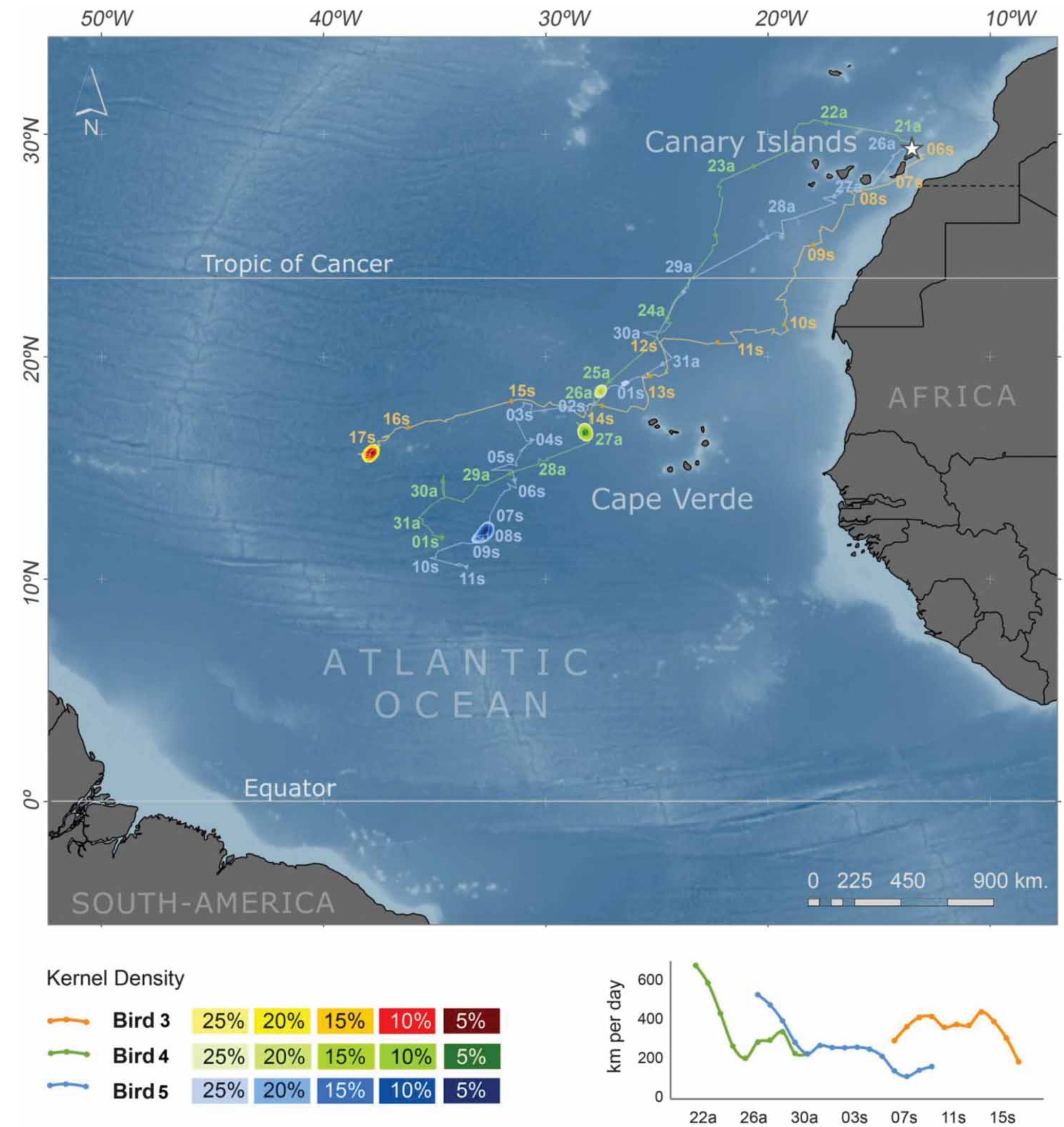

Figure 2. Satellite tracks of three Bulwer's Petrels *Bulweria bulwerii* (birds 3, 4 and 5) from Alegranza, Canary Islands, during their post-breeding dispersal, plus kernel density distributions once they reached presumed winter foraging areas. The tracking dates (day number plus first letter of month, a = August, s = September) and the daily speed (moving average over 3 days) are also reported.

colony. For dispersal movements, we estimated the distance covered per day, as well as the speed.

We also built Kernel density distribution maps (Animal Movement extension of ArcView 3.2) to identify the most used areas by the petrels on each trip. As the number of PTT locations per day was variable (from 5 to 20 per day in our case), we randomly selected a number of locations matching the minimum daily value obtained during that trip to build equally representative range kernels. We arbitrarily used a smoothing factor of $h = 0.1$, and selected the 50% kernel as an indicator of the main foraging areas (BirdLife International 2010). Then, we calculated the mean values of water depth obtained from ETOPO1 (NGDC & NOAA 2009), and distance to the colony and to the nearest coast, averaging the locations included within each individual trip's kernel.

The five birds tagged provided 631 locations. One (bird 1) stopped transmitting a few hours after the PTT deployment (with only 6 locations), and was not considered in the analyses. The remaining birds transmitted for a period of 9–24 days, and provided both foraging trips (birds 2 and 3) and post-breeding dispersal movements (birds 3, 4 and 5). Of the two birds conducting breeding foraging trips, three complete and one incomplete trips were reconstructed (Fig. 1). The completed trips lasted 4.9 days in the case of bird 2, and 6.1 and 6.0 days in the case of bird 3. Total foraging trip length was quite consistent between birds and trips, ranging from 1168 to 1364 km (mean = 1261 km, $n = 3$). Maximum distance from the colony was greater than 200 km in both birds monitored, reaching over 350 km. Foraging areas were located over the continental slope and the adjacent pelagic waters, with average depths of 1200–2000 m. However, the two birds monitored visited different areas (Fig. 1). Bird 2 moved northeastwards to feed in waters off the African continental slope, near Tamri (Morocco) for both foraging trips. Bird 3 flew southwards to forage off Fuerteventura–Lanzarote (E Canary Islands) in both trips, the same area visited by bird 1 during its short transmitting period. Three PTTs (birds 3, 4 and 5) provided data corresponding to the beginning of the post-breeding dispersal (Fig. 2). Birds 4 and 5 left the colony short after being fitted with the PTTs, while bird 3 first performed two foraging trips (12 days) and then left the colony. The post-breeding routes were quite similar, all birds flying southwestwards to reach tropical waters (10–20° N) in the Central Atlantic Ocean (Fig. 2). Birds moved fast until they reached the mid-Atlantic tropical waters, at over 2000 km from the colony, when post-breeding movements were alternated with apparently foraging activities (Fig. 2). These 'stopover' areas had depths greater than 5000 m.

Our data on foraging grounds roughly coincide with boat-based observations around the Canary Islands during the breeding season, and habitat models based on them, which showed a scattered distribution over pelagic waters, with preference for areas near the shelf slope (Arcos *et al.* 2009). This is also in agreement with the indirect information provided by Bulwer's Petrel diet, as it is primarily composed of vertically migrating mesopelagic fish, cephalopods and crustaceans, which are characteristic of these marine habitats (Zonfrillo 1986, Neves, Nolf & Clarke 2011).

Specific foraging areas differed between the two individuals conducting breeding trips, but showed similar features. The Lanzarote-Fuerteventura area used by bird 3 (Fig. 1c,d) was one of the three main foraging grounds identified by habitat models within the Canary Islands (Arcos *et al.* 2009), while the African shelf (were bird 2 foraged) was beyond the scope of that habitat model study. Further research is necessary to assess the relevance of other areas with similar habitat features around the Canary Islands and nearby waters, and to assess individual fidelity to the foraging grounds.

Data gathered on post-breeding movements are also interesting and apparently representative as the three birds performing migration trips used the same routes to the Central Atlantic Ocean. The speed of the birds slowed down shortly before the signal was lost (Fig. 2), thus indicating that their wintering areas may have been reached. This is in agreement with the idea that the Macaronesian population of Bulwer's Petrel might winter in a huge area in the Central Atlantic between 20°N and 10°S (Flood & Fisher 2011).

ACKNOWLEDGEMENTS

We thank to Laura Gangoso, Walo Moreno and Manolo Moreno for their collaboration and support making our stay very comfortable in the uninhabited Alegranza, to the personnel of the Cabildo de Lanzarote for their permission, and to the crew of the *César Manrique* for helping us during the trips from Alegranza to Lanzarote. Two anonymous referees and the editor Will Cresswell provided useful comments and suggestions that greatly improved the manuscript. This study was conducted by SEO/BirdLife within the frame of EC funded project LIFE+ INDEMARES (LIFE07NAT/E/000732).

REFERENCES

Arcos, J.M., Bécares, J., Rodríguez, B. & Ruiz, A. 2009. *Áreas Importantes para la Conservación de las Aves Marinas en España*. SEO/BirdLife, Madrid.

BirdLife International. 2004. Results from the Global Procellariiform Tracking Workshop, 1–5 September, 2003. Gordon's Bay, South Africa. *Tracking Ocean Wanderers: The Global Distribution of Albatrosses and Petrels*. BirdLife International, Cambridge.

BirdLife International. 2010. *Marine Important Bird Areas Toolkit: Standardized Techniques for Identifying Priority Sites for the*

Conservation of Seabirds at Sea. BirdLife International, Cambridge. Available at: http://www.birdlife.org/eu/pdfs/Marinetoolkitnew.pdf.

Bourne, W.R.P. 1995. The movements of Bulwer's Petrel and the larger shearwaters in the Atlantic Ocean. *Sea Swallow* **44:** 49–52.

Burger, A.E. & Shaffer, S.A. 2008. Application of tracking and data-logging technology in research and conservation of seabirds. *Auk* **125:** 253–264.

Cheng, L., Spear, L.B. & Ainley, D.G. 2010. Importance of marine insects (Heteroptera: Gerridae, *Halobates* spp.) as prey of eastern tropical Pacific seabirds. *Mar. Ornithol.* **38:** 91–95.

Flood, B. & Fisher, A. 2011. *Multimedia Identification Guide to North Atlantic Seabirds. Storm-petrels & Bulwer's Petrel*. R. Booth Ltd, Cornwall.

Madroño, A., González, C. & Atienza, J.C. (eds). 2004. *Libro Rojo de las Aves de España*. Dirección General para la Biodiversidad-SEO/BirdLife, Madrid.

Martín, A. & Lorenzo, J.A. 2001. *Aves del Archipiélago Canario*. Lemus Editor, La Laguna.

Mougin, J.-L. & Mougin, M.C. 2000. Maximum diving depths for feeding attained by Bulwer's petrels (*Bulweria bulwerii*) during the incubation period. *J. Zool.* **250:** 75–77.

NGDC & NOAA (National Geophysical Data Center & National Oceanic and Atmospheric Administration). 2009. *ETOPO1 Global Relieve Model Gridded 1-min Database*. Department of Commerce, Available at: http://www.ngdc.noaa.gov/mgg/global/relief/ETOPO1/ (accessed 15 September 2012).

Neves, V.C., Nolf, D. & Clarke, M.R. 2011. Diet of Bulwer's Petrel (*Bulweria bulwerii*) in the Azores, NE Atlantic. *Waterbirds* **34:** 357–362.

van Oordt, G.J. & Kruijt, J.P. 1953. On the pelagic distribution of some procellariiformes in the Atlantic and Southern Oceans. *Ibis* **95:** 615–637.

Phillips, R.A., Xavier, J.C. & Croxall, J.P. 2003. Effects of satellite transmitters on albatrosses and petrels. *Auk* **120:** 1082–1090.

Phillips, R.A., Croxall, J.P., Silk, J.R.D. & Briggs, D.R. 2007. Foraging ecology of albatrosses and petrels from South Georgia: two decades of insights from tracking technologies. *Aquat. Conserv.* **17:** S6–S21.

Ropert-Coudert, Y. & Wilson, R.P. 2005. Trends and perspectives in animal-attached remote sensing. *Front. Ecol. Environ.* **3:** 437–444.

Rodríguez, B., De León, L., Martín, A., Alonso, J. & Nogales, M. 2003. Status and distribution of breeding seabirds in the northern islets of Lanzarote (Canary Islands). *Atl. Seabirds* **5:** 41–56.

Rodríguez, A., Rodríguez, B. & Lucas, M.P. 2012. Trends in numbers of petrels attracted to artificial lights suggest population declines in Tenerife, Canary Islands. *Ibis* **154:** 167–172.

Wilson, R.P., Gremillet, D., Syder, J., Kierspel, M.A., Garthe, S., Weimerskirch, H., Schafer-Neth, C., Scolaro, J.A., Bost, C.A., Plotz, J. & Nel, D. 2002. Remote-sensing systems and seabirds: their use, abuse and potential for measuring marine environmental variables. *Mar. Ecol. Prog. Ser.* **228:** 241–261.

Zonfrillo, B. 1986. Diet of Bulwer's petrel *Bulweria bulwerii* in the Madeiran archipelago. *Ibis* **128:** 570–572.

(MS received 2 November 2012; revised MS accepted 11 February 2013)