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Macrofungal diversity in the forest litter of Nadia District, West Bengal, India

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Litter decomposing macrofungi (LDM) and ectomycorrhiza (ECM) play vital roles in maintenance of forest ecosystem. Since these soil-litter dwelling fungi produce lignolytic enzymes, they have been proved useful in soil bioremediation. However, literature of these groups is limited and therefore it is important to record and identify them. This study reports the diversity of litter growing macrofungi in three *sal* (*Shorea robusta* C.F. Gaertn.) dominated small forests, that is, Bethuadahari Wildlife Sanctuary (BWS), Ranaghat Forest (RF) and Zafarnagar Forest (ZF) of Nadia, West Bengal India. During the study period (2013 and 2014) 10,253 carpophores, belonging to 37 macrofungal species were sampled and 17 edible, 14 inedible and 4 poisonous species were identified based on previous records. *Podoscypha elegans* (G. Mey.) Pat. was recorded in India for the first time. Only 7 ECM (~18.91%) and 30 saprophytic (~81.08%) species were recorded. The differences of diversity pattern in the three forests varied significantly. Shannon and Brillouin indices were highest in BWS suggesting the most diverse fungal community in terms of α diversity whereas; β and Taxonomic diversity studies suggested that RF was the most heterogeneous forest among the sampled forests.

Key words: Brillouin, diversity, ectomycorrhiza, litter decomposing macrofungi, Shannon.

INTRODUCTION

India is a mega-diversity nation having a forest cover of 697,898 km^2 occupying 21.23% of the land area (State of Forest Report, 2011-2012) and is endowed with rich fungal flora (Manoharachary et al., 2005). Fungi are one of the most under-studied and under-protected groups (Minter, 2011) and thus, need special attention.

Saprotrophic decomposer fungi, mutualistic mycorrhizal fungi and parasitic fungi are the main functional groups which inhabit the forest litter (Simard and Austin, 2010). Some fungi of the first group and ectomycorrhiza (ECM) produce macroscopic carpophores and are referred to as macrofungi.

Litter decomposing macrofungi (LDM) colonize the forest litter and play a major role in litter decomposition (Osono, 2015) while ECM, is considered essential for the growth and health of forest tree species (Courty et al., 2010). Unfortunately, record of these groups is limited. Both ECM and LDM play vital roles in forest nutrition cycle (Cairney and Meharg, 2002). LDMs assume significance because a number of attempts have been made by different workers to exploit their lignolytic enzymes arsenal for bioremediation (Anastasi et al., 2013). The bioremediation property of both LDMs (Baldrian and Šnajdr, 2006; Liers et al., 2013) and ECM (Casieri et al., 2010) has been documented. Decontamination of pollutants from soil, water etc by the use of microorganisms is denoted as bioremediation (Rhodes, 2012) and this process is thought to be highly advantageous in recent years over other conventional processes (Ali, 2010). The forest area in West Bengal is around 11,879 km^2 occupying 13.38% land area and Nadia accounts for merely 0.30% (12 km^2) of this (State Forest Report, West Bengal 2011-12). Forests of Nadia are tropical moist deciduous broad leafed ones dominated by *Shorea robusta* C.F. Gaertn. (Dipterocarpaceae). The forest cover of the district is very low and is patchy in nature. Such a condition prevails in all other districts of tropical moist climate of West Bengal (Maldah, Murshidabad, Barddhaman, Hugli, Haora, Eastern parts of Bankura, West and East Medinipur and the Northern parts of North and South 24-Parganas).

With this in view, the current study intended to record the occurrence of this important but less studied group of macrofungi in three forests of Nadia District of West Bengal, India. Detailed survey were undertaken to also study the α, β and taxonomic diversity of the LDM species. This type of diversity study with LDM is the first of its kind in this area.

MATERIALS AND METHODS

Study areas

In the three forests the dominant tree is *S. robusta* (Dipterocarpaceae) along with other species like *Swietenia*

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mahagoni (Meliaceae), *Tectona grandis* (Lamiaceae), *Terminalia arjuna* (Combretaceae), *Mesua ferrea*, *Diospyros blancoi* (Ebenaceae), and *Saraca asoca* (Fabaceae). The tree density differed in the three forests, BWS (~67 ha) being the densest among them. BWS is a protected forest while RF (~34 ha) and ZF (~29 ha) are not protected. The distance between BWS and ZF is ~52 km while between BWS and RF is ~56.5 km.

Sampling, identification and diversity analysis

Forest areas were surveyed at intervals of 7 days from January 2013 till December 2014 and identified based on morpho-anatomical characterization and literature (Butler and Bisby, 1960; Arora, 1986) studies. *P. elegans* was further identified based on sequencing of 18S rDNA and NCBI blast. The sequence was published in NCBI genebank. Sampling was carried out in fixed random plots of 25 × 25 m^2 marked as B1 to B10 in BWS (that is, 10 plots), R1 to R7 in RF and Z1 to Z7 in ZF (that is, 7 plots each in RF and ZF). The total number of different species and individuals were recorded. Frequency of occurrence (F) was calculated after Tapwal et al., (2013) as follows:

$$\text{Frequency}(\%) = \frac{\text{Number of sites in which the species is present}}{\text{Total number of sites}} \times 100$$

Based on frequency percentage (F) the fungal species were classified in 4 categories as (1) Very Low occurring (F value =1-20), (2) Low occurring (F value =21-40), (3) Moderately occurring (F value =41-60) and (4) High occurring (F value =61-100).

All diversity analyses were done by PAST-3.11 software (Hammer et al., 2001). The different α-diversity indices namely Taxa S, Number of Individuals, Shannon (H) and Brillouin were calculated for each plot selecting percentile type bootstrap of 9999 replicates. The mean of Shannon (H) and Brillouin indices for each forest were calculated. Individual based rarefaction curve was constructed from the pooled data over two years. Whittaker β diversity (β_W) was calculated from the presence-absence data. Taxonomic distinctness and taxonomic diversity (Clarke and Warwick, 1998) with pooled 95% confidence (conditional method) were calculated.

RESULTS

Collection and identification

Altogether 5754, 2556 and 1943 numbers of carpophores were surveyed from BWS, RF and ZF respectively and 37 species were recognized (Table 1; Supplementary File 1) and classified into 18 genera of 12 basidiomycetous families. Two species of *Agaricus* and one species each of *Marasmius*, *Coprinus*, *Agrocybe* and *Podoscypha* could not be identified due to lack of literature. *P. elegans* was recorded for the first time in India. The identity of the species was further confirmed by 18S rDNA sequencing and blast analysis and the sequence was published in NCBI GenBank (Accession number: KP966113.1). The species was found growing on both wood litter and on soil-litter in BWS and RF during June to August.

28 fungal species belonging to 12 fungal families were recorded in BWS (Table 1), among which Agaricaceae represented the largest family. In RF, 21 species were recorded belonging to13 genera and 10 families while in ZF a total of 13 species were recorded among 10 genera and 6 families.

17 edible, 14 inedible and 4 poisonous (Table 1) species were recognized and only 7 species, previously reported as ECM, were recorded of which 6 namely *Agaricus sylvaticus*, *Marasmius oreades*, *Laccaria lacata*, *Lycoperdon pusillum*, *Boletus aestivalis* and *B. fallax* were present in BWS while 3, viz. *A. sylvaticus*, *Geastrum triplex* and *Boletus aestivalis* were recorded from RF and none was recorded from ZF.

Agaricaceae was the most dominant fungal family in terms of number of species (Figure 1). Five genera and 18 spp. of Agaricaceae were found in the three forests of which the maximum (14 spp.) were documented in BWS, followed by RF (10 spp.) and ZF (8 spp.). The genus *Agaricus* showed maximum of 11species (Table 1), of which 8, 6 and 3 were present in BWS, RF and ZF respectively. Among the other families, Marasmiaceae (*Marasmius siccus, Marasmius oreades and Marasmius* sp.) and Podoscyphaceae (*Phaps elegans, Phaps petaloides and Podoscypha* sp.) were the second most abundant having three species each.

Comparative frequency of different species in three forests

Based on frequency percentage (F) (Table 1), the frequency of the fungal species was found considerably different among forests.

In BWS, 4 very low occurring spp. (*A. porphyrocephalus*, *A. campestris*, *C. comatus* and *L. pusillum*) 9 low occurring spp. (*A. xanthodermus*, *C. molybdites*, *L. atrodisca*, *Coprinus* sp., *Agrocybe* sp., *H. capnoides*, *L.tigrinus*, *M. maculata* and *P. elegans*), 7 moderately occurring species (*A. bernardii*, *M. procera*, *M. siccus*, *M. oreades*, *V. taylori*, *L. lacata* and *B. fallax*) and 8 high occurring species (*A. sylvaticus*, *A. bisporus*, *A. amicosus*, *A. silvicola*, *M. mastoidea*, *L. felina*, *L. caerulescens*, and *B. aestivalis*) were recorded. In RF, *L. leucothites*, *V.taylori* and *G. triplex* comprised the very low occurring group, *Agaricus* sp. 1, *Agaricus* sp. 2, *L. atrodisca, Marasmius* sp. and *H. capnoides* comprised the low occurring group. 9 moderately occurring (*A. bernardii*, *A. campestris*, *M. mastoidea*, *L. caerulescens*, *L. tigrinus*, *M. maculate*, *P. elegans*, *P. petaloides* and *B. aestivalis*) and 4 high frequency species (*A. sylvaticus*, *A. semotus, M. siccus* and *C. comatus*) were also found in RF. In ZF the low occurring species were A. xanthodermus, *M. procera*, *L. leucothites*, *P. pellitus* and *Podoscypha* sp. 1 while the moderately occurring species were *A. bisporus*, *A. silvicola*, *M. mastoidea*, *L. atrodisca*, *C. comatus* and *L. tigrinus* and the high occurring species comprised of *C. molybdites* and *M. siccus* and no very low frequency species was recorded. Only 5 species (*M. mastoidea*, *L. atrodisca*, *M. siccus*, *C. comatus* and *L. tigrinus*) were recorded in all three forests, but, their frequency was different.

The different forests contributed different numbers of fungal taxa. Among the total, 9 species such as *A. porphyrocephalus, A. amicosus, L. felina, M. oreades, Coprinus* sp.*, Agrocybe sp.*, *Laccaria lacata, L. pusillum and B. fallax* were exclusive to BWS. Similarly 6 species (*A. semotus*, *Agaricus* sp. 1, *Agaricus* sp. 2, *Marasmius* sp., *G. triplex* and *P. petaloides*) and 2 species (*P. pellitus* and *Podoscypha* sp.) were limited to RF and ZF respectively. BWS and RF shared 9 species, while 5 species were shared by BWS and ZF (Table 1). Only one species, that is, *L. leucothites* was common in RF and ZF and 5 species were common in all the three forests. BWS contributed maximum fungal taxa singly. Percentage contribution of each forest in terms of total fungal species is presented in Figure 2.

Study of α-diversity

The different diversity indices such as Taxa S, Number of Individuals, Shannon (H) and Brillouin were calculated (Supplementary File 2). Maximum Taxa-S was recorded in B-2 and B6 (18 spp.) and minimum in Z-4 (5 spp.).

Plot wise Shannon (Figure 3) ranged from 1.81 (B-8) to 2.67 (B-10) in BWS, 1.49 (R-7) to 2.38 (R-2) in RF and 1.22 (Z-4) to 1.97 (Z-2) in ZF. The lowest and highest Shannon values among all 24 plots were recorded at Z-4 (in ZF) and B-10 (in BWS) respectively. The mean Shannon (Figure 4) for the three forests was 2.07, 1.92 and 1.56 in BWS, RF and ZF respectively. Plot-wise Brillouin (Figure 3), ranged from 1.77 (B-8) to 2.58 (B-10) in BWS, 1.44 (R-7) to 2.31 (R-2) in RF and 1.19 (Z-4) to 1.89 (Z-2) in ZF. The mean Brillouin (Figure 4) were 1.98, 1.82 and 1.47 in BWS, RF and ZF respectively. Comparative Mean Shannon and Brillouin (Figure 4) values were higher in BWS followed by RF and ZF.

Table 1. Fungal species, their functional role and comparative frequency in three forests.

Species	Family	Functional role	Edibility	Frequency BWS	Frequency RF	Frequency ZF
Agaricus sylvaticus Schaeff.	Agaricaceae	ECM	Ed	H	H	NA
Agaricus bisporus (J.E. Lange) Imbach	Agaricaceae	LDM	Ed	H	NA	M
Agaricus xanthodermus Genev.	Agaricaceae	LDM	Poi	L	NA	L
Agaricus porphyrocephalus F.H. Møller	Agaricaceae	LDM	Ined	VL	NA	NA
Agaricus bernardii (Quél.) Sacc.	Agaricaceae	LDM	Ed	M	M	NA
Agaricus campestris L.	Agaricaceae	LDM	Ed	VL	M	NA
Agaricus amicosus Kerrigan	Agaricaceae	LDM	Ed	H	NA	NA
Agaricus semotus Fr.	Agaricaceae	LDM	Ed	NA	H	NA
Agaricus silvicola (Vittad.) Peck	Agaricaceae	LDM	Ed	H	NA	M
Agaricus sp. 1	Agaricaceae	LDM	NA	NA	L	NA
Agaricus sp. 2	Agaricaceae	LDM	NA	NA	L	NA
Macrolepiota mastoidea (Fr.) Singer	Agaricaceae	LDM	Ed	H	M	M
Macrolepiota procera (Scop.) Singer	Agaricaceae	LDM	Ed	M	NA	L
Leucoagaricus leucothites (Vittad.) Wasser	Agaricaceae	LDM	Ed	NA	VL	L
Chlorophyllum molybdites (G. Mey.) Massee	Agaricaceae	LDM	Poi	L	NA	H
Lepiota felina (Pers.) P. Karst.	Agaricaceae	LDM	Ined	H	NA	NA
Lepiota caerulescens Peck	Agaricaceae	LDM	Ined	H	M	NA
Lepiota atrodisca Zeller	Agaricaceae	LDM	Ined	L	L	M
Marasmius siccus (Schwein.) Fr.	Marasmiaceae	LDM	Ined	M	H	H
Marasmius oreades (Bolton) Fr.	Marasmiaceae	ECM	Ined	M	NA	NA
Marasmius sp.	Marasmiaceae	LDM	Ined	NA	L	NA
Pluteus pellitus (Pers.) P. Kumm.	Pluteaceae	LDM	Ed	NA	NA	L
Volvariella taylori (Berk. & Broome) Singer	Pluteaceae	LDM	Ed	M	VL	NA
Coprinus comatus (O.F. Müll.) Pers.	Coprinaceae	LDM	Ed	VL	H	M
Coprinus sp.	Coprinaceae	LDM	NA	L	NA	NA
Agrocybe sp.	Strophariaceae	LDM	Ined/Poi	L	NA	NA
Hypholoma capnoides (Fr.) P. Kumm.	Strophariaceae	LDM	Poi	L	L	NA
Laccaria lacata (Scop.) Cooke	Hydnangiaceae	ECM	Ed	M	NA	NA
Lentinus tigrinus (Bull.) Fr.	Polyporaceae	LDM	Ined	L	M	M
Mycena maculata P. Karst.	Mycenaceae	LDM	Ined	L	M	NA
Lycoperdon pusillum Batsch	Lycoperdaceae	ECM	Ed	VL	NA	NA
Geastrum triplex Jungh.	Geastraceae	ECM	Ined	NA	VL	NA
Podoscypha elegans (G. Mey.) Pat.	Podoscyphaceae	LDM	Ined	L	M	NA
Podoscypha petaloides (Berk.) Boidin	Podoscyphaceae	LDM	Ined	NA	M	NA
Podoscypha sp.	Podoscyphaceae	LDM	Ined	NA	NA	L
Boletus aestivalis (Paulet) Fr.	Boletaceae	ECM	Ed	H	M	NA
Boletus fallax Kluzák	Boletaceae	ECM	Ed	M	NA	NA

Ed = Edible; Ined = Inedible; Poi = Poisonous; H = High frequency; M = Moderate frequency; L = Low frequency; VL = Very low frequency and NA = Not applicable.

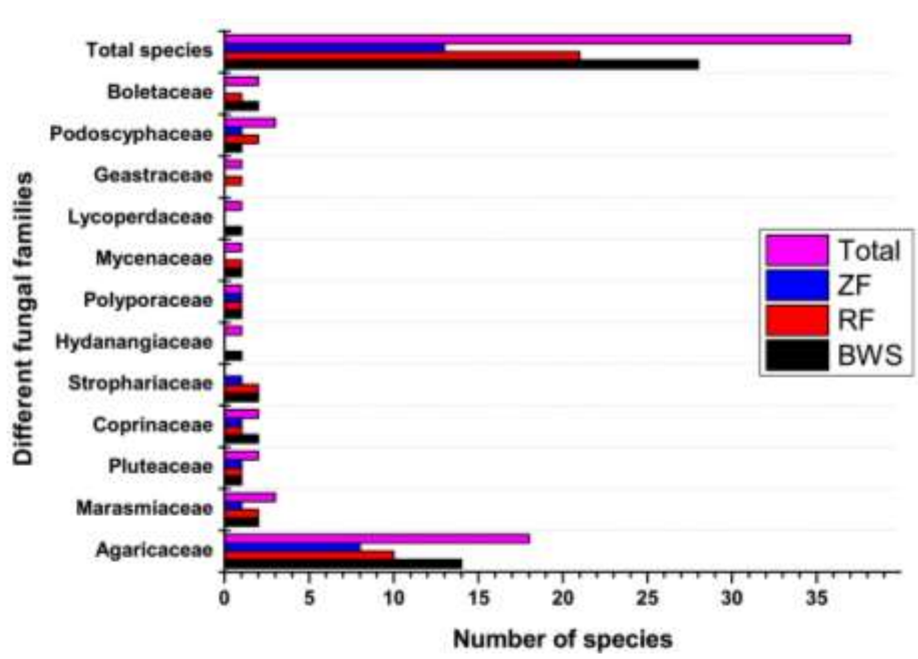

Figure 1. Number of different fungal species belonging to different families.

Rarefaction

The individual based rarefaction curve (Figure 5; Supplementary File 3) showed highest species richness in BWS. Since, the curve line of ZF lies significantly lower than RF, species richness was lowest

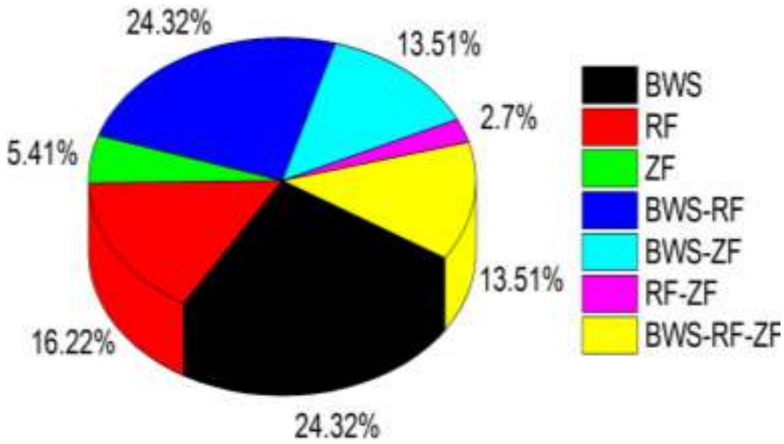

Figure 2. Percent contribution of each forest and combination of forests to the total collected fungal taxa.

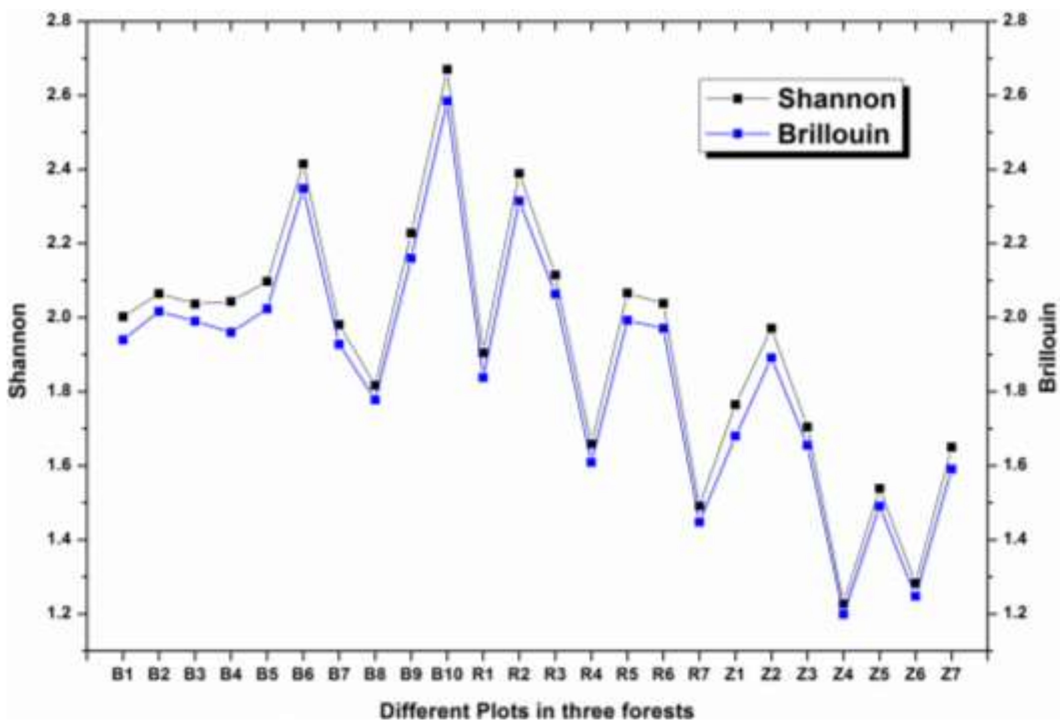

Figure 3. Shannon and Brillouin index values showing spatial distribution of fungal species in the 24 plots of the 3 forests.

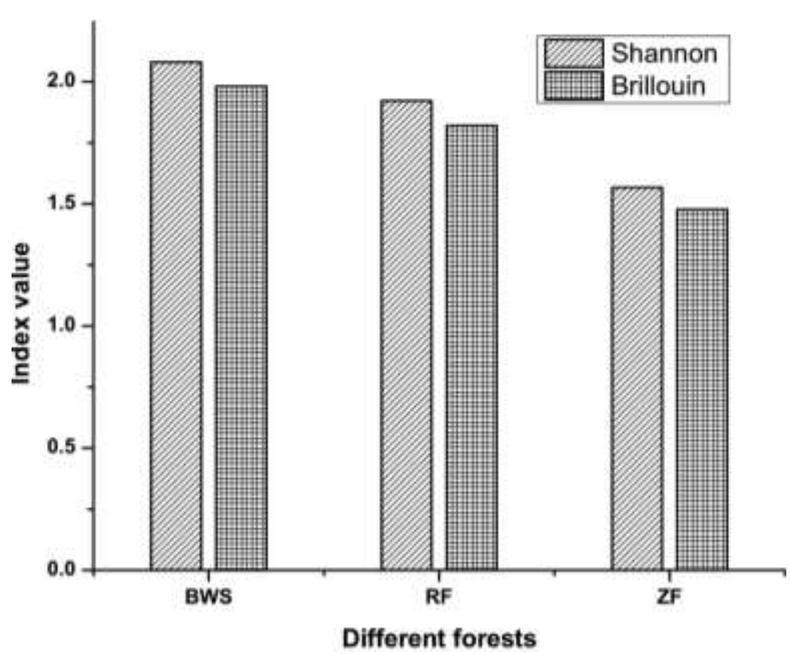

Figure 4. Mean Shannon and Brillouin values in three forests.

in ZF. At 101 sample size, 22.32, 18.84 and 12.68 specimens may be recorded in BWS, RF and ZF respectively.

β diversity

Whittaker (β_W) results showed (Table 2) that species

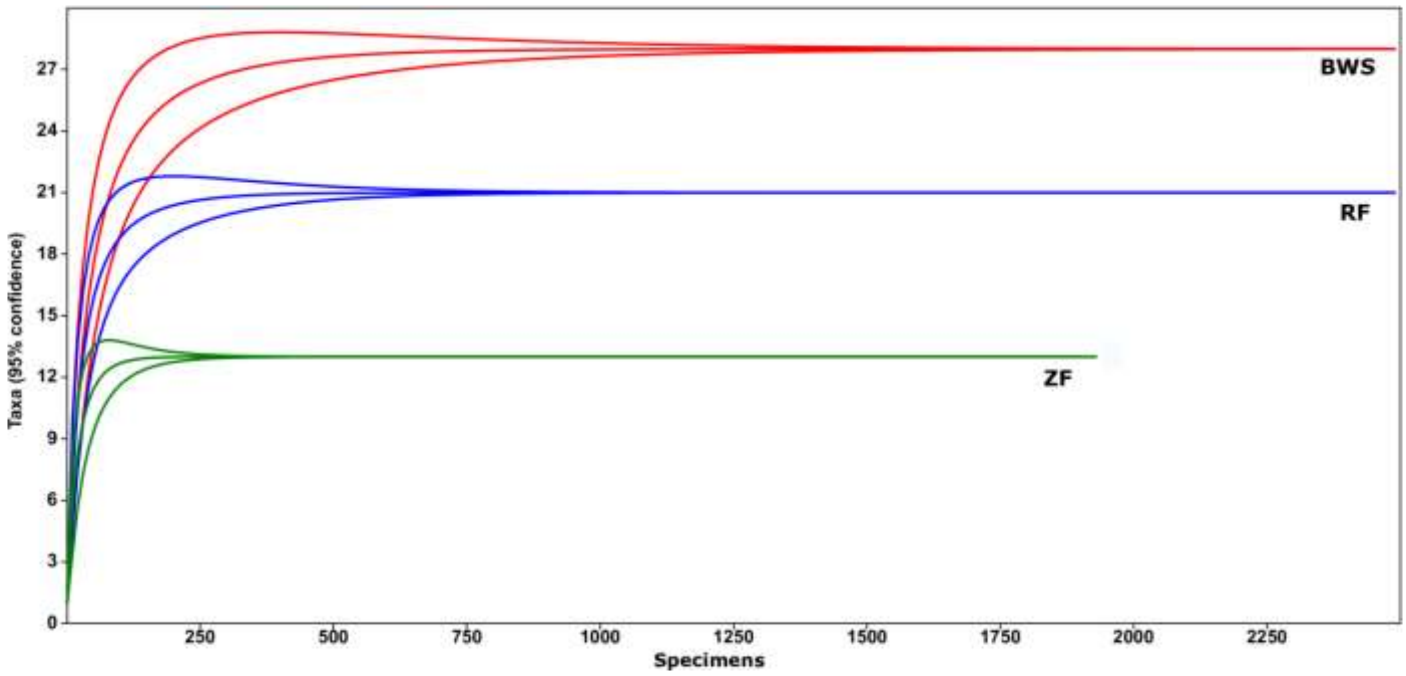

Figure 5. Individual rarefaction curve (95% conditional).

Table 2. Whittaker β-diversity index.

	BWS	RF	ZF
Whittaker (βW)	0.73913	1.0704	0.93617

Table 3. Taxonomic diversity and taxonomic distinctness in three forests.

Diversity and distinctness	Forests		
	BWS	RF	ZF
Diversity	2.509	2.689	2.372
Lower limit	2.537	2.522	2.510
Upper limit	2.574	2.591	2.598
Distinctness	2.821	3.038	2.964
Lower limit	2.853	2.841	2.835
Upper limit	2.882	2.895	2.899

composition differed in the three forests and RF had the highest β_W (1.07) followed by ZF (0.93) and BWS (0.73). Thus, BWS showed more uniform and less heterogenous species composition while in RF the heterogeneity was the maximum and in ZF heterogeneity was medium.

Taxonomic diversity (Δ) and taxonomic distinctness (Δ*)

Results of Δ showed (Table 3) that the diversity values were 2.50, 2.68 and 2.37 in BWS, RF and ZF respectively and maximum diversity was recorded in RF followed by BWS and ZF. The Δ* values (Table 3) for BWS, RF and ZF were 2.82, 3.03 and 2.96 respectively in an order of RF>ZF>BWS. Thus, in ZF the diversity (Δ) among the taxa was low, but the distinctness (Δ*) was higher.

DISCUSSION

Myco-vegetation in the litter layer of forests of Nadia

The transient nature of the carpophores makes fungal sampling challenging and to minimize the sampling error, pooled data was analyzed for overall presentation of fungal diversity in this study. Collections were done between May to October (2013-14) and no carpophores were found during December to April indicating that the pre-Monsoon, Monsoon and the cooler post-Monsoon periods (prior to winter) were favourable for fungal study in this region. The carpophores sprouted for varying periods from 1 to 5 months (Supplementary File 1).

There was also month-wise variation in the availability of LDMs (Figure 6) and 17, 23, 27, 25, 10 and 5 species were recorded during the months of May to October respectively. Maximum species were available during July (mid- Monsoon). The average rainfall recorded in the district of Nadia is 188.20, 955.00 and 118.40 mm in the pre-Monsoon, Monsoon and post-Monsoon periods respectively (Annual Flood Report, 2014).

In this Gangetic plain of Nadia summer (April-May) is associated with nor'westers (a natural phenomenon locally known as *Kal-Boishakhi*). The carpophores sprout in shady, moist forest litter after such 2 to 3 spells of rain. Seventeen macrofungi were found growing in May in the three forests. With the onset of the Monsoon (mid-June to mid-September), the number of macrofungi increased. At the end of monsoon (September) excessive wetness of the forest floor resulted in slight reduction in their appearance October coincides with the post monsoon season and macrofungi became significantly lower during the period.

Spatial distribution of agaric fungi in forest floor is common and affected by biotic factors like host resources, interspecific interactions etc. (Yamashita and Hijii, 2006) while ECM distribution is further affected by under soil

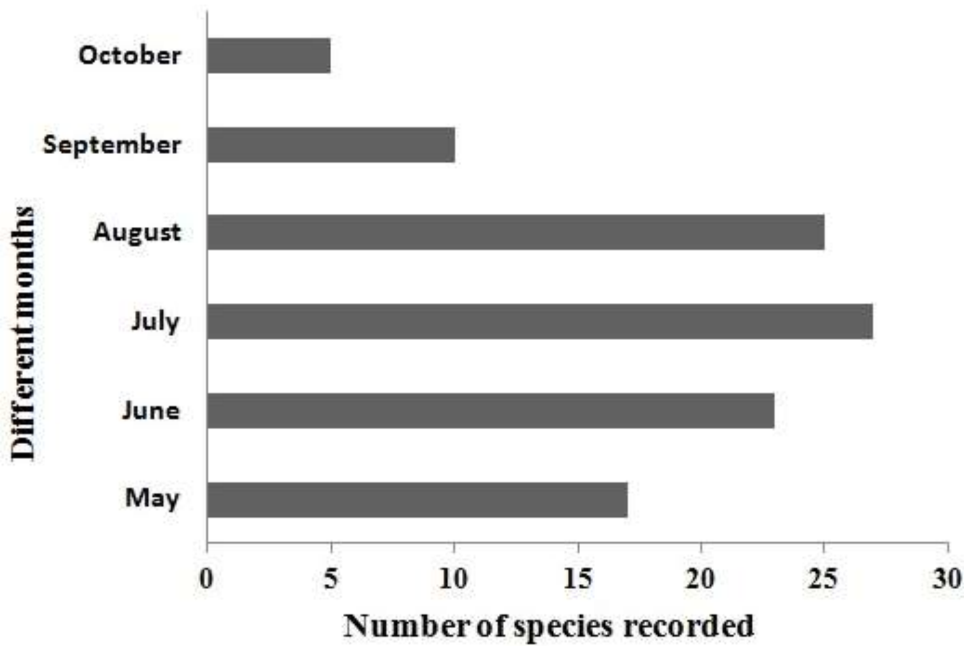

Figure 6. Total number of mushrooms recorded during different months of study (May to October 2013 to 2014).

root distribution (Matsuda and Hijii, 1998) and litter availability (Dahlberg et al., 1997). A similar spatial carpophore distribution was evidenced in the present study varying in between the different plots and also among the three forests.

Dipterocarp dominates the lowlands of South-East Asian forests (Slik et al., 2009) and they form ECM association (Brundrett et al., 1996). Such dipterocarp forests exist in the Indian sub-continent. The ECM constituents of such forests are unknown (Brearly, 2012) though ECM is essential for better health of such forests (Courty et al., 2010). However, their role in the tropical ecosystem is unclear (Brearley, 2012).

In the present study the percentage of ECM species was ~18.91% while in case of BWS the maximum ECM was recorded (~21.42%) followed by RF (~14.28%) and no ECM was recorded in ZF during the study. However, the presence of ECM in ZF cannot be ruled out since: (1) The undersoil diversity of ECM has been reported to be higher than that of the topsoil (Henkel et al., 2012).

Comparative study with other forest ecosystem

Comparison of fungal flora with other regions having similar or different geographical and climatic conditions is important for better understanding of myco-vegetation. Macrofungal diversity, including all groups, has previously been studied in West Bengal in different ecosystems. Dutta et al. (2013) recorded 62 species in 46 genera from the Sundarbans while Pradhan et al. (2016) reported 98 macrofungi (72 genera) including saprophytes, parasites and ECM, from Eastern Himalayas (Darjeeling). In their study 58.16% (a total of 57 species) were saprotrophs comprising of only one species of *Agaricus*. Only three species from the Sundarbans and five species from the Eastern Himalayas were common with the present study.

In similar studies in Assam, Gogoi and Prakash, (2015) reported 138 gilled mushrooms from wood and litter, belonging to 48 genera in 23 families. Baral et al. (2015) reported 115 macrofungi with Polyporaceae being the largest family from *sal* forests in central Nepal. Osono (2015) compared LDM diversity in subtropical, cool temperate and subalpine forests in Japan and recorded 35, 32, and 18 species respectively. Thus, the lower number of macrofungi in this study is due to the stress given on only LDMs. All other functional groups of forest fungi were not taken into account.

Agaricus comprised the dominant genera in the forests of Nadia, while *Russula* was dominant genera in both Darjeeling ecosystems of Eastern Himalayas and Assam. However, Usha and Janardhana (2014) found *Agaricus* to be the dominant genera in Parts of Western Ghats in Karnataka and reported 8 agaric species; while 11 species was recorded in this study.

Diversity pattern of fungi in the present study

Among the different α-diversity indices, Shannon increases as the richness and evenness of a community increases and it is common biodiversity index. However, Pielou (1966) suggested that Shannon must be applied when randomized samples are drawn from a community where the number of species is known. Since, the total number of macrofungi was not known Brillouin was used as it is more applicable where the composition of the community is not known (Pielou, 1975). Thus, Brillouin values were more interpretative as a measure of α-diversity and accordingly ranked the three forests as BWS>RF>ZF. BWS, being a protected land had lesser anthropogenic effect and also the forest being relatively dense, nurtured maximum number of macro-fungal species.

Since, in ecological analysis the number of species accumulates when sample size increases and thus, it is important to extrapolate the correlation between the number of species and sample size. Individual based rarefaction curve is a suitable way to express this relationship and in the present study at 101 sample size, 22.3299, 18.8454 and 12.6899 specimens may be recorded in BWS, RF and ZF respectively. Since, the rarefied sample (Figure 5) for the three forests was curved asymptotically parallel to the X axis no new species could be recorded as the curves reached their respective asymptotes.

Beta diversity (Whittaker, 1960) measures the differences in the composition of species between more than one local assemblages. For a given level of regional species richness, as there is an increase in beta diversity it is associated with the difference in individual localities more markedly from one another (Koleff et al., 2003). Thus, it may be applied to evaluate the extent to which two or more forests differ in terms of their species composition. In this study, Whittaker β (β_W) was calculated for each forest area from the presence-absence data. Beta measures change when there are differences between the species composition among the sites and it becomes zero when the species composition among sites does not change. Though, BWS showed maximum α-diversity, in terms of β-diversity it was least heterogeneous while, in RF the heterogeneity was the maximum and in ZF heterogeneity was medium.

The present study indicated that having high α value does not ensure that the community should also have a high β value. We found BWS having highest α but lowest β values while RF had a medium α but highest β values indicating that both the components were self-determining in nature. The independence of β and α diversity is a much debated topic (Jost, 2007; Baselga, 2010; Jost, 2010) and the statistical independence of the two components is not essential as well as expected and, rather, is a basic pragmatic question in biodiversity (Jost, 2010). The independence largely depends on the nature of ecosystem under study as well as on the experimental procedure. Independence noted in this study may be the outcome of both or either of these factors. Thus, the small forests of Nadia accommodate a considerable number of LDM and ECM. Occurrence of *P. elegans* was a new addition to Indian fungal flora as it was recorded for the first time in two subtropical moist deciduous forests (BWS and RF) of India. Low and moderate frequencies of occurrence of the species were recorded in BWS and RF respectively. The study presents the inventory of fungal diversity in the region and provides baseline information of LDMs and ECMs for further research in this field. Such fungi, being litter and soil growing and having lignolytic enzymes similar to white rot fungi, have an advantage over the latter for better adaptability in soil and should therefore be assessed for their role in soil-bioremediation (Baldrian and Šnajdr, 2006; Liers et al., 2013; Osono, 2015). Hence identifying and studying the diversity of the LDM is of prime importance and further studies are required.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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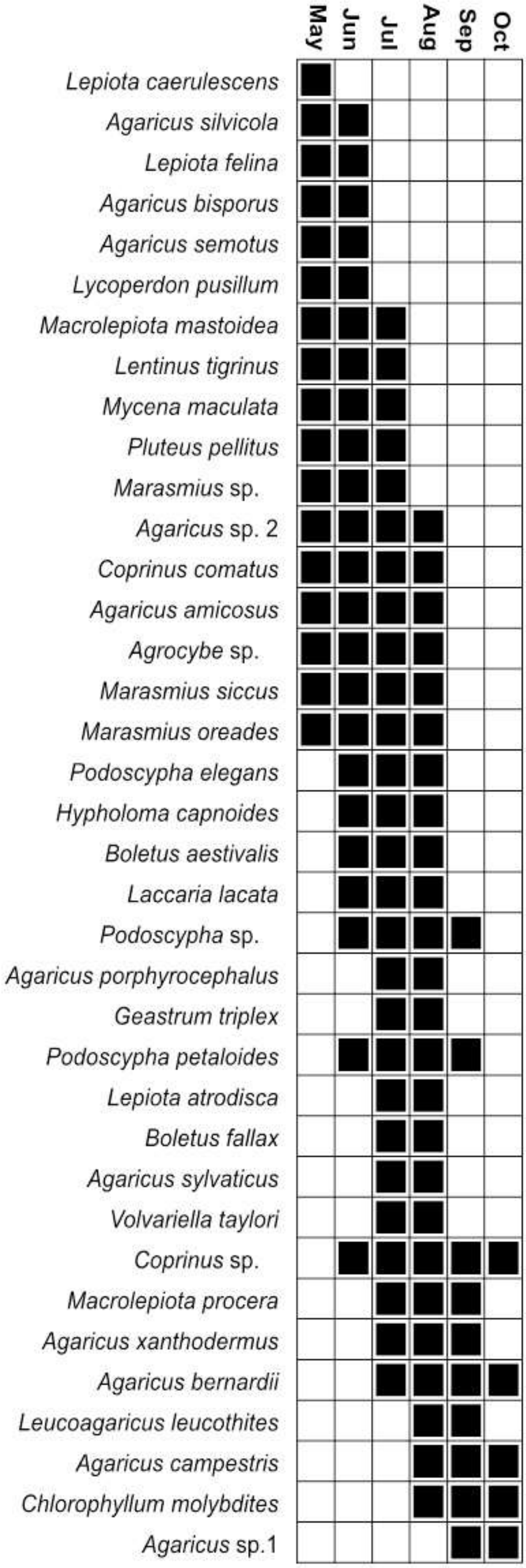

Supplementary File 1. Seriation model of month-wise availability of mycoflora in the district of Nadia.

Supplementary File 2. Plot wise values of different diversity indices calculated in the study.

	B1	Lower	Upper	B2	Lower	Upper	B3	Lower	Upper	B4	Lower	Upper	B5	Lower
Taxa_S	15	15	15	18	17	18	14	14	14	12	12	12	15	15
Individuals	498	498	498	782	782	782	669	669	669	281	281	281	405	405
Shannon_H	2.002	1.885	2.088	2.065	1.979	2.128	2.037	1.947	2.106	2.043	1.923	2.118	2.098	1.982
Brillouin	1.94	1.825	2.025	2.017	1.934	2.079	1.99	1.902	2.059	1.96	1.845	2.033	2.024	1.91
	Upper	**B6**	**Lower**	**Upper**	**B7**	**Lower**	**Upper**	**B8**	**Lower**	**Upper**	**B9**	**Lower**	**Upper**	**B10**
Taxa_S	15	18	18	18	15	15	15	14	14	14	17	17	17	23
Individuals	405	595	595	595	617	617	617	791	791	791	546	546	546	570
Shannon_H	2.19	2.415	2.325	2.481	1.981	1.874	2.063	1.817	1.725	1.891	2.228	2.112	2.314	2.67
Brillouin	2.115	2.348	2.26	2.413	1.928	1.822	2.009	1.778	1.687	1.85	2.16	2.046	2.245	2.584
	Lower	**Upper**	**R1**	**Lower**	**Upper**	**R2**	**Lower**	**Upper**	**R3**	**Lower**	**Upper**	**R4**	**Lower**	**Upper**
Taxa_S	23	23	10	10	10	14	14	14	11	11	11	8	8	8
Individuals	570	570	315	315	315	402	402	402	491	491	491	344	344	344
Shannon_H	2.571	2.727	1.905	1.78	1.992	2.389	2.308	2.432	2.115	2.036	2.168	1.659	1.542	1.744
Brillouin	2.488	2.64	1.838	1.715	1.924	2.314	2.235	2.355	2.063	1.985	2.116	1.609	1.494	1.694
	R5	**Lower**	**Upper**	**R6**	**Lower**	**Upper**	**R7**	**Lower**	**Upper**	**Z1**	**Lower**	**Upper**	**Z2**	**Lower**
Taxa_S	10	10	10	9	9	9	9	9	9	6	6	6	8	8
Individuals	274	274	274	292	292	292	438	438	438	135	135	135	206	206
Shannon_H	2.066	1.978	2.118	2.038	1.955	2.085	1.492	1.371	1.593	1.765	1.693	1.78	1.971	1.885
Brillouin	1.992	1.906	2.042	1.971	1.89	2.018	1.448	1.328	1.548	1.68	1.611	1.695	1.891	1.808
	Upper	**Z3**	**Lower**	**Upper**	**Z4**	**Lower**	**Upper**	**Z5**	**Lower**	**Upper**	**Z6**	**Lower**	**Upper**	**Z7**
Taxa_S	8	8	8	8	5	5	5	7	7	7	6	6	6	7
Individuals	206	340	340	340	365	365	365	301	301	301	365	365	365	231
Shannon_H	2.012	1.705	1.61	1.773	1.227	1.139	1.297	1.538	1.426	1.623	1.283	1.172	1.378	1.65
Brillouin	1.932	1.655	1.563	1.723	1.199	1.112	1.268	1.49	1.38	1.574	1.248	1.139	1.342	1.591
	Lower	**Upper**												
Taxa_S	7	7												
Individuals	231	231												
Shannon_H	1.548	1.721												
Brillouin	1.491	1.66												

Supplementary File 3. Individual rarefaction.

Sample size	BWS	Std. err 1s	RF	Std. err 1s	ZF	Std. err 1s
1	1	0	1	0	1	0
11	7.29087	1.355	7.20272	1.3073	5.91242	1.2531
21	11.0504	1.72959	10.7078	1.58441	8.37411	1.34996
31	13.8011	1.87176	13.0504	1.64316	9.86853	1.28813
41	15.9168	1.92031	14.7023	1.61761	10.8258	1.17551
51	17.5848	1.92183	15.9091	1.55684	11.4633	1.04985
61	18.925	1.89788	16.8154	1.48309	11.9001	0.92652
71	20.0192	1.86004	17.5118	1.40669	12.2055	0.81182
81	20.9254	1.81489	18.0576	1.33227	12.4222	0.70805
91	21.6853	1.76628	18.4928	1.26171	12.5776	0.61564
101	22.3299	1.71648	18.8454	1.19557	12.6899	0.53415
111	22.882	1.66682	19.1349	1.13381	12.7717	0.46275
121	23.3592	1.61805	19.3756	1.07611	12.8315	0.40047
131	23.7749	1.57059	19.578	1.02211	12.8754	0.3463
141	24.1397	1.52465	19.7496	0.97143	12.9078	0.29928
151	24.4619	1.48032	19.8965	0.92374	12.9316	0.25853
161	24.748	1.4376	20.0231	0.87874	12.9493	0.22325
171	25.0034	1.39646	20.1328	0.83619	12.9624	0.19272
181	25.2325	1.35684	20.2284	0.79587	12.972	0.16633
191	25.4389	1.31867	20.3122	0.75763	12.9792	0.14352
201	25.6255	1.28188	20.3858	0.7213	12.9846	0.12381
211	25.7949	1.24639	20.4508	0.68676	12.9885	0.10678
221	25.949	1.21213	20.5083	0.6539	12.9915	0.09208
231	26.0898	1.17904	20.5593	0.62261	12.9937	0.07938
241	26.2186	1.14705	20.6046	0.59282	12.9953	0.06841
251	26.3368	1.1161	20.6449	0.56444	12.9965	0.05895
261	26.4455	1.08614	20.681	0.53741	12.9974	0.05078
271	26.5457	1.05713	20.7131	0.51164	12.9981	0.04373
281	26.6382	1.02901	20.7419	0.48709	12.9986	0.03764
291	26.7238	1.00175	20.7677	0.46368	12.9989	0.0324
301	26.803	0.97531	20.7908	0.44138	12.9992	0.02787
311	26.8765	0.94965	20.8116	0.42012	12.9994	0.02397
321	26.9448	0.92474	20.8302	0.39986	12.9996	0.0206
331	27.0084	0.90055	20.847	0.38054	12.9997	0.0177
341	27.0675	0.87706	20.862	0.36213	12.9998	0.0152
351	27.1227	0.85423	20.8756	0.34459	12.9998	0.01305
361	27.1741	0.83205	20.8878	0.32787	12.9999	0.0112
371	27.2222	0.81049	20.8988	0.31193	12.9999	0.0096
381	27.2672	0.78952	20.9087	0.29675	12.9999	0.00823
391	27.3092	0.76914	20.9176	0.28228	13	0.00705
401	27.3486	0.74931	20.9257	0.26849	13	0.00603
411	27.3855	0.73003	20.933	0.25534	13	0.00516
421	27.4201	0.71127	20.9395	0.24282	13	0.00441
431	27.4526	0.69301	20.9454	0.23089	13	0.00377
441	27.4831	0.67525	20.9508	0.21952	13	0.00322
451	27.5118	0.65797	20.9556	0.20869	13	0.00275
461	27.5387	0.64114	20.9599	0.19837	13	0.00234
471	27.564	0.62477	20.9639	0.18854	13	0.00199
481	27.5879	0.60883	20.9674	0.17918	13	0.0017
491	27.6103	0.59331	20.9706	0.17026	13	0.00144
501	27.6314	0.5782	20.9735	0.16176	13	0.00123
511	27.6513	0.56349	20.9761	0.15367	13	0.00104
521	27.6701	0.54917	20.9785	0.14596	13	0
531	27.6878	0.53522	20.9806	0.13862	13	0
541	27.7045	0.52164	20.9825	0.13163	13	0
551	27.7202	0.50841	20.9843	0.12498	13	0
561	27.7351	0.49552	20.9858	0.11864	13	0
571	27.7491	0.48297	20.9872	0.11261	13	0
581	27.7623	0.47075	20.9885	0.10687	13	0
591	27.7748	0.45884	20.9897	0.1014	13	0
601	27.7867	0.44724	20.9907	0.0962	13	0
611	27.7978	0.43594	20.9916	0.09124	13	0
621	27.8084	0.42493	20.9925	0.08653	13	0
631	27.8184	0.4142	20.9932	0.08205	13	0
641	27.8279	0.40374	20.9939	0.07778	13	0
651	27.8368	0.39356	20.9945	0.07372	13	0
661	27.8453	0.38363	20.9951	0.06986	13	0
671	27.8533	0.37396	20.9956	0.06619	13	0

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681	27.8608	0.36454	20.9961	0.0627	13	0
691	27.868	0.35535	20.9965	0.05938	13	0
701	27.8748	0.3464	20.9968	0.05622	13	0
711	27.8812	0.33767	20.9972	0.05322	13	0
721	27.8873	0.32917	20.9975	0.05037	13	0
731	27.8931	0.32088	20.9977	0.04766	13	0
741	27.8986	0.3128	20.998	0.04509	13	0
751	27.9038	0.30493	20.9982	0.04265	13	0
761	27.9087	0.29725	20.9984	0.04032	13	0
771	27.9133	0.28977	20.9985	0.03812	13	0
781	27.9178	0.28247	20.9987	0.03603	13	0
791	27.9219	0.27536	20.9988	0.03404	13	0
801	27.9259	0.26842	20.999	0.03215	13	0
811	27.9297	0.26166	20.9991	0.03036	13	0
821	27.9333	0.25507	20.9992	0.02867	13	0
831	27.9366	0.24865	20.9993	0.02706	13	0
841	27.9399	0.24238	20.9993	0.02553	13	0
851	27.9429	0.23627	20.9994	0.02408	13	0
861	27.9458	0.23032	20.9995	0.02271	13	0
871	27.9486	0.22451	20.9995	0.02141	13	0
881	27.9512	0.21885	20.9996	0.02018	13	0
891	27.9536	0.21332	20.9996	0.01901	13	0
901	27.956	0.20794	20.9997	0.01791	13	0
911	27.9582	0.20269	20.9997	0.01686	13	0
921	27.9603	0.19757	20.9997	0.01587	13	0
931	27.9623	0.19257	20.9998	0.01493	13	0
941	27.9642	0.1877	20.9998	0.01405	13	0
951	27.966	0.18295	20.9998	0.01321	13	0
961	27.9678	0.17832	20.9998	0.01242	13	0
971	27.9694	0.1738	20.9999	0.01167	13	0
981	27.9709	0.1694	20.9999	0.01096	13	0
991	27.9724	0.1651	20.9999	0.01029	13	0
1001	27.9738	0.16091	20.9999	0.00966	13	0
1011	27.9751	0.15683	20.9999	0.00907	13	0
1021	27.9764	0.15284	20.9999	0.00851	13	0
1031	27.9776	0.14895	20.9999	0.00797	13	0
1041	27.9787	0.14516	20.9999	0.00747	13	0
1051	27.9798	0.14147	21	0.007	13	0
1061	27.9808	0.13786	21	0.00656	13	0
1071	27.9818	0.13434	21	0.00614	13	0
1081	27.9827	0.13091	21	0.00575	13	0
1091	27.9836	0.12757	21	0.00537	13	0
1101	27.9844	0.1243	21	0.00503	13	0
1111	27.9852	0.12112	21	0.0047	13	0
1121	27.986	0.11802	21	0.00439	13	0
1131	27.9867	0.11499	21	0.0041	13	0
1141	27.9874	0.11204	21	0.00382	13	0
1151	27.988	0.10916	21	0.00357	13	0
1161	27.9886	0.10635	21	0.00333	13	0
1171	27.9892	0.10361	21	0.0031	13	0
1181	27.9898	0.10094	21	0.00289	13	0
1191	27.9903	0.09833	21	0.00269	13	0
1201	27.9908	0.09579	21	0.0025	13	0
1211	27.9913	0.09331	21	0.00233	13	0
1221	27.9917	0.0909	21	0.00217	13	0
1231	27.9921	0.08854	21	0.00201	13	0
1241	27.9925	0.08624	21	0.00187	13	0
1251	27.9929	0.084	21	0.00173	13	0
1261	27.9933	0.08181	21	0.00161	13	0
1271	27.9936	0.07968	21	0.00149	13	0
1281	27.994	0.0776	21	0.00138	13	0
1291	27.9943	0.07557	21	0.00128	13	0
1301	27.9946	0.07359	21	0.00119	13	0
1311	27.9949	0.07167	21	0.0011	13	0
1321	27.9951	0.06979	21	0.00101	13	0
1331	27.9954	0.06795	21	0	13	0
1341	27.9956	0.06616	21	0	13	0
1351	27.9958	0.06442	21	0	13	0
1361	27.9961	0.06272	21	0	13	0

Supplementary File 3. Contd.

1371	27.9963	0.06106	21	0	13	0
1381	27.9965	0.05945	21	0	13	0
1391	27.9966	0.05787	21	0	13	0
1401	27.9968	0.05633	21	0	13	0
1411	27.997	0.05484	21	0	13	0
1421	27.9971	0.05338	21	0	13	0
1431	27.9973	0.05195	21	0	13	0
1441	27.9974	0.05056	21	0	13	0
1451	27.9976	0.04921	21	0	13	0
1461	27.9977	0.04789	21	0	13	0
1471	27.9978	0.04661	21	0	13	0
1481	27.9979	0.04535	21	0	13	0
1491	27.9981	0.04413	21	0	13	0
1501	27.9982	0.04294	21	0	13	0
1511	27.9983	0.04178	21	0	13	0
1521	27.9983	0.04065	21	0	13	0
1531	27.9984	0.03955	21	0	13	0
1541	27.9985	0.03847	21	0	13	0
1551	27.9986	0.03743	21	0	13	0
1561	27.9987	0.03641	21	0	13	0
1571	27.9987	0.03541	21	0	13	0
1581	27.9988	0.03444	21	0	13	0
1591	27.9989	0.0335	21	0	13	0
1601	27.9989	0.03258	21	0	13	0
1611	27.999	0.03168	21	0	13	0
1621	27.9991	0.03081	21	0	13	0
1631	27.9991	0.02996	21	0	13	0
1641	27.9992	0.02913	21	0	13	0
1651	27.9992	0.02832	21	0	13	0
1661	27.9992	0.02753	21	0	13	0
1671	27.9993	0.02677	21	0	13	0
1681	27.9993	0.02602	21	0	13	0
1691	27.9994	0.02529	21	0	13	0
1701	27.9994	0.02459	21	0	13	0
1711	27.9994	0.0239	21	0	13	0
1721	27.9995	0.02322	21	0	13	0
1731	27.9995	0.02257	21	0	13	0
1741	27.9995	0.02193	21	0	13	0
1751	27.9995	0.02131	21	0	13	0
1761	27.9996	0.02071	21	0	13	0
1771	27.9996	0.02012	21	0	13	0
1781	27.9996	0.01955	21	0	13	0
1791	27.9996	0.01899	21	0	13	0
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