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The mycosociology of macrofungi as indicators of the presence of stipitate hydnoids

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Abstract

Using a biodiversity quality approach to measuring the biodiversity of macrofungi (entailing the use of a standardised survey methodology and the creation of a set of Biodiversity quality indices) has allowed sites to be compared and the relationship between species shown. The example of stipitate hydnoids may be a guide to future studies on other species groups.

Key Words – Biodiversity quality – mycorrhizal fungi – standardized sampling – Twinspan.

Introduction

The activities of fungi are essential for the functioning of ecosystems and the biodiversity of macrofungi is often a reflection of the overall biodiversity (Christensen et al 2004). Macrofungi are a component that in some ecosystems are essential keystone organisms (Baldwin et al 2002, Dix & Webster 1995, Smith & Read 1997) and in particular the role of mycorrhizal species in plant nutrition is so fundamental that it is sometimes suggested that the colonisation of land was only possible through the creation of mycorrhizae and pioneer plants such as Rhynia appear to have beeen mycorrhizal (Remy et al 1997). Within the mycorrhizal species the ectomycorrhizal species are very evident when forming fruit bodies and much study has been devoted to these species.

Whilst macrofungi have been subjected to considerable study these studies are often limited to the occurrence of the fruit bodies (Ratowsky 2007). Studies looking at the occurrence of mycorrhizal species on roots have expanded (Walker et al. 2008) but there are problems in the interpretation of root tips in that a) presence on a root tip does not necessarily relate to the occurrence and abundance of fruit bodies b) it seems to be assumed that the root tip association is stable and unvarying so that much is assumed from single sampling whilst the evidence is that root tip occurrence is dynamic, unstable and subject to considerable variance (seasonally or annually) (Walker et al. 2008) and c) the identity of species is somewhat hazy and often limited to genus and a number to indicate difference from other members of the genus e.g. *Russula* 6 or *Leccinum* 2 (Feest 2009).

Macrofungal surveys are frequently conducted in a non-standardised way and as such are non-comparable. The surveys might state that the survey was between 2-4 hours with no relationship to the size of the site or the extent of coverage. The resultant list of species without quantification of the populations or calculations of the proportional biomass of fruit bodies is of interest only as a record of presence or absence of particular species albeit an enjoyable exercise.

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Fig. 1 – Biodiversity Quality Calculator programme output showing the accumulation of species as each plot is surveyed and the number of specimens of each species. The bottom left hand corner of the chart shows the calculated Biodiversity Quality indices.

Rapley 5 (BF)
16/10/01

Samples used = 20

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Sum	SCVI	BI
GPS easting / SU	88484	88501	88509	88520	88519	88536	88545	88544	88561	88536	88552	88542	88537	88526	88518	88509	88497	88492	88489	88483			
GPS northing / SU	65143	65150	65414	65141	65142	65146	65146	65131	65138	65123	65124	65134	65126	65125	65132	65138	65134	65137	65141	65317			
0: Baeospora myosura	1																				1	3	3.142
1: Cantharellus tubiformis	26	22	122	43	21	63	27	28							145	56	75	25			653	2	18,453.779
2: Gymnopilus penetrans	1																				1	3	19.635
3: Hygrophoropsis aurantiaca	2																				2	2	100.531
4: Mycena galericulata	2		1	1	1					1											6	2	169.646
5: Laccaria amethystina			3		5	10									120	69	25				232	2	6,559.646
6: Phellodon confluens			30													1					31	20	806
7: Mycena vitilis				1					1					1							3	3	9.425
8: Russula emetica var silvestris				1	1		3	1										1			7	3	197.92
9: Russula ochroleuca				1	3				3	1	1			1							10	2	785.398
10: Amanita vaginata					1																1	4	113.097
11: Collybia cookei					1																1	5	0.785
12: Hydnellum spongiosipes						15												14	42	20	91	10	6,665.75
13: Lactarius fulvissimus						1															1	5	50.265
14: Tricholoma portentosum						1															1	4	113.097
15: Lactarius camphoratus							4	1													5	3	141.372
16: Lactarius tabidus							1													1	2	3	56.549
17: Auriscalpium vulgare									1												1	5	3
18: Hypholoma fasciculare									13												13	2	367.566
19: Mycena inclinata									9												9	4	113.097
20: Psathyrella artemisiae									3												3	4	37.699
21: Collybia maculata										7											7	4	791.681
22: Lactarius cimicarius										4	2										6	4	230.907
23: Mycena galopus										3											3	2	9.425
24: Mycena epipterygioides											1										1	10	3.142
25: Scleroderma citrinum											7	5									12	2	942.478
26: Mycena capillaris												1	1						2		4	4	0.4
27: Laccaria laccata													2	14		3					19	2	238.761
28: Cantharellus cibarius														1							1	3	12
29: Cortinarius flexipes var. flexipes														4							4	5	28
30: Hydnum repandum														1	1						2	2	353.32
31: Inocybe lanuginosa														1							1	4	19.635
32: Russula fragilis														1							1	3	28.274
33: Amanita fulva															1		1				2	3	76.969
34: Lyophyllum leucophaeatum																3					3	5	235.619
35: Tricholoma orirubens																1					1	5	78.54
36: Phellodon niger																	12		20		32	4	1,231.36
37: Hydnellum concrescens																			1		1	10	28.27
38: Russula fellea																				1	1	3	78.54
Summary	32	22	156	47	33	90	35	30	30	16	11	6	3	24	267	133	113	40	65	22	1175	4.256	39,154.721

Species Richness = 39
Shannon-Wiener Index = 1.6456(1.8001)
Simpson Index = 2.8081(3.5415)
Berger-Parker Dominance Index = 0.5557(0.4713)
Density = 1.175 per sq.m.
Species Conservation Value Index = 4.2564+/-3.2716
Biomass Index = 39154.7213

Chao1 (pop.) Richness = 63.5+/-13.6416
Chao2 (pres./abs.) Richness = 69.25+/-13.5383
Bootstrap Richness = 52.5205+/-13.9498
Jackknife Richness = 59.9+/-26.0806

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Feest (2006) published a protocol for a standardised survey methodology so that sites might be compared or single sites might be followed for trends over time. This methodology allowed the measurement of a number of indices such that the balance/relationship between these indices will describe the biodiversity quality of the macrofungi of the site. Having the biodiversity quality of the site expressed as numerical indices also allows the statistical comparison of sites for difference temporally or spatially.

The relationship between species of fungi as denoted by the term mycosociology has been developing and in particular the group of species found on nutrient poor well grazed grassland (the CHEG group of species: *Clavaria, Hygrocybe, Entoloma and Geoglossidae*) have been identified as of conservation importance (Rotheroe 1997). The question then becomes can a group of macrofungal species indicate the presence of other, especially rare, species? In the CHEG group this is clearly the case. Can a rare group be indicated to be present by the occurrence of other species? We have applied this argument to the case of stipitate hydnoid species that are the subject of conservation action in the UK due to their perceived rarity.

Our research hypothesis is therefore:

H_1 Stipitate hydnoid species can be indicated as present by the observation of other indicator species.

In this hypothesis stipitate hydnoids are those we found within the genera *Hydnum, Hydnellum, Phellodon* and *Sarcodon.* Indicator species are species whose presence indicates either the presence or absence of Stipitate hydnoids.

Materials and Methods

We utilised a structured sampling process that allowed separate comparable surveys of macrofungi (Feest 2006). This survey methodology examined the fruit body content of 20 × 4m radius sample plots per site. The position of the sample plots was determined by adopting a linear transect through each site such that most parts of the site were visited but not particularly selected thus giving an unbiased picture of the whole site. The total area of the site examined was 20 × $50m^2$ (4m radius circle = 50 m^2) = $1000m^2$ or $1/10^{th}$ hectare. The identity of each species occurring in a plot was confirmed in the field or microscopically (especially for critical species) and the number of fruit bodies of each species also recorded.

The sample sites were five woodland sites in the south of England collectively part of the Bracknell Forest. All sites selected were known to have had stipitate hydnoids present at some time in the past. The samples were taken in October at the time of maximal fruit body formation.

The data from the samples were entered into the biodiversity quality calculator (BQC (Fungib), ecosulis ltd.) and the resultant indices calculated (see Table 1). An example of the BQC output is presented in figure 1. The full dataset of 126 species in 119 plots (one plot did not contain any macrofungi) were entered onto the CAP 4 programme (PISCES Conservation ltd.) and a twinspan analysis conducted on presence absence data (since we were analysing associations) to show how occurrence was related and thus the mycosociology analogous to plant sociology determined.

Results and Discussion

Fig. 2 presents the Twinspan analysis graphical output and shows the relationship between species occurrence. One Stipitate hydnoid (*Phellodon melalleucus*) species occurs separately (in cluster 1) in this presentation and six others (*Hydnellum concrescens, Phellodon niger, Sarcodon scabrum, Phellodon confluens, Hydnellum spongiosipes* and *Hydnum repandum*) occur within a single cluster (cluster 2). Examination of the similarly sorted species shows that both of the clusters consist of almost entirely mycorrhizal species but this reflects that mycorrhizal species outnumber the saprophytic species in the overall sample. Cluster 2 identifies that one stipitate hydnoid species will strongly indicate the presence of other species and that the following species might be regarded as indicators that Stipitate Hydnoids are present: *Cortinarius croceus, Lyophyllum leucophaetum,, Mycena polygramma, Tricholoma columbetta, Amanita vaginata, Armillaria mellea, Cantharellus*

Fig. 2 – Twinspan output showing clustering of stipitate hydnoids and their possible indicators.

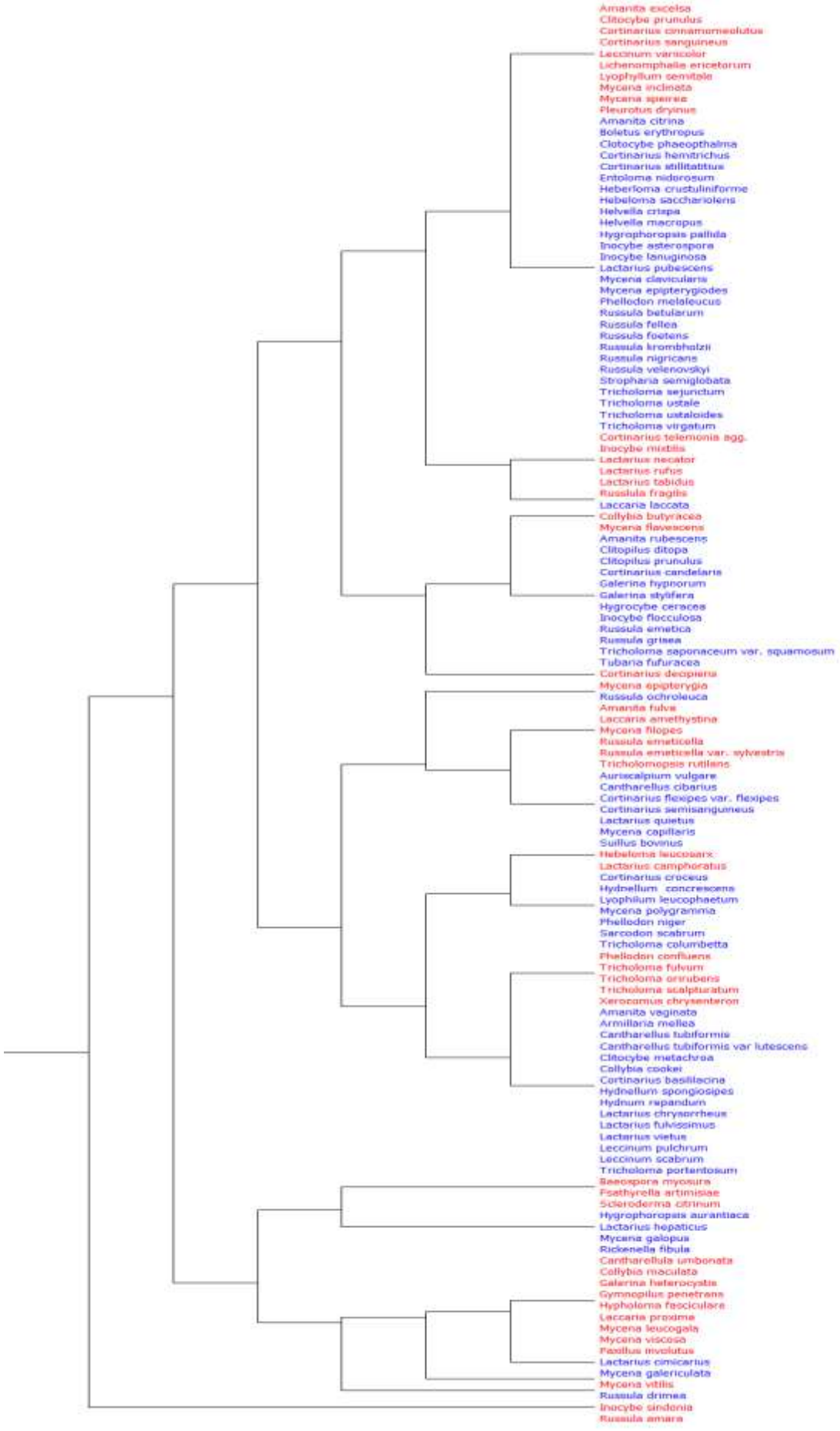

Table 1 Biodiversity quality indices of the five sites surveyed for presence of stipitate hydnoids.

Site	Species Richness	Simpson Index	Fruit body density	Species value Index	Cap area Index
Buttersteep Hill	38	7.604	1.041	4.184	35581
Rapley 3	64	8.371	1.334	3.672	52697
Rapley 4	43	7.321	0.814	3.791	29415
Rapley 5	40	3.145	1.175	4.15	35392
Rapley 9	47	6.668	0.838	3.574	41339

tubaeformis (and *var. lutescens*), *Clitocybe metachroa, Cortinarius basililacina, Lactarius chrysorrheus, Lactarius fulvisimus, Lactarius vietus, Leccinum pulchrum, Leccinum scabrum* and *Tricholoma portentosum*.

Clearly this long list of species has difficulties in use as indicators since it contains some very common species (*Armillaria mellea* and *Mycena polygramma* are very common) and an analysis of the separation of the quadrat divisions output showed that at quadrat division level 5 (Table 2) with an eigenfactor of 0.40032 a positive association of the following was found *Cantharellus tubaeformis, Hydnellum concrescens, Hydnellum spongiosipes, Phellodon confluens* and *Phellodon niger.* Thus the list of indicators has been reduced to a single species: *Cantharellus tubaeformis*. This is a moderately common species probably best described as locally common and as such probably a good indicator of the presence of the stipitate hydnoids. Review of the species negatively indicated gives four species whose presence might indicate the absence of stipitate hydnoids: *Laccaria laccata, Lactarius tabidus, Russula ochroleuca* and *Mycena galopus.* These are all very common species and thus the combination of the presence of *C. tubaeformis* and the absence of *L. laccata, L. tabidus, R. ochroleuca* and *M. galopus* should enable a more targeted search for stipitate hydnoids.

Field evidence was that we clearly noticed *C. tubaeformis* was present when we found stipitate hydnoids and that the sites were frequently mossy earth banks and slopes with sharp drainage implying that dryness of the substrate was a requirement. This therefore complemented the above analysis.

Table 2 Twinspan output showing indicators of presence and absence of stipitate hydnoids.

QUADRAT DIVISION 5 Number of quadrates in cluster = 104
eigenvalue = 0.400382 number of iterations = 5
Indicators and their sign
Cantharellus tubiformis [+];
Laccaria laccata [-];
Lactarius tabidus [-];
Russula ochroleuca [-];
Mycena galopus [-];

Variables preferring the negative group of quadrats
Laccaria laccata 1 (31, 1) Lactarius tabidus 1 (26, 2) Mycena galopus 1 (25, 2) Russlula fragilis 1 (15, 3) Scleroderma citrinum 1 (20, 0)

Variables biased towards the positive group of quadrats
Cantharellus tubiformis 1 (4, 27) Hydnellum concrescens 1 (6, 7) Hydnellum spongiosipes 1 (3, 8) Phellodon confluens 1 (2, 8) Phellodon niger 1 (6, 10)

Variables with no quadrat preference
Laccaria amethystina 1 (28, 14) Mycena galericulata 1 (20, 8) Mycena vitilis 1 (10, 8) Russula emeticella var. sylvestris 1 (29, 14) Russula ochroleuca 1 (44, 12)

Conclusions

The use of a standardized sampling process has allowed analysis macrofungal fruit bodies to provide a list of five species indicating the presence or absence of stipitate hydnoids. In particular the presence of a suite of four common species eliminates a large number of sites from consideration and this accords with the rarity of records of stipitate hydnoids. Stipitate hydnoids are a clearly defined group of species and it remains to be seen whether other species groups could be subject to the same analysis.

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