

**ECOLOGICAL,
PHENOLOGICAL AND
BIOCHEMICAL
SIGNIFICANCE OF BIMODAL FRUITING
OF *Boletus alutaceus* Morgan,
AN ECTOMYCORRHIZAL PARTNER
OF *Ficus benghalensis* L.**

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Mycorrhizal associations, a symbiosis between plants and fungi, are crucial for both agricultural and natural resource management.

This symbiosis has been studied for over a century, and our understanding of the interaction in the mechanisms of plant-fungus physiology is remarkably good.

However a single plant can form mycorrhizae with many fungi, and a single fungus can connect many plants

Ectomycorrhizal (EM) fungi are in three vast groups including Zygomycetes (Endogonales), Ascomycetes and Basidiomycetes.

Because there are so many independent evolutionary events, the distinctions between mycorrhizae, saprobic and parasitic fungi are unavoidably blurred.

•The crucial role of mycorrhizal fungi in improving the mineral nutrition of their host plants is well established.

Mycorrhizal roots take up P, N, Zn, Cu, Ni, S, Mn, B, Fe, Ca and K from soil more efficiently than nonmycorrhizal roots, especially at low fertility levels.

The extraradical hyphae effectively increase the volume of soil explored for nutrients, by growing beyond the areas of nutrient depletion around the roots.

The small diameter of fungal hyphae also allows them to penetrate small soil pores and access microsites that roots cannot reach.

Hyphae can proliferate rapidly and profusely in enriched nutrient patches. EM hyphae extend away from the EM mantle and increase the total absorbing surface by several orders of magnitude, and are responsible for much of the nutrient uptake

OBJECTIVES

- **Year-long study of *F.benghalensis* habitat to identify emergence of the EM fruitbodies on the basis of previous site records**
- **Collection, spatial locational mapping, photo documentation and morphometric measurements of the specimens**
- **Comparison of the harvest in different seasons**
- **Identification of any ecologically significant phenomena and phenological events associated with fructifications**

Methodology-1

- The habitat was mapped and the records of ambient temperature, humidity and soil temp. were maintained
- The specimens were located, counted, inscribed/labelled 'in situ', photographed in random quadrats and then plucked
- Identification was confirmed with type specimens collected in the past and with respect to standard keys for Indian boletaceae (Lakhanpal, 1996)

Methodology-2

- Measurements of pileal diameter, colour, thickness, shape, stipe length and thickness were made
- Biovolume of each specimen was calculated using standard formula
- Statistical comparison of the data was done for collections made six months apart

MAP OF THE FRAGMENTED HABITAT

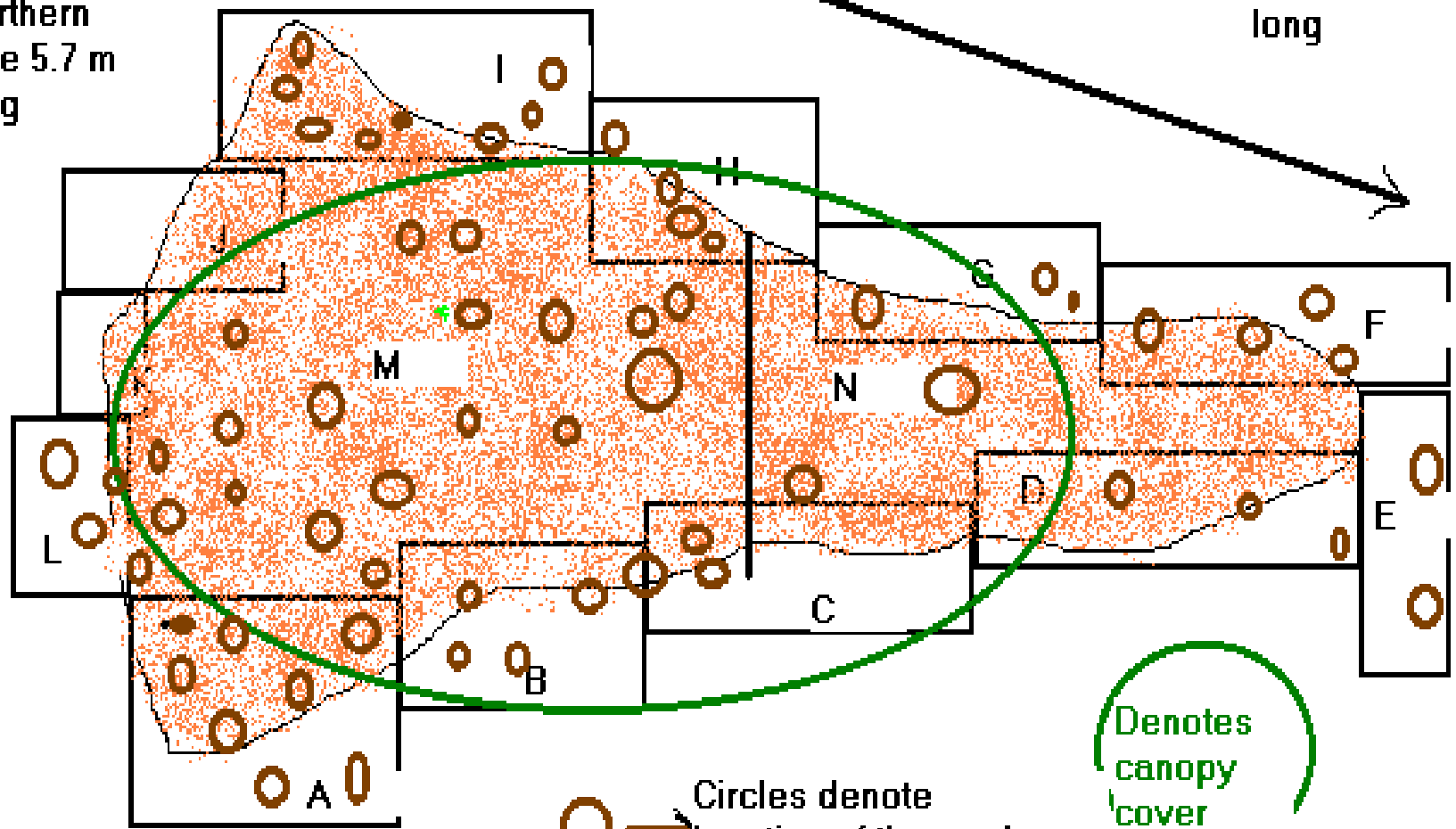
Rectangular boxes denote
random quadrats used for
collection

Height:- 0.9 m

ROADSIDE FACE

5m
long

Northern
face 5.7 m
long



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western face
5.7 m long

○ → Circles denote
location of the mushroom

Denotes
canopy
cover

THIS MAP REFERS TO MAY-2004 COLLECTIONS

RESULTS

There were pre-monsoon showers in the last week of May 2004. This brought down the temperature to 27-30 deg. Celsius and increased the % rel. humidity to 85-90%, the sky was overcast with less sunshine. The first crop of *B. alutaceus* appeared quickly and lasted for a week







Fruitbodies occurred solitary or in small clusters of 2- 4



Morphometric studies

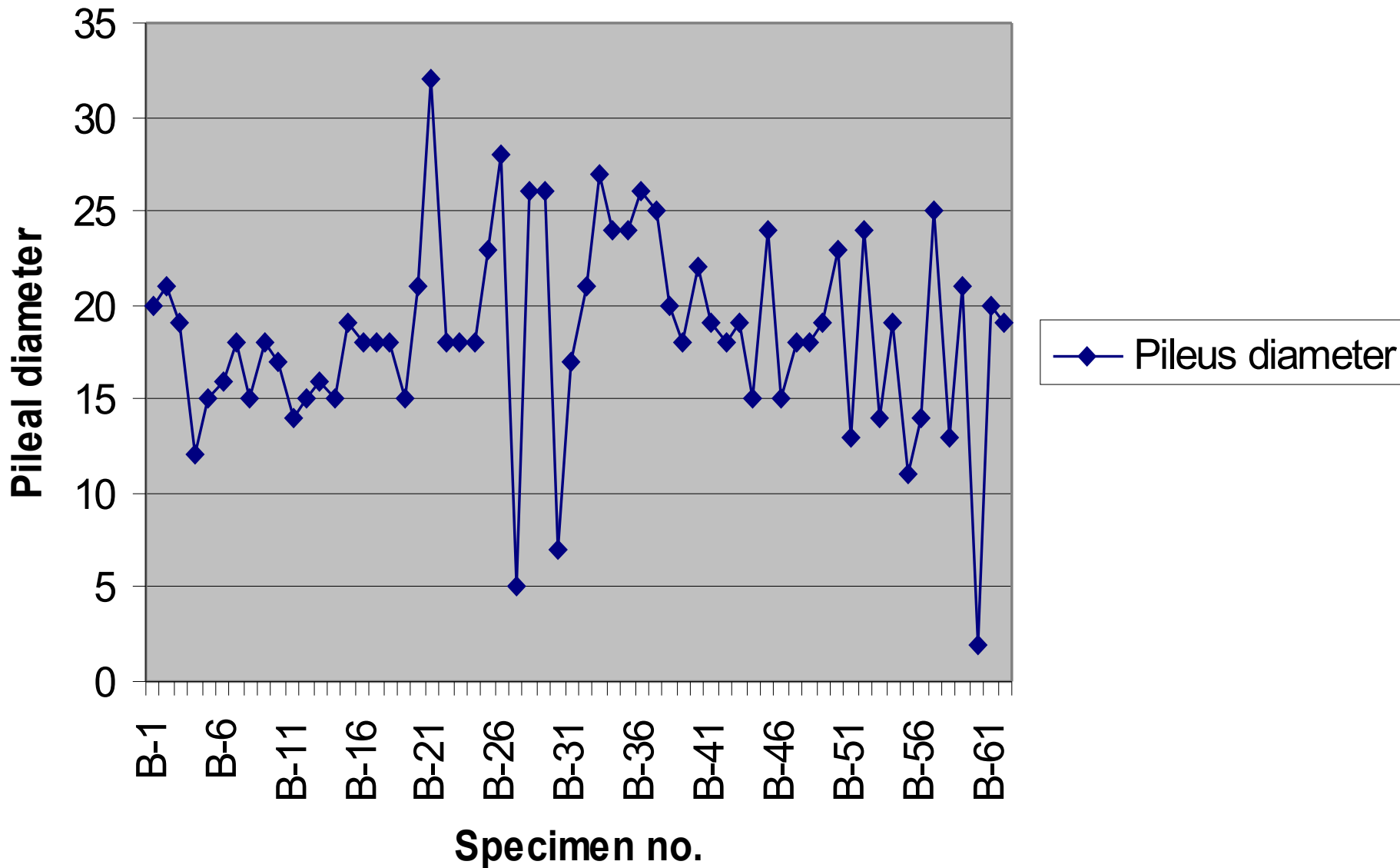
In the field



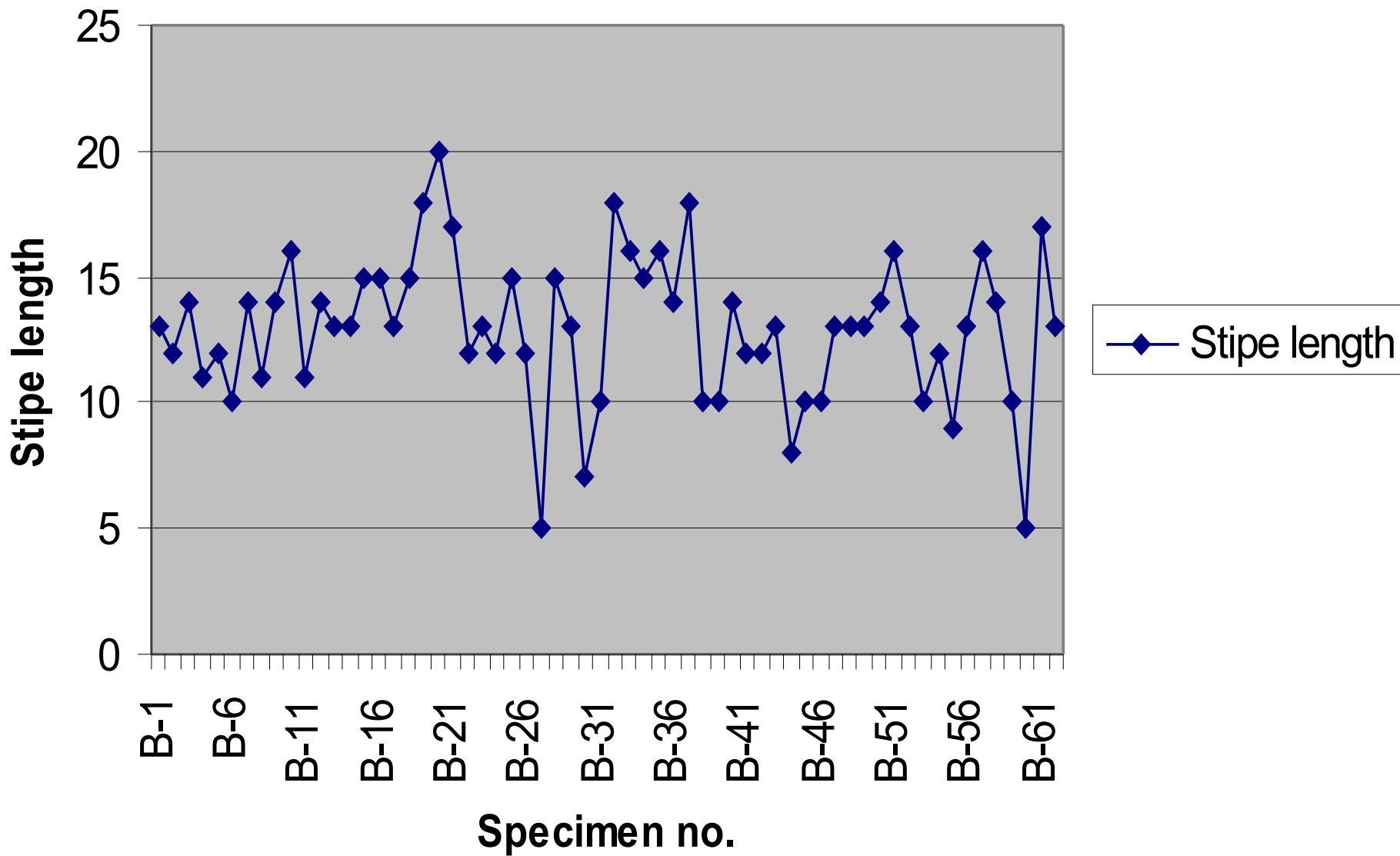
Morphometric features of May-2004 collections

- Total specimens:-62
- Largest pileus:-32 cms. in diameter
- Smallest:-2 cms.
- Longest stipe:-20 cms.
- Shortest:-5 cms.
- Specimen with largest biovolume:-2261 c.c.
- Thickest pileus:-7 cms. Thick
- Thinnest:-1 cm.
- Thickest stipe:-10 cms.
- Thinnest stipe:-2 cms.
- Specimen with smallest biovolume:-10 c.c.

Specimen no. v/s Pileal diameter



Specimen no. v/s Stipe length



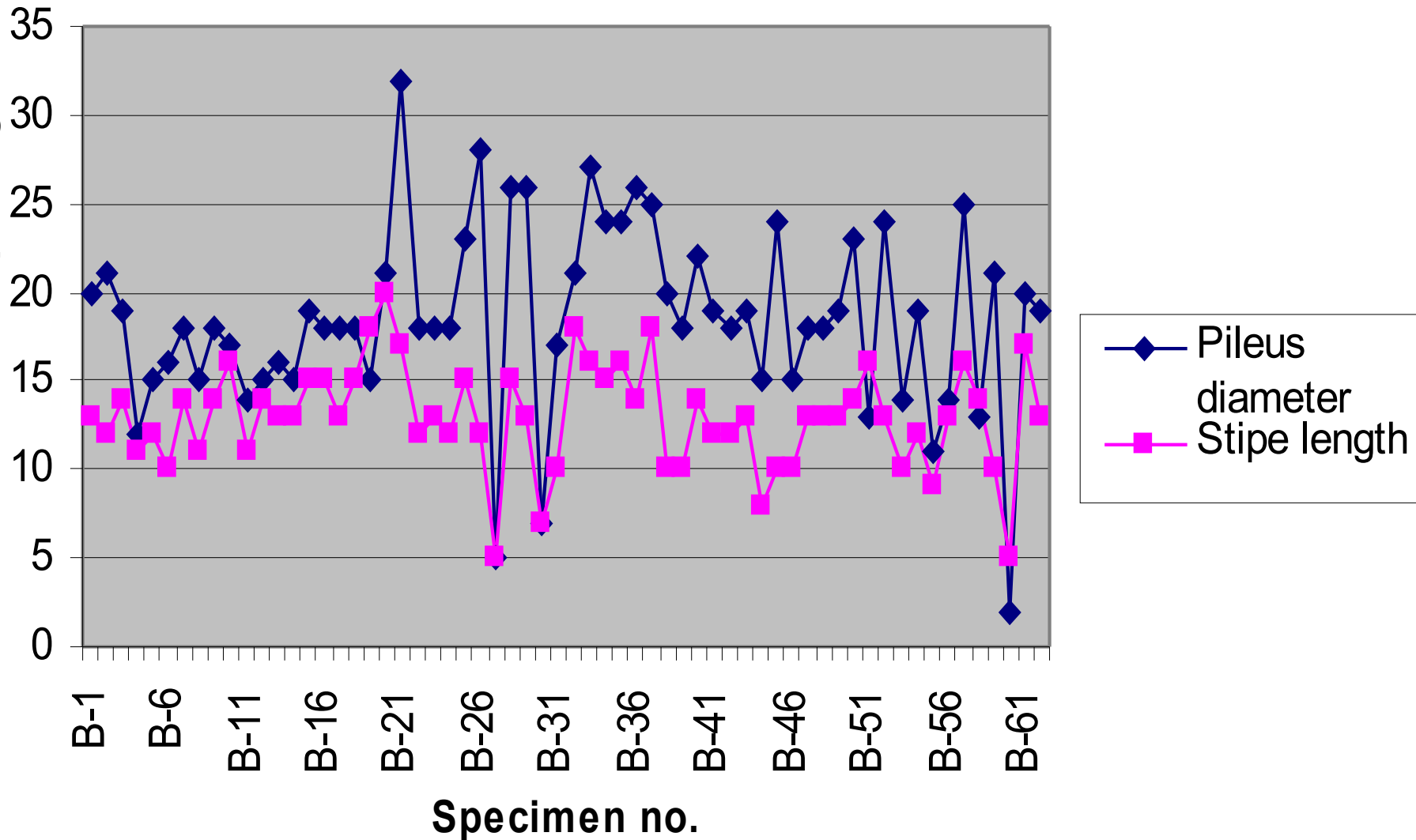
Large specimens have large stipes

- There is positive co-relation between the diameter of the pileus and the length of the stipe, confirming previous observations (Singer, 1986)
- Naturally, the larger the specimens, larger was the biovolume and probably higher basidiospore discharge

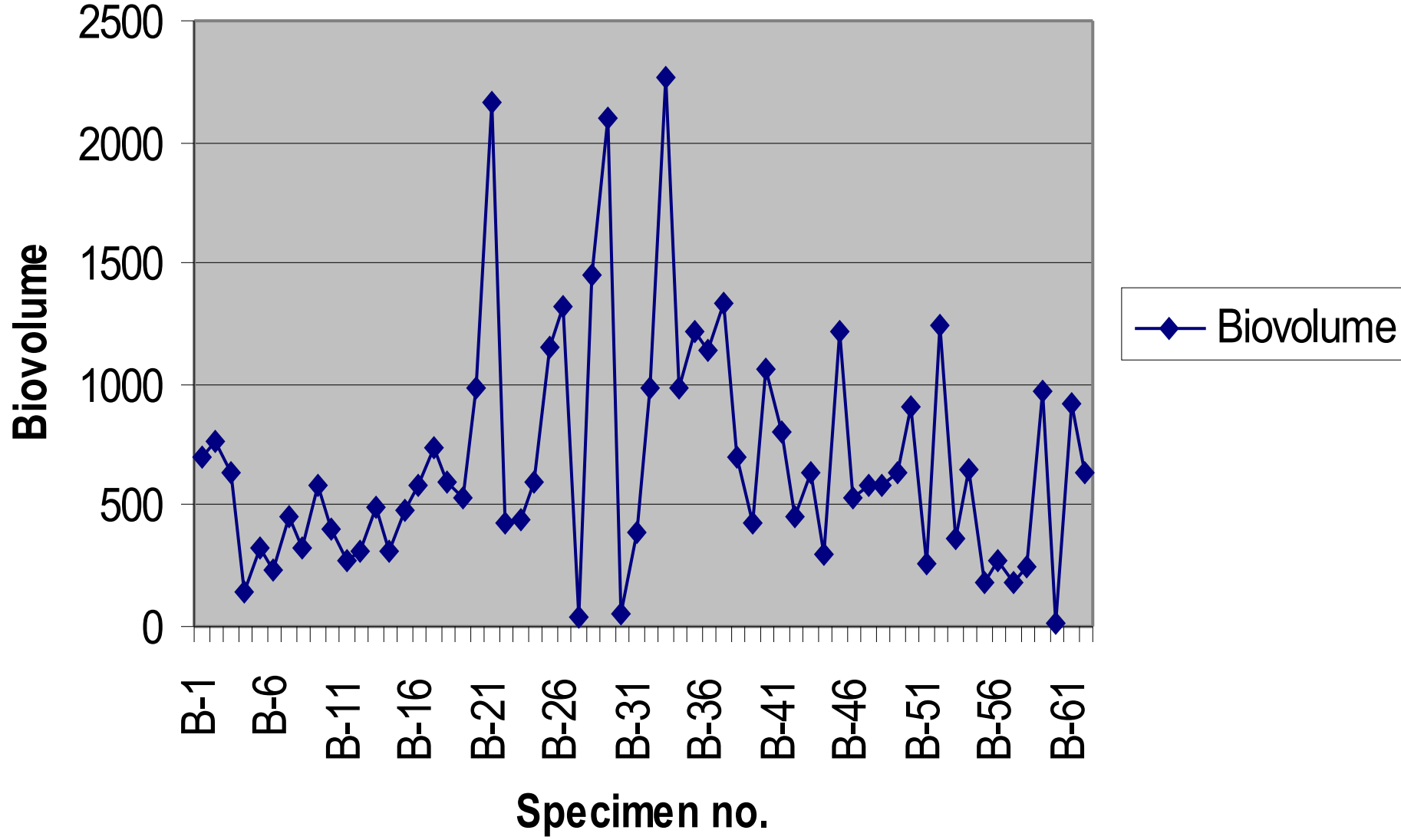
Specimen no. v/s Pileal diameter & Stipe length

Nature Precedings, doi:10.1038/npre.2009.28351.1, Posted 30 Jan 2009

Pileal diameter & Stipe length



Specimen no. v/s Biovolume



Post monsoon rainfall increasing the soil moisture content, a sudden drop in ambient temperature, increase in humidity triggered a second flush of *B. alutaceus*, in November 2004 and lasted for only five days

Morphometric features of November 2004 collections

- Total specimens:-100
- Largest pileus:-23 cms. in diameter
- Smallest:-1 cm.
- Longest stipe:-15 cms.
- Shortest:-2 cms.
- Specimen with largest biovolume:-1144 c.c.
- Thickest pileus:-5 cms. thick
- Thinnest:-1 cm.
- Thickest stipe:-6 cms.
- Thinnest stipe:-1 cm.
- Specimen with smallest biovolume:-8.9 c.c.







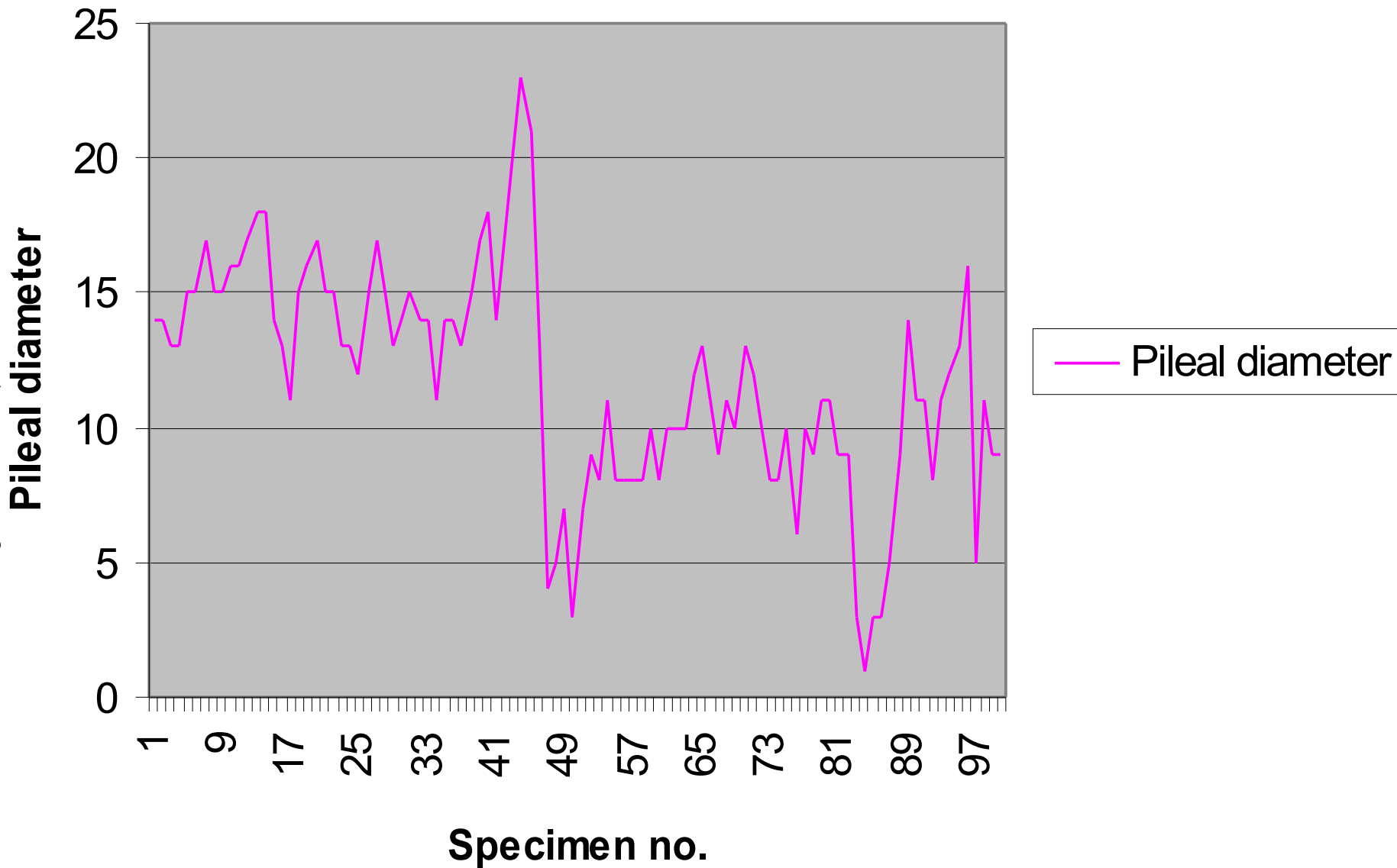




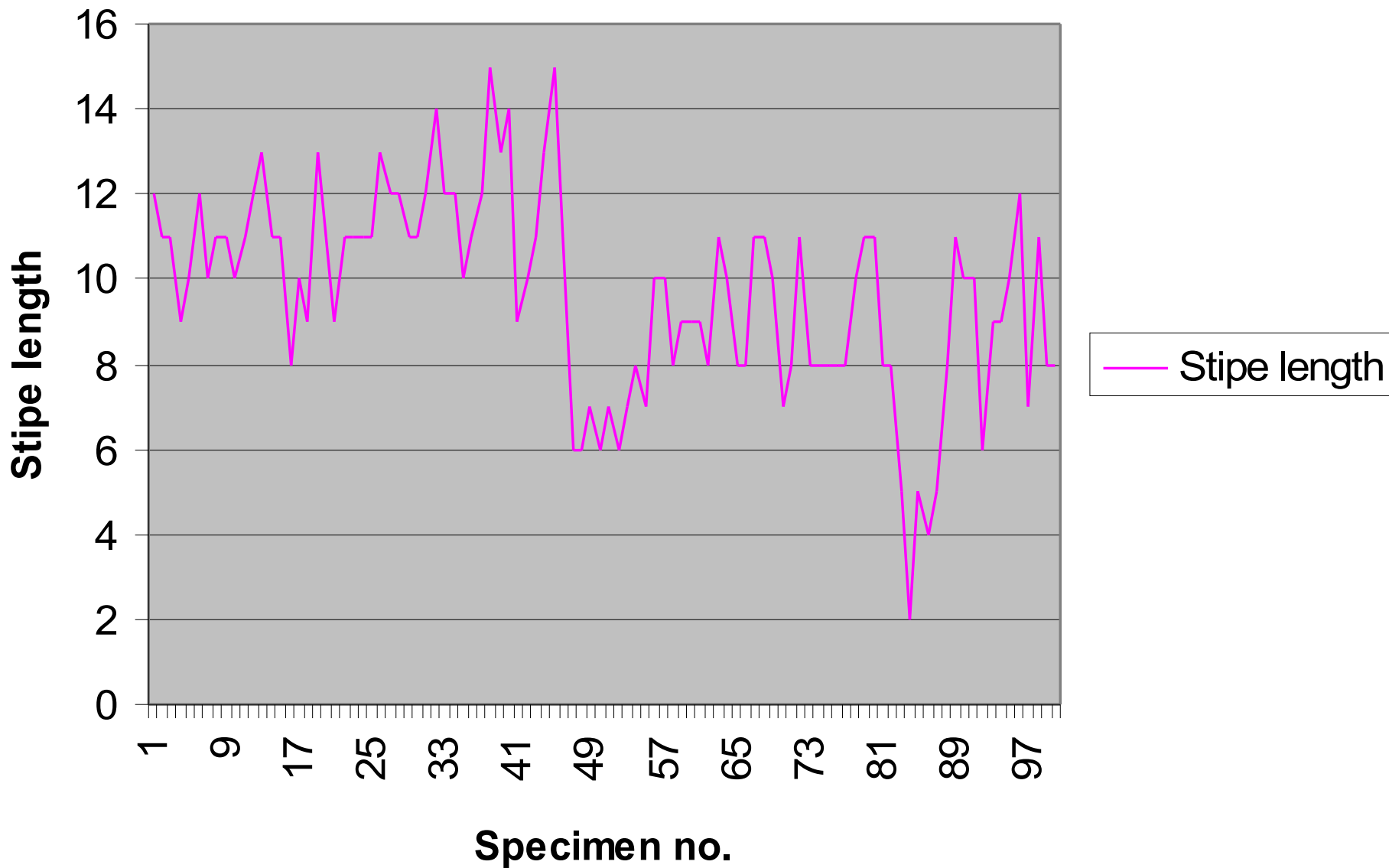




Specimen no. v/s Pileal diameter



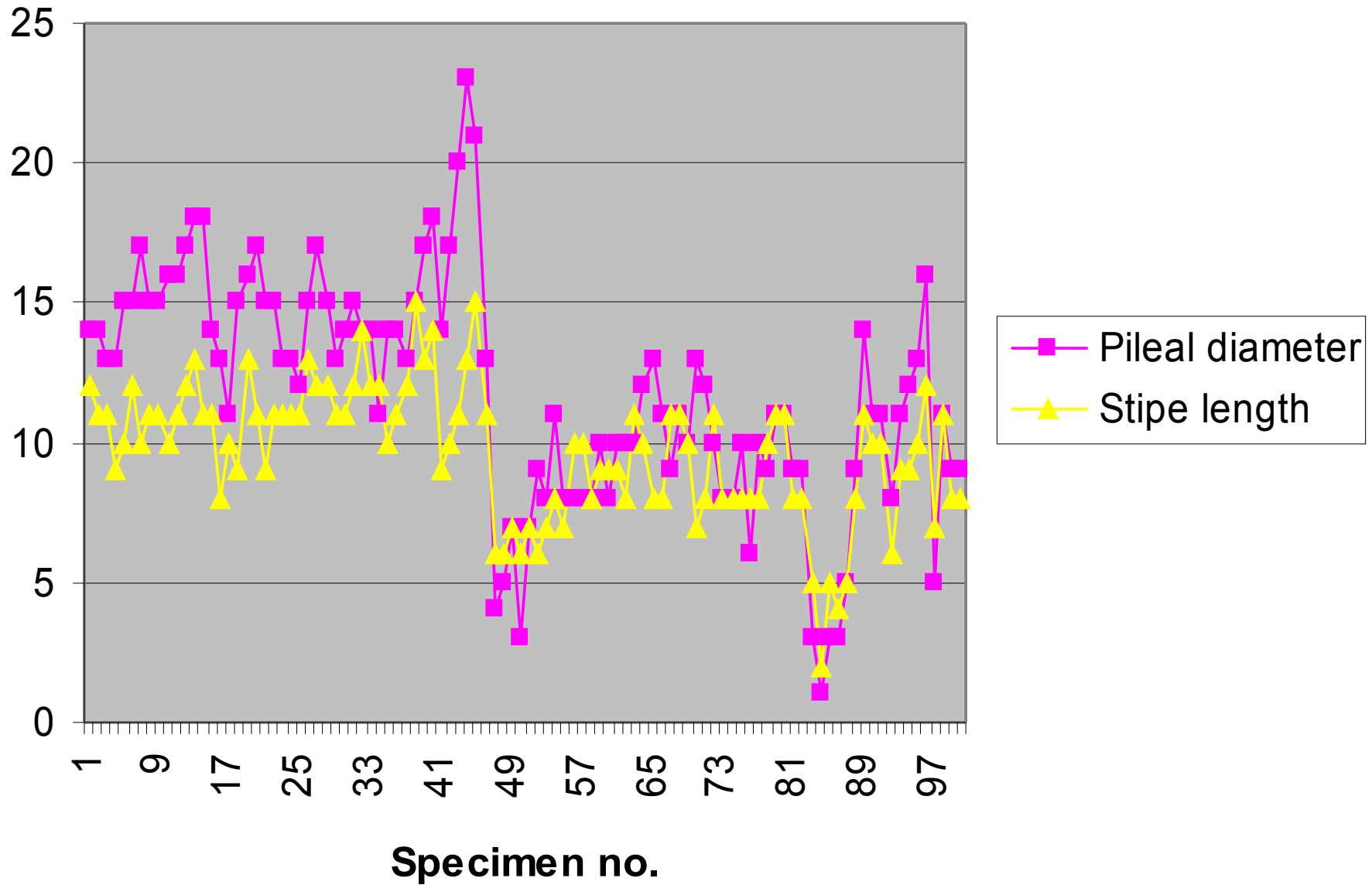
Specimen no. v/s Stipe length



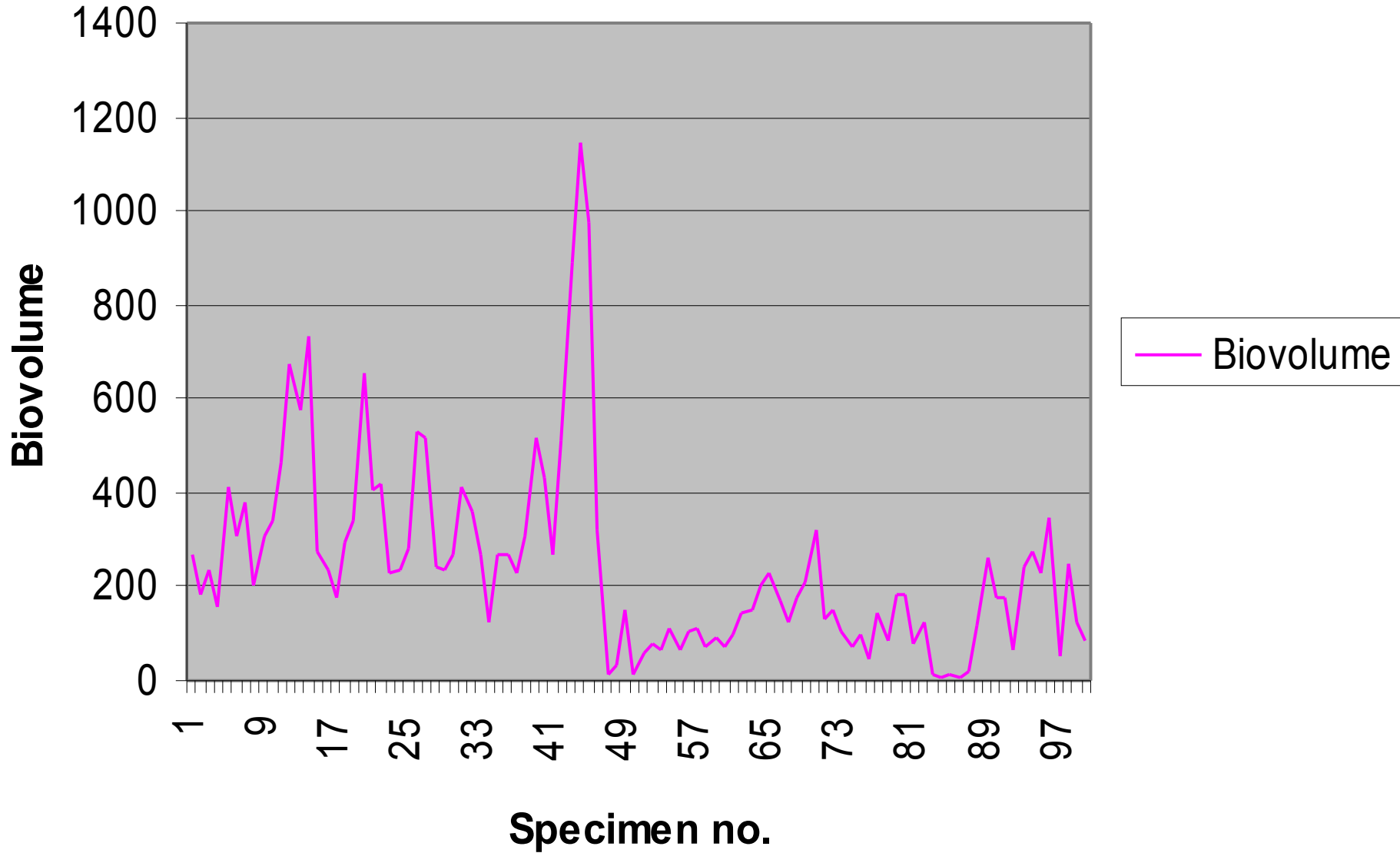
Specimen no. v/s Pileal diameter & Stipe length

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Pileal diameter & Stipe length



Specimen no. v/s Biovolume



DISCUSSION

Eco-climatic conditions *impact* the fructification

- The **monsoon** flushes produce small number of large fruitbodies with higher biovolumes (10-2260 c.c.s)
- The long stipes (5-20 cms.) indicate a positive and marked phototropic response in view of low sunlight
- The **post-monsoon** flushes produce a large crop of smaller and uniform fruitbodies with small biovolumes (8.9-1144 c.c.s)
- The shorter stipes (2-15cms.) indicate availability of good sunshine and a moderate to negligible phototropic response

B. alutaceus shows a bimodal fruiting response

- *B. alutaceus* produces two uneven flushes of fruitbodies in May and November
- These are in tune with the eco-climatic changes and the sudden onset of showers
- *B. alutaceus* basidiospores which escape grazing, ingestion and dispersal may germinate within the rhizosphere of the host to produce new vegetative mycelia
- The new mycelia may replenish the EM association

Why so many fruitbodies...?

An Ecogenetic argument:-

The *B. alutaceus* EM mycelial network may not remain efficient and vigorous for supplying the N & P rich nutrient flux from the soil to the huge rhizosphere of the host

New mycelial recruitment is possible with germination of freshly discharged basidiospores and intermixing of genetically diverse mycelial fronts which would create a clonal genetic mosaic

After every fructification cycle, the old EM network may be turned over and get replaced thus benefiting the host

- A positive correlation between fruiting in *F. benghalensis* after fruiting in *B. alutaceus* is possible

The Carbon flux from *F. benghalensis* to EM partner may increase substantially during the fruiting of *B. alutaceus*, considering the large Biovolume and the biomass of the fruitbodies

Mycorrhizal fungi acquire most or all of their C from their host plant.

On average, plants allocate 10% to 20% of their net photosynthetic yield to their fungal mutualists, although this value can range from 5% to 85%.

Depending on the rates of turnover, mycorrhizae can provide up to 15% of the total organic matter biomass in forest soils. Between 36% to 73% more C is assimilated in mycorrhizal than non-mycorrhizal plants owing to increased photosynthetic rate in mycorrhizal plants.

As mycorrhizal fungal tissue grows, much of that C is transferred from the host plant and allocated to the pool of live fungal tissue (20% to 29% net biomass C). a substantial amount of fungal C is allocated to the synthesis of recalcitrant compounds such as chitin (60% of the cell wall).

The remaining C is expired (43% to 64% C), accumulated as fungal-specific storage carbohydrates (mannitol, trehalose) or lipids, or deposited within the rhizosphere.

Speculations on the ‘Death Wish’ of *F. benghalensis* ?

- The host tree species studied during this work is at least 200 years old and is confined for past 15 years to a rocky platform and has been showing signs of stress, injury and decay
- There could be stress signals from the host to the EM partner to “disperse” or “save yourself”
- As a result, abundant fruiting of the fungal partner is witnessed
- What next....?. Would the host die?. Would the dispersed basidiospores find a new *Ficus* partner?.

The fate of the basidiospores

- ***B. alutaceus* produces huge number of basidiospores**
- **These are consumed by insects, snails, slugs, millepedes and a fraction is washed out by rains and blown out by the winds**
- **Without elicitor/signal molecules from the host the dispersed basidiospores may not germinate and if germinated the colonies would not be able to infect any plant roots except those of identical *Ficus* spp.**
- **So, it seems logical that a large portion of viable basidiospores are meant to be germinated under the host plant's canopy/ active rhizoplane**

B. alutaceus-*F. benghalensis* EM partnership is excellent example of ecosystem maintenance

- *F. benghalensis* supports the survival and sexual reproduction of *B. alutaceus*
- *B. alutaceus* replenishes itself twice a year through bimodal fruiting cycle
- *B. alutaceus* may be involved in leaching the lateritic minerals and the release of soil nutrients taken up by *F. benghalensis*
- Flowering and fruiting of *F. benghalensis* may depend on the biochemical vigour of its' EM partner

Thank you!