

# Do diurnal migrants follow the Guadiana River when crossing dry sectors of SW Iberia?

Será que os migradores diurnos seguem o rio Guadiana enquanto atravessam sectores áridos do sudoeste da Península Ibérica?

Paulo Catry<sup>1</sup>, Ana Campos<sup>2</sup>, Vanda Miravent<sup>3</sup> & João E. Rabaça<sup>3,4</sup>



**ABSTRACT** - Little is known on the importance of water courses as migratory corridors. Here, we present the results of an investigation on the movements of diurnal migrants associated with the Guadiana River when crossing dry and inhospitable regions of southern Iberia. Direct observations were carried out along the river and at control sites away from it, in late August-November 2006. The number of birds seen was extremely small ( $\ll 1$  individual per hour for most species) and most records probably involved individuals in local movements, as indicated from similar rates of birds moving up and downriver. The only exceptions were hirundines which, within our study area, were strongly associated with the Guadiana both when foraging and when engaged in medium to long-distance daily movements. House Martins *Delichon urbicum* were particularly numerous, and 98.7% of the birds seen in directed movement ( $n = 4122$ ) were flying above the river. However, passing hirundines (mostly Barn Swallow *Hirundo rustica* and Sand Martins *Riparia riparia*) were scarce and did not show the same degree of association with the Guadiana. Our results suggest that there is no significant migratory corridor along the lower Guadiana during summer-autumn, but hirundines strongly associate with this river when foraging and when commuting between foraging grounds and roosts.

Key-words: Migration; Leading lines; *Delichon*; *Hirundo*; *Merops*.

**RESUMO** - O conhecimento sobre a importância dos rios ou ribeiros enquanto estruturas físicas subjacentes a corredores migratórios é muito escasso. Neste artigo, apresentam-se resultados de um estudo dos movimentos de migradores diurnos associados ao rio Guadiana durante a passagem por sectores áridos do sul da Península Ibérica. Foram realizadas, de finais de Agosto a Novembro de 2006, observações directas ao longo do rio e em sítios-controle apartados do mesmo. O número de aves registado foi extremamente reduzido ( $\ll 1$  indivíduos por hora, para a maioria das espécies) e a maior parte das observações provavelmente envolveu indivíduos em movimentos locais, o que é sugerido por haver pouca diferença entre os movimentos para montante e para jusante. As únicas excepções foram as andorinhas, que na nossa área de estudo se associaram fortemente ao Guadiana tanto durante a actividade de alimentação como quando realizando movimentos de carácter local. Os registos de andorinhas-dos-beirais *Delichon urbicum* foram particularmente numerosos e 98,7% das aves vistas em movimento orientado ( $n = 4122$ ) encontravam-se a voar sobre o rio. Contudo, as poucas andorinhas vistas em aparente migração (sobretudo andorinhas-das-chaminés

<sup>1</sup> Eco-Etology Research Unit, ISPA, Rua Jardim do Tabaco 34, 1149-041 Lisbon, Portugal. / <sup>2</sup> Rua Armindo Rodrigues 19, 3º esq. 1600-414 Lisbon, Portugal. / <sup>3</sup> LabOr - Laboratory of Ornithology, Department of Biology, University of Évora, 7002-554 Évora, Portugal / <sup>4</sup> Research Group on Mediterranean Ecosystems and Landscapes, ICAM, University of Évora, 7002-554 Évora, Portugal / E-mail: paulo.catry@gmail.com

*Hirundo rustica* e andorinhas-das-barreiras *Riparia riparia*) não apresentaram o mesmo grau de associação com o Guadiana. Os nossos resultados sugerem que não existe qualquer corredor migratório importante no troço terminal do Guadiana no Verão ou no Outono, mas que as andorinhas têm uma forte associação com este rio quando se alimentam e quando se deslocam entre as zonas de alimentação e os seus dormitórios.

Migrant birds are known to, at medium to large geographical scales, select migratory routes that minimise the difficulties of overcoming ecological and physical barriers, such as deserts, oceans or mountain ranges. Coasts, isthmuses, island chains and mountain passes are well-known as features favoured by a diversity of migrant birds (Alerstam 1990, Berthold 1993). However, relatively little is known about the importance of water courses as migratory corridors. Birds might associate with rivers because water courses and their margins provide suitable resting and refuelling habitats for a wide range of species (e.g. Skagen *et al.* 1998, Izhaki *et al.* 2002). Furthermore, rivers can function as leading lines, helping the orientation of migrants, as long as their course runs approximately in the appropriate direction (Bingman *et al.* 1982, Lensink 1994, see also Åkesson 1993 for the use of coasts as leading lines).

The south-western sector of the Iberian Peninsula is used by large numbers of migrants in transit, particularly during the summer and autumn (e.g. Moreau & Monk 1957, Finlayson 1998). Both Iberian breeding birds that winter in Africa and European birds from higher latitudes cross this area in relatively large numbers (e.g. Catry *et al.* 2004). At the end of summer, however, southern Iberia is, in some areas away from the coast, extremely dry and relatively inhospitable, something that becomes evident when one considers the scarcity of migrants seen stopping over in those regions. One such area is the south-eastern part of Portugal, in the Baixo Alentejo and adjacent inland hills of the Algarve (pers. observation). This area, however, is crossed by the Guadiana river, a large watercourse that runs broadly North-South in this sector, and at the mouth of which important wetlands for waterbirds are found (Rabaça 2004).

To test the hypothesis that migratory birds associate with the lower Guadiana when crossing the above-mentioned region, we have conducted

observations of diurnal migrants in late summer and autumn, at several points along the river and in nearby dry areas. We considered not only birds obviously in transit, but also individuals that forage mostly on the wing, or from the air, such as swallows, martins, bee-eaters and terns.

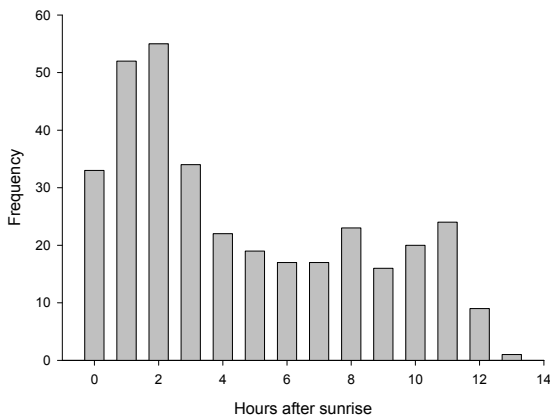
## METHODS

This study was carried out in summer-autumn 2006. Ten observation points were chosen along the lower ca. 100 km of the Guadiana River (but with no points located less than 20 km from the river mouth – see Fig. 1). Observations were split between those 10 points (with very little geographical bias of observation effort) and carried out in 30-minute blocks. These sampling units were paired with similar 30-minute blocks of simultaneous observations at locations 5–20 km from the river (on < 20% of the cases, simultaneous observations were not possible and observations away from the river started 20–35 min before or after the paired observation block by the Guadiana). All observations were made by single experienced observers, using 10× binoculars, placed on open sites with unobstructed views, generally covered by low scrub or dry pastures with scattered trees.

Observations were conducted between 25 August and 20 November 2006. From 25 August until 20 September observations were made on a daily basis; a total of 92 30-minute pairs of observations were carried out during this period, plus an extra 6 hours by the river only. In October and November, we carried out a total of 73 hours of observation (all by the river) on 9 different dates. Overall, we watched for visible migration by the river for a total of 125 hours, approximately 10% of the overall available daylight and on 38% of the available dates, from late August until the end of November. Observations covered the entire daylight period, but the effort was uneven, with a greater coverage of the morning periods (Fig. 2).



**Figure 1:** Study area in the lower Guadiana River, with locations of observation stations by the river.



**Figure 2:** Distribution of starting times of half-hour observation periods.

Paired observations (by the river and away from it) were used to assess the degree of association of different species with the river. Supplementary observations (unpaired - by the river only) were carried out with the objective of better assessing

the absolute magnitude of the visible (water) bird migration above the river.

During observation periods, we recorded all avian movements within visual range (maximum distance allowing safe identification), excluding apparent local movements. Birds were classified as being on local movements when the observed flight was seen to have started or finished within the visual range of the observers or when the individuals were seen inverting flight direction during the observation, disappearing on the same bearing where they had come from. When watching from the river margins, we noted if birds appeared to follow the river course or were clearly diverging from it. Whenever possible, directions of flight were visually determined using a compass. It was not always possible to get exact bearings for the movements of individuals or flocks. When not exactly measured, during fieldwork and throughout this paper, movements were said to be towards the south whenever they were towards  $180 \pm 45^\circ$ . The same broad definition applies to other main geographic bearings (North, East and West).

Weather conditions were noted and wind direction and strength were measured (using a portable anemometer) at an unobstructed point during observations or immediately after they took place. Virtually all paired observations were carried out (in August and September) under clear skies with relatively light winds (mean speed  $7.5 \text{ km}\cdot\text{h}^{-1}$ , range:  $0\text{-}16 \text{ km}\cdot\text{h}^{-1}$ ) mostly from the northern sector. In October/November weather conditions were very variable, ranging from clear skies and no wind to light rain and  $45 \text{ km}\cdot\text{h}^{-1}$  winds from the south.

To compare the incidence of foraging or passing migrants along the river with control sites away from it, we used paired non-parametric Wilcoxon rank test, for the 92 pairs of (nearly) simultaneous 30-minute observation periods. It should be noted that this involves a certain degree of pseudo-replication, as we had only 10 observation sites by the river. However, we opt to present the analyses as they are, as we believe the observation sites to be representative of the study area, there were no important bias in area coverage and between-site variance was not clearly larger than within-site variance (see Leger & Didrichsons 1994 for a detailed discussion of this type of approach). Nevertheless, we treat marginally significant results cautiously.

## RESULTS

### **Cormorants**

Cormorants *Phalacrocorax carbo* were absent in August, rare in September, but frequently seen (groups of 1-3) foraging on the river in October/November. Excluding obvious local movements, numbers moving up and downstream were similar (a total of respectively, 8 and 15) and probably also involved mostly local birds. One flock of 7 individuals moving south may have been an exception. No cormorants were seen away from the river.

### **Hérons and related species**

We recorded one single flock of 6 Spoonbills *Platalea leucorodia*, flying high above the Guadiana, but moving clearly to the SE (160°), not following the river course. Grey Herons *Ardea cinerea* were regularly seen feeding along the river. Counting only birds not known to be feeding locally, 4 movements were upriver, 5 were downriver and 1 did not follow the river course. A similar pattern was found for Little Egrets *Egretta garzetta* with 5 birds upriver and 3 birds downriver. No other Ardeidae were observed. The very few White *Ciconia ciconia* and Black Storks *C. nigra* observed were on local movements. No egrets, herons or storks were seen away from the river.

### **Waterfowl**

The only species observed was the Mallard *Anas platyrhynchos*, and it was uncommon. A total of 69 mallards were seen flying near the Guadiana, divided by 5 flocks. The largest flock (40 individuals) was not following the river. Of the remaining 29 individuals, 19 were flying upriver and 10 were flying downriver.

### **Birds of prey**

In August-September, we saw very few birds of prey that were not either resting or hunting/commuting between perches. Short-toed Eagles *Circus gallicus* were the only species frequently encountered, generally hunting. We recorded only 5 individuals that showed an orientated behaviour (3 moving south and 2 moving north); 1 out of 5 individuals was seen above the river. The only other migratory raptor observed that showed a behaviour suggesting a migratory movement was the Montagu's Harrier *Circus pygargus*. Two juveniles were seen moving

together over a distance of several kilometres, flying high (flight direction approximately 125°) and maybe following the course of the river from a distance.

In October / November, when observations targeted waterbirds moving along the river only, we saw Ospreys *Pandion haliaetus* twice (once up and once downriver), possibly involving one or two birds wintering locally.

### **Waders**

Excluding waders foraging or in obvious local movements, we only recorded Common Sandpipers *Actitis hypoleucos* once (heard moving south, high above the river) and Green Sandpipers *Tringa ochropus* on another occasion (2 individuals moving north).

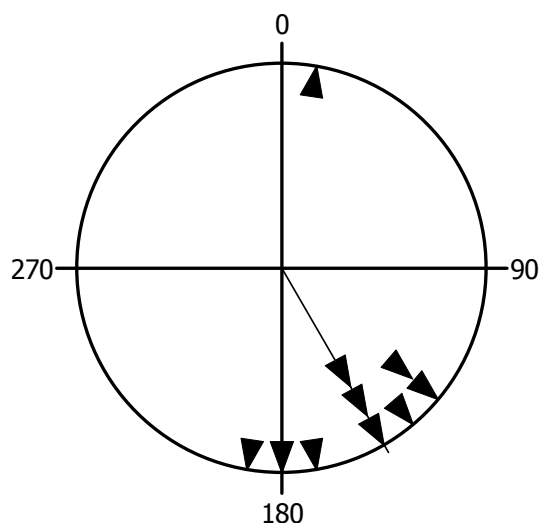
### **Gulls and terns**

Gulls and terns (mostly *Larus michabellis*, *L. ridibundus*, *Sterna sandvicensis*, *S. albifrons* and *S. caspia*) were frequently recorded, but only in the lower sectors (observation points 6-10 in Fig. 1). Movements up and down-stream were equally frequent (results not shown) and clearly represented foraging movements of birds that roosted by the estuary. No terns or gulls were recorded up-stream from Alcoutim (where 93 hours of observation were carried out by the river), except for a flock of 18 *Larus fuscus* flying south (apparently migrating) near Mértola in November, 2 *L. ridibundus* and 1 *Sterna sandvicensis* flying north, also near Mértola, in October. No gulls or terns were seen away from the river.

### **Bee-eaters**

Of 19 flocks of passing Bee-eaters *Merops apiaster* seen, 18 were recorded in the last 7 days of August and the last was on 3 September. Furthermore, stationary (foraging) bee-eaters were all recorded in August. Considering only flocks for which numbers could be properly assessed, mean flock size was  $13.7 \pm 8.5$  birds (range: 2-30; n = 13). Passing flocks were recorded at all times of the day, from just before sunrise to sunset. For a similar observation effort along the river and at other sites, 6 flocks were detected by the Guadiana and 13 others were away from it. Even birds seen at observation points by the river did not always, as far as we could assess, follow it. All flocks except one (seen at sunset and

maybe moving to a roost) were clearly orientated towards the south or southeast (Fig. 3). In 10 flocks for which direction could be visually assessed using a compass, mean direction ( $\mu$ ) was  $150^\circ$ , vector length ( $r$ ) was 0.77, Rayleigh test  $p = 0.001$ . Excluding the flock moving towards the north, flight direction varied between  $130^\circ$  and  $190^\circ$ , and  $\mu = 154^\circ$ ,  $r = 0.94$ , Rayleigh test  $p < 0.001$ .



**Figure 3** - Flight directions of 10 Bee-eater *Merops apiaster* flocks in late August and early September, in SE Portugal.

### Wagtails

Pied and Grey wagtails *Motacilla alba* and *M. cinerea* were often seen foraging or on local movements,

particularly in October and November, but there were no records of flocks apparently on migration. Yellow Wagtails *M. flava* were never recorded.

### Swallows and martins

Different hirundine species tended to be recorded predominantly moving in different directions (Table 1). Only Barn Swallows *Hirundo rustica* and Sand Martins *Riparia riparia* were moving predominantly in the seasonally appropriate migratory direction (south). Other species must have been mostly engaged in daily movements linked to foraging.

For an equal observation effort by the river and away from it, the vast majority of Crag Martins *Ptyonoprogne rupestris*, House Martins *Delichon urbicum*, Sand Martins and Red-rumped Swallows *Hirundo daurica* were seen by the river (Table 2). Note however, that results for Sand Martins are of dubious significance as most individuals were seen on one single occasion. For Barn Swallows the sample size is relatively small but, at least for moving individuals, results seem to be considerably different from other species in that this swallow was seen as frequently away from the river as above it. It is interesting to note, as a comparison, that Common/Pallid Swifts *Apus apus/pallidus* displayed a markedly different pattern from most hirundines, with only 27.7% ( $n = 112$ ) of the birds seen (including birds clearly foraging) being associated with the river. On the other hand, all 9 White-rumped Swifts *Apus caffer* seen (on 3 different locations) were by the river side.

**Table 1** - Percentage of hirundines of different species recorded moving in the seasonally appropriate migratory direction in the lower Guadiana region. Note that these results are indicative, as many birds moved in flocks or as a continuous stream and individuals cannot be taken as independent data points.

Species	Crag martin <i>Ptyonoprogne rupestris</i>	House martin <i>Delichon urbicum</i>	Red-rumped swallow <i>Hirundo daurica</i>	Barn swallow <i>Hirundo rustica</i>	Sand martin <i>Riparia riparia</i>
% moving south	10.8	24.8	55.5	75.0	100
Number of birds	65	4137	400	56	55

**Table 2** - Percentage of stationary and moving hirundines that were seen by the Guadiana river for an equal observation effort on the river and away from it and Wilcoxon rank tests comparing numbers (stationary and moving) seen in paired periods (n = 92 pairs) of observation by the river and at control sites (see methods for more details).

Species	<i>Crag martin</i>	<i>House martin</i>	<i>Red-rumped swallow</i>	<i>Barn swallow</i>	<i>Sand martin</i>
% stationary birds seen by the river	98.7 n = 158	89.1 n = 158	82.9 n = 281	80.0 n = 20	No records
Comparison stationary	Z = 3.52 P < 0.001	Z = 5.72 P < 0.001	Z = 5.49 P < 0.001	Z = 1.78 P = 0.076	No records
% moving birds seen by the river	98.5 n = 65	98.7 n = 4122	86.3 n = 388	56.4 n = 55	89.1 n = 55
Comparison Moving	Z = 2.12 P = 0.03	Z = 5.23 P < 0.001	Z = 4.11 P < 0.001	Z = 0.84 P = 0.40	Z = 1.25 P = 0.21

## DISCUSSION

Despite its limited temporal coverage, this study clearly shows that the magnitude of diurnal visible migration above the lower Guadiana is extremely reduced. Even if we multiply by 10 the number of birds seen (accounting for the fact that we covered only about 10% of the available daylight hours from late August to the end of November), the net flux of birds moving south (presumably migrating) is negligible. The overall coverage was reasonably even, with a slight bias towards early morning. As there were no noticeable time effects in migrant movements, such bias is unlikely to affect our results (but see discussion on hirundines below). This study was carried out at a time of the year when huge numbers of predominantly diurnal migrants, including both terrestrial and aquatic *taxa* (such as herons, egrets, cormorants, raptors, some waders, gulls, terns, bee-eaters, wagtails and hirundines), are known to migrate along the western part of Iberia, to winter in Africa, the Mediterranean or the southern coast of Portugal and Spain (e.g. Alertam 1990, Finlayson 1992, 1998). Our results suggest that those migrants make virtually no use of the Guadiana as a corridor of favourable habitat to cross the arid landscapes of SE Portugal. However, we should point out that our observations may have missed high flying migrants, as they may be virtually invisible from ground level.

Studies of nocturnal migrants landed in riparian vegetation when crossing arid habitats in Southeast Arizona also failed to find an association of migratory passerines with riparian corridors, as opposed to isolated oasis, which was attributed to the fact that most migrants follow routes that are predominantly influenced by wind patterns (Skagen *et al.* 1998).

The scarcity of waterbirds moving along the Guadiana may also be due to the fact that most migrants strongly associate with the coast when moving through SW Iberia.

Movements of bee-eaters were interesting in that, contrasting with hirundines (see below), they were not associated with the river. The general SE direction of movement probably indicates an orientation towards the strait of Gibraltar, where very large numbers of Bee-eaters are usually recorded crossing to Africa (Finlayson 1992), and contrasts with the regional orientation of nocturnal passerines migrants, that is more to the SW (e.g. Hilgerloh 1988). It is interesting to note, however, that while the main Bee-eater migration in Gibraltar is in the first half of September, in southern Portugal most birds generally leave until the end of August (this study and other pers. obs.).

Contrasting with other migratory birds (excluding waterbirds), the three most numerous hirundines were strongly associated with the Guadiana within

our study area. Such association was obvious for both foraging birds and for birds (generally in flocks) in directed flight. There was an obvious pattern of daily movement of House Martins and Red-rumped Swallows from large roosting sites (mostly located in small towns, such as Mértola or Alcoutim) to unknown foraging areas, in early to mid-morning, and in the reverse direction, in mid to late afternoon. At Pulo do Lobo (observation point number 2), up to one thousand house martins were seen flying north in one hour of observation, from 08.45h, in mid September. Those birds were almost certainly coming from Mértola, located almost 20km to the south. A similar pattern was observed in other occasions at this same site. Birds always followed a very narrow corridor above the river, at most 500m wide. Reverse movements were noted in the evening and, in particular towards dusk, many of those flights were directed, fast and involved little or no foraging. River following occurred not only in sections of the river orientated North-South but also on NW-SE directions (for example, at observation point number 4). Furthermore, river following also took place on windless days, suggesting that birds were not taking advantage of shelter provided by the river valley or of local air currents. From these and other observations, it was clear that hirundines followed the river in their daily local medium-distance movements.

In arid areas of North America, the association of migratory hirundines with riparian corridors has been noted and northern Rough-winged Swallows *Stelgidopteryx serripennis*, unlike the majority of other migrants, were found to be far more numerous in continuous corridors than in isolated oases (Skagen *et al.* 1998). It is still not very clear if hirundines engaged in long-distance migratory movements associate with the Guadiana. This is difficult to evaluate because of the paucity of observations of birds known/suspected to be migrating over long-distances. However, observations of barn swallows suggest that migrating individuals were as frequent above the river as at control sites. Sand Martins, on the other hand, may have been more numerous above the river and in late September were recorded moving south in mixed flocks with House Martins and Red-rumped Swallows. More research is needed to assess if hirundines follow the

Guadiana and other rivers when engaged in long-distance migration.

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