The North Atlantic Oscillation and UK butterfly populations

The North Atlantic Oscillation (NAO) is a natural climate fluctuation that has a considerable influence on the weather in Scandinavia, western Europe and the Mediterranean. The NAO influences the direction of travel of autumn and winter storms and depressions across the North Atlantic and has been shown to have an effect on a range of species as diverse as Red Deer, Soay Sheep, Cod and marine Copepods. Here we consider whether the NAO can also control the population size of butterflies in the UK.

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Title credit: *Pieris napi* on dead nettle. Photo: Robert Thompson/NHPA

The North Atlantic Oscillation is described by the NAO index, a number calculated from the difference in air pressure between Iceland and the Azores, Lisbon or Gibraltar – the choice of the location of the southern climate station makes little difference (Osborn, 2000). It is possible to obtain published NAO indices that are monthly, annual, winter (January to March) and extended winter (December to March). We used the NAO indices from the Climate Research Unit at the University of East Anglia, UK (2004).

The NAO index can be positive or negative. A positive NAO index is associated with depression systems taking a more northerly route across the Atlantic, with warmer and wetter autumn and winter weather in the UK. A negative NAO index is associated with drier and cooler weather as the depression systems travel in a more easterly direction, resulting in higher precipitation in the Mediterranean basin (Osborn, 2000). While the NAO predominantly controls autumn and winter weather in the UK, there are correlations between the NAO index in the winter and weather in the spring and summer (Westgarth-Smith *et al*, 2005b). It is possible that the mechanism for this control of summer weather is via sea surface temperature as North Atlantic sea surface temperature in January and February can be used to produce a forecast, issued in March, of temperature and rainfall in north-west Europe during the subsequent July and August (Meteorological Office, 2003). Correlation coefficients between the NAO index and temperature are stronger than with precipitation.

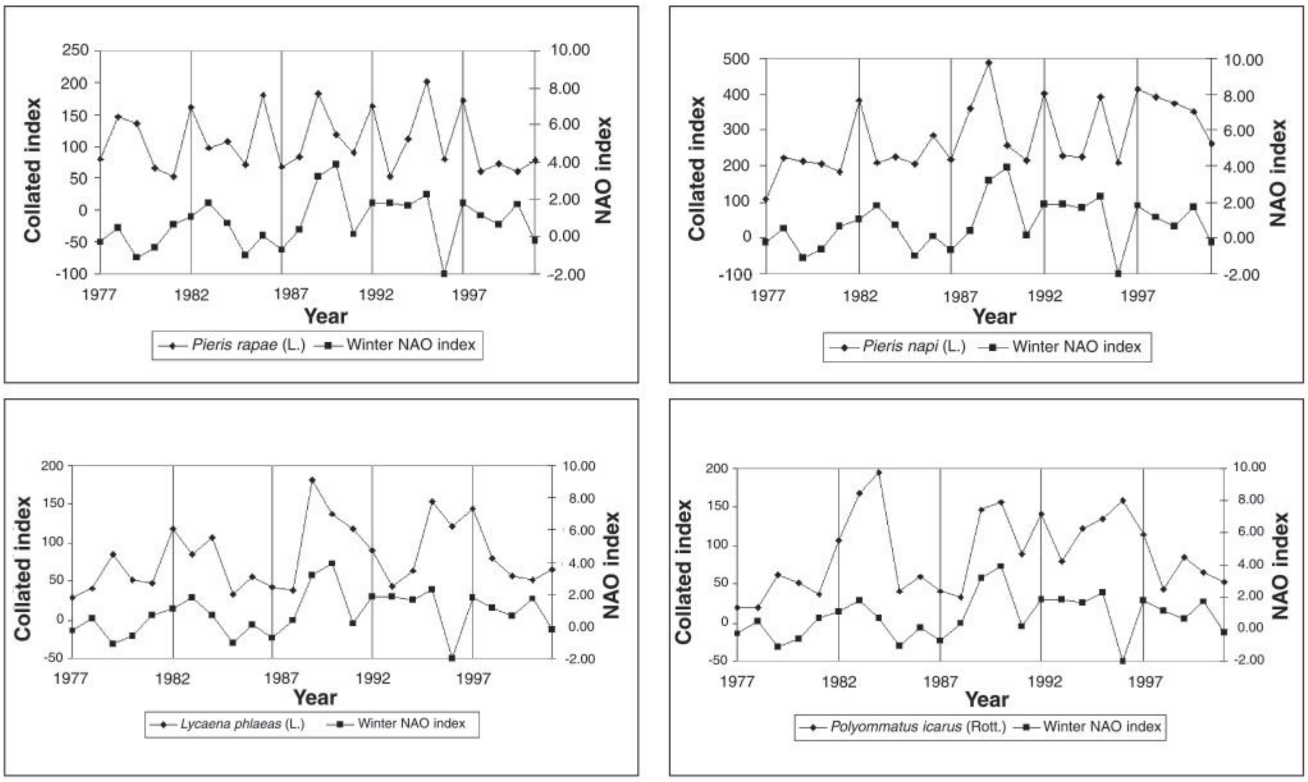
We have examined the effect of the NAO on UK butterfly populations. The UK has an excellent long-term database of butterfly population size, known as the Butterfly Monitoring Scheme (BMS), which is co-ordinated by staff at the Centre for Ecology and Hydrology (CEH) at Monks Wood, Cambridgeshire. This survey, which started in 1976, involves weekly monitoring of butterflies at 130 sites throughout the country using transect counts (Greatorex-Davies, 2003; and Pollard and Yates, 1993). A transect count means that an observer walks a standard route, or transect, counting the butterflies seen within a 5 metres by 5 metres *quadrat*. This quadrat is an 'imagined' box that moves with the observer. The weekly data from all the sites is then converted into an annual collated index – a number that describes the total annual population size of each species.

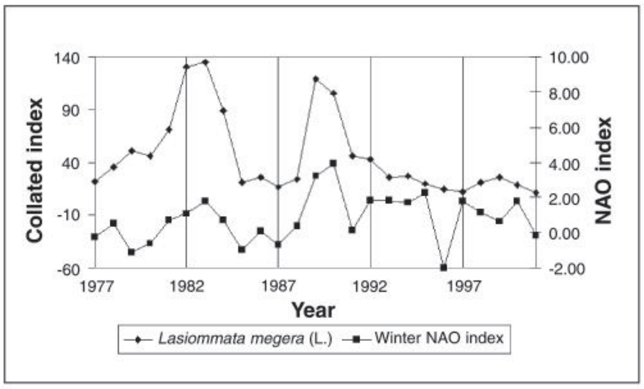
Significant correlation

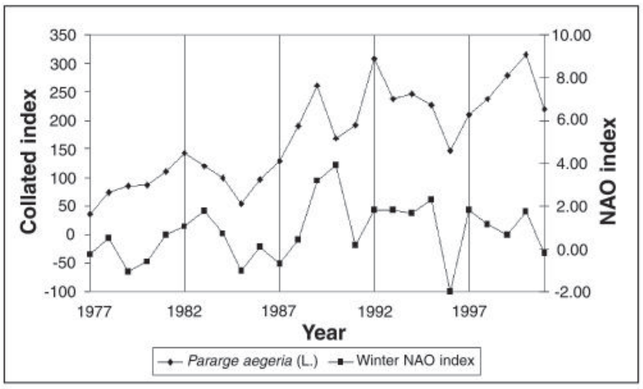
There are significant correlation coefficients (Figure 1) between the winter NAO index and the population size of some UK butterfly species. Theoretically, it is possible to calculate this NAO index by the end of March and as a result it may be possible to predict the population size of some butterfly species before they have even started flying. Furthermore, species that are more likely to be of conservation concern tend to be negatively correlated with the NAO index (Westgarth-Smith *et al*, 2005a). As such, if in the future meteorologists can predict long-term trends in the NAO, it may then be possible to predict which species will be of most concern to conservationists.

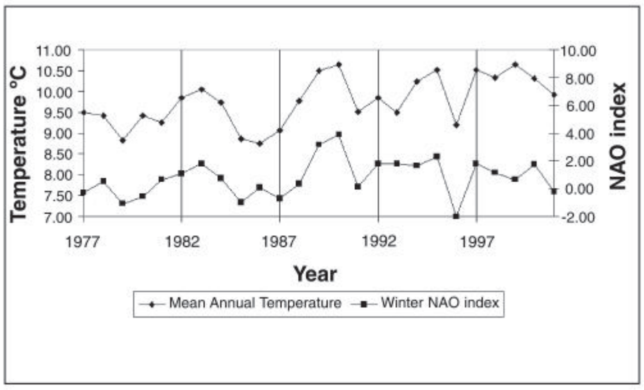
Species of butterfly that are more positively correlated with the NAO index are more likely to undergo two generations per year and tend to have more months in the year when the adults can be seen flying, presumably because positive NAO

Figure 1. Graphs showing the annual collated index for six species of butterfly and mean annual temperature for the period 1977-2001. Each graph includes the winter NAO index for comparison. The table gives the Pearson correlation coefficient and probability (*P.*) value for the correlations between the annual collated indices and mean annual temperature with the winter NAO index. Mean annual temperature data from Manley (1974) and Hadley Centre (2003). Continued on opposite page.









	Pearson correlation coefficient with winter NAO index	*P.*
Pieris rapae	0.390	0.054
Pieris napi	0.533	0.006
Lycaena phlaeus	0.491	0.013
Polyommatus icarus	0.462	0.020
Lasiommata megera	0.446	0.025
Pararge aegeria	0.553	0.004
Mean annual temperature	0.771	<0.001

indices are associated with warmer years allowing more time to complete two generations (Westgarth-Smith *et al*, 2005b).

Different species of butterfly over-winter in different stages of their life cycle (Pollard and Yates, 1993). However, butterflies that over-winter as adults seem less likely to be influenced by NAO controlled weather (Westgarth-Smith *et al*, 2005b). This may be due to adult butterflies having completed their development by late summer of the previous year, so their food requirements are low, whereas species that over-winter as larvae will often feed in warmer winter weather.

There is some evidence that the population size of species that have black larvae or black basal wing areas are independent of the effect of NAO controlled weather. This might be explained by these species using their dark colour to thermoregulate (Westgarth-Smith *et al*, 2005b). It is known that melanin can be used to absorb solar radiation to raise the body temperature of larvae (Bryant *et al*, 2002) and – used in conjunction with behavioural adaptations such as moving in and out of the shade and adult basking with the wings open – would provide a partial independence from fluctuations in ambient temperature.

Furthermore black objects radiate infra-red energy faster than paler objects (Duncan, 1975), giving further potential for controlling heat balance. The possibility that some species of poikilotherm might be able to use their melanic colouration to become independent of the NAO, which is a major fluctuation in UK weather, is exciting as this might present a mechanism for mitigating the consequences of another longer term climate trend, namely global warming.

Understanding the influence of weather

Since the Butterfly Monitoring Scheme was started in the mid-1970s, tremendous foresight and dedication has been required to maintain records for nearly 30 years. There is still much work to be done on understanding the effect of weather on organisms, both in terms of analysing existing data and in developing other long term surveys of insects and other groups of organisms in this country and abroad.

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Common Blue Butterfly, *Polyommatus icarus*, on Clematis alba in Wales.
Photo: Steve McWilliam

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