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Diversity of Gasteroid Fungi (Basidiomycota) in Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam, India

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Abstract

Hollongapar Gibbon Wildlife Sanctuary (HGWLS), Jorhat, Assam is mainly famous for Hollock Gibbon and other six primate species found in the sanctuary. A total of 22 gasteroid fungal species belongs to 9 genera, 4 families, 4 orders, 2 sub-classes and 1 class, have been found in the study site. The family Agaricaceae (8 spp.) is highly dominant in the study site followed by Phallaceae (7 spp.), Geastraceae (4 spp.), and Sclerodermataceae (3 spp.). The name of the gasteroid fungi species along with their occurrence percentage are *Phallus indusiatus* (9.46), *Phallus duplicatus* (3.55), *Phallus merulinus* (1.42), *Phallus cinnabarinus* (1.18), *Phallus atrovolvatus* (0.95), *Mutinus bambusinus* (17.73), *Clathrus delicatus* (0.47) belong to stinkhorns; *Scleroderma cepa* (0.71), *Scleroderma verrucosa* (2.36), *Scleroderma citrinum* (3.55) belong to earthballs; *Calvatia rubroflava* (0.95), *Calvatia cyathiformis* (0.71), *Bovista longispora* (5.91), *Bovista plumbea* (3.31), *Bovista dermoxantha* (10.64), *Morganella pyriformis* (1.18) belong to puffballs; *Geastrum schweinitzii* (7.09), *Geastrum lloydianum* (4.96), *Geastrum saccatum* (13.0), *Geastrum coronatum* (4.02) are earthstars and *Cyathus striatus* (3.07), *Cyathus hookeri* (3.78) are bird's nest fungi.

Key Words – Distribution – dominant – ecosystem –macro fungi – species richness

Introduction

According to Hawksworth et al. (1995), Richards & Murray (2002); Bates (2006) macrofungi can be defined as fungi that form macroscopic fruiting bodies, such as gilled fungi, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi. Macrofungi are distinguished by having spore-bearing structures visible to the naked (Mueller et al. 2007). Most terrestrial macrofungi are saprobes or mycorrhizal symbionts, but some are pathogens of plants. Fungi fruiting on woody substrata are usually either saprobes or plant pathogens (Mueller et al. 2007).

Fungi are among the most important organisms in the world, because of their vital role in ecosystem functions, influence on humans and human-related activities (Mueller & Bills 2004). Macrofungi are not only beautiful but play a significant role in the daily life of human beings besides their utilization in industry, agriculture and medicine (Cowan 2001, Chang & Miles 2004). Moreover, fungi

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help in bioremediation, in recycling nutrients and in decomposing the dead organic matter in soil and litter, as biofertilizers and in many other ways (Gadd 2001). While many wild mushrooms are edible, it can be difficult to identify them correctly in the field. Besides, some are toxic, even deadly when eaten (Das 2010). Fatality due to unwise consumption of wild mushrooms is a common affair amongst regional poor people. Wood decay fungi are commonly associated with woody host or humus rich soil. In the forest, fungi decay and recycle carbon and nitrogen and convert plant and animal debris into humus (Rossman et al. 1998). The fungus, mostly basidiomycetes are the most efficient lignin degraders in nature (Eriksson et al. 1990). White-rot fungi can progressively utilize all major cell wall components, including both carbohydrates and lignin (Jasalavich et al. 2000).

The gasteroid fungi are informal or non-taxonomic group of macrofungi in the Phylum Basidiomycota. They are placed in this informal group because they produce their spores inside their basidiocarps (fruit bodies) rather than on an outer surface. The gasteroid fungi includes stinkhorns, earthballs, puffballs, pseudo truffles, earth stars and bird nest's—are not closely related to each other. Like other fungi, gasteroid fungi are some of the most important organisms in the world, because of their vital role in ecosystem function and influence on humans and human-related activities.

The main publications about fungi in India were, Butler & Bisby (1931) later on revised by Vasudeva (1960), Bilgrami et al. (1979, 1981, 1991), Manjula (1983). Deshmukh (2004) reported 850 mushroom species, 2000 macrofungal species reported from India by Kaul (1999). Traditional mycological knowledge of most Indian ethnic groups has proven to be extensive and profound, consuming nearly 283 species of wild mushrooms out of 2000 species recorded world over (Purkayastha & Chandra, 1985). Dutta et al. (2012) described two *Phallus* spp. and one *Mutinus* sp. from West Bengal. Recently, Karun & Sridhar (2014) reported six species of Geasters from Western Ghat and West coast of India.

Verma et al. (1987) described fleshy fungal flora of the north-eastern hills (NEH) India from Manipur and Meghalaya belonging to the family Auriculariaceae, Clavariaceae, Cantharellaceae, Tricholomataceae, Pluteaceae, Paxillaceae, Cortinariaceae, Cycoperdaceae, and Sclerodermataceae of Basidiomycotina and Halvellaceae of Ascomycotina. Again, Verma et al. (1995) recorded 95 species of higher fungi. Among these, 85 species were new records from the NEH region and others were from different locations of India. Sharma & Sidhu (1991) recorded 12 species of macrofungi from West Bengal, Meghalaya, Assam and Arunachal Pradesh states. The extreme North Eastern hills bordering China, Burma and Bangladesh and marked by high rainfall have also yielded rich mushroom flora as reported by Verma et al. (1985, 1987, 1989, 1995). Some wild edible mushrooms have been reported from Manipur by Sing & Sing (1993). Boruah et al. (1997) reported 4 species of fleshy, edible fungi from North East India; 126 macrofungal species including *Clavaria fumosa* Pers. and *Clavaria vermicularis* Fr. were reported by Das (2010) from Sikkim**.** Singh & Chhetry (2010) recorded 7 species of macrofungi from Manipur, whereas from Assam, Sarma et al. (2010) reported 26 species of wild edible mushrooms including *Lycoperdon pyriforme* used by some ethnic tribes of Western Assam; 12 species of macrofungi including *Lycoperdon perlatum* were reported from Dhemaji district of Assam by Gogoi & Sarma (2012). Saharia & Sarma (2012) reported 50 morphotypes of macrofungi including *Clavaria cristata*, *Cyathus striatus* and *Rhizopogon lutiolus*, which were responsible post harvest bamboo decaying in Assam. Gogoi & Parkash (2014) reported 7 stinkhorn species from HGWLS, Jorhat, Assam. An attempt is made through this study to provide an updated list of gasteroid fungi as well as their diversity and distribution in the study site.

Materials and Methods

Study Area – The HGWLS (Fig. 1) is a homeland of seven primate species and this is the only sanctuary in India which was named in the name of an Ape e.g. Hollock Gibbon. It lies between 26.40–26.45^{0}N latitude and 94.18–94.23^{0}E longitude, covering an area of 20.98 km^2. The average annual rainfall is 2490 mm, situated at 100–120m asl (metre above sea level). As per Champion & Seth (1986), the forest type of the area is Assam Plain Alluvial Semi Evergreen Forest with pockets of Wet Evergreen forests. The sanctuary is composed of five compartments dominated with dipterocarps trees mixed with bamboos

and canes. The word "Hollongapar" is derived from an Assamese word "Hollong" tree, which means *Dipterocarpus retusus*. Therefore, the sanctuary was named as Hollongapar Reserved forest earlier.

Survey, Preservation and Examination – Stratified random sampling technique was used to make layout of transects (50m × 20m) in the different compartments of the sanctuary. A total 42 transects have been studied in the whole sanctuary in order to extrapolate the total number of gasteroid fungi and their fruit bodies in each compartment as well as in the whole sanctuary (Tables 1 & 2). The fruit bodies of stinkhorn mushrooms of gasteroid fungi are very delicate and persist only for a few hours. Hence, frequent survey was done during April 2012 to September 2013 as suggested by Largent (1977). Important characters require for identification of gasteroids, such as habit, habitat, substratum, odour, colour and size of the pileus, stipe and volva, presence or absence of veil were noted from the fresh material in the field and photographed the same in its natural habitat. Colour codes and terms were followed as per Methuen Handbook of Colour (Kornerup & Wanscher, 1978). The collected fruit bodies are also preserved in the laboratory, Rain Forest Research Institute, Jorhat for further study. Identification of the specimens was carried out by standard microscopic methods and also considering various morphological and anatomical features into account (Smith 1963, Ainsworth et al. 1973, Miller 1977, Natarajan 1978, Smith et al. 1979, Afyon et al. 2005, Bates et al. 2009, Trierveiller-Pereira & Baseia 2009, Trierveiller-Pereira et al. 2011, Trierveiller-Pereira & Baseira 2011, Yousaf et al. 2014, Karun & Sridhar 2014). The website, http://www.indexfungorum.org/ was also accessed for identification of gasteroid fungi during the study period.

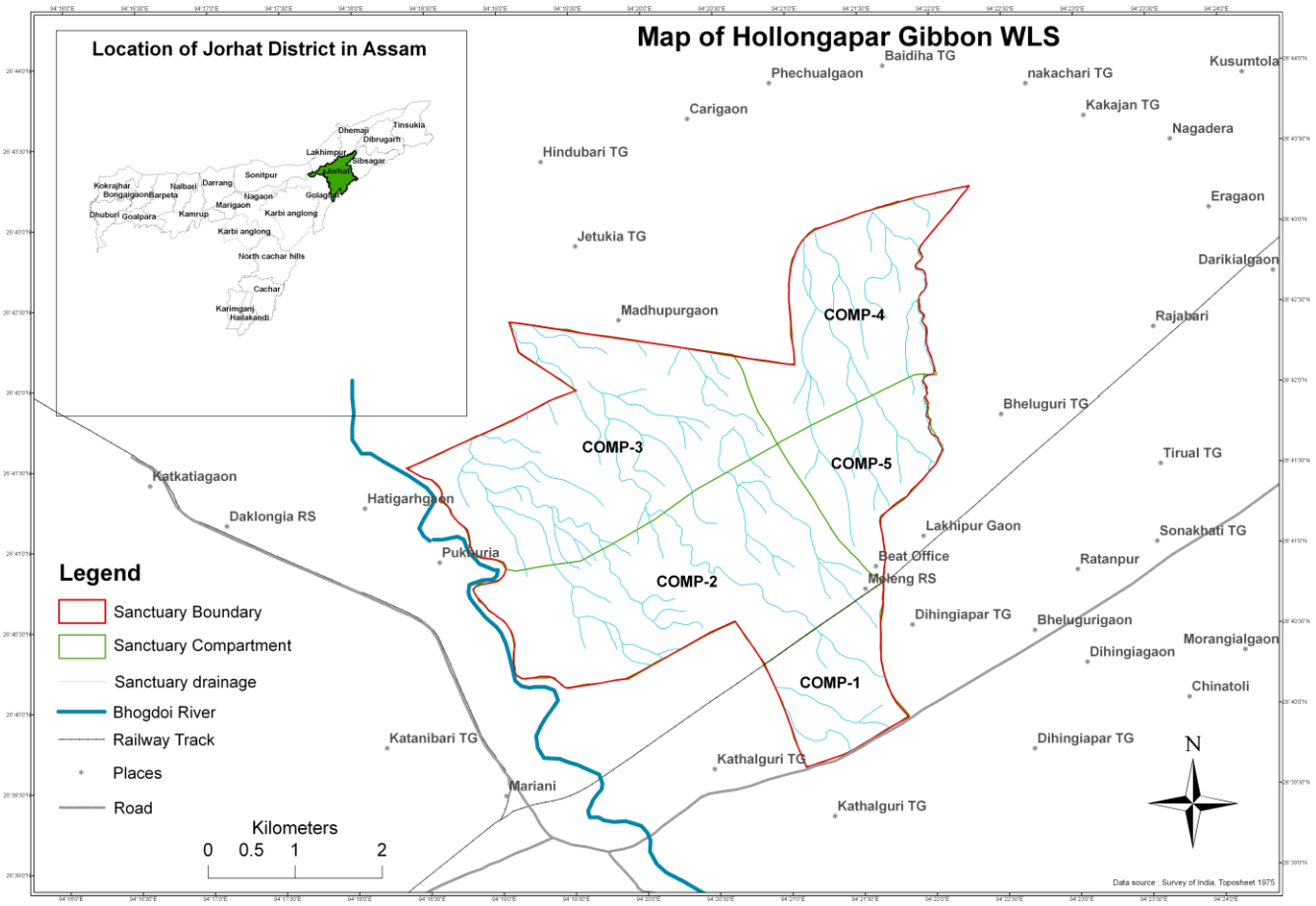


Fig.1 – Map of the study site showing five compartments

Results and Discussion

A total 22 gasteroid fungi species belongs to 9 genera, 4 families, 4 orders, have been found in the study site (Tables 1 & 2, Figs 2–22). The genus *Phallu*s (5 spp.) was found to be dominant in the study site followed by *Geastrum* (4 spp.), *Bovista* (3 spp.), *Scleroderma* (3 spp.), *Calvatia* (2 spp.), *Cyathus* (2 spp.), *Clathrus* (1 sp.), *Morganella* (1 sp.) and *Mutinus* (1 sp.). The family Agaricaceae (8 spp.) the under order Agaricales (8 spp.) is highly dominant in the study site followed by Phallaceae (7 spp.) under order Phallales (7 spp.), Geastraceae (4 spp.) under order Geastrales (4 spp.) and Sclerodermataceae (3 spp.) Boletales (3 spp.). Gogoi & Parkash (2014) have already reported 7 species of stinkhorns from the study site. Bamboo habitat is the most favorite for the gasteroid fungi, thus, 7 species have been found only in the dead bamboo stumps, followed by 5 species on the soil, 4 species in the bamboo leaf litter, 2 species each in the dung soil, grass land and dead bamboo stumps. Among 22 gasteroid fungal species, 9 species were found to be edible and the rest 13 species were inedible (Table 1). Like other macro fungi, these fungi have important ecological function mainly decomposition of dead wood and leaf litter in the forest floor.

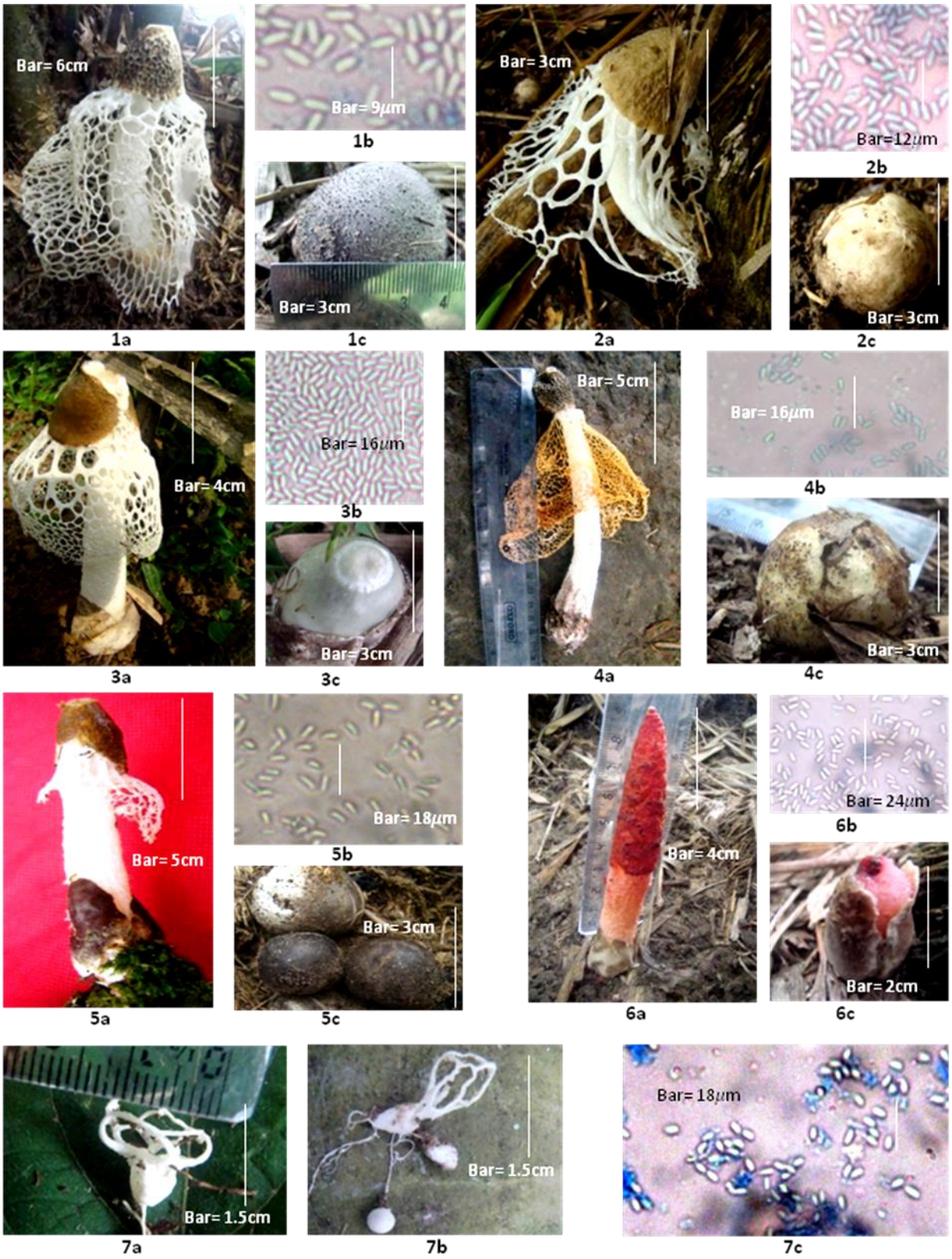
Table 1 Gasteroid fungi in the HGWLS with their taxonomy, substrata and importance

Sl.No.	Name of fungi	Family	Order	Substratum	Importance
1	*Phallus indusiatus* Vent.	Phallaceae	Phallales	Dead bamboo stump	Edible
2	*Phallus duplicatus* Bosc	Phallaceae	Phallales	Dead bamboo stump	Edible
3	*Phallus merulinus* (Berk.) Cooke	Phallaceae	Phallales	Dead bamboo stump	Edible
4	*Phallus cinnabarinus* (W.S.Lee) Kreisel	Phallaceae	Phallales	Dead bamboo stump	Decomposed dead wood and litter
5	*Phallus atrovolvatus* Kreisel & Calonge	Phallaceae	Phallales	Dead bamboo stump	Decomposed dead wood and litter
6	*Mutinus bambusinus* (Zoll.)E. Fisch.	Phallaceae	Phallales	Dead bamboo stump	Decomposed dead wood and litter
7	*Clathrus delicatus* Berk. & Broome	Phallaceae	Phallales	Bamboo leaf litter	Decomposed dead wood and litter
8	*Scleroderma cepa* Pers.	Sclerodermataceae	Boletales	Soil	Decomposed dead wood and litter
9	*Scleroderma verrucosa* (Bull.) Pers.	Sclerodermataceae	Boletales	Soil	Decomposed dead wood and litter
10	*Scleroderma citrinum* Pers.	Sclerodermataceae	Boletales	Soil	Decomposed dead wood and litter
11	*Calvatia rubroflava* (Cragin) Lloyd	Agaricaceae	Agaricales	Soil	Edible
12	*Calvatia cyathiformis* (Bosc) Morgan	Agaricaceae	Agaricales	Soil	Edible
13	*Bovista longispora* Kreisel	Agaricaceae	Agaricales	Dung soil	Edible
14	*Bovista plumbea* Pers.	Agaricaceae	Agaricales	Dung soil	Edible
15	*Bovista dermoxantha* (Vittad.) De Toni	Agaricaceae	Agaricales	Grass land	Edible
16	*Morganella pyriformis* (Schaeff.) Kreisel & D. Kruger	Agaricaceae	Agaricales	Grass land	Edible
17	*Geastrum schweinitzii* (Berk. &M.A. Curtis)Zeller	Geastraceae	Geastrales	Bamboo leaf litter	Decomposed dead wood and litter
18	*Geastrum lloydianum* Rick	Geastraceae	Geastrales	Bamboo leaf litter	Decomposed dead wood and litter
19	*Geastrum saccatum* Fr.	Geastraceae	Geastrales	Bamboo leaf litter	Decomposed dead wood and litter
20	*Geastrum coronatum* Pers.	Geastraceae	Geastrales	Dead bamboo stump	Decomposed dead wood and litter
21	*Cyathus striatus* (Huds.) Willd.	Agaricaceae	Agaricales	Dead tree stump	Decomposed dead wood and litter
22	*Cyathus hookeri* Berk.	Agaricaceae	Agaricales	Dead tree stump	Decomposed dead wood and litter

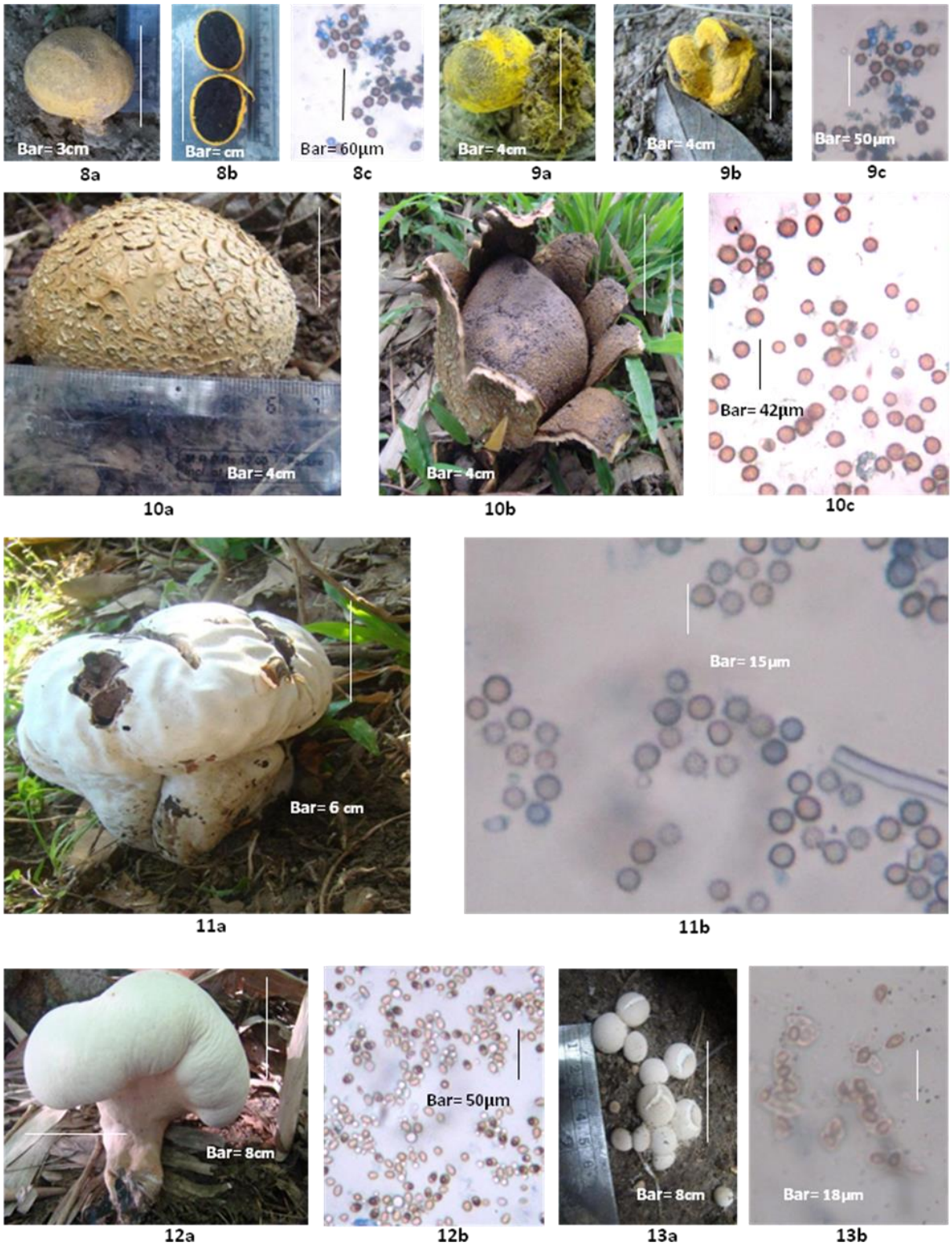
Table 2 Compartment wise distribution of gasteroid fungi and their occurrence % in the HGWLS

Sl. No.	Gasteroid fungi	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Total	Count	OC%
1	*Phallus indusiatus* Vent.		20	10	10		40	3	9.46
2	*Phallus duplicatus* Bosc		9			6	15	2	3.55
3	*Phallus merulinus* (Berk.) Cooke	3	2			1	6	3	1.42
4	*Phallus cinnabarinus* (W.S.Lee) Kreisel		4	1			5	2	1.18
5	*Phallus atrovolvatus* Kreisel & Calonge		4				4	1	0.95
6	*Mutinus bambusinus* (Zoll.) E. Fisch.	8	25	15	12	15	75	5	17.73
7	*Clathrus delicatus* Berk. & Broome		2				2	1	0.47
8	*Scleroderma cepa* Pers.			3			3	1	0.71
9	*Scleroderma verrucosa* (Bull.) Pers.		3	4	3		10	3	2.36
10	*Scleroderma citrinum* Pers.		10	5			15	2	3.55
11	*Calvatia rubroflava* (Cragin) Lloyd	2		2			4	2	0.95
12	*Calvatia cyathiformis* (Bosc) Morgan		3				3	2	0.71
13	*Bovista longispora* Kreisel		15		10		25	2	5.91
14	*Bovista plumbea* Pers.		4	6	4		14	3	3.31
15	*Bovista dermoxantha* (Vittad.) De Toni		15		30		45	2	10.64
16	*Morganella pyriformis* (Schaeff.) Kreisel & D. Kruger	5					5	1	1.18
17	*Geastrum schweinitzii* (Berk. &M.A. Curtis)Zeller		15	5	10		30	3	7.09
18	*Geastrum lloydianum* Rick			11		10	21	2	4.96
19	*Geastrum saccatum* Fr.		15	40			55	2	13.00
20	*Geastrum coronatum* Pers.		8	4	5		17	3	4.02
21	*Cyathus striatus* (Huds.) Willd.		10	3			13	2	3.07
22	*Cyathus hookeri* Berk.		7	4	5		16	3	3.78
	Total fruit bodies	**18**	**171**	**113**	**89**	**32**	**423**		100.00
	Count	**4**	**18**	**14**	**9**	**4**			

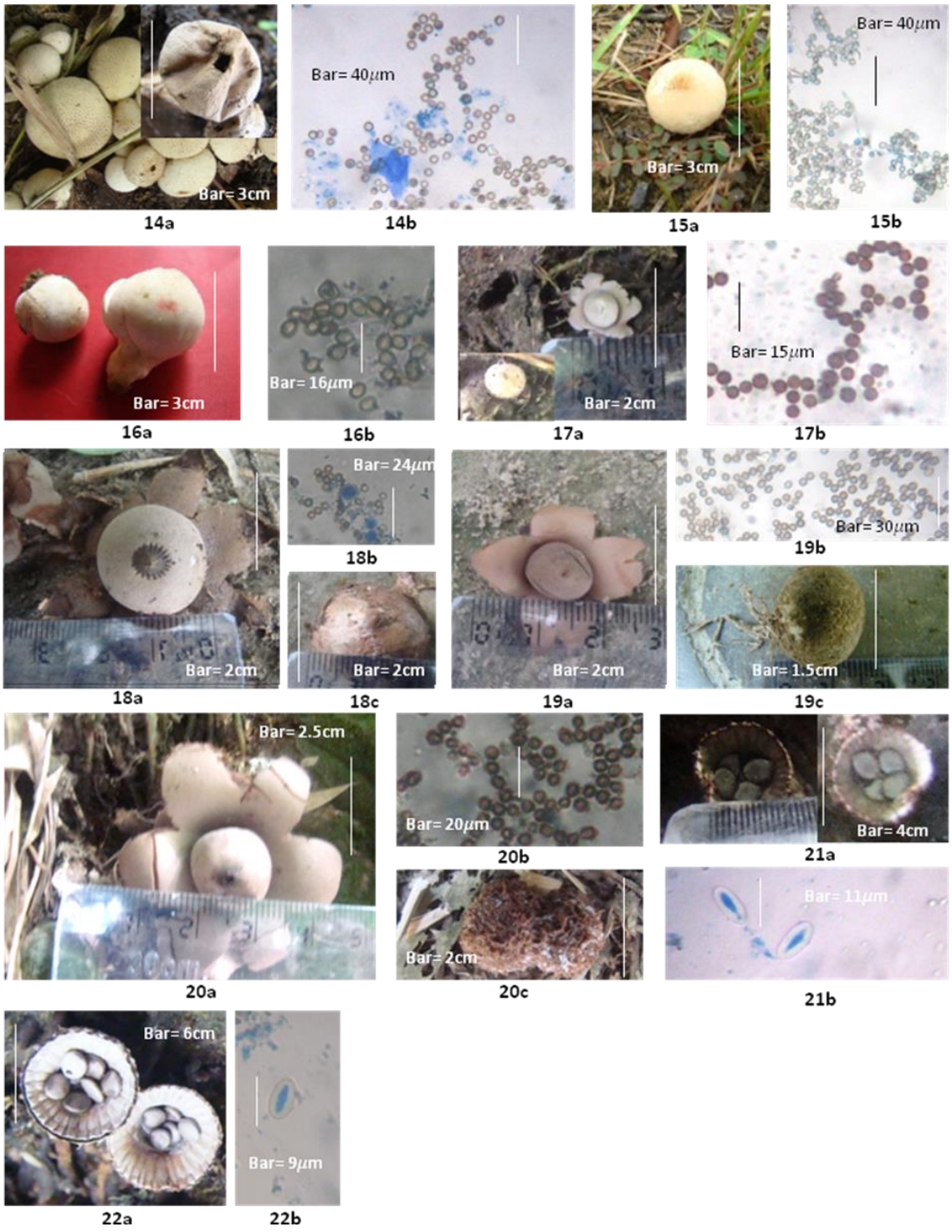
Mutinus bambusinus was found distributed in all the compartments and 7 species were found distributed in three compartments, 10 species were found in two compartments and the remaining 4 species were found in one compartment only of the HGWLS (Table 2). The number of fruit bodies (75) and occurrence percentage (OC%) of *Mutinus bambusinus* was found maximum (17.40) and *Clathrus delicatus* (with 2 number of fruit bodies) and occurrence percentage was found minimum (0.47) in the HGWLS (Table 2). The species richness was found highest in compartment 2 with 18 number gasteroid fungal species followed by compartment 3, 4, 5 and 1 with 14, 9, 4 and 4 number of species respectively. The compartment no. 2 is bigger in size, almost undisturbed and not located in the main roadside, so, species richness was found higher in comparison to other compartments. The size of compartments e.g. 3, 4, 5 and 1 were found decreased gradually with increased habitat disturbance due to illegal felling, encroachment and grazing. Accordingly, gasteroid fungal species richness was found decreased in compartments e.g. 3, 4, 5 and 1. The species like *Clathrus delicatus, Scleroderma cepa, Calvatia cyathiformis, Phallus atrovolvatus, Phallus cinnabarinus, Morganella pyriformis, Phallus merulinus, Scleroderma verrucosa* and *Bovista plumbea* need conservation in the study site. The images of matured fruit bodies and their eggs (immature stages) and spores of the gasteroid fungi collected from the Hollongapar Gibbon Wildlife Sanctuary are given in the Figs 1a-22b.



Fruit bodies, basidiospores and eggs of Figs-1a-1c- *P. indusiatus*, Figs-2a-2c- *P. duplicatus*, Figs-3a-3c- *P. merulinus*, Figs-4a-4c- *P. cinnabarinus*, Figs-5a-5c- *P. atrovolvatus*, Figs-6a-6c- *Mutinus bambusinus*, Figs-7a-7c- *Clathrus delicatus*



Fruit bodies and basidiospores of Figs-8a-8c- *Scleroderma cepa*, Figs-9a-9c, *Scleroderma verrucosa*, Figs-10a-10c- *Scleroderma citrinum*, Figs-11a-11b- *Calvatia rubroflava*, Figs-12a-12b- *Calvatia cyathiformis*, 13a-13b- *Bovista longispora*



Figs-14a-14b- Fruit bodies and basidiospores of *Bovista plumbea*; Figs-15a-15b- Fruit bodies and basidiospores of *Bovista dermoxantha*; Figs-16a-16b- Fruit bodies and basidiospores of *Morganella pyriformis*; Figs-17a-17b- Fruit bodies and basidiospores of *Geastrum schweinitzii*; Figs-18a-18c-Fruit bodies, basidiospores and eggs of *G. lloydianum*; Figs-19a-19c- Fruit bodies, basidiospores and eggs of *G. saccatum*; Figs-20a-20c- Fruit bodies, basidiospores and eggs of *G. coronatum*; Figs-21a-21b- Fruit bodies and Basidiospores of *Cyathus striatus*; Figs-22a-22b- Fruit bodies and Basidiospores of *Cyathus hookeri* (All spore images are at 400X)

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