Grassland Waxcap Identification Support Tool

Technical Note

Knowledge Base release:	version 1.0 beta [for field testing]
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Notes:	This knowledge base is based on published works by David Boertmann and others (see references).

1. Acknowledgements

This ID support tool is based to a very large extent on the published works of David Boertmann. Anyone with an interest in waxcaps (*Hygrocybe* s.l.) should buy his book: 'The genus *Hygrocybe*, 2nd revised edition' (2010).

I am very grateful to David Boertmann for allowing me to make comprehensive use of his book and for his very useful feedback on a previous version of this tool.

I would also like to thank: Peter Russell, whose 'Quick learning key for the macroscopic identification of Waxcaps' (2005) provided inspiration for this project; Brian Douglas, Community Fungus Survey Leader for the Lost and Found Fungi project at Kew, who has been a great source of encouragement; and Martyn Ainsworth, Senior Research Leader (Mycology) at Kew, for his advice on utilising the JNCC Guidelines and for explaining some of the context to recent nomenclatural changes. I would also like to thank Jim Howell of Sussex Fungus Group who has helped with testing the knowledge base; Rich Burkmar, from the FSC BioLinks project, for his advice on certain technical aspects of Identkit; and Bob Foreman at Sussex Biodiversity Record Centre, for his help deploying this knowledge base on the web.

1.1. Image credits

I am not much of a photographer myself, so I am enormously grateful to everyone who has allowed me to use their fabulous photographs to illustrate this tool, including Peter Russell, Thomas Kehlet, Malcolm Storey, Dawn & James Langiewicz, Jens Petersen, Rob Foster, Martyn Ainsworth, David Harries, Neil Barden, Mo Richards, Lukas Large, Amadej Trnkoczy and Laura Martin.

I have endeavoured to source photographs of critically identified specimens observed in the UK or Northern Europe, with the exception of *Hygrocybe canescens* which is illustrated with a collection from North America.

The Biodiversity Heritage Library has also been a fantastic resource in sourcing illustrations.

All images are individually credited either below the image, or if you click on the "i" button in the species images window.

2. Introduction

This ID support tool has been put together by an amateur field mycologist with limited experience in identifying waxcaps, as a hobby project. My primary motivation in developing this tool is as a learning exercise, for personal use – but I am keen to explore whether it has potential to be useful to others.

The FSC Identikit technology which has been used to develop this tool is straight forward to use and requires no specialist technical skills. I was spurred on by attending a free introductory training course run by Rich Burkmar, offered by the FSC BioLinks project.

The process of developing the knowledge base which sits behind this tool turned out to be more complicated than I anticipated – largely owing to my own naivety regarding the dynamic state of taxonomy and nomenclature in this area of mycology; and the challenges of codifying waxcaps' subtle and variable characters.

I don't know whether this tool will turn out to be a useful addition to the various ID resources that are already out there. **This version is being shared for field testing and I would very much welcome feedback from users, to inform further development.**

As mentioned above, the knowledge base which sits behind this tool draws heavily on the published work of David Boertmann and other authors. I see this tool as something to be used in conjunction with 'The genus *Hygrocybe* 2nd revised edition' by David Boertmann (2010), and not as a replacement for buying the book.

This note explains how I have gone about creating this Grassland Waxcap Identification Support Tool, and some of the choices and challenges I have encountered.

3. The technology

This ID support tool has been put together using FSC Identikit version 1.8.2 – a tool for creating and publishing interactive web-based identification resources, including multi-access keys, photo-based resources, species accounts and maps. FSC Identikit ID resources are driven by spreadsheets of information called 'knowledge bases'.

FSC Identikit automatically generates the html files which are used to interact with the knowledge base, through a browser. These files can be run locally, just on your own computer. They can also be deployed on a web server, and I'm grateful to Bob Foreman at the Sussex Biodiversity Record Centre (SxBRC) for publishing this knowledge base on the SxBRC web server – so that it can easily be shared.

4. The knowledge base

4.1. Characters included

4.1.1. Taxon

Choice: which taxa to include?

I started out using Boertmann (2010) to pull together a list of waxcap species.

My original vision for this waxcap ID support tool was that it would be focussed on species occurring in Sussex (vice-counties 13 & 14) in southern England. Because that's the geographic area that I personally am interested in. But I gave up on that idea because, if suitable habitat is present, it looks like rare waxcaps can turn up anywhere. There are, for example, a number of rare grassland waxcap species which (as far as I can see) have never been recorded in Sussex, but have turned up in neighbouring counties, e.g. *Hygrocybe laeta* var. *laeta* (recorded from Surrey, 2004), *Hygrocybe aurantia* (recorded from West Kent, 1969), *Hygrocybe substrangulata* var. *substrangulata* (recorded from Surrey, 1984). Presumably these could turn up in Sussex, as could very rare european species such as *Hygrocybe canescens*?

JNCC recently published a new chapter in the Guidelines on the Selection of Biological SSSIs, covering the non-lichenised fungi (Bosanquet et al, 2018). On advice from Brian Douglas and Martyn Ainsworth at Kew, I decided this would make a sensible starting list for species to include in this ID support tool. The Guidelines include a section on grassland waxcaps (*Hygrocybe* s.l.) as well as a handful of waxcap species in the dune fungal assemblage section.

For the most part, the list of grassland waxcaps in the JNCC Guidelines follows the concepts described in Boertmann (2010), but there are a couple of species – *H. marchii* and *H. radiata* – which follow Boertmann (1995)[1] and, following molecular and morphological studies, a form of *H. psittacina* var. *psittacina* (sensu Boertmann 2010) is recognised by the Guidelines as a morphologically distinct species: *Gliophorus reginae* (Ainsworth et al, 2013). The variation within *H. psittacina* var. *perplexa* (sensu Boertmann 2010) is also considered to include more than one distinct species (*G. europerplexus* and *G. perplexus* aff.) but, for recording purposes, these are grouped together under the name *H. psittacina* var. *perplexa* (sensu Boertmann 2010) / *G. perplexus* aff. and will count as "one taxon" for the purposes of calculating the assemblage score.

I decided to limit species included in this version of the ID support tool to grassland waxcaps (*Hygrocybe* s.l.), following the concepts utilised in the JNCC Guidelines.

[1] In his '2nd Edition' (2010), Boertmann notes that "I have changed my point of view of some taxa, i.e. *H. radiata* and *H. marchii*"; his interpretation is that *H. radiata* (Boertmann, 1995) is "partly small fruit-bodies of *H. flavipes* (without yellow) and partly *H. roseascens*". Regarding *H. marchii* he says, "my current view is that it is probably the same as *H. reidii*". Martyn Ainsworth (2019, pers comm) has advised me that, based on recent molecular studies which is he currently writing up, he thinks Boertmann (1995) was correct in recognising *H. radiata* and *H. marchii* as distinct species – and for that reason they are included in the JNCC Guidelines (Bosanquet et al, 2018). Although it is also worth noting the advisory footnote in the JNCC Guidelines: "it should be borne in mind that these current names are merely a snapshot taken in a period of relatively rapid taxonomic change. The recognition of further species that are morphologically similar (but phylogenetically different) to one another is anticipated."

The reasons for this are:

- It is the grassland waxcaps that I am particularly interested in at the moment.
- Following the grassland waxcaps list in the JNCC Guidelines is likely to have the greatest impact from a UK fungus conservation point of view, as records can make a major contribution to site assessment and SSSI selection.
- The dune waxcaps listed in the JNCC Guidelines are more difficult for me to add to the knowledge base, as they include *H. aurantiolutescens*[2] which Boertmann (2010) considers to be a synonym for *H. acutoconica*. I could add these later.
- The woodland / bog waxcap species listed in Boertmann (2010) – *H. viola* and *H. coccineocrenata* – are pretty unlikely to turn up in Sussex[3] and I can't really envisage a scenario where anyone (me included) would be using this ID support tool to identify such rare and distinctive waxcaps.
- The arctic / alpine waxcap species listed in Boertmann (2010) – *H. hygrocyboides*, *H. cinerella*, *H. citrinopallida*, *H. xanthochroa*, *H. lilacina*, *H. laeta* var. *flava*, *H. substrangulata* var. *rhodophylla* and *H. salicis-herbaceae* – are very unlikely to occur in Sussex, so fall outside my area of interest.
- Regarding the other waxcap species concepts detailed in Boertmann (2010) and not in the JNCC Guidelines, I have been advised that *H. roseascens* is not currently included on the Checklist of the British & Irish Basidiomycota (CBIB) (Ainsworth, 2019, pers comm). The rest are varieties of species which are listed in the JNCC Guidelines (e.g. *H. virginea* var. *fuscescens*, *H. virginea* var. *ochraeceopallida*, *H. psittacina* var. *sciophanoides*[4], *H. glutinipes* var. *rubra* and *H. spadicea* var. *albifolia*); I presume, if these varieties are encountered in the UK, it is advisable to record them at the species level , using concepts recognised in the JNCC Guidelines.

Choice: what to do about *H. marchii* and *H. radiata*?

As explained in footnote 1, there are differing opinions on the validity of these species concepts.

I decided to include *H. marchii* and *H. radiata* in the tool, but with an 'ID warning' flag next to them, to try and minimise any risk of confusion in identifications. I have also included extra information for users in the species details window, explaining the current taxonomic situation (as I understand it).

I looked into changing the formatting of the 'ID warning' text, to make it stand out. This is not technically possible at the moment, but it has been logged as an FSC Identikit feature request on GitHub (here).

[2] Martyn Ainsworth (2019, pers comm) has advised me that *H. aurantiolutescens* is a Peter Orton species, originally described from Britain and recognised by French mycologists, from the dunes of Northern France.
[3] I have found one previous Sussex record of *H. viola*, recorded in The Mens, West Sussex, in 2001 (FRDBI #633535, Legon, N.W.). I am not aware of any previous Sussex records of *H. coccineocrenata,* although it has been recorded from Surrey in 1991 (FRDBI #380090, Legon, N.W.) and Hampshire in 2008 (FRDBI #1476391, Hughes, B.)
[4] Ainsworth et al discuss *Hygrocybe sciophanoides* in their 2013 paper, and conclude that "*H. sciophanoides* should be regarded as a *nomen dubium*".

4.1.2. Nomenclature (scientific names)

Choice: which names to use?

Because I envisage this ID support tool being used in conjunction with David Boertmann's book on 'The genus *Hygrocybe*, 2nd revised edition' (2010), I decided to follow the names Boertmann (2010) uses as the primary display name – so it's as easy as possible for users to read across from the tool, to the book.

I recognise that many species in the genus *Hygrocybe* s.l. now have 'new' / different published names – reflecting advances in understanding of their phylogeny (i.e. how they have evolved, and how species are related to each other). I have included "current taxon name" as listed in the JNCC Guidelines (Bosanquet et al, 2018) in the knowledge base, so this displays when you click on each species.

I have checked (in early 2019) if these current names are available for use in the British Mycological Society's Fungal Records Database of Britain & Ireland (FRDBI) – for recording purposes. Most of them are, but many (the *Cuphophyllus* spp., *Neohygrocybe nitrata* & *N. ingrata*, *Gloioxanthomyces vitellinus* and *Porpolomopsis calyptriformis*) are treated as synonyms and not 'preferred names'. There are handful of instances where the current name used in the JNCC Guidelines does not appear to be available for use in the FRDBI, or there is a problem with it (?):

Cuphophyllus lacmus	Comes up as '*Cuphophyllus lacmus* nom. illegit.' *Cuphophyllus lacmus* is a legitimate name, so FRDBI users would be justified in using this name.
Cuphophyllus lepidopus[5]	Doesn't come up. FRDBI users would presumably need to choose *Hygrocybe lepidopus* (Rea) P.D. Orton & Watling as the nearest equivalent, although this is treated as a synonym of *Hygrocybe fornicata* var. *lepidopus*
Gliophorus perplexus aff.	Doesn't come up. FRDBI users would presumably need to choose *Gliophorus perplexus.* Although I note the FRDBI does include *Gliophorus psittacinus* agg. – so it might be possible to add *Gliophorus perplexus* aff.?

4.1.3. Nomenclature (English names)

I have included English names for fungi, following the recommended English names published by the British Mycological Society (BMS, 2016). This information only displays when you click on a particular species.

[5] Martyn Ainsworth (2019, pers comm) has told me that he made the '*Cuphophyllus lepidopus*' combination (Index Fungorum ID: 552988) ahead of the published evidence so that the opportunity to include this species in the JNCC Guidelines would not be missed.

There is a known issue with the English names for *H. ingrata* and *G. europerplexus*: “dingy waxcap” has been published for both of them (BMS, 2016) although, in the FRDBI, “dingy waxcap” only appears to be in use for *G. europerplexus*.

Liz Holden is aware of this issue (BMS Facebook group comm, 2018) and has indicated that it is her intention to suggest a new name for *G. europerplexus* (“Butterscotch Waxcap” is a possibility); and presumably keep “Dingy Waxcap” for *H. ingrata*. Until this issue is resolved, I have decided not to include English names for either of these species, and refer to them both as simply “A waxcap” – to avoid adding to the current confusion around these names.

4.1.4. Status in Sussex

As mentioned above, my own geographic area of interest is Sussex.

I have reviewed records held by the Sussex Biodiversity Record Centre, as well as some FRDBI1 and Lost & Found Fungi (LAFF) project records, to get a basic understanding of the status of each species, in Sussex. I have categorised them using these fairly-arbitrary categories:

Often recorded in Sussex	101+ records in SxBRC database
Recorded in Sussex	11 - 100 records in SxBRC database
Rarely recorded in Sussex	3 - 10 records in SxBRC database
Very rarely recorded in Sussex	1 - 2 Sussex records located
Not recorded in Sussex. Could occur?	0 Sussex records located, but the species is recorded from neighbouring counties
Not recorded in Sussex. Unlikely to occur.	0 Sussex records. Species is not recorded in the region

I would like to do a more thorough review of the Sussex records at some point and it is my intention to base this on number of sites (or monads), rather than number of records. But in the meantime, I would be interested to hear from local mycologists whether my categorisation fits with their experience.

I experimented with using this information to give higher weighting to the more often recorded species, but I couldn’t find a nice way of making this work within the current capabilities of Identikit.

4.1.5. Can be ID’d on field characteristics?

I would refer users to ‘The genus *Hygrocybe*, 2nd revised edition’(Boertmann, 2010), pages 11-15, for a discussion of macroscopic and microscopic features of species in the genus *Hygrocybe* s.l. – and their variability and reliability, from a species identification point of view.

I have attempted to glean a view on whether species can be reliably identified from field characteristics, based on information in Boertmann’s (2010) analytic keys to the species (pages 27-40). I have categorised species as follows:

Can be ID'd on field characteristics?	
Yes	Species has outstanding field characters; or is included in Boertmann's (2010) field key, without reference to microscopic characters
Microscopy recommended for critical ID	Is included in Boertmann's (2010) field key, but with some reference to microscopic features
Microscopy needed to recognise varieties	Species can be identified using Boertmann's (2010) field key, but microscopy is needed to separate the varieties, e.g. *H. acutoconica* var. *konradii*
Microscopy needed to separate from similar species.	Boertmann's (2010) field key takes you to a group of species and microscopy is required to separate them, e.g. *H. miniata* and *H. calciphila.*

I recognise that identifying waxcaps (*Hygrocybe* s.l.) species from field characters is not always easy, and becomes increasingly difficult (/ impossible) as specimens age and weather. So if any experienced field mycologists have thoughts on how I could develop this 'character' in the ID support tool – so it encourages accurate identification and appropriate reliance on field characters vs. microscopic characters, let me know.

It has been suggested to me that if surveyors could become more familiar with the different types of gill trama[6], that would help to address a major source of misidentifications. I would like to look at including more information on microscopic features in a future version of the tool, particularly if I can figure out a way of sourcing decent quality images.

I imagine there are some species (e.g. *G. europerplexus* / *G. perplexus* aff.?) where definitive species identification would ideally need to be supported by a DNA sequence. This is something I could potentially add in to a later version – if anyone wants to give me information on species for which a voucher specimen should, ideally, be retained?

4.1.6. Cap Shape

Choice: how to categorise cap shape?

Cap shape can vary so much in waxcaps, it was difficult to figure out how this could work as a useful 'key' character.

I decided just to pick out the species which can have an 'acutely conical' cap, as this seems to be a more consistent feature (e.g. in *H. calyptriformis* and *H. conica*) than other cap shapes.

I'm a bit concerned this character, and the way its handled in the tool, could cause confusion if users come across particularly conical specimens of other species, such as *H. intermedia* or *H. spadicea*. But it's hard to make these things work perfectly!

[6] The differing structures of the gill trama are described on pages 13-14 of Boertmann (2010).

4.1.7. Cap Colour

Choice: how to deal with cap colour?

This was one of the more challenging field characters of waxcaps to codify, for the purposes of generating the knowledge base.

I decided to focus on the colours seen in fresh specimens, and have not tried to account for the range of colours that can be seen in old and weathered specimens.

I started out by writing a list of all the colour terms which Boertmann (2010) uses, and ended up with a list of around 70. For the tool to work, I needed to condense this down into a shorter list of more generalised colour terms, and took inspiration from the approach used by Peter Russell (2005). I am currently working with the list of colour categories below.

#	Generalised colour categories	Species in category
1	whiteish	*H. pratensis* var. *pallida*, *H. canescens, H. russocoriacea*, *H. virginea* var. *virginea,H. fornicata* var. *fornicata, Cuphophyllus lepidopus, H. irrigata, H. vitellina*
2	apricot	*H. pratensis* var. *pratensis*
3	pale brown[7]	*H. ingrata, H. laeta*
4	warm brown (yellow-, orange- or red-brown)	*H. colemanniana*, *H. ingrata*, *H. psittacina* var. *perplexa* (sensu Boertmann, 2010 + *G. europerplexus*), *G. reginae, H. irrigata*
5	pink-brown	*H. psittacina* var. *perplexa* (sensu Boertmann, 2010 + *G. europerplexus*)
6	dark brown	*H. colemanniana*, *H. ingrata, H. spadicea* var. *spadicea*
7	dark grey or dark grey-brown	*H. flavipes, H. fornicata* var. *fornicata, H. ovina*, *H. spadicea* var. *spadicea*
8	grey-brown	*H. flavipes*, *H. radiata, H. fornicata* var. *fornicata*, *Cuphophyllus lepidopus*, *H. nitrata*, *H. irrigata*
9	grey (inc. pale grey, bluish grey)	*H. canescens, H. lacmus, H. flavipes, H. irrigata*
10	green	*H. psittacina* var. *psittacina*
11	yellow-green	*H. citrinovirens*
12	yellow	*H. psittacina* var. *psittacina, H. vitellina, H. reidii* (rarely) H. *phaeococcinea* (very rarely), *H. quieta*, *H. miniata* (occasionally), *H. cantharellus* (rarely), *H. turunda*, *H.ceracea*, *H. insipida* (sometimes), *H. punicea* (very unusually), *H. citrinovirens*, *H. chlorophana*, *H. glutinipes* var. *glutinipes*, *H. intermedia* (rarely deep yellow), *H. acutoconica* var. *acutoconica*, *H. acutoconica* var. *konradii, H. conica*
13	orange (inc. dull orange)	*H. aurantiosplendens*, *H. psittacina* var. *psittacina, H. reidii, H. splendidissima*, *H. quieta*, *H. constrictospora, H. aurantia, H. miniata* (after slight drying), *H. substrangulata*, *H. cantharellus*, *H. turunda*, *H. coccinea* (rarely), *H. ceracea* (rarely), *H. insipida*, *H. aurantiosplendens*, *H. mucronella* (later), *H. chlorophana* (sometimes), *H. glutinipes* var. *glutinipes*, *H. subpapillata*, *H. intermedia* (later), *H. acutoconica* var. *acutoconica*, *H.*

[7] If I was including *Hygrocybe virginea* var. *fuscescens* and *Hygrocybe virginea* var. *ochraceopallida* (Boertmann, 2010) I would include them in the 'pale brown' category. As these varieties are not explicitly recognised within the JNCC Guidelines, I wonder if I should include this possible colour variation within *Cuphophyllus virgineus*...?

		acutoconica var. *konradii, H. conica* var. *conica*
14	orange-red	*H. reidii, H. marchii*, *H. splendidissima*, *H. constrictospora, H. miniata, H. calciphila*, *H. substrangulata* var. *substrangulata*, *H. cantharellus, H. coccinea* ("bright red to blood red, rarely entirely orange" – assume orange-red fits within this spectrum), *H. insipida*, *H. aurantiosplendens*, *H. mucronella, H. helobia* ("scarlet, discolouring to dull orange"), *H. subpapillata*, *H. intermedia, H. acutoconica* var. *konradii, H. conica* var. *conica*
15	red (i.e. bright red, scarlet)	*H. marchii*, *H. splendidissima, H. phaeococcinea*, *H. constrictospora*, *H. miniata, H. calciphila*, *H. substrangulata* var. *substrangulata* (sometimes), *H. cantharellus* (rarely), *H. coccinea*, *H. mucronella*, *H. helobia*, *H. subpapillata*, *H. intermedia*, *H. acutoconica* var. *konradii*, *H. conica* var. *conica*.
16	dark red (inc. blood-red, brick-red)	*H. psittacina* var. *perplexa*, *H. phaeococcinea*, *H. punicea*
17	pink (inc. pale pink to lilac)	*H. psittacina* var. *psittacina* ("drying pale pinkish ochre"), *H. psittacina* var. *perplexa* ("drying pale pinkish"), *G. reginae, H. calyptriformis*
18	dull purple	*G. reginae*

For species which occasionally occur with rare colour forms, e.g. *Hygrocybe phaeococcinea* which Boertmann (2010) describes as "very rarely yellow" I was in two minds regarding whether to include this variation within the knowledge base. I have included rare colour forms in this version – leaving it up to the user to decide if that's what they've found. **I would welcome feedback on whether this seems to work okay – or is tripping users up – as I intend to look at tightening some of the species characteristics in a future version of this tool.**

I've set up the knowledge base so that the user can only select a single colour for cap colour. (There is a multi-select option within Identikit, but the way it's programmed at the moment, I think it would give misleading answers[8].)

I experimented with trying to make the colour character work like a spectrum (by making it an 'ordinal character', in the language of Identikit). So if the user selects 'orange-red' cap, then some weighting would also be given to species with the character 'orange' cap or 'red' cap. However, I came to the conclusion this was just adding a load of extra complication, without significant benefit for the user.

[8] An example, to illustrate how the multi-select facility works in FSC Identikit (1.8.2):

> *Say, Parrot Waxcap can be orange OR green (or orange AND green). Orange Waxcap can only be orange. User finds a waxcap that has orange and green colours, so selects both of these under the multi-select… The key then gives them both Parrot Waxcap and Orange Waxcap as equally likely options, as both of these species can be orange. However, Orange Waxcap is never green, so the answer here is misleading.*

I have contacted Rich Burkmar, the developer, about this. There are no plans at present to change how the multi-select works, so I decided to switch to single-select.

4.1.8. Texture of cap surface

The user can choose from dry, greasy, lubricous, moist or viscid. Descriptions of what these terms mean, with images to illustrate most of them, can be accessed by clicking on the character help.

I have included "moist" as Boertmann (2010) uses that term to describe *H. conica*: "young fruit bodies moist or viscid, but soon dry…" However, as far as I can see, that is the only species for which he uses the term moist to describe the surface texture. I wonder if it would be better to describe *H. conica* as simply "viscid" or "dry" in the knowledge base – to avoid potentially bringing in confusion for users of this tool with the term "moist" only being used for one species?

4.1.9. Appearance of cap surface

The user can choose from smooth, fibrillose and squamulose. I have also included pruinose, tomentose, 'finely hairy or with scattered fibrils' and 'finely veined or nodulose'.

4.1.10. Colour of cap squamules, or coating

The user can offer additional information on the colour of the squamules, or cap coating (as in *H. phaeococcinea*).

4.1.11. Cap width

This character should be self-explanatory. Species will score on this character if the size falls within the range given in the knowledge base.

As the reference description for *Cuphophyllus lepidopus* is based on examination of only a handful of specimens, I decided to go with the cap size for *H. fornicata* given in Boertmann (2010), which is 20-80 mm, rather than the 30-75 mm quoted in Boertmann and Barden (2007).

4.1.12. Stipe colour

This character uses the same colour categories as cap colour. The user can only select a single colour.

4.1.13. Stipe top / base colour

I've added this in to accommodate species such as *H. flavipes*, *H. punicea* and *H. psittacina*, where the colour of the stipe base or top can be a distinctive feature. Users can access images illustrating these characteristics by clicking on the character help.

4.1.14. Texture of stipe surface

Functions the same as texture of cap surface.

4.1.15. Appearance of stipe surface

Functions the same as appearance of cap surface.

4.1.16. Gill shape

Users can choose from the following:

emarginate
free
adnexed
narrowly adnate
adnate
broadly adnate
shortly decurrent
decurrent
deeply decurrent

This character is set up to work as a continuum (an 'ordinal character'), so whichever character state you choose, the ones either side will also be given some (lesser) weighting. Users can access images illustrating the different gill shapes by clicking on the character help, obtained from Wikimedia Commons.

Other characteristics of the gills – i.e. whether they are toothed, furcate, arcuate, intervenose, ventricose, broad, thin, distant – is not currently addressed in the knowledge base. This could be added, but would need some thinking about, in terms of whether these would work all together, under one gill-related character, or be better split into separate characters (e.g. furcate: yes / no; intervenose: yes/no).

4.1.17. Gill edge

This offers the user a choice between 'dry' and 'viscid'.

4.1.18. Blackening or reddening of fruit body

This offers a choice between 'blackening', 'reddening', 'turning greyish' or 'no colour change'. I thought it was probably better to treat this as a separate character – rather than try and bundle it up with cap colour.

4.1.19. Smell

Self-explanatory.

Note that the smell of *H. constrictospora* and *H. aurantia* are not recorded in Boertmann (2010) so this character is left blank for those two species. If anyone knows what they smell like, please let me know!

4.1.20. Taste

I decided to include this, particularly to assist with identification of *H. mucronella*.

Would be good to know if people feel the character tip and detailed help are sufficiently cautious – don't want to be encouraging people to munch on mushrooms without knowing what they are.

4.2. Characters not included

I haven't included all the characters Boertmann (2010) describes, largely because I didn't want to clutter up the tool with loads of characters that aren't needed for field identification. For the most part, I have stuck with characters that Peter Russell used in his 'Quick learning key' (2005).

I could add in any/all of the following characters to a subsequent version, if they would be useful.

4.2.1. Nuances of cap colour

Forcing users to select a single colour category for 'cap colour' means a lot of the nuances of waxcap colouration are missed, such as:

- the multi-coloured nature of some species, particularly *H. psittacina*
- the "narrow yellow margin" that can be observed in *H. punicea*, *H. miniata* or *H. calciphila*
- the "brownish central spot" that is a feature of *H. virginea* var. *fuscescens* (although this variety is not listed in the JNCC Guidelines, and – if encountered – should presumably be recorded as *H. virginea* var. *virginea*)

4.2.2. Striation on the cap

This doesn't appear to be a character which Boertmann (2010) relies on in his field key, so I've left it out. However, it has been suggested as potentially a useful feature for identifying *H. radiata*, so I could add it in to a future version.

4.2.3. Gill colour

This doesn't appear to be a character which Boertmann (2010) relies on much in his field key, so I've left it out. However, it has been suggested as a potentially useful feature for identifying *H. quieta*, with its salmon coloured gills, so I could add it in to a future version.

4.2.4. Microscopic features

I have not attempted to add information on any microscopic characters.

If I could get access to representative images of spores and features like the gill trama, this would be a nice feature to add in to a future version – particularly for species where microscopy is needed to separate species / varieties.

5. Species images

The Identikit technology includes a facility for adding images associated with individual species. I have just included an image of *H. pratensis* var. *pratensis* in the initial release version, for illustration of this feature.

I would be keen to include images of the other species, if it is possible to source images of critically identified specimens collected in the UK. All images would be individually credited.

6. Species NBN map

I have used the built-in functionality of Identikit to include UK & Ireland distribution maps for each species. These are pulled from the NBN Atlas using the Taxon Version Key (TVK) – a unique species identifier code[9].

Data on the NBN Atlas comes from a variety of different data partners, including the British Mycological Society. I don't think the NBN Atlas web services API currently allows users to just select and display datasets from specific data providers (it's all or nothing). Data on the NBN Atlas includes unverified as well as verified records. It's also worth being aware that not all fungal records datasets are shared via the NBN Atlas[10]. *Gliophorus reginae* is an interesting example in this respect, as the Lost & Found Fungi Project has put concerted efforts into mapping its known distribution (here), with records from nearly 20 locations; by comparison, the NBN Atlas (here) shows 2 records from 2 locations. **The NBN map for any given species should therefore not be treated as a definitive map of its distribution.**

Nevertheless, I thought the maps are still potentially helpful to give an indication of how commonly recorded and widespread the different species are. I'd be interested to know what other people think.

It should also be noted that datasets are shared on the NBN Atlas under a number of different data licences. Many datasets are shared for non-commercial purposes only. Guidance on using data shared through the NBN Atlas can be found here.

I am working on the assumption that this ID support tool, and the NBN maps within it, will not be used for commercial purposes.

7. Species details

I have included brief field identification notes for some species, mostly adapted from Peter Russell's 'Quick learning key' (2005), as well as information on where to find a detailed description for each species.

The 'species details' element of the tool can be used to provide as much detail as you care to include (drawn from an html file). However, I can't see any point in duplicating information which is already well covered and easily accessible elsewhere. And I'm conscious of the importance of making sure any information I do include is accurate and reflective of currently accepted species concepts, in a UK context.

[9] Note I have had to link the maps to the 'preferred / recommended' species names, as defined by the UK Species Inventory. These are not necessarily the same as the current published name, but I think in most cases should refer to broadly the same thing. See section 4.1.2 on nomenclature.

[10] Fungal records held by Sussex Biodiversity Record Centre, for example, are not shared via the NBN Atlas. But can be accessed through their data request service: https://sxbrc.org.uk/services/dataRequests.php (free if the data is wanted for research purposes, or personal interest).

8. References

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