Commentary

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Human–wildlife conflicts in the aerial habitat: Wind farms are just the beginning

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Abstract
The aerial habitat occupies an enormous three-dimensional space around Earth and is inhabited by trillions of animals. Humans have been encroaching on the aerial habitat since the time of the pyramids, but the last century ushered in unprecedented threats to aerial wildlife. Skyscrapers, jet-age transportation and recently huge wind turbines kill millions of flying animals annually and despite substantial efforts, our detection and mitigation capabilities are lagging far behind. Given the situation, our readiness to handle the impact of millions of drones buzzing through the sky carrying batteries, payloads and soon also people, is questionable at best. In radar aero-ecology, radars are used to document and analyse animal movement high above the ground, opening a hatch to ecological processes in the aerial habitat. Differentiating bats from birds, a simple task at ground level, was impossible aloft, which limited our ability to study and characterise high-altitude bat behaviour. Many high-altitude infrastructure developments around the world were thus planned and executed with no regard to possible impacts on bats and caused millions of bat fatalities. BATScan, the first automatic bat identifier for radar, demonstrates how artificial intelligence can be implemented together with ecological insight to solve basic scientific questions and minimise negative human impact on natural habitats. We demonstrate a facet of the complexity of bat aero-ecology using the Israeli BATScan database and substantiate the claim that activities taken by the wind energy industry to minimise bat mortality may prove limited and leave bats unprotected. We further discuss upcoming challenges in the face of a forthcoming transportation revolution that will change the human–aerial wildlife conflict from a conservation concern to a major human safety issue.

Keywords
Radar, bats, aero-ecology, wind energy, conservation, machine learning, UAV, drones

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A threatened habitat

The aerial habitat is defined as the atmospheric layer in which biological phenomena occur, from treetops up to 11 km above ground for the highest flying vertebrates.[1,2] Countless creatures exploit the aerial habitat for basic functions, many of which directly and indirectly affect terrestrial ecosystems and human activity.[3–5] As humans reach ever higher into the sky, the human–wildlife conflict takes its toll on this relatively unscathed environment.[6] Taking to the skies seems to be an obvious solution for fulfilling many basic human needs in an era of extreme population expansion and accelerated technological advancements. Our ability to fulfil increasing demands for energy, transportation and accommodation at ground level is diminishing due to dwindling resources, competition for space and population increase. These pressures make vertical expansion, despite its inherent difficulties, a valid and even favourable avenue of development in many fields of human activity.[7] This rapid increase in human presence encroaches on the aerial habitat, home to complex and delicate ecosystems that we know very little about.

The human–aerial habitat conflict was widely acknowledged with the accelerated expansion of the wind energy industry. As turbines got taller and became abundant, their impact on wildlife could not be ignored. Turbines kill millions of birds and bats every year, destroy habitats and disrupt spatial connectivity.[8–10] As the extent of the damage became clear, strict regulations were applied in many countries, and new facilities now require preliminary surveys, monitoring during operation and mortality mitigation programmes.[9,11] Unfortunately, thousands of turbines are still badly placed, monitoring is limited in scope and accuracy, and mitigation measures are not as efficient as they should be.[6,12,13] If we are to learn from faults made during the rise of the wind energy industry, now is the time to critically observe drone transportation and its place in the aerial habitat.

Unmanned aerial vehicles (UAVs), commonly known as drones, are the next 'big thing' in human–aerial habitat interaction. Birds were already shown to respond to drone presence in various ways with some even attacking the machines,[14,15] a very unwelcome response which indicates stress and may lead to collisions. Apart from the obvious detrimental effects of direct mortality on populations and communities, increased levels of stress associated with UAV disturbance[16] are likely to cause cascading physiological reactions. Such reactions to space use-related stress were shown to negatively impact immune response, reproduction and general health in various species of bats.[17,18] These are basic organismal processes, and their impairment is likely to entail long-term changes in population demography, community structure, etc.[19]

Drone use is rapidly increasing due to ease of operation and affordability, and the technology is utilised for a variety of purposes all over the world. Drones are constantly becoming bigger and faster, and are expected to herald a new era of human transport.[20,21] Many large-scale development plans include UAV flight routes, parking spaces and other infrastructure. That being said, drones pose an unprecedented challenge for both humans and animals utilising the sky. Unlike aeroplanes and helicopters, they are small enough to be critically damaged even by small birds but are rapidly becoming large enough to cause serious damage if brought down. Encouragingly, unlike modern jet aircrafts, even the fastest drone prototypes being tested today are slow enough for potential active preventatives to be efficient. These preventatives would have to be mounted, activated and controlled onboard the vessels themselves because it will be impossible to maintain any constant physical infrastructure around future ‘drone highways’ in the sky. Efficient preventatives would have to compound meteorological and ecological information into real-time risk management that would either control active deterrents or manage flight routes. These ‘highways in the sky’ will soon become reality, and it must be made clear that both animal and human safety is on the line.

For wind turbine-related mortality mitigation, curtailment at times and weather conditions when flying animals are active around windfarms and at risk of collision is considered the most efficient way to prevent collisions.[6,22] Operators set operation rules, usually related to season or wind speed, based on which turbine cut-in speeds (minimal wind speed for power generation) are raised to reduce rotation-wildlife activity overlap. Feathering (turning turbine blades to an angle that prevents rotation) is usually done at lower windspeeds (3–6 m/s) when energy yields are low and wildlife activity is high.[23] These mitigation regimes are based on scientific insight and on-site surveys, both of which often rely on near ground observations. As such, they risk oversimplifying the intricate aerial ecosystem and neglecting crucial aspects of animal behaviour.

In Werber et al.’s study,[24] we describe the construction and implementation of an artificial intelligence (AI)-based bat identification tool for the BirdScan MR1 vertical looking radar (https://swiss-birdradar.com/), and the resulting Israeli BATScan database (63,630 bat detections in the airspace). The BirdScan MR1 is a dedicated animal radar formerly only capable of identifying birds and insects.[25,26] We used the Israeli BATScan database to visualise the risk of using oversimplifying rules in mitigation programmes by comparing local and regional scale bat abundances across two major weather gradients.

Bat activity densities, aggregated over the entire radar detection range for bats (100–800 m above ground), were plotted relative to temperature and windspeed, taken from ECMWF’s ERA5 reanalysis.[27] The average density across all sites was overlayed over the specific density in each site (Figure 1), presenting a simple visual comparison of local and regional activity patterns. The plot clearly demonstrates high variability across sites (many of which are geographically adjacent and ecologically similar) and varying levels of mismatch between local activity patterns and the average pattern. The aggregation of observations across altitudes omits local variation across the vertical dimension, which may further accentuate the discrepancy. Peak local density in charts 1 (Northern Golan) and 3 (Eastern Upper Galilee) are completely different from the average, and if average-density-based mitigation schemes were to operate in these locations bat mortality would not be efficiently prevented. The average-local overlap is not complete for other sites as well, which would either cause bat activity to go unprotected (6,8,10) or result in unnecessary losses and inefficiency due to unneeded turbine feathering. We note that most bat activity in Israel does occur below wind speed of 6 (m/s), but local activity ranges are mostly narrower and largely temperature dependent.

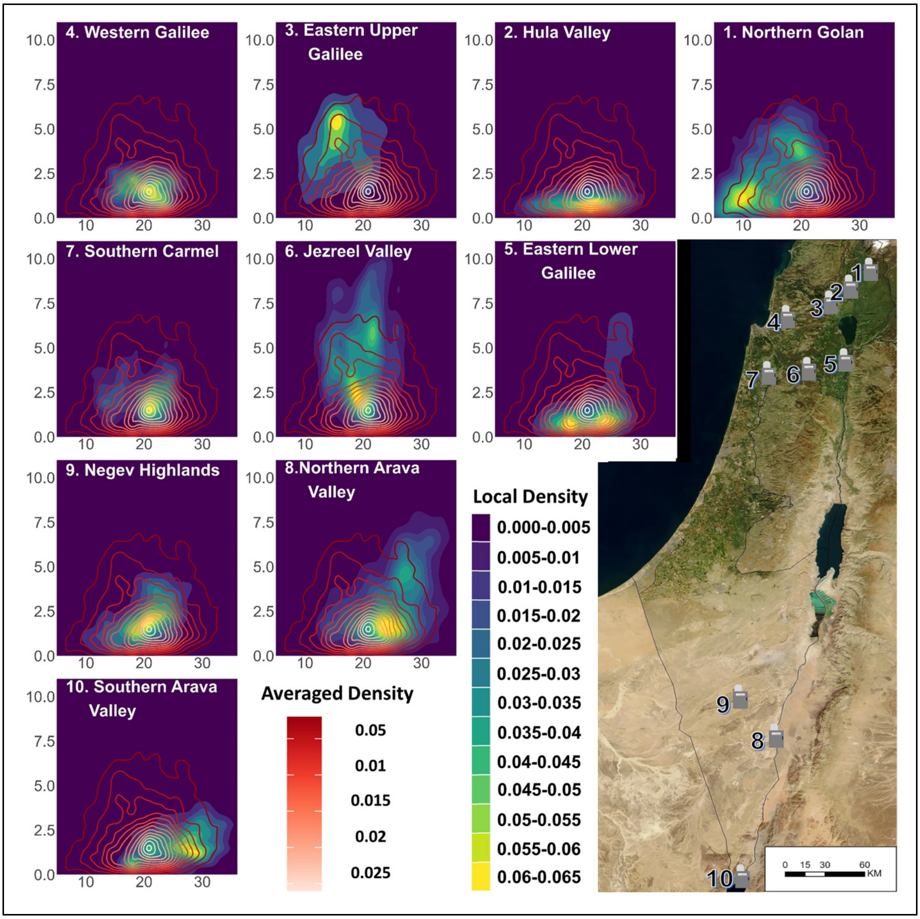

Figure 1. Bat activity densities (proportion of bat detections in different temperature/wind speed combinations) across temperature in celsius (*x*-axis) and wind speed in metres/second (*y*-axis) in 10 radar monitored sites in Israel. Each panel portrays the overlap between local activity density (blue-yellow shades) and total averaged density (red contour lines). Radar deployments were made in 10 locations covering a wide variety of habitats including mountainous (1,3), Wetland (2), Mediterranean (4–7) and desert (8–10).

Conclusion

What we see from the ground as ‘clear blue skies’ is actually a highly complex, constantly changing ecosystem that we are still largely unequipped to understand from our terrestrial vantage point. This fact should be kept in mind as we extend our reach further, faster, and bigger into the aerial habitat. Our preliminary analysis shows that ‘rule of thumb’ aerial wildlife mortality mitigation programmes (like feathering turbine blades at wind speeds between 3 and 6 ms) may only be efficient to a limited extent. Their implementation under legislative approval implies that decision-makers regard such approaches as sufficient for conservation purposes. However, the observed margins of error are unlikely to be acceptable in a future scenario of UAV-based human transportation, as it will put human lives, not just wildlife, at considerable risk. Such developments would have to be supported by accurate monitoring capabilities, currently only achievable using radar-AI combinations.

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