

Of Lincolnshire High Skies, Hay Meadows and Mazarine Blues *Cyaniris semiargus*

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Abstract: This article explores the most likely ecological reasons for the extinction of the Mazarine Blue in Great Britain using, as its principal model, the butterfly's last known breeding colony in England. It is strongly hoped that the information will be useful in either justifying more research into the Mazarine Blue's precise needs or possibly show the way forward for the successful re-establishment of this species. The benefit provided to the Mazarine Blue will inevitably halt the decline and further loss of both British and Continental meadowland invertebrates, which are still being badly affected by the same processes which are, here, thought to have been the primary cause of the Mazarine Blue's extinction. This research solidly complements the work of Cizek et al. (2012), arriving at exactly the same conclusion from an entirely different angle.

Introduction

The Mazarine Blue is long thought to be extinct in the British Isles yet, until the early 1800s, this butterfly was widespread in scattered but localised colonies south of the Humber Estuary. In searching through old records, and from surviving accounts, its chosen haunts were unanimously described as being of meadowland or pasture. Such established grasslands would have been kept in a constant state of rejuvenation by the traditions of the haymaker with a scythe or the agricultural application of livestock for grazing. These workaday pastimes doubtless maintained, therein, a wealth of wild flowers, as do their modern counterparts, wrought with some innovation, in our own age. Of primary importance for the butterfly's survival amongst this ready supply of flora was its main larval foodplant, Red Clover *Trifolium pratense*.

Other grassy settings given less prominence in earlier works on natural history have also been attributed to this species' former existence in Britain, including heathland, arable fields and old quarries. Arguably, such sites were of secondary importance, possibly periodically supplied or temporarily colonised from the aforementioned farmed grasslands. Open-wood pasture, the largely feral ancestor of these later more human-influenced landscapes, may also have provided stock for natural colonisation (Vera, 2000; NVC, 2013).

On the European continent the butterfly remains almost exclusively a species characteristic of such botanically rich meadow and pasture to this day. Its fairly rapid decline and disappearance from our shores is therefore most likely implicated by some homespun and wholesale change in the use of such areas. Only then would genetic instability and potential swings in climate have played any part in its loss.¹ Though often speculated, there appears to be no compelling evidence that changes in our weather patterns might have affected this insect. Equally, there appears to be no corroborative or anecdotal data that the zoography of any resident species in other corresponding British landscapes were similarly impacted or, indeed, that this particular butterfly was impacted elsewhere in Europe.² Virtually all authors regard this species as indigenous to the British Isles. It most probably withstood far worse inclemency from the time it became isolated from the continent than in its final, fateful hundred years before 1900. To use an analogy: Rasputin might well have survived a slight head-chill had he first not been bludgeoned, shot and half-drowned. The 'blunt weapon' or 'smoking-gun' of Mazarine Blue in Britain was seemingly set on course at the time of the Enclosure Acts which saw our bucolic landscape and way of life altered forever during the late 1700s to early 1800s.³

This research will examine what happened as a result of these Acts for the uninitiated. Additionally, it will investigate the history, habitat and theoretical British ecology of this species, by concentrating on the last known example of an English-resident colony which occurred on our final remaining block(s) of meadowland, which were still managed by the pre-enclosure system of farming. A block of land which, due to strong local custom, had not been unduly tampered with, destroyed or abandoned.⁴ These last mediievally-operated grasslands were situated within large communal open fields near the small market town of Epworth in the north of Lincolnshire.⁵

History at Epworth

The first Epworth example of a Mazarine Blue is believed to have been taken by William Norwood Hudson in 1859. He would most likely have shown this to his elder brother, Samuel. Despite this, it wasn't until the following summer that Samuel, a keen naturalist and later a noted photographer and taxidermist, captured a similar prize; a female in fine condition, on Monday 23rd July 1860, in the same field.⁶ William married, moved away to nearby Newington and died in 1896. Samuel, unmarried, lived on at Epworth until his death in early-April 1904.

By chance, in the final year of his life, Samuel Hudson had been in communication with the Rev. Woodruffe-Peacock of Cadney. He'd rather brusquely replied to an evident enquiry from the cleric that the butterfly was not extinct. It appeared Peacock was anxious to glean information from the possibly ailing Hudson as to the exact whereabouts of this elusive creature, and thereby treat himself with some small but glorious glimpse of it. In fact, it looks as if Peacock failed in this quest, even after he obtained a six-inch map (a scale of 6 inches to a mile) and offered to supply this to anyone who might know the precise locality and have it recorded thereon.

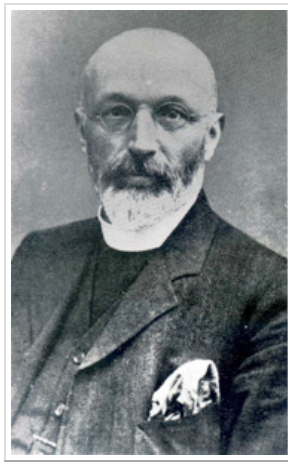


Figure 1 - Rev. E. A. Woodruffe-Peacock (1858-1922)

Photo © Lincolnshire Naturalists' Union

For whatever reason Samuel kept his own counsel although, back in 1864, through the medium of the *Zoologist*, he does inform us "I have always found it between the 10th and 25th of July". With regard to the meadows, they are "of such large extent, and the insect appearing just before the grass is ready for the mower, prevents a proper search being made for it." (Hudson, 1860 and 1864; Anon, 1904; Limbert, 2007).

Despite the railway coming to Epworth in 1901, and with it improved accessibility to the local countryside, apparently no entomologist came looking for the butterfly in the period following Samuel Hudson's death. Nor indeed did Peacock, it seems, despite his valiant attempt to gain prudent particulars. Just how long the butterfly continued its precarious existence into the early 1900s is therefore unknown. Though, by the 1920s, the butterfly's meadowland home had in all probability been ploughed away. A search at the time by eminent Lincolnshire moth and butterfly man, Richard Pilcher, failed to reveal sufficient meadow, let alone the butterfly. Nonetheless, his diligent searches did result in the discovery of two colonies of Marsh Fritillary *Euphydryas aurinia*; a species, at Epworth, more likely to be seen at large on damp roughly-grazed common-land (Richard Pilcher, pers. com., c.1985).

The Human Landscape

An agricultural depression around 1730 (caused by a fall in grain prices), an increasing need for more livestock, and a more profitable use of land used for both pasture and arable farming, put greater pressure on grazed areas. Enclosure of less-efficient communal holdings, especially that of the medieval open fields, was widely viewed as the main solution. Over the course of the following hundred years or so, virtually all of the country's remaining common fields were enclosed, with a majority of them enclosed before 1810, two thirds by voluntarily agreements and a third by Acts of Parliament (Mingay, 1989).

In a unique case, Epworth's large open field system, together with its concomitant meadowland and those meadows abutting in neighbouring Belton, Burnham and Haxey, held on to a pre-Enclosure Act system of farming for far longer than any other area in England. The locals of this small region resisted any modification to their fields, least of all by an Act of Government. This manifestly stemmed from inherited grievances dating from 1626, when Charles I issued plans that infringed the local rights in the use of the outlying commons. The primary infringement was the draining of this land and then its redistribution as arable, mainly to outsiders. Such was the resentment shown that the local militia were at times permanently encamped at nearby Sandtoft and called upon to dispel rioting mobs of disaffected commoners (Ella, 1994).

The open field system of farming was practiced over much of Midland England and large parts of Europe for hundreds of years, from the Late Medieval Period until the Napoleonic Era (c.1154-1810), though Epworth, together with its satellite communities, continued with the old farming methods to the end of the 1800s because, although their Enclosure Acts had been passed, a majority of the occupiers failed to agree on a date for this ordinance to be implemented. However, in all likelihood, Epworth's large rotational fields would have been slowly pecked away at from the middle of the century, and finally, in some greatly reduced form, only became completely defunct with the start of the First World War. The only other extended British example of open field communal farming, away from Epworth and just of a single village and long without proper meadowland, is at Laxton, in Nottinghamshire. Here, for the want of a better expression, a modern parody of pre-enclosure agriculture is still performed (Williams and Fairbank, 1986; Beckett, 1989; Ella, 1994).

Surely it cannot be just a coincidence that the Mazarine Blue and several other rare butterflies survived at Epworth for so long. The following table lists certain species, their characteristic local habitat and final sightings:

Species	Habitat	Final Sighting
Marbled White <i>Melanargia galathea</i>	Meadows	1874 or 1877
Mazarine Blue <i>Cyaniris semiargus</i>	Meadows	1903
Silver-studded Blue <i>Plebejus argus</i>	Heath	1908
Marsh Fritillary <i>Euphydryas aurinia</i>	Commons	1930s
Grizzled Skipper <i>Pyrgus malvae</i>	Commons	1970

Habitat

During the normal enclosure process, the open fields, with their communally-tilled strips and meadows, would have been parcelled into regular chunks, and these then allocated freehold to the commoners in accordance with the amount of land they had worked previously (Beckett, 1989; Ella, 1994). Thus, the ancient meadows formerly held in common, and mostly to be found on the outer-edges of the once great fields, became fractured, and their seasonally rotated management became redundant. This resulted in the singular more prosaic practice of continuous haying we now know today.

Perhaps of equal importance was that areas of meadowland straddling the precincts of neighbouring villages lost an additional link to overall temporal variety or composition. This was due to fate very likely determining that next-door villages, with their two-, three- or even four-yearly management systems, might easily have had annual cycles phased out of synchronicity with one another. Typically, the meadow blocks of these settlements were to be found abutting one another across their recognised borders at the furthest margins of each of their particular open fields. Up to a maximum of four villages, with differing field formats, operating opposing systems over a single but extensive tract of grassland, may once have been a distinct possibility, where this multiple of old parish boundaries sometimes intersect and their ancient meadows would perhaps happen to meet. Though two, or occasionally three, separate annually-timed management schemes operating on different portions of the same intrinsic meadow or pasture areas would have been a far more likely occurrence.

On the continent a very similar extra link to increased variety still exists in some places, where meadow blocks are not entirely fractured, although allocated, and mobile species are still able to move freely to pastures new. Quoting today's leading butterfly expert, Jeremy Thomas, "In central France, the colonies [of Mazarine Blue] appear to move between the patchwork of little hay meadows that are still mown over a range of dates." (Thomas and Lewington, 1991, p.208). It would appear that the Mazarine Blue, and doubtless others too, couldn't survive indefinitely on meadowland standardised to a yearly routine. At the time of the Hudson brothers at Epworth, the butterfly was only just hanging on and struggling to survive. Presumably because, by this date, the culture of its meadowland home had already become more annually unified, resulting in a slow but ultimately huge and inevitable loss to its overall ecological diversity (to be examined later in more detail). August and June haymaking, "which resulted in clover being cut at a time when the eggs and caterpillars were still present", is given credence by Thomas as having plausibly detrimental effects. With an invariably-timed single August cut, the Clover would have been gradually choked, especially by dominating grasses such as Tor Grass sp. *Brachypodium pinnatum* agg. on calciferous lands, Tufted Hair-grass *Deschampsia cespitosa* ssp. *cespitosa* on damper more neutral soils, plus Common Reed *Phragmites australis* and Small Purple-reed *Calamagrostis canescens* on alluvial, humic or peaty grassland. Hogweed *Heracleum sphondylium*, and other invasive ruderal species, dominate on modern meadows without sufficient grazing or later mowing (personal observations, 2015).⁷

It appears that, on the particular meadowland habitat at Epworth once frequented by Mazarine Blue and Marbled White, there had been a related 'tipping point', leading these species on ultimate paths to extinction. With the Marbled White disappearing first, it might seem the more vulnerable of the two species and, therefore additionally susceptible to whatever caused their ultimate demise. However, perhaps more perplexing questions need to be answered first. The greatest mystery should not be why the Mazarine Blue became extinct when it did, but how the Chimney Sweeper moth *Odezia atrata* survives in such profusion on today's annual monoculture treatment of its meadows; this sees its sole larval foodplant, Pignut *Conopodium majus*, presumably with all of its overwintering eggs, cut back and then removed.

Culture

Haymaking in the midlands, during the middle Victorian years, typically began in mid-June.⁸ A traditional starting date of around Waterloo Day, 18th-22nd June, is usually quoted for Nottinghamshire, an average lowland county (Lyth, 1989, p.9). With favourable weather and good luck the work would usually be long finished by August. At the quaintly out-of-sync Epworth of Victoria's reign, the first hay to be cut seemingly started somewhat later, shortly following the 10th of July, when, as previously quoted, the Mazarine Blue usually appeared "just before the grass is ready for the mower".

Anecdotal evidence suggests that prior to the early 1700s, the customary mowing regime of most mid-country villages commenced sometime later in early-July, dated using today's Gregorian Calendar. On the face of it, with an increasing need for more livestock, hay meadows around this time began to be cut earlier to accommodate a longer period of summer-grazing.

Normally, before enclosure, once a field had been harvested and with its incumbent meadowland cut, all would then be inclusively grazed. The timing, duration and possible exclusion of this practice, just like the mowing, was dependent on that particular season's overriding arable or fallow employment of each field. Fields would usually be folded with sheep in the autumn when the choice tups, with some necessity, were first segregated and then put to the ewes, colloquially known as 'tupping-time', but not in the following wetter months of winter.⁹ The grazing of most lands finally ceased with the start of the Julian November. Meadows would on occasion be spread with manure using the product of stock that had been kept farm-penned during these darker months. The general implication also being that when the meadows of fallow fields were collectively grazed early, they would in all probability have been cut last or not at all during that particular season. At Laxton the general uses for such communal large open fields included, and uniquely still does: winter-sown crops, spring-sown crops and left fallow.¹⁰ (Beckett, 1989, pp.9-10).

Annually rotated cutting and grazing in spring and high summer during these same yesteryears also seems to have occurred on the meadow headlands or common baulks, sometimes called sykes or meres, in the same open field systems. Sheep, or possibly other stock, would be folded afresh each day along these baulks when the adjoining strips were planted with crops (Lincolnshire Naturalists' Union, c.1998). Spring-grazing usually taking place one fallow season in three on baulks and meadows, presumably gave the resident plants and less mobile insect life two potential years of vernal recovery. There is no obvious evidence in the historical record to suggest that British meadows were cut more than once in the same season as is sometimes the case on the continent.

The once periodic grazing and mowing of pre-enclosure meadows in many instances gave way to a more continuous use by stock. The unfortunate ungulates involved were routinely penned during the winter, and given root-crops to chomp rather than a (less flatulent) diet largely consisting of sweetly sun-kissed cut grass with herbs. Britain leading the way into industrialisation was doubtless the root cause behind many such ill-fated series of events, with the demise of the Mazarine Blue perhaps one of the least-understood examples of its many consequences.

The Lost Meadows

There are several contenders to the whereabouts of Samuel Hudson's lost meadows (Compton, 1977; Ella, 1994; Garner, 1994; The Humberside Archaeology Unit, 1988). One is along the northern boundary of Epworth Low or Eilers Field, running west to east at an average height of 5m, from SE764059 to SE780059 and totalling c.85 hectares. The area is connected to another meadowland block in Belton Field that was also historically managed using the rotational system.

A second, and perhaps the most likely, contender was at the eastern extremity of Epworth South Field. This is a compact block of land, west of the road between Melwood Grange and High Melwood, at an average altitude of 20m, centred on SE790027. These, c.1380-1914, "Melwood Meadows" are also the likely site of the 640 acres (260 hectares) of 'pasture wood' mentioned in Domesday; 1087 (Domesday, 1087), a large surviving fragment of which is possibly the solitary patch of woodland depicted nearly five centuries later on Tomlinson's map of 1526 (Tomlinson, 1526)^{11,12}. These trees are not shown on later maps of the early 1600s, so in all probability they may have been cleared at around the time of the Reformation; 1540. Interestingly, a fellow researcher into the Mazarine Blue, Peter Andrews, has also found strong anecdotal evidence connecting the species with such woodland (Andrews, 2015).



Figure 2 - Today's view showing the location of former meadowland at Epworth; thought the most likely area for the last known English colony of Mazarine Blue ('Melwood Meadows', SE785023, Lincolnshire)

Photo © Martin White

Originally completely contained within Epworth Manor, the site of these destroyed meadows until recently had long been divided between the hamlet of Burnham (c.15%) and the parish of Owston Ferry (c.85%). Two large parts of the abutting meadows at Owston have historically been enclosed, probably since the woodland was cleared and presumably therefore not under a rotational management system since the 1500s. Equally, a large part of the area had not been enclosed and even by Victorian times abutted onto the meadows of the rotational Burnham Field near Holy Well (SE785023). These lands are notably at a higher elevation than the other possible sites, and while all contenders are on base-rich Keuper Marl soils, this area has less naturally deposited or warped alluvial material and is therefore slightly more calciferous in nature. Most of the area overlays gypsum deposits which in the past was dug as an alkaline additive to fertilizer and for plaster.

Two relatively small areas of meadowland both within Epworth South Field, each of approximately 8 hectares, centred on SE769035 and SE772026 were also evidently extant in the Victorian period, as was another block at the far eastern end of Epworth East Field, SE804040, of about 38 hectares. These areas, which are of very low elevation, would previously have been prone to alluvial flooding and therefore would have had a lower calciferous influence. All were well isolated from other past meadows with potentially different rotational systems. The commons, heaths and bogs, and indeed all areas outlying the fields around Epworth, were likewise frequently flooded until the implementation of the drainage schemes, and even afterwards would have made unlikely situations for Mazarine Blue. Hence, the name attributed to the region's higher gypsum land with its once insular settlements and fields of "Isle of Axholme".¹³

Today's Meadows

On today's meadows it is mostly the flora of early-season fecundity which are to be found in mid-June flowering abundance. Here the flora happily thrives, without apparent competition from later counterparts, about two or three weeks before our modern mechanical scythes are put to their speedy application. It is somewhat moot that these grasslands now show a remarkable uniformity in their respective floristic composition and species density despite what must have been a long period of isolation. This suggests a common ancestry or origin and a temporal descent of particular constancy, indicative perhaps of continuous year on year early mowing, or even grazing of such places which started with the enclosures, and concluded with their modern uneconomic conservation.

Plants and Pretty Insects

Spaced over 50 kilometres, five botanically-rich hay meadows survive nearby on the same band of base-rich Keuper Marl soils as those formerly at Epworth.¹⁴ Between 2007 and 2015 all the vascular plants, together with a few of the insects found on each of these meadows, were given scores for density by myself. These points were then amalgamated over several visits at differing times of year to obtain an

optimum frequency index. A scale of one to five was used, with a single point equating as rare to five being abundant. The scores for each species from each site were then added together. To each of these figures an extra score of five points was awarded if a species occurred on all five sites, three if it occurred in four, and one point if it occurred on three out of the five meadows. Therefore, if a species is given a higher index, this may provide a good indication of how likely its former existence at Epworth might have been. Although the objectivity of this method is far from ideal (the level of error cannot be properly qualified), for the foreseeable future it has to remain the best guesswork until time travel or something similar is invented.



Figure 3 - Theorised habitat for Mazarine Blue at Epworth in Lincolnshire based on surveys of contemporary hay meadows. All the vascular plants found at five approximate sites have been scored for density and the results then amalgamated to give an indication of which plants might previously have existed on Epworth's lost meadowlands. The graphic shows axiophyte species only and these are depicted within their respective National Vegetation Classification communities. The areas of circles suggested by partial or whole outlines symbolize these discrete plant associations, each given their type notation centred in red. Differences in the sizes of these circles are relative to the number of species recorded for each community with richer groupings having larger circuits eclipsing smaller, poorer ones. Species shared between communities are represented within the spaces of inferred eclipses. The major community groupings are: MG = Mesotrophic Grassland, M = Fen and Rush Pasture and CG = Calcareous Grassland. Axiophytes are based on those used to qualify Sites of Importance for Nature Conservation in Nottinghamshire using data from NBGRC (Nottinghamshire Biological and Geological Records Centre, 2007), with additional characteristic herbs and grasses mentioned in NVC (National Vegetation Classification, 2013). Plant locations within the graphic are formed along the generalised axes of soil pH value (horizontal) against relative soil humidity (vertical) and show their estimated ecological mid-points.

Photo © Martin White

The highest plant index was for Sweet Vernal Grass *Anthoxanthum odoratum* with 28 points. Red Clover came in with a reassuring 23 points, with interesting species such as Red Fescue *Festuca rubra* 24, Bird's-foot Trefoil *Lotus corniculatus* 20, Meadow Vetchling *Lathyrus pratensis* 19, Green-winged Orchid *Anacamptis morio* 18, Yellow Rattle *Rhinanthus minor* 17, Tufted Hair-grass 7, Tall Fescue *Festuca arundinacea* 3 and Heath Grass *Danthonia decumbens* 1. Green-winged Orchid has perhaps a somewhat-biased result as four out of the five meadows involved were (or are) nature reserves specifically managed and designated for the primary purpose of protecting this plant.

One site has a slightly higher alluvial content than the others and its soil type closely matches the areas of Epworth's former meadows at lower elevation.¹⁵ Botanically speaking, all are nonetheless remarkably similar, and to use rather technical terminology fall within the National Vegetation Classification of the Mesotrophic Community MG5, forming a transitory stage towards various Calcareous Grassland Communities (Figure 3; Rodwell, 1992). Not surprisingly, overall, this grassland community is ubiquitous with, or characteristic of, a great many lowland hay meadows rich in Red Clover. Recent research indicates it is possibly analogous to near natural vegetation being derived from an open parkland flora than a closed woodland environment and is thought a likely artefact of post-Neolithic farming, from 2,500 BCE.¹⁶ (Vera, 2000; NVC, 2013). Interestingly, Pignut scored an index of 22, and if the Holy Well site within Domesday's swine-pannaged Mel Wood is anything to go by then the local pigs must have been in clover.¹⁷ Red Clover!

A majority of plants with low scoring indices are late-season in terms of flowering or in setting their seed due, presumably, to the reason given above under "Today's Meadows". Doubtless, several more later-flowering axiophytes representative of this base-rich transitional MG5 community, while absent now, would have been present when the meadows were subject to later rotational haymaking, paced sequentially in annually-timed cycles over a wider timeframe.¹⁸ This, no doubt, would also have been the case on Epworth's Victorian meadowland with its extended history of later husbandry. Notable examples of such absent or low-scoring plants from this neutral x calcareous community are as follows, with their scores: Salad Burnet *Sanguisorba minor* 0, Harebell *Campanula rotundifolia* 0, Dyer's Greenweed *Genista tinctoria* 0, Burnet Saxifrage *Pimpinella saxifraga* 0, Hoary Plantain *Plantago media* 0, Saw-wort *Serratula tinctoria* 1, Common Spotted Orchid *Dactylorhiza fuchsii* 2 and Devil's-bit Scabious *Succisa pratensis* 3. The most interesting non-axiophyte is Tufted Vetch *Vicia cracca* 2; a noted nectar source abroad for our extinct blue (Bakowski, 2005). Additionally, Bush Vetch *V. sepium* 2 and Common Vetch *V. sativa* 12, typical of meadowland hedgerows, attract black ant *Lasius niger sens lat.* 1 and red ant *Myrmica rubra* 6 with extra-floral nectaries. *Myrmica scabrinodis*, another red ant, fond of open areas, scored 5.

Several plants have been suggested by various authors as food material for British Mazarine Blue caterpillars, which might have provided an alternative pabulum to Red Clover. These fall outside the grassland community of the habitat categorised in Figure 3. Such species include: Kidney Vetch *Anthyllis vulneraria*, Thrift *Armeria maritima* and Melilot *Melilotus officinalis*. It is tentatively speculated that if colonies of the butterfly were ever supported on our side of the channel by any of these plants then the various habitats represented by them would probably have been transitory in nature. It is perhaps equally debatable the species used Meadow Vetchling in an open woodland or parkland environment in the absence of sufficient Clover or on Zigzag Clover *Trifolium medium* which tends to replace Red Clover on more calciferous soils or in ageing calcareous grasslands. These particular species have yet to be confirmed as edible to the larvae.

The Common Blue *Polyommatus icarus* 6 is perhaps the only example of a butterfly capable of forming discrete long-term breeding colonies on the isolated meadows surveyed as they stand today with the Chimney Sweeper 21 heading a short cast of the most abundant and independently fecund day-flying species of moth on the sites.

A small number of butterfly and moth species have habitat that superficially appears to be suitable for them on the sites under this investigation but were seemingly absent. These include Marbled White, Dingy Skipper *Erynnis tages*, Small Heath *Coenonympha pamphilus* and Burnet Companion *Euclidia glyphica*. Greater Yellow Rattle *Rhinanthus angustifolius*, despite now considered to be a very rare non-native; a noteworthy damp meadowland plant from the Epworth region which is also currently missing from the surveyed locations.¹⁹

However, a similar, and perhaps a more intriguing once-common MG5+ plant, might have been a July-flowering form of Yellow Rattle.²⁰ Characteristic of damper areas and part of an intergrading series of inter-fertile hybrids between ssp. *stenophyllus* and ssp. *minor*, it is here described as being 30-50cm in height, well-branched and with longer flowering branches than the May and June flowering form. This latter form is typically shorter than 30cm in height than the July-flowering form, has four or fewer flowering branches attached to the main stem and is the more likely of the two forms to be found on drier calciferous soil.

Ecology

Ants are the ecological engineers of the invertebrate realm (Crompton, 1954). They farm, plant, cultivate and manipulate the world around them to best suit their survival. A number of British butterfly larvae appear to use some form of ant defence or compliance strategy and these can sometimes be clearly witnessed in their morphology or behaviour. Yet, whether their strategies include defence, compliance or in rare circumstances parasitism or possibly attack, welfare dependence is invariably formed towards the whole ant ecology. A loss or reduction in the correct ants and the butterfly species involved are then open to various threats. It is tentatively theorised that this is a major reason for the disappearance of many of our native butterflies whose habitat-specific colonies have undergone some seemingly subtle change.²¹ What exactly causes these changes is, unfortunately, the difficult part to uncover. Conversely, as most British ants are at the northern limits of their European range, this may suggest a lowering of the ground temperature might be a likely conclusion.



Figure 4 - A mossy micro-habitat below the multi-branched ecotype of Yellow Rattle, providing just the right brood-warming areas on neutral x calcareous grassland for an abundance of ants; a possible example of facultative meadowland mutualism (Minting Triangle, TF159740, Lincolnshire)

Photo © Steve Bamford

In Great Britain pairs of ant species tend to dominate on any given habitat. These are usually represented by one species from each of the two major British sub-families; the Myrmicinae and Formicinae. Each pair mutually co-exists, generally operating within non-competing niches in a single terrain, perhaps with one species primarily foraging above, and the other below, ground level. In easily-defined, single natural allied plant communities, further ant species tend to be harder to locate because they are actively predated or out-competed by the predominant partnership. It is in association with these presumably long-established pairings that various members of our butterfly fauna must have likewise co-evolved (Brian, 1977, pp.160-161).

The Large Blue *Maculinea arion* is the most noted British butterfly directly dependent on a principal ant; the red ant *Myrmica sabuleti*. In Britain, a warm short grass sward is essential for the ant to thrive. The Yellow Meadow Ant *Lasius flavus*, which is the usual Formicinae partner to *sabuleti*, also looks to be present on all of the Large Blue's known British locations and may yet prove to be important in maintaining the overall health of this particular butterfly's ecology.

The larvae of the Mazarine Blue attract ants by secreting amino acids from glands and the resulting pupae are likely buried by ants as with many other blues (Emmet and Heath, 1990, p.142; Thomas and Lewington, 1991, p.206).²² This may not be an accident of fate. This butterfly was almost certainly dependent on specific ants in sufficient quantity for its survival. As with various examples, a fundamental cause of its loss in Britain was probably due to a reduction in, or the complete elimination of, one or two species of ant fauna from the butterfly's staple sites. In turn, this was likely to have been partially affected by the cessation of spring rotational grazing of hay meadows, culminating in the 1800s, as a result of land enclosure, both private and official.²³ Thereby the ant's domain would have been cooled at a crucial early stage of the season. The presence of ants themselves, feeding on honeydew from aphids farmed on root systems, is known to inhibit plant growth which, in theory, also helps ameliorate the ground-layer temperature.

The ultimate demise of the butterfly in England, at Epworth, has a prosaic, slightly less ecologically-based explanation. As previously stated, this most likely resulted from the ploughing-up of its meadows. Nevertheless, it is with somewhat academic interest that the former Epworth meadowland site, also mentioned beforehand, not far from Holy Well, is at the top of a dish-shaped hollow on a south-facing slope and would

therefore have been better warmed than all other Victorian meadow locations in the area. Moreover, at the time, this region was probably open-wood pasture before c.1540, within the vanished Mel Wood, an even warmer micro-climate might well have then prevailed. Incidentally, in the near vicinity are locally isolated relict populations of MG5 specialities Common Knapweed *Centaurea nigra*, occurring in robust patches, and a small pocket of Meadow Cranesbill *Geranium pratense*.

Due to the root-hemiparasitic ecology of the damp-loving multi-branched Rattle it provides just the right warm mossy ground-layer under which ants flourish on neutral x calcareous grassland; especially *Myrmica scabrinodis* (personal observations, 2015). Jeremy Thomas provided a vivid description in central France of steamy, warm hay meadows on damp soils being particularly attractive for Mazarine Blue (Thomas and Lewington, 1991, p.206). Evermore intriguingly, the disappearance of the pure-strain Yellow Rattle ssp. *stenophyllus* is a good match for the extinct distribution of the butterfly in lowland Britain, though this definitive Rattle occurred chiefly hereabouts in our fens and on peaty-grassland (Emmet and Heath, 1990, p.167; Preston, Pearman and Dines, 2003, p.574; Botanical Society of the British Isles, 2015). More recently this precise subspecies has been re-introduced to several sites within its acknowledged extinction zone and therefore that of the butterfly although, evidently, it is indigenous at two newly discovered locations in Nottinghamshire.²⁴ One of these locations is fairly close to Epworth (Wood and Woods, 2013, p.62). In both situations mosses grow beneath this particular Rattle which in turn, just like its close hybrids, provide a munificent substrate for *Myrmica scabrinodis*, with *Myrmica rubra* and *Lasius niger sens lat.* likewise situated, though on just one of these sites.

In the absence of Rattle on damper or water-soaked Mesotrophic meadowland areas, *Myrmica scabrinodis* is mainly reliant on Heath Grass and the late-seeding Tufted Hair-grass.²⁵ It is within the fortress-like root-ball of this second plant that this insect especially builds large permanent nests, as do *Myrmica rubra* and *Lasius niger sens lat.*, but this latter pair tend to utilise this grass far less frequently. *Myrmica scabrinodis* does make the most of other species in a similar fashion in other plant communities. Unfortunately, however, such sites notably lack Red Clover. These include: Purple Moor-grass *Molinia caerulea*, Harestail Cotton-grass *Eriophorum vaginatum* and Mat Grass *Nardus stricta* on heath, bog and moorland locations, respectively.

Conclusions

It is speculated that the past British ecologies of Marbled White and Mazarine Blue on MG5+ hay meadows very likely converged. While neutral x calcareous meadowland larvae of Marbled White would mainly have fed on Red Fescue and Mazarine Blue on Red Clover, the presence of similar ant species dominating their landscape would almost certainly have been needed to create a niche suitable for both these butterflies to exist, which ostensibly they did in the same place at the same time on Epworth's meadows up to at least the mid-1870s.^{26, 27} For such a niche to be present the ants in turn are equally dependent on specific plants growing in equitable quantity. In all the MG5+ hay meadows and managed neutral x calcareous grassland sites so far investigated by this researcher, all these plants are considered late-season, with the partial exception of Heath Grass, which at its earliest can flower at the beginning of June and, uniquely among the grass species of these communities, produce some low-spreading panicle-branches capable of bearing seed below normal mowing height.^{28,29} Still, the vast majority of all our later-flowering flora were almost certainly removed or unilaterally suppressed from the entirety of the British meadowland scene by an annual unification in haymaking practices unwittingly intensified following the Enclosure Acts.³⁰ Modern conservation seems to have put this process into a slight reverse by mowing some meadows later. However, this is almost certainly not the way a substantial proportion were intra- and inter-seasonally variably cut and grazed for the first 750 years of the last millennium under the communal open field system of farming or its immediate precursor practices.

The most likely ants to have been well represented on these damp meadowlands are suggested as red ant sp. *Myrmica scabrinodis* and black ant sp. *Lasius niger sens lat.* These insects tend to favour open sunny positions on moister habitats than other members of their respective sub-families. Both form substantial colonies at the root-level of large marsh grasses, especially Tufted Hair-grass and, to a lesser extent, Tall Fescue. They also create smaller more widespread colonies under moss, typically on damp neutral+ soils where late-flowering multi-branched ecotypes of the Yellow Rattle occur. Presumably, the less mobile grass colonies receive far better protection from grazing or trampling animals and other possible disturbance.³¹ Nonetheless, both types of colonies can occur in isolation from one another.

Regarding ridge and furrow meadowland: This habitat is one of two distinct moduli alternating in a rippled effect between the relatively dry ridges and wetter furrows. The ecologies of the plants involved tend to obey these sub-habitats resulting in striped formations. Ant species represented should therefore, theoretically, be more complex than those of the ancient, undisturbed, meadows on even topography.³² Then again, reality can be quite different and there seem little observable differences in ant distribution between one meadow type and the other. The commonest ant on the meadows surveyed is *Myrmica rubra* and its colonies utilize exactly the same grass hassocks and moss locations as *Myrmica scabrinodis* and *Lasius niger*, but only skirt within 10 metres of the boundary hedges.³³ The sunnier ground towards the middle of the meadowland is dominated by its rival, *scabrinodis*, and what few *niger* were found were distributed without any noticeable bias.



Figure 5 - The best meadow habitat for ants from five surveyed sites (West Burton Meadow, SK787851, Nottinghamshire)

Photo © Martin White

It is difficult to critically analyse what causes the different abundances of ants on just five meadows as the results tend to agree far too readily with what is already wishful thinking to this researcher. What follows is my attempt at mustering whatever dispassionate objectivity I can. The best of these sites for these creatures has reasonable amounts of widespread hair-grass, a good growth of multi-branched Yellow Rattle, plenty of moss, and is cut in mid-August to a generous height of about 10cm. The second abundant ant site is clearly cut much earlier than this and in consequence has no hair-grass. However, it does have Tall Fescue, with incumbent ant colonies occurring around one uneven boundary where, presumably, the cutting-machinery has been inconsistent in cutting back this plant. It retains a lesser supply of Rattle and moss, and was probably grazed at some time in the recent past judging by the presence of a watering trough. The third site has plenty of hair-grass, no Rattle, no moss and just a single *scabrinodis* colony making use of a solitary tussock of Heath Grass growing in an area of somewhat shorter vegetation. Additionally, it appears not to be cut until at least October. The fourth site with ants, while having a good hair-grass population and some Rattle, is in many places scalped to ground-level in mid-July and has no moss to speak of. Regarding the site where no ants have yet been located, it does have plenty of the wrong Rattle, lacks all of the hassock-forming grasses or any noticeable moss and to my knowledge has been cut in the earliest part of July every year since at least 1986. It is rather doubtful, even on the most optimistic of days, that the best one of these habitats has the correct management or possible ant-dosage for a proper colony of either Mazarine Blue or Marbled White.³⁴

The great irony of the Mazarine Blue is that its two probable British ant species (*scabrinodis* and *niger*) become more obvious in neutral plant communities with greater amounts of Tufted Hair-grass, which typically have little or no Red Clover, and these ants are similarly more abundant on sites where this Clover is also thinly distributed on mature chalk and limestone grassland. Indeed, this ant-pairing together with other ant species gain greater prominence on drier more calcareous sites.³⁵ In fact, mossy areas beneath all Yellow Rattle ecotypes, and much else besides, become frequent ant-nesting areas on higher pH soils where the Clover struggles, away from its typical neutral habitat. Moreover, unlike the Marbled White, Mazarine Blue seemingly lacks the ability to switch its primary larval foodplant found on neutral sites to a different, albeit closely-related one, on calciferous soils.³⁶

It is notable that *Myrmica scabrinodis* and *Lasius niger sens lat.* are represented on each of ten Midland Marbled White habitats this researcher has so far examined whether on neutral+ or calcareous grassland. The absence of both or either ant also outwardly prevents the successful colonisation or long-term survival of this butterfly introduced into virgin sites.³⁷

Attention needs to be paid to the manuring by animals under whose diligent orifices produce what was provided for the use of meadowland ecology for at least two millennia whilst their owners undoubtedly helped create the habitat in the first place. Only one of the meadows surveyed has a watering trough and presumably was therefore once grazed. This site does look to have more humic matter at, and just beneath, the soil surface and correspondingly, a fair measure of ants. However, the practice of grazing British hay meadows now looks to have come to a near conclusion and with it the functions of the animals involved.³⁸ Only the Rabbit now makes any natural contribution, and a very modest one at that. A lack of such fibre, in all probability, does not help the ants. However, without additional examples for verification this is merely conjectural.

Three separate sub-types of MG5 grassland are given details by modern science (NVC, 2013, p.5). Of particular interest to the Mazarine Blue is MG5c where, within this frequently damp habitat, the enigmatic and ant-amenable Heath Grass is given prominence as a constant species together with Tormentil *Potentilla erecta* and Bitter Vetchling *Lathyrus linifolius*. Included also, are the usual MG5 suspects of Red Clover and its latter-day, early-flowering allies. These are, of course, the survivors from a relatively recently imposed yearly monoculture treatment of a much older grassland culture. This may suggest, with one minor reservation, that Tufted Hair-grass, Tall Fescue and Yellow-rattle ssp. *stenophyllus* may also, equally, have once been associated with this type of fenny-community.³⁹ This would have provided in one place all the right plants and probable ecology needed to create a 'perfect storm' for our extinct blue.⁴⁰ If we were to wind the clock back to the Mesolithic; 8,000 to 4,000 BCE before farming, then deer and wild cattle would have maintained such an 'open-wood fen pasture' as, no doubt, did our hunter-gatherer ancestors by setting fire to this type of range to provide better conditions for sampling these choice game. Luckily, not least for this theory, the majority of meadowland ants would usually vacate any overgrown grassland site before a closing canopy made it suitable for burning, although Burnt-tip Orchid *Orchis ustulata* might find itself somewhat scorched.

It was likely the one-time village custom of springtime grazing on long established meadows, critically every third or fourth year, that held the greatest benefit for Mazarine Blue in Britain for the better part of the last thousand years. According to Thomas and Lewington (1991) the research by Jeremy Thomas in central France indicated that the species is particularly attracted to regenerated Clover about three or four weeks after an early season cropping. Moreover, the butterfly's larvae feed on the relatively high flowers of Red Clover before entering hibernation. Afterwards in the spring, they utilize the plant's lower newly-sprouted leaves, quickly dropping to the ground, and a possible safer environment if disturbed by, for example, a mower with a scythe, or the actions of chewing animals.

Before enclosure, the likelihood of large adjoining meadows being cut or grazed at varying times within the same season would have given butterfly species a better opportunity to move to more promising pasture. The ants could surely have survived periods of phased management both within their perennial and their other, more mobile, smaller nests. It is noted that rank vegetation is certainly inimical to the long-term abundance of Red Clover and for a warm ground surface with a potential plethora of ants.

The continuous survival and abundance of the singularly annual Yellow Rattle, within a landscape of phased management, would however depend on the ability of its seed to undergo more than just one typical winter in a state of feral-dormancy before germinating.⁴¹ No research on this can be found, but the vernal grazing, mentioned, would have disadvantaged earlier-flowering, less-branched ecotypes, which today are so common on our habitually, singular July-cut, ant-starved meadowlands.

The Mazarine Blue would probably have thrived on post-Neolithic semi-natural, open-park grasslands whether in Britain or abroad. These were most likely formed and maintained by periodic light grazing. Later phased management under the medieval open field system would

then have preserved the originality of these areas. Grassland, say April-grazed one year, cut in early-July the next, and September in the third, would not have caused an imbalance towards an earlier-flowering flora. The ultimate result for British meadowland of enclosing farmland and especially our Enclosure Acts, discriminated against late-season species and doubtless a sizeable chunk of their natural ecology was simply thrown away. When James Dale's son, Charles Dale, made the comment about the butterfly during the early 1800s at Glanville's Wootton in Dorset, "as the grass in the meadows which it frequented was cut and the hay carried in exactly the same fashion all through my father's life", he gave a good account as any of why the species only lingered here and an essential reason how it became extinct in Britain⁴² (Dale, 1902).

Nevertheless, more investigation into continental Mazarine Blue habitat would clearly give a much better picture of this butterfly's precise needs.

Of High Skies

I intend to write a follow-up article examining the probable mistakes made here after the species has hopefully been successfully re-established as a wild butterfly in Britain.

In anticipation of this, there is a well-warmed artificial hill in lowland Derbyshire capped with calciferous subsoil. Its grasslands are still youthful and full of flora. These are mown late summertime and with good providence closely match the total acreage of the bygone meadows of Melwood. Even more sobering is that they are well-populated by both *Myrmica scabrinodis* and *Lasius niger*. Introduced Marbled White increases exponentially year on year, apparently prospering in association with these two ants. Tor Grass sp. is absent from the main body of the site and nearly everywhere Red Clover abounds. Yellow Rattle abounds too, in extraordinary abundance and not infrequently encountered with more than the customary fourfold branch arrangement. Its seed was found unusually plentiful in one *Lasius niger* nest. Plenty more of the axiophytes, aforementioned, are likewise comfortably well represented, including local rarity Burnet Companion. Outsiders, Kidney Vetch and Melilot, are also at hand, if needs must. Alas, dear old Pignut is missing and the habitat is but transitory in nature; maybe satisfactory for no more than 30 years. But one cannot, of course, have everything. Good luck and good hunting!

Footnotes

1. Climate-modelling by Carroll et al. provides a fascinating forecast suggesting the species could easily combat our conditions until 2050 (Carroll et al., 2009).
2. There is a parallel with the demise of the European Swallowtail *Papilio machaon* ssp. *gorganus* from British shores during the period of Mazarine Blue's quickening disappearance during the 1800s. This subspecies is however known to migrate whereas the blue is less inclined to do so, indicating it is therefore far more likely a long-term resident. The Swallowtail's probable small breeding populations disappeared or withdrew in the direction of the continent, possibly along a front, suggesting that changes in climate play a part in most if not all its zoographical movements. The waning of the Mazarine Blue on the other hand wasn't inclined towards any recognisable geographic position including coastal or altitudinal stimuli. These random and widespread 'scattergun' losses suggest a retreat towards sites where its favourite haunts lingered longest, again, indicating the butterfly was indigenous and, in keeping with all our other habitat-specific resident butterflies that have retracted their ranges at one time or another.

Moreover, a substantial, almost ubiquitously distributed area of suitable 'MG5+' habitat for the species existed within our islands before the turn of the first millennium. Nor had this been unduly modified with the slow developments in agriculture at that time (Vera, 2000; NVC, 2013). It is here given the most likely airing that the Mazarine Blue would have been present on such widespread and common habitat or on its ecological precursor, within our lands, when all were suitably set-adrift from mainland Europe around 6,100 BCE. As will shortly be discussed, the butterfly would in all probability have remained well provisioned and no doubt still widely extant until around a hundred or so years before our Aurelian friends witnessed its spluttering last days.

3. Rasputin being the Mazarine Blue. A 'slight head-chill' being whatever fluctuations may have occurred in the British weather over the mere course of about a century and 'bludgeoned', 'shot' and 'half-drowned' being what the Enclosure Acts ultimately did to the remaining habitat of the butterfly.
4. Superficially, the meadowland communal baulks [sykes] at Laxton in Nottinghamshire are still maintained within a medieval open field system. This situation is discontinuous, as these areas were not cut for hay but entirely used as pasture before 1730. Plus this village's communally-operated, cut and grazed, meadow-blocks were enclosed into private ownership by the early 1700s, and its last, non-rotationally operated, ancient hay meadow was probably put to the plough around 1870.
5. During the late Medieval Period (1154-1485) an average lowland midland village would have operated a two, three or even four field system. Each village would have held a yearly Manor Court to decide on the general use of each these extensive fields for the coming season. Lords of the Manor overseeing these courts were originally created under Feudal Rule by William [the Conqueror] in the years following the conquest (Williams and Fairbank, 1986, pp. 6, 25; Beckett, 1989, pp. 6-7).
6. The reference in Newman (1871, p. 133) to a single specimen taken at Epworth, made by a Mr. T.H. Allis of York, is thought to refer to the same butterfly captured by Samuel Heaton Hudson in 1860.
7. Perennial Ryegrass *Lolium perenne* also dominates on high traffic areas of meadowland such as footpaths, MG5 communities under grazing stress or tending towards MG4 (Figure 3).
8. It was certainly known by then that the nutritional quality of hay steadily decreases the later it is cut after its optimum value in mid-June (NVC, 2013).
9. A fold would normally have been a fairly mobile square pen, conventionally made of hurdles and placed over herbage for sheep etc. to graze. Lands being worked or sensitive areas under crops could thereby be excluded or protected from otherwise miscellaneous animals which instead could be given fresh, completely unsoiled foliage at regular intervals. Tethering is also quoted as an alternative to folding, but this has the disadvantage of inefficacious fitted grazed-circles and it is not normal procedure to put a noose around the neck of a sheep.
10. Permanent meadow at Laxton on the base-rich Keuper Marl soils would have existed at the time of Domesday and possibly ran along the large syke within what ultimately became South Field (Beckett, 1989 p. 7). Indeed, South Field Syke SSSI (SK730655) holds the

richest sward of any of today's sykes at Laxton, including a mostly typical damp neutral and partial calcareous grassland flora. Anyone wishing to take a nostalgic trip to see what is almost certainly the nearest thing we have in Britain which topographically equates to our long-lost Mazarine Blue sites then this is the one to visit for easy friendly access.

11. Laxton's three great open fields date from 1189 to 1232, even if what remains of these today are somewhat reduced in size. South Field was possibly the last of these to have evolved into its maximum historic size at around this time (Beckett, 1989).
12. The gathering of information for the Domesday Book was commissioned by William at his Christmas Court in 1085 and was completed by August of 1086 (Williams and Fairbank, 1986).
13. It has to be noted that the details showing the open field systems several centuries extending into Victorian Epworth by HAU (1988), Ella (1994), Garner (1994) and Compton (1997) only examine the likely whereabouts of areas under tillage and not specifically the locations of meadows. Using these sources as the best educated assessment available it is here assumed that areas within the mapped fields not shown under 'ridge and furrow' cultivation are best deemed to be meadows of likely antiquity. Though, it is well known that areas normally cultivated could have been grassed-over in times of want just as meadows might well have been ploughed-up on a needs-be ad-hoc basis. For example, mainly around the 1400s when sheep farming became more profitable, large areas of ridge and furrow were turned to 'leyfields'; the corrugated features of which still remain preserved in today's pasture landscape (Williams and Fairbank, 1986; Beckett, 1989).

Each field would have been sub-divided into strips and shared out annually amongst the villagers according to farming considerations. Strips under cultivation would in all probability have been ploughed up one side and down the other so that in time a midway ridge of soil would have been thrown-up and furrows created on either side effectively acting as the boundaries between participants. Many villages and their open field systems were abandoned after the medieval period ended. These desertions, peaking during the 1400s, were due to the then greater prosperity in the wool-trade, with landowners forcing out villagers in favour of the sheep pasture mentioned above which, required less labour than arable farming. The medieval period under this discussion is understood to have begun with the Norman Conquest in 1066 and ended with the battle of Bosworth Field in 1485 (Williams and Fairbank, 1986).

14. These are: Eastoft Meadow SSSI [ex.LWT NR] (SE786142), Rush Furlong SSSI LWT NR (SE780004), West Burton Meadow SINC NWT NR (SK787851), Ashton's Meadow SSSI NWT NR (SK786799) and Laxton South Field Syke SSSI. Three other botanically-rich hay meadows on the Keuper Marl near Epworth also survive but were excluded from the main survey. All were deselected due their close proximity repetition to better representative, richer sites. These are: Seggholme Meadow LWT NR (SK792996), Laxton West Field Syke SSSI (SK712674) and Laxton Copthorne Syke SSSI (SK736660).
15. Eastoft Meadow.
16. At Laxton [South Field Syke] no other comparable sized area of midlands meadow grassland exists which has not apparently known the attention of the ploughman for nearly a thousand years. One authority even suggests that this mature meadowland has been in existence "long before the Norman Conquest" (Orwin and Orwin, 1970). It certainly does seem worthy of investigation by the curious of mind (Beckett, 1989) for a far less evocative appraisal.
17. Medieval 'Mel Wood' translates as Mill Wood. Whether the indicated mill was a wind-powered post-mill on the high ground of Mel Wood or a watermill possibly somewhere on the wood's southern edge along Burnham Beck is not known (Garner, 1994).
18. The term 'axiophyte' here is used to denote a plant or animal showing a discreet ecological connection to one another in the same type of habitat.
19. The species was found at three sites in Lincolnshire in the decade up to 1960; all near Epworth (Gibbons, 1975). Recently however, it has been subject to something of a revival, thanks to the attention of one dedicated individual.
20. The term 'MG5+' here is used to indicate MG5 grassland influenced by base-rich soils although, strictly speaking, Mesotrophic Grasslands (MG) are not supposed to exist on such a substrate. Conversely, sites with the root-hemiparasitic Yellow Rattle encourage botany with greater nutritional autonomy, mimicking plant communities more usual of poorer soils. Those species that notably profit are members of the Festuceae (Fescue grasses) and Fabaceae (Vetches, Clovers, and Trefoils etc.). Furthermore, long established haying practice reduces soil mineral content which also results in the potential for a more diverse flora that is less dependent on high nutritional values.
21. Arguably, both ants and butterflies may be responding to the same environmental stimuli resulting in their joint [correlated] loss, with the ecological bonds between them being far too circumspect to be viewed as empirical evidence, especially outside the Lycaenidae (Blues, Coppers and Hairstreaks). Nevertheless, this researcher strongly believes in a more holistic approach to butterfly ecology. This, currently provides more probable answers to difficult questions, before more thoughtful research is tentatively aimed at the trickier problems of causality.
22. Konrad Fiedler (Fiedler, 1991) gives details that "almost all older larvae are nearly permanently attended by ants" (*Lasius* sp.) and therefore are "steadily myrmecophilous", having both the tentacle organ and dorsal nectary organs.
23. Invariably, a mediievally operated open field left fallow for a one year in a standard three year rotation would provide grass, weeds and possibly meadowland for the grazing of sheep, fowl or other stock. On occasion, forage crops may have been sown as an alternative to laying fallow and cut as additional hay for animal feed (Beckett, 1989, pp. 9-11).
24. Misson Carr SSSI NWT NR (SK710977) and Potwell Dyke Grasslands SINC (SK703534).
25. Other archetypal ant-nesting substrates such as old stumps, rotten logs, underneath rocks and various Rushes *Juncus* sp. are normally absent from modern meadow sites, although under the conditions of their formative years this was probably not necessarily so.
26. All stages of Marbled White have morphology suggesting an association with ants. The even-surfaced pupae, for example, apparently 'sing' and as such are outwardly appealing to ants and have been found in black ant sp. *Lasius niger sens lat.* nests in Yorkshire chalk districts, suggesting this is where at least some of the butterflies emerge. Equally, the eggs are hard and smooth and so impervious to ant-attack. The larvae have a tough woolly coat and are toxic. The adults emerge with fluffy body-scales which doubtless easily disengage into the jaws of potential foe, especially ants, during the vulnerable eclosion process.
27. The distinct possibility exists that Marbled White also survived into Victorian times on meadowland abutting the mediievally operated open field system at Laxton. Until the 1870s an area believed to be extant ancient meadow previously contained within the northern extremity of Laxton West Field, centred on SK708680, connected with two other likely areas of meadow where the species is known to have been present in the 1860s. These were located on the west and east sides of this particular field in the next-door parishes of Kirton and Egmanton (Newman, 1871, p. 80). Mazarine Blue collected in the general domain of Sherwood Forest by John Trueman of

- Edwinstowe in the 1830s and 40s, could also, not impossibly, relate to the same Laxton area (Sterland, 1875, p. 267).
28. However, all these species only retain a primary importance for ants on sites that lack a build-up of thatch. Where thatch or a thick layer of dead plant-matter exists under the growing substrate almost any type of grass may harbour ants. Though, through an ill-fate of destiny, such a deposit is inimical to a wide variety of flora, especially Red Clover; indicating an unlikely abode for Mazarine Blue. By the very nature of this butterfly's meadowland home, all vegetative resources are episodically and practicably removed by the haymaker or grazed-away as forage so thatch isn't allowed to develop. A state of rejuvenation is thereby maintained on grasslands treated as meadow or pasture or a combination of both providing at least some key elements for the blue's survival. Moreover, doubtless all the cultural ingredients necessary if operations are preformed in the correct sequence paced over several years. For cost-effective conservation solutions to arrest Arthropod losses using such phased management see the seminal work of Cizek et al. (2012).
 29. Heath Grass growing in wetter areas normally has more of the lower-seeding panicle-branches (Hubbard, 1968, p. 353).
 30. It is here assumed that this grassland in its original natural state would have been formed with more equitable flowering throughout the spring and summer. Any latter-day bias is therefore due to an ecological constraint subsequent to its creation caused by humankind. In this case, mowing meadows consistently at the same time of year, every year, has to be seen as the main and quite possibly only culprit involved.
 31. Tufted Hair-grass is the most notable of the larger British grasses for having little nutritional benefit. It is exceedingly tough and razor-like and its lower growth tends to be left unmolested by grazing animals.
 32. Modern haymaking of these areas is however a model of expediency rather than a timeless tradition as anyone pitting their skills to hand-scything an undulating surface soon appreciates. Originally the tops of ridges may have been up to a metre higher than the bottoms of the furrows. These once cultivated lands were almost certainly grassed-over entirely for pasture not haying and it is only after the slow passage of time and gravity acting to moderate their appearance or the arrival of mechanisation, that cutting became realistic.
 33. The term 'hassocks' was the original country-name for Tufted Hair-grass (Hubbard, 1968). An area not far from Epworth called "Bull Hassocks" (SE727005), surely gives a good indication to the steadfast nature of this species in the erstwhile landscape.
 34. In ant-abundant order they are: 1st West Burton Meadow, 2nd Ashton's Meadow, 3rd Eastoft Meadow, 4th Rush Furlong and 5th Laxton South Field Syke. An educated guess as to the ant-dosage needed for the Marbled White would be in the region of no less than 1 million ants per hectare (around 100 ants per square metre). The best site, West Burton Meadow, probably had something like 20,000 ants when surveyed in September 2015, covering 1 hectare (an average of 2 ants per square metre); = approximately a fiftieth of the minimum required.
 35. The foremost southern and midland lowland grassland ants to increase with calcareous influence are *Myrmica sabuleti* and *Lasius flavus*.
 36. In the case of Marbled White: Red Fescue on neutral+ soils to Sheep's Fescue *Festuca ovina* on calciferous ones.
 37. At my main study area of Shireoaks Colliery Spoil-heap (SK561804), Marbled White only flies in abundance directly over places where the best populations of red ant sp. *Myrmica scabrinodis* are found in company with equally good numbers of black ant sp. *Lasius niger sens lat*. Within the locality only scant butterflies are seen straying even short distances from these areas into positions where either or both ants are missing. This insect also vacates areas without these ants if deliberately placed in such spots. Moreover, probable butterflies, from sites lacking such ants, poorly chosen for introduction by this researcher, have repeatedly been discovered later where both ant species are to be found. It is likely, of course, these events are circumstantial as not all habitats with the two particular ant species attract Marbled White or are capable of supporting colonies. Although the exact determination of what type or even possibly types of black ant might occur on some sites still needs more research. It does nonetheless suggest that stimuli in addition to ants are important in holding the butterfly to localised areas and presumably in directing it somewhat precisely to new ones.

The Marbled White and Ringlet *Aphantopus hyperantus* are unique among British butterflies in scattering their eggs during flight or from perching-points without coming into corporeal contact with the food materials necessary for their respective progeny. This lack of direct verification suggests both are operating sophisticated scent detection systems (Thomas and Lewington, 1991, pp. 83-84, 190). In the case of Marbled White larvae they also ingest various species of endophytic fungi (Acremonium, Neotyphodium and Epichloa taxa) along with their main diet of grass. In the digestive system of each caterpillar these are then sequestered, possibly together with plant flavonoids, into species-specific profiled loline and peramine alkaloids (Miriam Rothschild, pers. com., 2001). According to Brower and Brower (1964), such unsavoury substances are then known to repel potential foe such as predators or parasitoids. This defence stratagem is ultimately maintained by the adult butterfly. Its black and white chequer-board wing-pattern almost certainly indicates a warning to birds not to attack because the species is poisonous (Wilson, 1986; Brodie, 2009).

- Presuming ants and fungi are important for the ecological wellbeing and potential survival of the Marbled White it would certainly make a lot of sense for this butterfly to have evolved the best possible mechanism to detect both before casting its eggs so wantonly to the breeze as indeed, appears to be the case with the detection of ants. It is perhaps more than just a mere theory that the butterfly with foremost efficiency locates its chosen ant species, at times from several kilometres away, and then at much closer-quarters the fungi which because they tend to utilize precise grasses, by this predominantly singular association, the choice of larval foodplant. Alternatively, the pabulum chosen by the butterfly for its larvae has a characteristic 'smell' coming from a particular fungus that is essential if the next generation are to be benefitted by being deadly if eaten or simply highly repellent to budding undesirables. Moreover, any butterfly whose caterpillars attract ants with amino acids emitted from deliberately evolved and still functional glands, such as those of the Mazarine Blue, would axiomatically have an equally strong evolutionary imperative to detect them, presumably unseen, before it likewise deposits any of its unwitting offspring as eggs. It is here strongly implied that this is in fact the case, despite a lack of critical proof to back this somewhat leading assumption.
38. The application of Farmyard Manure (FYM) to meadowland is nevertheless given the go-ahead by Natural England, providing would-be farming entrepreneurs with detailed prescribed dosages (NVC, 2013, p.7). Yet, its producers are nowadays nearly always treated with antibiotics for a varying array of ailments and pathogens, resulting in faeces etc. being largely immune to the immediate natural decaying processes.
 39. There is conversely quite an 'ecological distance' between Red Clover and Bitter Vetchling. Both these plants, despite being tolerant of the same neutral conditions, are rarely found growing in abundance together. That is, unless the underlying soils show distinct variations in pH value; with the Clover on a more alkaline substrate and the Vetchling, a more acidic one, and such areas are invariably

uneven or hilly which is certainly not characteristic of modern meadowland. The main implication here being that this ideal forerunner of MG5c grassland would have been on the calcareous side of neutral and either lacked or was poorly represented by Bitter Vetchling. Periodic Mesolithic burning of scrubland in a natural succession would also have favoured the Clover by destroying any build-up of thatch; which is so easily tolerated by the Vetchling.

40. Another MG5c community constant is Common Sorrel *Rumex acetosa*; a noted foodplant for the larvae of the Scarce Copper butterfly *Lycaena virgaureae*. Now equally missing from our shores or disputed as ever having occurred within Britain. Perhaps therefore, only a 'blustery-squall' was once provided here for this, another notably damp meadowland species on the continent.
41. All other plant axiophyte species depicted in Figure 3 are perennial, apart from Meadow Brome *Bromus commutatus* and Soft Brome *B. hordeaceus*, which can survive as biennials.
42. Dale senior's evidence provides an almost unbroken account of a diminishing butterfly over a 34 year period from 1808 to 1841 at Glanville's Wootton and it is cautiously suggested that a yearly singular-timed cutting-regime might take several decades to stress the ecology of a large healthy population to an extent where ants become scarce and the butterfly extinct. The species only just survived 1816, "the year with no summer", at this famed Wootton site and evermore subtle environmental factors would then have played an increasing part in the timing of its decline to eventual dearth as implied by Cooper (2015).

The last mediievally-operated open field [MG5+] grasslands at Wootton apparently came to a voluntary conclusion at Newlands around 1770 where, "the regularity of the fields indicates enclosure of a very late date". Presumably, the best meadowland candidate area being the seven post-enclosure fields totalling c.30 hectares, centred on ST693094, on the Oxford Clay. Probable dating of the field-system formats at next-door Holwell are seemingly unknown. While similar lands in neighbouring Pulham, likely had meadows isolated from those at Newlands within its two large rotationally-managed fields until c.1730 (BHO, 1970).

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