USING GPS TRACKING TO DETERMINE MOVEMENT PATTERNS AND FORAGING HABITAT SELECTION OF THE COMMON BARN-OWL (*TYTO ALBA*)

Carolina Massa [1,3], Fabián M. Gabelli [2] and Gerardo R. Cueto [1]

[1] *Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires and IEGEBA (UBA–CONICET). Piso 4, Pabellón 2, Ciudad Universitaria, C1428EHA Buenos Aires, Argentina.*
[2] *Facultad de Psicología, Universidad de Buenos Aires. Hipólito Yrigoyen 3242, C1207ABQ Buenos Aires, Argentina.*
[3] *cmassa@ege.fcen.uba.ar*

Abstract.— For the first time a Common Barn-owl (*Tyto alba*) individual was tracked using a GPS technology to evaluate the use of a commercial and economic GPS pet tracker device, and to test GPS tracking as a technique for determining movement patterns and foraging habitat selection. A GPS pet tracker device was removed from its plastic frame and attached to the back of an adult male. The device recorded during eight consecutive nights a total of 12501 waypoints. The home range, estimated as the minimum convex polygon, was 1746 ha. Tracks obtained allowed the identification of three movement patterns that could be attributed to different behaviours: meandering, linear and point, corresponding to hunting, straight-lined flights and roosting, respectively. The overlap of tracks with a land cover map revealed that the owl selected vegetated areas (except where pigs were present) and barren areas with pigs for hunting. The use of this technique represents an improvement for behavioural studies of this species.

Key words: *Common Barn-owl, foraging habitat selection, GPS, movement patterns,* Tyto alba.

Resumen. Uso de GPS para la determinación de los patrones de movimiento y la selección de hábitat de alimentación de la Lechuza de Campanario (*Tyto alba*).— Se realizó por primera vez el seguimiento con GPS de un individuo de Lechuza de Campanario (*Tyto alba*) para evaluar el uso de un dispositivo de uso comercial económico diseñado para el seguimiento de mascotas y el uso del seguimiento con GPS como técnica para determinar los patrones de movimiento y la selección de hábitat de alimentación. El dispositivo original fue reacondicionado y colocado en un macho adulto. El dispositivo registró 12501 puntos georreferenciados durante ocho noches consecutivas. El área de acción, estimada a través del mínimo polígono convexo, fue de 1746 ha. Los recorridos obtenidos permitieron la identificación de tres patrones de movimiento que pueden ser atribuidos a diferentes comportamientos: tortuoso, lineal y puntual, correspondientes a caza, traslado y descanso, respectivamente. La superposición de los recorridos con un mapa de la cobertura de distintos usos de la tierra reveló que la lechuza seleccionó para cazar áreas con vegetación (excepto donde había ganado porcino) y áreas denudadas con ganado porcino. El uso de esta técnica representa un avance para los estudios comportamentales en esta especie.

Palabras clave: *GPS, Lechuza de campanario, patrones de movimiento, selección de hábitat de alimentación,* Tyto alba.

Received 12 December 2014, accepted 30 August 2015

The use of data loggers and tracking devices is allowing scientists to study time use, movement, behaviour and ecology of free living animals in more detail (Cagnacci et al. 2010). Due to technological innovations the size and weight of animal-attached devices are decreasing, and the use of this technology to measure geographical position, movements, physiological parameters and environmental variables is increasing (Tomkiewicz et al. 2010). The numerous comprehensive reviews that have recently been published show that the development of tracking and bio-logging devices is a fast moving field, catalysed by the necessity of biologists to learn more about their study systems as well as by the ongoing technological advances (Wikelski et al. 2007, Rutz and Hays 2009, Cagnacci et al. 2010, Robinson et al. 2010, Bridge et al. 2011, Guilford et al. 2011, Sokolov 2011, Bouten et al. 2013).

Many avian species were studied with GPS technology, especially large birds who live in colonies like seabirds (e.g., Burger and Shaffer 2008, McLeay et al. 2010, Votier et al. 2010, Tew Kai et al. 2013), and migratory birds like songbirds (e.g., Fudickar et al. 2012, Hallworth and Marra 2015). Regarding raptors, the most extensively studied ones with the above mentioned technology are those of large size like eagles (Cadahía et al. 2007, Krone et al. 2009, Moss et al. 2014, Urios et al. 2014), vultures (Phipps et al. 2013, López-López et al. 2014) and falcons (Nemcek et al. 2014). Among the smallest raptors, only the diurnal roosting behaviour of the Burrowing Owl (*Athene cunicularia*) was studied with GPS data-loggers (Scobie et al. 2014).

The Common Barn-owl (*Tyto alba*) is a well-studied nocturnal species. It is a worldwide distributed bird. Many aspects of the ecology, evolution and life history of this owl are accurately known (e.g., Taylor 1994, Love et al. 2000, van den Brink et al. 2012). Notwithstanding, the knowledge of nocturnal behaviours out of the nest, like foraging behaviour, is scarce. To date, the available information was obtained using radio-telemetry and direct observations (Taylor 1994, Arlettaz et al. 2010, Naim et al. 2012). Until recently, the main obstacle of using GPS technology on medium and small raptors was the weight of the devices. The body mass of the Common Barn-owl is around 260–550 g depending on the subspecies considered (Taylor 1994). As the device carried by the bird should affect its behaviour as little as possible, it must be light (<3% body mass; Casper 2009). The way to obtain the lightest data loggers was the addition of a solar panel and a small battery to prolong unit operation life (Soutullo et al. 2007); for obvious reasons this is not useful for nocturnal birds that generally stay indoors during the day. This study was developed in 2012, when the smallest GPS devices on the market (<15 g) could record up to five days maximum 1 point/min, and the storage capacity could not exceed 400 waypoints. Furthermore, their cost was more than US$ 1000. These features were not enough for the study of movement patterns or foraging behaviour.

Within any study, the choice of GPS sample interval will be limited by logistical factors such as battery constraints and data storage capability of the device. These factors limit the number of locations that can be recorded, and this constraint can affect the predictive accuracy of GPS data. The spatial relationships that are being studied should determine the sample interval settings; however, spatial accuracy should not be compromised by a desire to run a longer experiment (Swain et al. 2011).

The objective of this study was to evaluate for the first time the use of a GPS technology to track Common Barn-owl individuals. We evaluated the use of a commercial and economic GPS pet tracker device (with a large storage capability) to track a Common Barn-owl individual and tested GPS tracking as a technique for determining movement patterns and foraging habitat selection.

METHODS

This study was conducted in an agro-ecosystem in Argentinean's rolling pampas. The study site (34°50'S, 59°47'W) was located at a pig farm surrounded by crops and pastures crossed by a stream.

A GPS pet tracker device (22 g) was removed from its plastic frame and its original battery of 230 mA was replaced by a 650 mA one. This 24.2 g device was then attached, inside a waterproof bag, to the back of an adult male of *Tyto alba tuidara* by means of a nylon 0.9 mm diameter back pack harness. The body mass of this subspecies is 387–560 g (Weick 2006). The weight of the complete harness device was between 4–6% of the body mass of the bird. Harness design was previously tested with this and other captive bird species (e.g., pigeon, vultures, canaries, blackbirds) to be sure the bird's welfare and flying ability were normal.

The owl was captured in the nest at 01:47 h with a manually operated trap placed at the entrance of a little silo where it was found. There were seven chicks, 35–49 days old (age was estimated comparing with reference photographs and body weight), that remained in the nest. The trap was active during 40 min until the capture. The owl was freed with the attached device 40 min later.

Variables recorded by the data logger were: latitude and longitude (position accuracy: 5–10 m), hour, velocity, distance, altitude, and angle. The logger was set to record waypoints with these variables every 30 s at speeds slower than 10 km/h, and every 20 s when speed was faster than 10 km/h, between 18:00–07:00 h from 30 June 2012 (winter in the Southern Hemisphere). Sunset occurred at 17:50 and sunrise at 08:00, approximately. The owl was recaptured 20 days later for GPS removal.

We estimated the home range with the minimum convex polygon technique, the smallest polygon in which no internal angle exceeds 180 degrees and which contains all points (Mohr 1947). It was estimated with the extension "animal movement" for ArcView software (Hooge and Eichenlaub 1997). Tracks were processed with the Map Source and Quantum GIS software. Images for landscape calculations were taken from Google Earth. The different types of land cover were classified in the field as: barren, barren with pigs, build-up, forest, pasture, road, natural vegetation with cattle, natural vegetation with pigs, natural vegetation, and wetland. The Ivlev's Electivity Index (Ivlev 1961), calculated from point density within the minimum convex polygon, was used for the estimation of land cover type selection.

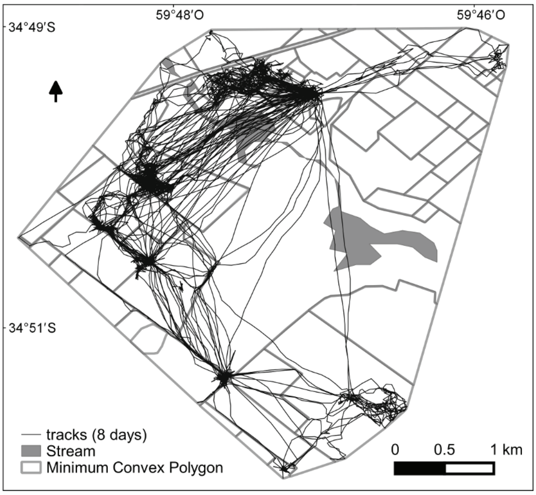

Figure 1. Tracks recorded during eight consecutive nights for a Common Barn-owl (*Tyto alba*) instrumented with a GPS pet tracker device in an agroecosystem in Argentinean's rolling pampas. The home range (estimated as the minimum convex polygon) is shown.

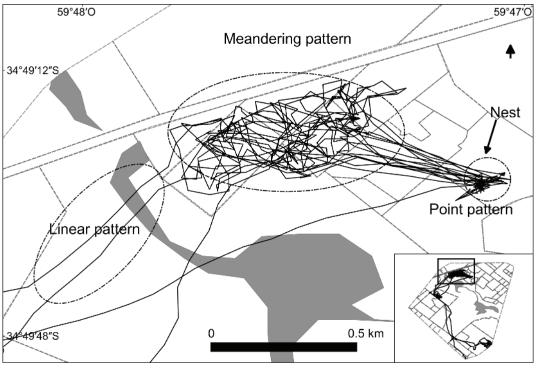

Figure 2. Detail of tracks recorded during one night for a Common Barn-owl (*Tyto alba*) instrumented with a GPS pet tracker device in an agroecosystem in Argentinean's rolling pampas, showing different movement patterns (meandering, linear and point, corresponding to hunting, straight-lined flights and roosting, respectively). The inset depicts the home range showed in figure 1.

RESULTS

The device recorded during eight consecutive nights without gaps in the period of time that the GPS was turned on (13 h/day) until it run out of battery (12501 waypoints). Records obtained during the first night were not considered for the analyses. The home range, estimated as the minimum convex polygon, was 1746 ha (Fig 1).

From the speed and angle of each waypoint, we identify three movement patterns (Fig. 2) that could be attributed to different behaviours: (1) straight-lined flights, with a linear pattern, speeds higher than 18 km/h and a low variation of the direction between subsequent segments (angles between 135–225°); (2) hunting, with a meandering pattern, speeds between 4–18 km/h and abrupt changes in directions between subsequent segments (0–135° or 225–360°); and (3) roosting, with a point or a star (with a recurrent center) pattern, speeds lower than 4 km/h and acute angles. The star pattern is typically produced by the GPS error when no movement occurs.

The beginning of daily activity was recorded at 18:32 h (± 4 min); i.e., a few minutes after twilight. The end was after 07:00 h, when the GPS turned off. The owl remained during the day in a roost 4.6 km far from the nest. During the first four hours of activity, a clear pattern was observed in six of the seven analyzed nights (Fig. 3). The owl, after leaving the day roost, showed a hunting behaviour during approximately 45 min. The first visit to the nest occurred on average at 19:15 h (range: 18:47–19:50 h). During the first four hours of activity, the owl visited the nest 2–6 times. This behavioural pattern (alternating hunting and visits to the nest) continued until 21:00 h. Thereafter the percentage of time the owl remained active decreased (Fig. 3). In the remaining nine hours of activity this percentage was variable between the analyzed nights.

Taking into account only the waypoints contained in the meandering patterns (i.e., during hunting), the values of the Ivlev's Electivity Index revealed that the owl selected vegetated areas (except where pigs were present) and barren areas with pigs for hunting (Fig. 4).

Discussion

The results of this first study evaluating the use of a GPS technology with a pet tracker device to track Common Barn-owl individuals showed that the obtained information is useful to study the nocturnal behaviour of this bird. Storage capability, fix success rate, fix interval and battery power enhanced allowed to obtain a detailed track that could be analyzed and interpreted.

To conserve battery power, GPS receivers integrated into wildlife telemetry collars typically are programmed to attempt to obtain a location for 90–180 s (Cain et al. 2005); in this case we fixed intervals at 20–30 s, increasing the accuracy of the locations, insomuch as fix interval also has an effect on fix success rates with shorter fix intervals being associated with higher fix success rates (Moen et al. 2001). The recording frequency used resulted in a detailed track. From the speed and angle of each waypoint we identified three different movement patterns that could be attributed to different behaviours, which could not have been identified with largest intervals. The estimated home range was within the standard home range limits recorded for this species (as large as 3174 ha and as small as 72 ha; Evans and Emlen 1947, Taberlet 1983, Taylor 1994).

The overlap of tracks with a land cover map allowed the calculation of the electivity index, estimating hunting habitat selection within the home range for six nights. All the selected areas presented high plant cover, which could be associated with the probability of prey capture. Common Barn-owl individuals catch a variety of prey, although rodents are by far the most important one (Taylor 1994). Rodents of the rolling pampas select habitats with high plant cover (Busch et al. 2001) such as the

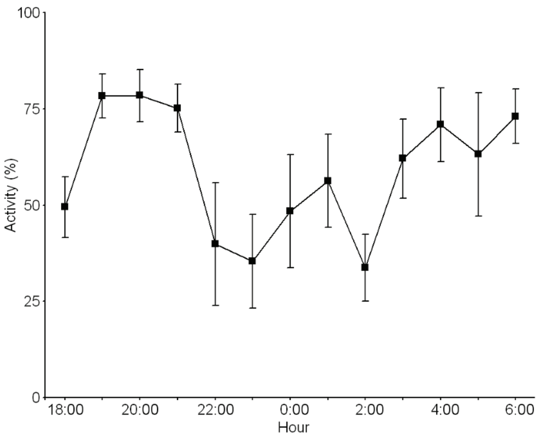

Figure 3. Mean (± SE) activity level of a Common Barn-owl (*Tyto alba*) instrumented with a GPS pet tracker device in an agroecosystem in Argentinean's rolling pampas during the period of data collection.

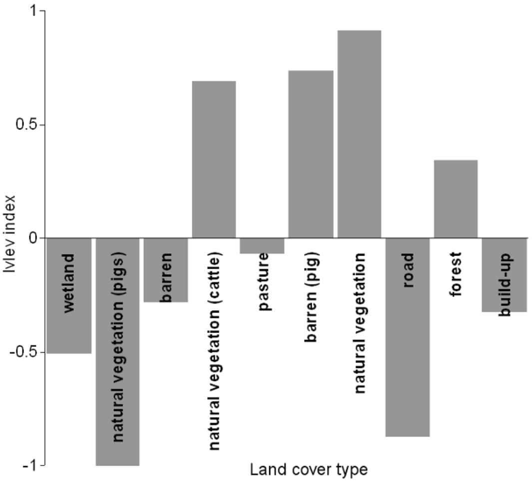

Figure 4. Values of the Ivlev's Electivity Index estimating land cover type selection by a Common Barn-owl (*Tyto alba*) instrumented with a GPS pet tracker device in an agroecosystem in Argentinean's rolling pampas.

patches selected by this owl. However, a land cover type without plant cover (barren areas overgrazed and trampled by pigs) was also selected. These particular areas presented a high abundance of rodents (pers. obs.).

The use of this technique represents an improvement for behavioural studies of this species. The quality of the data obtained with this device warrant the identification of movement patterns associated with different behaviours. Moreover, if data were to be collected every few seconds it would be possible to identify another hunting technique (perch-hunting) described for this bird (Taylor 1994, Arlettaz et al. 2010). This hunting technique could have been confused with roosting with the setting interval used in this work. Therefore, information collected with this technology will improve studies in diverse areas such as foraging behaviour, courtship, mate guarding, parental inversion, and prey capture strategies.

Acknowledgements

We would like to thank the Poy family, Gustavo García Zivano and Sergio Olea for their assistance in the field, and Dr. Segio Lew and Eduardo Puga for their technical support. We thank M. Victoria Vadell for reviewing a draft of the manuscript. We are also grateful for the comments of the reviewers that improved the quality of the work. Financial support was received from Universidad de Buenos Aires. Our experiments comply with the current laws of Argentina.

Literature Cited

Arlettaz R, Krähenbühl M, Almasi B, Roulin A and Schaub M (2010) Wildflower areas within revitalized agricultural matrices boost small mammal populations but not breeding Barn Owls. *Journal of Ornithology* 151:553–564

van den Brink V, Dreiss AN and Roulin A (2012) Melanin-based coloration predicts natal dispersal in the barn owl, *Tyto alba*. *Animal Behaviour* 84:805–812

Bouten W, Baaij EW, Shamoun-Baranes J and Camphuysen KC (2013) A flexible GPS tracking system for studying bird behaviour at multiple scales. *Journal of Ornithology* 154:571–580

Bridge ES, Thorup K, Bowlin MS, Chilson PB, Diehl RH, Fléron RW, Hartl P, Kays R, Kelly JF, Robinson WD and Wikelski M (2011) Technology on the move: recent and forthcoming innovations for tracking migratory birds. *BioScience* 61:689–698

Burger AE and Shaffer SA (2008) Application of tracking and data-logging technology in research and conservation of seabirds. *Auk* 125:253–264

Busch M, Miño MH, Dadon JR and Hodara K (2001) Habitat selection by *Akodon azarae* and *Calomys laucha* (Rodentia, Muridae) in pampean agroecosystems. *Mammalia* 65:29–48

Cadahía L, Urios V and Negro JJ (2007) Bonelli's Eagle *Hieraaetus fasciatus* juvenile dispersal: hourly and daily movements tracked by GPS: capsule birds cover daily distances not normally exceeding 20 km during the initial phase of dispersal, with the daily peak of movement/activity in the afternoon. *Bird Study* 54:271–274

Cagnacci F, Boitani L, Powell RA and Boyce MS (2010) Animal ecology meets GPS-based radiotelemetry: a perfect storm of opportunities and challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365:2157–2162

Cain JW III, Krausman PR, Jansen BD and Morgart JR (2005) Influence of topography and GPS fix interval on GPS collar performance. *Wildlife Society Bulletin* 33:926–934

Casper RM (2009) Guidelines for the instrumentation of wild birds and mammals. *Animal Behaviour* 78:1477–1483

Evans FC and Emlen JT Jr (1947) Ecological notes on the prey selected by a Barn Owl. *Condor* 49:3–9

Fudickar AM, Wikelski M and Partecke J (2012) Tracking migratory songbirds: accuracy of light-level loggers (geolocators) in forest habitats. *Methods in Ecology and Evolution* 3:47–52

Guilford T, Åkesson S, Gagliardo A, Holland RA, Mouritsen H, Muheim R, Wiltschko R, Wiltschko W and Bingman VP (2011) Migratory navigation in birds: new opportunities in an era of fast-developing tracking technology. *Journal of Experimental Biology* 214:3705–3712

Hallworth MT and Marra PP (2015) Miniaturized GPS tags identify non-breeding territories of a small breeding migratory songbird. *Scientific Reports* 5:art11069

Hooge PN and Eichenlaub B (1997) *Animal movement extension to ArcView, version 1.1*. US Geological Survey, Anchorage

Ivlev VS (1961) *Experimental ecology of the feeding of fishes*. Yale University Press, New Haven

Krone O, Berger A and Schulte R (2009) Recording movement and activity pattern of a White-tailed Sea Eagle (*Haliaeetus albicilla*) by a GPS datalogger. *Journal of Ornithology* 150:273–280

López-López P, Gil JA and Alcántara M (2014) Post-fledging dependence period and onset of natal dispersal in Bearded Vultures (*Gypaetus barbatus*): new insights from GPS satellite telemetry. *Journal of Raptor Research* 48:173–181

Love RA, Webon C, Glue DE and Harris S (2000) Changes in the food of British Barn Owls (*Tyto alba*) between 1974 and 1997. *Mammal Review* 30:107–129

McLEAY LJ, PAGE B, GOLDSWORTHY SD, PATON DC, TEIXEIRA C, BURCH P AND WARD T (2010) Foraging behaviour and habitat use of a short-ranging seabird, the crested tern. *Marine Ecology Progress Series* 411:271–283

MOEN R, PASTOR J AND COHEN Y (2001) Effects of animal activity on GPS telemetry location attempts. *Alces* 37:207–216

MOHR CO (1947) Table of equivalent populations of North American small mammals. *American Midland Naturalist* 37:223–249

MOSS EH, HIPKISS T, ECKE F, DETTKI H, SANDSTRÖM P, BLOOM PH, KIDD JW, THOMAS SE AND HÖRNFELDT B (2014) Home-range size and examples of post-nesting movements for adult Golden Eagles (*Aquila chrysaetos*) in boreal Sweden. *Journal of Raptor Research* 48:93–105

NAIM M, UMAR J AND HAFIDZI M (2012) The ranging behaviour of *Tyto alba* in oil palm under baiting with anticoagulant rodenticides, warfarin and brodifacoum and a biorodenticide *Sarcocystis singaporensis*. *Pertanika Journal of Tropical Agricultural Science* 35:209–221

NEMCEK V, CHAVKO J AND DEUTSCHOVÁ L (2014) Movement of satellite-tracked juvenile saker falcons (*Falco cherrug*) in SW Slovakia. *Slovak Raptor Journal* 8:97–103

PHIPPS WL, WOLTER K, MICHAEL MD, MACTAVISH LM AND YARNELL RW (2013) Do power lines and protected areas present a catch-22 situation for Cape vultures (*Gyps coprotheres*). *PLoS One* 8:e76794

ROBINSON WD, BOWLIN MS, BISSON I, SHAMOUN-BARANES J, THORUP K, DIEHL RH, KUNZ TH, MABEY S AND WINKLER DW (2010) Integrating concepts and technologies to advance the study of bird migration. *Frontiers in Ecology and the Environment* 8:351–361

RUTZ C AND HAYS GC (2009) New frontiers in biologging science. *Biology Letters* 5:289–292

SCOBIE C, BAYNE E AND WELLICOME T (2014) Influence of anthropogenic features and traffic disturbance on burrowing owl diurnal roosting behavior. *Endangered Species Research* 24:73–83

SOKOLOV LV (2011) Modern telemetry: new possibilities in ornithology. *Biology Bulletin* 38:885–904

SOUTULLO A, CADAHÍA L, URIOS V, FERRER M AND NEGRO JJ (2007) Accuracy of lightweight satellite telemetry: a case study in the Iberian Peninsula. *Journal of Wildlife Management* 71:1010–1015

SWAIN DL, FRIEND MA, BISHOP-HURLEY GJ, HANDCOCK RN AND WARK T (2011) Tracking livestock using global positioning systems — are we still lost? *Animal Production Science* 51:167–175

TABERLET P (1983) An estimation of the average foraging radius of the barn owl *Tyto alba* based upon rejection pellets analysis. *Terre et la Vie* 38:171–178

TAYLOR IR (1994) *Barn owls. Predator-prey relationships and conservation*. Cambridge University Press, Cambridge

TEW KAI E, BENHAMOU S, VAN DER LINGEN CD, COETZEE JC, PICHEGRU L, RYAN PG AND GRÉMILLET D (2013) Are Cape gannets dependent upon fishery waste? A multi-scale analysis using seabird GPS-tracking, hydro-acoustic surveys of pelagic fish and vessel monitoring systems. *Journal of Applied Ecology* 50:659–670

TOMKIEWICZ SM, FULLER MR, KIE JG AND BATES KK (2010) Global positioning system and associated technologies in animal behaviour and ecological research. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365:2163–2176

URIOS V, DONAT-TORRES MP, BECHARD M AND FERRER M (2014) Movements of a juvenile Crowned Eagle (*Harpyhaliaetus coronatus*) tracked by satellite telemetry in central Argentina. *Journal of Biological Research* 21:art12

VOTIER SC, BEARHOP S, WITT MJ, INGER R, THOMPSON D AND NEWTON J (2010) Individual responses of seabirds to commercial fisheries revealed using GPS tracking, stable isotopes and vessel monitoring systems. *Journal of Applied Ecology* 47:487–497

WEICK F (2006) *Owls (Strigiformes). Annotated and illustrated checklist*. Springer-Verlag, Berlin

WIKELSKI M, KAYS RW, KASDIN NJ, THORUP K, SMITH JA AND SWENSON GW (2007) Going wild: what a global small-animal tracking system could do for experimental biologists. *Journal of Experimental Biology* 210:181–186