THE ROYAL SOCIETY biology letters

Plant species descriptions show signs of disease

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Recd 10.04.03; *Accptd* 16.06.03; *Online* 06.08.03

It is well known that diseases can greatly influence the morphology of plants, but often the incidence of disease is either too rare or the symptoms too obvious for the 'abnormalities' to cause confusion in systematics. However, we have recently come across several misinterpretations of disease-induced traits that may have been perpetuated into modern species inventories. Anther-smut disease (caused by the fungus *Microbotryum violaceum*) is common in many members of the Caryophyllaceae and related plant families. This disease causes anthers of infected plants to be filled with dark-violet fungal spores rather than pollen. Otherwise, their vegetative morphology is within the normal range of healthy plants. Here, we present the results of a herbarium survey showing that a number of type specimens (on which the species name and original description are based) in the genus *Silene* from Asia are diseased with anther smut. The primary visible disease symptom, namely the dark-violet anthers, is incorporated into the original species descriptions and some of these descriptions have persisted unchanged into modern floras. This raises the question of whether diseased type specimens have erroneously been given unique species names.

Keywords: taxonomy; conservation; species inventories

Over the past several years, as part of a study to identify the host range and geographical distribution of anther-smut disease, we have been examining herbarium specimens for the presence of diseased anthers. Our initial studies (Antonovics *et al.* 2003; see also Rabeler 1993) focused on North American plant species and showed that herbarium data can provide valuable information on long-term regional dynamics of disease occurrence and spread.

In extending our distribution study, we recently surveyed plant collections in the French Muséum National d'Histoire Naturelle, Paris. We examined the herbarium's collections of the genera *Silene* and *Lychnis* from Asia because references to the disease on that continent are extremely limited (Tai 1979; Guo 1988) yet these host genera are represented by numerous species. These closely related genera are commonly found diseased in Europe and North America. In all, we examined 3531 herbarium sheets of 287 species of *Silene* and 13 species of *Lychnis* from Asia, with numbers of specimens per species varying from 1 to greater than 100. (A list of the species examined is available from the authors upon request.) Among the herbarium sheets that we examined, plants diseased with anther-smut were found in the following 21 species of *Silene* and four species of *Lychnis*: *S. adenantha*, *S. argaea*, *S. aucheriana*, *S. bungei*, *S. bupleuroides*, *S. cappadocica*, *S. cardiopetala*, *S. chloraefolia*, *S. delavayi*, *S. griffithii*, *S. libanotica*, *S. melanantha*, *S. napuligera*, *S. odontopetala*, *S. pachyrhiza*, *S. persica*, *S. rechingeri*, *S. reuteriana*, *S. schafta*, *S. sedoides*, *S. splendens*, *L. fulgens*, *L. miqueliana*, *L. nigrescens* and *L. senno* (species names given are as indicated on the specimen labels). We confirmed the presence of the fungal spores in the anthers by microscopic examination (figure 1). These observations establish the widespread occurrence of anther-smut disease on members of the Caryophyllaceae in Asia in spite of only sporadic references to the disease there in the literature.

Owing to the fact that we expected the disease to have been detected by collectors, we were surprised to find that the type specimens of four species of *Silene* were diseased with anther-smut. The type specimens for about two dozen species of *Silene* and *Lychnis* were present in this collection. Because a type specimen represents the sample on which the original description and the name of a species are based, we were curious to discover whether the person who first described the species had noted the presence of the disease. In particular, we wanted to know whether the species descriptions were erroneous, and perhaps more seriously whether different species names had been given to diseased and healthy specimens.

It is interesting that in no case (type specimen or otherwise) did we find an annotation indicating that the collectors or subsequent annotators recognized the presence of the disease. This was also true in the US collections that we had previously examined (Antonovics *et al.* 2003), which included 110 diseased specimens of *S. virginica* and *S. caroliniana*. A partial exception to this was a diseased specimen collected by P. Raven, where, on the label, the presence of unusually dark anthers had been noted.

In this context, it is particularly noteworthy that C. Linnaeus, in *Hortus Cliffortianus* (Linnaeus 1738; Liro 1924) mistook a specimen of *Silene* with anther-smut disease as representing a new species. Linnaeus originally called this specimen *Cucubalus floribus hermaphroditis pentagynis*, *capsulis unilocularibus*, *calycibus angulatis* and described the flowers as being fully covered with black powder. Subsequently, he reduced the status to that of variety 'γ' of *Lychnis dioica* (Linnaeus 1767), but we do not know whether in doing so he recognized the plant as being diseased. The specimen is present in the collection of the Clifford Herbarium at the British Natural History Museum, London and an image (number BM000628512) is available at www.nhm.ac.uk/botany/databases/clifford/index.html.

We obtained the original Latin descriptions associated with the four type specimens from the Asian collection in Paris. Two of the descriptions refer to the floral characteristics of the species as including dark purple anthers: *S. bungei* Bocquet (Bocquet 1967) (nom. nov. for *L. tristis* Bunge (Ledebour 1830)), 'antherae subinclusae, atro-purpureae'; *S. cardiopetala* Franch. (Franchet 1886), 'antherae atroviolaceae exsertae'. The original description of *S. cardiopetala* notes that it resembles *S. tatarinowii* but can be easily distinguished by the shape of the petals and the nearly black emergent anthers. The dark anthers are a clear sign of anther smut, and the difference in petal shape might also be related to infection because diseased flowers can have a changed petal morphology (Antonovics

DOI 10.1098/rsbl.2003.0063

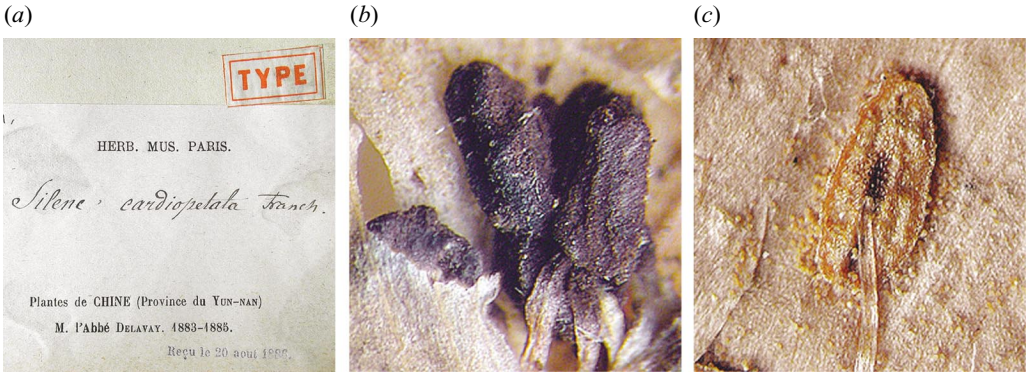

Figure 1. Photomicrographs of (*a*) the label of *Silene cardiopetala* from the herbarium type specimen, (*b*) diseased anthers from this type specimen and (*c*) a healthy anther of *S. cardiopetala* from the herbarium isotype specimen.

et al. 2002). For the third type specimen (*S. pachyrhiza* Franch.; Franchet 1886), a lack of available capsules for inclusion in the species description was noted by the phrasing 'capsula...' [*sic*], which may reflect the sterilizing effects of the anther-smut disease. When the anther-smut pathogen infects a plant, the ovaries are aborted and, even in female plants, a male-like morphology develops with spore-filled anthers (Baker 1947). In the description of the fourth species, *S. adenantha* Franch. (Franchet 1886), no reference was made to the anther colour.

Because purple-coloured anther sacs are known in some species of *Silene*, we investigated whether healthy specimens of these particular species actually have purple anthers. A healthy specimen of *S. cardiopetala* was available and we found that the anther sacs were yellow and bore pollen (figure 1), and therefore that the original description of this species, at least, was misleading. Some caution is necessary with this interpretation because polymorphism and some variation in anther sac colouring are known within these plant genera (e.g. *S. virginica*), and also because the colour of plant tissues can fade in herbarium specimens.

Most of these original descriptions are quite old and one might expect that they have been superseded by observations on other specimens, either in collections or in the field. However, when we traced the description of these species into the recently published *Flora of China* (Zhou *et al.* 2001), we found that in the case of *S. cardiopetala*, the misleading descriptions had been propagated.

A more critical issue is whether errors similar to that made by Linnaeus could have been repeated, and different species names given to diseased and healthy specimens. In searching monographs or floras published in the last few decades, we find that several species are described as having dark purple, violet or brown anthers. Some of these are species that were named many decades ago (*S. nigrescens*, *S. principis*, *S. cardiopetala* (Zhou *et al.* 2001) and *L. senno* (Lu *et al.* 2001)), while others have been named only recently (*S. vautierae*, *S. birgittae* (Bocquet 1967) and *S. tubulosa* (Oxelman *et al.* 2001)). This leads us to suspect that some of these descriptions may reflect diseased individuals or even that new species names may have been created owing to the presence of the disease. Clearly, these issues can be resolved with further investigation.

Such erroneous descriptions (and perhaps misidentifications) would be understandable because these species are often known through only a few collections, especially for species named many years ago. Moreover, in the case of anther-smut, we know that populations can be heavily diseased and infection can prolong the flowering period such that diseased individuals are overrepresented among the plants in flower (Baker 1947; Alexander 1990).

Even though taxonomists have a long and successful history of assessing the relative importance of variation caused by environmental factors, rare mutations or disease, this study shows that misinterpretation of morphological variants is still possible. Special caution is needed when, as is often perforce the case, descriptions are based on only a few specimens of species that are rare or that have a very limited distribution. These are also the species that might seem a natural focus for conservation goals. While we do not think that these problems are very widespread, they could lead to strange interpretations. For example, if a diseased set of specimens is given a unique species name, then the disappearance of the disease might be interpreted as a plant species extinction!

Acknowledgements

The authors thank the herbarium staff of the Muséum National d'Histoire Naturelle, Paris for their hospitality and help with accessing the specimens. They also thank B. Oxelman and M. Lidén of the University of Uppsala for help with the systematics of the Chinese *Silene* species and helpful comments. This research was supported in part by a grant from the Nation Institutes of Health.

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