

## **REPORT ON THE POTENTIAL FOR EXPOSURE OF BRITISH LEPIDOPTERA TO TOXIC GM MAIZE POLLEN**

The current global decline in biodiversity stems essentially from the demands of a burgeoning human population. The noticeable dwindling populations of Lepidoptera (butterflies and moths) in Britain and continental Europe is attributed largely to habitat loss and agricultural practices, in particular the widespread use of chemical pesticides.

Losey, Reyer and Carter (1999) have demonstrated delayed development and increased mortality in Monarch butterfly *Danaus plexipus* larvae fed on *Asclepias* foliage carrying deposits of pollen from transgenic maize (N4640-Bt). Such plants are transformed with genetic material from the bacterium *Bacillus thuringiensis*, an organism long in use as a biological control agent against lepidopterous and other larvae.

Since maize, like other grasses is wind pollinated, large quantities of the pollen are dispersed in the vicinity of crops during flowering. This is estimated to carry for at least 60 metres (Raynor, Ogden & Hayes, 1972).

Losey, Raynor and Carter's results carry the implication that not only are Monarch butterflies vulnerable to elevated mortalities in the vicinity of such transgenic maize crops, but also the larvae of many other species of Lepidoptera. The toxicity of this pollen to other species is presently unknown but must be presumed to be significant until appropriate tests have been carried out.

It is possible, from a knowledge of life-cycle schedules, food plants and distribution data, to prepare a list of potentially highly vulnerable species. The timing of flowering (tasselling) of maize varies according to location, season and variety, but in the UK extends from June, throughout July and into August. The following lists rank vulnerability of British Lepidoptera species according to these criteria.

### **British Butterfly Species**

Of the 61 butterfly species recorded as breeding in the British Isles in recent years, 35 have larvae which feed during the month of July. A further 24 have larvae which feed in either June or August, and are therefore potentially vulnerable to exposure to maize pollen in years with early or late seasons. Only two species have life cycles with larval feeding outside the vulnerable period.

Most species have herbaceous foodplants, many of which are commonly found in the near vicinity of fields used for arable crops. In particular the Satyridae and Hesperidae are grass feeders, and many Nymphalidae are Violet and Stinging Nettle feeders. Species such as the Orange-tip (*Anthocharis cardamines*), presently widespread in England and Wales, feed on cruciferous herbs along hedgerows at margins of agricultural land.

Rarer species, e.g. the Chequered Skipper (*Carterocephalus palaemon*) and those of limited distribution, e.g. the Chalk Hill Blue (*Lysandra coridon*) may be highly vulnerable if Bt maize is planted close to their restricted habitats.

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### **British Moth Species**

There are many more species of moths (Heterocera) than butterflies in Britain. Excluding the microlepidoptera, there are of the order of 870 species of moths recorded from the British Isles. Of these, more than 250 species have larval stages feeding in July and including a substantial proportion which feed on herbaceous plants associated with agricultural land. Many of these must have the same potential high vulnerability of the butterfly species.

### **European Butterfly Species**

In comparison with the British Isles, the entomofauna of continental Europe has a much greater diversity of species in all the major orders. The British Lepidoptera which arguably include about 60 resident breeding species of butterflies (Rhopalocera), represent less than 20% of the European fauna, which is in excess of 380 species (Higgins and Riley, 1980). Among these are 100 species of Lycaenidae, 122 of Satyridae, and 69 of Nymphalidae, a majority of which feed as larvae on herbs and grasses. It is to be expected that among these will be further potentially vulnerable species.

### **European Moth Species**

There are no definitive works covering the Heterocera of continental Europe. Despite the intrinsic dangers of extrapolation, it is possible to suggest that of between an estimated 4000 and 5000 species of moths more than 25% may be potentially vulnerable.

### **Ecological Impact**

The phytophagous larvae of the order Lepidoptera render a number of species significant pests of agriculture. This number of species is a small minority, and the vast majority are of no consequence to the direct health of crops. However they represent a substantial component of natural ecosystems and many are key species in food webs.

They suppress weeds and serve as food sources for birds and mammals.

It is to be expected that a 'broad spectrum' poison of agricultural origin might have extensive repercussions on wildlife, were it to be widely used. The experience with the persistent chlorinated hydrocarbon insecticides in wide use during the 1950s should serve as a salutary warning. At present we only have data concerning the susceptibility of one species to transgenic maize pollen. It would be foolhardy indeed

to embark on a wide introduction of such crops without a much more comprehensive evaluation.

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6<sup>TH</sup> June 1999

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### References

Higgins, L.G. and Riley, N.D.(1980)  
A Field Guide to the Butterflies of Britain and Europe.  
Collins, London

Losey, J.E., Reyor, L.S. and Carter, R.E. (1999)  
Transgenic pollen harms monarch larvae.  
*Nature* **399**, 214

Newman, L.W. and Leeds, H.A. (1913)  
Text book of British butterflies and moths.  
Gibbs & Bamforth, St. Albans.

Raynor, G.S., Ogden, E.C., & Hayes, I.V. (1972)  
*Agron. J.* **64**, 420-427

**BRITISH LEPIDOPTERA POTENTIALLY VULNERABLE TO TOXIC GM  
MAIZE POLLEN**

**I Species temporally highly vulnerable in all years**

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
<u>Pieridae</u>				
Orange-tip <i>Anthocharis cardamines</i>	+	+	+	Cruciferae (Herbs)
Large White <i>Pieris brassicae</i>	+	+	+	Cruciferae (Herbs)
Small White <i>Pieris rapae</i>	+	+	+	Cruciferae (Herbs)
<u>Lycaenidae</u>				
Adonis blue <i>Lysandra bellargus</i>	+	+	+	Vetch (Herbs)
<u>Riodinidae</u>				
Duke of Burgundy Fritillary <i>Hamearis lucina</i>	+	+	+	Cowslip, Primrose (Herbs)
<u>Nymphalidae</u>				
Pearl Bordered Fritillary <i>Clossiana euphrosyne</i>	+	+	+	<i>Viola</i> (Herbs)
<u>Satyridae</u>				
Small Heath <i>Coenonympha pamphilus</i>	+	+	+	Grasses
<u>Hesperiidae</u>				
Dingy Skipper <i>Erynnis tages</i>	+	+	+	Trefoil (Herbs)
Grizzled Skipper <i>Pyraus malvae</i>	+	+	+	Bramble, Cinquefoil (Herbs/Shrubs)

## II Species highly vulnerable in years with average and early seasons

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
<u>Pieridae</u>				
Clouded Yellow <i>Colias croceus</i>	+	+	-	Lucerne, Clover (Herbs)
Pale Clouded Yellow <i>Colias hyale</i>	+	+	-	Papillionaceae, lucerne (Herbs)
Green-veined white <i>Pieris napi</i>	+	+	-	Cruciferae (Herbs)
<u>Lycaenidae</u>				
Brown Argus <i>Aricia agestis</i>	+	+	-	Geraniaceae <i>Erodium</i> (Herbs)
Chalk Hill Blue <i>Lysandra coridon</i>	+	+	-	Vetch (Herbs)
Brown Hairstreak <i>Thecla betulae</i>	+	+	-	Sloe ( <i>Prunus</i> ) (Shrubs/Trees)
Green Hairstreak <i>Calophrys rubi</i>	+	+	-	Bramble, Broom, Trefoil (Herbs)
<u>Nymphalidae</u>				
Large Tortoiseshell <i>Nymphalis polychloros</i>	+	+	-	Elm/Willow (Trees)
Painted Lady <i>Cynthia cardui</i>	+	+	-	Thistles ( <i>Carduus</i> ) (Herbs)
Peacock <i>Inachis io</i>	+	+	-	Nettles ( <i>Urtica</i> ) (Herbs)
Queen of Spain Fritillary <i>Issoria lathonia</i>	+	+	-	<i>Viola</i> (Herbs)
Red Admiral <i>Vanessa atalanta</i>	+	+	-	Nettles ( <i>Urtica</i> ) (Herbs)
<u>Satyridae</u>				
Wall	+	+	-	Grasses ( <i>Poa, Dactylis</i> )

*Lasiomatta megera*

Hesperidae

Silver-spotted Skipper

+ + -

Grasses

*Hesperia comma*

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**III Species highly vulnerable in average and late seasons**

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
<u>Papilionidae</u>				
Swallow-tail *	-	+	+	Umbelliferae (Herbs)
<i>Papilio machaon</i>				
<u>Lycaenidae</u>				
Common Blue	-	+	+	Trefoil, Vetches, Clovers (Herbs)
<i>Polyommatus icarus</i>				
Mazarine Blue	-	+	+	Trefoil, <i>Anthyllis</i> (Herbs)
<i>Cyaniris semiargus</i>				
Small Blue	-	+	+	Leguminosae (Herbs)
<i>Cupido minima</i>				
Purple Hairstreak	-	+	+	Oak ( <i>Quercus</i> ) Trees
<i>Quercusia quercus</i>				
<u>Nymphalidae</u>				
Glanville fritillary	-	+	+	<i>Plantago</i> (Herbs)
<i>Melitaea cinxia</i>				
Marsh Fritillary*	-	+	+	Scabious ( <i>Succisa</i> ) (Herbs)
<i>Eurodryas aurinia</i>				
Small Pearl Bordered Fritillary	-	+	+	<i>Viola</i> (Herbs)
<i>Clossiana selene</i>				
<u>Satyridae</u>				
Small Mountain Ringlet	-	+	+	Grasses ( <i>Deschampsia</i> )
<i>Erebia epiphron</i>				
Speckled Wood	-	+	+	Grasses ( <i>Agropyron</i> )
<i>Pararge aegeria</i>				
<u>Hesperidae</u>				
Chequered Skipper*	-	+	+	Grasses ( <i>Bromus</i> )

*Carterocephalus palaemon*

Large Skipper <i>Ochlodes venatus</i>	-	+	+	Grasses ( <i>Festuca</i> , <i>Poa</i> )
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**IV Species marginally vulnerable in years with early and late seasons**

Species	Month Larvae Feeding			Food plants	
	JUN	JUL	AUG		
<u>Pieridae</u>					
Wood White <i>Leptidea sinapis</i>	+	-	+	Leguminosae (Herbs)	
<u>Lycaenidae</u>					
Holly Blue <i>Celastrina argiolus</i>	+	-	+	Holly, Ivy, Buckthorn  (Shrubs)	
<u>Nymphalidae</u>					
Comma <i>Polygonia c-album</i>	+	-	+	Nettles ( <i>Urtica</i> ) (Herbs)	
Small Tortoiseshell <i>Aglais urticae</i>	+	-	+	Nettles ( <i>Urtica</i> ) (Herbs)	
Purple Emperor <i>Apatura iris</i>	+	-	+	Sallow ( <i>Salix</i> ) (Shrubs)	
White Admiral <i>Limenitis camilla</i>	+	-	+	Honeysuckle ( <i>Lonicera</i> ) (Climber)	
<u>Satyridae</u>					
Hedge Brown <i>Pyronia tithonus</i>	+	-	+	Grasses ( <i>Poa</i> )	
Grayling <i>Hipparchia semele</i>	+	-	+	Grasses ( <i>Deschampsia</i> )	
Marbled White ( <i>Agropyron</i> )		+	-	+	Grasses

<i>Melanargia galathea</i>				
Ringlet	+	-	+	Grasses ( <i>Milium, Poa</i> )
<i>Aphantopus hyperantus</i>				

Hesperiidae

Small Skipper	+	-	+	Grasses ( <i>Deschampsia</i> )
<i>Thymelicus flavus</i>				
Lulworth Skipper	+	-	+	Grasses ( <i>Bromus</i> )
<i>Thymelicus acteon</i>				

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**V Species marginally vulnerable in years with early seasons**

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
<u>Lycaenidae</u>				
Silver-studded Blue	+	-	-	Leguminosae
<i>Plebejus argus</i>				(Herbs)
White-letter Hairstreak	+	-	-	Wych Elm ( <i>Ulmus</i> )
<i>Strymonidea w-album</i>				(Trees/Shrubs)
Large Copper*	+	-	-	<i>Rumex</i>
<i>Lycaena dispar</i>				(Herbs)
<u>Nymphalidae</u>				
Dark Green Fritillary	+	-	-	<i>Viola</i>
<i>Argynnis aglaia</i>				(Herbs)
High Brown Fritillary*	+	-	-	<i>Viola</i>
<i>Fabriciana adippe</i>				(Herbs)
<u>Satyridae</u>				
Scotch Argus	+	-	-	Grasses ( <i>Molinia</i> )
<i>Erebia aethiops</i>				
<u>Hesperiidae</u>				
Essex Skipper	+	-	-	Grasses (Various)
<i>Thymelicus lineola</i>				

## VI Species marginally vulnerable in years with late seasons

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
<u>Lycaenidae</u>				
Large Blue <i>Maculinea arion</i>	-	-	+	<i>Thymus</i> (Herbs)
Small Copper <i>Lycaena phleas</i>	-	-	+	Dock, Sorrel ( <i>Rumex</i> ) (Herbs)
<u>Nymphalidae</u>				
Heath fritillary* <i>Mellicta athalia</i>	-	-	+	Cow wheat, <i>Plantago</i> (Herbs)
<u>Satyridae</u>				
Large Heath <i>Coenonympha tullia</i>	-	-	+	Grasses ( <i>Eriophorum</i> )
Meadow Brown <i>Maniola jurtina</i>	-	-	+	Grasses ( <i>Poa</i> )

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## VII Non-vulnerable species whose larvae do not feed at the time of maize pollen release

Species	Month Larvae Feeding			Food plants
	JUN	JUL	AUG	
Black Hairstreak <i>Strymondia pruni</i>	-	-	-	Sloe ( <i>Prunus</i> ) (Shrubs)
Silver-washed Fritillary <i>Argynnis paphia</i>	-	-	-	<i>Viola</i> (Herbs)

Data from Newman & Leeds (1913)

\* UK legislation prohibits the capture of these species.