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Size and shape of basidiospores in the Hymenomycetes

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Summary. - Basidiospores of the species of Hymenomycetes are of moderate size (mean length L = 8.4 µm, width W = 4.9 µm, volume V = 156 µm^3) and elongated form (mean L/W quotient Q = 1.80). According to the Stokes' law, velocity of falling of spores in atmosphere of 80% of species might be about 0.3-2.7 mm/s (average: 1 mm/s). Variation of L and W data are approximately normal at individual and specific levels in Hymenomycetes; unlike this, variation of spore length, width and (transformed to equivalent spore diameter D) volume data at generic, family and order levels are in most cases log-normal or hyperlog-normal. As a general rule, supraspecific variation of spore characters is asymmetric. Comparison of mean L, W, Q and D values in Aphyllophorales, Agaricales and Polyporaceae demonstrates, that these parameters are different between these groups at 0.001 significance level. In Agaricales and Aphyllophorales, in only 10 cases out of 309 both spore size and spore shape are not significantly different in any two families compared. The differences are significant both statistically and biologically; taxonomically the statistical spore data are properties of families but not diagnostic characters.

INTRODUCTION

Strategies of organismic and specific dispersal of fungi are correlated with the number of spores produced by an individual, with spore size and spore shape. There is great diversity of dispersal strategies in different groups of fungi, obviously connected not only with life forms but also with their taxonomic position, i. e. with their phylogenetic origin.

Basidiospores are the main propagules in the Hymenomycetes. The aim of this paper is to characterize the size and shape of these spores, and to find possible differences between families and orders of Hymenomycetes. However, there are no detailed studies on spore size and spore form either for Hymenomycetes or for Fungi in general (Pentecost, 1981: 677). The few literature data available are given below.

Singer (1986: 80) stated that "the size of the basidiospores ranges from 2 to 48.5 µm in length and accordingly in volume" in Agaricales. On p. 73 he asserted that cylindrical (rarely fusoid or ellipsoid-oblong) spores are characteristic for wood-inhabiting species, and even more for Polyporaceae where this shape is a family character. Kramer (1982: 34) assumed that the spores of the saprotrophic Hymenomycetes are mostly 5-7 µm long and elongated. Einhellinger (1985: 280) calculated the mean volume of spores in 83 taxa of the genus Russula and found it to be 215 m^3. A one-page abstract on the size of basidiospores in the families of Agaricales was published by the authors of this paper (E. & I. Parmasto, 1989).

Pentecost (1981) studied spore size and shape of British lichen ascospores and of a sample of non-lichenized Ascomycetes of the same country. Matsumoto & Tajimi (1985) demonstrated, that in obligate plant parasitic fungi asexual spores are less variable when compared with saprotrophic species or with non-obligate parasites. They asserted the spores of white rust, downy mildew, powdery mildew and rusts to be "invariably subglobose to ellipsoidal and of moderate size, ranging 19.9-32.2 x 14.5-21.8 µm".

Taxonomy of Hymenomycetes is not well established even at family level. In this paper families of Agaricales are defined according to Singer (1986); families of Aphyllophorales mainly following Donk (1964) and Parmasto (1968, 1986). A list of genera which include polyporoid and clavarioid families, Polyporaceae and Steccherinaceae, as well as a list of families of Cantharellomycetes and Corticiomycetes are given in the Appendix. Polyporaceae are treated separately, i.e. not included either in Aphyllophorales or in Agaricales.

Methods

Spore length and width were calculated as the average of the range of measurements given for any species in the literature. The many books and articles used is too long to be listed here. Altogether, data for 9650 species have been used. The number of species in Hymenomycetes has been given as 8000 in Ainsworth & Bisby's Dictionary of Fungi (Hawksworth, Sutton & Ainsworth, 1983: 189); consequently, most species of Hymenomycetes and possibly also a number of synonymous ones have been included.

When mean spore length and mean width were indicated in literature, these were used. Extreme measurements given in brackets were omitted.

Spore shape was designated as the quotient of mean spore length to mean spore width ($Q = L/W$).

Mean spore volume for a species was calculated employing the formulas used by Corner (1948): for more or less spherical or ellipsoid spores ($Q < 2$)

$$V = 0.5236\, L\, W^2;$$

for elongated and cylindrical spores ($Q \geq 2$)

$$V = 0.5236\, W^3 + 0.7854\, W^2\, (L - W).$$

For statistical estimation and comparison spore volume of each species was transformed to equivalent sphere diameter (D). However, in most aerobiological studies particles under study are frequently treated as spheres: there are not any good formulas to describe particles (incl. spores) of other form falling in air (see Gregory, 1973).

The data sources used raise a number of problems. Spore measurements given in handbooks, articles, and descriptions of new species are usually not adequate (see Parmasto & Parmasto, 1987: 11-12). Spore size given in various papers is usually based on the measurement of insufficient number of spores from an insufficient number of specimens, and is usually rounded to the nearest half or full µm. Methods of measurement and how these are given differ with the author; there may be systematical errors in papers compiled by some author. One and the same species may have been treated several times under synonymic names unnoticed by us. One part of the biases is caused by attitude of authors of handbooks, monographs, etc. According to the distribution of means calcuated by us, range of spore measurements has been indicated in most papers as full micrometers. When spore length is less than about 6-7 µm, the limit of spore length variation is usually given as 1 µm (e. g., "4-5 µm long"); when spore length is more than 10 µm, limit of spore variation is more frequently given as even number (e. g., "10-12 µm", "12-14 µm", or "12-16 µm" but not "10-13 µm", "12-15 µm" or "13-16 µm"). When using chi-square test or studying distribution fitting, lower and upper limits of variation and number of groups would be chosen in accordance with this biases.

However, most of the biases are obviously randomly distributed, i. e. without any trend, and in large groups of species (i. e., in most families) they obviously balance each other out.

Spore volumes calculated have two main sources of error. First, spores of the Hymenomycetes are never isodiametric, and "spore width" is only one measurement of the two needed for more exact calculations. Secondly, spore form is neither exactly ellipsoidal nor cylindrical with hemispherical ends as assumed in the formulas used by us.

In comparison of mean V and Q values using analysis of variance, the main obstacle is usually non-normality of the frequency distribution. In many cases this may be surpassed using D values instead of V, and log- or hyperlog- {Log(log)-}transformation of the data. When D or Q values have different frequency distributions in the families compared, only nonparametric methods are available. Pentecost (1981: 669) used Mann-Whitney U-test in his comparison of groups of Discomycetes. Two different methods were applied in this study:

1. Analysis of variance in all cases when distribution of data was normal or log-normal in both taxa; accordingly species data or their log-transformations were used. In some cases log(log)transformation was used, but in most cases it was technically impossible (log(log) values below zero!).

2. Informational chi-square test in all cases when the two taxa under study have different types of data distribution, or when the data do not fit with any of the distribution types indicated above.

Results

Statistics of the spores of Hymenomycetes

Abbreviations: L: spore length; W: spore width; Q: spore length/width ratio; V: spore volume; D: equivalent diameter of spores; Mo: mode; Significance level (first number: of chi-square test, second: when present, of Kolmogorov-Smirnov test); g_1: coefficient of skewness; g_2: coefficient of kurtosis.

After the abbreviation following statistics (or parameters) are mentioned: arithmetic mean; in parentheses observed range (minimal and maximal values), then 10 and 90% percentiles; mode; characterization of distribution type (distribution curve) where "obviously" means that it has been characterized visually, g_1 and g_2 values given in parentheses are valid for the distribution type indicated before these.

A condensed version of the data represented below is also given in Table 1.

Hymenomycetes in general
(9560 species in 555 genera)

Spore lengths (fig. 1; table 2)

Mean = 8.36 µm (2.25-32.75 µm; 80% of specimens (according to 10% and 90% percentiles) 4.9-12.3 µm ; Mo = 7.9). Distribution curve approximately log-normal (g_1 = -0.15; g_2 = 0.13). There are 52 species with spore length less than 3 µm; only 3 of them belong to Agaricales, 6 to Polyporaceae; 43 species belong to Aphyllophorales. 44 species have spore length more than 20 µm ; 13 of them belong to Agaricales and 31 to Aphyllophorales. Shortest spores (2.25 µm) occur in *Heteroporus flavus, Podoscypha mellisii, "Poria" totara* and *Trichaptum basifuscum;* largest spores (32.75 µm) occur in *Marasmius megistosporus.*

Spore widths (fig. 2)

Mean = 4.94 µm (0.60-22.50; 80% 2.25-8.25; µm Mo = 4.35). Distribution curve appr. log-normal but negatively skewed and leptokurtic (g_1 = -.0.47; g_2 = 1.15).

Spore quotients (fig. 3)

Mean = 1.80 (0.86-7.28; 80% 1.07-3.05; Mo = 1.7). Distribution curve obviously hyperlog-normal: log-curve positively curved and leptokurtic (g_1 = 0.66; g_2 = 0.62).

Spore volume (fig. 5; table 3)

Mean = 156.08 µm3 (0.74-6162.9; 80% 13.9-440.3; Mo= 20.5). Distribution curve obviously hyperlog-normal.

There are 27 species with spore volume less than 3 µm³; only one belongs to Agaricales (*Panellus microsporus*), most of the others belong to the pore fungi. 30 species have spore volume more than 1800 µm³; 6 of them belong to Agaricales and 24 toAphyllophorales. Smallest spores (about 0.75 µm³) has *Gloeoporus coceopallens*, largest spores (about 6163 µm³) occur in *Oudemansiella australis*.

Equivalent diameter of spores (fig. 4)

Mean = 5.95 µm (1.12-22.75; 80% 2.98-9.44; Mo= 5.1). Distribution curve m ay be described as asymmetrical: with normal left-hand limb, and log-normal right-hand limb (log-curve negatively skewed: g_1 = -0.39; g_2 = 0.63).

Statistics of the spores of the orders of Hymenomycetes (Figs. 6-8)

Agaricales (6011 species in 166 genera)

L = 8.87 µm (2.7-32.8; 80% 5.7-12.5; Mo = 8.5); appr. log-normal (g_1 = -0.11; g_2 = 0.34).
W = 5.26 (0.8-22.5; 80% 3.4-7.5; Mo = 4.5); appr. log-normal (g_1 = -0.09; g_2 = 0.47).
Q = 1.76 (0.86-7.28; 80% 1.20-2.38; Mo= 2.0); obviously appr. hyperlog-normal (log-curve: g_1 = 0.64; g_2 = 0.87).
V = 165.95 µm³ (1.6-6162.9; 80% 41.7-330.1; Mo= 84.8).
D = 6.32 µm (1.46-22.75; 80% 4.3-8.6; Mo = 5.6); appr. log-normal (g_1 = -0.21; g_2 = 0.53).

Aphyllophorales (except Polyporaceae; 3344 species in 373 genera)

L = 7.42 µm (2.2-29.0; 80% 4.0-11.5; Mo = 4.5); appr. log-normal (g_1 = 0.27; g_2 = -0.18).
W = 4.41 µm (0.6-21.5; 80% 2.2-7.3; Mo = 3.5); appr. log-normal (g_1 = -0.13; g_2 = 0.45).
Q = 1.85 (0.8-6.9; 80% 1.1-2.8; Mo = 1.0); obviously appr. hyperlog-normal (log-curve: g_1 = 0.56, g_2 = -0.14).
V = 139.84 µm³ (0.7-5687.8; 80% 11.4-293.2; Mo = 24.9).
D = 5.31 µm (1.30-21.55; 80 % 2.8-8.2; Mo = 3.6); appr. log-normal (< 0.001; g_1 = 0.05; g_2 = 0.09).

Statisticsof the alternative taxonomic groups of Hymenomycetes (See Parmasto, 1986: 12, and appendix of this paper).

Cantharellomycetes (7173 species in 270 genera)

L = 8.77 µm (2.2-32.8; 80% 5.5-12.5; Mo = 7.95); appr. log-normal (g_1 = -0.28; g_2 = 0.47).
W = 5.14 µm (0.8-22.5; 80% 3.2-7.3; Mo = 4.55); log-normal (g_1 = -0.13; g_2 = 0.11).
Q = 1.77 (1.0-7.3; 80% 1.2-2.5; Mo = 1.75); obviously appr. hyperlog-normal (log-curve: g_1 = 0.65; g_2 = 0.64).
V = 160.5 µm³ (1.6-6162.9; 80% 36.6-324.0).
D = 6.22 µm (1.46-22.75; 80% 4.12-8.52; Mo = 5.15); appr. log-normal but fit not good (g_1 = -0.27; g_2 = 0.25).

Corticiomycetes (2319 species in 291 genera)

L = 7.14 µm (2.2-29.0; 80% 4.0-11.3; Mo = 4.5); obviously appr. hyperlog-normal (log-curve:g_1 = 1.95; g_2 = 5.42).

W = 4.33 µm (0.6-21.5; 80% 2.0-7.5; Mo = 2.25); obviously appr. hyperlog-normal (log-curve: g_1 = 1.93; g_2 = 6.21).
Q = 1.86 (1.0-6.9; 80% 1.1-3.0; Mo = 1.0); obviously appr. hyperlog-normal (log-curve: g_1 = 0.59;g_2 = -0.24).
V = 153.1 µm^3 (0.7-5687.8; 80% 10.6-297.5; Mo = 24.9).
D = 5.19 µm (1.11-26.90; 80% = 2.72-8.28; Mo = 3.6); obviously appr. hyperlog-normal (log-curve:g_1 = 2.19; g_2 = 8.12).

Statistics of the spores of Hymenomycete families

(Families with less than 15 species are omitted). Table 1.

Agaricaceae (370 species in 19 genera; fig. 9)

L = 6.70 µm (2.7-17.5; 80% 4.2-9.5; Mo = 5.0); log-normal (α = 0.63; 1.00).
W = 4.04 µm 1.8-11.5; 80% 2.6-5.5; Mo = 3.5); log-normal (α = 0.42; 0.19).
Q = 1.68 (1.00-3.56; 80% 1.33-2.05; Mo = 2.0); obviously hyperlog-normal.
V = 79.70 µm^3 (5.9-1211.8; 80% 16.8-154.4).
D = 4.84 µm (2.2-13.2; 80% 3.2-6.7; Mo = 3.6); hyperlog-normal (α = 0.83; 1.00).

Albatrellaceae (44 species in 12 genera)

L = 5.98 µm (3.7-14.5; 80% 4.2-8.8; Mo = 4.5); hyperlog-normal (α = 0.90; 1.00).
W = 4.22 µm (2.2-7.2; 80% 3.0-5.8; Mo = 4.0); hyperlog-normal (α = 0.23; 1.00).
Q = 1.45 (1.09-3.00; 80% 1.14-1.81; Mo = 1.3); distr. curve obviously truncated log-normal; 4 species with high Q values (2.20; 2.33; 2.90; 3.00).
V = 68.11 µm^3 (9.9-252.0; 80% 20.0-155.8).
D = 4.75 µm (2.7-7.8; 80% 3.4-6.7; Mo = 3.8); hyperlog-normal (α = 0.33; 1.00).

Amanitaceae (80 species in 3 genera)

L = 9.44 µm (4.0-14.5; 80% 5.0-12.4; Mo = 11.0); appr. normal (α = 0.002; 0.18) or log-normal (= 0.02; 0.01).
W = 7.27 µm (3.0-13.5; 80% 4.5-10.4; Mo = 7.5); log-normal (α= 0.62; 0.52)
Q = 1.34 (1.00-2.31; 80% 1.00-1.67; Mo = 1.0); appr. log-normal but fit not good, m any species with Q value near 1.0.
V = 323.45 µm^3 (22.1-1383.7; 80% 47.7-607.9).
D = 7.92 µm (3.5-13.8; 80% 4.5-10.5; Mo = 4.5); appr. normal (α = 0.09; 1.00)

Apheliaceae (16 species in 4 genera)

L = 7.34 µm (3.6-14.0); W = 5.28 µm (3.2-9.0); Q = 1.39 (1.07--2.36); V = 140.25 µm^3 (20.2-593.8); D = 5.90 µm (3.4-10.4).

Auriscalpiaceae (19 species in 4 genera)

L = 5.14 µm (3.5-9.3); W = 3.99 µm (2.6-7.0); Q = 1.29 (1.00-1.6 5); V = 51.47 µm^3 (13.3-237.3); D = 4.34 µm (2.9-7.7).

Bankeraceae (21 species in 2 genera)

L = 4.23 µm (3.3-5.1); W = 3.58 µm (2.8-4.5); Q = 1.19 (1.00-1.6 0); V = 29.21 µm^3 (14.2-53.0); D = 3.78 (3.0-4.7).

Bjerkanderaceae (168 species in 27 genera)

L = 5.00 µm (2.3-10.0; 80% 3.5-6.8; Mo = 4.5); appr. log-normal (α = 0.06; 0.12).
W = 2.72 µm (0.6-6.5; 80% 1.3-4.3; Mo = 2.25); appr. normal (α = 0.005; 0.24).
Q = 2.16 (1.00-5.77; 80% 1.27-3.89; Mo = 2.0); obviously appr. hyperlog-normal.
V = 27.26 µm^3(0.7-188.5; 80 % 4.8-58.3).
D = 3.39 µm (1.1-7.1; 80% 2.1-4.8;Mo = 3.05); log-normal (α = 0.43; 1.00).

Bolbitiaceae (116 species in 6 genera)

L = 10.92 μm (5.0-20.0; 80% 7.5-14.0; Mo = 12.25); log-normal (α = 0.32; 1.00).
W = 6.38 μm (3.5-11.1; 80% 4.5-8.9 ; Mo = 4.5); appr. log-normal (α = 0.13; 0.31).
Q = 1.73 (1.26-2.48; 80% 1.50-1.95; Mo = 1.7); log-normal (0.74; 1.00).
V = 283.63 μm^3(32.1-1267.1; 80% 76.9-572.6).
D = 7.66 μm (3.9-13.4; 80% 5.3-10.3; Mo = 6.8); log-normal (α = 0.48; 1.00)

Boletaceae (373 species in 12 genera)

L = 12.10 μm (4.0-25.5; 8.0-16.0; Mo = 10.5); appr. log-normal (α = 0.01; 0.02).
W = 4.77 μm (2.7-10.3; 80% 3.5-6.0; Mo = 4.5); appr. log-normal (α = 0.015; 0.015).
Q = 2.59 (1.07-4.31; 80% 1.87-3.25; Mo = 3.0); appr. normal (α < 0.001; = 0.37).
V = 208.52 μm^3 (17.0-1358.0; 80% 70.6-384.1).
D = 7.00 μm (3.2-13.7; 80% 5.1-9.7; Mo = 6.8); log-normal (α = 0.40; 1.00).

Cantharellaceae (86 species in 4 genera)

L = 8.76 μm (4.5-14.2; 80% 6.5-10.5; Mo = 9.0); normal (α = 0.27; 1.00).
W = 5.96 μm (3.0-9.8; 80% 4.1-8.0; Mo = 5.5); normal (α = 0.07; 1.00).
Q = 1.50 (1.09-2.25; 80% 1.26-1.79; Mo = 1.45); log-normal (α = 0.45; 1.00).
V = 185.28 μm^3 (25.9-666.8; 80% 62.4-346.7).
D = 6.86 μm (3.7-10.8; 80% 4.9-9.0; Mo = 6.23); log-normal (α = 0.65; 1.00).

Clavariaceae (126 species in 5 genera)

L = 6.42 μm (2.8-12.5; 80% 4.0-9.0; Mo = 6.5); appr. normal (α = 0.02; 0.09).
W = 4.23 μm (2.1-8.5; 80% 2.7-6.3; Mo = 3.0); appr. log-normal (α < 0.001; = 0.05).
Q = 1.60 (1.00-4.23; 80% 1.11-2.24; Mo = 1.3); log-normal (α < 0.001; = 0.11) or obviously hyperlog-normal.
V = 78.57 μm^3 (6.9-425.6; 80% 16.9-196.8).
D = 4.90 μm (2.4-9.3; 80% 3.2-7.2; Mo = 4.3); log-normal (α = 0.76; 1.00).

Clavariadelphaceae (145 species in 7 genera)

L = 9.87 μm (4.5-18.5; 80% 6.5-13; Mo = 9.0); appr. log-normal (= 0.013; 0.02) with a saddle at about 7 μm .
W = 4.43 μm (2.0-8.1; 80% 3.2-5.6; Mo = 3.25); appr. log-normal (= 0.005; 1.00).
Q = 2.26 (1.12-3.70; 80% 1.8-3.0; Mo = 2.0); appr. log-normal (= 0.03; 0.52).
V = 142.75 μm^3 (12.0-754.1; 80% 40.6-237.7).
D = 6.13 μm (2.8-11.3; 80% 4.3-7.7; Mo = 5.9); log-normal (= 0.18; 0.19).

Clavulinaceae (35 species in 2 genera)

L = 8.82 (4.7-11.8; 80% 6.7-11.0; Mo = 9.0); normal (α = 0.31; 0.51).
W = 7.45 μm (4.0-10.0; 80% 5.7-9.0; Mo = 6.75); normal (α = 0.24; 1.00).
Q = 1.20 (1.00-1.86; 80% 1.07-1.38; Mo = 1.1); obviously hyperlog-normal.
V = 278.37 μm^3 (39.8-605.1; 80% 118.9-445.3).
D = 7.87 μm (4.2-10.5; 80% 6.1-9.5; Mo = 8.3); normal (α = 0.41; 1.00).

Coniophoraceae (39 species in 9 genera)

L = 9.08 μm (4.0-26.0; 80% 4.5-16.5; Mo = 11.0); appr. hyperlog-normal (α = 0.02; 1.00).
W = 5.12 μm (1.7-8.5; 80% 2.7-7.0; Mo = 6.25); appr. normal (α = 0.09; 1.00).
Q = 1.74 (1.00-3.42; 80%: 1.37-2.67); obviously hyperlog-normal
V = 195.94 μm^3 (8.2-1314.6; 80% 18.8-523.1).
D = 7.73 μm (2.7-26.9; 80% 3.3-17.5; Mo = 6.55); appr. hyperlog–normal but fit not good (α = 0.04; 1.00).

Coprinaceae (663 species in 6 genera)

L = 9.58 µm (4.5-20.5; 80% 6.7-13.5; Mo = 8.0); obviously hyperlog-normal but fit not good (α < 0.001; = 0.005).
W = 5.48 µm (2.6-11.5; 80% 4.0-7.5; Mo = 4.5); appr. hyperlog–normal but fit not good.
Q = 1.77 (1.00-2.60; 80% 1.45-2.04; Mo = 2.0); appr. normal (α = 0.013; 0.045).
V = 192.40 μm^3 (17.7-1419.6; 80% 59.4-410.5).
D = 6.68 µm (3.2-13.9; 80% 4.8-9.2; Mo = 5.45); appr. hyperlog-normal (α = 0.006; 0.11).

Coriolaceae (306 species in 46 genera)

L = 6.52 µm (2.4-20.0; 80% 3.5-11.0; Mo = 6.0); appr. hyperlog-normal (α = 0.03).
W = 3.26 µm (0.7-8.5; 80% 1.6-5.4; Mo = 2.25); appr. log-normal (α = 0.02; 0.06).
Q = 2.16 (1.00-5.12; 80% 1.18-3.15; Mo = 3.0); appr. log-normal but fit not good (< 0.001; = 0.02), distribution curve with a saddle at about 1.7-2.0.
V = 63.66 μm^3 (1.3-567.5; 80% 5.8-150.5).
D = 4.25 µm (1.3-10.3; 80% 2.2-6.6; Mo = 3.3); log-normal (α = 0.90; 1.00).

Corticiaceae (799 species in 129 genera; fig. 10)

L = 7.71 µm (3.0-26.0; 80% 4.2-12.8; Mo = 6.0 ; appr. hyperlog-normal (α = 0.004; 0.01).
W = 4.35 µm (0.6-21.5; 80% 2.2-7.3; Mo = 2.25); obviously appr. hyperlog-normal.
Q = 1.96 (1.00-5.78; 80% 1.17-2.97; Mo = 1.0); appr. log-normal (α= 0.02; 0.12).
V = 191.83 μm^3 (1.1-5687.8; 80% 13.1-325.2).
D = 5.36 µm (1.3-22.2; 80% 2.9-8.5; Mo = 3.4); appr. hyperlog–normal (α = 0.06; 0.25).

Cortinariaceae (971 species in 12 genera)

L = 9.57 µm (4.2-18.5; 80% 7.0-12.3; Mo = 9.0); appr. log-normal but fit not good.
W = 5.70 µm (3.0-10.2; 80% 4.5-7.0; Mo = 5.5); appr. log-normal but fit not good.
Q = 1.69 (1.0-2.92; 80% 1.35-2.00; Mo = 2.0); appr. normal (α< 0.001; = 0.007).
V = 183.66 μm^3 ((21.4-1036.0; 80% 78.5-310.1).
D = 6.82 µm (3.4-12.6; 80% 5.3-8.4; Mo = 6.7); appr. log-normal (α = 0.005).

Crepidotaceae (176 species in 8 genera)

L = 7.09 µm (4.5-11.0; 80% 5.3-9.0; Mo = 7.0); appr. normal (α= 0.03; 0.07).
W = 5.14 µm (2.7-9.1; 80% 4.0-6.3; Mo = 5.0); normal (α= 0.20; 0.06).
Q = 1.41 (1.00-2.55; 80% 1.00-1.79; Mo = 1.0); distribution curve irregular, with a deep saddle at 1.1-1.3.
V = 104.03 μm^3 (24.9-401.1; 80% 56.1-147.8).
D = 5.71 µm (3.6-9.2; 80% 4.7-6.6; Mo = 5.75); appr. normal (α= 0.01; 0.23).

(Aphyllophoroid) Cyphellaceae (48 species in 9 genera)

L = 7.71 µm (3.2-17.0; 80% 4.3-13.5; Mo = 5.5); hyperlog-normal (α= 0.45; 1.00).
W = 5.00 µm (2.1-15.5; 80% 2.5-8.0; Mo = 4.0); log-normal (α= 0.32; 1.00).
Q = 1.63 (1.00-3.71; 80% 1.08-2.14; Mo = 1.8); obviously appr. hyperlog-normal but fit not good.
V = 170.23 μm^3 ((8.6-2138.5; 80% 18.8-412.3).
D = 5.78 µm (2.5-16.0; 80% 3.3-9.2; Mo = 5.45); appr. log-normal (α = 0.035; 1.00) but with a saddle at about 6.7-8.5 µm .

Dichostereaceae (97 species in 4 genera)

L = 8.99 µm (2.9-22.5; 80% 4.5-15.3; Mo = 5.5); distribution curve bimodal with Modes at about 5.5 and 15 µm , and with a saddle at about 9.5-12 µm .
W = 4.25 µm (2.0-8.5; 80% 2.7-6.5; Mo = 6.0); distribution curve rather irregular, platykurtic.
Q = 2.20 (1.00-6.92; 80% 1.00-4.18; Mo = 1.0); distribution curve obviously truncated log-normal.
V = 122.41 μm^3 ((8.6-378.5; 80% 20.9-263.2).
D = 5.72 µm (2.5-9.0; 80% 3.4-8.0 Mo = 7.25); normal (α = 0.59; 1.00)

Entolomataceae (472 species in 3 genera)

L = 9.57 µm (4.2-18.0; 80% 7.3-11.5; Mo = 11.0); appr. normal (α = 0.001; 0.09).
W = 7.17 µm (2.7-13.5; 80% 5.7-8.8; Mo = 7.0); obviously appr. normal but fit bad.
Q = 1.35 (1.00-2.19; 80% 1.03-1.63; Mo = 1.0); appr. log-normal (α < 0.001; = 0.06) but fit bad.
V = 279.41 μm^3 ((16.8-1288.3; 80% 127.8-445.3).
D = 7.88 µm (3.2-13.5; 80% 6.2-9.5; Mo = 7.5); obviously appr. normal (α < 0.001; = 0.07).

Favolaschiaceae (56 species in 1 genus)

L = 8.63 µm (5.9-12.5; 80% 6.8-10.7; Mo = 8.25); log-normal (α = 0.15; 1.00).
W = 5.90 µm (3.8-9.5; 80% 4.5-8.0; Mo = 4.5); hyperlog-normal (α = 0.22; 1.00).
Q = 1.50 (1.09-2.20; 80% 1.22-1.78; Mo = 1.35); log-normal (α = 0.69; 1.00).
V = 175.28 μm^3 ((50.3-519.8; 80% 76.9-349.9).
D = 6.69 µm (4.6-10.0; 80% 5.3-8.7; Mo = 6.35); log-normal (α = 0.18; 1.00).

Fomitopsidaceae (45 species in 8 genera)

L = 7.10 µm (3.2-11.7; 80% 4.0-10.5; Mo = 7.0); normal (α = 0.11; 1.00).
W = 3.16 µm (1.2-5.8; 80% 2.0-4.5; Mo = 3.75); normal (α = 0.27; 1.00).
Q = 2.34 (1.21-3.50; 80% 1.45-3.20; Mo = 2.6); normal (α = 0.64; 1.00).
V = 53.19 μm^3 (3.5-136.0; 80% 11.1-107.6).
D = 4.37 µm (1.9-6.4; 80% 2.8-5.9; Mo = 4.6); normal (α = 0.25; 1.00).

Ganodermataceae (122 species in 4 genera)

L = 11.14 µm (6.7-29.0; 80% 8.3-14.5; Mo = 10.0); appr. hyperlog- normal (α = 0.003; 0.13).
W = 7.97 µm (4.3-17.0; 80% 5.7-11.0; Mo = 6.25); hyperlog-normal (α = 0.46; 0.44).
Q = 1.43 (1.00-2.95; 80% 1.09-1.71; Mo = 1.5); appr. log-normal (α = 0.04; 0.36).
V = 466.90 μm^3 (77.9-4388.3; 80% 171.5-865.9).
D = 8.89 µm (5.3-20.3; 80% 6.9-11.8; Mo = 7.75); hyperlog-normal (α = 0.11; 0.31).

Gomphaceae (215 species in 11 genera)

L = 10.46 µm (3.9-25.0; 80% 6.9-14.7; Mo = 10.0); log-normal (α = 0.19; 1.00).
W = 4.89 µm (2.1-9.8; 80% 3.5-6.7; Mo = 4.0); appr. log-normal (α = 0.001; 0.04).
Q = 2.18 (1.00-5.56; 80% 1.54-2.82; Mo = 2.0); log-normal (α = 0.45; 1.00).
V = 181.92 μm^3 (19.8-1284.8; 80% 58.5-343.7).
D = 6.60 µm (3.4-13.5; 80% 4.8-8.7; Mo = 7.2); log-normal (α = 0.07; 1.00).

Hericiaceae (29 species in 3 genera)

L = 4.95 µm (2.7-7.5; 80% 3.6-6.6); W = 3.53 µm (1.7-5.6; 80% 2.0-5.5);
Q = 1.47 (1.15-2.63; 80% 1.19-2.00); V = 40.58 μm^3 (7.3-123.2; 80% 7.9-104.5);
D = 3.97 µm (2.4-6.2; 80% 2.5-5.8)

Hygrophoraceae (321 species in 9 genera)

L = 8.18 µm (3.7-16.0; 80% 5.8-10.5; Mo = 8.0); appr. log-normal (α< 0.001; = 0.02).
W = 5.05 µm (2.6-10.0; 80% 4.0-6.5; Mo = 4.5); appr. log-normal (α= 0.0005; 0.002).
Q = 1.63 (1.00-3.46; 80% 1.22-1.95; Mo = 2.0); appr. normal (α= 0.0001; 0.14).
V = 125.98 μm^3 (16.8-706.9; 80% 47.7-232.3).
D = 5.95 µm (3.2-11.1; 80% 4.5-7.6; Mo = 5.45); appr. log-normal (α= 0.03; 0.35).

Hymenochaetaceae (321 species in 15 genera)

L = 5.55 µm (2.5-13.0; 80% 3.5-8.0; Mo = 4.5); log-normal (α = 0.58; 0.12).
W = 3.79 µm (0.7-12.3; 80% 1.7-5.8; Mo = 3.25); appr. normal (α= 0.003; 0.14).
Q = 1.64 (1.00-5.00; 80% 1.10-2.62; Mo = 1.0); obviously appr. truncated hyperlog-normal.
V = 58.91 μm^3 1.3-962.5; 80% 9.1-131.9).
D = 4.31 µm (1.4-12.3; 80% 2.6-6.3; Mo = 3.6); log-normal (α = 0.35; 1.00).

Paxillaceae (31 species in 7 genera)

L = 7.45 µm (3.6-14.8; 80% 4.5-11.9); W = 4.94 µm (2.5-13.0; 80% 3.2-6.5);
Q = 1.52 (1.00-2.32; 80% 1.12-1.90); V = 143.56 µm^3 (11.8-1150.4; 80% 23.8-259.4);
D = 5.67 µm (2.8-13.0; 80% 3.57- 7.91).

Physalacriaceae (36 species in 4 genera)

L = 7.08 µm (3.2-16.5; 80% 4.1-11.5; Mo = 5.5) W = 3.31 µm (1.9- 5.0; 80% 2.4-4.8; Mo = 2.5);
Q = 2.12 (1.00-6.00; 80% 1.40-2.88; Mo = 2.0); V = 60.35 µm^3 (8.6-198.8; 80% 11.4-149.3);
D = 4.44 µm (2.5-7.2; 80% 2.8-6.6).

Pluteaceae (109 species in 3 genera)

L = 6.87 µm (5.0-15.0; 80% 5.5-8.3; Mo = 6.0); appr. log-normal (α = 0.07; 0.31) but most species with spores up to 9 µm long, two species 12.5 and 15.0 µm long.

W = 5.24 µm (3.0-8.5; 80% 4.0-6.2 µm ; Mo = 5.5), in Most species up to 6.5 µm , two species 8.5 µm wide; distribution curve negatively skewed.

Q = 1.32 (1.00-2.08; 80% 1.14-1.57; Mo = 1.18); appr. log-normal (α= 0.008; 0.45) but distribution curve with a gap at about 1.6-1.75.

V = 106.72 µm^3 (25.4-567.5; 80% 48.9-155.8)

D = 5.72 µm (3.6-10.3; 80% 4.5-6.7); Mo = 5.8); appr. log-normal (α = 0.026; 0.26); all species except two with D < 7.2 µm .

Podoscyphaceae (60 species in 6 genera)

L = 5.13 µm (2.2-9.8; 80% 3.3-7.4; Mo = 6.0); log-normal (a = 0.25; 1.00).
W = 3.19 µm (1.4-6.3; 80% 2.0-4.6; Mo = 2.1); log-normal (a = 0.48; 1.00).
Q = 1.65 (1.12-3.11; 80% 1.29-2.36; Mo = 1.3); obviously hyperlog-normal.
V = 36.71 µm^3 (2.2-143.2; 80% 6.9-82.2).
D = 3.78 µm (1.6-6.5; 80% 2.4-5.4; Mo = 3.3); log-normal (a = 0.30; 1.00).

Polyporaceae (161 species in 17 genera)

L = 8.88 µm (6.0-18.0; 80% 6.2-12.5; Mo = 8.0); appr. hyperlog-normal (α = 0.08; 0.05).

W = 4.05 µm (1.9-10.5; 80% 2.5-6.0; Mo = 3.5); appr. log-normal (α= 0.17; 0.06) or hyperlog-normal (= 0.07; 0.21).

Q = 2.33 (1.07-3.82; 80% 1.40-3.10; Mo = 2.0); normal (α= 0.12; 1.00).
V = 116.08 µm^3 (17.5-721.6; 80% 30.3-212.7).
D = 5.55 µm (3.2-11.1; 80% 3.9-7.4; Mo = 4.8); hyperlog-normal (α = 0.92; 1.00).

Pterulaceae (61 species in 6 genera)

L = 10.37 µm (4.5-21.0; 80% 6.0-15.5; Mo = 6.0); appr. (truncated) log-normal (= 0.07; 0.37).
W = 5.17 (2.6-12.5; 80% 3.0-9.0; Mo = 3.75); appr. log-normal (α = 0.01; 0.37).
Q = 2.13 (1.00-4.80; 80% 1.33-2.95; Mo = 1.9); log-normal (α = 0.08; 1.00).
V = 230.94 µm^3 (16.5-1145.1; 80% 34.6-593.8).
D = 6.73 µm (3.2-13.0; 80% 4.0-10.4; Mo = 8.3); hyperlog-normal (α = 0.69; 1.00), platykurtic.

Russulaceae (271 species in 2 genera)

L = 8.54 µm (5.2-15.0; 80% 7.2-9.9; Mo = 8.0); appr. hyperlog-normal (α = 0.03; 0.015).
W = 7.08 µm (4.1-14.5; 80% 5.9-8.5; Mo = 7.0); appr. hyperlog-normal (α = 0.03; 0.17).
Q = 1.21 (1.00-1.54; 80% 1.11-1.32; Mo = 1.2); normal (0.14; 1.00).
V = 238.93 µm^3 (47.3-1651.3; 80% 134.2-359.4).
D = 7.53 µm (4.5-14.7; 80% 6.3-8.8; Mo = 7.0); hyperlog-normal (α = 0.26; 0.40).
There is one species with very big spores (15.0 x 14.5 µm) ;
V = 1651.3; D = 14.7)

Steccherinaceae (80 species in 18 genera)

L = 4.63 µm (2.6-14.0; 80% 3.1-6.4; Mo = 4.25); hyperlog-normal (α = 0.77; 0.45).
W = 2.65 µm (1.2-6.5; 80% 1.5-3.8; Mo = 2.5); log-normal (α = 0.44; 1.00).
Q = 1.82 (1.00-3.60; 80% 1.24-2.40; Mo = 2.0); log-normal (α = 0.38; 1.00).
V = 25.61 μm^3 (3.1-243.3; 80% 4.7-41.7).
D = 3.25 µm (1.8-7.8; 80% 2.1-4.3; Mo = 3.6); hyperlog-normal (α = 0.15; 1.00).

Stereaceae (56 species in 10 genera)

L = 7.18 µm (4.3-17.5; 80% 5.0-10.8; Mo = 6.25); hyperlog-normal (α = 0.32; 0.43).
W = 3.71 µm (1.7-15.0; 80% 2.3-5.5; Mo = 3.25); hyperlog-normal (α = 0.24; 0.53).
Q = 2.10 (1.09-4.14; 80% 1.33-3.63; Mo = 1.54); hyperlog-normal (α = 0.56; 1.00).
V = 93.67 μm^3 (14.7-2061.7; 80% 18.8-134.6).
D = 4.74 µm (3.0-15.8; 80% 3.3-6.4; Mo = 3.8); hyperlog-normal (α = 0.65; 1.00).

Strophariaceae (380 species in 9 genera; fig. 11)

L = 7.96 µm (3.5-17.4; 80% 6.0-11.0; Mo = 8.0); obviously hyperlog-normal but fit not good.
W = 4.81 µm (2.2-10.0; 80% 3.6-6.6; Mo = 4.25); obviously hyperlog-normal but fit not good.
Q = 1.67 (1.00-3.00; 80% 1.42-1.90; Mo = 1.7); appr. log-normal (α = 0.03; 0.06).
V = 120.54 μm^3 (9.3-890.1; 80% 44.2-256.5).
D = 5.71 µm (2.6-11.9; 80% 4.4-7.9; Mo = 5.45); obviously hyperlog-normal but fit not good.

Thelephoraceae (238 species in 12 genera)

L = 7.22 µm (3.2-12.0; 80% 5.0-9.8; Mo = 7.0); appr. log-normal (α = 0.04; 0.16).
W = 6.27 µm (2.3-12.0; 80% 4.0-9.0; Mo = 7.0); appr. log-normal (α = 0.06; 0.015).
Q = 1.19 (0.86-2.25; 80% 1.00-1.44; Mo = 1.0); obviously truncated hyperlog-normal,
Most species with Q value near 1.0.
V = 183.11 μm^3 (17.6-904.8; 80% 41.9-381.7).
D = 6.56 µm (3.2-12.0; 80% 4.3-9.0; Mo = 7.0); appr. log-normal (α = 0.04; 0.15), platykurtic.

Tricholomataceae (1669 species in 64 genera; fig. 11)

L = 8.25 µm (2.8-32.8; 80% 5.1-11.8; Mo = 8.0); obviously appr. log-normal.
W = 4.44 µm (0.8-22.5; 80% 3.0-6.0; Mo = 3.5); obviously appr. log-normal.
Q = 1.96 (1.0-7.28; 80% 1.25-2.85; Mo = 2.0); obviously appr. hyperlog-normal.
V = 121.38 μm^3 (1.6-6162.9; 80% 29.0-199.1)D = 5.55 µm (1.5-22.8; 80% 3.8-7.2; Mo = 4.8); obviously log-normal.

Comparison of families and their groups

Of the four spore parameters given in **Table 1**, spore volume and quotient (Q) are characters determining velocity of sedimenation of spores. Spore volume also represents the amount of food supply available in spore germination. Consequently, these parameters are important as characters indicating possibly different life strategies in different taxa.

The results of all comparisons are presented in tables 4 (families of Aphyllophorales) and 5 (families of Agaricales).

Comparison of mean spore volume (D values), Q values, but also spore length and width in Aphyllophorales, Agaricales and Polyporaceae demonstrates, that all these parameters are different between these three groups at 0.001 significance level (see **figs. 6-8**) except spore length in Agaricales and

Polyporaceae where the difference between these groups is insignificant. Cantharellomycetes and Corticiomycetes, too, are different from each other at 0.001 significance level in all four parameters (L; W; Q; D).

Spores of Agaricales are on the average longer, broader and less elongated than in Aphyllophorales; spores of Polyporaceae have approximately the same mean length as those of Agaricales, but have on the average more elongated shape than spores of Agaricales or Aphyllophorales.

The data given in tables 4-5 show that in about three cases out of four the difference in mean spore size and spore form between families are both statistically significant. In only 10 cases out of 309, both spore size and spore shape are not significantly different in two families compared.

Agaricales:

Amanitaceae - Entolomataceae

Aphyllophorales:

Albatrellaceae - Clavariaceae
Albatrellaceae - Hymenochaetaceae
Cantharellaceae - Favolaschiaceae
Clavariadelphaceae - Gomphaceae
Coriolaceae - Fomitopsidaceae
Coriolaceae - Physalacriaceae
Corticiaceae - Coniophoraceae
Corticiaceae - Cyphellaceae
Corticiaceae - Physalacriaceae.

In addition, in 27 cases out of 309, mean Q value is not significantly different between two families under comparison, and in 39 cases the difference is not significant in mean spore volume (transformed to D value). However, we must understand that absence of statistically significant difference is not equal with reliable equality (identity).

Frequency distribution of spore data in some genera

In the genera of Hymenomycetes which have 100 or more species, frequency distribution of spore length, spore width, Q value and equivalent spore diameter D were studied. For distribution fitting histograms were studied visually; coefficients of skewness and kurtosis and their significances were calculated; chi-square and Kolmogorov-Smirnov tests were used to check normal, log-normal or hyperlog-normal distribution curves. When the histograms approximately fit with some of the three types of curves, significance levels for chi-square test and Kolmogorov-Smirnov test are given in brackets.

Agaricus (Agaricaceae; 127 species)
L: hyperlog-normal (α = 0.32, 0.32).
W: appr. hyperlog-normal but fit not good (α = 0.0002, 0.44).
Q: normal (α = 0.09, 0.39).
D: appr. log-normal (α = 0.04, 0.44); distribution curve with a saddle at about 4 µm .

Boletus (Boletaceae; 114 species)
L: approx. hyperlog-normal (α = 0.04, 0.37), some species with very large spores 12.2-13.7 µm long.
W and Q: appr. log-normal (α = 0.0002, 0.06; 0.13, 1.00). D: appr. normal (α = 0.005, 0.09).

Clitocybe (Tricholomataceae; 100 species)
L, W and Q: appr. log-normal (α = 0.10, 0.44; 0.45, 0.39; 0.002, 0.10).
D: hyperlog-normal (α = 0.07, 0.35).

Crepidotus (Crepidotaceae; 139 species)
L: appr. log-normal (α = 0.09, 0.20) but curve with a saddle (depression) at about 6.4-6.5 µm .
W: log-normal (α = 0.92, 0.22).
Q: approximately log-normal (g_1 = 0.11, g_2 = 1.12) but curve with a saddle at about 1.1-1.2.
D: appr. hyperlog-normal (α = 0.13, 0.15).

Coprinus (Coprinaceae; 131 species)
L, W and D: log-normal (α = 0.66, 0.53; 0.27, 1.00; 0.26, 1.00). Q: normal (α = 0.88, 1.00).

Hygrophorus (Hygrophoraceae; 199 species)
L and W: log-normal (α = 0.06, 0.08; 0.04, 0.08). Q: appr. normal (α < 0.001, = 0.007).
D: hyperlog-normal (α = 0.05; 0.19).

Inocybe (Cortinariaceae; 177 species)
L and W: appr. hyperlog-normal (α = 0.014, 0.11; 0.08, 0.48). Q: log-normal (α = 0.47, 1.00).
D: similar to hyperlog-normal but several species with very large spores
(D = 14-17 µm).

Marasmius (Tricholomataceae; 325 species)
W and D: log-normal (α = 0.38, 0.11; 0.08, 1.00).
L and Q data obviously hyperlog-normal in general but with bad fit due to relatively low frequency in the region of about 23-24 µm in spore length and a saddle at about 3-3.5 in Q values.

Mycena (Tricholomataceae; 191 species)
L: normal (α = 0.56, 1.00). W, Q and D: appr. log-normal (= 0.13, 0.40; 0.01, 0.44; 0.09, 1.00).

Phellinus (Hymenochaetaceae; 144 species)
L, W and D: appr. log-normal (α = 0.09, 0.32; 0.001, 0.17; 0.98, 1.00).
Q: obviously hyperlog-normal.

Pholiota (incl. *Flammula* and *Kuehneromyces;* Strophariaceae; 231 species)
L, W and D: appr. hyperlog-normal (α = 0.001, 0.10; 0.04, 0.002; < 0.001, 0.02).
Q: normal (α = 0.26, 0.47).

Ramaria (Gomphaceae; 168 species)
L, W, Q and D: log-normal (α = 0.60, 0.53; 0.13, 0.06; 0.66, 1.00; 0.09, 0.30).

Russula (Russulaceae; 181 species)

L, W and D: hyperlog-normal (α = 0.16, 0.02; 0.41, 0.54; 0.17, 0.39). Q: normal (α = 0.88, 1.00).

The data given above demonstrate that in most cases (45 cases out of 52) distribution curves are approximately log-normal or hyperlog-normal, and in only 7 cases approximately normal. However, of these 7 cases, in 5 the normality is really 'abnormal': distribution of Q values is usually log-normal, not normal!

Discussion and conclusions

Basidiospores of the species of Hymenomycetes are characterized by moderate size (mean length about 8.4 µm, width 4.9 µm , volume 156 μm^3) and elongated shape (mean Q = 1.80). As in all taxonomic groups of fungi, spore characters are variable from species to species and may be better characterized by their tolerance limits or 10 and 90% percentiles. Observed limits for 80% of species are: mean spore length 4.9-12.3 µm ; width 2.2-8.3 µm; Q = 1.1-3.1; volume 14-440 μm^3. According to the Stokes' law, the velocity of falling of such spores in atmosphere is about 0.3-2.7 mm/s (average: about 1 mm/s).

Most species of Hymenomycetes may be characterized as having a special kind of r-selected life-history (including dispersal) strategy: long-living individual (mycelium) has short-living basidiomata producing very numerous small propagules, i.e. are characterized by high dispersal ability. However, in several, mainly 'polyporoid' families (Ganodermataceae, Fomitopsidaceae, partly also Coriolaceae) basidiomata are usually long-living. The innumerous species having relatively large spores only represent a slight trend towards K-strategy of dispersal. Obviously, as in all organisms, there is an r-K continuum in Hymenomycetes, too (cf. Pianka, 1970).

Normal frequency distribution is a very common phenomenon in metric characters of most biological objects. This is not the case in the objects of this study. Approximately normal curves of frequency distriution are only met with in Hymenomycetes in Amanitaceae (L and D values), Cantharellaceae (L; W); Clavariaceae (L), Clavulinaceae (L; W; D), Crepidotaceae (L; W; D), Entolomataceae (L; W; D) and Fomitopsidaceae (L; W; D), and in two genera of the 13 studied by us (*Boletus*: D values; *Mycena*: L values). The distribution curves of spore length, width, Q and D data of both orders, Most families and genera may be characterized as log-normal or hyperlog-normal (see figs. 1-4 and 6-12). In almost all taxonomic groups of fungi studied by us the number of species with large spore length or width, great volume and elongated form (greater Q value) is significantly higher than may be expected in the case of normality of data distribution. However, Pentecost (1981: 672 and fig. 1) found the same in lichen ascospores: the length and breadth data appear to be lognormally distributed. It seems to be a general rule: variation of spore characters is asymmetric.

It may be asked whether or not the strongly positively skewed distribution curves are caused by the low value of the spore means in Hymenomycetes: there is a biologically caused minimal possible spore size, and spore measurements do not exist below zero. This limitation is obviously correct regarding the (asymptotic) distribution of Q values but not of spore measurements. It has been demonstrated by the authors of this paper that variation of spore length and width data are approximately normal at individual and specific levels in Hymenomycetes (E. & I. Parmasto, 1987: 34-40).

Locquin (1979) has asserted it to be a rule that some exceptional elements could exist within the limits of every taxon (see also Raitviir, 1988). According to the spore variation data at order, family and generic levels given in this paper, this rule applies even more generally. If we exclude the 'exceptional' elements, the distribution curve remains usually anyway log- or hyperlog-normal. Let us give an example. Distribution curve of spore length data in Strophariaceae (fig. 11) is obviously hyperlog-normal (g_1 of the log-transformed data set is 1.52). After excluding 'atypical' species with spore length above 15 µm, the curve remains still hyperlog-normal (log-curve: $g_1 = 0.47$). Spore measurements and shape have been used in the taxonomy of Hymenomycetes for the characterization of several genera but not families. According to the data given above, the differences in family averages of these characteristics are quite remarkable. There are serious problems in how to handle statistically the data to characterize and compare the groups of fungi under study. Mean spore measurements, Q value and volume in any species are statistics drawn from a sample of spores and specimens of unknown size, and have an unknown error. The number of species in a family (genus, order, etc.) is a definite quantity. (Even if we have described only half of the existing species, this difference is for statistical estimating unimportant). The species of a genus or family form a population (in statistical sense of this term) which will be characterized by parameters not by statistics. If we assume that the data of species in groups (families) are correct or with randomly distributed errors, the comparison of group averages using t-test, analysis of variance, chi-square test or other statistical methods gives us not probability but measure of their difference. Indeed, any difference of parameters of two populations is always significant. In reality, the difference expressed as significance level is a statistic where both probability and measure of difference are combined in unknown proportions.

In many cases absence of significant difference has obviously no connection with taxonomical or ecological relations of the two families under comparison (e. g. Albatrellaceae - Coniophoraceae; Clavariaceae - Fomitpsidaceae). In some other cases absence of significant difference may be connected with taxonomic relations (Clavariadelphaceae - Gomphaceae, Cantharellaceae - Gomphaceae, Cantharellaceae - Clavulinaceae, Corticiaceae - Coniophoraceae, Coriolaceae - Fomitopsidaceae) or similar ecology (Hymenochaetaceae - Coriolaceae, Hymenochaetaceae - Fomitopsidaceae, Hymenochaetaceae - Stereaceae, Fomitopsidaceae - Coriolaceae).

The difference in mean spore size between families is a biologically significant character. According to Stokes' law, the terminal velocity V_S of spherical particles is approximately $V_S = 0.03\ D^2 mm/s$; according to McCubbin (1944) it is $V_S = (L \cdot W)/40\ mm/s$, where D is the diameter of a particle in micrometers.

Proceeding from the Stokes' law, average speed of falling of spores in air is about 0.3 mm/s in Steccherinaceae (D = 3.25 µm) and 2.4 mm/s in Ganodermataceae (D = 8.89 µm). Average distance of spore dispersal is dependant on this velocity. Consequently, the difference is about 7.5 times in spreading capability, and more than 18 times in food supply available in spore germination (mean spore volume is 466.9 μm^3 in Ganodermataceae and 25.6 μm^3 in Steccherinaceae).

Ingold (1965: 14) mentioned, that "the mean rate for randomly oriented particles decreases as the particles become more elongated. Consequently if the velocity of fall is an important factor in aerial dispersal, selection must favour the elongated shape". This may be true in many individual cases but our data do not support it to be a general rule: many advanced families have (as an average) ellipsoidal or moderately elongated spores. The differences between families may be interpreted as differences between "mean" dispersal strategies of these taxa.

According to Gregory (1973: 16), size and shape of fungal spores "must be looked upon as probably functional adaptations". Indeed, spores in several families with mainly wood-inhabiting basidiomata have more elongated form than in most other families (Bjerkanderacae, Fomitopsidaceae, Coriolaceae, Stereaceae, Polyporaceae, Dichostereaceae), and are in many families smaller than in most families with soil-inhabiting basidiomata. But there are several exceptions, and this may be called a general trend but not a rule. Functionally adapted are species, not supraspecific taxa. Nevertheless, every higher taxon has an "average" life-history (including dispersal) strategy caused by common origin.

Differences between orders and most families of Hymenomycetes are significant statistically and biologically. Taxonomically these differences are not usable to discriminate the taxa; they are properties of the taxa, not diagnostic characteristics. Differences at generic level may be used in practical systematics in many cases, but even then intrageneric variation may be considerable. Every species has its own, individual life-history strategy, and every taxon (including genera) may have some 'extreme' or 'deviate' subtaxa (species). Most supraspecific taxa are polythetic groups, and spore characters are useful in systematics when using not typological but statistical approach.

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Appendix

1. A list of genera

included in polyporoid and clavarioid families, in Polyporaceae and Steccherinaceae.

Albatrellaceae

Abortiporus Murrill, Albatrellus S.F. Gray, Dendropolyporus (Pouz.) JGl., Diacanthodes Sing., Grifola S.F. Gray, Henningsina Möller, Hydnopolyporus Reid, Jahnoporus Nuss, Loweomyces (Kotl. & Pouz.) JGl., Meripilus P. Karst., Osteina Donk, Spongipellis Pat.

Bjerkanderaceae

Amylocystis Bond. & Sing., Anomoporia Pouz., Aurantiporus Murill, Auriporia Ryv., Bjerkandera P. Karst., Cautinia Maas G., Ceriporia Donk, Ceriporiopsis Donk, Climacocystis Kotl. & Pouz., Flaviporus Murrill, Gelatoporia Niem., Gloeoporus Mont., Hapalopilus P. Karst., Heteroporus Lzaro, Leptoporus Qu)l., Leucophellinus Bond. & Sing., Macrohyporia Johansen & Ryv., Oligoporus Bref. (Postia Fr.), Oxyporus (Bourd. & Galz.) Donk, Parmastomyces Kotl. & Pouz., Phaeolus Pat., Physisporinus P. Karst., Pseudophaeolus Ryv., Pycnoporellus Murrill, Tyromyces P. Karst.

Clavariaceae

Clavaria Fr., Clavulinopsis v. Over., Multiclavula Peters., Ramariopsis (Donk) Corner, Scytinopogon Sing.

Clavariadelphaceae

Araeocoryne Corner, Ceratellopsis Konr. & Maubl., Chaetotyphula Corner, Clavariadelphus Donk, Gloeomucro Peters., Macrotyphula Peters., Typhula (Pers.) Fr.

Clavicoronaceae

Artomyces JGl., Clavicorona Doty.

Clavulinaceae

Clavulina Schroet., Clavulicium Boid

Coriolaceae

Amyloporia Bond. & Sing., Antrodia P. Karst. (? Fomitopsidaceae), Antrodiella Ryv. & Johansen, Cerrena S.F. Gray, Cineromyces JGl., Coriolopsis Murrill, Daedaleopsis J. Schroet., Datronia Donk, Dichomius Reid, Diplomitoporus Dom., Earliella Murrill, Echinoporia Ryv., Flavodon Ryv., Fomes (Fr.) Fr., Fomitella Murrill, Funalia Pat., Fuscocerrena Ryv., Globifomes Murrill, Heterobasidion Bref., Hexagonia Fr., Ischnoderma P. Karst., Lamelloporus Ryv., Laricifomes Kotl. & Pouz., Lenzites Fr., Lignosus Lloyd, Loweporus Wright, Melanoporiella Murrill, Microporus Beauv., Navisporus Ryv., Nigroporus Murrill, Pachykytospora Kotl. & Pouz., Paratrichaptum Corn., Perenniporia Murrill, Phaeotrametes Lloyd, Piloporia Niem., Pseudopiptoporus Ryv., Pycnoporus P. Karst., Pyrofomes Kotl. & Pouz., Rigidoporopsis Johansen & Ryv., Rigidoporus Murrill, Scenidium (Kl.) Kuntze, Skeletocutis Kotl. & Pouz., Tinctoporellus Ryv., Trametes Fr., Trichaptum Murrill.

Fomitopsidaceae

Daedalea Pers.: Fr., Donkioporia Kotl. & Pouz., Fomitopsis P. Karst., Gloeophyllum (P. Karst.) P. Karst., Haploporus Bond. & Sing., Melanoporia Murrill, Wolfiporia Ryv. & Gilbn., Xerotus Fr.

Polyporaceae

Buglossoporus Kotl. & Pouz., Cryptoporus (Peck) Shear, Echinochaete Reid, Elmerina Bres., Favolus Fr., Flabellophora G.H. Cunn., Geopetalum Pat., Laetiporus Murrill, Lentinus Fr., Mycobonia Pat., Nothopanus Sing., Ossicaulis Redh. & Ginns, Phyllotopsis Gilbn. & Donk, Piptoporus P. Karst., Pleurotus (Fr.) Kummer, Polyporus Fr., Pseudofavolus Pat.

Pterulaceae

Allantula Corner, Deflexula Corner, Dimorphocystis Corner, Parapterulicium Corner, Pterula Fr., Pterulicium Corner.

Steccherinaceae

Amethicium Hjortst., Australohydnum JGl., Ceraceohydnum JGl., Crustomyces JGl., Cystostereum Pouz., Dendrodontia Hjortst. & Ryv., Epithelopsis JGl., Fibriciellum J. Erikss. & Ryv., Fibricium J. Erikss., Fibrodontia Parm., Irpex Fr., Junghuhnia Corda, Merulicium J. Erikss. & Ryv., Mycoaciella J. Erikss. & Ryv., Schizopora Velen., Scytinostromella Parm., Skeletohydnum JGl., Steccherinum S.F. Gray.

2. Alternative taxonomic groups of Hymenomycetes

Cantharellomycetes Parm.

Agaricaceae, Albatrellaceae, Amanitaceae, Amylariaceae, Aphelariaceae, Auriscalpiaceae, Bankeraceae, Bolbitiaceae, Boletaceae, Bondarzewiaceae, Cantharellaceae, Clavariaceae, Clavariadelphaceae, Clavicoronaceae, Clavulinaceae, Coprinaceae, Cortinariaceae, Crepidotaceae, Entolomataceae, Favolaschiaceae, Fistulinaceae, Gomphaceae, Gomphidiaceae, Hericiaceae, Hydnaceae, Hygrophoraceae, Lachnocladiaceae, Paxillaceae, Physalacriaceae, Pluteaceae, Podoscyphaceae, Polyporaceae, Pterulaceae, Russulaceae, Sparassidaceae, Strophariaceae, Tricholomataceae.

Corticiomycetes Parm.

Amylariaceae, Bjerkanderaceae, Coniophoraceae, Coriolaceae, Corticiaceae, (Aphyllophoroid) Cyphellaceae, Dichostereaceae, Fomitopsidaceae, Ganodermataceae, Hymenochaetaceae, Steccherinaceae, Stereaceae, Thelephoraceae.

Table 1: MEAN SPORE CHARACTERISTICSOF FAMILIES OF HYMENOMYCETES
V = volume in μm^3; D = equivalent diameter of spores in µm;
Q = spore length/width quotient; L = spore length; W = spore width.

Family	no of spec.	V	D	Q	L	W
Amylariaceae	1	7.95	2.48	1.17	2.75	2.35
Clavicoronaceae	9	22.81	3.39	1.35	4.09	3.11
Steccherinaceae	80	25.61	3.25	1.82	4.63	2.65
Bjerkanderaceae	168	27.26	3.39	2.16	5.00	2.72
Bankeraceae	21	29.21	3.78	1.19	4.23	3.58
Fistulinaceae	5	35.46	3.99	1.36	4.91	3.61
Podoscyphaceae	60	36.71	3.78	1.65	5.13	3.19
Hericiaceae	29	40.58	3.97	1.47	4.95	3.53
Auriscalpiaceae	19	51.47	4.34	1.29	5.14	3.99
Fomitopsidaceae	45	53.19	4.37	2.34	7.10	3.16
Sparassidaceae	4	53.63	4.66	1.51	6.13	4.08
Lachnocladiaceae	11	58.90	3.87	1.64	5.55	3.79
Hymenochaetaceae	321	58.91	4.31	1.64	5.55	3.79
Physalacriaceae	36	60.35	4.44	2.12	7.08	3.31
Coriolaceae	306	63.66	4.25	2.16	6.52	3.26
Albatrellaceae	44	68.11	4.75	1.45	5.98	4.22
Clavariaceae	126	78.57	4.90	1.60	6.42	4.23
Stereaceae	56	93.67	4.74	2.10	7.18	3.71
Crepidotaceae	176	104.03	5.71	1.41	7.09	5.14
Pluteaceae	109	106.72	5.72	1.32	6.87	5.24
Hydnaceae	8	111.50	5.80	1.30	6.90	5.30
Polyporaceae	161	116.08	5.55	2.33	8.88	4.05
Bondarzewiaceae	2	120.45	6.13	1.00	6.13	6.13
Strophariaceae	380	120.54	5.71	1.67	7.96	4.81
Tricholomataceae	1669	121.38	5.55	1.96	8.25	4.44
Dichostereaceae	97	122.41	5.72	2.20	8.99	4.25
Hygrophoraceae	321	125.98	5.95	1.63	8.18	5.05
Aphelariaceae	16	140.25	5.90	1.39	7.34	5.28
Clavariadelphaceae	145	142.75	6.13	2.26	9.87	4.43
Paxillaceae	31	143.56	5.67	1.52	7.45	4.94
Cyphellaceae	48	170.23	5.78	1.63	7.71	5.00
Favolaschiaceae	56	175.28	6.69	1.50	8.63	5.90
Gomphaceae	215	181.92	6.60	2.18	10.46	4.89
Thelephoraceae	238	183.11	6.56	1.19	7.22	6.27
Cortinariaceae	971	183.66	6.82	1.69	9.57	5.70
Cantharellaceae	86	185.28	6.86	1.50	8.67	5.96
Corticiaceae	799	191.83	5.36	1.96	7.71	4.35
Coprinaceae	663	192.40	6.68	1.77	9.58	5.48
Coniophoraceae	39	195.94	7.73	1.74	9.08	5.12
Boletaceae	373	208.52	7.00	2.59	12.10	4.77
Pterulaceae	61	230.94	6.73	2.13	10.37	5.17
Russulaceae	271	238.93	7.53	1.21	8.54	7.08
Clavulinaceae	35	278.37	7.87	1.20	8.82	7.45
Entolomataceae	472	279.41	7.88	1.35	9.57	7.17
Bolbitiacea	116	283.63	7.66	1.73	10.92	6.38
Amanitaceae	80	323.45	7.92	1.34	9.44	7.27
Ganodermataceae	122	466.90	8.89	1.43	11.14	7.97
Gomphidiaceae	9	597.71	10.91	3.02	19.67	6.57

Table 2: SPECIES WITH SHORTEST AND LONGEST SPORES

Mean length µm	**Species, (family)**
2.25	*Heteroporus flavus* (Bjerkanderaceae)
2.25	*Podoscypha mellisii* (Podoscyphaceae)
2.25	*Poria totara* (Polyporaceae s. l.)
2.25	*Trichaptum basifuscum* (Polyporaceae s. l.)
2.40	*Antrodiella subundata* (Coriolaceae)
2.50	*Antrodiella hydrophila* (Coriolaceae)
2.50	*A. liebmannii* (Coriolaceae)
2.50	*Artomyces pyxidatus* (Clavicoronaceae)
2.50	*Loweporus fuscopurpureus* (Coriolaceae)
2.50	*Phellinus ferrugineovelutinus* (Hymenochaetaceae)
2.50	*Podoscypha involuta* (Podoscyphaceae)
2.50	*Polyporus canadensis* (Polyporaceae)
2.50	*Rigidoporus sulphureus* (Coriolaceae)
2.50	*Trichaptum suberosum* (Polyporaceae s. l.)
2.60	*Pleurotus luctuosus* (Polyporaceae)
2.65	*Steccherinum rawakense* (Steccherinaceae)
2.70	*Flaviporus brownei* (Bjerkanderaceae)
2.70	*Podoscypha corneri* (Podoscyphaceae)
2.70	*P. Molleri* (Podoscyphaceae)
2.75	*Amylaria himalayensis* (Amylariaceae)
2.75	*Antrodiella hunua* (Coriolaceae)
2.75	*A. straminea* (Coriolaceae)
2.75	*Cyclomyces setiporus* (Hymenochaetaceae)
2.75	*Dentipellis isidioides* (Hericiaceae)
2.75	*Flabellophora velutinosa* (Polyporaceae)
2.75	*F. ochracea* (Polyporaceae)
2.75	*Flaviporus semisupiniformis* (Bjerkanderaceae)
2.75	*Fomitiporia flavomarginata* (Hymenochaetaceae)
2.75	*Hymenochaete multisetae* (Hymenochaetaceae)
2.75	*H. microspora* (Hymenochaetaceae)
2.75	*H. nanospora* (Hymenochaetaceae)
2.75	*H. patelliformis* (Hymenochaetaceae)
2.75	*Lepiota langei* (Agaricaceae)
2.75	*Phellinus fragrans* (Hymenochaetaceae)
2.75	*Ph. minimus* (Hymenochaetaceae)
2.75	*Pleurotus armeniacus* (Polyporaceae)
2.75	*P. musae* (Polyporaceae)
2.75	*Skeletocutis niveicolor* (Coriolaceae)
2.75	*Trichaptum ceraceicutis* (Polyporaceae s. l.)
2.75	*Tyromyces canadensis* (Bjerkanderaceae)
2.75	*T. galactinus* (Bjerkanderaceae)
2.75	*T. hydrophilus* (Bjerkanderaceae)
2.80	*Gloeoporus croceopallens* (Bjerkanderaceae)
2.85	*Clavulinopsis spiculosa* (Clavariaceae)
2.85	*Panellus dichotomus* (Tricholomataceae)
2.85	*Rigidoporus adnatus* (Coriolaceae)
2.88	*Vararia alticola* (Dichostereaceae)
2.90	*Pleurocollybia apoda* (Tricholomataceae)
2.90	*Steccherinum confragosum* (Steccherinaceae)

Table 2: SPECIES WITH SHORTEST AND LONGEST SPORES (cont.)

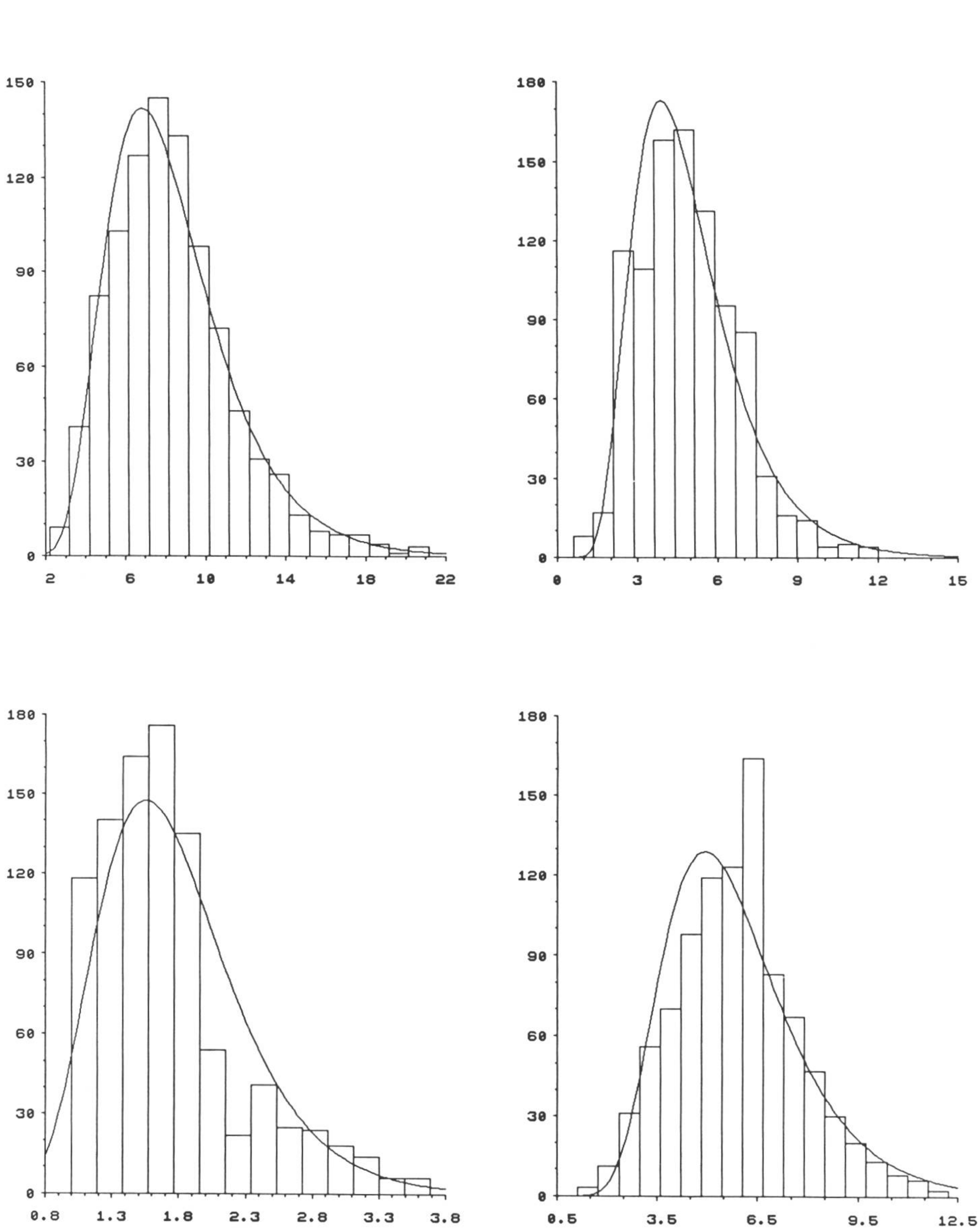
Mean length µm	**Species, (family)**
2.90	*S. exiguum* (Steccherinaceae)
2.90	*S. zeylanicum* (Steccherinaceae)
2.98	*Podoscypha philippinensis* (Podoscyphaceae)
20.25	*Chroogomphus corallinus* (Gomphidiaceae)
20.30	*Gomphus guadelupensis* (Gomphaceae)
20.50	*Coprinus sterquilinus* (Coprinaceae)
20.50	*Ganoderma asperulatum* (Ganodermataceae)
20.50	*Gomphidius maculatus* (Gomphidiaceae)
20.50	*Jaapia argillacea* (Coniophoraceae)
20.75	*Ganoderma tsunodae* (Ganodermataceae)
21.00	*Chroogomphus rutilus* (Gomphidiaceae)
21.00	*Deflexula mangiformis* (Pterulaceae)
21.00	*Dendrothele macrodens* (Corticiaceae)
21.00	*D. subfusispora* (Corticiaceae)
21.00	*Gomphus megasporus* (Gomphaceae)
21.00	*Laeticorticium griseoeffusum* (Corticiaceae)
21.50	*Aleurodiscus oakesii* (Corticiaceae)
21.50	*A. wakefieldiae* (Corticiaceae)
21.50	*Boletus mirabilis* (Boletaceae)
21.50	*Laeticorticium durangense* (Corticiaceae)
22.00	*Aleurodiscus croceus* (Corticiaceae)
22.00	*Epithele typhae* (Corticiaceae)
22.00	*Leccinum proliferum* (Boletaceae)
22.00	*Marasmius caryotae* (Tricholomataceae)
22.50	*Scytinostroma caudisporum* (Dichostereaceae)
23.00	*Aleurodiscus amorphus* (Corticiaceae)
23.00	*Dendrothele strumosa* (Corticiaceae)
23.00	*Megaspororia mexicana* (Incertae sedis)
23.25	*Oudemansiella australis* (Tricholomataceae)
23.50	*Aleurodiscus vitellinus* (Corticiaceae)
23.50	*Dendrothele seriata* (Corticiaceae)
23.50	*Marasmius brunneolus* (Tricholomataceae)
23.85	*M. decipiens* (Tricholomataceae)
24.00	*M. litoralis* (Tricholomataceae)
24.25	*Acanthophysium moniliferum* (Corticiaceae)
24.87	*Aleurodiscus australiensis* (Corticiaceae)
25.00	*Laeticorticium quercicola* (Corticiaceae)
25.00	*Lentaria macrospora* (Gomphaceae)
25.00	*Vuilleminia megalospora* (Corticiaceae)
25.50	*Boletus projectellus* (Boletaceae)
25.50	*Dendrothele maculata* (Corticiaceae)
26.00	*Aleurodiscus mirabilis* (Corticiaceae)
26.00	*Corneromyces kinabalui* (Coniophoraceae)
26.00	*Ganoderma ochrolaccatum* (Ganodermataceae)
27.50	*Marasmius megistus* (Tricholomataceae)
29.00	*Humphreya eminii* (Ganodermataceae)
32.75	*Marasmius megistosporus* (Tricholomataceae)

Table 3 : SPECIES WITH SMALLEST AND LARGEST SPORES

Volume μm^3	Species, (family)
0.75	*Gloeoporus croceopallens* (Bjerkanderaceae)
1.09	*Chaetoporellus latitans* (Corticiaceae)
1.17	*Tyromyces hyalinus* (Bjerkanderaceae)
1.33	*Microporus luteoceraneus* (Coriolaceae)
1.33	*Pyrofomes albomarginatus* (Coriolaceae)
1.44	*Skeletocutis nivea* (Coriolaceae)
1.55	*S. ochroalba* (Coriolaceae)
1.55	*Tyromyces tephronotus* (Bjerkanderaceae)
1.56	*Hymenochaete nanospora* (Hymenochaetaceae)
1.63	*Panellus microsporus* (Tricholomataceae)
1.75	*Skeletocutis stellae* (Coriolaceae)
1.88	*S. lilacina* (Coriolaceae)
1.90	*Antrodiella hunua* (Coriolaceae)
1.93	*Skeletocutis kuehneri* (Coriolaceae)
1.95	*Tyromyces setiger* (Bjerkanderaceae)
2.14	*Gelatoporia pannocincta* (Bjerkanderaceae)
2.23	*Podoscypha mellisii* (Podoscyphaceae)
2.25	*Gloeoporus thelephoroides* (Bjerkanderaceae)
2.31	*Trichaptum basifuscum* (Polyporaceae s. l.)
2.49	*Porodisculus pendulus* (Incertae sedis)
2.56	*Loweporus fuscopurpureus* (Coriolaceae)
2.74	*Skeletocutis alutacea* (Coriolaceae)
2.86	*Hymenochaete multisetae* (Hymenochaetaceae)
2.88	*Gloeoporus cystidiatus* (Bjerkanderaceae)
2.88	*G. phleboporus* (Bjerkanderaceae)
2.88	*Pilopora sajanensis* (Coriolaceae)
2.94	*Plicaturopsis crispa* (Corticiaceae)
1813.1	*Aleurodiscus aurantiacus* (Corticiaceae)
1847.3	*Acanthophysium limonisporum* (Corticiaceae)
1902.5	*Aleurodiscus oakesii* (Corticiaceae)
1926.5	*Dendrothele candida* (Corticiaceae)
1981.6	*Humphreya endertii* (Ganodermataceae)
2004.0	*Dendrothele macrodens* (Corticiaceae)
2061.7	*Licrostroma subgiganteum* (Stereaceae)
2138.5	*Cyphella digitalis* (Cyphellaceae)
2138.5	*Oudemansiella japonica* (Tricholomataceae)
2284.3	*Ganoderma tsunodae* (Ganodermataceae)
2375.1	*Vuilleminia megalospora* (Corticiaceae)
2385.7	*Laeticorticium quercicola* (Corticiaceae)
2412.8	*Oudemansiella canarii* (Tricholomataceae)
2530.3	*Aleurodiscus penicillatus* (Corticiaceae)
2668.3	*Ganoderma ochrolaccatum* (Ganodermataceae)
2846.3	*Marasmiellus gigantosporus* (Tricholomataceae)
2851.0	*Acanthophysium ljubarskii* (Corticiaceae)
2875.1	*A. abietis* (Corticiaceae)
2881.9	*Aleurodiscus wakefieldiae* (Corticiaceae)
2966.5	*Oudemansiella venosolamellata* (Tricholomataceae)
3050.5	*Acanthophysium moniliferum* (Corticiaceae)

Table 3 : SPECIES WITH SMALLEST AND LARGEST SPORES (cont.)

Volume μm^3	Species, (family)
3063.1	*Aleurodiscus mirabilis* (Corticiaceae)
3843.5	*A. australiensis* (Corticiaceae)
3901.9	*A. amorphus* (Corticiaceae)
3942.5	*A. croceus* (Corticiaceae)
4388.3	*Humphreya eminii* (Ganodermataceae)
4921.8	*Aleurodiscus vitellinus* (Corticiaceae)
5061.0	*Dendrothele strumosa* (Corticiaceae)
5687.8	*D. seriata* (Corticiaceae)
6162.9	*Oudemansiella australis* (Tricholomataceae)



Figures 1-4. Frequency histograms of spore characteristics in Hymenomycetes (with log-normal distribution curves): 1: spore length in µm; 2: spore width in µm , 3: Q values, 4: spore volume transformed to equivalent sphere diameter in µm .

Table 4

Significance of difference of D values (upper row) and Q values (lower)

	THE	STR	STC	PTE	POD	PHY	HYM	GOM	GAN	FOM	FAV	DIC	CYP	CRT	CRI	CON	CLU	CLD	CLA	CAN	BJE
Albatrellaceae	+++	-	+++	++	++	-	-	+++	+++	-	+++	+	-	-	+	-	+++	++	-	+++	+++
	+++	+++	***	***	+	+++	-	***	-	+++	-	**	++	***	***	+++	++	+++	-	-	++
BJErkanderaceae	***	+++	++	+++	*	++	***	***	+++	+++	***	+++	***	+++	+++	+++	+++	+++	+++	***	
	+++	++	+	+++	-	-	+++	+++	+++	++	++	+++	+	+++	+++	+	+++	+++	+++	+++	
CANtharellaceae	-	+++	+++	+++	***	+++	***	-	+++	+++	-	++	***	+++	***	++	-	++	+++		
	+++	+++	***	***	-	+++	+++	***	*	+++	-	***	+	***	***	+	+++	+++	-		
CLAvariaceae	***	-	+++	+++	***	-	***	+++	+++	-	***	+++	++	-	+++	++	+++	+++			
	+++	+++	***	***	++	+++	++	***	**	+++	-	***	+	***	***	+++	+++	+++			
CLavariaDelphac.	+++	+++	+++	+++	+++	+++	+++	-	+++	+++	-	++	+++	+++	+++	+++	+++				
	+++	+++	+++	+++	+++	+++	+++	-	+++	+++	+++	+++	+++	+++	+++	+++	+++				
CLavUlinaceae	+	+++	+++	+++	+++	+++	+++	++	-	***	++	***	+++	+++	+++	+					
	+	+++	+++	+++	+++	+++	+	+++	+++	+++	+++	+	++	+++	+++	+++					
CONiophoraceae	++	+	+++	+	+++	-	+++	+++	+++	++	++	+	+	-	+++						
	+++	++	+++	++	+	+	+++	+++	++	+++	+	+	-	-	++						
CoRIolaceae	***	+	+++	+++	-	-	-	***	+++	-	***	+++	+++	+++							
	+++	++	**	-	+++	-	+++	-	***	-	***	-	+	***							
CoRTiciaceae	+++	-	+++	++	-	-	++	+++	+++	-	+++	+++	-								
	+++	+	-	-	++	-	+++	***	***	+	***	-	-								
CYPhellaceae	***	-	+++	++	***	-	***	***	+++	-	***	++									
	+++	++	+	++	+	++	-	+++	-	+++	+	-									

DIChostereaceae	+++	+++	+++	+++	+++	+	+++	++	+++	***	+
	+++	+++	-	-	+++	++	+++	**	***	+++	**
FAVolaschiaceae	-	+++	+++	+++	***	+++	***	-	+++	+++	
	+++	+++	***	***	-	+++	+	***	-	+++	
FOMitopsidaceae	+++	-	+++	+++	-	-	-	+++	+++		
	+++	++	+++	+	+++	+	+++	+	+++		
GANodermataceae	+++	+++	+++	+++	+++	+++	+++	+++			
	+++	+++	***	***	+++	+++	+++	***			
GOMphaceae	-	+++	+++	+++	***	+++	***				
	+++	++	***	-	+++	-	+++				
HYMenochaetaceae	***	-	+++	+++	*	-					
	+++	+++	+++	+++	+	+++					
PHYsalacriaceae	+++	-	+++	++	-						
	+++	++	++	-	++						
PODoscyphaceae	***	+	+	+++							
	+++	+	+	+++							
PTErulaceae	+++	+++	+++								
	+++	***	**								
STeCcherinaceae	+++	+++									
	+++	**									
STeReaceae	+++										
	+++										

Significance of difference is indicated with asterisks (anovar) or plus signs (informational chi-square test):

- *** or +++ significant at $\alpha = 0.001$
- ** or ++ significant at $\alpha = 0.01$
- * or + significant at $\alpha = 0.05$
- \- statistically insignificant

Table 5

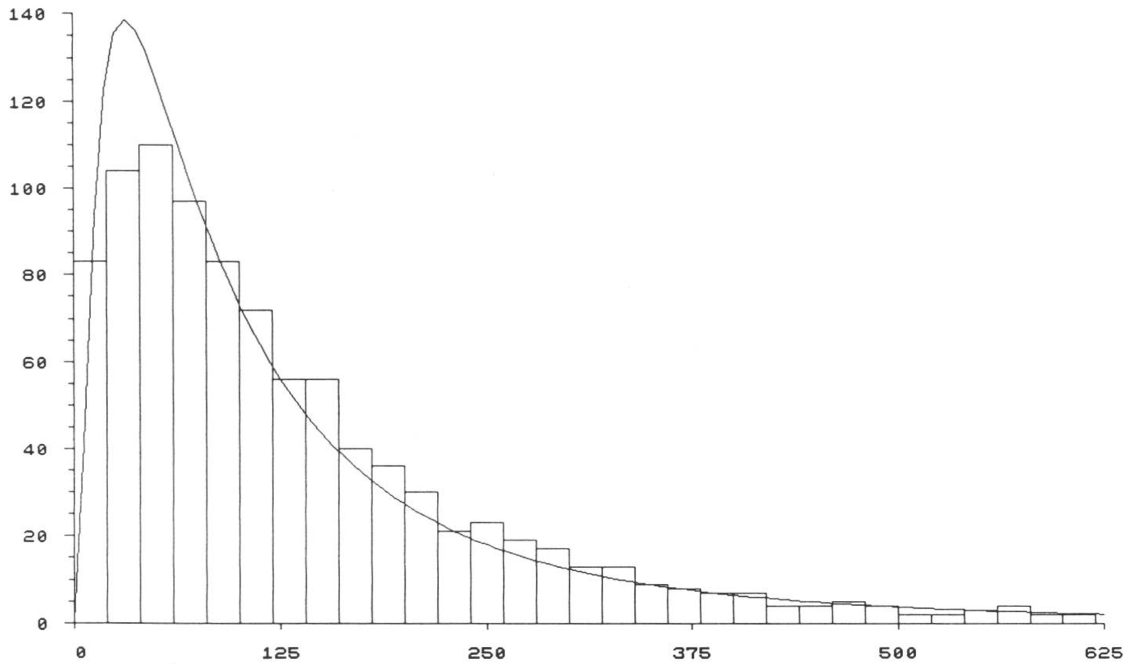
Significance of difference of D values (upper row) and Q values (lower) between the families of Agaricales

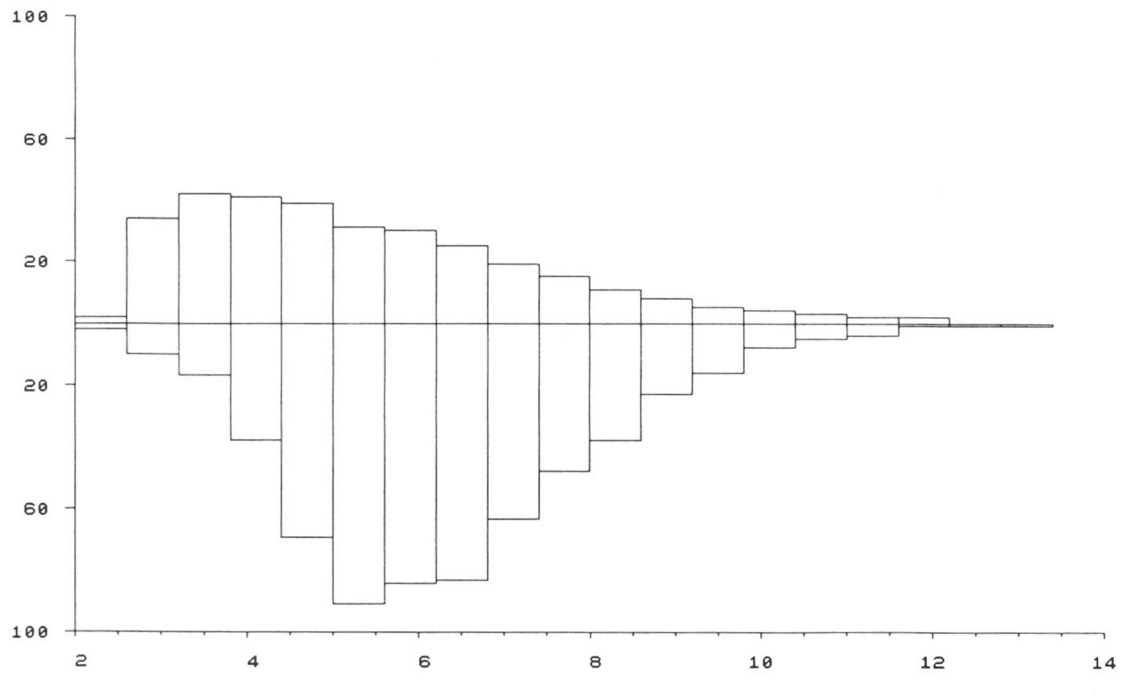
	TRI	STR	RUS	PLU	HYG	ENT	CRE	COR	COP	BLE	BLB	AMA
Agaricaceae	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
AMAnitaceae	+++	+++	+++	+++	+++	-	***	+++	+++	+++	+	
	+++	***	+++	-	+++	-	+++	+++	+++	+++	***	
BoLBitiaceae	***	+++	+++	***	***	+++	+++	***	++	++		
	+++	**	+++	***	+++	***	+++	+	+	+++		
BoLEtaceae	***	+++	***	***	***	+++	+++	-	**			
	+++	+++	***	+++	***	+++	***	***	+++			
COPrinaceae	+++	+++	***	+++	***	+++	+++	-				
	+++	+++	***	+++	+++	+++	+++	***				
CORtinariaceae	***	+++	+++	***	***	+++	+++					
	+++	+++	***	+++	***	+++	+++					
CREpidotaceae	+++	+++	+++	-	++	***						
	+++	+++	+++	+++	+++	+++						

	TRI	STR	RUS	PLU	HYG	ENT	CRE	COR	COP	BLE	BLB	AMA
ENTolomataceae	+++	+++	+++	+++	+++							
	+++	***	+++	-	+++							
HYGrophoraceae	***	+++	+++	-								
	+++	+++	***	+++								
PLUteaceae	*	+++	+++									
	+++	***	+++									
RUSsulaceae	+++	+++										
	+++	+++										
STRophariaceae	+++											
	+++											
TRIcholomataceae												

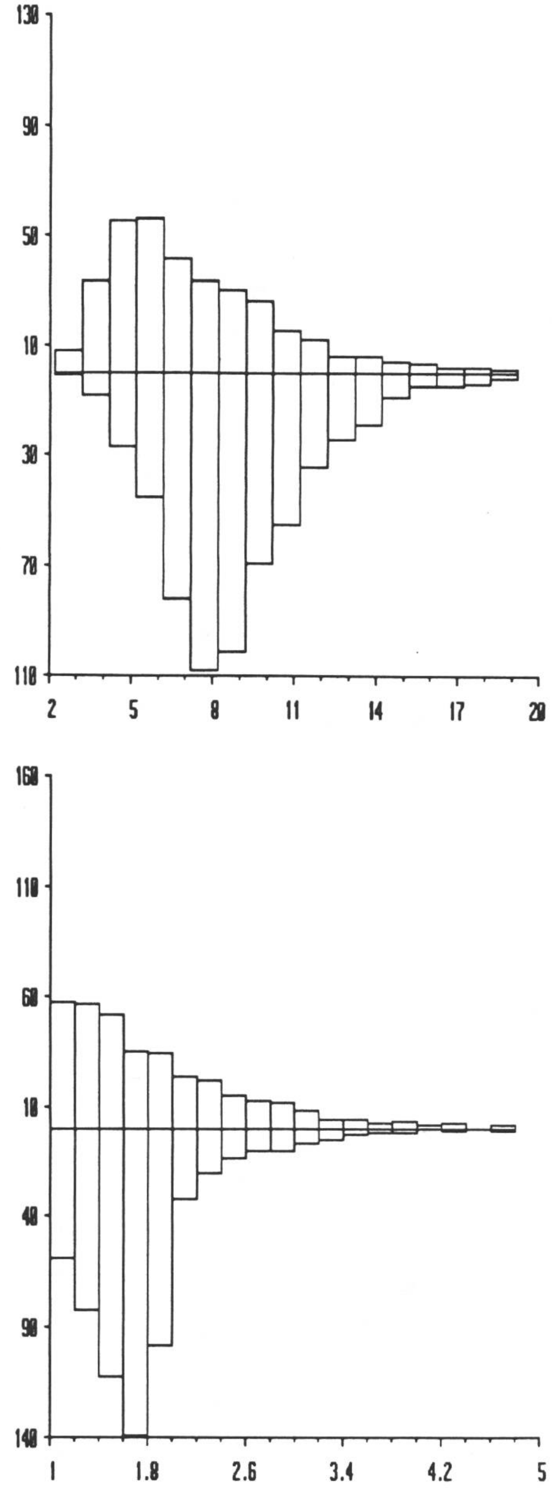
Significance of difference is indicated with asterisks (anovar) or plus signs (informational chi-square test):

*** or +++ significant at $\alpha = 0.001$
** or ++ significant at $\alpha = 0.01$
* or + significant at $\alpha = 0.05$
- statistically insignificant

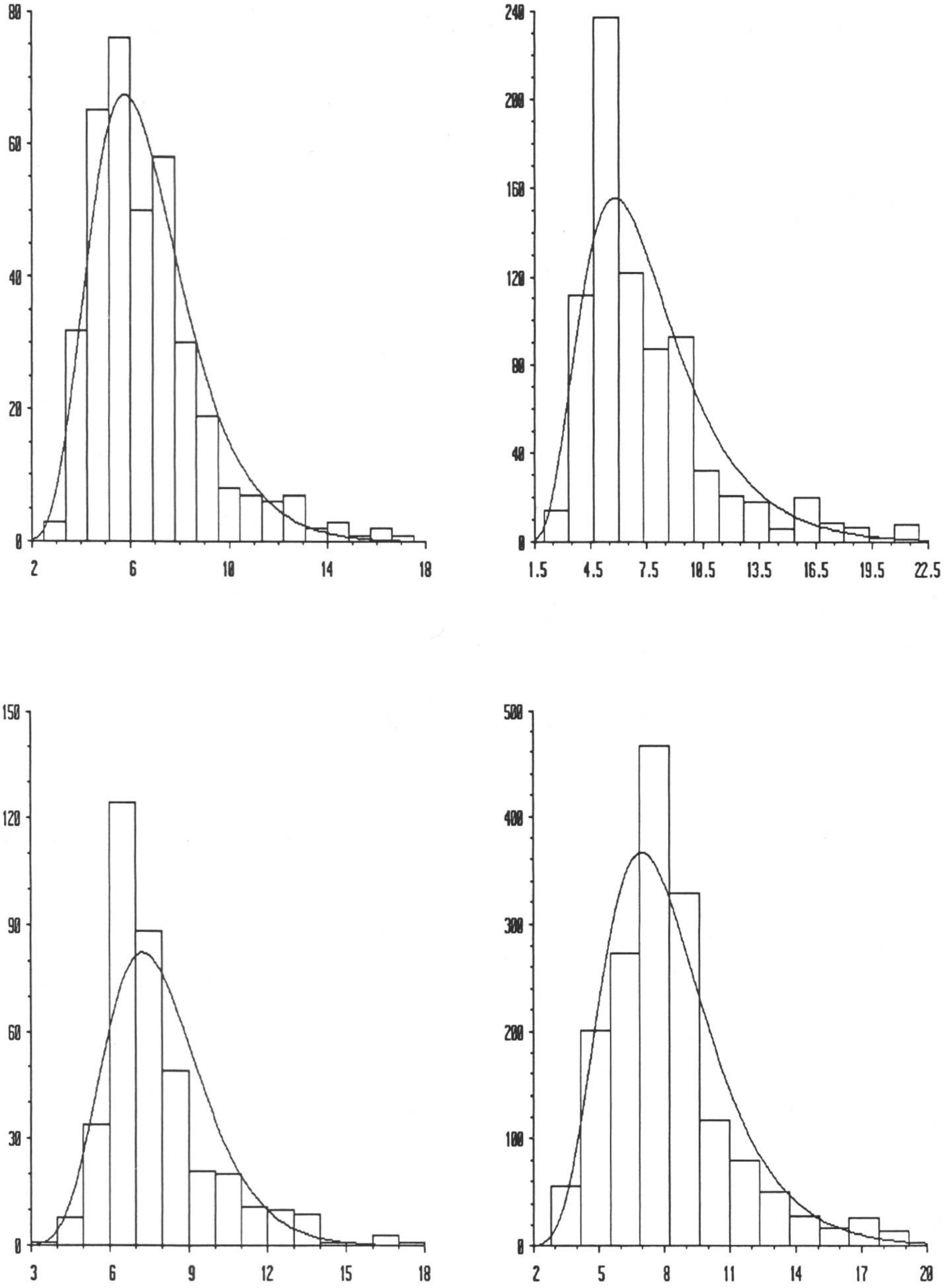




Figures 5-6. Frequency histograms of spore characteristics: 5: spore volume in µm^3 in Hymenomycetes (with log-normal distribution curve); 6: spore volume transformed to equivalent sphere diameter (in µm): above the x–axis – Aphyllophorales, below the axis – Agaricales.



Figures 7-8. Frequency histograms of spore characteristics in Aphyllophorales (above the x-axis) and Agaricales (below); Polyporaceae data are omitted. 7: spore length in µm , 8: Q values.



Figures. 9-12. Typical frequency histograms of spore length data (with log-normal distribution curves): 9: Agaricaceae, 10: Corticiaceae, 11: Strophariaceae, 12: Tricholomataceae.