**Moth populations and bad weather – four speculative observations** (published in *Entomologist's Record and Journal of Variation* (2013) **125**: 33-37. Minor style/format corrections may have been made by the Editor)

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There is no doubt in my mind that fifty years ago substantial defoliation of more than just spindle and bird cherry trees was not really unusual; that the regular cleaning of car headlamps and even radiator grills was necessary in summer; that garden buddleia and valerian were always plastered with butterflies and other insects practically the whole summer long; and that an open lavatory window with the light left on made a reliably high-yielding moth trap. These things seemed fairly constant, though I suppose it is possible that my memory has dumped the bad years. If I never again experience the (quite noisy!) steady rain of caterpillar faeces falling from oak woodland canopy in spring, or myriad moths fluttering in the car headlights down every country lane, it is because various long term trends over the past half century (unrelated to global warming *per se*, albeit with similar roots) have progressively made Britain unsuitable for high populations of most species of Lepidoptera. However, there are also shorter-term effects (that is, ones that may not persist) that result simply from runs of unsuitable weather. Whether or not it is right to categorise recent events as aspects of real climate change (and even then, whether or not as a consequence of global warming), such runs are not new and are to be expected simply on a stochastic basis. So optimists can say they may not last – though there is no denying that in the past the British environment has undoubtedly presented much more favourable conditions for moth and other insect populations to recover than at present.

My main interest in Lepidoptera is as hosts for parasitic wasps, so I habitually try to collect caterpillars, leaf mines, etc. in bulk in order to rear these fascinating and little-studied insects. Often, in order to obtain livestock of particular parasitoids for experiments, I have collected the same species of common Lepidoptera caterpillars over several years, sometimes witnessing declines and even local extinctions of species apparently as a result of abnormal runs of unsuitable weather. This has led to a few observations and ideas that might be worth sharing, although unfortunately I had not usually collected the kind of quantitative data that would raise my recollections and comments above being merely anecdotal and speculative.

## (1) Effect of cold springs on overwintered adults.

In the early part of summer 1980, a few weeks after coming to live in Scotland, I was able to collect larvae of the choreutid moth *Choreutis pariana* (Clerck) in the southern Edinburgh suburbs in sufficient numbers to assess not only its parasitoid complex, but also its distribution across the various rosaceous trees and shrubs present (it was found on six species in four genera, and was used by several species of parasitoid:

Shaw, 1984). This day-flying moth overwinters as an adult in both sexes, and depends on spring warmth for the crucial activities of feeding, mating, and maturing and laying its eggs. The population had been known in the area for many years (E. C. Pelham-Clinton, pers. comm. in 1980), and there are published records of it from as early as 1857 (Logan, 1958) traceable via the Scottish Insect Records Index (cf. Shaw, 1987) maintained at the National Museums of Scotland (NMS), as well as Edinburgh specimens in the NMS collection from 1950 and 1956 (*A. B. MacNicol*), and probably also from various occasions in the first half of the 20$^{th}$ century (*R. F. Logan*, *K. J. Morton*) but these lacking clear data.

Following my survey there was a run of particularly miserable springs in the mid 1980s, which were particularly short of sunshine, and by 1987 (when I next looked) it was not possible to find any evidence of the larvae of *C. pariana* even on its most favoured tree (*Malus*). This situation has persisted to the present (I still search briefly for it every year), and it is clear that a local extinction took place, almost certainly coincident with the consecutive run of adverse springs. Perhaps recolonisation will eventually occur, or perhaps there is no longer a nearby population able to access the Edinburgh suburbs.

The butterfly *Gonepteryx rhamni* (Linnaeus) has a life cycle broadly similar to that of *C. pariana*, and during the same run of cold and sunless springs its population in the places that I regularly visit in the Morecambe Bay area of S. Cumbria and N. Lancashire seemed also to suffer badly, though fortunately without being extinguished.

**(2) Effect of cold springs on common early-feeding arboreal caterpillars.**

For several years, sporadically between 1989 and 2007, I used to beat various hedges in May, mainly concentrating on blackthorn and to a lesser extent hawthorn, in S. Cumbria/N. Lancashire in order to collect caterpillars of (especially) the geometrids *Operophtera brumata* (Linnaeus ) and *Theria primaria* (Haworth ), both of which supported parasitoids that I needed for a succession of experiments that lasted several years. These moths have flightless, non-feeding females and do not depend on good spring weather for mating and oviposition, as that precedes bud-burst. However, female flightlessness does mean that local movements and hence replenishment of populations tend to be sluggish.

During the years from 1989 to about 1994 there was no difficulty in finding good numbers of these (and other) caterpillars at the right time in May, but from about 1995 onwards (and the phenomenon persists to the present time in that area) the populations in exposed hedges declined so strongly that by 2003 it became commonplace to beat for up to ten minutes or even longer between finds of any kind of caterpillar. (No, I wasn't always beating in the same place!) Although some of my sites were field hedges, the general area in which I was collecting was almost devoid of arable crops (and some sites were on Nature Reserves), so there seemed little reason to blame agrochemicals for the decline; and, indeed, populations of later-feeding caterpillars that I was also collecting, such as the geometrid *Lomaspilis marginata* (Linnaeus) feeding on *Salix* in the same sites in July and August, seemed relatively unaffected.

It was only when in 2003 I beat along a hedge adjoining the busy A6 road on one side with a bustling factory on the other that I felt I understood the phenomenon.  Here the populations of the various early-feeding caterpillars, including *O. brumata* and *T.*

*primaria*, had not suffered the same catastrophic decline, and in fact were as high as I had remembered their being of old, in strong contrast to quieter hedges. A logical explanation seemed to be reduced bird predation compared with elsewhere, as a result of continuous daytime disturbance. There had been a recent and more or less continuous run of cold springs, and the time needed for the caterpillars to become fully grown and leave the birds' foraging arena would have been prolonged by that, such that the consistent predation pressure from (endothermic) birds would have had an enhanced impact on the (exothermic) insect populations in areas in which the birds were not deterred. After a run of such springs, a really major decline was apparent where birds could be fully active. (It is also possible that the hedge between the road and the factory was made significantly warmer, allowing faster larval development and a better escape from predation in that way too).

Indeed, this sort of effect seems likely to be a major factor in the climatic limits of distribution for many insects that need to feed in situations in which they are vulnerable to predation by vertebrates – if it isn't warm enough to feed up quickly, predation levels may simply be too high for a population to persist. In this respect bird predation might also have contributed to the declines mentioned in (1) above.

**(3) The effect of wet foliage on particularly small adults?**

During the early and mid 1970s I was part of a project based at Manchester University that surveyed the parasitoids of arboreal leaf-mining *Phyllonorycter* (Gracillariidae) species (Askew & Shaw, 1974). For this, moderately large samples of the host mines were collected from various trees at many sites, largely in N. W. England, and it was generally found possible to collect large samples, at least of the commoner species, just about everywhere we tried. Indeed, one sampling programme involved collecting at least 90 *Phyllonorycter* mines from each of oak and birch at the same site twice a week (from mid-June to mid-October), which – even in the sparser first generation – was easily accomplished within a couple of person-hours, and we simply moved our pitches on a few yards on successive occasions, with no real worry that our sampling was heavy enough in relative terms to distort the populations of the insects we were studying (Askew & Shaw, 1979).

It so happened that in 2012 I made a promise to others to try to collect and rapidly preserve several individuals of the exothecine braconid wasp *Colastes braconius* Haliday, which is a regular parasitoid of *Phyllonorycter* (among a wide range of other leaf-mining hosts). From the 1970s I knew that well-grown *Phyllonorycter* species on alder and sycamore were attractive to this parasitoid (Shaw & Askew, 1976), so I attempted to collect more or less fully-formed mines from these trees in Fife (July 13-15). However, even with the help of Keith Bland, I could collect only half a dozen mines on alder and two on sycamore in a total of about 3 person-hours of searching at several sites. Subsequently in S. Cumbria (August 4-5) I failed to find a single mine on alder at the alder-dominated Borrodale Wood near Tebay in two hours, and found only 14 mines on sycamore at sites around Witherslack in another two hours. (Brief examination of several different trees suggested that other *Phyllonorycter* species were doing no better.)

Even for the usually relatively less numerous first generation, this is pretty abysmal – and, although unfortunately I have no idea of the size of the relevant populations in the autumn of last year, it is hard to believe that the atrocious weather in the first half of the 2012 summer was not playing a significant part. These *Phyllonorycter* species overwinter as pupae, the adults then needing to feed, mate and oviposit in early summer. The abnormally wet and miserable May and June this year wouldn't have made that easy (though perhaps nowhere near as bad as for species overwintering as adults, with additional needs in spring), but it might have been especially hazardous for females of such small and frail moths to negotiate the persistently sodden tree leaves onto which they would easily bedraggle – even though actual oviposition is on the leaf underside (in all but one of the species being sought).

Of the mines collected, only two were parasitised (by eulophid chalcidoids, not by *C. braconius*), this low level (cf. Askew & Shaw, 1979) perhaps suggesting that these tiny parasitoids were also finding it difficult to deal with persistently wet leaves. Interestingly, although avian predation might have been expected to be higher in a cold summer (see above), only two of the very conspicuous mines on sycamore seen at Witherslack had been predated by birds, possibly because their very low density hadn't promoted an effective search image.

**(4) Horses for courses...**

A brighter note in conclusion is that at Angle Park, Fife, in mid July 2012 Keith Bland and I found very large numbers of two nymphuline pyralids, *Elophila nymphaeata* (Lnnaeus) and *Nymphula stagnata* (Donovan) flying around a shallow lochan with good growths of *Potomogeton* and *Sparganium*. So perhaps not all moths were suffering!

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