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The Butterfly Monitoring Scheme

Progress Report for 2001/2002

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SUMMARY

1. This report reviews the national Butterfly Monitoring Scheme (BMS) for the 2001 season and marks the twenty-sixth year of monitoring since the scheme started in 1976.

2. The scheme continues to be run by Mr Nick Greatorex-Davies at the Centre for Ecology and Hydrology (CEH, formerly ITE), Monks Wood. Mr David Roy gives technical assistance with database management and programming and is also involved in writing research papers using BMS data. The BMS is jointly funded by the Joint Nature Conservation Committee (JNCC) and by CEH. Dr Dorian Moss, Head of the Environmental Information Centre at Monks Wood, has overall responsibility for management of the BMS.

3. Data were received from 118 transects (including 11 Environmental Change Network (ECN) transects) for the 2001 season, though for 16 transects data were too few for any annual indices to be calculated. A further 9 transects produced no data due to the Foot and Mouth Disease epidemic (FMD) and data from 4 transects have yet to be submitted! Five transects produced no data but remain part of the BMS with the hope that new recorders can be found (see point 5 below). The total number of transects in the BMS in 2001 was 136.

4. The impact of FMD on transect recording was not as great as was feared initially. Apart from the nine transects that did not produce any data at all due to FMD, about 50 transects missed all or most of April. A further 14 did not commence until mid to late May, two not until June and three not until mid-late July. These delays were mainly due to FMD. Overall the number of annual indices that could be calculated was approximately 20% down on the number calculated in 2000, with the biggest effect being on the early spring species.

5. No new transects were added to the BMS in 2001. New recorders have been found for the 2002 season for two of the transects ‘lost’ from the scheme in 2000. No recording was carried out at a further three transects and these will be lost from the scheme unless new recorders can be found.

6. CEH, JNCC and Butterfly Conservation are in the process of forming a three-way equal partnership with respect to butterfly monitoring. It will take time for the partnership to evolve and for the various monitoring activities to be merged, but the result will be an enlarged scheme with much improved scope.

7. A new version of Transect Walker (1.3) (TW) became available in May 2001 and was sent out to more than 40 BMS recorders who cover 55 transects. Data were received from TW from 24 transects. An additional 6 BMS recorders have requested the software for the 2002 season. The software can now be downloaded directly from Butterfly Conservation’s website.

8. Recorders provided habitat information using the new classification (based on the European Nature Information System, EUNIS) for a further 30 transects in 2001 which, combined with that submitted in 2000, provides habitat information for nearly 80 transects.

9. Changes in abundance of species are examined. The year 2001 was one of the poorest years for butterflies and the worst since 1988 when compared with data from the other 25 years of the scheme (ranking 5th lowest). Of 34 species for which collated indices (all-season or summer) were calculated, 7 species showed an increase and 27 a decline on the 2000 figures. The declines, which in most cases were not great, occurred across all species groups. It seems likely that the exceptionally wet autumn and winter of 2000/2001 was at least partly the cause of the poor butterfly season.

10. Four species produced their ***lowest collated index*** of the series. These were **Dingy Skipper**, **Brimstone**, **Wall Brown** and, for the second year running, the **Small Heath**. The northern univoltine **Common Blue** also produced its lowest collated index of the series. No species produced its ***highest collated index***. The only species to show a substantial increase was the **Holly Blue** (in both generations). Despite the decreases, numbers of some of the Satyrinae remained relatively high, these were **Speckled Wood**, **Marbled White**, **Hedge Brown**, **Meadow Brown** and **Ringlet**. There was another small increase in the index of the **Small Tortoiseshell** whose numbers have been very low since 1998. Migrants did less well than in 2000 with a drop in the indices of both **Red Admiral** and **Painted Lady**.

11. Recent and forthcoming publications using data from the BMS are listed.

12. Appendix I contains graphs showing annual fluctuations in the all-sites collated indices of 33 species from 1976-2001. For the first time the graphs include standard error bars.

13 Appendix II compares collated indices generated by the usual BMS chaining method and by an alternative method that uses log linear models performed by a statistical software package called TRIM. The results produced by the two methods mostly show a very close correspondence and therefore increase confidence in the robustness of the BMS method. Graphs show the results overlaid on each other with standard errors.

1 INTRODUCTION

The purpose of this report is to review the Butterfly Monitoring Scheme (BMS) for the years 2001 to 2002 and to summarise the results of the scheme for the year 2001.

The report is shorter than last year's special 25 year report and the section which discusses each species in turn (species accounts) has been omitted. Site visits reports for 2001 will be included in the 2002 report.

1.1 ORIGINS, ORGANISATION AND AIMS OF THE BMS

The BMS was launched in 1976 by Dr Ernie Pollard based at the Institute of Terrestrial Ecology (ITE) at Monks Wood. The scheme was initially financed jointly by the Nature Conservancy Council (NCC) and ITE. Since 1991 it has been jointly financed by the Joint Nature Conservation Committee (JNCC) (acting on behalf of the statutory conservation agencies (successors to NCC): English Nature, Countryside Council for Wales, Scottish Natural Heritage and the Environment and Heritage Service Northern Ireland), and ITE (now the Centre for Ecology and Hydrology (CEH)).

Dr Dorian Moss, Head of the Environmental Information Centre at Monks Wood, currently has overall responsibility for the management of the BMS. The scheme has been run by Mr Nick Greatorex-Davies since the beginning of 1995 when he took over from Mrs Tina Yates. Mr David Roy provides technical assistance with database management and programming. Dr Ernie Pollard retired from active involvement in the scheme in 1998 (apart from walking a transect as part of the scheme) but is still available for advice when required.

The primary aims of the scheme are to provide information at regional and national levels on changes in the abundance of butterfly species, to detect trends which may indicate changes in their status and to provide a reliable long-term reference against which population changes in species studied elsewhere on individual sites, or in other countries, can be monitored. It also aims to monitor changes at individual sites and, by comparison with results elsewhere, to assess the impact of local factors such as habitat change caused by management. The scheme also provides information on aspects of the population ecology and phenology of individual species, both in relation to the effect of environmental changes (including climate change) and as a contribution to butterfly ecology. Results are reported on annually in this report and those from more detailed analysis of the data are published in the scientific literature. A synopsis of the first fifteen years of the scheme has also been published (Pollard & Yates 1993).

1.2 SITES FROM WHICH THE BMS RECEIVES DATA

The year 2001 was the 26th year of the BMS. Currently 136 transects at sites throughout the United Kingdom are part of, or contribute to, the BMS. At least some data were received from 118 BMS (including 11 Environmental Change Network (ECN) transects[1]). Of these, 103 transects provided sufficient data to produce annual site index values for at least some species. Twenty transects produced

[1] The ECN was set up in 1993 with funding from the Department of the Environment (now Department for Environment, Food and Rural Affairs) in conjunction with a number of research organisations (including CEH) to monitor changes in the environment, particularly in relation to climate change. Butterfly monitoring is just one part of this programme. ECN transects are not managed as part of the BMS, but data from most of the ECN sites are now used together with the BMS data to calculate the annual all-sites collated indices. Two of the BMS transects are now also ECN transects, making a total of 13 ECN transects. Within the rest of this report BMS and ECN transects will simply be referred to as BMS transects because all potentially contribute to the scheme in providing data for the calculation of the collated annual indices.

sufficient data for annual indices to be calculated for all the species recorded compared with 40 in 2000. This figure reflects the impact of the Foot and Mouth Disease epidemic (FMD) on recording. As in 2000 a further 19 sites provided sufficient data for indices for all but one or two species.

1.3 THE IMPACT OF THE FOOT AND MOUTH DISEASE EPIDEMIC ON RECORDING

The impact of FMD on transect recording was not nearly as great as was first feared. Some other monitoring schemes did not operate at all as a result, but we made the decision early on to encourage BMS recorders to walk their transects providing that they could obtain permission from the landowners where necessary, and providing that they did not breach the restrictions that had been put in place in their particular area.

Only nine transects produced no data as a direct result of the FMD. A further 50 transects missed all or most of April. Another 14 did not commence until mid-May, two not until mid June and three not until July. As a result of this the number of annual indices that could be calculated was reduced, but not hugely being down about 20% on the number calculated in 2000. The species most affected were those that fly in the spring, however in all cases there were sufficient data for an all-sites collated index.

1.4 SITES LOST AND GAINED FROM THE BMS IN 2001

Sites lost
In 2001, due to time constraints, no recording was carried out at **Avon Gorge** (Avon), **Morrone Birkwood** (Highland) or **Cors y Llyn** (Powys), however in each case a contact person remains and efforts are being made to find new recorders.

Sites gained
No new sites were added to the BMS in 2001, however thanks to the efforts of Nick Bowles and Mike Wilkins of Butterfly Conservation, recorders have been found for the **Shabbington Wood** and **Waterperry Wood** transects in Oxfordshire. Both these long-running transects were reported as lost to the scheme in the report for 2000.

After a two year gap monitoring was resumed at **Loch Garten** in Highland.

Monitoring at **Ben Lawers** in the Highlands (which has been in the BMS since 1977) has been reduced to cover the Mountain Ringlet flight period only.

2 UPDATES ON THE CONTINUED DEVELOPMENT OF VARIOUS FEATURES OF THE BMS

2.1 CEH AND JNCC WORKING IN PARTNERSHIP WITH BUTTERFLY CONSERVATION ON BUTTERFLY MONITORING

Further progress has been made in developing a butterfly monitoring partnership between CEH, JNCC and BC. At a meeting earlier in 2002, attended by representatives from the three organisations, it was agreed that a three-way partnership agreement between the three organisations should be established with respect to butterfly monitoring. A draft partnership agreement was discussed at the meeting. Details of the agreement will be worked out over the next few months before the agreement is finalised. In the meantime the three organisations will continue to work closely together and investigate ways of practically merging our respective butterfly monitoring operations.

2.2 TRANSECT WALKER – BUTTERFLY TRANSECT RECORDING SOFTWARE

In May 2001 a new version of Butterfly Conservation's transect recording software Transect Walker (TW) became available (version 1.3). Copies on CD were sent out to 50 BMS recorders who either already had a copy of TW or had asked for it.

Funding was provided by JNCC in 2001 for further development of TW so that some of the major additional features that have been recommended by users can be added. Work to implement at least some of these changes is due to be carried out in 2002. In the meantime version 1.3 is perfectly adequate for recorders to produce digital data.

It is hoped that in time the majority (at least) of recorders will record and submit their transect data to the scheme digitally using TW. However recorders are strongly advised to record in the field onto the standard field forms provided by CEH, rather than into a notebook (or onto a scrap of paper) as the evidence suggests that this way transcription errors are reduced and the associated data (weather etc.) are more likely to be recorded fully. Also notebooks or odd bits of paper seem to be more likely to get lost. Alternatively recorders can use the form TR5 provided by Butterfly Conservation. These can either be printed out from TW or obtained direct from Butterfly Conservation. In addition there are forms customised for some areas of the UK, these are forms TR5a-d. For users of TW the forms have the advantage that the butterflies are listed in the same order as in TW and so use of these forms should help reduce transcription errors.

2.3 HABITAT RECORDING

Site Data Forms (SDFs)
In 2000 a Site Data Form (SDF) (designed by Tom Brereton of Butterfly Conservation in discussion with CEH) for recording habitat and management on butterfly transects, section by section, was issued to recorders together with a habitat classification based on the European Nature Information System (EUNIS); for more details see page 7 of the 2000 report. A simple 13 category management classification was also issued. The ability to record this information electronically is also incorporated in Transect Walker, though currently not as on the revised form (see below).

SDF revised
In July 2001 a revised version of the SDF was sent out to all BMS recorders. The main change from the first version was dividing the information required into three parts for each transect section, a) the habitat that is actually in the recording 'box' (5m – or whatever fixed 'box' width is recorded), b) the adjacent

habitat to the right of the transect, and c) the adjacent habitat to the left of the transect. The codes given by the recorders for each habitat type represented in each section and in each of the three categories (a-c above) will enable detailed analysis of changes in butterfly numbers in different habitat types.

SDFs received from nearly 80 transects so far!
Habitat forms for 45 transects were sent in after the 2000 season and 58 of the revised forms after the 2001 season. Forms for 25 transects were sent in for both years and we now have up-to-date habitat information for 78 transects. We very much hope that all recorders will provide this information for their transects in due course as it will enable us to evaluate how the individual species of butterfly are faring in different types of habitat.

2.4 DERIVING MEASURES OF HABITAT QUALITY FOR BUTTERFLIES

We have been successful in obtaining an undergraduate student, Daria Dadam, to work with us for six months (from late June 2002) on a BMS project. She will seek to develop a system of repeatedly recording habitat, habitat structure and habitat management information, that can be used to help explain patterns of butterfly diversity and abundance on BMS transects.

To carry out this work it is planned that Daria will test and develop a range of systems for recording habitat, habitat structure and management on butterfly transects with a view to developing habitat quality models of butterfly diversity and abundance. She will seek to optimise the habitat quality models by taking account of the time taken to gather relevant data in the field and to recommend a practical methodology for recording this information on BMS transects, i.e. one that could readily be carried out by recorders without them spending an undue amount of time gathering the information.

2.5 BMS WEBSITE http://www.bms.ceh.ac.uk/

Some updating and some minor modifications were made to the BMS website during May and June 2001. Further more substantial work to the web site is planned during the spring and summer of 2002.

2.6 THE CALCULATION OF THE ALL-SITES COLLATED INDICES

We are always looking for ways of improving the calculation and presentation of BMS results. This year you will see that there have been some changes to the graphs of the all-sites collated indices (Appendix I on page 33). The collated indices for these graphs have been calculated using a ‘chaining’ method that has been used since the scheme began in 1976, though modified in the early 1990s (Moss & Pollard 1993). Standard errors have been calculated for these and are included on the graphs. The standard errors enable the statistical significance of changes in the index value of a particular year relative to a base-line year to be assessed. A difference of more than two standard errors is significant at the 5% level.

This year we have taken the opportunity to compare the BMS method of calculating indices with a widely used method that uses log-linear models calculated by statistical package called TRIM (Pannekoek & van Strien 2001). This method is used by the Dutch Butterfly Monitoring Scheme for calculating their collated indices. Graphs for this comparison are shown in Appendix II and the results from the two methods are compared. How the indices and standard errors for both methods are calculated is explained in Appendix II.

3 SUMMARY OF THE 2001 SEASON

3.1 REVIEW OF CHANGES IN INDICES

A poor year for butterflies in general with most species declining

The year 2001 was one of the poorest years for butterflies on BMS sites since the scheme began in 1976, ranking the 5th lowest of the 26 years and the worst year since 1988 (Figure 8, page 27). Of the 33 species (plus univoltine Common Blue) for which all-sites collated indices have been produced, there were 27 decreases and 7 increases from 2000 to 2001[2]. There was no obvious pattern to the changes with declines showing across all species groups. Details are summarised in Table 1 on page 10, Table 7 on pages 25 and 26 and graphs showing the collated indices for all years are in Appendix I on pages 34-38.

Lowest collated index of the series for four species

Four species produced their ***lowest collated index*** since the BMS began, these were the **Dingy Skipper** (21% drop), the **Brimstone** (34% drop), **Wall Brown** (33% drop) and for the second year running the **Small Heath** dropping just 5% from 2000. The northern univoltine **Common Blue** also produced it's ***lowest collated index*** (31% drop).

Most declines were not great

Decreases were generally not large and the biggest decrease was shown by the **Painted Lady** which dropped by 85% from its second highest collated index in 2000. The **Red Admiral** also declined (36%). The collated indices show that 2001 was an average year for these migrants. However only four Clouded Yellows were recorded on BMS transects.

The **Brown Argus** declined substantially in both generations (>40% and 50% respectively) from the relatively high indices of 2000 to well below average in both generations. The **Comma** dropped by >40% from it's all-series high of the previous year to give an average year.

Overall the Whites did not do well in 2000. All dropped in their first generation with the **Large White** and **Green-veined White** in their second generation producing low values. However the index of the **Green-veined White** remained above average in the second generation. The **Orange Tip** dropped to it's lowest level since 1988.

Other species which declined between 10 and about 30% included **Large Skipper**, **Grizzled Skipper**, **Green Hairstreak**, **Common Blue** (southern and northern populations), **Chalkhill Blue**, **Small Pearl-bordered Fritillary**, **Speckled Wood**, **Meadow Brown**, and **Ringlet**. The **Pearl-bordered Fritillary** index dropped by 12%, but comparisons were only possible for four transects. Smaller declines were experienced by the **White Admiral** and the **Hedge Brown.**

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[2] Unless otherwise stated comments throughout this section refer to the second generation index of multivoltine (two or more generations per year) species or to the summer/autumn flight period index of single generation species which fly in the summer and autumn, hibernate and fly again in the spring.

There was a drop in the first generation / spring index for all species for which one is calculated except for the **Holly Blue**. These were **Brimstone**, **Large White**, **Small White**, **Green-veined White**, **Small Copper**, **Common Blue**, **Brown Argus**, **Peacock**, and **Wall Brown**. Only the index of the **Peacock** remained high, the rest being below average or very low.

There were a few increases

The only big increase in collated index was experienced by the **Holly Blue**. There was a substantial increase in both generations (87% and 125% respectively). If the pattern follows cycles of other years a much bigger increase can be expected in 2002.

Moderate increases were shown by the **Small White**, **Small Copper** (both after a substantial drop in the first generation index) and **Dark Green Fritillary**, with small increases shown for the **Small Skipper**, **Small Tortoiseshell** and **Grayling**.

3.2 TABULAR SUMMARY OF CHANGES 2000 TO 2001

Details of the changes outlined on the preceding pages are summarised in Table 1 on page 10, with further details in Table 7 on pages 25 and 26.

In the last column of Table 1 (Trend in all-sites [collated] index), significant trends are identified using simple regressions of $\log_{10}$ all-sites collated index on years (for method see Pollard *et al* 1995). The figure gives the degree of slope (trend) of the regression line, positive or negative. Asterisks indicate the degree of statistical significance of trend: * P <0.05, ** P<0.01; *** P< 0.001. It should be noted that simple regression results may give rather too many significant results with population data (Diggle, 1990), so these figures should be treated with caution. Nevertheless they do give an indication as to how the different species are faring on monitored sites. Particular caution needs to be exercised in looking at the results for species for which relatively few sites are used for the calculation of all-sites collated indices such as Common Blue (northern univoltine), Chalkhill Blue, Small Pearl-bordered and Pearl-bordered Fritillaries. The very big fluctuations in the index for the Holly Blue may make testing for a trend of relatively little value.

Table 1. Summary of changes 2000 / 2001.

SPECIES	2000 all-sites index	2001 all-sites index	% change Down	% change Up	% of the mean all-sites index	Rank order of 25 years 2000	Rank order of 26 years 2001	Lowest / highest all-sites index	Comments	Trend in all-sites index
Small Skipper	168	173		3	84	16	17			0.008
Large Skipper	145	127	12		72	18	22	Lowest since 1991		0.004
Dingy Skipper	14	11	21		41	23	**26**	**Lowest ever**		-0.021***
Grizzled Skipper	31	27	13		56	19	21	Lowest since 1995		-0.012*
Brimstone 1 (Spring)	115	92	20		92	8	15	Lowest since 1994		0.005
Brimstone 2 (Summer/Autumn)	102	67	34		60	11	**26**	**Lowest ever**		-0.003
Large White 1 (1st generation)	53	22	58		42	11	24			-0.013
Large White 2 (2nd generation)	85	65	24		52	20	24	Lowesst since 1987		-0.001
Small White 1	32	11	66		49	19	25			-0.032***
Small White 2	62	79		27	73	23	18			-0.003
Green-veined White 1	173	89	49		67	3	24			-0.0003
Green-veined White 2	352	263	25		96	9	11			0.014***
Orange Tip	146	109	25		90	5	19	Lowest since 1988		0.004
Green Hairstreak	228	177	22		130	2	7			0.014***
Small Copper 1	68	26	62		45	9	23	Lowest since 1989		-0.003
Small Copper 2	52	65		25	79	18	14			0.007
Common Blue 1	46	28	39		50	15	23			-0.002
Common Blue 2	65	53	18		59	15	18			0.012
Common Blue (univoltine)	13	9	31		26	23 of 24	25 of 25	**Lowest ever**		-0.021*
Brown Argus 1	99	57	42		79	6	17	Lowest since 1994		-0.006
Brown Argus 2	117	59	50		66	6	19	Lowest since 1993		0.011
Chalkhill Blue	77	61	21		74	11	16	Lowest since 1990		0.018***
Holly Blue 1	62	116		87	46	16	13			0.016
Holly Blue 2	101	227		125	76	11	9		Second year of increase	0.037*
White Admiral	24	22	8		56	18	21			-0.008
Red Admiral	138	89	36		105	5	11			0.026***
Painted Lady	1701	251	85		26	2	13			0.031
Small Tortoiseshell	49	55		12	46	24	23			-0.005
Peacock 1	305	260	15		148	3	4			0.021***
Peacock 2	209	206	1		117	6	8			0.016***
Comma	326	192	41		112	1	13		A big drop after 2000 all-time high	0.025***
Small Pearl-bordered Fritillary	22	18	18		39	23	25			-0.016**
Pearl-bordered Fritillary	2.4	2.1	12		13	23	25		Collated indices from 4 sites only	-0.05***
Dark Green Fritillary	40	49		23	76	22	19			-0.003
Silver-washed Fritillary	51	46	10		85	13	18			0.01*
Wall Brown 1	18	10	44		30	17	24			-0.026***
Wall Brown 2	18	12	33		24	22	**26**	**Lowest ever**		-0.025**
Speckled Wood	315	219	30		130	1	9			0.026***
Marbled White	289	247	15		128	6	8			0.02***
Grayling	60	63		5	95	16	14			-0.012**
Hedge Brown	129	119	8		110	7	9			0.005
Meadow Brown	165	134	19		103	6	10			0.009**
Small Heath	21	20	5		40	25	**26**	**Lowest ever**		-0.02***
Ringlet	642	518	19		145	**1**	3			0.033***

3.3 SUMMARY OF THE WEATHER IN 2000 / 2001 AND SOME APPARENT EFFECTS ON BUTTERFLIES

Table 2 shows a summary of UK weather in 2000/2001 and is taken from a weather summary provided by Dr M. Hulme of the University of East Anglia on the internet at website: http://www.cru.uea.ac.uk/~mikeh. The information is also published in *The Guardian* newspaper. The summary is for the UK as a whole and so will not necessarily describe weather in particular regions precisely. [Anomalies are with respect to the 1951-80 average].

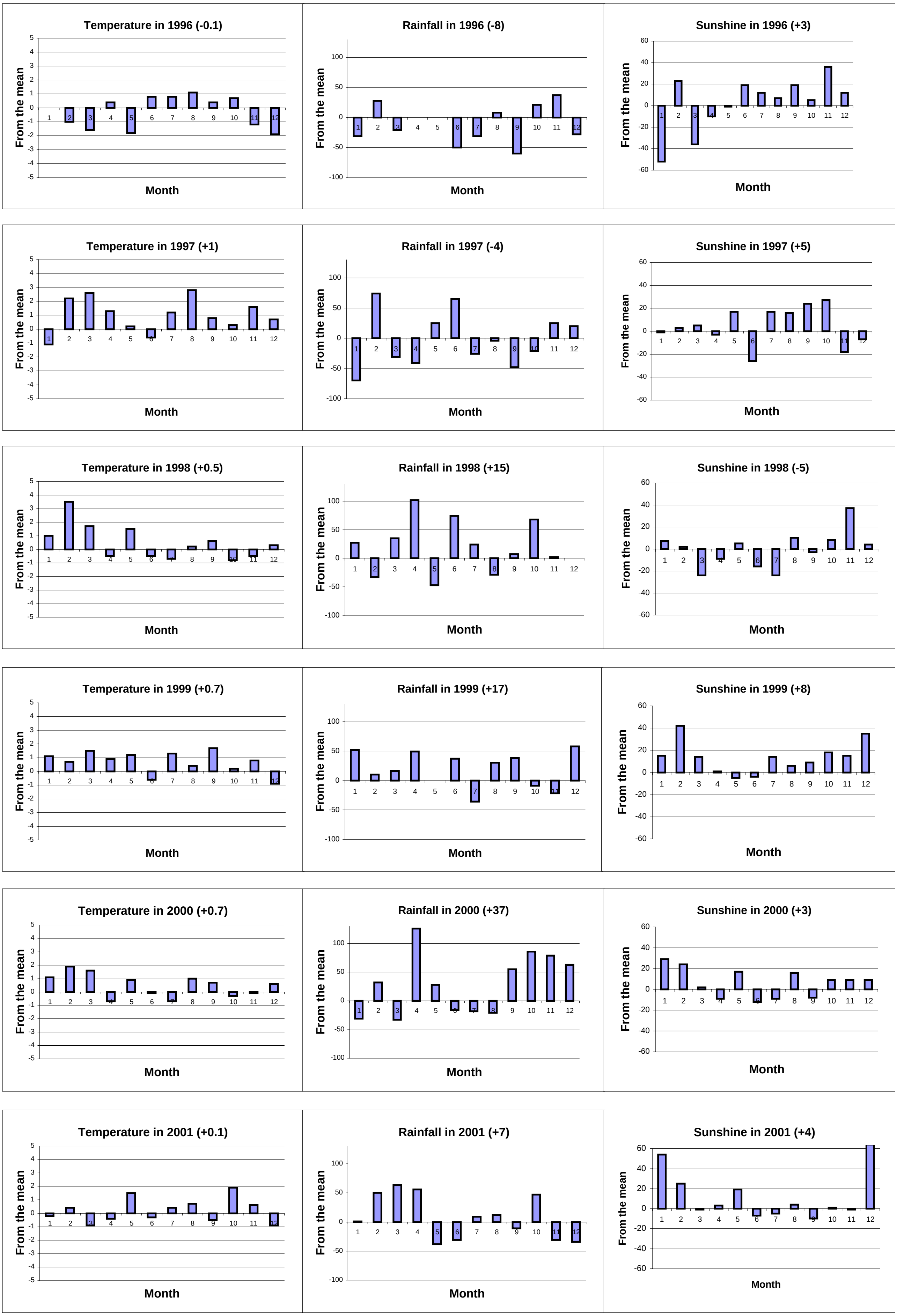
The most notable feature of the weather, is that overall the autumn, winter and early spring of 2000/2001 were exceptionally wet. This is very apparent in the rainfall graphs in Figure 1. In view of this fact it is not surprising that numbers of most species of butterfly declined from 2000 and that it was a generally poor year for butterflies. Ground-dwelling early stages of many species would almost certainly have been detrimentally affected by the unusually wet conditions. However it is unclear why most of the species that overwinter as adults should also have declined.

Table 2. Summary of UK weather in 2000/2001

2000	Daytime Temp (^{0}C)	Rainfall (%)	Sunshine (%)	Brief description
January	+1.1	-31	+29	Mild, sunny and dry
February	+1.9	+32	+24	Mild, wet and sunny
March	+1.6	-33	+2	Mild and dry
April	-0.7	+126	-9	Cool and very wet
May	+0.9	+28	+17	Warm, sunny and wet
June	-0.1	-16	-12	Warm in the south, cool in the north
July	-0.7	-18	-9	Cool in the east, dry in Scotland
August	+1.0	-21	+16	Warm, dry and sunny
September	+0.7	+55	-8	Wet, but mild
October	-0.3	+86	+9	Very wet, especially in the south
November	-0.1	+79	+9	Very wet, especially in the south
December	+0.6	+63	+9	Very wet, mild at first
Annual	**+0.7**	**+37**	**+3**	**A warm and very wet year**

2001				
January	-0.2	+1	+54	Very sunny, wet in the south
February	+0.4	+50	+25	Wet and mild in the south; sunny elsewhere
March	-0.9	+63	-1	Cloudy and wet in the south; cool everywhere
April	-0.4	+56	+3	Cool and wet, but dry in Scotland
May	+1.5	-38	+19	Rather warm, sunny and dry
June	-0.3	-31	-7	Dry; warm and sunny in south
July	+0.4	+9	-5	A rather average month; cool in north
August	+0.7	+12	+4	Rather warm; on the wet side
September	-0.5	-11	-10	Cool; wet in the east
October	+1.9	+47	+1	Wet and very mild
November	+0.6	-31	-1	Rather mild and dry; sunny in the south
December	-0.9	-34	+64	Very sunny and dry; rather cold
Annual	**+0.1**	**+7**	**+4**	**An average year; slightly wet**

Figure 1. United Kingdom monthly mean temperatures, rainfall and sunshine 1996-2001, showing departures from the 1951-1980 averages (data from: http://www.cru.uea.ac.uk/~mikeh).



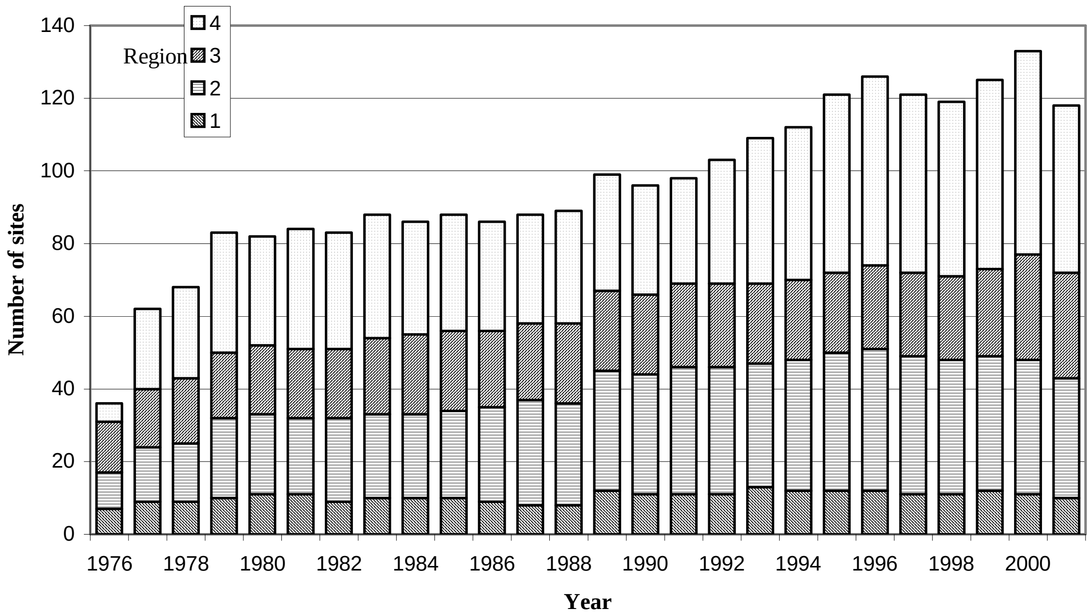
4 SITES CONTRIBUTING DATA TO THE BMS IN 2001

4.1 THE NUMBER OF SITES CONTRIBUTING DATA TO THE BMS IN ALL YEARS

The BMS was officially launched in 1976 with just 36 sites contributing to the scheme. However three years of trials preceded this when data were being gathered to test the methodology. Seven sites still in the BMS, which were monitored during this period as part of this process, have data going back to 1974. The number of sites contributing to the BMS (Figure 2) has gradually increased over the years with at least one site being added to the scheme in most years. However no new transects were added in 2001.

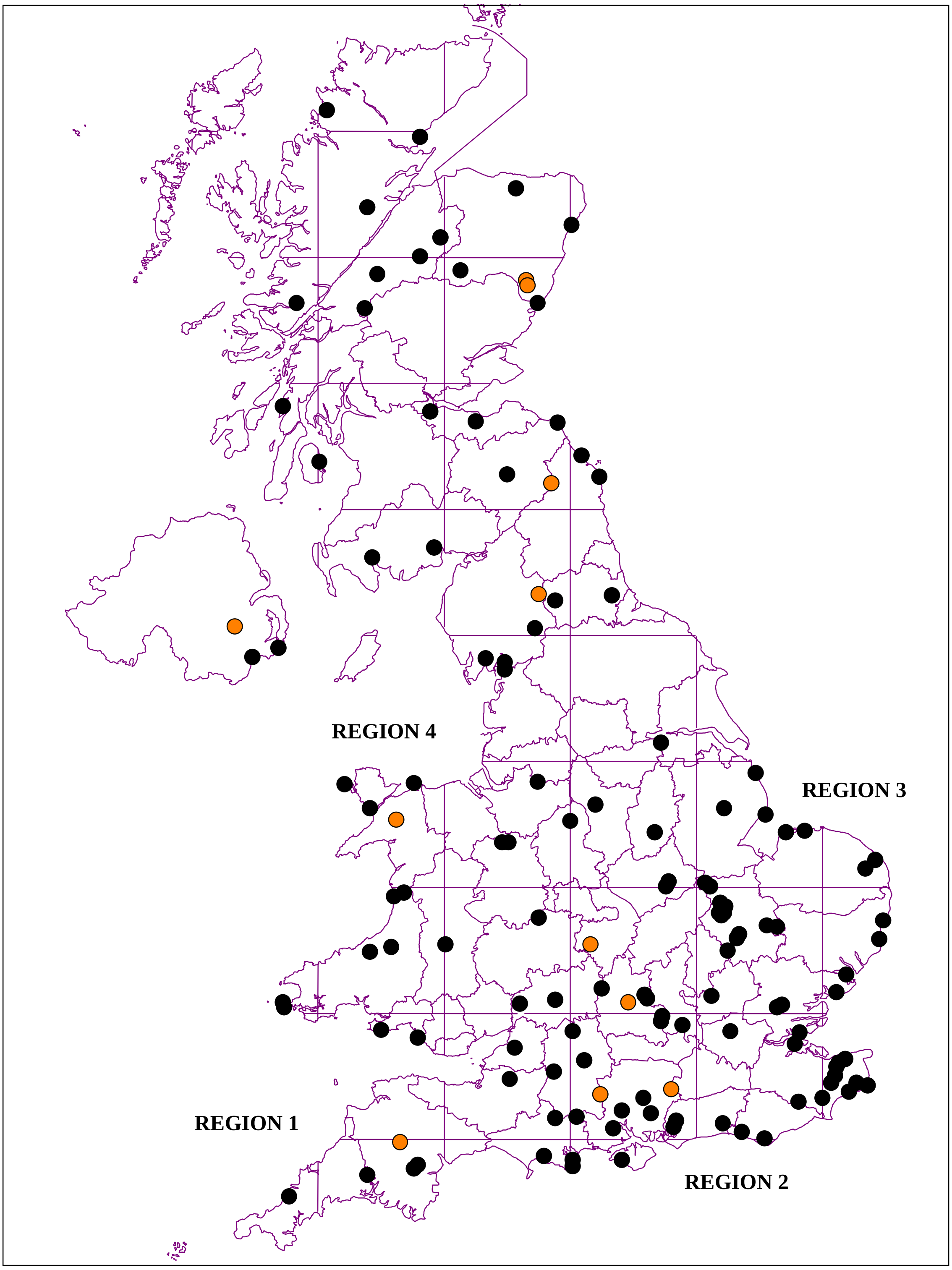
In 2001, 118 of the 136 transects currently part of the BMS submitted at least some data to the scheme. Nine transects produced no data at all due to FMD restrictions, but these should all be operational in 2002. Data for four transects were collected but have yet to be submitted! A further five transects produced no data for 2001 as no recorders were available, although a contact person remains and the transects remain in the scheme with the hope that new recorders can be found for 2002. The distribution of the transects currently part of, or contributing to, the BMS is shown on Map 1 on page 14.

Figure 2. Number of sites contributing data to scheme each year



4.2 THE CURRENT UK DISTRIBUTION OF BMS SITES

Map 1. BMS and ECN sites in 2001, (BMS = black circles, ECN = grey circles), showing county boundaries (*not* Vice-counties) and the four BMS regions.



5 ANALYSIS OF THE AMOUNT OF DATA RECEIVED

5.1 PERCENTAGE OF COUNTS COMPLETED

The overall percentage of counts completed in 2001 was 68%, this was only a small drop from 2000 (Table 3) and this despite the FMD. All sites submitting at least some data have been included in the analysis. There are small changes from the percentages shown in last year's report. This is because data from a few additional sites have been added to the BMS database since last year's report was produced.

From Table 3 it can be seen that the percentage of weeks completed has been fairly consistent over the years with the higher percentages of counts being completed in the sunniest summers (e.g. 1982, 1984, 1990, 1992, 1995 and 1997).

Table 3. Percentage of counts completed 1974-2001

YEAR	% of weeks completed	Number of sites	Number of weekly counts
1976	68%	36	639
1977	62%	62	996
1978	69%	68	1219
1979	74%	83	1587
1980	76%	82	1610
1981	74%	84	1607
1982	79%	83	1714
1983	72%	88	1649
1984	79%	86	1761
1985	73%	88	1659
1986	72%	86	1621
1987	73%	88	1680
1988	75%	89	1732
1989	78%	99	2012
1990	80%	96	2002
1991	75%	98	1920
1992	78%	103	2098
1993	73%	109	2076
1994	72%	112	2089
1995	75%	121	2370
1996	73%	126	2388
1997	76%	121	2380
1998	68%	119	2109
1999	74%	125	2406
2000	74%	133	2548
2001	68%	118	2082

The most poorly recorded weeks are usually those early in the season and is mostly due to the generally poorer weather at this time. In 2001 this was exacerbated by the FMD epidemic. For details of regions see Map 1 on page 14.

Figure 3. Number of sites with completed transects in each recording week in 2000

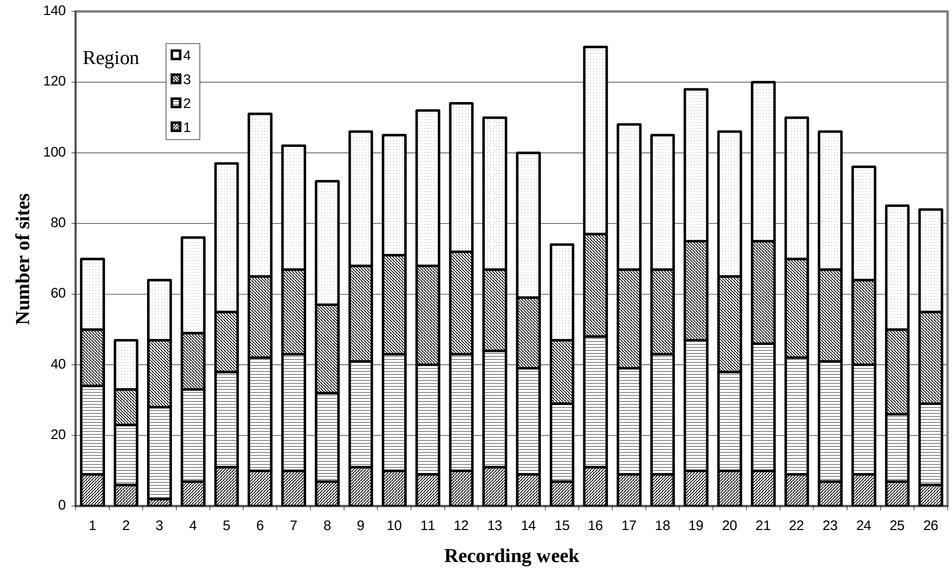
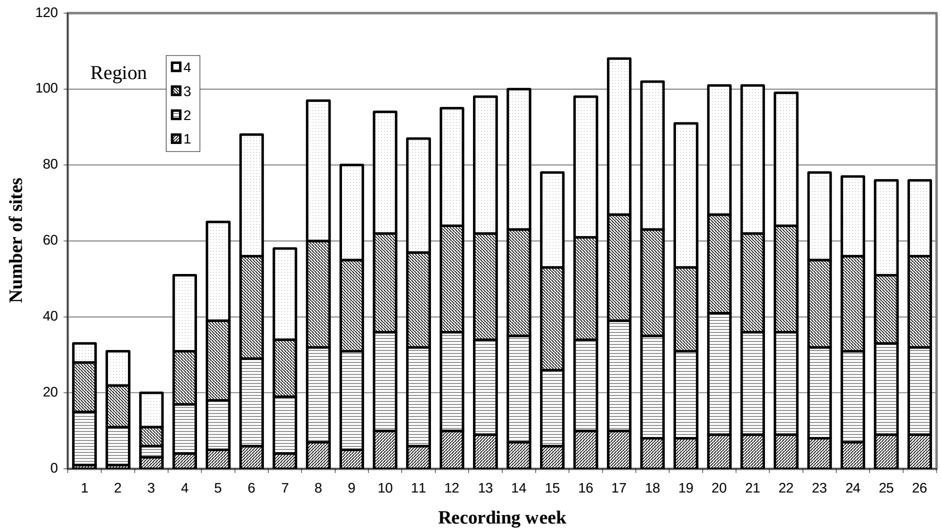


Figure 4. Number of sites with completed transects in each recording week in 2001



5.2 THE NUMBER OF WEEKS RECORDED FOR EACH TRANSECT

The number of weeks recorded for each transect in 2000 and 2001 are shown in Figures 5 and 6 respectively. Note that in 2000 and 2001 all 26 weeks were recorded on six and four transects respectively. The area covered by each region is shown on Map 1 on page 14.

Figure 5. Number of weeks recorded for each transect in 2000

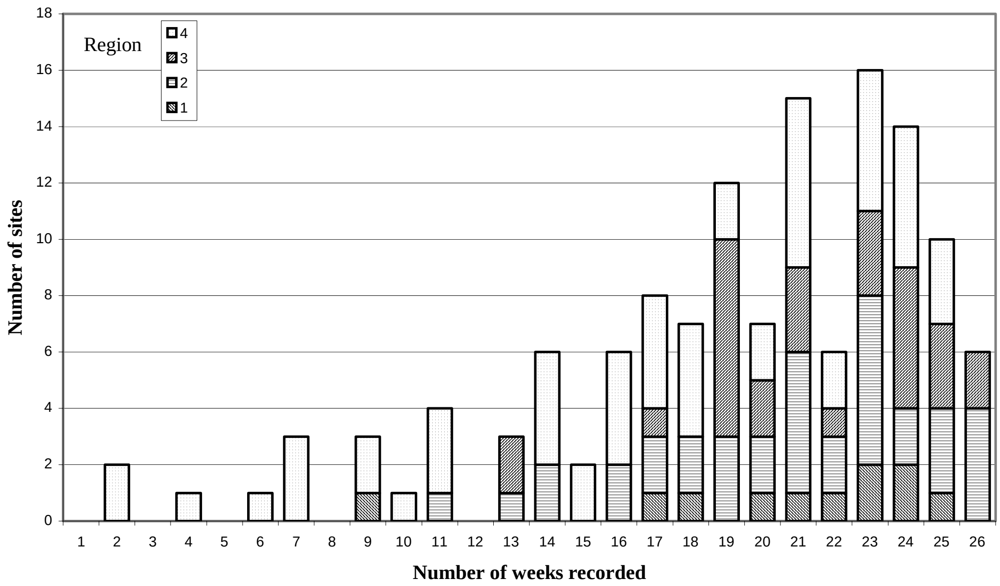
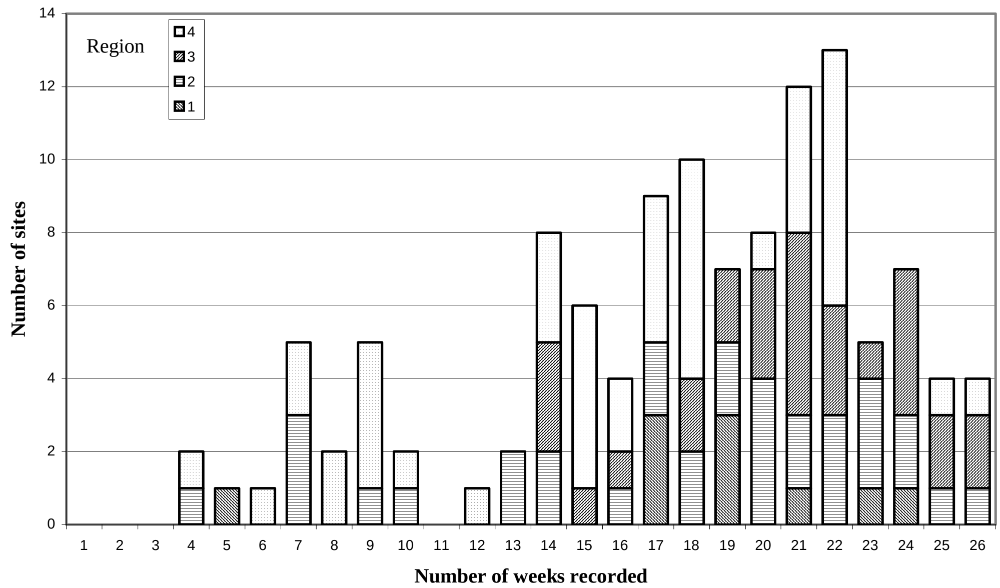


Figure 6. Number of weeks recorded for each transect in 2001



5.3 ANNUAL INDICES AND THE PROPORTION THAT COULD BE CALCULATED

Annual indices

An annual index for a species is simply the total mean weekly count on a transect for the year including estimates (see section on estimates below). Where a species is double-brooded or, in the case of the hibernating species Peacock and Brimstone where there is a separate spring and summer flight, two separate indices are calculated. Where species produce a third brood (notably Small Copper and Wall Brown) third brood figures are combined with those of the second brood. In some cases the divisions between the broods are indistinct and a single index is given for the year. These species are Red Admiral, Painted Lady, Small Tortoiseshell, Comma, Speckled Wood and Small Heath.

Estimates

Estimates are calculated for weeks where the counts have been missed (e.g. due to unsuitable weather, holidays etc.) and where they are considered appropriate.

Table 4. The number of transects for which different proportions of annual indices could be calculated for all years (1976 – 2001) for all transects recorded in each year.

YEAR	0%	>0-20%	20-40%	40-60%	60-80%	80-<100%	100%	Total no. transects contributing data
1976	2	0	1	1	2	22	8	36
1977	11	1	1	2	3	15	29	62
1978	9	2	2	4	5	17	29	68
1979	5	2	2	2	5	12	55	83
1980	3	0	2	2	9	14	52	82
1981	4	1	2	1	2	13	61	84
1982	4	1	0	1	5	18	54	83
1983	2	0	1	1	6	20	58	88
1984	2	0	1	3	11	12	57	86
1985	5	3	2	3	7	16	52	88
1986	2	3	3	5	13	7	53	86
1987	6	2	2	2	18	22	36	88
1988	6	1	5	8	9	10	50	89
1989	6	2	2	4	10	16	59	99
1990	3	2	2	3	8	16	62	96
1991	5	4	2	5	17	25	40	98
1992	5	5	2	7	3	20	61	103
1993	17	6	2	1	6	20	57	109
1994	13	2	3	5	18	19	52	112
1995	9	3	8	11	17	23	50	121
1996	20	2	7	10	9	32	46	126
1997	16	9	7	10	11	26	42	121
1998	20	5	7	12	20	40	15	119
1999	17	5	12	12	20	32	27	125
2000	13	10	9	12	20	34	35	133
2001	17	7	11	19	15	30	19	118

The process of calculating estimates is partly automated and as a general rule no estimates are calculated for a species (and therefore no annual index) when estimates comprise 30% or more of the annual index. This has meant that in a few cases where a week has been missed at the peak of the flight period no estimate has been calculated. However in some cases, for example where numbers were very low or where the flight period pattern of increase and decrease is very smooth annual indices have been calculated where the estimates comprise more than 30% of the total.

Table 5. The proportion of annual indices which could be calculated from all transects recorded in each year (1976 – 2001) expressed as a percentage (another way of looking at the data in Table 4).

YEAR	0%	>0-20%	20-40	40-60	60-80%	80-<100%	100%	Total number of transects contributing data
1976	6%	0%	3%	3%	6%	61%	22%	36
1977	18%	2%	2%	3%	5%	24%	47%	62
1978	13%	3%	3%	6%	7%	25%	43%	68
1979	6%	2%	2%	2%	6%	14%	66%	83
1980	4%	0%	2%	2%	11%	17%	63%	82
1981	5%	1%	2%	1%	2%	15%	73%	84
1982	5%	1%	0%	1%	6%	22%	65%	83
1983	2%	0%	1%	1%	7%	23%	66%	88
1984	2%	0%	1%	3%	13%	14%	66%	86
1985	6%	3%	2%	3%	8%	18%	59%	88
1986	2%	3%	3%	6%	15%	8%	62%	86
1987	7%	2%	2%	2%	20%	25%	41%	88
1988	7%	1%	6%	9%	10%	11%	56%	89
1989	6%	2%	2%	4%	10%	16%	60%	99
1990	3%	2%	2%	3%	8%	17%	65%	96
1991	5%	4%	2%	5%	17%	26%	41%	98
1992	5%	5%	2%	7%	3%	19%	59%	103
1993	16%	6%	2%	1%	6%	18%	52%	109
1994	12%	2%	3%	4%	16%	17%	46%	112
1995	7%	2%	7%	9%	14%	19%	41%	121
1996	16%	2%	6%	8%	7%	25%	37%	126
1997	13%	7%	6%	8%	9%	21%	35%	121
1998	17%	4%	6%	10%	17%	34%	13%	119
1999	14%	4%	10%	10%	16%	26%	22%	125
2000	10%	8%	7%	9%	15%	26%	26%	133
2001	14%	6%	9%	16%	13%	25%	16%	118

In the past estimates were calculated by simply taking the mean of the values from the weeks on either side of the missing week(s). The semi-automated method takes three recorded values and interpolates the missing value from these. Although the two methods are slightly different the results of the two methods are similar and differences in figures obtained are likely to be insignificant. Therefore the change in the method does not compromise what was done before.

Proportion calculated

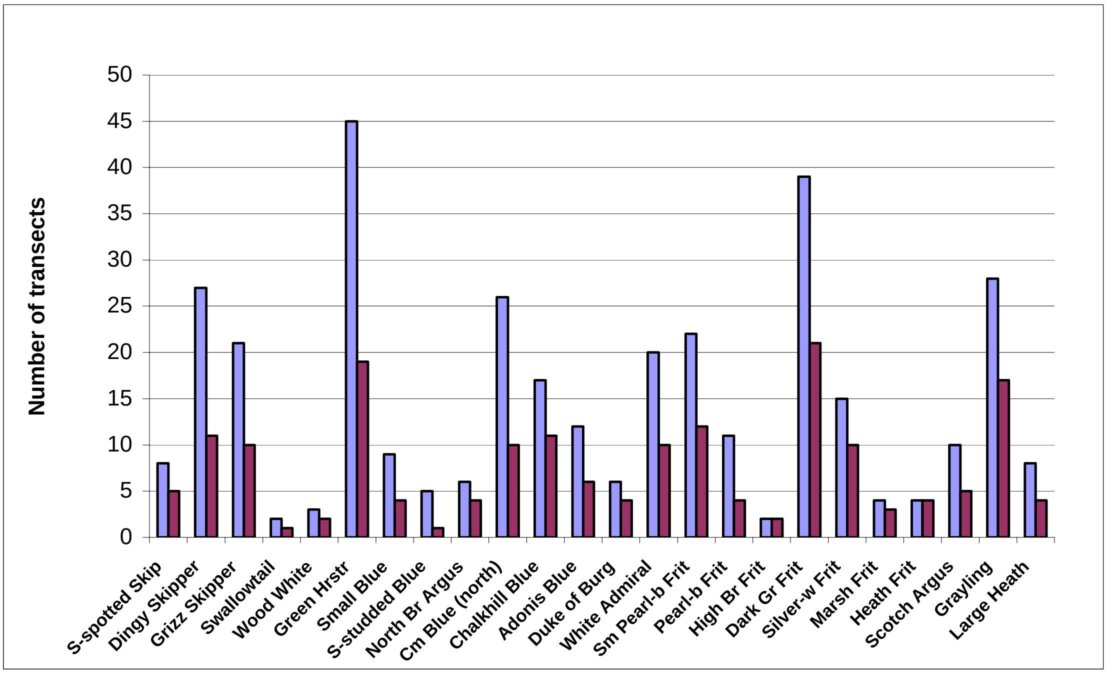
Site annual indices are calculated for each species for each transect where the species occurs and where data are sufficient. There was an overall decrease in the percentage of annual indices that could be calculated in 2001 as compared to 2000 due to restrictions on access imposed by the FMD epidemic. Sixteen transects provided too few data for any annual indices to be calculated (Table 4).

5.4 NUMBER OF ANNUAL INDICES FOR THE SCARCER SPECIES

In general, all-sites collated indices are only calculated if data from seven or more sites are available in every year since the start of the BMS in 1976, (data from sites where a zero index was produced in both of any pair of years are excluded). This limit was set based on a subjective assessment on the number of sites needed to produce a meaningful index at the start of the scheme in 1976. Usually the number of sites is much larger than this, and for the majority of species the number of sites for which data are available has increased greatly since the start of the scheme as the number of sites in the scheme has increased. However the fewer the number of sites then the less reliable are any trends in the data likely to be. The species whose collated indices need to be treated with the greatest caution are Common Blue (northern, univoltine), Chalkhill Blue, White Admiral (though the number of sites providing data for this species has increased markedly over the years), Small Pearl-bordered Fritillary and Pearl-bordered Fritillary. Consequently for these and other species represented on a relatively low number of sites, it is important to make sure that recording fully covers the flight periods so that site annual indices can be calculated which in turn will enable more reliable all-sites collated indices to be produced.

Figure 7 shows for many of the scarcer species the number of transects on which each was recorded in 2000 or 2001, including where an annual index could not be calculated (first column), and the number of transects for which data were sufficient to calculate an annual index in both years (second column), but excluding transects where the annual index was zero in both years. The second column therefore represents the number of transects which could contribute to an all-sites collated index for 2001 (or which did, in the case of those species for which one is calculated), and the first column those which potentially could have!

Figure 7. The number of annual indices calculated for the scarcer species compared with the number of sites where the species was actually recorded in 2000 and/or 2001. [*Some species have been excluded, these are the 'canopy' hairstreaks, the Purple Emperor, and species that occur on a single BMS transect only (Chequered Skipper, Lulworth Skipper and Glanville Fritillary)*].



Only a proportion of these species have been sufficiently represented on BMS transects over the years for an all-sites collated index to be produced. In the future collated indices will be possible for more species as data from the existing BMS and the many other transects operated by Butterfly Conservation volunteers and others are combined.

For nearly all of these scarcer species where an all-sites collated index is produced, a relatively high number of sites did not produce enough data for annual indices to be produced in both years and therefore these sites could not be used in the calculation of the all-sites indices. Some of these are Spring species and recording was adversely affected because of the FMD epidemic.

6 ANALYSIS OF CHANGES IN BUTTERFLY NUMBERS

6.1 NUMBERS OF BUTTERFLIES RECORDED

The number of sightings of butterfly species recorded on BMS transects in 2001 are listed in Table 6. Numbers included in this analysis are only those where sufficient data were provided in either 2000 or 2001 for site annual indices to be calculated.

Table 6. Sum of site indices and order of abundance for 2000 and 2001

Species	2000	2001	2000 order	2001 order
Meadow Brown	50070	31682	1	1
Gatekeeper	14224	12939	2	2
Ringlet	13727	10318	3	3
Green-veined White	10803	7076	4	4
Small Skipper	6527	5914	6	5
Small White	3869	4112	11	6
Common Blue	6213	4093	7	7
Speckled Wood	7225	3902	5	8
Peacock	6170	3663	8	9
Small Heath	4911	3590	10	10
Marbled White	5140	2409	9	11
Chalk-hill Blue	3468	2277	13	12
Marsh Fritillary	1983	1848	18	13
Large White	2784	1649	14	14
Large Skipper	2750	1628	15	15
Adonis Blue	1878	1303	19	16
Small Tortoiseshell	1517	1178	20	17
Small Copper	920	1131	27	18
Red Admiral	1997	1001	17	19
Brimstone	2338	904	16	20
Wall Brown	1042	877	25	21
Grayling	1063	768	24	22
Orange Tip	1158	750	23	23
Scotch Argus	1419	707	21	24
Common Blue (northern)	970	547	26	25
Dark Green Fritillary	914	534	28	26
Heath Fritillary	594	481	34	27
Brown Argus	1329	415	22	28
Small Blue	175	295	40	29
Northern Brown Argus	739	291	33	30
Silver-washed Fritillary	466	281	36	31
Comma	847	274	30	32
Dingy Skipper	582	233	35	33
Silver-spotted Skipper	766	183	32	34

Species	2000	2001	2000 order	2001 order
Small Pearl-bordered Fritillary	216	179	38	35
Pearl-bordered Fritillary	189	163	39	36
Holly Blue	103	161	43	37
Green Hairstreak	280	142	37	38
High Brown Fritillary	117	142	42	39
Grizzled Skipper	134	87	41	40
Silver-studded Blue	3679	87	12	41
Duke of Burgundy Fritillary	54	81	48	42
Painted Lady	905	80	29	43
Wood White	69	80	47	44
Purple Hairstreak	71	73	46	45
Large Heath	97	65	45	46
White Admiral	102	44	44	47
Swallowtail	33	30	49	48
Lulworth Skipper	8	19	53	49
Brown Hairstreak	15	14	51	50
Black Hairstreak	4	8	54	51
Purple Emperor	3	4	55	52
White-letter Hairstreak	12	4	52	53
Clouded Yellow	832	1	31	54
Glanville Fritillary	30	0	50	55
Pale Clouded Yellow	1	0	56	56

6.2 SUMMARY OF CHANGES AT SITE LEVEL 2000/2001

Table 7 summarises the changes in the site indices for all species from 2000 to 2001 (number of sites for which site annual indices could be calculated, increases, decreases, no change). The all-sites collated indices for 2000 and 2001 are shown where these are calculated and the species names shown in bold type (second generation / flight where two separate collated indices are calculated). Many of the rarer species do not have collated indices because they are recorded on too few BMS transects for a meaningful index to be calculated. Where collated indices have been calculated for species recorded on relatively few transects these figures should be treated with caution. These include Chalkhill Blue, Small Pearl-bordered and Pearl-bordered Fritillaries and Silver-washed Fritillary. For species with two distinct flight periods the second is used here.

Table 7. Summary of changes at site level 2000/2001. (*Column headed ' No. of sites with index in 2000 or 2001', includes transects where the index was zero in both years)*

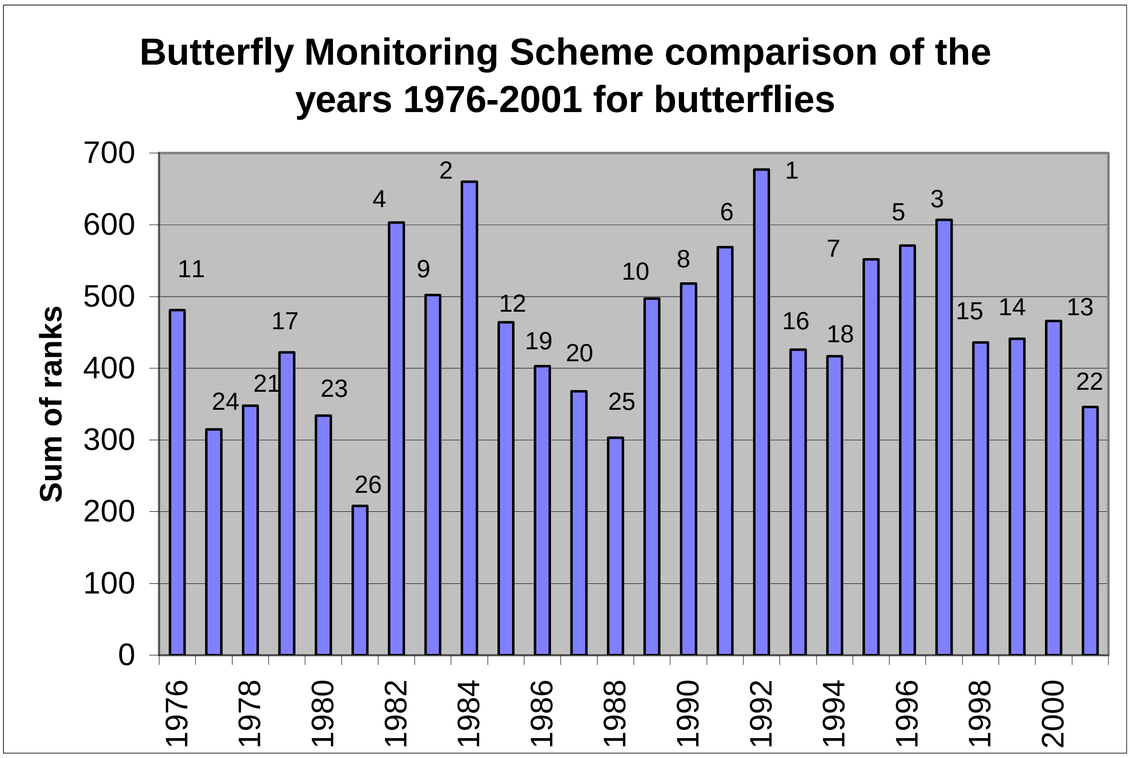
SPECIES	Brood	No. of site with index in 2000 or 2001	No. of site with index in 2000 and 2001	Increase	Decrease	No change	Index in 2000 only	Index in 2001 only	All-sites collated index 2000	All-sites collated index 2001
Small Skipper/Essex skipper	1	84	56	32	23	1	20	8	168	173
Lulworth Skipper	1	1	1	1	0	0	0	0		
Silver-spotted Skipper	1	9	5	2	3	0	4	0		
Large Skipper	1	91	58	26	32	0	23	10	145	127
Dingy Skipper	1	30	11	3	6	2	16	3	14	11
Grizzled Skipper	1	26	10	5	3	2	12	4	31	27
Swallowtail	1	1	1	0	1	0	0	0		
Wood White	1	4	1	1	0	0	3	0		
Pale Clouded Yellow	1	1	1	0	1	0	0	0		
Clouded Yellow	1	75	44	0	44	0	28	3		
Brimstone	1	63	18	8	10	0	36	9	115	92
Brimstone	2	72	47	10	33	4	18	7	102	67
Large White	1	90	43	9	31	3	33	14	53	22
Large White	2	105	68	26	40	2	31	6	85	65
Small White	1	89	51	9	41	1	27	11	32	11
Small White	2	101	60	36	24	0	28	13	62	79
Green-veined White	1	93	54	8	43	3	21	18	173	89
Green-veined White	2	111	64	22	42	0	35	12	352	263
Orange Tip	1	83	39	13	24	2	29	15	146	109
Green Hairstreak	1	42	19	7	10	2	19	4	228	177
Brown Hairstreak	1	9	6	3	3	0	3	0		
Purple Hairstreak	1	37	19	8	10	1	16	2		
White-letter Hairstreak	1	13	8	1	6	1	5	0		
Black Hairstreak	1	2	2	1	1	0	0	0		
Small Copper	1	64	23	3	17	3	30	11	68	26
Small Copper	2	82	50	28	18	4	28	4	52	65

SPECIES	Brood	No. of site with index in 2000 or 2001	No. of site with index in 2000 and 2001	Increase	Decrease	No change	Index in 2000 only	Index in 2001 only	All-sites collated index 2000	All-sites collated index 2001
Large Copper	1	0	0	0	0	0	0	0		
Small Blue	1	10	4	2	2	0	5	1		
Small Blue	2	7	5	2	2	1	2	0		
Silver-studded Blue	1	6	1	1	0	0	4	1		
Brown Argus	1	33	17	6	11	0	12	4	99	57
Brown Argus	2	46	33	6	23	4	12	1	117	59
Northern Brown Argus	1	6	4	1	3	0	2	0		
Common Blue	1	66	37	11	25	1	20	9	46	28
Common Blue	2	80	57	21	29	7	22	1	65	53
Common Blue (northern)	1	21	10	5	5	0	6	5	13	9
Chalk-hill Blue	1	16	11	4	7	0	4	1	77	61
Adonis Blue	1	12	6	3	3	0	5	1		
Adonis Blue	2	11	8	2	6	0	2	1		
Holly Blue	1	55	17	7	4	6	26	12	62	116
Holly Blue	2	57	34	23	9	2	20	3	101	227
Duke of Burgundy	1	8	4	3	1	0	3	1		
White Admiral	1	22	10	5	5	0	8	4	24	22
Purple Emperor	1	3	2	1	1	0	1	0		
Red Admiral	1	89	53	13	39	1	27	9	138	89
Painted Lady	1	88	50	3	46	1	32	6	1701	251
Small Tortoiseshell	1	73	22	12	10	0	45	6	49	55
Camberwell Beauty	1	0	0	0	0	0	0	0		
Camberwell Beauty	2	0	0	0	0	0	0	0		
Peacock	1	75	16	7	9	0	44	15	305	260
Peacock	2	102	61	30	29	2	33	8	209	206
Comma	1	63	18	4	13	1	39	6	326	192
Small Pearl-bordered Fritillary	1	20	13	4	8	1	6	1	22	18
Pearl-bordered Fritillary	1	13	4	2	2	0	5	4	2.4	2.1
High Brown Fritillary	1	6	2	1	1	0	2	2		
Dark Green Fritillary	1	39	21	12	8	1	13	5	40	49
Silver-washed Fritillary	1	20	10	4	6	0	9	1	51	46
Marsh Fritillary	1	5	3	1	2	0	2	0		
Glanville Fritillary	1	1	0	0	0	0	1	0		
Heath Fritillary	1	4	4	2	2	0	0	0		
Speckled Wood	1	82	49	13	35	1	28	5	315	219
Wall Brown	1	50	19	4	14	1	23	8	18	10
Wall Brown	2	61	34	10	24	0	24	3	18	12
Scotch Argus	1	7	5	3	2	0	1	1		
Marbled White	1	42	25	6	17	2	11	6	289	247
Grayling	1	26	17	8	9	0	7	2	60	63
Gatekeeper	1	88	63	27	36	0	19	6	129	119
Meadow Brown	1	111	71	23	47	1	28	12	165	134
Small Heath	1	73	36	15	21	0	26	11	21	20
Large Heath	1	5	4	0	4	0	0	1		
Ringlet	1	91	50	17	32	1	26	15	642	518

6.3 COMPARISON OF THE 26 YEARS OF THE BMS

The following method has been used to assess the overall relative abundance of butterflies in each of the 26 years of the BMS. For the 33 species (plus the northern univoltine Common Blue) for which all-sites collated indices are calculated, the years have been ranked 1 to 26 according to the collated index value for the species, with a score of 26 given to the year with the highest value (best year), and 1 to the year with the lowest value. For each year, the 34 ranks were summed, to give an overall indication of the year's quality for butterflies compared with the other years in the series. Figure 8 shows these sums of ranks, which theoretically could have ranged from 34 (if there had been a year in which every species was at its lowest collated index) to 884 (34 x 26). The overall ranking of years is shown above the columns in the histogram. Here 1 indicates the best year overall, and 26 the worst. 1981 emerges as the worst butterfly year of the series overall, and 1992 as the best. Four of the six worst years occurred in the five years following the drought year of 1976. 2001 comes out as one of the poorest years ranking only 22 out of 26 (fifth worst).

Figure 8. Histogram showing the sum of the ranks of each species for which a collated index is calculated for each year of the BMS.



6.4 THE RISE AND FALL OF THE SMALL TORTOISESHELL

In 1997 the Small Tortoiseshell produced its highest collated index since the BMS began in 1976. This was followed by a massive drop in 1998, and with a further drop in 1999 it produced its lowest collated index of the series. In the two years since 1999, numbers recorded on transects generally have remained very low relative to the whole series. In addition, until this spring (2002), casual observers have continued to comment that numbers seen have been exceptionally low. This has led some to ask whether the drop in numbers is a regional phenomenon or general throughout the United Kingdom. Others have asked whether this drop in numbers is likely to be a permanent one, and to ask what the cause(s) might be.

The extremes from high to low have occurred over a very short period of time. Although numbers have remained low since 1999 there are signs from BMS counts that numbers are increasing again. In addition, recent reports strongly suggest (in most cases) that numbers are higher this spring 2002 than in the past four years (Nick Bowles *pers. comm.* and subscribers to the egroup UK-Leps).

Figure 9 shows the regional trends for this butterfly, and as can be seen, there is a high degree of synchrony in the fluctuations between the four regions (see Map 1 on page 14 for regional boundaries). The huge synchronous drop in all four regional indices in 1998 and 1999 indicates that the decline in numbers has been a general phenomenon throughout the four regions and not restricted primarily to one or two regions.

Since the all-time low of 1999 there have been small increases overall in both 2000 and 2001. This was not reflected in the collated index for the south-west region in 2001. However it should be noted that this is a region with relatively few BMS transects (Figure 10), and the number of transects that could be used for the 2000 to 2001 comparison was reduced to just one due to FMD. This transect may well not be representative of the other sites in this region.

In general there is a high degree of synchrony in the fluctuations between the regions. This coupled with the often big and erratic fluctuations from year to year, indicate that numbers are highly affected by some broad overriding environmental factor, and the weather is the most likely candidate. However other factors such as the influence of parasites cannot be discounted. Note that in the north and west numbers of Small tortoiseshell were particularly adversely affected in 1986. There was a drop in the other regions too, but it was less dramatic.

Analysis of Small Tortoiseshell data from the BMS for the years 1976 to 1995 against weather variables indicated that increased breeding success of the summer generation of Small Tortoiseshells is strongly associated with high rainfall and cool temperatures in May and especially in June (Pollard *et al* 1997). It is thought that high rainfall at this time of year results in the nettles being more suitable for the larvae to feed on during the summer. Laboratory work has

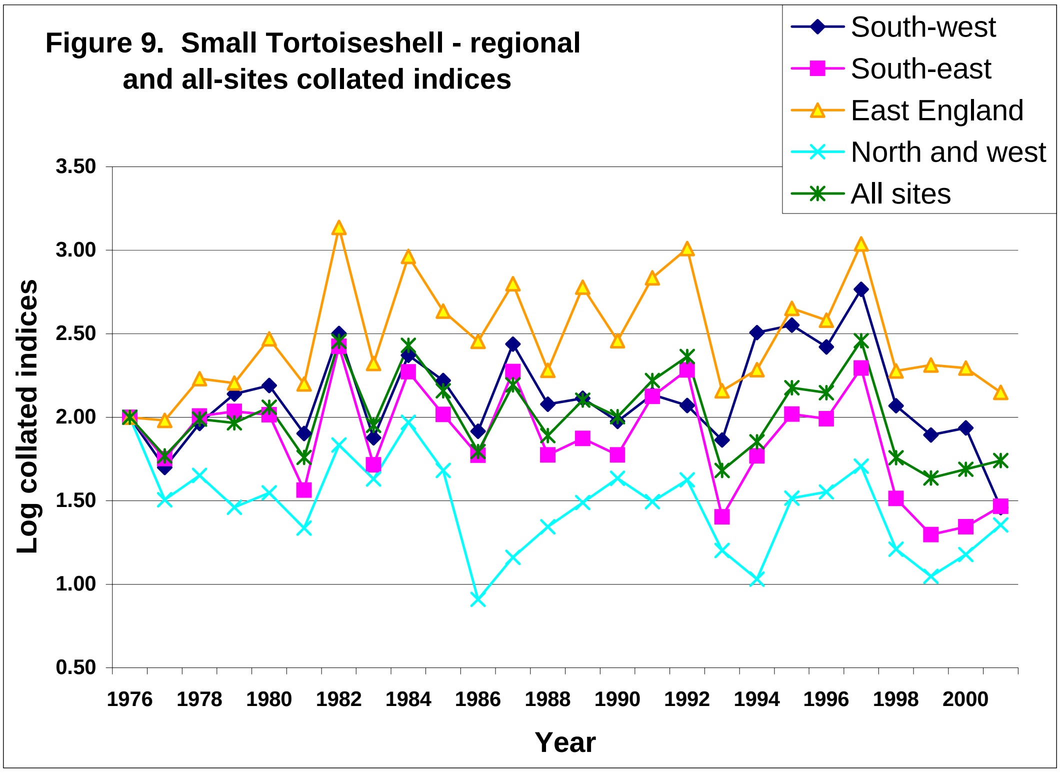


Figure 9. Small Tortoiseshell - regional
and all-sites collated indices
South-west
South-east
East England
North and west
All sites
Log collated indices
3.50
3.00
2.50
2.00
1.50
1.00
0.50
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
Year

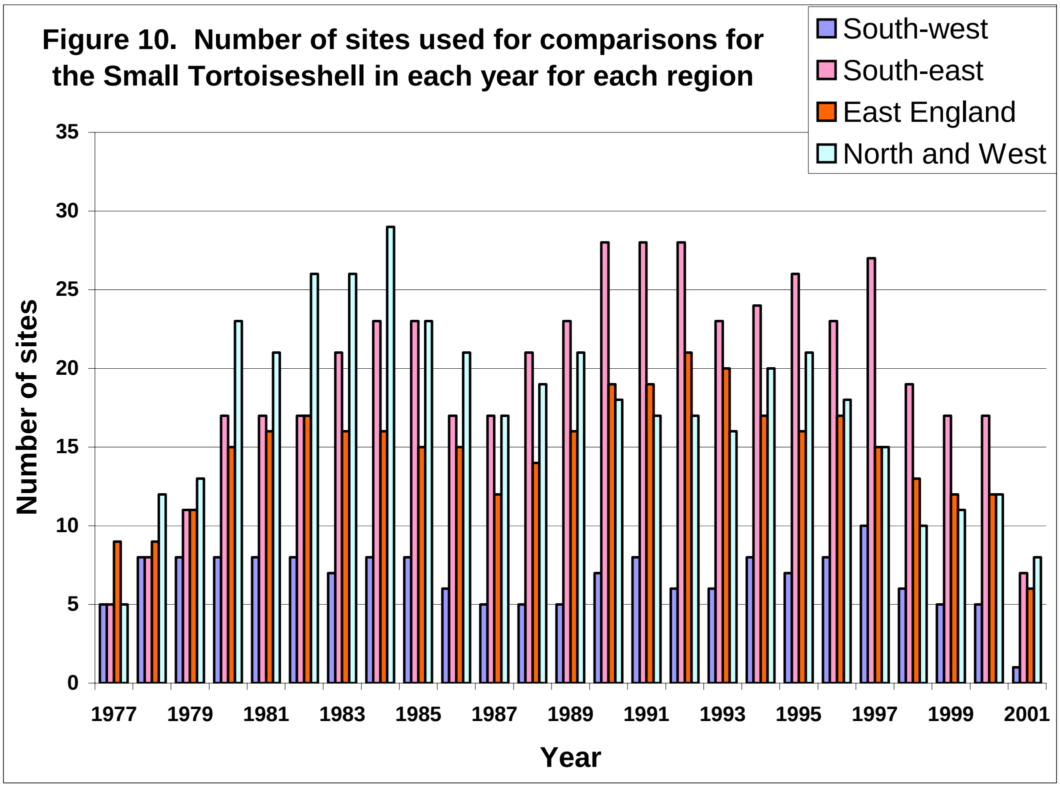


Figure 10. Number of sites used for comparisons for
the Small Tortoiseshell in each year for each region
South-west
South-east
East England
North and West
Number of sites
35
30
25
20
15
10
5
0
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Year

indicated that Small Tortoiseshell larvae fare better when the water and nitrogen content of the nettles is high (Pullen 1987). We have not looked to see whether this relationship between summer breeding success and rainfall has continued since 1995, but if it did, it was clearly unimportant in determining the overall abundance of the species. This could be the case if, for example, large overwinter mortality was responsible for the recent crash in numbers.

Further analysis for weather effects was carried out for all species for which a collated index is calculated using data for the years 1976 to 1997 (Roy *et al* 2001). Associations between the abundance of each species and monthly temperatures and rainfall in both the current and previous were looked for. The only significant associations that the analysis for the Small Tortoiseshell revealed were positive associations with warmer weather in August in both the previous and current years and negative associations with cooler weather in May of the previous year higher rainfall in April of the current year, so that it seems that any rainfall effects on summer breeding are not very important. In summary, for the present we cannot identify a weather factor which is clearly responsible for the crash of the Small Tortoiseshell.

It seems unlikely that the drop in Small Tortoiseshell numbers indicates a permanent decline in this species. BMS data indicate that numbers have been relatively low at other times during the past 26 years since the scheme began, notably in 1993 (see Figure 11c), and although the drop in numbers has lasted longer on this occasion, there are already signs of a turn in the fortunes of this species in 2002.

7 PUBLICATIONS USING BMS DATA

PUBLICATIONS IN 2001/2002

Rothery, P. & Roy, D. (2001). Application of generalised additive models to butterfly transect count data. *Journal of Applied Statistics* **28** (7), 897-909.

Roy, D.B., Rothery, P., Moss, D., Pollard. E & Thomas, J.A. (2001). Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. *Journal of Animal Ecology* **70**, 201-217.

Shreeve, T., Dennis, R.L.H., Roy, D.B., & Moss, D. (2001) An ecological classification of British butterflies: ecological attributes and biotope occupancy. *Journal of Insect Conservation* **5**, 145-161.

Warren, M.S., Hill, J.K., Thomas, J.A., Asher, J., Fox, R., Huntley, B., Roy, D.B., Telfer, M.G., Jeffcoate, S., Harding, P., Jeffcoate, G., Willis, S.G., Greatorex-Davies, J.N., Moss, D. &Thomas, C.D. Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature*, **414**, 65-69.

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Pannekoek, J. & van Strien, A. (2001) ***TRIM 3 Manual (Trends & Indices for Monitoring** *data)*. Statistics Netherlands.

Pollard, E.P., Greatorex-Davies, J.N. & Thomas, J.A. (1997). Drought reduces breeding dsuccess of the butterfly *Aglais urticae*. *Ecological Entomology*. **22,** 315-318.

Pollard, E., Moss, D., & Yates, T.J. (1995) Population trends of common British butterflies at monitored sites. *Journal of Applied Ecology*, **32**, 9-16.

Pullin, A. S. (1987). Changes in leaf quality following clipping and regrowth of *Urtica dioica*, and consequences for a specialised insect herbivore, *Aglais urticae*. *Oikos*, **49**, 39-45.

Roy, D.B., Rothery, P., Moss, D., Pollard. E & Thomas, J.A. (2001). Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. *Journal of Animal Ecology*, **70**, 201-217.

9 ACKNOWLEDGEMENTS

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APPENDIX I

COLLATED INDEX GRAPHS, 1976-2001

Species for which collated indices are calculated

The graphs in this Appendix (Figures 11a-e pages 34 to 38[1]) show fluctuations in the national (all-sites) collated indices for 33 species, and include all species which are recorded on a sufficient number of transects for a collated index to be considered meaningful (see also page 21). Two separate indices are shown for the Common Blue, one for the southern bivoltine (two generations per year) populations and one for the northern univoltine (single generation per year), making 34 collated indices in all. Where species are bi- or multivoltine (two or more generations per year) or have a separate spring and summer autumn flight (i.e. Brimstone and Peacock) only the second brood/flight figures are normally used to identify and quantify changes. In the case of species which have a partial third brood, such as the Small Copper and Wall Brown, third brood figures are included with the second brood figures. For some bivoltine species it is difficult to separate the generations due to significant overlap. These are Painted Lady, Red Admiral, Comma, Small Tortoiseshell, Speckled Wood and Small Heath. In these cases a single all-season index is calculated.

Graphs should be interpreted with caution for species which produce, or have produced, collated indices from relatively few sites, notably, Common Blue (northern, univoltine), Chalkhill Blue, White Admiral, Small Pearl-bordered Fritillary, Pearl-bordered Fritillary and Silver-washed Fritillary. The Brown Argus is now recorded on many transects and despite possible identification problems (especially confusion with brown Common Blue females), we consider that the collated index for this species has become increasingly reliable in recent years. All figures are of logged values and, where practical, are shown to the same scale so that visual comparisons between graphs can be made.

In the cases of the Holly Blue and the Painted Lady, the fluctuations in the “all sites” indices are somewhat greater than for other species. These are shown together on a separate figure (11e on page 38) to draw attention to the fact that due to the particularly large fluctuations in the indices of these two species the scale is different to accommodate this.

Standard errors

For the first time standard error bars have been added to the graphs. These are used to assess the significance of changes in the index value for a particular year relative to a base-line year. A difference of more than two standard errors is significant at the 5% level. How the standard errors are calculated is explained in Appendix II.

Comparing BMS calculated indices with those from TRIM

This year we have taken the opportunity to make comparisons between the BMS (chaining) method and a widely used method performed by a statistical software programme called TRIM that uses log-linear models to produce collated indices. TRIM is used by the Dutch Butterfly Monitoring scheme to produce their collated indices. The two methods are explained in Appendix II and the results compared.

In general we have found excellent agreement between the two methods and this promotes confidence in the reliability of the indices produced from the BMS data by the chaining method. It also means that results obtained by the chaining method can be legitimately compared with those produced by log linear models using TRIM. Because of the close agreement in the results produced by the two methods, there seems no reason at present to change the method we have been using to date to calculate the collated indices.

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[1] Please note that these figures (including Figure 12a-e on pages 42-46) are for information only and should not be quoted or used in any way without prior permission from CEH

Figure 11a. Log collated indices, 1976-2001

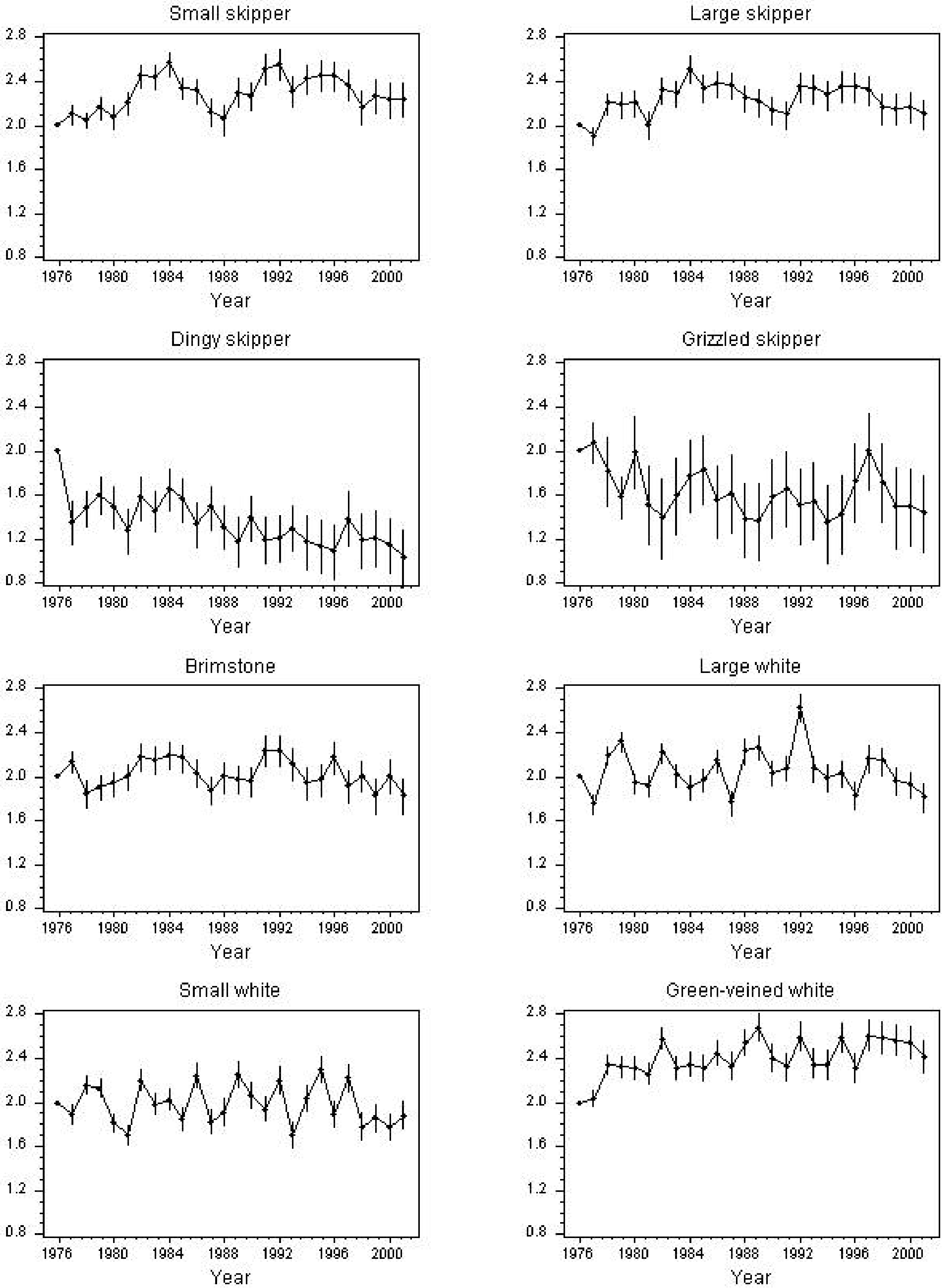


Figure 11b. Log collated indices, 1976-2001

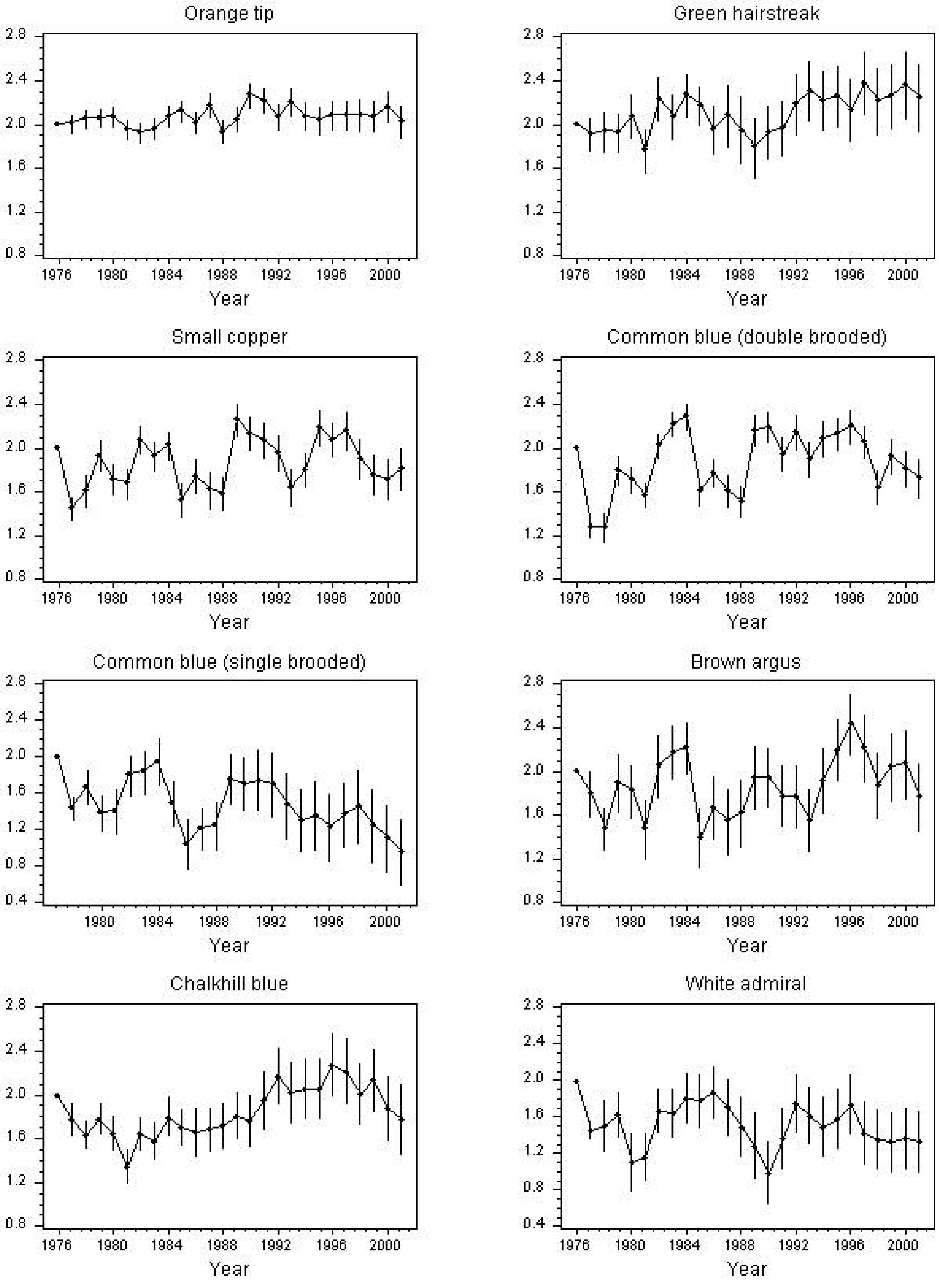


Figure 11c. Log collated indices, 1976-2001

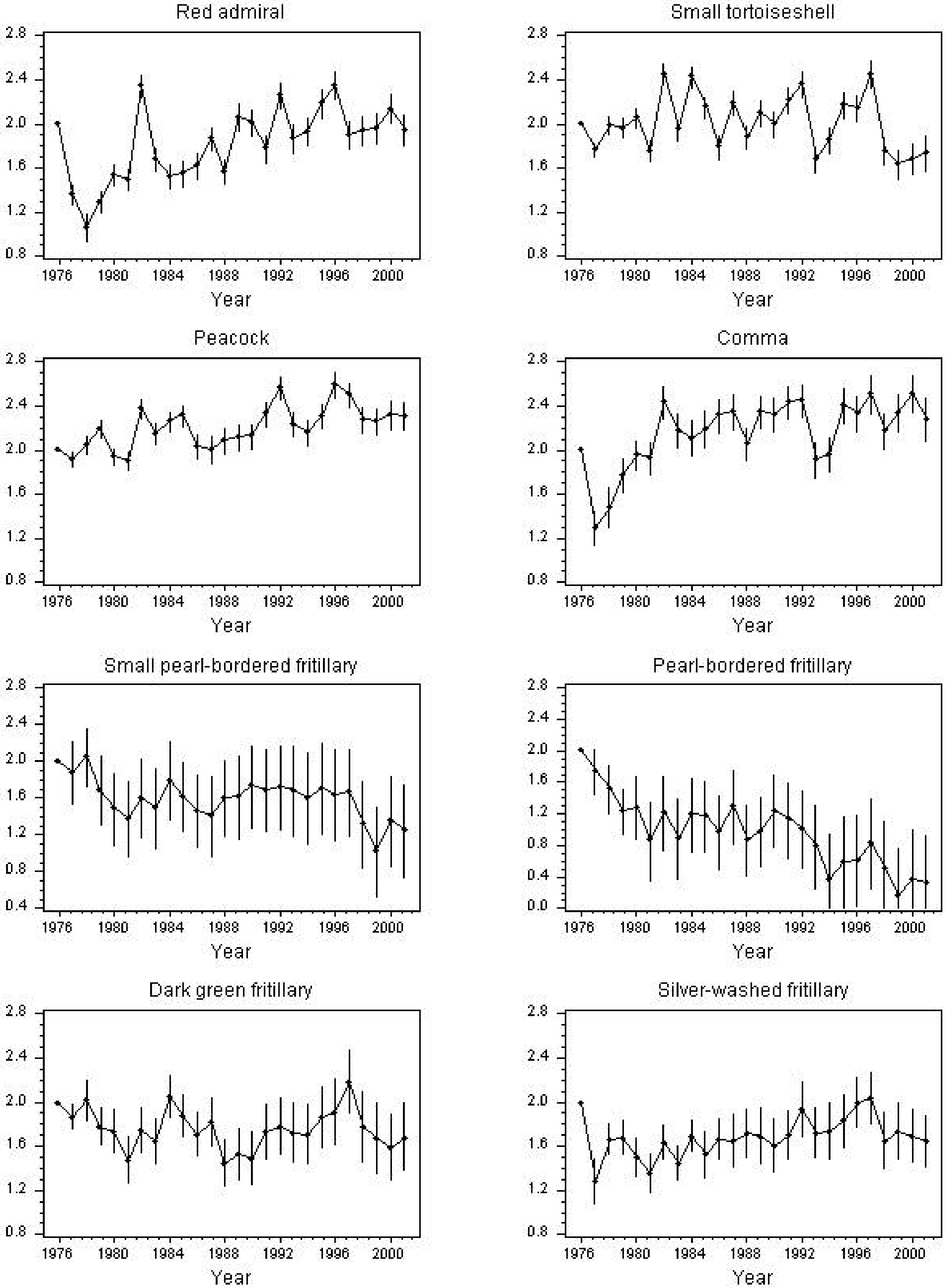


Figure 11d. Log collated indices, 1976-2001

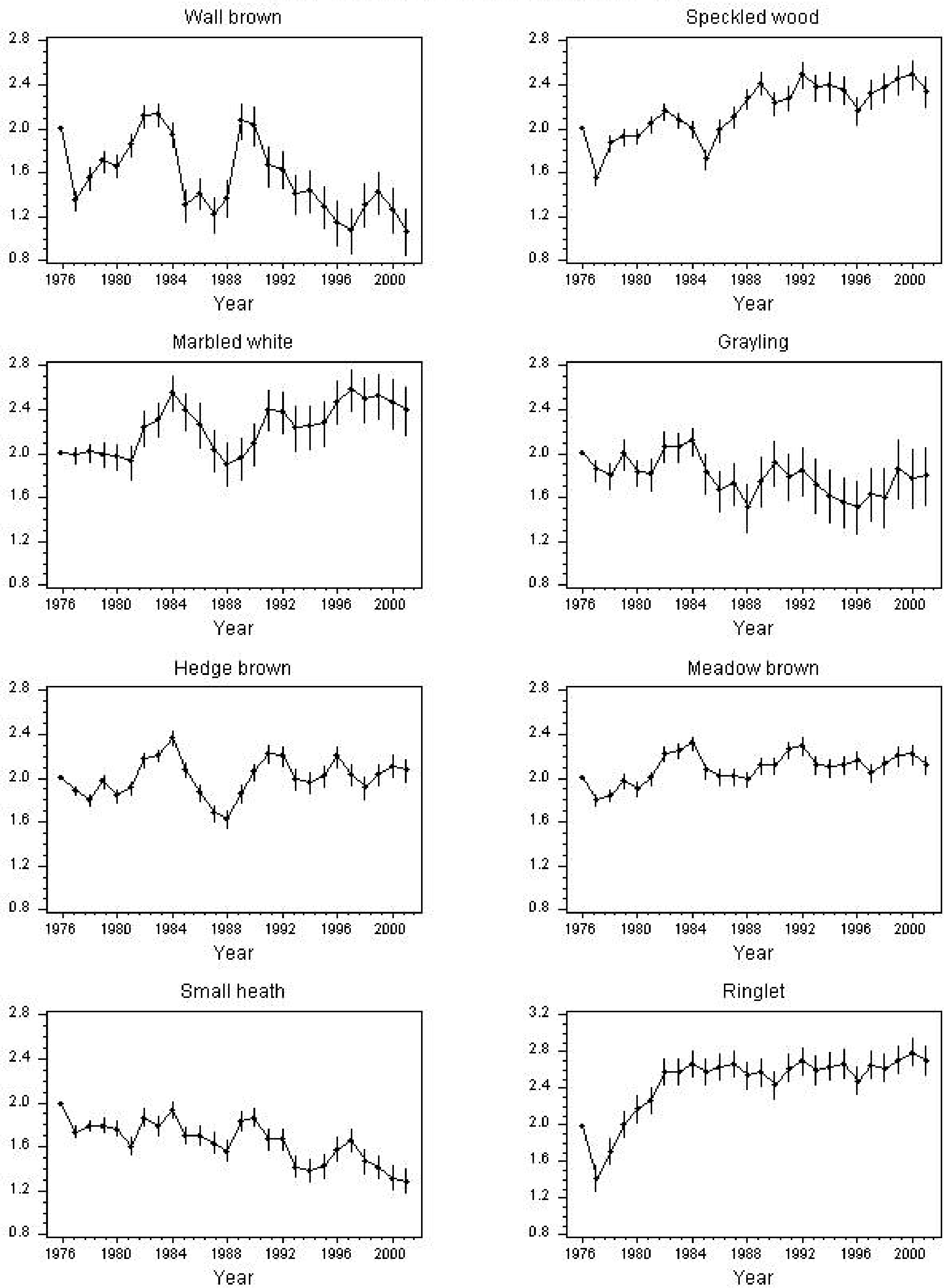
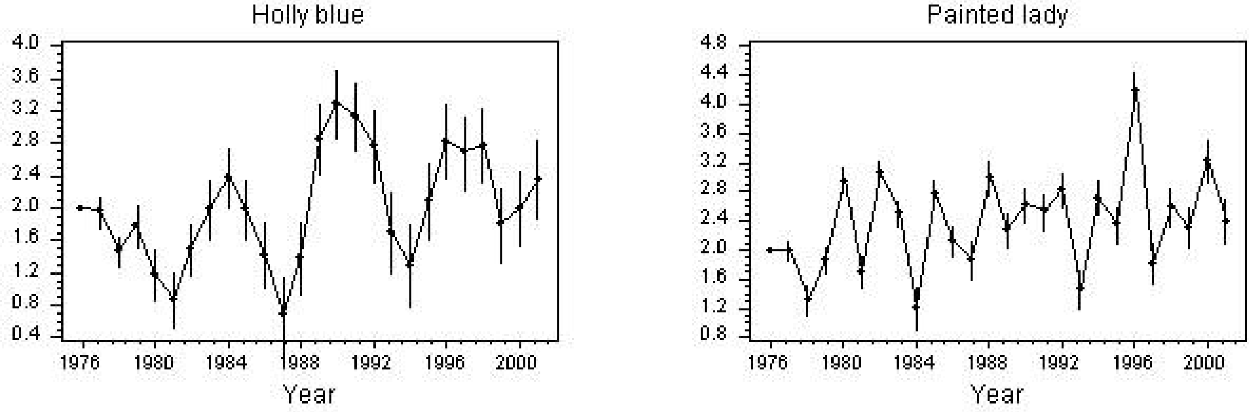


Figure 11e. Log collated indices, 1976-2001



APPENDIX II

COMPARISON OF THE BMS (chaining) AND TRIM (log-linear) METHODS FOR THE CALCULATION OF COLLATED INDICES

Roy, D.B., Rothery, P.

Background

A number of techniques have been suggested to calculate indices of abundance from wildlife monitoring data (ter Braak *et al*, 1994). The main methods used to analyse butterfly monitoring data are 'chaining' methods and log-linear models. The current method adopted by the UK Butterfly Monitoring Scheme is based on a modified chaining method as described by Moss & Pollard (1993); the Dutch Butterfly Monitoring Scheme use log-linear models as performed by the statistical software package TRIM (Pannekoek & van Strien 2001). In this appendix we apply both methods to UK-BMS data. We include a method for calculating standard errors for the chaining index, and compare indices and standard errors produced by both the chaining and TRIM indices. Graphs of both indices are given.

Notes on graphs

Figure 11 shows fluctuations on a $\log_{10}$ scale in the national (all sites) collated index values for all species for which this figure is calculated. Standard error bars are given based on the method detailed below. The collated indices are derived from the site annual indices (see page 18) using the method of Moss and Pollard (1993). Indices are calculated relative to the first full year of the scheme, i.e. 1976 is set to 2 (i.e. $\log_{10}$ of 100, the arbitrary starting figure to which all collated indices were set in 1976). For species for which two separate indices are produced, the second is shown.

Figure 12 shows fluctuations on a $\log_{10}$ scale, including standard errors, in indices of abundance for both the chaining and TRIM method. In both cases the index values are calculated relative to the series mean which is arbitrarily set to 2.

Bootstrap standard errors for BMS (chaining method) indices

Standard errors for the BMS indices have been obtained by the bootstrap method (Efron, B. & Tibshirani, R.J. 1998, Manly, 1997). Bootstrapping involves drawing repeated random samples, with replacement, from the original sample. The bootstrap samples are then used to calculate properties of estimates, e.g. bias and standard error. This resampling method is computer-intensive, but requires no theoretical calculations and can be easily implemented for any estimate. For the BMS data, bootstrapping proceeds by drawing random samples of *n* sites, with replacement, from the original set of *n* sites. For each bootstrap sample, the BMS index is calculated. The standard error of the index is then estimated from the values in large number of bootstrap samples - in this case 500. Note that a typical bootstrap sample will generally include some sites more than once, with other sites omitted altogether, but in the calculation of the indices the sites are treated as distinct. The method has been successfully applied in the analysis of long-term trends in birds (e.g. Fewster *et al.* 2000), and is suited to the BMS data.

Figure 11 shows annual fluctuations in the index together with standard error bars. Values of the index are shown relative to the baseline year 1976 with a value of 2. The standard error for a given year therefore refers to the change from 1976; a difference exceeding two standard errors is statistically significant at the 5% level.

For many of the species the standard errors show an increase in time. This is a result of two effects. First, counts which are close together in time are more highly correlated than counts taken further apart, so that standard errors of changes measured relative to 1976 tend to be larger at the end of the series. Second, errors in estimated year-to-year changes are accumulated in the chaining method used by the BMS index, resulting in ‘random drift’ and increased standard errors. For a complete table of counts, in which each site occurs in each year, differences in index values over a particular period involve only the ratio of counts at the beginning and the end, so there is no effect of random drift. The effect of random drift increases with the extent of the missing counts. The situation is further complicated because standard errors also depend on the number of sites available in each year.

Loglinear Poisson regression and TRIM indices

An alternative method for estimating annual indices is to use a loglinear Poisson regression model (ter Braak *et al*. 1993). In this approach the expected count at a particular site in a given year is assumed to be a product of a site and a year effect, i.e. Expected count = site effect * year effect. If the expected count for site *i* in year *j* is denoted by μ_{ij} then the model can be written as

$$\log(\mu_{ij}) = \alpha_i + \beta_j$$

where α_i and β_j denote the effects on a log scale for the *i*th site and the *j*th year ($i = 1, \ldots, a$; $j = 1, \ldots, b$). The index for year *j* relative to year 1 is defined as $\beta_j - \beta_1$. Alternatively, an index could be defined relative to the series mean index, i.e. $\beta_j - (\beta_1 + \beta_2 + \ldots + \beta_b)/b$. Note that the choice of baseline does not affect the pattern of year–to-year fluctuations. However, using the series mean provides a more stable reference for assessing individual years, and also helps to compare indices using different methods (see below).

Observed counts are subject to random variation reflecting natural fluctuations in abundance and sampling error. In the log linear Poisson regression model the variance of the observed count is proportional to the mean, i.e. var [*count*] = $c\mu_{ij}$, where *c* is the dispersion parameter.

The loglinear Poisson regression model can be fitted using the software TRIM (Pannekoek & van Strien 2001). The program estimates the dispersion parameter, and can allow for serial correlation between counts at the same site in different years. Standard errors of the indices are based on the assumption of variance proportional to mean, and a pattern of serial correlation which declines exponentially with time between counts. For the BMS data, however, these assumptions appear unrealistic, so standard errors have been obtained by applying the bootstrap method (see previous section), to indices derived using a loglinear Poisson regression model without serial correlation. The approach relaxes the assumption of variance proportional to mean, and allows for the effect of serial correlation. Bootstrap standard errors are not currently available in TRIM, so they have been calculated here using the statistical package Genstat 5 (Genstat Committee 2000).

Comparison of BMS and TRIM indices

Figure 12 shows annual fluctuations in indices based on the loglinear Poisson regression model (blue line) with bootstrap standard errors, together with corresponding values for the BMS indices (red line). In both cases the index values are calculated relative to the series mean which is arbitrarily set to 2. The standard error for a given year therefore refers to the deviation of that year from the mean; a difference exceeding two standard errors is statistically significant at the 5% level.

For almost all species, the BMS and TRIM indices show very similar patterns of fluctuations. Note that index values measured relative to 1976 show the same correlations but tend to drift in and out of phase; using the series mean as a baseline aligns the series and helps visual comparison. For both indices, standard errors generally show a decline from higher values in the early years to lower values in middle of the series and, for some species, an increase in later years. In general, standard errors were very similar for both indices, but for 10 species there was a suggestion of larger standard errors for BMS indices.

In general we have found excellent agreement between the two methods and this promotes confidence in the reliability of the indices produced from the BMS data by the chaining method. It also means that results obtained by the chaining method can be legitimately compared with those produced by log linear models by TRIM.

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ter Braak, C.J.F., van Strien, A.J., Meijer, R. & Verstrael, T.J. (1994). *Analysis of monitoring data with many missing values: which method?* **In:** W. Hagemeijer & T. Verstrael, Eds. Bird Numbers 1992. Distribution, Monitoring and Ecological Aspects. Proceedings of the 12th International Conference of the International Bird Census Committee and European Ornithological Atlas Committee. SOVON, Beek-Ubbergen, The Netherlands.

Figure 12a. Log collated indices, 1976-2001 (error bars are 1 s.e.)

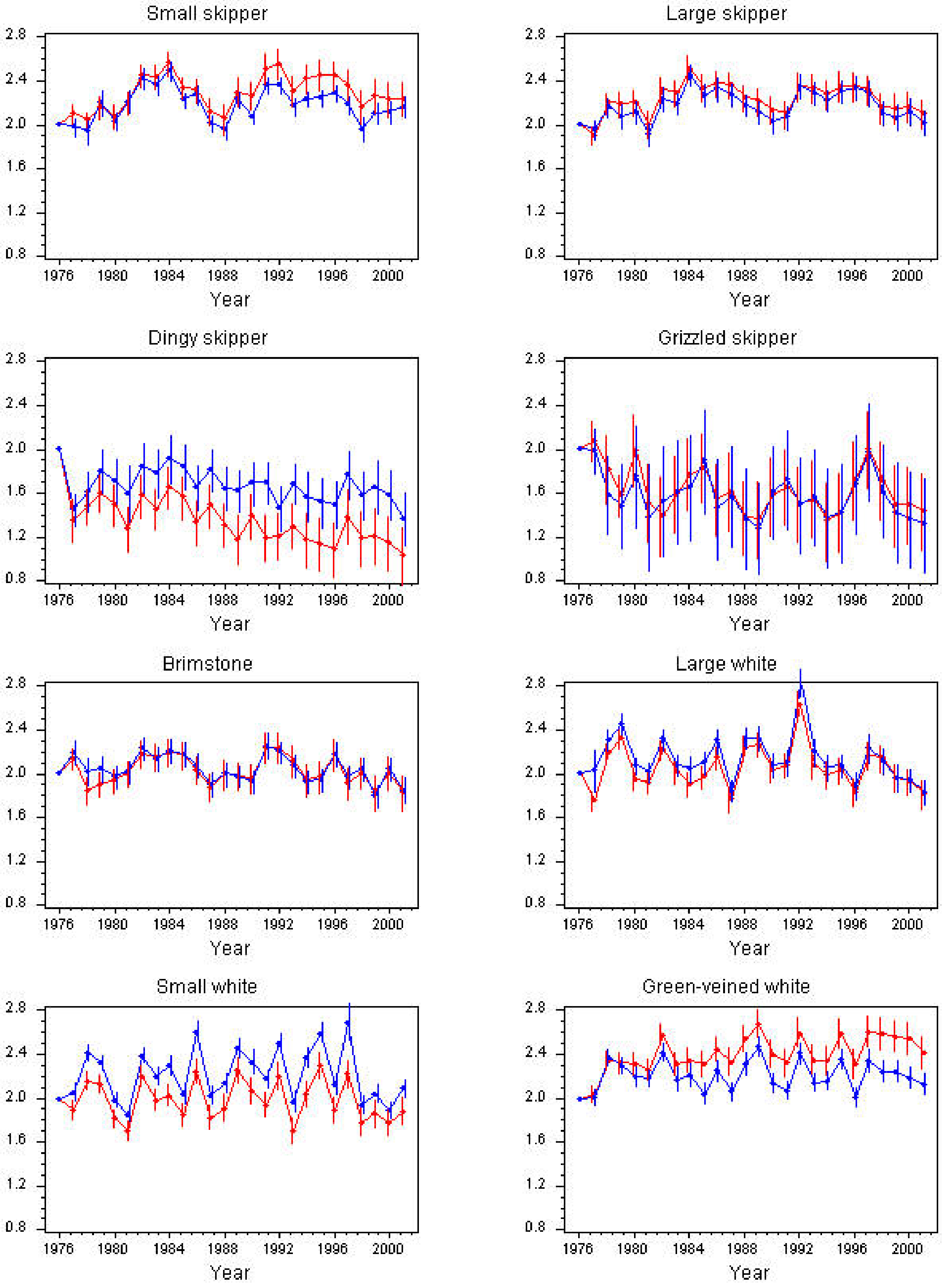

Figure 12b. Log collated indices, 1976-2001 (error bars are 1 s.e.)

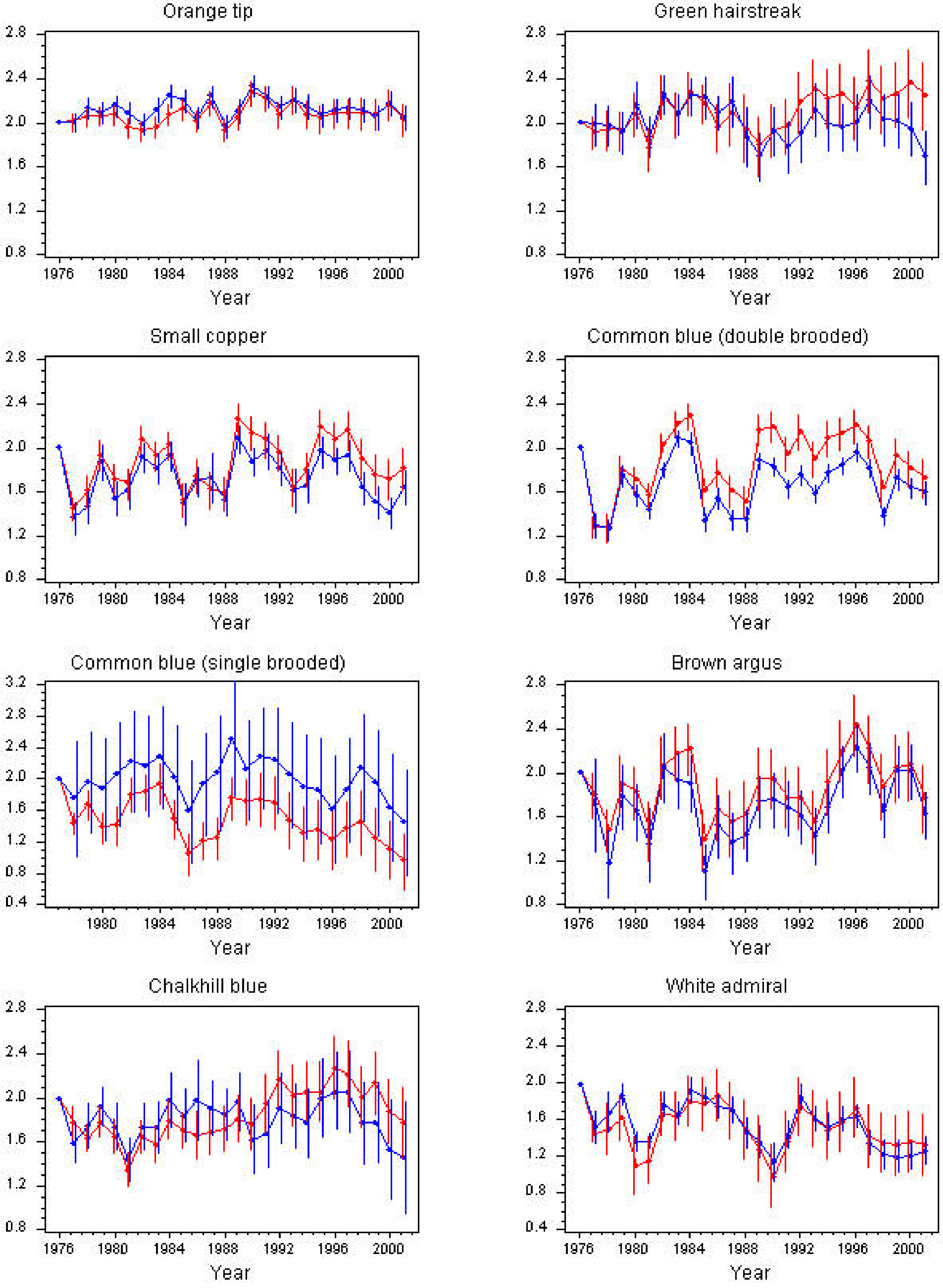

Figure 12c. Log collated indices, 1976-2001 (error bars are 1 s.e.)

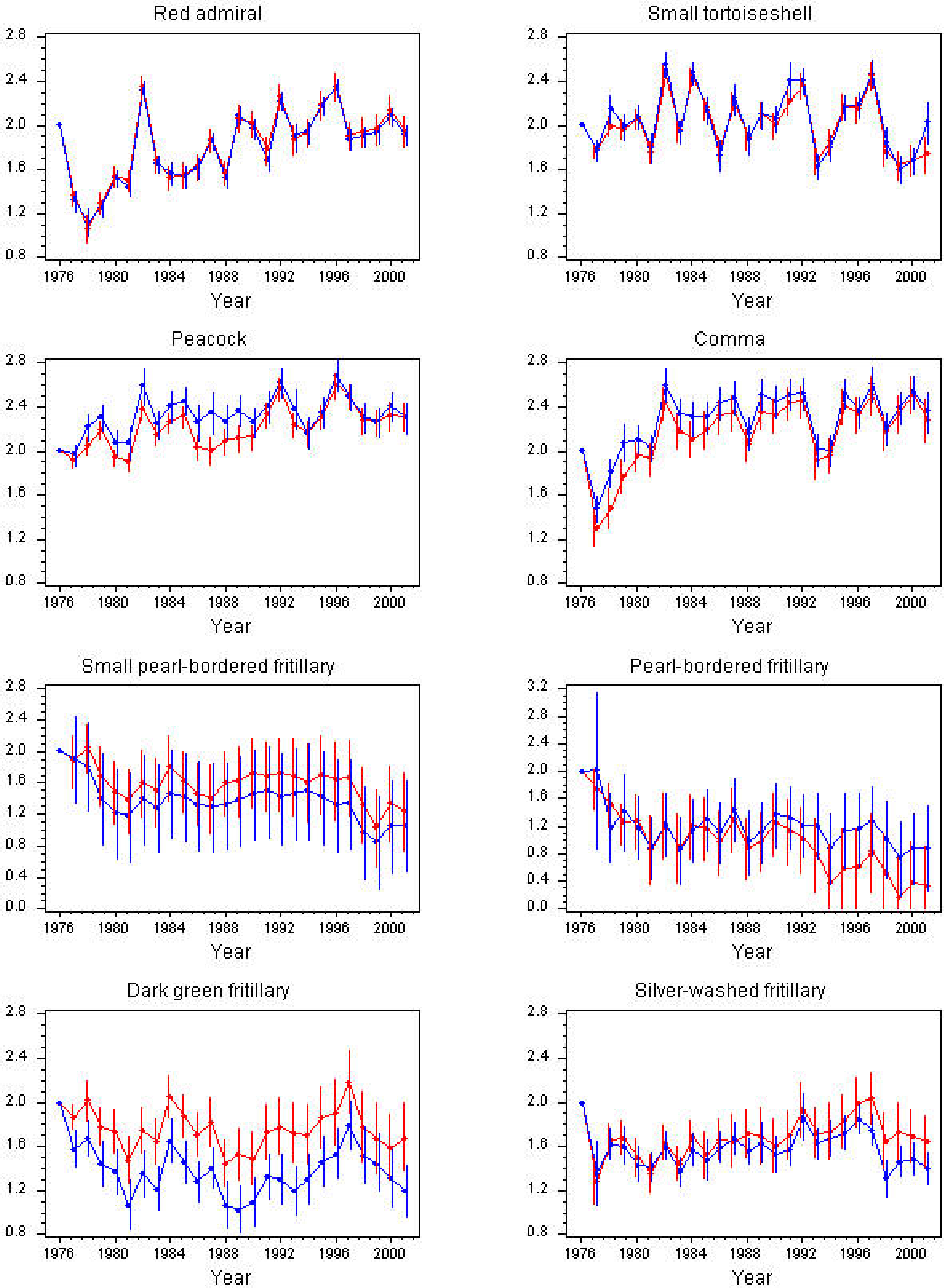

Figure 12d. Log collated indices, 1976-2001 (error bars are 1 s.e.)

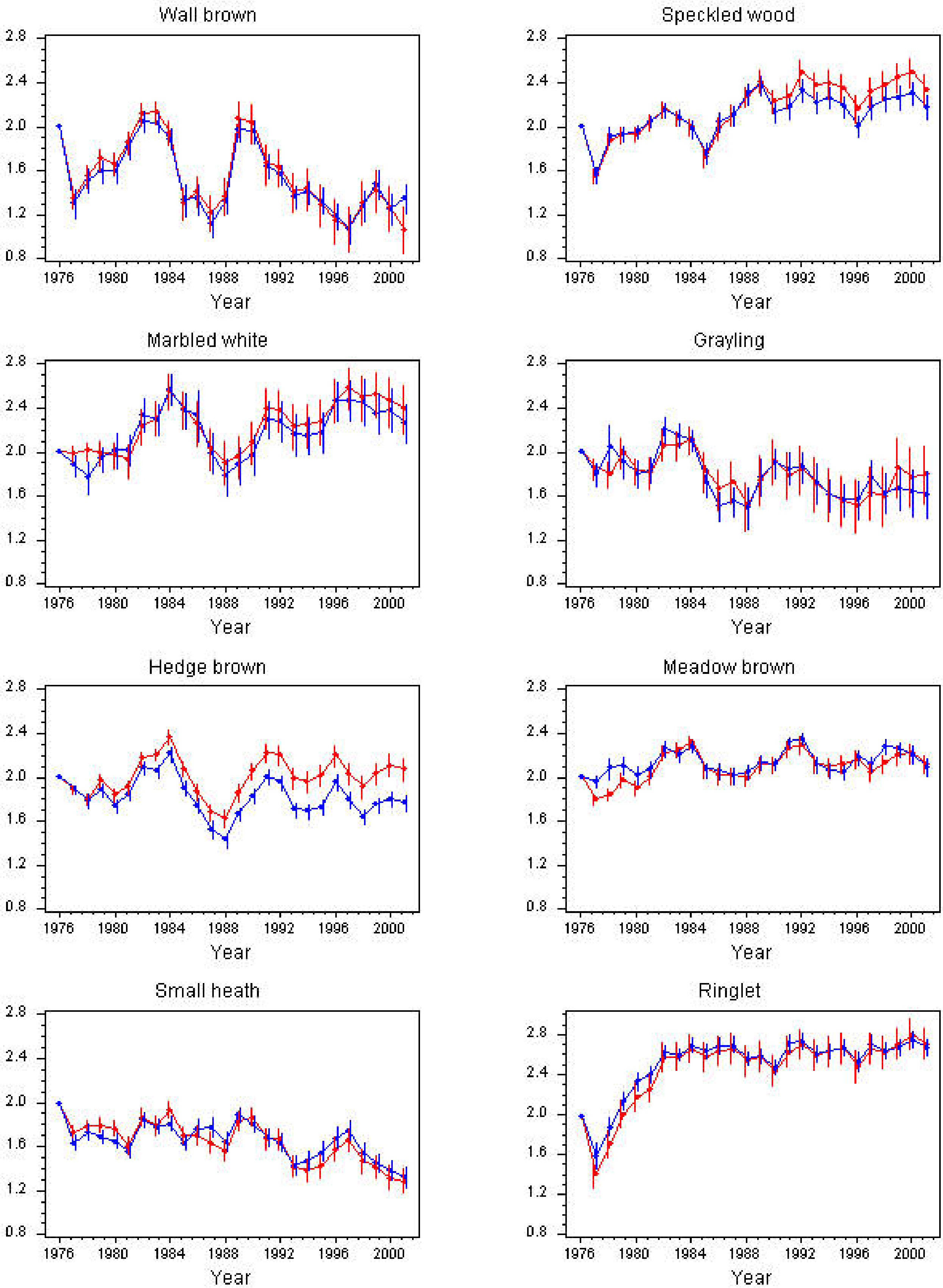

Figure 12e. Log collated indices, 1976-2001 (error bars are 1 s.e.)