Pattern of bat fatalities at wind turbines in Europe comparing north and south

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In April 2011, a total of 3791 bat fatalities at wind turbines had been reported from 15 countries in Europe (update by authors of the mortality table prepared for EUROBATS (http://www.eurobats.org/documents/pdf/AC16/Doc.AC16.8_IWG_Wind_Turbines.pdf) The victims belong to 27 taxa out of 39 living in the European Community. The aim of this poster is to compare the situation in northern and southern Europe based on available data. Only standardized monitoring studies have been analyzed.

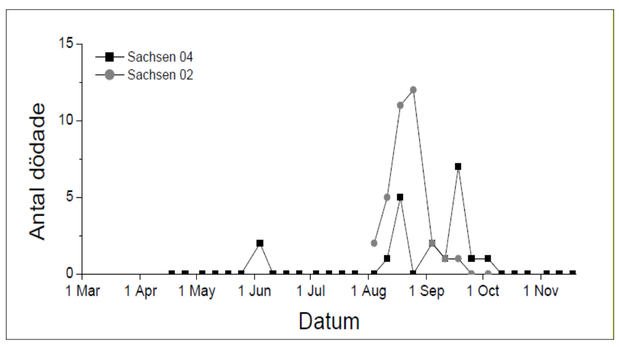
Which bats are killed and where?

Most European data on bat fatality at wind turbines come from a) Germany and surrounding countries in the north (above 46°N) and b) southern France, the Iberian peninsula and Greece in the south.

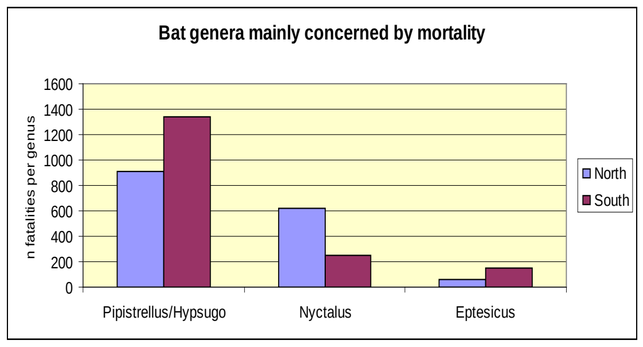
Most fatalities (> 98%) concern open-air species of the genera *Pipistrellus/Hypsugo*, *Nyctalus* and *Eptesicus*, and very few the genera *Myotis*, *Plecotus, Miniopterus*, *Barbastella* and *Rhinolophus*. Differences appear between the northern and southern regions mostly at the species level.

The two high altitude flying species, *Tadarida teniotis* and *Nyctalus* lasiopterus are relatively seldom killed at wind turbines; there are 30 and 27 fatalities, respectively.

Comparing northern and southern Europe



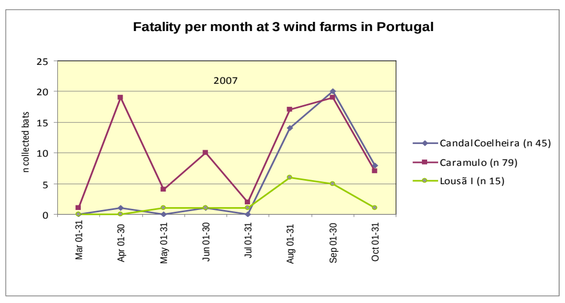
Pattern of mortality that reflects the situation in northern Europe (after Endl 2004)



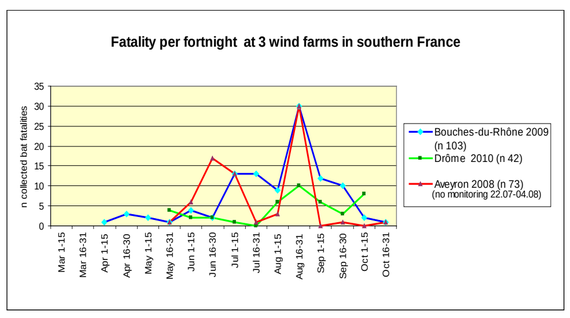
Comparison of bat fatalities per genus in northern and southern Europe

The temporal patterns in fatality records were consistent across the three countries in southern Europe, but differed consistently from those of northern Europe (Rydell *et al.* 2010a). In the south, fatalities occurred more or less throughout the summer, while in the north (mostly Germany) 90% occurred in August and September. The fatality pattern at wind turbines is probably linked to certain weather systems, possibly through the behaviour of flying insects, as suggested earlier (Rydell *et al.* 2010b).

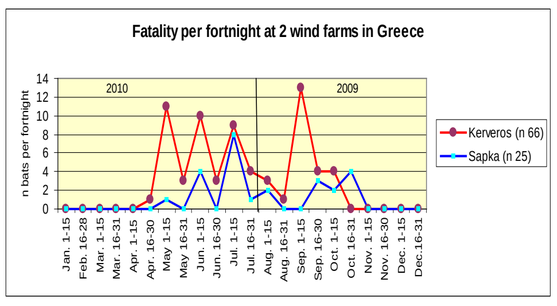
The three data sets (Portugal, France and Greece) were heterogeneous in several respects and were therefore analysed separately. Authors' mortality estimates were corrected for differences in monitoring duration.



The **Portuguese** data set consisted of 28 inland localities, mostly from peaks and ridges at mid-altitude (500-1200 m). Fatality rates were in the range 0 to 8 bats/WT/year at all but two sites. These two showed much higher fatality rates (14 and 26 bats/WT/year). What makes these sites outstanding is not obvious. There were no significant relationships between fatality rate and absolute altitude, predominant land use, or distance to nearest water. There was an unexpected but significant relationship between fatality rate and tree cover with more dead bats at tree-less sites.



The **French** data set consisted of 5 sites at low or medium altitude, 3 of which were situated along the Rhône river valley. Fatality rates were 6.8 bats/WT/year or much higher (79,2 bats/WT/5,5 months – conservative result after testing 4 statistics methods). One the 2 most dangerous sites is located in the Rhône delta, ca. 8 km from the Camargue wetland. For the second one (Drôme), the most dangerous of its 2 wind turbines is on a small col in woodland, 16 km east from the Rhône river. With only five sites included, the French data set was too small for a meaningful statistical analysis.



The **Greek** data set consisted of nine inland sites on mountain tops and ridges at 750-1000 m altitude. The fatality rates were in the range of 2 to 14 bats/WT/year. The sites were similar with respect to topography, land use and their virtual lack of forest cover, and we found no statistically significant relationships between fatality rate and other variables within this data set. For example, the fatality rate at Kerveros was 9 times higher than at the adjacent Geraki, only 400 m away separated by a small valley.

Country	Locality	Year	Predominant land use	% tree cover <500 m of WTs	Mean alt. (asl) (m)	Topo-graphy	Closest wood or hedge (m)	Closest water line (m)	N WTs	Total n of deaths	Adjusted fatality rates	Author & year
Portugal	Caramulo	2006, 2007	mountain	6.0-24	1000	top	60-220	6-388	45	47, 89	14.2	Hortencio et al. 2007, Silva et. al. 2008
Portugal	Chão Falcão	2005, 2006	forest	47	466	top	5	600	15	0	0	Silva et al. 2005, 2007
Portugal	Videira	2006, 2007, 2008	forest	68	510	top	10	260	3	0	0	Strix 2007
Portugal	Borninhos	2005	agriculture	33	1050	top/ridge	70	367	1	0	0	Plecotus 2008
Portugal	Caravelas	2006	mountain	4	1240	top/ridge	350	776	2	1	0.22	STRIX 2008a, b, c
Portugal	Gardunha:	2007	forest	37	896	top/ridge	90	643	54	5	4.2	Alves et al. 2009
Portugal	Moradal	2007	forest	43	820	top/ridge	43	1793	?	0	0	Lopes et al. 2009
Portugal	Outeiro	2006, 2008	shrubland	2	1166	top/ridge	264	63	15	32	26.3	al. 2008
Portugal	Pinhal Interior - Mata-Álvaro	2006, 2007	forest	4	922	top/ridge	260	826	18	0	0	Alves et al. 2009, 2010
Portugal	Pinhal Interior - Furnas	2006, 2007	forest	35	925	top/ridge	65	353	6	0	0.8	Alves et al. 2009, 2010
Portugal	Pinhal Interior - Seladolinho	2006	forest	6	923	top/ridge	38	391	8	1	0.8	Alves et al. 2009, 2010
Portugal	Pinhal Interior - Proença I e II	2006	agriculture	20	883	top/ridge	95	1345	21	5, 2	1.8	Lopes et al. 2008, Alves et al. 2010
Portugal	Marão - Penedo Ruivo	2006, 2007, 2008	forest	12	1125	top/ridge	156	1096	10	0	0	Strix 2007, 2008
Portugal	Marão - Seixinhos	2006, 2007, 2008	mountain	0	1198	top/ridge	530	386	8	1	0.17	Strix 2007, 2008
Portugal	Marão - Teixeiró	2006, 2007, 2008	mountain	6	969	top/ridge	240	1657	7	0	0	Strix 2007, 2008
Portugal	Marão - Mafómedes	2008	forest	14	1074	top/ridge	170	1815	2	0	0	Strix 2008
Portugal	Guarda	2008	mountain	20	954	top/ridge	260	20	4	1	1.3	Profico/Bio3 2009
Portugal	Candal Coelheira	2006, 2007	mountain	8	1023	top/ridge	285	522	20	69	7.8	Alves et al. 2007, Amorim 2009
Portugal	Fonte da Quelha	2006	mountain	0	1149	top/ridge	1380	604	8	0	0	Ecosfera 2007
Portugal	Candeeiros I	2005, 2006, 2007	grazing fields	0	474	flat	760	49	26	4	0.38	Alves et al. 2006, Barreiro et al. 2007, ProSistemas 2009
Portugal	Candeeiros II	2006, 2007	grazing fields	0	474	flat	760	49	11	0	0	Barreiro et al. 2007, ProSistemas 2009
Portugal	Arga	2008	mountain	2	680	top/ridge	320	9	12	0	0	ProSistemas 2009
Portugal	S. Pedro	2006	mountain	4	1143	top/ridge	455	598	5	15	12	Alves et al. 2007
Portugal	Freita I e II	2006	mountain	14	1024	top/ridge	82	12	16	4	0.5	Alves et al. 2007
Portugal	Mosqueiros I	2008	mountain	14	1100	top/ridge	170	325	4	2	3.6	Barreiro et al. 2009
Portugal	Alto Minho I - Sto António	2008	forest	22	1080	top/ridge	173-610	31	16	9	1.9	Procesl 2009
Portugal	Sabugal	2009	forest	29	1124	top/ridge	125	41	12	0	0	Tecneira (2010)
Portugal	Ralo	2007	agriculture	4	924	top/ridge	70	492	16	4	0.22	Duarte et al. 2008, 2009
S. France	Aveyron	2008, 2009	pastures	60	1080	top/ridge	15	300	13	73, 98	not applicable	LPO 12 2008, EXEN - KJM 2009
S. France	Bouches-du-Rhône	2009	grass	0		flat	50	0	9	103	62.7	Aves Environment & GCP 2010
S. France	Ardeche	2010	River, commercial	5	100	flat	15	30	2	6	6.8	Cornut J. & Vincent S., GCRA-LPO26, 2011
S. France	Drome	2010	mixed forest, agriculture	38	380	col	50	>500	2	42	79.2 (no adaptation)	Cornut J. & Vincent S., GCRA-LPO26
S. France	Lozere	2009	forestry	83	1253	hill top	10	450 (small stream)	7	20	48.3	F.Sane -ALEPE 2011
Greece (Thrace only)	D (Dydimos Lofos)	2010	land, 30% oak forest	10	870	Top/ridge	20m (average)	> 10000m	8	20	5.5	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	G (Geraki)	2010	land, 30% oak forest	10	950	Top/ridge	35m (average)	> 10000m	42	13	1.6	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	K (Kerveros)	2010	land, 30% oak forest	10	980	Top/ridge	100m (average)	> 10000m	14	66	13.9	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	MA (Mati)	2010	land, 30% oak forest	10	850	Top/ridge	30m (average)	> 10000m	3	9	10.8	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	MO (Monastiri)	2010	land, 30% oak forest	0	750	Top/ridge	60m (average)	> 10000m	13	13	3.0	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	P (Peltastis)	2010	land, 30% oak forest	0	850	Top/ridge	80m (average)	> 10000m	10	9	6.5	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	M (Mytoula)	2010	land, 30% oak forest	5	870	Top/ridge	40m (average)	> 10000m	19	22	4.7	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	X (Sapka)	2010	land, 30% oak forest	25	1000	Top/ridge	30m (average)	> 10000m	5	25	13.2	Georgiakakis P., Papadatou E. and WWF Hellas 2010
Greece (Thrace only)	S (Soros)	2010	land, 30% oak forest	0	750	Top/ridge	100m (average)	8500m	13	9	2.2	Georgiakakis P., Papadatou E. and WWF Hellas 2010

Caramulo in Portugal (S. Barreiro)

Bouches-du-Rhône, France: partial view of one of the most deadly wind farms for bats (L. Allouche)

Kerveros wind farm in Greece (C. Sauvage)

Conclusions

High flying bat species are the most frequently killed by wind turbines in southern Europe as well as in northern Europe. Most fatalities belong to *Pipistrellus* and *Nyctalus* spp. This pattern can be generalised for the entire Europe.

In northern Europe most fatalities of bats at wind farms occur during late summer. But this is not the only dangerous period in southern Europe, where May-June and/or June-July, depending on the region, also need to be considered. Hence, the seasonal fatality patterns cannot be generalised across Europe.

Our data confirm the potential danger of hilltops and ridges, of sites near the coast or along rivers and on obvious flyways near such places. This pattern seems to be consistent across Europe.

Acknowledgments

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Quoted references

Rydell, J., Bach, L., Dubourg-Savage, M.-J., Green, M., Rodrigues, L. & Hedenström, A. 2010. Mortality of bats at wind turbines links to nocturnal insect migration? *European Journal of Wildlife Research* 56, 823-827 doi: 10.1007/s10344-010-0444-3.
Rydell, J., Bach, L., Dubourg-Savage, M.-J., Green, M., Rodrigues, L. & Hedenström, A. 2010. Bat mortality at wind turbines in northwestern Europe. *Acta Chiropterologica* 12, 261–274 doi: 10.3161/150811010X537846
Endl, P., U. Engelhart, K. Seiche, S. Teufert & H. Trapp 2004. Verhalten von Fledermäusen und Vögeln an ausgewählten Windkraftanlagen. Landkreis Bautzen, Kamenz,Löbau-Zittau, Niederschlesischer Oberlausitzkreis, Stadt Görlitz, Freistadt Sachsen. Report to Staatlisches Umweltfachamt Bautzen.