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The dotted bee-fly

(*Bombylius discolor* Mikan 1796)

A report on the survey and research work undertaken between 1999 and 2003

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A report on the survey and research work undertaken between 1999 and 2003

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Summary

- In four years of survey work from 1999-2003 70 sites were searched for *B. discolor*.
- *B. discolor* was found at 36 sites, just over half.
- Of these, 19 (53%) were proven to be breeding colonies (ie exuvia found) or shown to be very probable breeding colonies (ie oviposition observed).
- Over the survey period, records were obtained from Kent, Sussex, Isle of Wight, Dorset, east Devon, south Wiltshire, Somerset, Gloucestershire, Warwickshire and the Gower in South Wales.
- In the Home Counties, east midlands and East Anglia *B. discolor* appears to have gone extinct.
- In Kent, coastal Sussex, Isle of Wight, Dorset, coastal east Devon, south Wiltshire, Somerset, south Gloucestershire and the Gower *B. discolor* is locally frequent with many strong colonies.
- In Warwickshire and north Gloucestershire it is still rare with colonies small; data for other parts of its range is lacking.
- Ecological research was conducted at Uphill Quarry and several other colonies near Bristol; success was limited by vandalism and foot and mouth disease.
- *Andrena flavipes* was confirmed as a host; *A. cineraria* was shown to be strongly associated in some areas and almost certainly a host; both of these species produce large dense nesting aggregations.
- It is concluded that *B. discolor* is not strongly host specific but is attracted to large dense colonies in suitable habitat and could develop on any *Andrena* species of the correct size.
- *B. discolor* first appears in the third week of March, peaks in the second week of April, a few surviving to the end of May with no sign of shift to earlier emergence in recent decades.
- *B. discolor* does best on open unimproved or semi-improved grassland with nearby woodland or scrub for shelter, a southerly aspect, bare or very sparsely vegetated ground, exposed dust patches and an abundance of pollen sources in early spring.
- One flower species, *Glechoma hederacea*, is very much favoured as a nectar source for *B. discolor* with *Primula vulgaris* of secondary importance.
- The host bees studied collect pollen predominately from Brassicaceae, Rosaceae and Taraxacum but a wide range of other species are used.
- The decline of *B. discolor* in the 1950's coincides very closely with the catastrophic decline of rabbits between introduction of myxomatosis and 1958-59 when they reached their lowest numbers.
- Other factors contributing to the decline of *B. discolor* are likely to be the loss of unimproved calcareous grassland, reduction of grazing of domestic animals on this habitat and agricultural intensification leading to the loss of pollen sources.

- The recent observed recovery in parts of the country is likely to be due to conservation grazing, a warming climate which has favoured the bees and increased recorder effort.

Contents

1. Introduction

The Dotted Beefly *Bombylius discolor* is a very distinctive and attractive element of the British fly fauna. It is a decidedly local species but still sufficiently frequent for survey and research work to yield illuminating results. It went through a period of great rarity in the middle of the 20th century and, being a parasitoid of bees, is entirely dependent on the success of these insects which are themselves prone to fluctuating populations. All these characteristics make *B. discolor* an ideal species for a Biodiversity Action Plan.

2. Methods

2.1 Survey

The first year of this project, 1999, was dedicated to survey while in subsequent years the time was more or less evenly divided between survey and research. The survey had two main aims: 1) to confirm the presence of *B. discolor* at known sites, particularly where there had been no records for many years; 2) to discover new colonies.

The vast majority of known sites were listed by Ismay (1999) and where a six-figure grid reference is provided then finding the site of the observation was usually an easy matter. When only a four or two figure grid reference was available then it was often not possible to deduce the exact location of the observation. It soon became apparent that many of the known records of *B. discolor*, perhaps the majority, were observations of single foraging individuals and did not at all indicate the close proximity of a breeding colony. Only those records where exuvia had been found or oviposition observed could one be sure that the recorder had come across a colony. Thus, even when visiting locations with previous records, it was often necessary to deduce potential breeding sites by looking at maps to appreciate topography and search quite widely from the site of the original observation. Priority was given to those areas where observations had been made at sites likely to hold breeding colonies, such as quarries, downland, coastal slopes and railway cuttings. Many of the observations were from woodland rides or gardens; in these cases it was often better to search the nearest suitable habitat rather than go to the exact location of the previous observation.

New sites were found in two ways, by examining maps for likely sites, notably south-facing steep slopes, old quarries, Iron Age hill forts and railway cuttings and by simply spotting suitable sites while driving around. *B. discolor* frequently used warm sunny slopes much too small to show up on any but the most large scale maps so finding these colonies was largely a matter of luck.

When *B. discolor* was found, its sex was determined, location pinpointed on a sketch map and behaviour noted. Additionally, all bee species with the potential to be the host for *B. discolor* were noted, specimens being taken to confirm identification if necessary. Where a bee colony was located, a thorough search for exuvia was made. All exuvia found were retained for later examination to confirm species and sex. In the absence of any exuvia being found, any female beeflies in the area were watched in the hope that oviposition could be observed to confirm that the bee colony was being used.

2.2 Research

This proved to be much more problematic than first thought and suffered seriously from misfortune and lack of time. The research instigated had the following aims:

- to confirm suspected host species;
- to more fully characterise the habitat requirements, both for breeding and foraging and deduce common features;
- to record preferred nectar sources;
- to assess fecundity relative to other bombylid species;
- to estimate the productivity of colonies;
- to attempt to explain the drastic decline of *B. discolor*.

Much of this could be achieved by careful observation of many individuals at many colonies then collating the data. An assessment of the productivity of colonies was achieved by collecting as many exuvia as possible over the season. Fecundity involved taking four females and dissecting out the egg masses then simply counting all recognisable eggs.

The attempt to confirm host preference was considered to be a priority. Observation and identification of bees at colonies where *B. discolor* was seen ovipositing or exuvia found pointed at the most likely species. However, because bee colonies were often mixed, one could never be absolutely certain which bee species had been parastised. Several experiments were devised to try to show with certainty which bee species was being used as the host. The option of digging up parts of bee colonies and rearing beeflies in the laboratory was not available both because this would have damaged the colony on which further work would be conducted and also because the study sites were all nature reserves and permission for such intervention would not be granted.

Artificial nesting sites (Figures 5 & 6 appendix 2); three deep wooden boxes measuring 50x34x24 cm were constructed of untreated pine screwed together. The depth was hoped to be sufficient for *Andrena* nests, the other dimensions gave as large an area as possible without making it so heavy as to be immovable. The boxes were taken to the main study site at Uphill and placed close to the *Andrena flavipes* colony. One was placed next to a very dense aggregation, the other two in rather more dispersed colonies. The boxes were then filled with sieved soil taken from a disturbed area on the reserve, packing it down well. After the first few inches drinking straws were pushed into the soil to be removed when the box was full so leaving a deep hole. It was hoped that these holes would encourage bees to investigate and increase the possibility of nest chambers being dug in the boxes. The boxes were then disguised with rocks and grass as much as possible and left undisturbed.

Monitoring of natural colonies to identify areas used by a single species. The theory was that if sufficiently large enough areas could be identified then emergence traps could be placed over them the following spring. If *B. discolor* emerged from these areas then this would be as good a confirmation of the host as is possible without destructive or laboratory based techniques. Many hours were spent observing bees carrying pollen back to their colony to be as sure as possible that only one species was involved. At the main study sites this was always *Andrena flavipes*.

3. Results

3.1 The natural history of *B. discolor*

3.1.1 Distribution

In the time available it was only possible to visit a relatively small sample of sites to assess the current status of *B. discolor*. In the first year (1999) when most of the survey was done, a total of 36 sites (1km squares) were explored between 6 April and 10 May in east Devon, Dorset, Isle of Wight, Kent, Somerset and Gloucestershire. The three sites closest to Bristol (Troopers Hill, Hellenge Hill and Uphill) were visited on several dates each, the remainder on a single date; between one and five hours spent searching each site dependent upon its size and potential. The weather conditions during the survey were highly variable as might be expected at this time of the year. Early and middle April was relatively dry with sunny periods but there was generally a very cold wind which restricted observations to sheltered spots. Similar sunny but very windy conditions were encountered up to the end of April, but this did not seem to affect the activity of *B. discolor* along the sheltered undercliff. On the 23 April it rained continuously precluding the possibility of observing adults although exuvia could still be found. Early May saw ideal conditions for the survey but conditions rapidly deteriorated and the last days survey was done in changeable, windy weather.

In 2000 monitoring continued on sites close to Bristol, Uphill, Troopers Hill and Hellenge Hill, but attempts to survey those sites in Dorset which had been rained off in 1999 had to be aborted due to cold drizzly weather conditions.

In 2001 there was no survey or research due to the foot and mouth outbreak which made it impossible to access the sites.

In 2002 survey effort was directed to counties north of Bristol where the species is more localised and on the margins of its British range. As many sites as possible, both known and potential, in Gloucestershire, The Gower, Warwickshire, Worcestershire and south Shropshire were visited. The trip to the Gower was rendered inconclusive due to poor weather but all other visits were in conditions quite adequate to expect *B. discolor* to be flying. Monitoring Uphill, Troopers Hill and Hellenge Hill continued.

In 2003 several new sites were searched in Somerset, Gloucestershire, Wiltshire and south Wales including the Gower. Monitoring at Uphill, Troopers Hill and Hellenge Hill continued. This spring was more consistently sunny than most and all survey work was undertaken in good weather conditions.

Table 1. Summary of sites visited and *B. discolor* observed

COLONY=successful breeding proven by finding exuvia
colony=probable breeding shown by observing ovipositing
present=foraging or territory holding in suitable habitat
present= foraging or territory holding away from suitable breeding habitat

Site	***B. discolor***		***A. flavipes***	***A. cineraria***
	previous records	**this survey**		
Wyre Forest	1986			
Hartlebury Common LNR				
Ufton Fields	1969			
Harbury Spoil Banks NR	2002			
Combrook	1977			
The Mythe	1997	cloudy		
Cleeve Hill		cloudy		present
Chedworth	1960			present
Shortwood				
Haresfield Beacon				present
Daneway	1997			present
fields north of Siccaridge Wood		present		
Strawberry Banks NR	1997			
Rodborough Common (south end)	1997	*present*		present
Hailey Wood		present		
Devil's Churchyard (covert)	1986	present		present
Uley Bury				
Owlpen Manor	1996	**COLONY**	present	present
Breakheart Hill Quarry	1990	present		
Coombe Hill, Wotton-under-Edge	1892	**colony**		present
Swillbrook Lakes	1997			present
Midger NR	1979	present		
Horton	2001	**COLONY**	present	
Merthyr-mawr (north)				
Dunraven Park			present	
Hinton Hill, South Gloucestershire		**colony**		present
Marshfield	1996			
Troopers Hill, Bristol		**COLONY**	common	common
Knap Hill NNR				present
Roundway Hill Covert NR				present
Cam Valley		present		
Dolebury Warren			present	
Hellenge Hill		**COLONY**	frequent	frequent
Uphill		**COLONY**	common	rare
Cheddar Wood	1984			
Cheddar Gorge		*present*	present	present
Brent Knoll		*present*	present	
Collard Hill		**colony**		present
Moorlinch	1998	**colony**		
Walton Hill		*present*		
Broad Chalke	1994	*present*		
Ebblesbourne Wake		**COLONY**	present	

Site	***B. discolor***		***A. flavipes***	***A. cineraria***
	previous records	**this survey**		
Cadbury Castle		*present*		1
St Michael's Hill	1984	rain		
Hartington Moor				
Park Gate	1996			
Dowlings Farm	1983			
St Margret's at Cliffe		**colony**		present
Peene		**colony**	present	
Asholt Wood		*present*		
Folkstone Warren	1925	**colony**	2	present
Copt Point		**colony**	common	
Pilgrims Way		late in day		
Hogs Back	1989	rain		
Powerstock Common	1995	**COLONY**		
Golden Cap				
Branscombe	1973	*present*	common	frequent
Sutton Poyytz	1991	rain		
Gurnard Ledge			frequent	
Bembridge Down	1900	*present*	present	1
Redcliff		**colony**	common	
Headon Warren				
Mottistone Down		*present*		
Brook Bay			few	
Ballard Down	1949	*present*	common	
Luccombe	1947	**colony**	common	1
Landslip		**colony**	common	
Durlstone Country Park				present
St. Catherine's Point	1972	**colony**	common	present
Totals 70 sites	32 sites	36 sites	22 sites	25 sites

The summary table above lists all sites surveyed ordered by latitude from north to south. It is notable that there are no observations at any of the sites at the northern limit of the range of *B. discolor*, even where it is known from observations by other dipterists that the species is present. In Warwickshire it seems that colonies are very small, rarely more than a single individual being observed (Steve Falk pers comm.) thus, despite good conditions, surveys in 2002 failed to come across any individuals. The same seems to be true of north Gloucestershire where observations have been confined to singletons and none could be found during survey work for this project. However, a little further south, level with Stroud, suddenly *B. discolor* appears regularly, not only at known sites but it proved easy to find at new localities. This situation also appears to be true for Somerset, far south of Wiltshire, Dorset, Isle of Wight and east Kent. However, the northern half of Wiltshire failed to produce any and in South Wales it seems to be largely confined to the Gower, the few records away from this peninsular being of single individuals (Howe 2002).

Unfortunately no survey work was done in Cornwall, Devon (except the easternmost part), mainland Hampshire, Sussex, the Home Counties, East Anglia or the east midlands, all areas where there have been records up until the 1980’s. Most of these areas, especially the Home

Counties, are well covered by dipterists, yet the only record to come to my notice is a colony in the grounds of the University in Brighton, Sussex.

Thus it would appear that *B. discolor* has a core distribution with strong populations covering south Gloucestershire, Somerset, south Wiltshire, east coastal Devon, Dorset, Isle of Wight, coastal Sussex and east Kent. There is also a strong outlier population on coastal parts of the Gower peninsular. Outside this core distribution are scattered, potentially fragile colonies in Warwickshire, north Gloucestershire and parts of coastal South Wales. Present data suggests that it has disappeared from the Home Counties, mainland Hampshire, inland Sussex, East Anglia and the east midlands. The situation in the southwest peninsular is uncertain but it seems highly unlikely that it holds a very strong population. However, it would be equally surprising if it has gone extinct here.

3.1.2 Status

Of the 70 sites visited, more than half were shown to have *B. discolor* present and 19 of these (27%) were proven to be breeding colonies by discovering exuvia or observing oviposition. 32 of the sites visited were known to have previous records; most of these were listed in Ismay (1999) with a few from Alexander (1999). Of these known sites 16, exactly half, still had *B. discolor* present, including one where they had not been observed for over 100 years. 37 sites were visited speculatively, often because there had been an observation in a garden or some other unsuitable habitat within a few miles and the topography and known habitat seemed likely to be favourable for the species. Of these *B. discolor* was found at 20 sites, a proportion of 54%. If the same analysis is done for those sites in the core area of distribution then 55 sites produced 36 with *B. discolor* (65%); known sites 26 with *B. discolor* still present at 16 (61%); speculative visits to 29 sites with *B. discolor* found at 20 (69%).

It can be seen from these results that speculative visits to likely sites was as successful in discovering *B. discolor* as was following up records from previous years. Within the core area of distribution this tendency is even stronger. This is not the result that would be expected for a very local species confined to most favoured sites. Within the core distribution *B. discolor* is very well established and seems to be present at a fairly high proportion (perhaps as much as 50%) of suitable sites.

Certainly *B. discolor* did decline dramatically, a situation reflected in other Diptera such as the disappearance of *Villa venusta* (Meigen, 1820) as a British species (Stubbs & Drake 2001) and the contraction of the range of *Volucella inanis* (Linnaeus, 1758) to the London area (Morris & Ball 2003). From the table above it does appear that *B. discolor* declined to a low level in the 1950's to 1970's and then increased dramatically. The decline in the 1950's would seem to be real as there is no evidence of a reduction in recording effort at this time. Indeed records of Empids and Pipunculids doubled in this time, more than doubling in the next decade and increased nearly three fold from the 1960's to the 1970's. However, the sudden jump in records in the 1980's is almost entirely due to recording effort; Diptera recording increased about 10 fold over this period. It is notable that this increase only appears to occur in Dorset and Somerset and is almost entirely due to the efforts of the Levy's and associates who recorded *B. discolor* while surveying these counties for hoverflies (Syrphidae). In Gloucestershire and the Isle of Wight records remained fairly constant in the 1980's, increasing dramatically in Gloucestershire in the 1990's.

Chart 1. Records of *B. discolor* per decade for selected regions
(does not include records from the present survey)

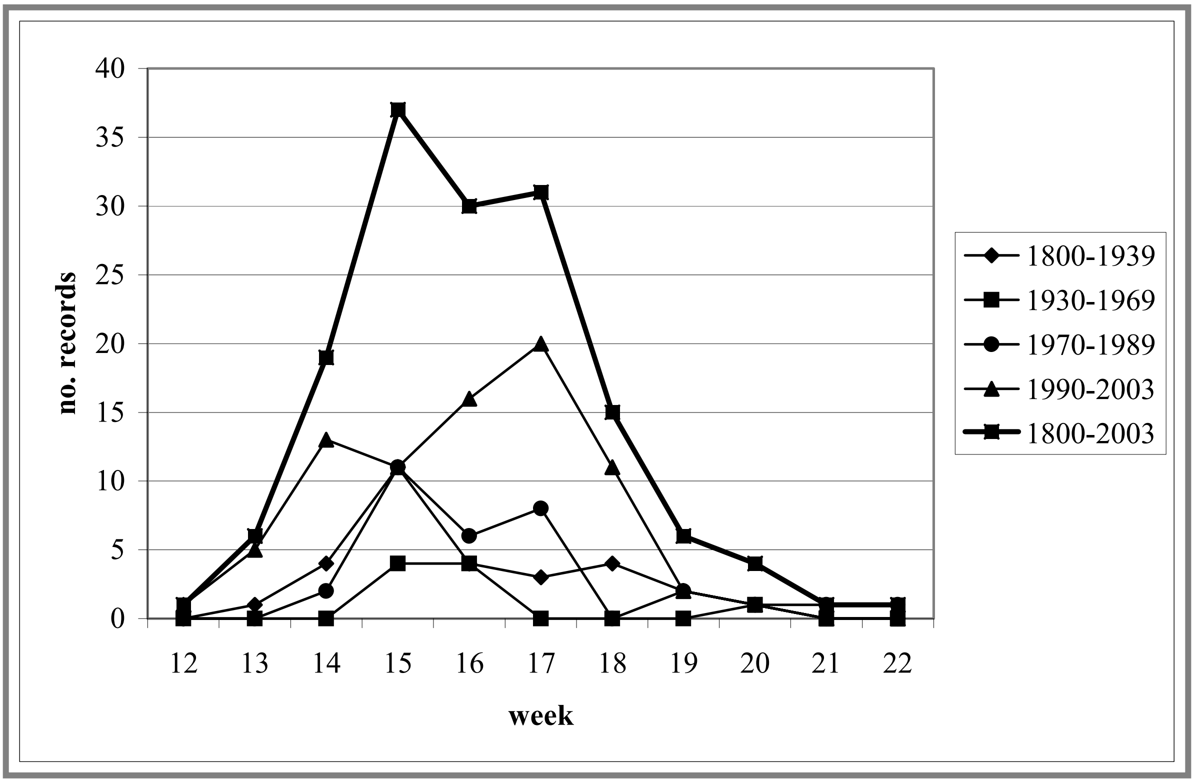
So having taken the effects of recording effort into account, it seems reasonable to conclude that *B. discolor* declined considerably between 1940 and 1950. In the peripheral parts of its range this decline seems to have been catastrophic with no evidence of breeding and few records of individuals in some of the best-recorded parts of the county. In the core areas where recording was decidedly less this decline seems to have mirrored that of the peripheral areas with no records at all in the 1950’s; in this decade there were only six records for the whole country, most in the most intensively recorded part of the country. However it seemed clear that, while colonies contracted to levels which made detection of the species very unlikely, many did not go extinct and as soon as they were looked for in the 1980’s they were found to be very widespread and not infrequent. In Gloucestershire, where there was no systematic Diptera recording in the 1980’s, its recovery did not become apparent until the 1990’s.

By the time this survey started it seems as if the recovery of *B. discolor* had been substantial in the core areas of distribution. Although it is still far from being “Fairly common in the spring” as it was once described in Somerset and Gloucestershire (Audcent 1948) it is probably locally frequent. Given the very serious reduction in natural grassland since the 1940’s it is never likely to recover to its 1940 status. In the peripheral areas it is still very rare and local in Warwickshire, South Wales (away from the Gower) and north Gloucestershire but showing definite signs of recovery and may be no scarcer in these areas now than it was historically. In the Home Counties, East Anglia and east midlands it still appears to be largely absent; there is no sign of recovery even where host bee colonies are now strong.

3.1.3 Phenology

Bombylius discolor is an early spring species with the earliest record for 23 March and often surviving until the third week of May. There are a couple of records after this time, one in June and one in August. There is absolutely no evidence from either this country or the continent that *B. discolor* has a second brood so both these records, are certain to be errors of transcription or labelling. Ismay (1999) put all the dated records into 10-day date classes and concluded that the peak of the flight period fell in mid to late April. I have analysed the same data but putting it into 7-day date classes and adding further data up to the present.

Chart 2. The Phenology of *B. discolor* over the 20th century



The chart above shows the flight period peaking in the second week of April which is a little earlier than the conclusion reached by Ismay (1999). The data used for this chart is exactly the same as that used by Ismay (1999) but with post 1999 data added; so has there been a recent shift of flight peak to an earlier date? This seems most unlikely as the 1990 to 2003 data peaks in the third week, two weeks later than the overall data. Thus the difference is certainly an artefact of the different date classes used and not evidence of a shift in flight peak.

Far more interesting is a comparison of the different periods through the 20th century. In recent years it has been noticed that many elements of temperate fauna and flora are responding to increasing temperatures by breeding or flowering earlier. If might be expected that an early spring fly would be one of the species especially prone to responding to climatic change. But this does not seem to be happening with the peak of records being very similar, if anything the 1990-2003 data set showing a later peak. This later peak is largely due to the preponderance of records coming from my own survey work in 1999 when most success happened to be in late April and early May.

In conclusion *B. discolor* first appears in the third week of March, reaches a peak in the second week of April, a few surviving to the end of May with no sign of any change in this pattern over the 20th century.

3.1.4 Habitat and colony locations

B. discolor is often found in woodland, gardens and similar sheltered and flowery spots, especially early in the season and during periods of cold northerly winds. However, such sites are rarely used for breeding and during this survey the few woodland sites which yielded records were either territory holding males or foraging females, no ovipositing behaviour was seen. The single exception is Powerstock Common where a colony was present within a large woodland area, but the actual colony was along a disused railway line where calcareous grassland had developed. All other proven colonies were on more or less open grassland, often calcareous, on downs and soft rock coastal slopes.

The type of grassland *B. discolor* is found on varies considerably in both type and quality from the ungrazed acid grassland at Troopers Hill, through closely sheep-grazed unimproved calcareous grassland of Collard Hill to semi-improved cattle pasture such as at Owlpen Manor. Many of the coastal sites, especially on the Isle of Wight, are rapidly eroding slopes with a largely ruderal flora. All colonies were on south, southwest or, less often, southeast-facing slopes, thus not only gaining maximum warming from the early spring sunshine but being sheltered from the cold north or northeast winds which often occur during their flight period. The essential elements common to nearly all sites seem to be.

1. open unimproved or semi-improved grassland;
2. shelter in the form of nearby woodland with sunny rides, scrub, sunken lanes or gardens;
3. southerly aspect;
4. bare or very sparsely vegetated ground (created by erosion, steep slopes or grazing);
5. exposed dust patches such as the margin of tracks and paths, exposures caused by grazing animals and rabbit scratchings;
6. an abundance of flowers to provide a pollen source for the host bees in early spring.

With the exception of the eroding soft-rock cliffs of the south coast, all breeding sites for *B. discolor* seen have been formed by human activity and are often maintained by continued activity. Even on these coastal slopes the bees are likely to depend to some measure on pastureland on the adjacent farmland and the habitat in many cases is grazed even if only by rabbits. The majority of sites are calcareous grassland created and maintained by domestic grazing animals. At these sites the sheep or cattle not only maintain the open nature of the grassland but also create bare soil and keep glades in scrub open. Cattle particularly seem to be very important for creating exposures of soil along paths or on slightly steeper banks where the bees can nest. Usually these sites are relatively lush with a dense sward and without the exposures caused by cattle there would be no suitable sites for nesting bees.

Of the ungrazed sites many have an industrial history such as mining, quarrying or old railway lines. Although these sites have invariably been abandoned for many decades, it does show that *B. discolor* has in the past followed its host bee when a new site is colonised. At least one of these sites, Troopers Hill in Bristol, erosion caused by human use of the site is an important contributor to maintaining the bare and sparsely vegetated areas.

3.1.5 Colony size

Attempting to estimate the size of a colony of *B. discolor* is not at all easy and it soon became obvious that a count of adults was not very informative. For example on a visit to Owlpen Manor on 15 April 2002 9 adults were seen but 20 exuvia found in a very small area. Exuvia are very difficult to spot, often barely protruding from the soil and if flies emerge amongst grass they are unlikely to be found. Further, flies will often emerge through the same hole so pushing out earlier exuvia which then soon blow away, and any shower of rain will soak and destroy any exposed exuvia. Thus it is certain that any exuvia count will underestimate the productivity of a colony, and a count from a single visit will probably do so very considerably. However, what such exercises did show was that only a very small proportion of the adult *B. discolor* which had hatched from a colony that spring would be present at any one time.

In 2003 an attempt was made to get a better idea of the total number of *B. discolor* emerging at the nearest colony on Troopers Hill, Bristol. In addition to the proximity of this site, Troopers Hill had the advantage that I was very familiar with it, having watched the bees and beeflies here over several years, so knew all the likely locations for emerging *B. discolor*. The site was visited three times in the early part of the flight period and searched thoroughly for exuvia.

Table 2. Exuvia counts at Troopers Hill (2003)

date	3 April	7 April	17 April	total
male	8	2	1	11
female	15	6	0	21
total	25	8	1	32

The highest count of adults on this site was of 10 individuals on 3 April but 8 of these were females freshly emerged and not yet taken their maiden flight. On 17 April six females were seen ovipositing and on the 22 April many females were observed but counting them as they flew around without duplication proved impossible. However, the exuvia found show that there were many more *B. discolor* emerging than could be counted on any one visit as adults.

There is no reason to believe that the sex ratio in *B. discolor* is anything other than 50:50. Thus it can be assumed that the minimum productivity of Troopers Hill in 2003 is 42 individuals. The preponderance of female exuvia found can almost certainly be explained by the earlier emergence of males, most having hatched in the last two weeks of March and most of the exuvia having been washed away by rain and destroyed soon after. It is very hard to know what proportion of exuvia were found, those protruding from bare soil have a high chance of discovery, those amongst grass are unlikely to be spotted. I feel that it is highly unlikely that much more than half of the exuvia cast at Troopers Hill in 2003 were found. An estimate of the total number of *B. discolor* emerging in 2003 of 60 to 80 individuals does not seem unreasonable. Over the years the best count of adults at Troopers Hill during the time of peak activity is about 6-8 individuals. Thus as a very approximate rule of thumb, a colony is about one order of magnitude greater than the count of adults at the peak of activity (2nd-3rd week of April).

Troopers Hill was one of the strongest colonies observed over the study but several others were also as large. The largest continuous colony was along the coastal slopes east of Horton on the Gower. On the 6 April 2003 I counted 25, most of them territory holding males suggesting that females were yet to finish emerging. Applying the criteria derrived from Troopers Hill data, then along this 3 km of coast hundreds of *B. discolor* had emerged.

3.1.6 Host preferences

Confirming the bee species on which *B. discolor* depends was, at the start of this project, considered to be one of the most critical aims and, it soon transpired, would be the most difficult to achieve. There appears to be only one confirmed rearing record of *B. discolor*, from *Andrena vaga* Panzer, 1799 (fide Yeates & Greathead 1997), a very rare species in Britain so certainly not a possible host in this country. All other suggested hosts have been arrived at by association and include *Andrena cineraria*, *Andrena flavipes*, *Andrena clarkella* and *Andrena labialis* (Ismay 1999). The latter two species have only been associated with *B. discolor* once each and then some time ago and by the same person. All recent observations where the bees have been recorded, including my own, suggest *Andrena cineraria* and/or *Andrena flavipes* as the most likely hosts.

Because techniques which would damage the bee colonies were not desirable, no attempt to dig up and dissect bee colonies was made. Instead, it was hoped to encourage bees to use artificial nests as described in methods above. The artificial nest boxes placed in a colony of *Andrena flavipes* at Uphill Quarry were visited on the few sunny days which occurred in the weeks after they were put in place. During these visits there was no sign of new holes, bees using the artificial holes or any bees showing an interest at all. Unfortunately, before the *Andrena* nesting season was more than half over the boxes were vandalised by local children, their contents being spilled down the slope and all three broken up. The remains were salvaged but it was far too late to start again.

The fact that the bees did not seem to take to the nest boxes in the few weeks they were in situ. suggests that this technique would not work in the short term. It is noticeable when observing the species at close quarters that emerging bees leave behind them distinct holes which are barely different from those being used for a new brood. Prospecting bees frequently investigate emergence holes and it is highly likely that the same holes are used year after year. The integrity of the colony is likely to be maintained if the bees are preferentially attracted to areas of closely packed holes which smell of *Andrena flavipes*. There were no further attempts to get *Andrena* bees to nest in artificial sites.

Close observations of colonies of *Andrena flavipes* at Uphill continued through the spring of 2000. Three parts of the population were chosen to look at in detail. These three differed in the density of nests and slope; the densest area on a 30 degree slope; medium density on an almost flat area and a dispersed colony on a 45+ degree slope.

The theory was that areas occupied by a single species are identified and emergence traps placed over these areas the following spring. If *B. discolor* emerged from these areas then this would confirm the host as far as is possible without destructive or laboratory based techniques.

During my observations which spanned the entire *B. discolor* oviposition period in 2000 only two species of bee were seen to nest in the observed areas, the very abundant *Andrena flavipes* and a single *Lasioglossum leucozonium*. Unfortunately, the following year all research was cancelled due to foot and mouth disease.

Further observations in 2002 confirmed the presence of pure *Andrena flavipes* colonies at Uphill Quarry, Walborough Hill and Hellenge Hill. In spring 2003 emergence traps were placed over colonies at all of these and checked on a daily basis during the peak emergence time in early April. These traps caught two bee species, *Andrena flavipes* (up to 10 in one trap in one morning) and its cleptoparasitoid *Nomada fucata*. This certainly seems to confirm the observations of the previous season that these were pure *A. flavipes* colonies. Unfortunately this endeavour failed to yield the hoped for results, no *B. discolor* were caught in any of the traps. However, at two of these known pure *A. flavipes* colonies, Hellenge Hill and Walborough, the exuvia of *B. discolor* were found. Although this is still only an association, the long, close observation of these colonies can virtually rule out the possibility of a different host being available for *B. discolor* at these locations. Thus it can safely be concluded that *A. flavipes* is a host for *B. discolor*.

But this is certainly not the whole story, while *A. flavipes* is certainly a host, there is no reason to believe that it is the only host. Indeed, further north in the Cotswolds *B. discolor* seems to occur where *A. flavipes* is scarce or absent but *A. cineraria* is common. Unfortunately, there was no time to do the same studies to confirm that any of these colonies were both pure *A. cineraria* and supported a population of *B. discolor*. The following table summarises the correlations between observations of *B. discolor* and these two *Andrena* species at confirmed or likely *B. discolor* breeding sites.

Tables 3-5. Host bee correlations

All sites

	A. flavipes	*A. cineraria*
present	14	12
absent	11	13

North of Bristol

	A. flavipes	*A. cineraria*
present	2	5
absent	3	0

South of Bristol

	A. flavipes	*A. cineraria*
present	12	7
absent	8	13

The first of these tables presenting the overall data shows only a slight bias towards finding *B. discolor* in association with *A. flavipes* rather than *A. cineraria* and this difference is unlikely to be significant. However, when these data are separated into North (essentially Cotswolds populations) and South (all other populations) then there seem to be distinct associations. South of Bristol *B. discolor* was found at 12 sites where *A. flavipes* was present but a little more than half this number could be associated with *A. cineraria*. North of Bristol the data is limited because fewer colonies were located but it can be seen that more than half of them were associated with *A. cineraria* and not *A. flavipes*. It seems reasonable to conclude that *A. cineraria* is also a host bee and seems to be the main host in those areas where *A. flavipes* is absent or scarce.

During my survey work no *A. labialis* were found and only a single *A. clarkella* identified at Luccombe Chine on the Isle of Wight. Indeed neither of these species seem to be particularly abundant at the moment and I have yet to see colonies the size and density typical of *A. cineraria* and *A. flavipes* with which *B. discolor* is usually associated.

It is probably significant that all the four species associated with *B. discolor* in Britain (and *A. vaga* on the continent) tend to form large, dense nesting aggregations. Those *Andrena* species which do not seem to be used by *B. discolor* are either rare, small species, late spring or summer species or have much more dispersed nesting habits. Studies of a wide range of beeflies have shown that, when there are many rearing records available for a single species, there is usually a wide range of host species. Unlike the hymenopterous parasitoides and Tachinidae which are often very host specific, particularly the scarce species, Bombyliidae seem to be much more catholic. Close host specificity is probably least likely in those beeflies which are ectoparasitoides (the vast majority), such as *Bombylius*. Even some species known to be endoparasitoides, such as *Villa*, have been reared on a range of different genera and a few ectoparasitoides have been recorded from different families (Yates & Greathead 1997). For these reasons I conclude that an ovipositing *B. discolor* is not searching for any of the *Andrena* species discussed above, but rather is looking for large, densely packed aggregations of the larger *Andrena* species active in early spring and nesting in bare or sparsely vegetated soil with a southerly aspect. I suspect that an *Andrena* colony of any species fulfilling these criteria would do.

3.1.7 Foraging preferences

Beeflies of most species are very often found at flowers and those with a long proboscis such as *B. discolor* have clearly evolved to specialise in those with deep flowers. However, choice of nectar source proved to be very wide as can be seen from the following table.

Table 6. *Bombylius discolor* nectaring preferences

Flower species	**number of observations**
Glechoma hederacea	18
Primula vulgaris	8
Primula veris	1
Viola sp.	1
Veronica arvensis	1
Geranium molle	1
Geranium robertianum	1
Myosotis sp.	1
Cerastium sp.	1
Prunus spinosa	1

It is very apparent from these results that one flower species, *Glechoma hederacea*, is very much favoured. Indeed it seemed to attract them to such a degree that finding a patch of this plant was by far the easiest way of discovering *B. discolor* at a new site. With fewer than half the number of observations is *Primula vulgaris*, a conspicuous spring species with fairly deep nectaries. All the remaining nectaring records are single observations on plants of different colour, family and flower type. *B. discolor* is willing to take nectar from any flower it comes across but when they are present will always use *Glechoma hederacea* and *Primula vulgaris*. However, many *B. discolor* colonies, including some of the largest, completely lacked one or both of these plants so their presence is not essential. It is also apparent from records in gardens and woodlands well away from any suitable breeding habitat that *B. discolor* is capable of travelling considerable distances to find shelter and nectar sources. At Troopers Hill, where I have many hours of observations, I have only ever seen one briefly nectaring on *Veronica*; there is no *Glechoma* or *Primula* on the site. Presumably they fly to adjacent gardens to refuel. At one woodland site, Asholt Wood which is adjacent to open downland suitable for breeding colonies, a single female was seen to fly down to the path to load up with dust. Once it completed dusting it flew to nearby *Glechoma* flowers and nectared for a while before flying vertically up at high speed and disappearing over the treetops towards the downland.

3.1.8 Host pollen requirements

As the beeflies depend on healthy colonies of *Andrena* so the bees need plenty of pollen sources within easy flying range. Both of the host species identified during this survey are very catholic in their pollen gathering behaviour, especially *A. flavipes* which is described by Edwards (2002) as “very widely polylectic”. *A. cineraria* is recorded taking pollen from Ranunculaceae, Poaceae, Brassicaceae, Rosaceae, Apiaceae (Edwards 2002) but will certainly use a wider range than this.

At the main study site, Uphill Quarry, five *A. flavipes* where taken together with their pollen loads and sent off for pollen identification. The table below presents these data.

Table 7. *Andrena flavipes* pollen samples from Uphill

	date	Brassicaceae	Rosaceae	Taraxacum	Liliaceae
specimen 1.	6 April			100%	
specimen 2.	26 April	50%			50%
specimen 3.	13 May	50%	50%		
specimen 4.	13 May	present	present		
specimen 5.	13 May	100%			

It can be seen that Brassicaceae seem to be the most important with all but one of the specimens carrying some. At this site there are two main sources, the saltmarsh where *Cochlearia* sp. is abundant and ruderal areas along road and track margins and disturbed areas where a range of crucifers are found. The Rosaceae pollen is most likely to be collected from hawthorn blossom, and *A. flavipes* is often seen on this tree. The site has a very large population of dandelions and related yellow composites so finding Taraxacum pollen on only one specimen is surprising, but the sample size is too small to draw any conclusion here. The presence of Liliaceae pollen on one specimen is surprising and may not be typical, the site has small amounts of *Hyacinthoides non-scripta* but more likely is that this bee has been visiting gardens in nearby Uphill where numerous flowers of this family could be found.

These data in combination with observations of the flora and foraging bees at many sites suggests that *A. flavipes* and *A. cineraria* require a variety of foraging opportunities. These include unimproved grassland with abundant yellow composites, ruderal areas with Brassicaceae species and scrub or woodland edge with plenty of rosaceous shrubs, particularly *Prunus spinosa* and *Crataegus monogyna*.

3.1.9 Breeding biology

Emergence

Adult *B. discolor* emerge from their underground development sites from mid-March to about mid-April. There is reason to believe that males appear first with the majority of very early observations being of this sex. Emergence occurs early in the morning, on 3 April 2003 at Troopers Hill 8 emerging flies were found, all of them females. At 8.10am 3 were already out with fully expanded wings and stayed immobile for more than an hour; all had flown by 9.45am. Others freshly emerged were found on the same day including one at 9.25am still with milky wings so it had probably been out only a few minutes. Flies still not ready to take to the wing were found up to 10.13am but all had disappeared soon after this time.

Territoriality and mating

After emergence a large percentage of the flies seem to disappear from the breeding colony into adjacent gardens, scrub and woodland. Here females can be seen visiting flowers and males often holding territory. These males spend long periods of time hovering from 2-3m above the ground, occasionally dashing off at high speed to investigate a passing insect before returning to its station. The function of this behaviour is presumably the defence of an area where they are likely to have mating opportunities. Unfortunately no matings were observed during this survey but certainly this is the interpretation for identical behaviour in *B. major* where mating has been observed (Stubbs & Drake 2001).

Territory holding males can be found in the same spot for several days in the early part of their flight season. It is probable that favoured sites are occupied by a series of males, as is known to be the case in dragonflies. Certainly a territory will be occupied by new individuals in subsequent years so they are choosing sites with particular characteristics, most likely shelter and the presence of a nectar source.

None of the freshly emerged females observed at Troopers Hill attracted the attention of males, despite the fact that there were two males a very short distance away. Thus it seems likely that females have to mature for a while after emergence before mating. There is no information on how long after mating a female can start egg laying but evidence from other species of beefly suggest it need not be very long, the next day in the case of *Villa quadrifasciata* (Stubbs & Drake 2001).

Oviposition and fecundity

Ovipositing has been observed as early as 29 March at Troopers Hill, but is more often seen from the second week of April to the end of the flight period. Before any eggs can be laid she needs to fill her dust chamber so the eggs can be coated with camouflaging dust. To do this she lands on a patch of bare soil, often along the edge of a path or rabbit scratching, and thrusts the tip of her abdomen against the substrate. She then extrudes an off-white discshaped pad from the tip of her abdomen and with wings buzzing the substrate is agitated and dust gathered. Females will start ovipositing immediately after gathering dust. Females quarter around bee colonies a few cm above the ground casting eggs with a downward flick of her abdomen. Extended observations suggest that there is very little attempt to direct eggs at occupied bee holes. *B. discolor* females seem to cast their eggs at anything darker, as well as new and old bee holes this included cracks in the soil or darker shaded areas under tussocks of grass.

It is possible that when a female was flicking eggs at the ground where no bee hole could be seen, it was responding to other cues, such as smell, to locate a closed bee hole not apparent to the human observer. To try to see if this was the case I conducted a series of experiments at several sites where females were actively ovipositing. At locations where there were definitely no nesting bees within a 100cm or so, I created an artificial nest hole by pushing a pencil into the soil. This created a hole almost exactly the same size as an *A. flavipes* nest hole. At Owlpen Manor one such hole immediately attracted a *B. major* which hovered in from of the hole and flicked 12 eggs in two batches. None of the *B. discolor* at the site found the artificial hole. At Troopers Hill I did the same thing in an area where at least three *B. discolor* were quartering the grass flicking eggs. Eventually one female hovered over a hole for four seconds but failed to oviposit. A while later a female again hovered over an artificial hole inspecting it for several seconds before flicking an egg and flying on.

These results are inconclusive and many more such experiments would be needed to draw any firm conclusions. However, tentatively it does suggest that *B. discolor* is rather more fussy about where it flicks its eggs than *B. major*. It does show that a pencil-made hole by itself is sufficient stimulus for *B. discolor* to oviposit, but not with any great enthusiasm. It seems likely that the female *B. discolor* is responding to more than visual stimuli when choosing oviposition sites.

That *Bombylius* are highly fecund is very apparent from their oviposition behaviour, large numbers of eggs being flicked by one female in a short time. *B. discolor* has been counted flicking from 6 to 35 eggs a minute (average 13 per minute n=12). Many females, especially towards the end of April, spent long periods of time ovipositing, pausing only to recharge their dust chambers and visit flowers. Observations certainly suggest that several hours might be spent ovipositing in a single day. At the average rate calculated above this means many hundreds, perhaps thousands, of eggs can be distributed in a single day. Some other genera of beeflies have been shown to be prodigious egg producers, *Heterostylum* and *Anthrax* 1000, *Xenox* 2000-3000 and *Comptosia* 800 eggs per day (Yeates & Greathead 1997).

To get an alternative measurement of fecundity four female *B. discolor* were taken in order to dissect out and count egg masses. In 2002 this was done for a single *B. major* and a total of 928 eggs counted (Uffen 2003). Using the same technique as Uffen (2002) the following results were obtained.

Table 8. *Bombylius discolor* egg productivity

Site	date	no. eggs
Horton	6 April 2003	560
Hinton Hill	17 April 2003	320
Troopers Hill	17 April 2003	200
Ebblesbourne	18 April 2003	330

The results suggest a productivity of eggs considerably less than that found for the single *B. major* dissected by Uffen. However, all specimens (including Uffen's *B. major*) were in the process of ovipositing so will already have scattered an unknown quantity of eggs. Further, while doing the dissections it was apparent that there was a full range of eggs in different stages of development, from easily distinguished fully mature eggs to those barely recognisable as such. It seems as if eggs are developing continuously so, as a measure of total productivity, the usefulness of these counts are very suspect. It is probable that these counts represent the number of eggs available for a single day.

Combining observations of oviposition behaviour and egg counts, *B. discolor* seems to employ a broadly similar strategy as *B. major*. That is they rely on scattering a vast number of eggs in a rather unspecific way in the hope that a few will find an appropriate host. However, they are probably more directed in their egg laying than *B. major* in that they always oviposit within the general area of appropriate bee colonies and are most likely to oviposit at high rates where the bees nests are most concentrated.

Larval and pupal development

There are no direct observations of the larvae of *B. discolor* so the following is based on extrapolation from related species. Once the adult female beefly has deposited its eggs in the vicinity of a host colony then it is the responsibility of the first instar larvae to search for a host. The first instar larvae, known as the planidium, is elongate with two bristles on each thoracic segment and long setae on the tip of the abdomen to facilitate locomotion while searching for a host. The few which find a suitable bee nest will then attach themselves to the bee larvae or pollen mass and then lay dormant. The planidia of *Villa brunnea* can travel 1m from the oviposition site and live for one month before it needs to feed. Once the host is close to fully-grown then the planidium will start feeding, in *Heterostylum robustum* this stage lasts 36 hours. It then changes dramatically as it goes into its second instar (hypermetamorphosis), a scarabaeform larvae evolved for a much more sedentary existence. In this form it completes its development consuming its host. Some species are able to move to a second host bee if the first is not large enough (Yeates & Greathead 1997) and judging from the size of some female *B. discolor* relative to the host bees it is very likely that this sometimes happens in this species.

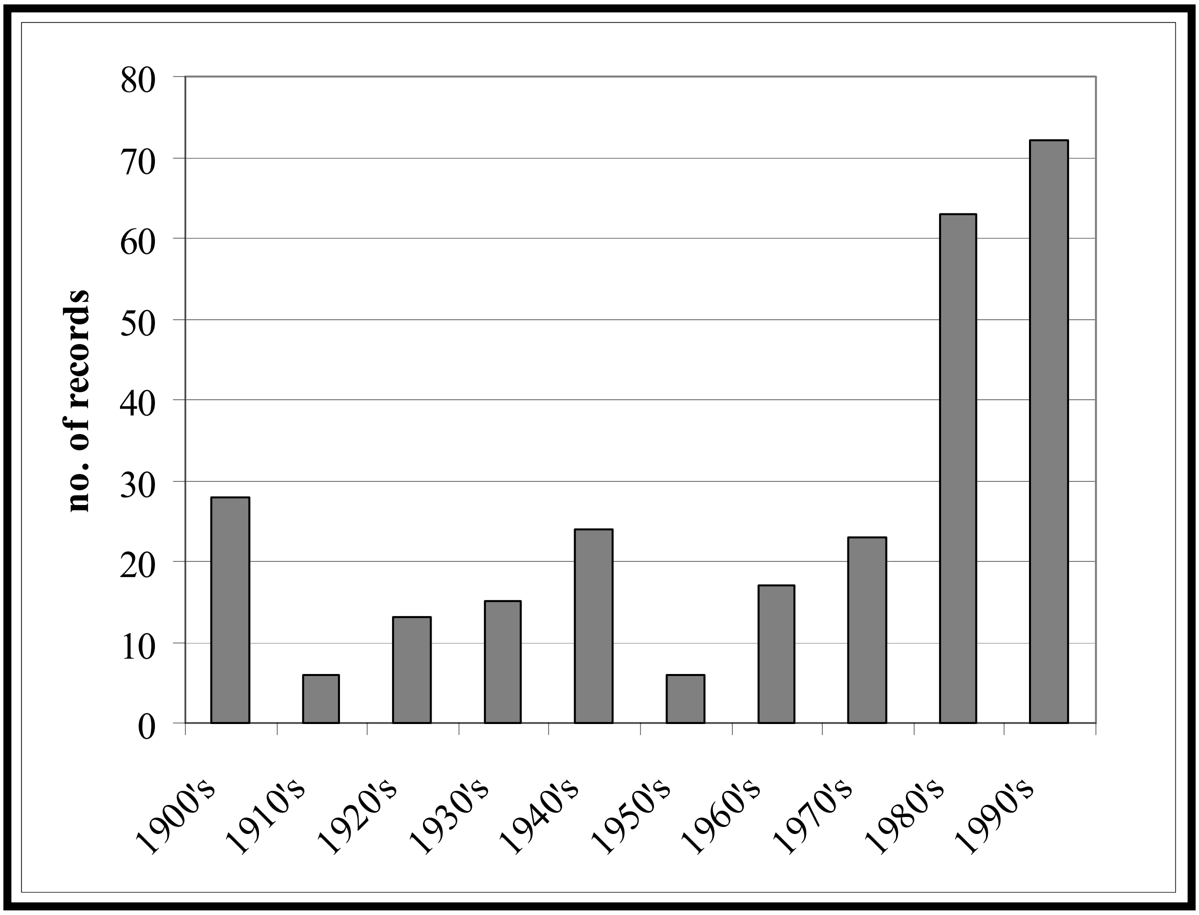
It is assumed that *B. discolor* completes its lifecycle in a single calendar year as is usually the case in other ectoparasitoided Bombyliidae which have been studied. However, there is every likelihood that the occasional larvae will diapause for longer and emerge the following spring. The final instar larvae of the locust egg consumer *Systoechus somali* has been known to stay alive for 3 years without pupating. Length of larval development is unknown but other ectoparasitoides such as *Heterostylum robustum* and *Anthrax limulatus*, are known to develop very quickly once they start feeding. The former then goes into diapause, over wintering as a fully mature larvae and pupating the following spring. It has been shown that beeflies of widely divergent genera all have very similar life histories, for example *Systoechus somali* also has a very short pupal period of 9-15 days (Yeates & Greathead 1997).

When ready to eclose the pupae works its way to the surface with the aid of the backwardly pointed spines all over the pupae, especially those on the head and thorax which will loosen the soil. It is likely that the pupae take the route of least resistance and move through the bee tunnel to emerge from the original entrance. Certainly more than one beefly will emerge through the same hole as two exuvia have been found wedged in the same hole on several occasions (pers.obs.). However, in some species such as *Systoechus somali* the full fed larvae is able to move several times to find over wintering sites in the soil (Yeates & Greathead 1997) so it is certainly possible that the *B. discolor* larvae move away from its host nest to over winter and pupate.

4. Discussion

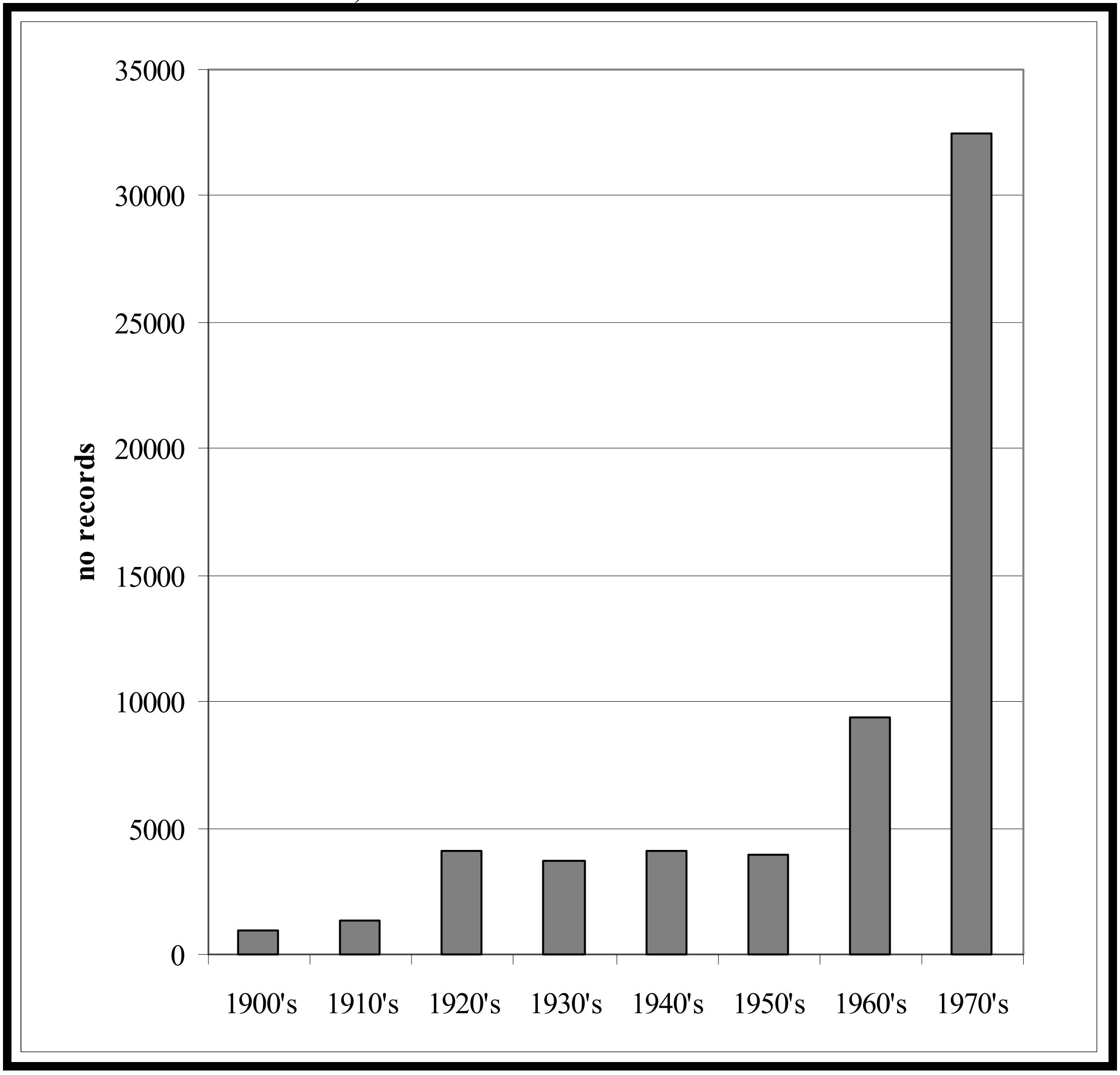
One of the most interesting problems which needs resolving if *B. discolor* is to be properly conserved is the reasons for the dramatic decline of the species in the mid 20th century.

Chart 3. Records of *Bombylius discolor* by decade in the 20th century
(data from Ismay 1999, Larger Brachycera Recording Scheme, Alexander 1999 and pers obs.)



The chart above shows that there were two dips in population levels, one in the 1910's and the second in the 1950's, in both cases the number of records reduced to less than 10% of the maximum. One obvious possibility is that it is all a function of recorder activity, the 1910's dip coinciding with the nation's entomologists being sent to the trenches in the 1914-18 war. But there is no equivalent dip in the 1940's when many people were distracted by WWII; the dip comes in the decade after the war. The 1950's were years of austerity when entomologists were less able to afford to travel in search of flies but certainly the problems would be no greater than in the 1940's.

Chart 4. Records submitted to the Hoverfly recording scheme in 20th century
(data from Ball & Morris 2000)

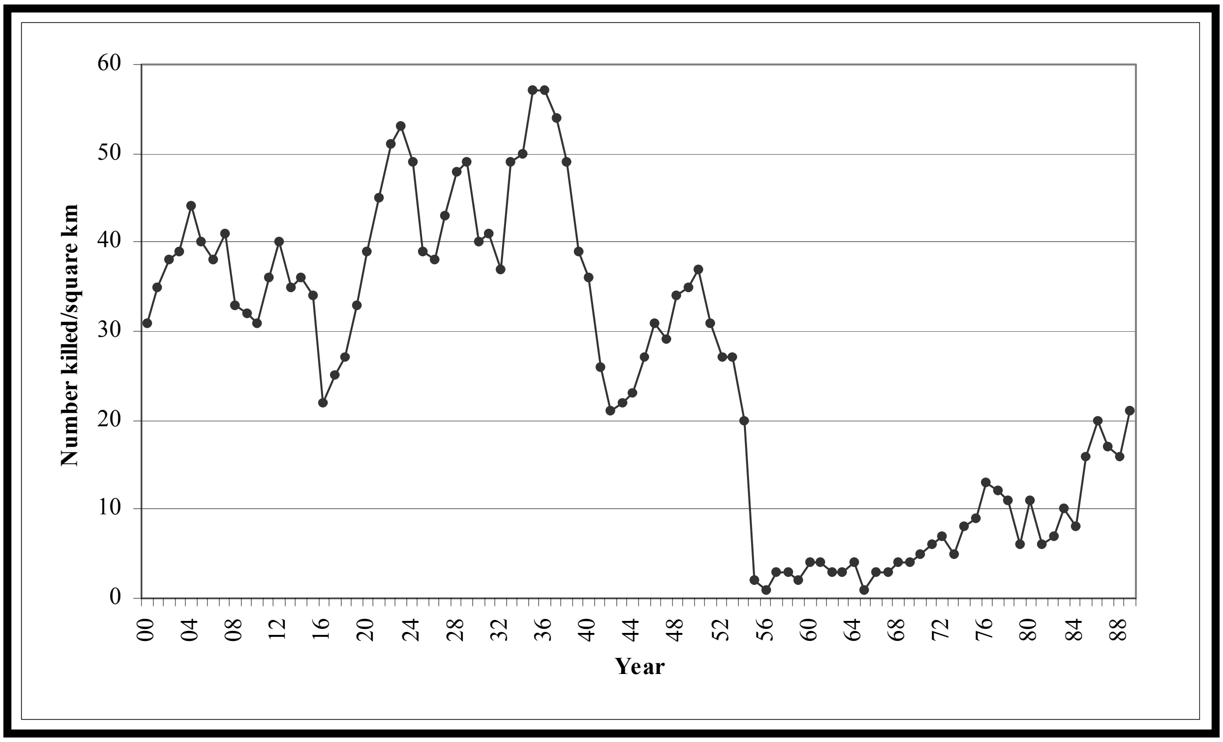


The chart above can be taken as a measure of recording effort by dipterists from 1900 to 1979 (1980's and 1990's data are omitted because the massive increase in records at this time distorted the chart). Recorders of hoverflies would almost invariably be competent to identify *B. discolor* and would note them. This chart shows no sign of the dips in the 1910's and 1950's seen in *B. discolor* data, not even WWI seems to have reduced recording when compared to the previous decade. Thus it can reasonably be concluded that reductions in records received of *B. discolor* cannot be explained by fluctuations in recorder effort, at least not entirely.

Climatic fluctuations are often put forward to explain changes in insect populations and recent warming certainly seems to have had a dramatic effect of some helophilous insects. A run of cold summers in the 1960's is often cited at the point when several species went extinct or declined dramatically, but *B. discolor* declined a decade earlier than this. Data on phenology presented above also suggests that *B. discolor* is not responding to the earlier springs of recent decades by emerging earlier. So although the decline of *B. discolor* is unlikely to have anything to do with climatic fluctuations, recent warming has almost certainly helped both the host bees and *B. discolor* recover from their low point.

Other factors likely to be important are the decline of domestic grazing animals on unimproved grassland and the decline in the area of unimproved grassland itself. Both of these were steadily declining through the early part of the century, accelerated by the Common Agricultural Policy after entry into the EEC. The eastern part of England was especially affected by these factors where mixed farms were more likely to become exclusively arable.

Chart 5. ‚Average trend in rabbits killed in the 20th century
(bag of rabbits from 63 estates which have continuous records since 1900 after Tapper 1992)



The decline in populations of many grassland species, particularly those found on calcareous habitats, have been correlated with fluctuations in the rabbit population. It is accepted that butterflies such as *Lysandra bellargus* and various grassland orchids suffered severely due to scrub encroachment and deterioration of the grassland after myxomatosis eliminated rabbits as a significant grazer. The chart above illustrated the catastrophic decline of rabbits between introduction of myxomatosis and 1958-59 when they reached their lowest numbers. This coincides very closely with the 1950’s low of *B. discolor* records and the steady recovery of rabbits through the 60’s, 70’s and early 80’s also seems to mirror the *B. discolor* data. Thus it seems highly likely that the myxomatosis outbreak was a significant contributory factor in the decline of *B. discolor* in the 1950’s.

However, one factor strongly suggests that the decline of rabbits is not the whole story. Rabbits declined over the entire country and it seems that *B. discolor* did too with the few 1950’s and early 1960’s records being spread over much of the historic range. As rabbits recovered they did so most strongly in the east and the Home Counties (Harris *et al.* 1995) and yet by the 1970’s records of *B. discolor* were still declining in these regions and there have been none there since 1990.

In conclusion the fortunes of the *B. discolor* population in Britain over the 20th century can be explained by a combination of the factors discussed above. The decline in records from the 1900's to 1910's does not seem to correlate with any of the factors investigated but after WWI records mirror recorder effort. In the 1950's, for a population weakened by habitat loss and reduced grazing by domestic animals, the myxomotosis outbreak was too much and reduced many populations to unviable levels. This was particularly the case in eastern England where loss of unimproved grassland and reduction in grazing was more severe so rabbits were much more important for the continuity of *B. discolor* habitat. As habitat destruction and degradation continued through the 1960's and 1970's so the few remaining tiny populations in East Anglia, east midlands and the Home Counties disappeared. In south coast counties and the west populations hung on, records increasing in line with recorder effort. The very dramatic rise in records in the 1980's and 1990's is likely to be a combination of warming climate, recorder effort, increased rabbit populations and increased conservation grazing. The failure of *B. discolor* to return to its former haunts in the east is most likely due to poor colonising ability as all the other factors are in place and the host bees are colonising rapidly.

5. The future

When *B. discolor* was first given Nationally Scarce status there was real reason to worry that the dramatic decline of the 1950's could recur. However, research and analysis during this project suggests that the situation is more promising. Although populations will no doubt fluctuate in response to some of the variables which affect *B. discolor*, if colonies are appropriately managed then it is unlikely that extinction will result. Even if average temperatures drop, contrary to all predictions, and rabbit populations crash, which is certainly possible, if grassland is still grazed sufficiently and pollen sources maintained then the beeflies will survive.

One area which is an unknown quantity is the ability of *B. discolor* to recolonise its old haunts in east central England. Other inquilines, such as the cleptoparasitoid *Nomada fucata* have closely followed its host *Andrena flavipes* into the Home Counties. The presence of large dense colonies of *A. flavipes* able to support large numbers of *Nomada* shows that the habitat is there and good enough for *B. discolor* if it found these colonies.

In order to ensure the continued success of existing colonies of *B. discolor* and encourage new colonisations the following are recommended.

- monitor target colonies in different parts of the country and on different habitats so that any decline will be picked up within a few years;
- liase with landowners known to have colonies on their land, inform them of the presence of *B. discolor* and appropriate management;
- where sites have been maintained by grazing of domestic animals it is essential that this continue; cattle grazing is probably most important but on calcareous grassland sheep grazing is also valuable;
- where a short sward is maintained partly by rabbit grazing then fluctuations in rabbit populations need to be monitored and domestic animal grazing regulated to prevent both over and under grazing;

- if rabbits are the only grazing influence present (there are very few of these as such sites probably went extinct in the 1950's but Powerstock Common is probably an example) then a dramatic decline in rabbit numbers will have to be compensated for by grazing domestic animals or direct human intervention;
- never surround colonies with rabbit proof fencing if the area is not being grazed by domestic animals;
- a very few sites have no grazing animals of any kind (eg Troopers Hill) and are kept open because of very thin infertile soil and erosion from human use. At such sites public access must be retained and anti erosion interventions, such as putting down plastic webbing, discouraged;
- where human intervention is deemed necessary, scrub removal should never be complete but always leave adequate patches to provide shelter; grass over bee colonies needs to be cut very short; some areas of bare soil needs to be maintained or created;
- colonies on nature reserves might be encouraged to grow by creating suitable bee nesting sites. Steep, south-facing slopes and banks which have become scrubbed over could be cleared to allow in grazing animals. Weeding the area will be necessary for several years and possibly the removal of topsoil. This process has been started at Hellenge Hill and *A. flavipes* and *B. discolor* has already been observed in the new area (although breeding not proven);
- ensure that grassland remains as floristically rich as possible (flower abundance is more important than flower diversity);
- when removing scrub ensure that large amounts of spring flowering Rosacous shrubs (especially *Crataegus* and *Prunus*) are retained within easy flying distance of bee colonies;
- Brassicaceae are an important pollen source and species used by *A. flavipes* are usually found on ruderal and marginal habitats such as arable field margins, roadsides and other disturbed areas. Identify and maintain such areas if possible. Often such pollen sources will be on adjacent land away from the control of a reserve manager so creating habitat for such flora is likely to be valuable.

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Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

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