Mammals and a changing climate

We have just witnessed the warmest year on record, not only in the Netherlands, Belgium and Europe, but worldwide. Average global temperatures have now been increasing year on year for more than thirty years. But how should we react to this phenomenon? With concern or by enjoying it? Few people complain about spring temperatures in winter, or a walk on the beach in a t-shirt and shorts in early November. True, in the Netherlands, there were complaints about the month of August last year, the only month that was cooler, and wetter, than average; and about the absence of snow and ice in winter, frustrating (yet again) the dream of many an ice skater to participate in the *Elfstedentocht*. But generally, people seem to feel more than comfortable with the conditions they know from their holiday destinations further south and with lower gas bills.

Years with record high temperature averages, such as those in Europe (2014), Australia (2013) and North America (2012), are not solid proof of a changing climate. They may be coincidences, like all extremes. But the bigger picture has convinced most scientists and non-scientists that, worldwide, our climate is indeed shifting towards higher average temperatures and more extreme weather. In the Netherlands, climatologists expect a further temperature rise (i.e. milder winters and warmer summers) and the increased probability of extreme rainfall (KNMI 2014).

Climate change might affect animals and plants in a number of ways, but primarily through three mechanisms: (1) spatial changes: shifts in distribution area, including local extinctions near the edge of a species' distribution and changes in abundance, (2) temporal changes: timing of breeding, flowering, hibernation, etc. (phenology), and (3) erratic effects caused by extreme events such as hurricanes, flooding and wildfires.

The effects of climate change on birds and butterflies have been relatively well-studied. We are familiar with the studies of migrating birds arriving in their breeding territories too late to catch the insect peaks, leading to a decreased breeding success. Birds, butterflies and other insects have been shown to have become locally extinct in parts of their former areas of distribution, due to changing climate conditions that they can't cope with. But they also profit from warmer conditions, and expand their ranges into new areas where the climate is becoming more suitable (e.g. the swallowtail *Papilio Machaon* expanding into the Netherlands and Belgium).

So far, nearly half of the mammal species studied don't seem to have yet shown a response to climate change. Of the half that do, some are responding positively with increasing distribution ranges (usually in the direction of the poles or towards higher elevations), population sizes, or growth rates. Other mammal species, however, are and will be negatively influenced by climate change. These include primate species in the tropics as well as marine mammals, including the polar bear, which rely on the presence of sea ice in the arctic.

Levinsky et al. (2007) used two different models to assess extinction risks of European mammals, based on different assumptions about species' ability to disperse. In the first model, which assumed that the species were able to disperse with no restrictions, they predicted that 1% of the 120 terrestrial, non-flying, mammal species in Europe are at risk of future extinction and 32–46% may be severely threatened (i.e. lose > 30% of their current distribution) through climate change. In the second model, which assumed that none of the species are able to expand their range the figures were 5-9% and 70–78% respectively. Obviously, in reality, most species will fall somewhere between these two extremes.

One of the most important constraints on mammals' movements is that, as opposed to birds and insects, the majority of mammal species can't fly. Their movements over land are slower, or may be constrained by barriers. As such, expansion towards new territory isn't that easy for most mammals, especially if the habitats are fragmented. In a study of 493 mammals currently present in the Western Hemisphere, Schloss et al. (2012) compared the velocities at which species will probably need to move in order to keep pace with expected changes in suitable climates with the speeds at which they are able to disperse. According to their analysis, up to 39% of mammal species will not be able to keep up with climate change; 87% of the species are predicted to have smaller distribution ranges, and 20% of these range reductions are likely to be caused by the mammals' limited dispersal abilities.

Therefore, dispersal limitation is an important factor for any species that has to cope with climate change. Flexibility may be another one. Species that are able to enlarge the range of temperatures and humidity they experience by modification of habitat choices, timings of key activities, and temperature regulation may be less vulnerable to climate change than species which do not have those options. McCain & King (2014) reviewed 73 North-American mammal species and found that mammals that were active only during the day or only at night were more vulnerable to climate change than mammals having flexible activity times. Some small mammals may be able to escape from climate change by using a wider array of micro-climates available in the vegetation and soil. Such areas and conditions are not available to bigger mammals, which live above the vegetation and only experience ambient temperatures.

So, when it comes to mobility, large mammals seem to have the benefit, but flexibility seems to be in favour of the smaller mammals.

In the Netherlands and Belgium, last year's very mild winter, early spring and warm autumn have brought benefits and disadvantages to plants and animals. Some mammals may have benefited, for example by the high food availability in the colder months. This possibly explains the overabundance of voles (Arvicolinae) in 2014, especially in agricultural lands in the northern Netherlands. Others, such as bats, were able to store fat for a longer period in autumn, increasing their chances of surviving the winter. In the Oostvaardersplassen, one of the Netherlands' most treasured nature reserves, the populations of large herbivores (i.e. red deer, Heck cattle and koniks) started to increase again in 2014; after years of severe winter starvation, their winter survival rate was much higher. This is a fenced area, so the grazers cannot expand their territory when the population densities increase, making the Oostvaardersplassen less of a natural ecosystem than some want us to believe (see also Canters & Verboom's editorial in *Lutra* 56 (2)). The debate on this is one of the subjects of the paper by van Vuure in this issue. He discusses the konik, a breed of horse that is commonly put out as a grazer in nature reserves in the Netherlands, and its supposed relation to the extinct wild horse.

In another paper in this issue, Piza Roca et al. review the current literature on the environmental factors that determine the distribution of European badgers. If we want to understand how climate change might influence badgers, it is necessary to know these factors and their relative importance. Earthworms, one of the badgers' main food items, play a key role here, and climatic features are one of the factors that determine earthworm abundance. A future climate with periods of drought alternated with periods of heavy rainfall might have a negative effect on the availability of earthworms to badgers.

One of the consequences of climate change is the future invasion of non-native species that can survive in areas which, formerly, had an unsuitable climate (see also Canters' editorial on 'moving mammals' in *Lutra* 56 (1)). Some of these new species compete with native species, with possible negative consequences. This seems to be the case with the American mink, although this mink invaded our countries after having escaped or been released from captivity. In their study on American mink in the Czech-Moravian Highlands, Hlaváčová & Hlaváč used different methods, including telemetry and camera trapping, to monitor several of these animals. Their findings on its spatial behaviour and reproductive biology help us to further understand this invasive species and its possible negative effects on the populations of native endangered animals.

Readers may be surprised by the findings of Lagerveld et al., who performed a pilot study of bats on offshore wind farms in the North Sea. Nathusius' pipistrelles was commonly recorded, albeit only in favourable weather conditions, by the ultrasonic detectors that were installed in two marine wind parks. These bats were probably migrating to suitable wintering areas.

We live in exciting times with many opportunities and threats ahead of us. Many of these are unknown and will be unexpected, but for scientists, they at least provide plenty of challenges.

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KNMI 2014. URL: http://www.klimaatscenarios.nl/images/Brochure_KNMI14_NL.pdf

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