Scientific contributions

Fruit bats and wind turbine fatalities in South Africa

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Figure 1. *Rousettus aegyptiacus* carcass found on 16 October 2014 (Durban Natural Science Museum: Catalog number 14798).

Figure 2. *Epomophorus wahlbergi* carcass found on 16 March 2015 (Durban Natural Science Museum: Catalog number 14751).

Figure 3. *Epomophorus wahlbergi* carcass found on 23 June 2015 (Durban Natural Science Museum: Catalog number 14799).

Figure 4. *Rousettus aegyptiacus* carcass found on 24 June 2015 (Durban Natural Science Museum: Catalog number 14800).

Figure 5. *Rousettus aegyptiacus* carcass found on 29 June 2015 (Durban Natural Science Museum: Catalog number 14805).

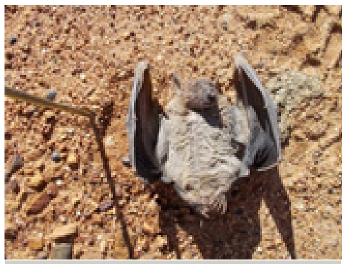

Figure 6. *Rousettus aegyptiacus* carcass found on 28 July 2015 (Durban Natural Science Museum: Catalog number 14797).

A variety of Megachiroptera of the single family Pteropodidae or Old World fruit bats occur throughout the tropics and sub-tropics of the Asia, Africa and the Pacific Islands (MICKLEBURGH *et al*., 1992). They are vital plant seed dispersers and pollinators in several ecosystems (HODGKISON *et al*., 2003; KUNZ *et al*., 2011). Fruit bats face a variety of known threats globally, such as destruction of habitat, disturbance to roosts, conflict with fruit growers, epidemic disease, hunting and trade and tropical storms (JACOBSEN *et al*., 1986; FUJITA and TUTTLE, 1991; BENDA *et al*., 2008; KAMINS *et al*., 2011). Some species have faced serious population declines (PIERSON and RAINEY, 1992). However, as far as I can establish through literature reviews and consultation with local and international scientists, there have been no confirmed or reported fatalities of fruit bats by wind turbines globally.

The world's wind energy industry is growing rapidly, with 2014 being a record year for the global wind industry, as annual wind turbine installations exceeded 50 GW for the first time (GLOBAL WIND ENERGY COUNCIL, 2015). Wind energy is a significant new threat facing several species of bats, with several reports of small insectivorous species being killed worldwide (ARNETT *et al*., 2008; BAERWALD and BARCLAY, 2011; DOTY and MARTIN, 2012; HULL and CAWTHEN, 2012; LEHNERT *et al*., 2014).

In South Africa, three species of Megachiroptera – Peters's Epauletted Fruit Bat (*Epomophorus crypturus* Peters, 1852), Wahlberg's Epauletted Fruit Bat (*Epomophorus wahlbergi* (Sundevall, 1846)) and Egyptian Rousette (*Rousettus aegyptiacus* (É. Geoffroy Saint-Hilaire, 1810)) occur (MONADJEM *et al*., 2010). The South African First Quarter 2015 Renewable Energy Map (DEPARTMENT OF ENVIRONMENTAL AFFAIRS, 2015) shows the distribution of wind energy facility applications in South Africa. Due to overlapping distributions of potential wind facilities and the pteropodid bats, two of the three species in South Africa will be the most at risk of fatality: *E. wahlbergi* and *R. aegyptiacus*.

Using the methodologies recommended in ARONSON *et al.* (2014), I have monitored bat fatalities at wind energy facilities in South Africa since May 2014 and have found several carcasses of insectivorous bats, consisting mainly of three species – Egyptian Free-tailed Bat (*Tadarida aegyptiaca* (É. Geoffroy Saint-Hilaire, 1818)), Cape Serotine (*Neoromicia capensis* (A. Smith, 1829)) and Natal Long-fingered Bat (*Miniopterus natalensis* (A. Smith, 1834)). SOWLER and STOFFBERG (2014) suggest the likely risk of impact from wind turbine blades on the various families of bats, due to their foraging ecologies (MONADJEM *et al*., 2010). Bats of the family Molossidae, including *T. aegyptiaca* are at a high risk of impact, Miniopterids and bats of the genus *Neoromicia* are at a medium to high risk of impact, and Pteropodids are at a medium to high risk of impact.

Between May 2014 and October 2015, 68 bat carcasses were recovered from 44 wind turbines (not the total number of turbines at the facility, but the number of turbines that had bat carcasses) from the one wind energy facility in the Eastern Cape, along the southern coastline of South Africa. Most carcasses were insectivorous bat species, however, six were frugivorous species - four *R. aegyptiacus* and two *E. wahlbergi*. Whilst data is available from other facilities, some wind farm operators are not prepared to share these results. The six fruit bat carcasses (Figures 1 to 6) were found below five different wind turbines in October 2014, March 2015, June 2015 and July 2015. It is important to note that whilst 68 bat carcasses in total were found during this period, these are unadjusted values and the number of fatalities is definitely much higher due to searcher inefficiency and carcass removal by scavengers (HUSO, 2011; HUSO *et al.,* 2012). Both of these bias variables were accounted for in the fatality estimations in the final operational monitoring report (available only with the permission of the wind farm operator).

The significance of these findings is twofold:

1) to my knowledge, despite the medium to high risk for fruit bats to be impacted on by wind turbine blades (SOWLER and STOFFBERG, 2014), these are the first wind turbine related fruit bat fatality records at a wind energy facility in the world and such fatality confirmation can assist with assessment and planning of future wind farm developments in areas where fruit bats occur; and
2) numerous large scale wind energy facilities are either already operational, in the process of being constructed or approved for construction within the distribution range of these two species. In particular, several facilities are extremely close

to known large roosts of *R. aegyptiacus* (INKULULEKO WILDLIFE SERVICES, *unpublished data*). Now that it is confirmed that *R. aegyptiacus* is susceptible to wind turbine related fatality, appropriate mitigation measures should be implemented proactively prior to impacts occurring.

R. aegyptiacus roosts gregariously in caves (MONADJEM *et al*., 2010) and roost site fidelity in cave-dwelling fruit bats is generally high (MARSHALL, 1983). In South Africa, colonies can be in the 100s or 1000s of individuals per roost. The maximum known foraging distances that they travel at night are 6.9 to 24 km (JACOBSEN *et al*., 1986; BARCLAY and JACOBS, 2011) and individuals have also been recorded to move distances of 500 km seasonally (JACOBSEN and DU PLESSIS, 1976).

E. wahlbergi roosts either individually or in small groups (up to 100 individuals) in large trees with dense foliage or in man-made structures (thatch roofs, bridges, eaves of houses) (WICKLER and SEIBT, 1976; FENTON *et al.,* 1985; ACHARYA, 1992; MONADJEM *et al*., 2010). Most roosts are found in riparian vegetation and forest edges, but some occur in savanna and wooded urban areas (WICKLER and SEIBT, 1976; ACHARYA, 1992; MICKLEBURGH *et al,*. 2008). *E. wahlbergi* has been found to move roosts in response to seasonal ripening of fruit (and possible simultaneously reducing the risk of predation), but will generally remain relatively sedentary where possible. They can travel over 13 km to and from roosting and foraging sites, with females generally moving further than males. Movement is, however, generally confined to 4 km of their day roosts (FENTON *et al.,* 1985; ACHARYA, 1992; MONADJEM *et al,*. 2010).

Whilst *E. wahlbergi* and *R. aegyptiacus* are broadly distributed and abundant and listed as Least Concern, both internationally and nationally (FRIEDMANN and DALY, 2004; BENDA *et al*., 2008), the threat of wind energy related fatalities means that fatality rates at wind energy facilities must be carefully monitored and where there are known roosts, population numbers should be monitored, with action plans put in place if multiple fatalities are observed and/ or populations declines are recorded. In addition, the conservation status of the species should be regularly updated. Fruit bats are long-lived animals with low reproductive rates and females do not give birth for the first time until they are one or two years old (THOMAS and MARSHALL, 1984). With such slow reproductive rates, rapid declines due to development related fatalities could occur.

Although there are various international conventions, unions and treaties in place for the protection of biodiversity, such as the Convention on Biological Diversity, the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), there are not many countries where fruit bats are specifically protected by national law. Ethiopia protects all members of the Family Pteropodidae, while Leschenault's Rousette (*Rousettus leschenaulti* (Desmarest, 1820)) is fully protected in Sri Lanka, as is the Greater Mascarene Flying Fox (*Pteropus niger* (Kerr, 1792)) on Réunion, Rodrigues Flying Fox (*Pteropus rodricensis* Dobson, 1878) in Mauritius, and Marianas Flying Fox (*Pteropus mariannus* Desmarest, 1822) on Guam (MICKLEBURGH *et al*., 1992). Fruit bats are not nationally protected in South Africa; though certain provinces in South Africa list certain bat species as protected or specially protected, depending on what level of utilisation is permitted for that species (hunting, selling, etc.). This is different for each province. Of relevance to the current study site is legislation related to the Eastern and southern Cape areas. The Ciskei Nature Conservation Act: Act 10 or 1987 recognizes eight protected species of bats in the Eastern Cape, including *E. crypturus* and *E. wahlbergi*.

There are detailed pre-construction (SOWLER and STOFFBERG, 2014) and operational (ARONSON *et al.,* 2014) bat monitoring guidelines in place in South Africa. Most proposed and operational facilities are adhering to these, however, not all are. I recommend that the South African Department of Environmental Affairs enforce compliance and that bat population monitoring projects at an ecoregion level are commissioned in South Africa and that, where needed, action plans are developed and implemented to avoid bat population declines.

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References

ACHARYA, L. 1992. *Epomophorus wahlbergi*. *Mammalian Species* **394**:1-4. url: www.science.smith.edu/msi/pdf/i0076-3519-394-01-0001.pdf.

ARNETT, E. B., BROWN, W. K., ERICKSON, W. P., FIEDLER, J. K., HAMILTON, B. L., HENRY, T. H., JAIN, A., JOHNSON, G. D., KERNS, J., KOFORD, R. R., NICHOLSON, C. P., O'CONNELL. T. J., PIORKOWSKI, M. D. and TANKERSLEY Jr, R. D. 2008. Patterns of fatality of bats at wind energy facilities in North America. *Journal of Wildlife Management* **72(1)**:61–78. doi: 10.2193/2007-221.

ARONSON, J., RICHARDSON, E., MACEWAN, K., JACOBS, D., MARAIS, W., AIKEN, S., TAYLOR, P., SOWLER, S. and HEIN, C. 2014. *South African good practice guidelines for operational monitoring for bats at wind energy facilities*. First edition. South African Bat Assessment Advisory Panel, Johannesburg: 17 pp. url: www.ewt.org.za/WEP/pdf/SAGPG%20for%20Operational%20Monitoring_1stEdition.pdf.

BAERWALD, E. F. and BARCLAY, R. M. R. 2011. Patterns of activity and fatality of migratory bats at a wind energy facility in A berta, Canada. *The Journal of Wildlife Management* **75(5)**:1103–1114. doi: 10.1002/jwmg.147.

BARCLAY, R. M. R. and JACOBS, D. S. 2011. Differences in the foraging behaviour of male and female Egyptian fruit bats (*Rousettus aegyptiacus*). *Canadian Journal of Zoology* **89(6)**:466–473. doi: 10.1139/Z11-013.

BENDA, P., AULAGNIER, S., HUTSON, A. M., AMR, Z. S., KOCK, D., SHARIFI, M., KARATAŞ, A., MICKLEBURGH, S., BERGMANS, W. and HOWELL, K. 2008. *Rousettus aegyptiacus*. The IUCN Red List of Threatened Species 2008: e.T29730A9527058. doi: 10.2305/IUCN.UK.2008.RLTS.T29730A9527058.en.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS. 2015. *First Quarter 2015 Renewable Energy Map*. Department of Environmental Affairs, Pretoria, South Africa. url: https://dea.maps.arcgis.com/apps/webappviewer/index.html?id=b8452ef22aeb4522953f1fb10e6dc79e (accessed May 2015).

DOTY, A. C. and MARTIN, A. P. 2012. Assessment of bat and avian mortality at a pilot wind turbine at Coega, Port Elizabeth, Eastern Cape, South Africa. *New Zealand Journal of Zoology* **40(1)**:75–80. doi: 10.1080/03014223.2012.741068.

FENTON, M.B., BRIGHAM, R.M., MILLS, A.M. and RAUTENBACH, I.L. 1985. The roosting and foraging areas of *Epomophorus wahlbergi* (Pteropodidae) and *Scotophilus viridis* (Vespertilionidae) in Kruger National Park, South Africa. *Journal of Mammalogy* **66(3)**:461-468. doi: 10.2307/1380920.

FRIEDMANN, Y. and DALY, B. [Eds.] 2004. *Red data book of the mammals of South Africa: A conservation assessment*. CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN). Endangered Wildlife Trust, Johannesburg: 1 - 716.

FUJITA, M. S. and TUTTLE, M. D. 1991. Flying foxes (Chiroptera: Pteropodidae): Threatened animals of key ecological and economic importance. *Conservation Biology* **5(4)**: 455–463. doi: 10.1111/j.1523-1739.1991.tb00352.x.

GLOBAL WIND ENERGY COUNCIL. 2015. *Global wind report annual market update 2014*. Global Wind Energy Council, Brussels, Belgium: 80 pp. url: www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf.

HODGKISON, R., BALDING, S. T., ZUBAID, A. and KUNZ, T. H. 2003. Fruit bats (Chiroptera: Pteropodidae) as seed dispersers and pollinators in a lowland Malaysian rain forest. *Biotropica* **35(4)**: 491–502. doi: 10.1646/03043.

HULL, C. L. and CAWTHEN, L. 2012. Bat fatalities at two wind farms in Tasmania, Australia: bat characteristics, and spatial and temporal patterns. *New Zealand Journal of Zoology* **40(1)**: 5-15. doi: 10.1080/03014223.2012.731006.

HUSO, M. 2011. An estimator of wildlife fatality from observed carcasses. *Environmetrics* **22(3)**: 318 - 329. doi: 10.1002/env.1052.

HUSO, M.M.P., SOM, N. and LADD, L. 2012. Fatality estimator users guide. *US Geological Survey Data Series* 729. url: http://pubs.usgs.gov/ds/729/.

JACOBSEN, N. H. G. and DU PLESSIS, E. 1976. Observations on the ecology and biology of the Cape fruit bat (*Rousettus aegyptiacus leachi*) in the eastern Transvaal. *South African Journal of Science* **72**: 270–273.

JACOBSEN, N. H. G., VILJOEN, P. C. and FERGUSON, W. 1986. Radio tracking of problem fruit bats (*Rousettus aegyptiacus*) in the Transvaal with notes on flight and energetics. *Mammalian Biology* **51**: 205–208. url: http://www.zobodat.at/pdf/Zeitschrift-Saeugetierkunde_51_0205-0208.pdf.

KAMINS, A. O., RESTIF, O., NTIAMOA-BAIDU, Y., SUU-IRE, R., HAYMAN, D. T. S., CUNNINGHAM, A. A., WOOD, J. L. N. and ROWCLIFFE, J. M. 2011. Uncovering the fruit bat bushmeat commodity chain and the true extent of bat hunting in Ghana, West Africa. *Biological Conservation* **144(12)**: 3000–3008. doi: 10.1016/j.biocon.2011.09.003.

KUNZ, T. H., BRAUN DE TORREZ, E., BAUER, D., LOBOVA, T. and FLEMING, T. H. 2011. Ecosystem services provided by bats. *Annals of the New York Academy of Sciences* **1223(2011)**: 1–38. doi: 10.1111/j.1749-6632.2011.06004.x.

LEHNERT L.S., KRAMER-SCHADT, S., SCHÖNBORN, S., LINDECKE, O., NIERMANN, I., VOIGT, C.C. 2014. Wind farm facilities in Germany kill Noctule bats from near and far. *PLoS ONE* **9(8)**: e103106. doi:10.1371/journal.pone.0103106.

MARSHALL, A. G. 1983. Bats, flowers, and fruit: evolutionary relationships in the Old World. *Biological Journal of the Linnean Society* **20(1)**: 115–135. doi: 10.1111/j.1095-8312.1983.tb01593.x.

MICKLEBURGH, S. P., HUTSON, A. M. and RACEY, P. A. 1992. *Old World fruit bats. An action plan for their conservation*. IUCN, Gland, Switzerland. doi: 10.2305/IUCN.CH.1992.SSC-AP.6.en.

MICKLEBURGH, S., HUTSON, A.M. and BERGMANS, W. 2008. *Epomophorus wahlbergi*. In: The IUCN Red List of Threatened Species 2008: e.T7906A12865054. doi: 10.2305/IUCN.UK.2008.RLTS.T7906A12865054.en.

MONADJEM, A., TAYLOR, P. J., COTTERILL, F. P. D. and SCHOEMAN, M. C. 2010. *Bats of southern and central Africa – A biogeographic and taxonomic synthesis*. Wits University Press, Johannesburg, South Africa: i - xii; 1 - 596.

PIERSON, E. D. and RAINEY, W. E. 1992. The biology of flying foxes of the genus *Pteropus*: A review. Pp. 1-17 In: Wilson, D. E. and Graham, G. L. (eds.), Pacific island flying foxes: Proceedings of an international conservation conference. *U.S. Fish and Wildlife Services Biological Report* **90(23)**.

SOWLER, S. and STOFFBERG, S. 2014. *South African good practice guidelines for surveying bats in wind farm developments: pre-construction*. Third edition. South African Bat Assessment Advisory Panel, Johannesburg: 38 pp.

THOMAS, D. W. and MARSHALL, A. G. 1984. Reproduction and growth in three species of West African fruit bats. *Journal of Zoology* **202(2)**: 265–281. doi: 10.1111/j.1469-7998.1984.tb05954.x.

WICKLER, W. and SEIBT, U. 1976. Field studies on the African fruit bat *Epomophorus wahlbergi* (Sundevall), with special reference to male calling. *Zeitschrift für Tierpsychologie* **40(4)**: 345–376. doi: 10.1111/j.1439-0310.1976.tb00941.x.

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