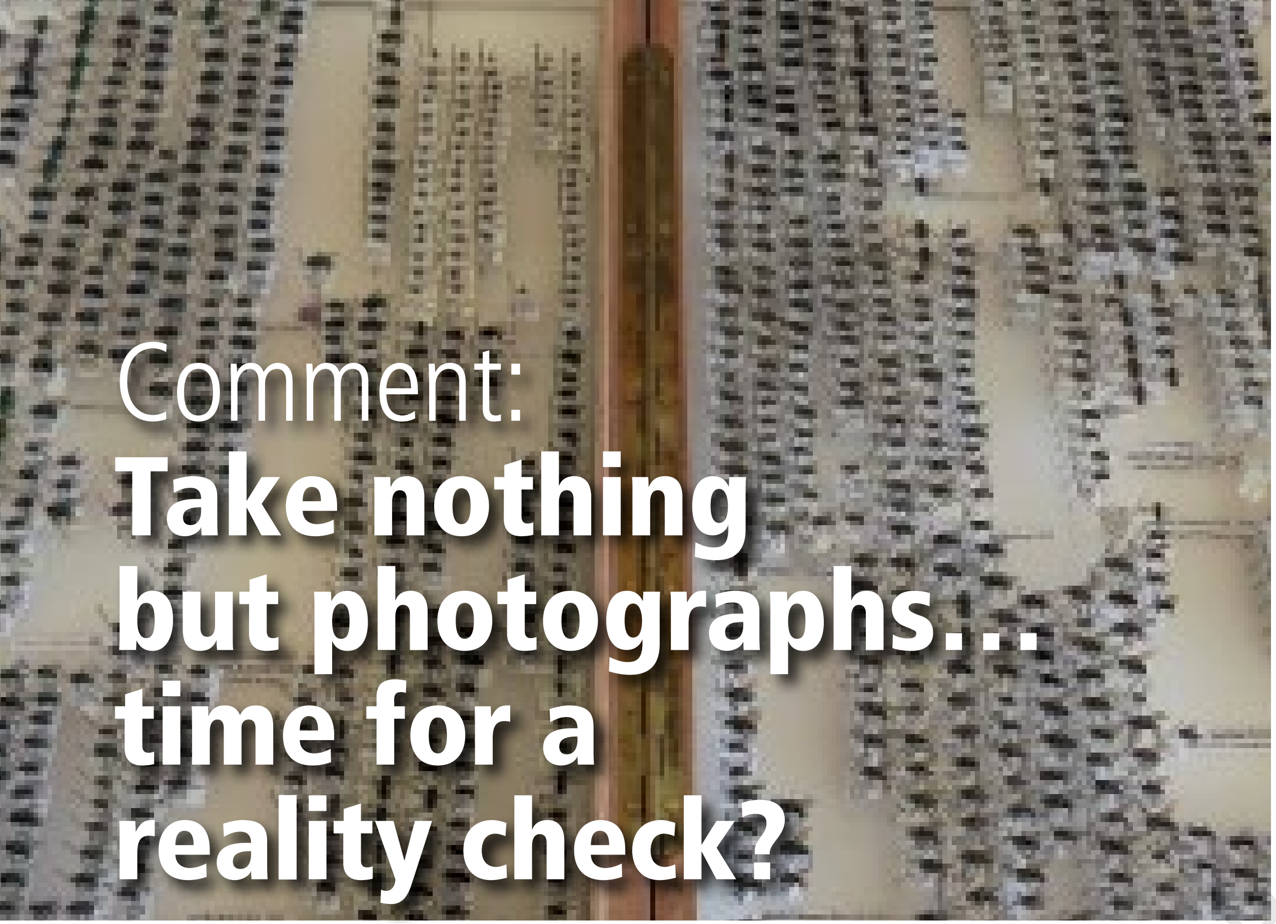


Comment: Take nothing but photographs… time for a reality check?

Roger K. A. Morris

The use of lethal methods in insect-recording is increasingly frowned upon, but without it many species would be missed entirely. Roger Morris

The decline of global insect populations has generated a great deal of media coverage. In some quarters, at least, alarm bells are ringing. While more detailed and reliable data are needed to allow these losses to be quantified, there is a growing and very real risk that the system of producing data is being weakened. Opposition to scientific data collection by means of lethal techniques is increasing, despite the fact that these methods are vital for the reliable identification of many insects.

Meanwhile, there is a burgeoning demand for taxonomic expertise to verify data submitted to iRecord and the many specialist Facebook groups. A sound knowledge of certain taxonomic groups and the geographical range and variation of individual species takes decades to develop and is dependent upon lethal methods. At the moment, there is a robust technical capacity – but it is ageing, and unless a new generation develops similar skills there will be a shortfall, even if the current cohort can keep up with demand.

Antipathy towards the concept of 'collecting', with all its connotations of the Victorian butterfly-hunter, is understandable. It creates a perception that entomology is simply stamp-collecting with insect specimens. That may be the case for some Lepidoptera collections, but for true flies (Diptera), bees, wasps and ants (Hymenoptera), beetles (Coleoptera), true bugs (Hemiptera) and many other smaller orders reliable identification of most species hinges upon the retention of specimens. Even within the Lepidoptera there are species complexes that cannot be identified without genitalia dissection.

Changes in attitudes towards lethal methods of insect-recording have many origins, including (understandable) concerns about populations lost to collector pressure and an increasing belief in photography as a means of establishing accurate identifications. The potential of DNA analysis to replace lethal methods is also cited, although specimens are still required initially in order to build a database of genetic sequences.

With experience, a proportion of species within many insect orders can be identified in the field, and once the aspiring specialist has gained sufficient knowledge to be able to recognise insects within this category there is little justification for taking specimens. Entomology recognised this a long time ago, and the Joint Committee for the Conservation of British Invertebrates' code (Invertebrate Link 2002) provides important guidance on what is and is not acceptable. It advises on how to avoid the potential problems associated with the use of static traps and other lethal methods (such as potential impacts on non-target species and from the assembly of long series of specimens from the same locality). For some taxa, however, only a small subset can be identified from photographs: while the exact numbers have not been quantified, 10% would probably be an over-optimistic estimate for the British lists of Diptera (c. 7,100 species) or Hymenoptera (5,000–7,000 species).

At present there appears to be a dichotomy between the demands for data and the understanding of how such data are gathered. If consent for lethal methods is withheld by the conservation organisations that use the data in policy development and for advocacy, one must wonder why nobody has thought about the implications? I have sympathies with the philosophy, but at a practical level there needs to be an understanding of the potential problems. This article seeks to highlight some of the large-scale differences between data collected using non-lethal methods and data gained through lethal methods.

It is difficult to identify some species, such as members of the *Eumerus* genus, from photos alone, especially if key identification features are hidden. Brian Valentine

The importance of taxonomic rigour

Although it is fast disappearing from education, taxonomy underpins almost every facet of the environmental sciences. DNA libraries are totally reliant upon accurate identification of the subject matter; ecological studies depend upon knowledge of the identity of the organisms in question; and conservation management necessitates knowing the organisms that are present on a site and how they will respond to different management prescriptions. Thus, in the most fundamental aspects of modern biology, there is no escaping the need for sound taxonomy and, in places, for the use of lethal methods in order to ensure accurate diagnoses. Yet the numbers of competent taxonomists in the professional environment appear to be continually declining, while increasing reliance is placed upon specialists who have either retired or developed their skills outside the workplace. While some talented younger people are moving into this field, the numbers are small and are unlikely to be sufficient to meet the growing demand for such abilities.

It also clear that most of the high-quality biological data used in conservation science comes from amateurs and volunteers many of whom, through necessity, use lethal methods as part of the process of making reliable determinations. The specialists who provide much of the underpinning of modern biological recording have often spent decades peering down the microscope, examining many thousands of specimens and puzzling over taxonomic complexities, which provides a strong awareness of possible identification pitfalls and of the variation within species. Unless these skills are maintained and developed in a new generation, it is likely to become difficult, if not impossible, to estimate with accuracy changes within invertebrate populations. Some studies point to the potential of 'citizen science' projects coupled with higher-grade specialist sampling as the way forward for invertebrate-monitoring (Sumner *et al*. 2019). Such analyses assume that specialist data collection will be ongoing, but can that hold true in light of the pressures outlined above?

Statistics used in studies such as the most recent *State of Nature* report (Hayhow *et al.* 2019) comprise a mixture of non-specialist and specialist records. In some datasets, the balance is changing quite rapidly, as can be seen in the contributions to the British Hoverfly Recording Scheme (HRS) (Figure 1, and discussed in greater detail below).

The biggest demands on a specialist's time are, arguably (in no particular order): to generate high-quality data for their taxonomic group; to remain up to date with developments in the taxonomy of their area; to develop and maintain databases of the occurrence of wildlife; and to provide an identification and validation service for interactive media such as iRecord, Facebook groups and iSpot. Somewhere in the process, the conservation world has grown used to the idea that you can have a pool of specialists who will do these important tasks even if the route to developing and maintaining those skills is blocked owing to restrictions on the collection of specimens.

Figure 1. The proportion of records entering the British Hoverfly Recording Scheme dataset, based on data extracted directly from web-based sources (■) or from photographs (■) sent by email. Within the HRS dataset there will be many thousands more records based on photographs, but sent as spreadsheets and therefore trickier to separate.

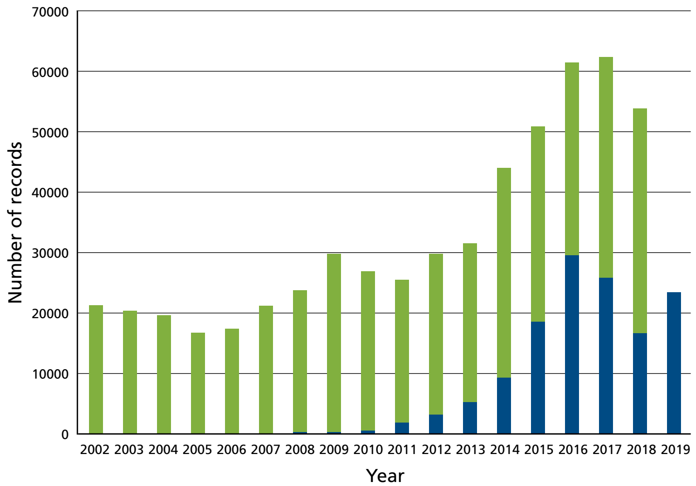
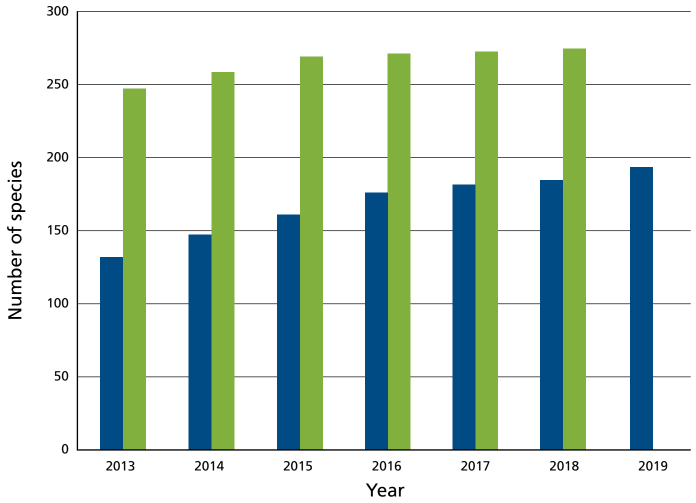


Figure 2. Numbers of species recorded cumulatively in the main HRS dataset (■) and by photographers (■) between 2013 and 2019. HRS data for 2019 have still to be compiled, hence the lack of data for that year.



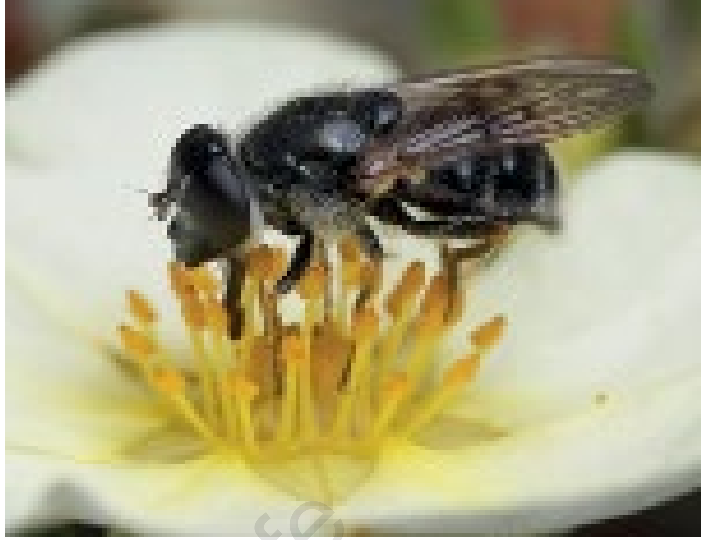
Imperfect detection

If specialists are barred from collecting at a particular site, the pool of available information will, over time, diminish and cover only the species that can be detected and identified by non-lethal techniques. Banning collection is, therefore, an active decision to create a dataset with built-in shortfalls in records of taxonomically challenging species and to accelerate the problem of imperfect detection (Kellner & Swihart 2014). Unfortunately, we have remarkably few data upon which to assess the scale of imperfect detection in existing datasets.

More worryingly, unless there are sufficient active specialists the national dataset will gradually decline in quality as difficult taxa are overlooked and the data become dominated by species that can be recognised from photographs. It is difficult to estimate how datasets will change, but some indications can be gained from the HRS.

Since 2013, the HRS has engaged actively with photographic recorders through the UK Hoverflies Facebook group, with good results: the volumes of records reaching the scheme are now more than twice those that were submitted by traditional recorders alone. It is a major success story and one that has had innumerable benefits (see Morris & Ball 2019a, b) because there are now big blocks of data for at least some species. In those seven years, 194 species have been recorded at least once and some species, such as *Cheilosia caerulescens*, are recorded almost entirely by photographers. Furthermore, the process has led to many photographers attempting to record everything that they see on a daily basis. This sort of recording is essential for many aspects of monitoring, and in due course it will be possible to assess trends from a subset of hoverfly species based entirely on photographic recording.

The problem arises when the numbers of species recorded photographically are compared with the numbers recorded by specialists who retain specimens and who collect by using a range of techniques, including sweep netting and Malaise traps. From comparison of the data for the period 2013 to 2019, it can be seen that specialist recorders detected almost all of the British hoverfly fauna, whereas photography revealed just 68.6%. In other words, imperfect detection alone means that almost a third of hoverfly species would have gone undetected in the absence of specialists. That figure also assumes that somebody would have been available to name all the species depicted in photographs. The specialists who are the final arbiters of problematic photographs all employ lethal techniques and have gained familiarity with those species that photographic recorders might never see or recognise.



Almost all records of the recently arrived *Cheilosia caerulescens* are generated by photographers. Brian Valentine

This first analysis is further complicated because many hoverflies are highly photogenic, and the group has therefore attracted a huge following of active recorders. In other orders/families, the level of recognition is likely to be far lower, but has not been analysed. More effort is needed to address this shortfall.

Detectability is more than presence/absence

Occupancy models are now a standard way of utilising the opportunistic data compiled by recording schemes. It has been assumed that the models corrected for many recorder biases (van Strien *et al.* 2013; Isaac *et al.* 2014), but it is difficult to see how such models will continue to do so if imperfect detection becomes a bigger influence on the data.

In the absence of a wider spectrum of techniques, datasets are likely to be confined to those species that make themselves obvious to the non-specialist observer. This not only means that some species will go undetected, but also that there will be changes in the proportions of records for those species that are detected. For hoverflies, some measure of the differences between specialist and non-specialist datasets can be gained by considering the differences between photographic and total records in the representation of different tribes. The results based on HRS data for the period 2013–2018 are presented in Figure 3. These show that, in a substantial proportion of the assemblage, the photographic dataset generates fewer records of difficult taxa such as the Bacchini, Cheilosiini and Chrysogastrini and, to a lesser extent, the Pipizini and Xylotini, while the contributions of tribes with more conspicuous members, such as the Volucellini, Sericomyiini and Eristalini, are higher. Figure 3 also includes a similar analysis of my own dataset (>17,000 records) compiled over the same period and using a mixture of lethal and non-lethal techniques (in all instances attempting to generate a full site list for the visit). This second dataset shows that the main positive deviations are within the difficult taxa that cannot be identified from photographs (i.e. the Bacchini, Cheilosiini, Chrysogastrini and Pipizini).

As with all data, there are caveats and complications that make it important to look at the minutiae. In Figure 3, it would appear that photographic recording is more effective for the Merodontini, within which *Merodon equestris* is extremely abundant and a popular subject for photographers, whereas *Eumerus* species are rarely seen and, when photographed, are rarely taken to a firm identification because in three of our five species the critical characters are on the ventral surface or within the male genitalia. Thus, when data for *M. equestris* are excluded from both datasets, the representation of the genus *Eumerus* is just 0.01% of the photographic dataset, whereas in the HRS dataset it comprises 1.5% of the total records. In other words, *Eumerus* is almost invisible in the photographic dataset.

That the Eristalini, Syrphini and Volucellini form a far greater proportion of the data compiled by photographic recorders is simply because they contain species that are predominantly large, colourful and, in many cases, simpler to identify. Analysis of the proportions of photographs that are taken to a firm (full) identification illustrates the problems faced by those who work only from photographs. Figure 4 examines the proportions within each tribe that have been recorded from photographs and the proportions of photographs that have been successfully diagnosed. It needs to be treated with some caution, because there are several tribes in which the majority of photographs cannot be taken to a firm diagnosis but occasionally somebody manages to get the right angle to capture the salient feature – for example, the tubercle on the hind femora of *Parhelophilus frutetorum*, which cannot be seen in top-down images or in most side-on photographs. In a few others, the salient features have been seen because the insect was captured and photographed through a transparent receptacle so that underside features could be seen, and a few are microscopy photographs of dead specimens; for these reasons, the columns for the Merodontini, Paragini and Microdontinae should be treated with caution. Those of the Microdontinae are especially problematic because two species (out of four), *Microdon mutabilis* and *M. myrmicae*, can be identified only from larvae or puparia (which are occasionally found and depicted by more diligent photographic observers).

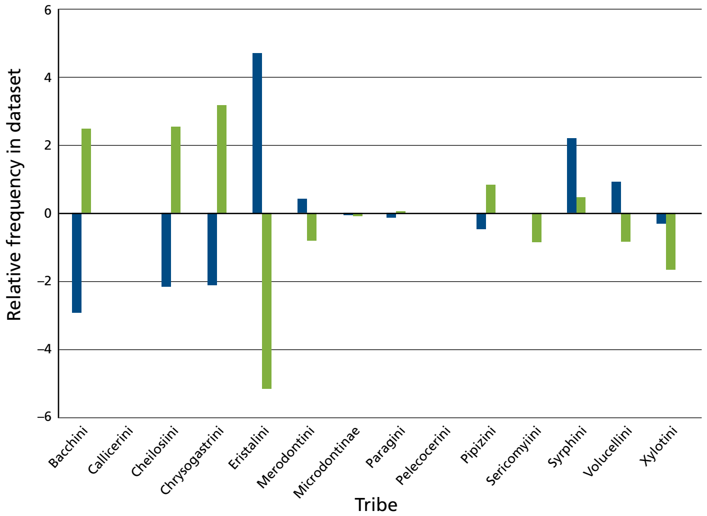


Figure 3. **Comparison between representation of tribes in photographic records (■) received by the HRS with that in data generated by the author using a mixture of lethal and non-lethal methods (■). The columns represent the degree of deviation from the proportions present in the total HRS dataset.**

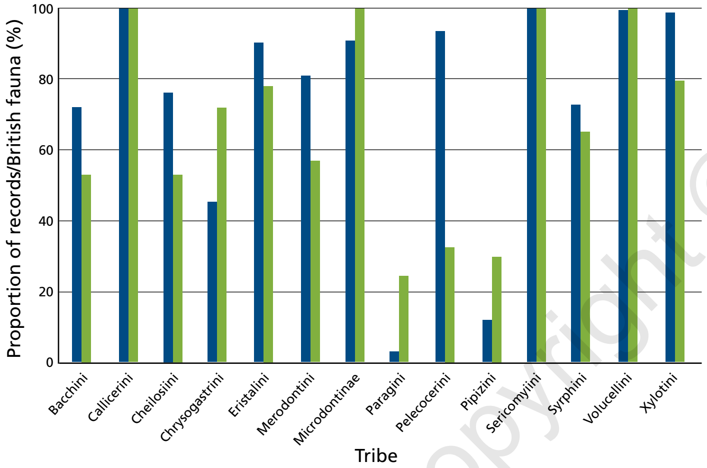


Figure 4. **The proportions (%) of photographic records (■) in which it was possible to determine the species involved, and the proportion of each tribe represented in the photographic dataset (■).**

Don't forget the positives

We must recognise that there is imperfect detection among most (if not all) datasets for mobile organisms (and doubtless many sessile ones, too, especially within the fungi). Some have behavioural traits that make them more or less visible; others occur for very short or greatly extended time periods; others still may be ignored by the specialist because they are 'common'. Making sense of biases within specialist data is far more complicated, and at this stage I cannot offer strong evidence of the nature of such biases. Many recording-scheme organisers, however, will be familiar with potential contributors telling them, 'I will let you have data for rarities and for first and last dates but I cannot be bothered with the common species.' This is a form of recording that creates unhelpful biases, such that rare species appear to be commoner and in which it is impossible to analyse phenological shifts accurately because first and last dates are meaningless without the context of the median date or a percentile of the data.

Unlike specialists, the novice photographer is more likely to depict everything that he or she sees, and highly visible and abundant species therefore are better represented. Many new recorders have been exposed to the importance of logging all records (especially within the HRS, where I make an effort to demonstrate the uses and the science). Consequently, there are in many cases very good data for common species, some of which will doubtless prove to be bellwethers of environmental change in a manner similar to, say, that of the Skylark *Alauda arvensis*.

Moreover, there are some species for which photographic recording has made a major contribution to our knowledge of their distribution. For example, photography has provided at least 60% of the data for the recently arrived *Cheilosia caerulescens*, a species whose larvae mine house leeks *Sempervivum* and which is mainly confined to urban areas. Similarly, better data mean that some aspects of individual species can be discerned from more accurate phenology data and flower-visit records (e.g. Morris & Ball 2019b, c).

We must not forget that photographic recording also provides a first opportunity to acquire basic identification skills. Thus, some entrants to this discipline may eventually pick up the net, pooter and microscope because they want to find a greater proportion of the British fauna. In so doing, they start to move towards becoming the specialists of tomorrow. The impact of this on the breadth of recorder effort is readily demonstrated by Figure 1. Ball *et al.* (2011) reported that 50% (approx. 360,000 records) of the data for the second provisional atlas of British hoverflies was supplied by just 20 recorders whereas 50% (approx. 550,000

Volucella inanis **(top) and** ***V. zonaria*** **(bottom) are among the conspicuous species that are recorded more frequently in the photographic dataset.**
Brian Valentine

records) of the current dataset has been provided by 51 recorders. Clearly, there are more serious recorders as well as proportionately more records each year.

Application and implications

In this article, I have used data for a comparatively photogenic family of flies. There are good keys available, and a relatively small proportion of species requires detailed examination of genitalia or other obscure/microscopic characters. Despite these advantages, at least one third of the British fauna has gone unrecorded by photographers over a period of seven years, whereas just eight species have not been reported from a cohort of contributors who retain specimens. There are many taxa in which identification from photographs is more problematic. Examples within the Diptera include many acalypterate flies and most of the Nematocera. Problems within the Hymenoptera are probably far higher, especially where critical characters lie within enclosed areas, such as the saw sheaths of female sawflies or the genital capsules of male *Sphecodes* bees.

This level of imperfect detection cannot be smoothed out by existing computational methods in the long term, although some smoothing is likely to be achieved so long as there are data coming from traditional taxonomists. Nevertheless, as the balance shifts towards a subset of the fauna, the outputs of occupancy models will inevitably become less believable – in which case so, too, will the political messages emerging from publications such as the biannual *State of Nature* report.

Given this conundrum, I believe that there is a strong case for improving our understanding of the real level of imperfect detection within critical wildlife datasets. Furthermore, it seems to me that there is a need for the conservation world to examine its policies towards entomologists who use lethal techniques and to reflect upon whether the more limited data that can be assembled from non-lethal methods are adequate for all aspects of wildlife management – from investigations into the effects of climate change to the loss of pollinators and the detail needed to inform land-management decisions. Excluding such specialists could, at worst, exacerbate invertebrate decline simply because there are no data upon which to base campaigns and take action.

We must, however, recognise that there is an implicit partnership: if specialists are permitted to use lethal techniques, they really must make sure that all of their records enter the biological recording process. Ideally, this will be through specialist recording schemes so that the data are verified and compiled in order to provide an accurate basis for future conservation decision-making.

Acknowledgements

This article draws upon the contributions of several thousands of recorders of varying abilities, all of whom make a valuable contribution and are greatly appreciated. I am also most grateful to Stuart Ball, who provided the tabulation of data from the HRS dataset upon which this account is based. Ken Gartside, David Rayner and Rob Wolton provided thought-provoking and helpful comments on an earlier draft of this article, for which I am very thankful.

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