Effect of climatic warming on the flight periods of Irish macro-moth species

Bridget O'Neill*and Alison Donnelly

Centre for the Environment and Department of Botany, School of Natural Sciences, Trinity College Dublin, Ireland

*oneillb6@tcd.ie

Abstract

Global temperatures are increasing due to anthropogenic-driven climate change. This increase in temperature has been shown to effect the phenological phases of plants and birds in Ireland, but little is known about the effect on the phenophases of Irish insects. Observation records of the flight periods of 58 common species of Irish macro-moths were obtained from a public monitoring group, MothsIreland. These participants have been monitoring moth activity from eight to 36 years. Statistical analysis by generalized additive models (GAMs) showed that 29 out of 58 species are emerging earlier in the year now than when observation began in 1974 and that 25 out of 58 species have a longer flight period. These changes varied across the country and were correlated with raising temperatures, primarily in the late spring/early summer. We discuss the implications for these species, and the possibilities of potential mismatches with their food plants and predators if warming as predicted.

Methods

Fifty eight moth species were monitored nightly with the help of backyard light traps (Table 1). There were 14, eight, 36, and 13 years of observations recorded between 1974 and 2009 at Raphoe, Ashford, Tramore, and Cork respectively (Fig. 1). From the nightly counts, first, last, and median date of observation, total flight period and total numbers were calculated for each species and year. Each of these flight parameters for each species and site were weighted by total numbers observed and analyzed by generalized additive models (GAMs) in relation to year. Relationships between each parameter for each species at each site and temperature (monthly (January-December) maximum, minimum, and mean air temperature at each site) were analyzed by Pearson correlations.

Results

Of the 58 moth species observed, 29 are emerging significantly earlier in the year now than they were at the start of the various study periods (1974-2002). 25 species have a significantly longer flight period now than they had at the beginning of the study periods as well. Focusing on one of these species, *Noctua pronuba* (Fig. 2) is emerging earlier and flying longer at three of the four study sites (Fig. 3). The changes in this species' phenophases are correlated with mean, max. and min. temperatures in various months, largely dependent on what part of the country the species was observed in (Tables 1 and 2). As a larvae, this species feeds on grass roots and overwinters before pupating in the spring. Adult emergence and flight period depend on temperatures beneficial to grass growth in the summer for early larval feeding (Tramore and Cork sites) and on temperatures beneficial to larval survival in the winter and early spring (Ashford and Raphoe sites).

Figure 1 - Locations where moth observations were taken

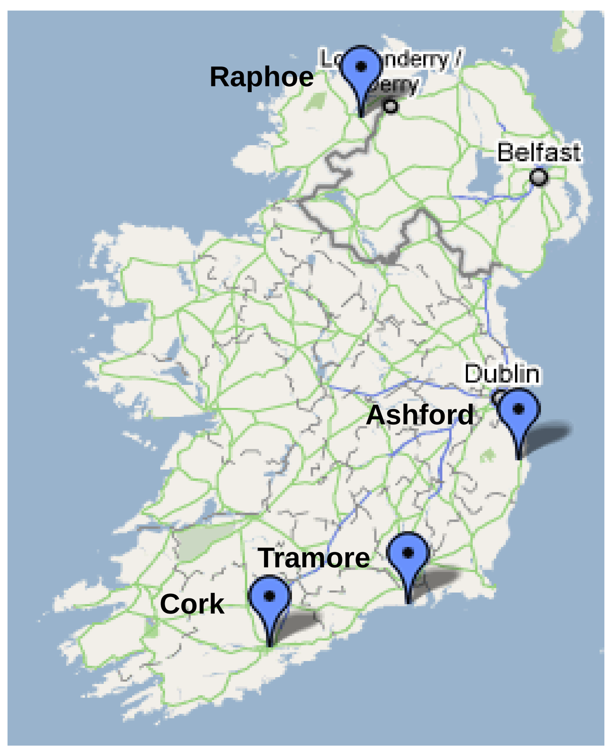

Figure 2 - One of the species showing longer flight periods, *Noctua pronuba.*

Figure 3 - First sighting (left) and flight period (right) for *Noctua pronuba* observed in Tramore. Both are significant at the P = 0.05 level.

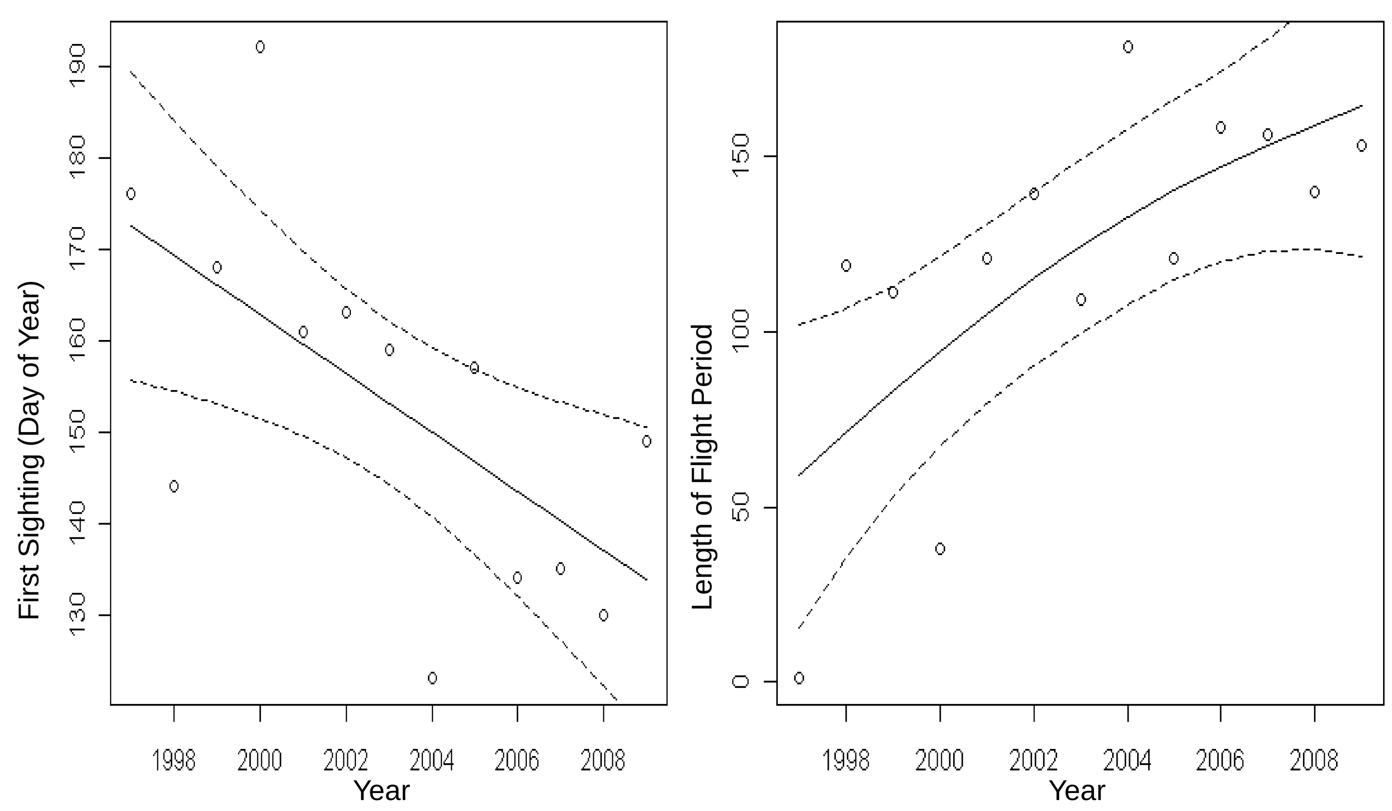

Table 1 – Some of the correlations for the relationships between date of first sighting and monthly temperatures for *Noctua pronuba* (significant correlations in bold).

Monthly Temperatures	Ashford	Raphoe	Tramore
Feb mean temp °C	**.825**	-.024	.139
Feb mean min temp °C	**.897**	.082	.099
May mean temp °C	-.612	**-.599**	-.466
May mean max temp °C	-.692	**-.659**	-.315
June mean temp °C	.252	-.004	**-.663**
June mean max temp °C	.074	.062	**-.609**
June mean min temp °C	.405	-.072	**-.632**
Jul mean temp °C	-.456	-.022	-.079
Jul mean min temp °C	-.647	-.196	-.221
Sept mean min temp °C	.341	**-.569**	-.370
Dec mean min temp °C	**.877**	-.234	-.275

Table 2 – Some of the correlations for the relationships between length of flight period and monthly temperatures for *Noctua pronuba* (significant correlations in bold).

Monthly Temperatures	Cork	Raphoe	Tramore
Jan mean max temp °C	.053	-.235	**.646***
Feb mean max temp °C	.240	-.165	-.238
March mean temp °C	**.473***	.007	-.516
March mean min temp °C	**.424***	.033	-.459
March mean max temp °C	**.493***	-.020	-.488
May mean min temp °C	**.505***	.318	.304
June mean max temp °C	-.033	.075	.567
Aug mean max temp °C	.043	-.006	-.072
Sept mean temp °C	.267	**.534***	.464
Sept mean min temp °C	.276	**.611***	.274
Oct mean min temp °C	.254	**.502***	.027

Introduction

Recent changes in global climate, such as increasing temperature, have had notable effects on the phenology (timing of life cycle events) of plants and animals. The effects are variable across habitats and between species, but increasing temperatures have been shown to advance certain key phenophases of insects, such as first sighting in the spring after winter dormancy. Moths in particular are a useful species group to monitor for these changes. They are an important food source for birds and mammals, they can be important pollinators, they can be important crop pests, and they are attractive to humans. Because of this, observations of moths are readily recorded and are available for analysis.

Discussion

In general, the longer the time series, the more species are exhibiting a phenological change. There are more changes in first and median sighting recorded in the longer time series while more changes in last sighting recorded in the south of Ireland. The majority of significant changes are correlated with temperatures in late spring and early summer as opposed to early spring as is often found for plants. There are several phenological mismatches possible. Earlier adult emergence than the food source for the larvae could lead to potential larval starvation or slower growth as food plants may not be in the appropriate stage for feeding upon. Earlier adult emergence could also lead to mismatches with endangered predatory bats that depend on moths to replenish their fat stores after hibernation. More research is required for accurate predictions for this system.

Acknowledgements

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