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Autor: Vellinga, E.C.

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Mushroom recording in the Netherlands

What can 900,000 data tell us?

E. C. Vellinga

c/o Rijksherbarium, P.O. Box 9514, 2300 RA Leiden, The Netherlands, on behalf of the Netherlands Mycological Society

Zusammenfassung – Das holländische Pilzinventar läuft seit 18 Jahren; die Niederländische Mykologische Gesellschaft hat schon 900 000 Fundmeldungen registriert. So kann man jetzt sagen, dass das ganze Land inventarisiert worden ist, aber mit unregelmässiger Intensität. Die Kenntnisse über die Verbreitung der Arten, der Prozentsatz der Fruktifikationen und deren Variationen wurden im Laufe der Zeit verbessert, beträchtlich die fleischigen Pilze, die man gut erkennen kann. Die objektive Interpretation dieser Angaben sowie deren Eintragung benötigen eine grosse Aufmerksamkeit. Deswegen schlagen wir eine Serie von Methoden vor, die dafür besonders gut geeignet sind. Von jetzt an sollte man einen Akzent auf die Datensammlung ungeachteter oder nie bestimmter Arten setzen. Hinzu kommt, dass die Eingliederung älterer Angaben ins Inventar dringend wird.

Résumé – Depuis 18 ans que son projet d'inventaire des champignons a débuté, la Société mycologique des Pays-Bas a enregistré 900 000 récoltes. Ainsi, on peut dire qu'actuellement, l'ensemble du pays a été inventorié, mais à des degrés divers. Les connaissances sur la distribution des espèces, le taux de fructification ainsi que ses variations au cours du temps, se sont beaucoup améliorées et ceci pour les champignons charnus facilement reconnaissables. Mais l'interprétation objective de ces données ainsi que la façon dont elles sont transcrites requièrent une grande attention. Aussi poposons-nous une série de méthodes qui conviennent particulièrement à leur utilisation. Dès maintenant, il faudra mettre l'accent sur la récolte de données concernant des espèces qui passent souvent inaperçues ou ne sont jamais déterminées. De plus, l'incorporation dans l'inventaire de données anciennes devient urgente.

Summary – The Netherlands Mycological Society has gathered over 900,000 records in the 18 years its mushroom recording project has been in existence. In this time virtually the whole of the Netherlands has been inventoried to some degree. Much is known about the distribution, fruiting patterns and changes over time of the easily recognizable fleshy fungi, but proper interpretation of the data requires attention to biases in how they were acquired. Suitable methods of using the data are described. Emphasis on inconspicuous, and generally unappealing fungi is now needed and entering old data is an urgent priority.

Introduction

The organization of the mushroom recording project of the Netherlands Mycological Society (NMV) and the changes in the Dutch mycoflora inferred from it have been the subject of quite a number of articles (e.g. Arnolds, 1989; Arnolds & Jansen, 1992). The focus of this article is on the methods to interpret the data concerning species distribution, fruiting pattern and changes through time, based on the data as available in December 1997. Methods to evaluate the mycological changes in an area, and the present richness of regions, are not discussed. First an introduction is given to the composition of the database and the way the data have been collected.

Mushroom recording in the Netherlands

The Netherlands mushroom recording project began in 1980. It aims to provide insight into the geographical distribution and rarity of mushroom species in the Netherlands and into changes that are occurring. Enhanced knowledge of fruiting patterns and of the ecology of the fungi are secondary goals. Most data are recent but from the very beginning old records were entered into the database to establish a basis for showing changes in numbers and distribution. Herbarium collections, literature and field books have been searched for mycological information, though many data still remain to be extracted. The British Mycological Society recently showed what can be done along these lines by entering 100,000 records from the literature into its database (Cannon, 1998).

Comprehensive information on the organization of the project and the procedures of data entry are given in the project manual (De Vries et al., 1997).

All macrofungi, including myxomycetes, are recorded. Macromycetes are here defined as fungi (ascomycetes, basidiomycetes) with fruitbodies of 1 mm and bigger, though in practice some smaller ascomycetes are recorded as well. Plant pathogens as rusts, smuts, and mildews are not included. A recent list of taxa is available (Arnolds et al., 1996) and serves as a basis for the species concept in use.

The recording project is a low-threshold one, i.e. participants are free to enter all kinds of mycological data. So records vary from a single sighting of *Macrolepiota procera* spotted from the train, to ones derived from an extensive inventory programme for a small area. But all records are entered on forms, with a choice of more or less detailed information on place, date, ecology and of course the identity of the mushroom species observed. There are no standard plots and no species which have been the target of monitoring over an extended period. The impossible, that all fungi should be recorded in a given area, is not required. Visits to areas which do not result in finds leave no trace in the database. Neither the amount of time spent on a recording trip nor any other measure of searching effort is reported.

There are several levels of precision with which date, locality, and ecology can be given. The date can be given as "year", "month" or "day", and the locality on a scale varying from 100×100 m^2 to 5×5 km^2. Of course people are urged to be as precise as possible, and also to fill in the fields concerning the ecology of the species, but the latter is not compulsory. Here as well different ways of precision are possible: "growing in a wood" to "growing on a fallen leaf of *Fagus sylvatica* in a deciduous wood on nutrient-poor, dry sand".

Over 95% of the country has already been inventoried and it is aimed to reach 100% by the year 2000; to that purpose, participants are being encouraged to go to hitherto unvisited areas. Increasing attention is now being given to the more difficult and the less accessible groups (e.g. the genus *Cortinarius*, smaller ascomycetes), and to the ecology of the species.

This project has wide appeal: each year around 125–150 people participate and contribute c. 45,000 – 60,000 records. To put this in perspective, the Netherlands Mycological Society has c. 500 members inside the Netherlands. Collectors are provided with an instruction manual and there are no costs (e.g. postage charges are refunded). A newsletter is sent to participants each summer and everyone shares the reward of a spectacular growth of the database. The latest results are also communicated at society meetings. Of course the greatest satisfaction lies in discovering new and exciting fungi. The list of species recorded in the Netherlands is growing by an average number of c. 70 species per year.

People make mistakes, so the database is not without flaws. The most common mistakes are due to collectors who misidentify their finds or enter the wrong species code (a 6-digit number) and to data entry people who misread the mycologists' scribbles or make typing errors. Fortunately all the original paper forms are preserved and can be consulted in case of doubt. The use of more specialised, pre-printed forms and of computer programmes for collectors to submit data electronically will probably lessen the number of mistakes in the future.

It is mandatory to keep herbarium material of very rare or extremely rare species to be checked by specialists in that particular group of fungi.

Results

Eighteen years of recording in a flat, densely populated country, comparable in size with Switzerland, have resulted in over 900,000 records (a "record" is the occurrence of a single mushroom taxon in a certain locality, on a certain date and submitted by a single collector). By 1998 around 3600 species of macrofungi had been recorded, and over 1600 out of the 1677 25 km^2 grid units in the Netherlands had been inventoried (see Fig. 1).

The records are not evenly distributed over the country; some areas are apparently less interesting to inventory than others, and wooded areas are much richer in mushroom species than high-production fields and meadows. The clay-peat areas in the western and northern parts of the country are not well-visited. But, the number of grid units from which only a few species are known are dwindling at a rapid rate. At present only 45 grid units are known from which a single species has been recorded (Fig. 1 shows 121 grid units in which less than ten species had been found). The number of grid units from which 1000 species or more have been recorded is, unfortunately, smaller: only two. One of these is situated in the dunes near Haarlem, which is visited quite often, because of its varied and rich habitat, and its accessibility. The other, in the south-eastern part of the sand-loam area, was the target of an intensive weekly inventory for eight years (Lammers & Raaymakers, 1994). On account of such inventories, it was estimated that in the province of Drenthe in the north east of the country, the number of species recorded per grid unit varied from one tenth to one half of the actual number of species growing there (Arnolds, 1994, based on the figures available in 1992). This means that the present state of knowledge

Fig 1: Numbers of species per grid unit of 5×5 km^2.

of the majority of the country is only a dim reflection of the real situation.

It has to be remembered, that the data as presented above, are on a 5×5 km^2 scale, the biggest scale on which records can be submitted. For most records more precise data are available.

At present the most recorded species grow on wood, but the database shows that the situation before 1950 was quite different. At that time, ectomycorrhizal species, like *Cantharellus cibarius*, were the most frequently reported (see Table 1). The most widespread species, *Xylaria hypoxylon*, has been recorded from 75 % of the number of grid units. The number of very common species is small; only eleven have been recorded from 1000 grid units or more (i.e. 60 % of the total number), but this small number of species accounts for a substantial part of the entire dataset. At the other extreme are the rare to very rare species, and their number is very high: 592 species have been recorded from one grid unit only. In total 42% of the species are very rare to extremely rare, though their contribution to the total number of records is necessarily small.

Fig. 2: Distribution of Claviceps purpurea, *showing a concentration of records in the southwestern part of the Netherlands.*

Table 1. The five most recorded species overall (excluding Amanita muscaria, *see text), and before 1950.*

1808–1998: 3630 species recorded in total.
1. *Hypholoma fasciculare*
2. *Mycena galericulata*
3. *Xylaria hypoxylon*
4. *Paxillus involutus*
5. *Trametes versicolor*

1808–1950: 1350 species recorded in total.
1. *Cantharellus cibarius*
2. *Amanita citrina*
3. *Lycoperdon perlatum*
4. *Thelephora terrestris*
5. *Scleroderma citrinum*

Interpretation of the data

The question arises how reliable the data are. As described above, they have been collected in unsystematic ways, and they relate to erratically appearing fruitbodies, with in general a short life span. Are these data suitable for revealing distribution patterns, for establishing the time of fruiting, and for discovering trends of decline or increase?

Distribution

How do we know whether the map based on the records shows the actual distribution of the species and not the distribution of the observers?

In the case of small inconspicuous fungi the latter is still often the case. For example, *Claviceps purpurea* appears to be concentrated in the south-western part of the Netherlands, thanks to the inventorying efforts of a single individual, who collected 100 records out of the total of 135 (Fig. 2). Despite a presentation of his finds at one of the Society's annual meetings and the publication of the distribution map of Ergot (Arnolds, 1994), the number of records from other regions has not increased. The species is probably just as common in the rest of the western part of the country. My own experience, this late summer, shows that it is easily found on my way to work. Perhaps the time of year in which the sclerotia appear, and the preference of this species for weedy grasses like *Lolium perenne* and *Elymus (Elytrigia) repens*, are the cause of a lack of interest on the part of mycologists.

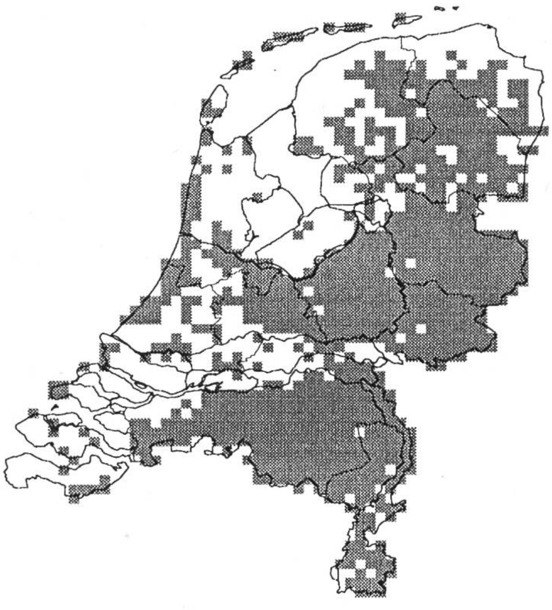

Fig. 3: Distribution of Amanita muscaria, *restricted to data collected in 1991 by the Royal Dutch Natural History Society.*

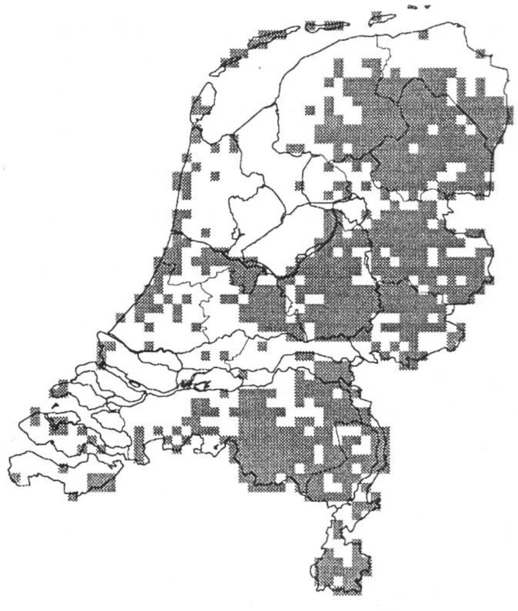

Fig. 4: Distribution of Amanita muscaria, *restricted to data collected by the Netherlands Mycological Society recording project.*

Fig. 5: Phallus hadriani *occurring in the coastal dunes, and formerly along the coast of the Zuyder Zee. It is encountered very rarely inland on river sand.*

Fig. 6: Myriostoma coliforme *is confined to the calcareous dune area.*

Of course, comparison of the distribution of the records of a particular species with the distribution of the records of all species is always necessary, especially when the recording project has only been running for a few years. The results from some very common species can also suggest ideas about real and artificial distribution patterns. In the case of *Amanita muscaria,* extensive data were gathered in 1991, in response to a call for collaboration by the Royal Dutch Natural History Society (KNNV). Over 10,000 records were submitted, making *Amanita muscaria* the best recorded species (Oosterbaan et al., 1992). However, the distribution pattern itself was hardly changed (Figs 3 and 4). The conclusion from this is that the records of well-recognizable big mushrooms truly represent their distribution.

Examples of species which show a distinctive distribution pattern are given in Figs 5–10; these patterns are due to environmental, especially edaphic and geomorphological, factors. Many other patterns do occur, but are mostly combinations of the ones shown here (for extensive information, see Nauta & Vellinga, 1995).

Fruiting patterns

Every Dutch child will tell you that mushrooms appear in autumn. Mycologists know better, and they go out at all times of the year to search for fungi.

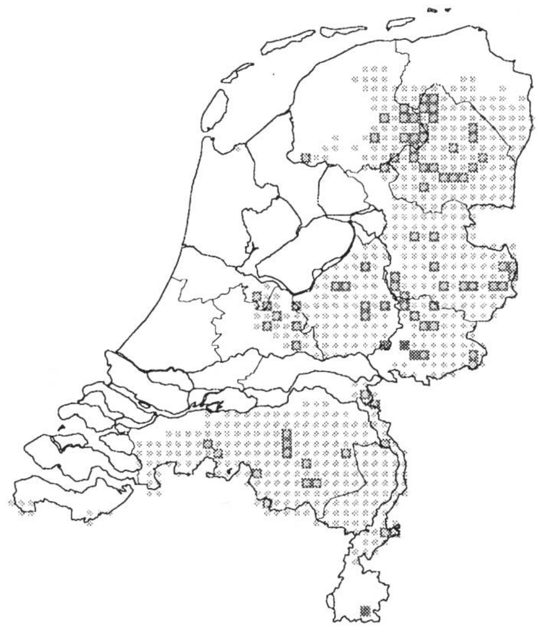

Fig. 7: Boletinus cavipes, *forming ectomycorrhiza with* Larix, *and only known from the Pleistocene area (dotted).*

Fig. 8: Amanita ceciliae *is growing mainly along the rivers, but occasionally elsewhere on clay (river area dotted).*

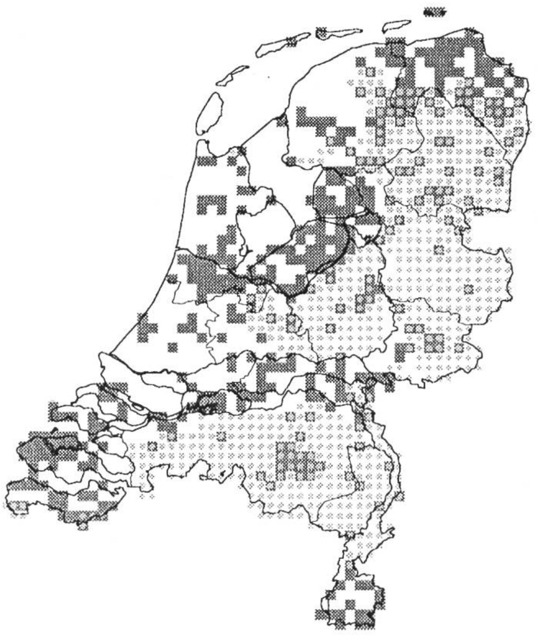

Fig. 9: Crepidotus cesatii *avoids the sandy inland areas (Pleistocene area dotted).*

Fig. 10: Macrolepiota rachodes *is found all over the country, as it requires locally nutrient-rich habitats, like compost heaps.*

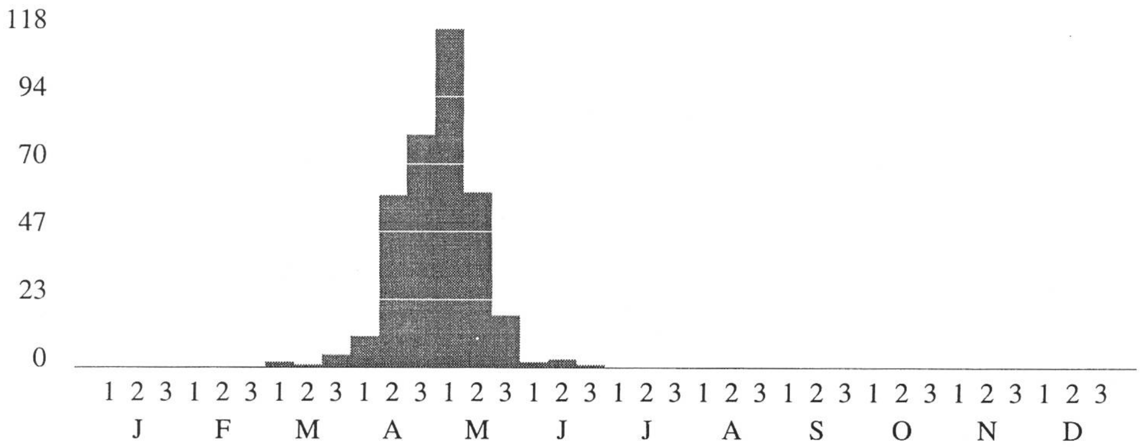

Fig. 11: Fruiting pattern of Morchella esculenta.

Nevertheless, autumn is indeed the high season for mushrooms and for the enthusiasm of mycologists, resulting in a peak in activities in October and a low in January. The activity of mycologists at any given time (measured by the number of visits, where a visit is the presence of one recorder in a certain 5×5 km^2 grid unit on one particular day), turns out to be more or less proportional to the number of records of perennial fungi, like *Ganoderma applanatum* and *Trametes versicolor.*

According to the numbers of records, *Flammulina velutipes* is most plentiful in November (monthly records) or even mid-October (ten-day period counts) (Vellinga, 1996). This species certainly occurs in October, but it has a long fruiting season. New fruitbodies appear in December and January or even later, and it is able to endure periods of frost. When its records are scaled against those of *Ganoderma applanatum, Trametes versicolor* or the activity of mycologists, as defined above, the peak of its fruiting shifts from November to January (Fig. 12).

In many cases the actual numbers of records per ten-day period give a good idea of the fruiting period; *Morchella esculenta* serves as an example (Fig. 11). Scaling the data for *Morchella esculenta* by mycological activity does not change its time of maximum abundance.

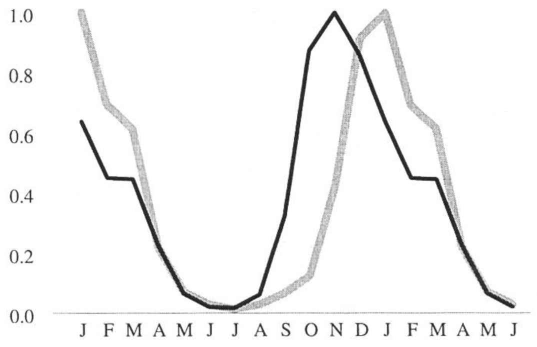

Fig. 12: Fruiting pattern of Flamulina velutipes. *The darker line plots the numbers of records per month, the lighter line plots the same values divided by the number of records of* Ganoderma applanatum. *Both graphs are then scaled to 1.*
Note that 18 months are represented to clarify the annual fruiting pattern.

For these examples the data have been taken from the entire database, assuming that there was no change in the pattern of fruiting over time. However, Schmitt (1993) has claimed to find considerable changes in 20 years for several species of Agarics in Saarland (Germany), some species fruiting earlier, others later in that time. In the Netherlands there is no change in the mycologists activities; October has always seen most activities, with September coming second; the activities in the first three months of the year have increased slightly.

Temporal changes

In general, species have been adversely affected during the last century as agriculture has become much more intensive. Together with increasing urbanization and road building, this has changed the country almost beyond recognition. Another important factor is the change in forest management. In the past every dead piece of wood was taken out of the woods, now dead wood is left to decay in peace. Furthermore, mushrooms are subject to natural succession; an example is the changing ectomycorrhizal community with progressing age of the trees. Not only is there a change in relative abundance of species (for instance nitrogen loving species have increased), but also the species composition is not the same, as illustrated already in Table 1. Other sources than the database, like excursion reports, illustrate the differences in the mycological situation through time as well.

Before looking at examples of particular species which have declined or increased, there are some general points to consider.

The number of records at present in the database is not at all evenly distributed over time (Fig. 13). However, more old records are available to redress the balance somewhat. Literature and herbarium collections still harbour a treasure trove of data, waiting for volunteers to dig them up. Figure 13 also shows the important data in the history of the recording project: the start in 1980, the appearance of a first check list (Arnolds, 1984) and the use of forms in 1984, and the surge of activities in relation to the preparation of the atlas (Nauta & Vellinga, 1995), a project started in 1989. Regional projects and activities, like the before-mentioned active recorder in the south-west, the elaborate inventory of Amsterdam and surroundings, and the project in progress to make an atlas of

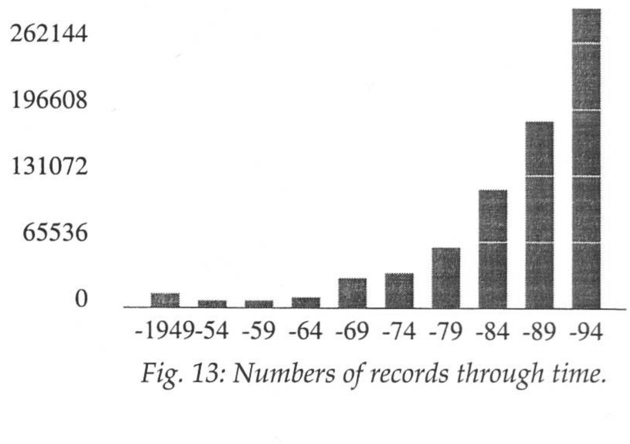

Fig. 13: Numbers of records through time.

Fig. 14: Distribution of records before 1900.

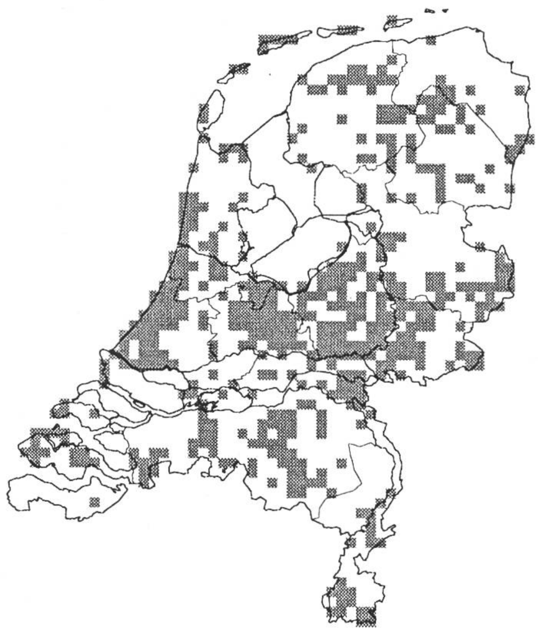

Fig. 15: Distribution of records in the period 1900–1950.

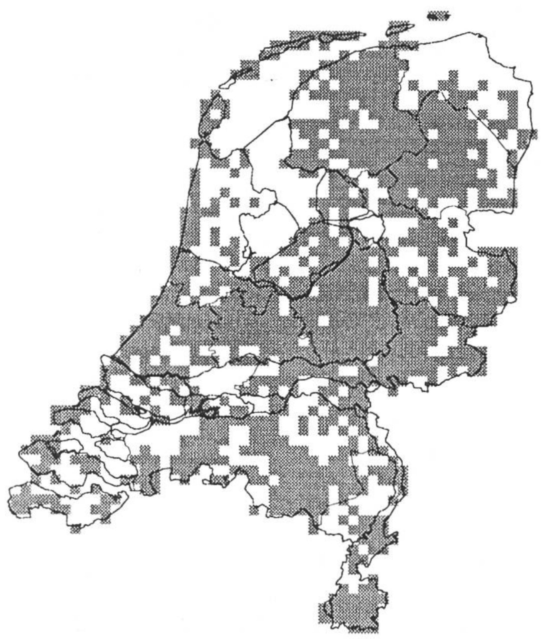

Fig. 16: Distribution of records in the period 1950–1980.

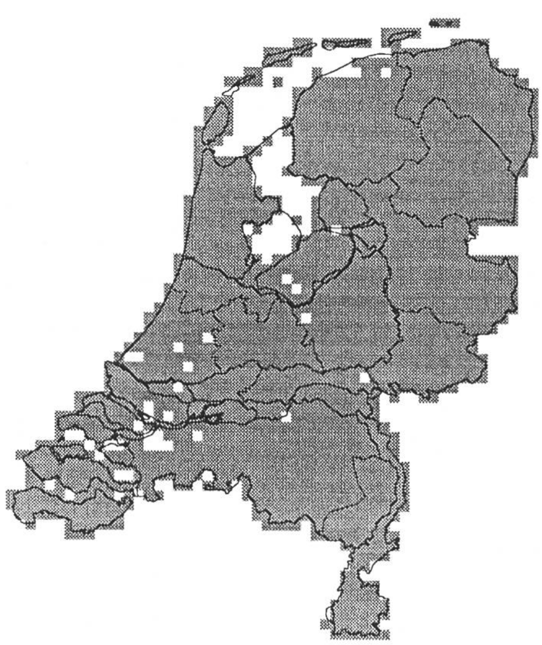

Fig. 17: Distribution of records since 1980.

the province of Groningen are other incentives with a large impact on the species number and composition of the database. All these are also short-term projects.

Regional floras of the 18th and 19th century often provide some information about the mycoflora, but interpretation of the names is difficult and not always possible. One nice exception is the listing of *Poronia punctata* as "Peziza turbinata truncata, disco punctato" in a treatise on the Frisian flora published in 1760 (Meese, 1760), where this species is said to grow on old horse dung around Franeker.

Small as well as large species were recorded before 1950, as the oldest record yet in the database demonstrates. This is *Dumontinia tuberosa,* dating from 1808. Another example may be found in the Flora Batava (Kops & Van Hall, 1836), a series of books seeking to describe and illustrate all the plants occurring in the Netherlands. The first two mushrooms depicted there are *Amanita muscaria* (pl. 495) and surprisingly *Xylaria hypoxylon* (pl. 510). The 19th century records are mostly occasional observations, the time of the complete lists had still to come.

After the founding of the Netherlands Mycological Society in 1908 the character of the literature data changed. Complete lists of society's excursions and forays were published, and discussed (e.g. Cool, 1913). In these reports a glimpse of the mycological richnesses in those days is shown. This tradition of making species lists is to be cherished as it has greatly improved the present day knowledge of the mushroom flora of the past.

The parts of the country visited have changed with time (Figs 14–17). In the past the emphasis was on wooded areas. Now that the inventory has been extended to almost the entire country, many new habitats have been visited. With recording being one of the most popular activities in the society, people have been stimulated to explore the open country side, to stop at road verges, and to visit churchyards; nor are compost heaps, city streets, land fills and airfields shunned any more. So the changes in coverage are both distributional and ecological.

Methods for studying temporal changes

The changes in distribution of some species can be demonstrated with maps from different periods, despite the increase in inventorying, resulting in more records from more places. However, this is true only for those species which occur in areas which have always been visited and for those species that have been subject to substantial changes: the decline should be really dramatic, or the increase larger than the increase in the number of grid units (in its potential area) visited. And of course the species should still be known in the same sense as in the past.

Fig. 18: Distribution of Sarcodon imbricatus *before 1970.*

Fig. 19: Distribution of Sarcodon imbricatus *since 1980.*

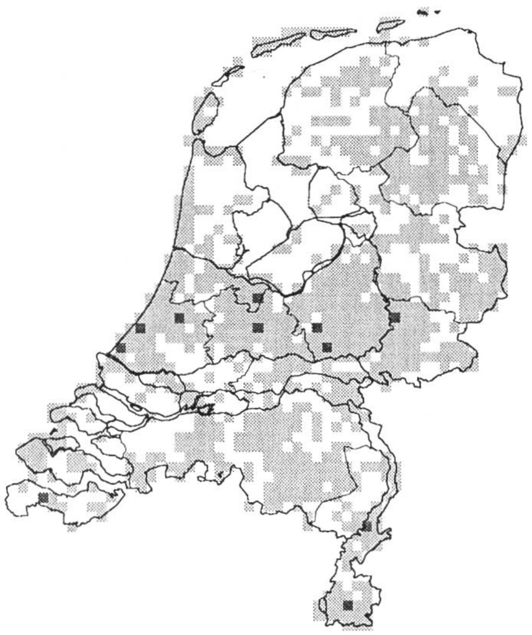

Fig. 20: Distribution of Fomes fomentarius *before 1970 (inventoried area light grey).*

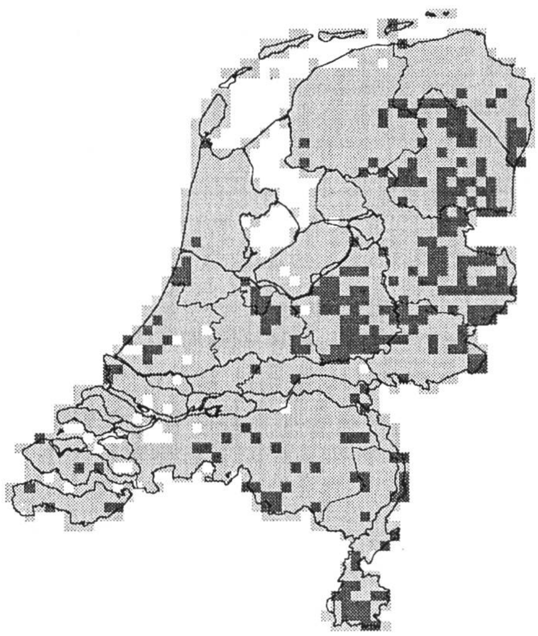

Fig. 21: Distribution of Fomes fomentarius *since 1980 (inventoried area light grey).*

The classic example of a severely declining species is *Sarcodon imbricatus* (Figs 18 and 19) (Arnolds, 1985b; 1989), while *Fomes fomentarius* is an increasing one (Figs 20 and 21) (see also Arnolds, 1985b).

Xylaria carpophila is another species that has been increasing rapidly, but here the cause is the special attention given to this small and inconspicuous, specialized fungus, appearing in large numbers in wet springs on beech debris. In 1930 it was already considered common (Vuyck, 1930), but only since 1985 have the numbers in the database born this out (Nauta & Vellinga, 1995).

Fortunately not all species have declined so dramatically as *Sarcodon imbricatus* that maps of different periods actually show their decline. Therefore, other methods to show changes have to be used. Some of these methods apply to all records in the database, others use only a subset. Seven methods, most of them already applied and published, are now summarised.

1. Percentages of records in different periods are used (using periods of five or ten years, for example).

Amanita rubescens can serve as an example (see also Nauta & Vellinga, 1993; 1995). It is a rather common species (Fig. 22), growing on sandy soils throughout the country, in areas which have been visited both in the past and in the present. As expected the absolute numbers of records increase, as do the numbers of grid units in which the species has been found (Figs 23 and 25 resp.). The situation is different when the percentages of numbers per five-year period are considered (Fig. 24), then the population seems to have been stable. (The percentage is with respect to all records in the period.) The exceptionally high percentage of *Amanita* records during the period 1950–1955 is attributable to the activities of C. Bas who started working on the genus *Amanita* in the Netherlands at that time. A single find can make a significant contribution to enlarging the range of a species, in terms of grid units, as there are only 1677 grid units in the Netherlands, but it makes a negligible contribution to the numbers of records, when the species is a common one. It is hardly surprising then, that the growth of collecting quickly increased the percentages of grid units of *Amanita rubescens* (Fig. 26).

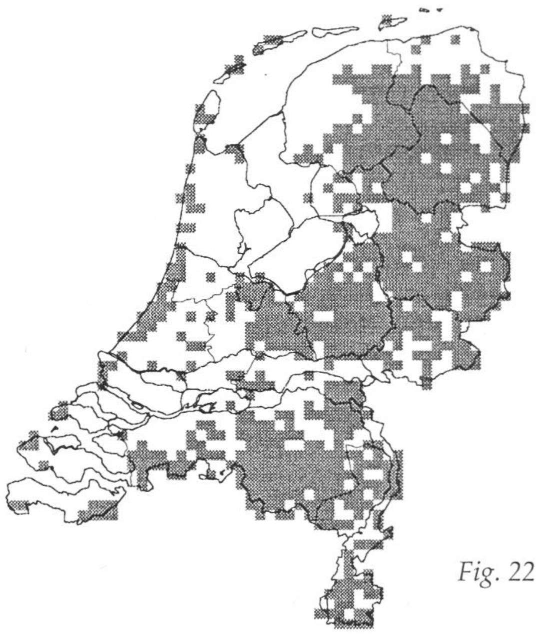

Fig. 22

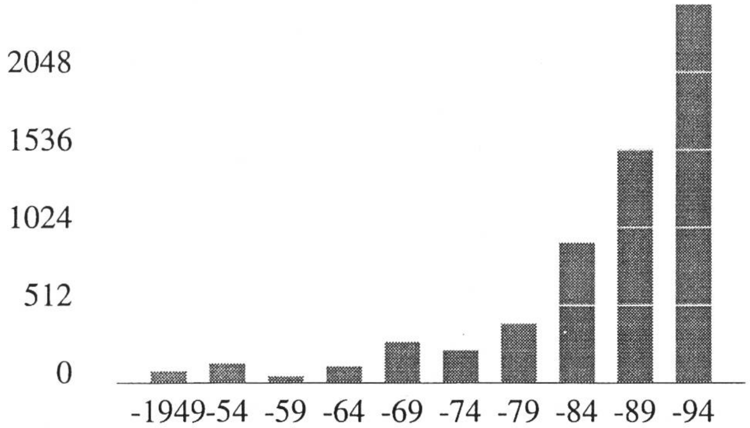

Fig. 23: Numbers of records of Amanita rubescens *through time.*

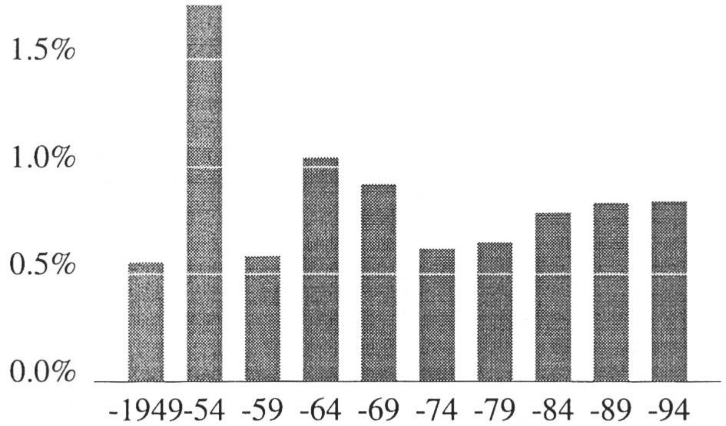

Fig. 24: Percentages of records of Amanita rubescens *through time.*

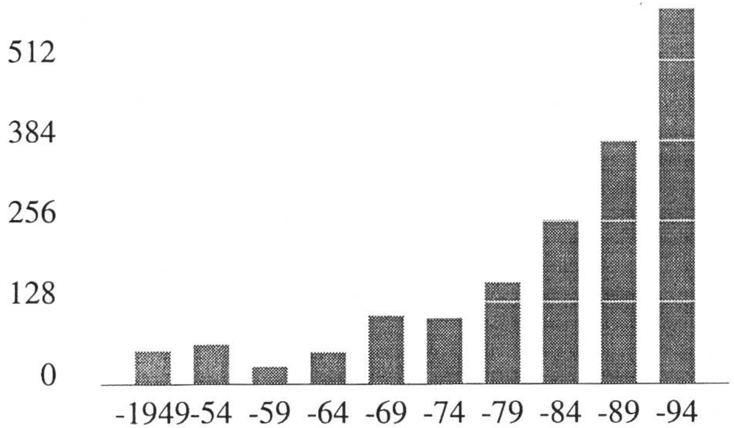

Fig. 25: Numbers of grid units from which Amanita rubescens *is recorded through time.*

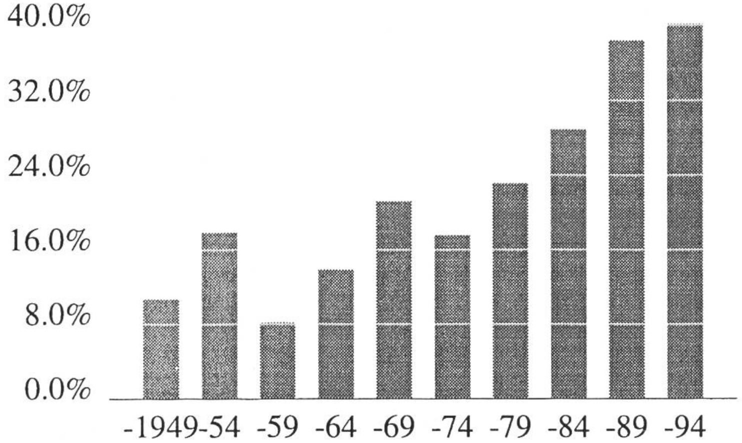

Fig. 26: Percentages of grid units from which Amanita rubescens *is recorded through time.*

The use of percentages of records, not grid units as is shown above, is appropriate for many species. The records of areas formerly not visited can influence the outcome considerably, as the species composition of clay and peat regions is totally different from the sandy areas. Modifications of this method, with restrictions in space and time, are applicable for more species, depending on the time of inventarisation of that particular area. Several of the following methods are such modifications.

2. The whole database is split up into two parts of equal size, before and after a certain date. The numbers of records, or of grid units, of a species before and after this median are compared. This method, using grid units, was implemented to prepare the Red Data List (see Arnolds, 1997); at that time the median date was 1 Jan. 1986, while in 1998 this median falls in 1989. A disadvantage of this method is that the greatest changes affecting occurrence did not happen in the eighties, but much earlier, around 1960, and probably also around 1900, with the surge in use of artificial fertilizers in agriculture and the planting of many *Pinus woods* on the sandy soils. The fundamental disadvantage is that the rate of sampling has increased so that, for any date that is chosen to divide the data, the past is longer than the future. And when the rate has changed, other factors have also changed – different areas are visited, etc. Species that only fruit under rare weather conditions are likely to be left out in the shorter period. There is no good reason not to allow unequal-sized data sets and apply scaling. Decline of species which show an evenly distributed decline over the total of their grid units, where they occur in high numbers, in other words a decline in numbers of records, but not yet in numbers of grid units, will not be noted either.

According to this method also *Amanita rubescens* is not declining, and as the species is not rare either, it was not incorporated in the Red Data List (Arnolds & Van Ommering, 1996).

The next five methods make use of only a part of the database.

3. Only the records from grid units which have been visited throughout the period are taken into account (Nauta & Vellinga, 1992, 1993, 1995). There are 44 such grid units, mostly situated in the sandy, wooded areas of the country or the dunes, though some lie along the main rivers. Percentages of records are used here as well. These data can be tested statistically, as the bias of a change in geographical and ecological coverage has been taken away (Nauta & Vellinga, 1995). *Amanita rubescens* is unaltered according to this method.

4. Absolute numbers of records of species, occurring in foray reports from two periods, are compared (Arnolds, 1985a). These forays have taken place in more or less the same areas, and the total numbers of records in both periods are more or less equal. These data can be statistically tested, as disturbing factors, such as a different species composition due to different habitats, and a

varying amount of effort put into the collection of the data, are ruled out. Again *Amanita rubescens* appears to be stable.

5. A modification of method 4 is to use all foray reports, i.e. all lists with more than 50 species (Arnolds & Jansen, 1992). Percentages of records are subsequently used to determine the changes in occurrence of a single species. A disadvantage of this method is that different areas and habitats are compared, and statistical testing is not appropriate. Again the percentages of records of *Amanita rubescens* remain equal through time.

6. Only data from a specific habitat or geographical area are used, using percentages of records per period. This method is useful to determine if there were different rates of change. For instance, it was assumed that decline of ectomycorrhizal species was not as severe in the calcareous dune area as on the nutrient-poor Pleistocene soils (see for instance Arnolds, 1985). Unfortunately, this method cannot be applied to some areas of interest where no old records exist.

7. The data can also be confined to those species which have been recorded throughout time, or by leaving out all those small inconspicuous fungi which have been recorded only recently. In this way, the dataset was restricted for the composition of the Red Data List (Arnolds & Van Ommering, 1996, Arnolds, 1997).

The results for *Amanita rubescens* turn out to be the same, whatever method is used to determine change. For other species, too, the results of the different methods, despite methodological shortcomings, are similar. In general ectomycorrhizal species (especially those associated with *Pinus* species) and species of nutrient-poor grasslands are declining, whereas lignicolous species are on the increase.

Prospects and possibilities

Unfortunately mushrooms are not yet self-recording, and must rely on humans to report their occurrence. This means that human behaviour plays a big role in the way the data are compiled, and has to be taken into account for the interpretation of the data. People have their own specific group of fungi they are interested in, they prefer going to nice mushroom-rich areas, which are easily accessible, and they change their hunting areas and/or their group of interest every five to ten years. They do not like to spend too much time filling in forms with all kinds of detail they may have neglected to note in the rainy field.

It is shown that a single observer can considerably increase the numbers of data of a specific area or species, even now. The effect of several important mycological events is also quite visible in the numbers of records (Fig. 13).

At present, a set of data which have been collected in a standard way at a set date, of which the plots are more or less randomly distributed over the country, and where the amount of effort going into the inventarization is being registered as well is clearly lacking. The Swiss moss monitoring programme sets an example with a network of randomized plots (Geissler, pers. comm.). These plots might be situated in species-rich areas, but might well be quite inaccessible, like on steep rock faces or in the middle of a motorway.

The number of such plots and the frequency, and length of visits made to them depends on the precision with which changes have to be determined. The more plots are visited over a longer period of time, the more precise the assessments of change and predictions for future change can be.

In the Netherlands some mycocoenological research, with a standardized method of making resumés, has been carried out, especially by the mycologists at the Biological Station of Wijster. Examples are the investigations in oak woods on nutrient-poor sandy soil (Jansen, 1981, & Arnolds, 1992), and in grasslands in the northeastern part of the country (Arnolds, 1981). Often this kind of research spans a limited number of years. Fortunately, the plots in the oak woods have been visited for extended periods over the course of 19 years. Another example is the inventory of 16 permanent plots in forest reserves throughout the country (Veerkamp, 1992). Due to the enormous time invested in all these cases, only a very limited number of plots could be researched. Some amateur mycologists participated in the forest reserve research, but this kind of research demands considerable effort and perseverance.

To guarantee a high participation and a high degree of reliability of the data the set-up and protocols for future inventories should carefully be thought out.

Future plans of the society amount to the monitoring of c. 100 carefully selected species in plots where the species occur. For each species the numbers of fruitbodies have to be counted during the two to four visits per fructification period. This programme aims at Red Data List species from a wide array of habitats, with some attention to common species. All species should be easy to identify to avoid determination errors. A ten-year period should yield enough data to draw conclusions on trends. This project coincides with existing programmes in the country to monitor other groups of organisms. It seems an excellent opportunity to put the effort made in looking for the species into a parameter. This project might offer a good compromise between the impossible (what really is wanted), and the feasible.

The mushroom recording project in its present form should not be abandoned. It is the source of many interesting and new finds, it covers the country as a whole and it is a school for more advanced fieldworkers.

To conclude

For the interpretation of the data it is not sufficient to rely on numbers of records of species and their spatial distribution alone, as these data as such do not always yield correct information about fruiting patterns, trends in time, and distribution. Careful evaluation of the composition of the database and knowledge of the way in which the data have been collected are necessary before conclusions can be drawn. A large database, such as the Dutch dataset, collected over an extended period of time, from all corners of the country, yields reliable data, as shown above. But the proviso must be added, that this is true only for the conspicuous, easily recognizable species, without taxonomic problems, whereas the situation of the small, inconspicuous fungi is badly in need of improvement.

Priority should be given to the time consuming tasks of searching literature for old data, and to scanning herbarium collections. Good taxonomic insight and knowledge are necessary for this enterprise.

Inventories of permanent, randomized plots over extended periods of time, with standardized ways of data collection, are necessary to evaluate data collected unsystematically and to give more precise estimates of the changes species are undergoing. Unfortunately, long term research is very time consuming and labour-intensive and at odds with customary research politics.

Enthusiasm and perseverance of the participants, and ample information on aims, progress, and procedures are necessary for successful recording projects, of whatever kind. It is important to provide the possibility to participate with different levels of ability, including a basic knowledge of one or a few species. The *Amanita muscaria* programme showed that recording mushrooms has also its appeal for a wider public.

And finally, even in a relatively well-investigated country as the Netherlands, hitherto unreported Agaric species are still being discovered, showing that inventorying has enormous potential for improving our knowledge of the appearance, ecology and distribution of fungal species.

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