Cryptogamie, Mycologie, 2002, 23 (2): 135-162

Mycological researches in beech woods in Western Ligurian Apennines, province of Savona (Italy)

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Résumé – Ce travail présente les résultats de recherches sur la flore mycologique des hêtraies apennines de Ligurie occidentale. Les forêts étudiées, situées dans la province de Savona, entre le Col de Cadibona et le Col du Giovo, bénéficient de conditions climatiques très particulières, liées à la proximité de la mer et à l'altitude, dépassant légèrement 700 m. Du point de vue phytosociologique et malgré la pauvreté floristique, les hêtraies ont été attribuées à l'association *Trochischanto-Fagetum* (alliance du *Geranio nodosi-Fagion*). Les relevés menés sur quatre placettes mesurant environ 1 km^2 chacun, ont été conduits sur une période de huit ans. Trois cent deux espèces (292 Basidiomycota et 10 Ascomycota) ont été identifiées, dont 4 nouvelles pour la Ligurie. La liste systématique des champignons présentée est enrichie de données sur la fréquence des découvertes, le groupe écologique auquel ils appartiennent (selon l'habitat), et l'index de fructification du genre. Enfin, des comparaisons avec les données d'autres hêtraies européennes et italiennes sont tentées.

Fungi / fonge / hêtraies / Ligurie occidentale / Italie

Abstract – A study of the mycological flora of the Western Ligurian Apennines beech woods was conducted in selected areas of the province of Savona, between the Cadibona pass and the Giovo pass. The average altitude is 700 meters above sea level and the climate is quite peculiar due to the presence of relatively high mountains very close to the sea. From a phytosociological point of view and despite the limited diversity of the flora, the woods were classed as featuring a *Trochischanto-Fagetum* association (*Geranio nodosi-Fagion alliance*). The study was carried out through eight years of observations on four plots measuring about 1 square km. Three hundred and two species (292 Basidiomycota and 10 Ascomycota) were collected, four of which as new to Liguria. A taxonomically arranged list of all the species collected is reported in a table showing the abundance and the ecological group of each species, along with a fructification index of each genus. Finally, a comparison with other Italian and European beech woods is presented and discussed.

Fungi / mycological flora / beech-woods / Western Liguria / Italy

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INTRODUCTION

The investigation of Macrofungi from beech woods is a very important topic in the field of mycology. Several related issues are discussed in the literature: Thoen (1970, 1971) analysed in details three beech forests in Belgium, from the point of view of both mycoflora and mycosociology, Tyler (1985) investigated beech forests in the Southernmost province of Sweden seeking a relationship between soil properties and fungal occurrence. Lisiewska (1972, 1974) studied a great number of beech woods in various parts of the Polish Lowland. A comparison with results obtained from some observation plots outside Poland is also presented in her work. A recent paper on the macromycetes of southern Polish beech forests, can be found in Adamczyk (1996). Discussions about other beech woods are available for various regions of Europe, e.g. for Germany (Carbienier *et al.*, 1975), Britain (Wilkins *et al.*, 1937) and Romania (Chifu, 1975).

In Italy, few authors have focused their attention on such kind of woods: Ceruti *et al.* (1987-88) conducted a study on some forests in Piedmont (a North-Western region of Italy), while Orsino & Dameri (1996) considered the woods of Melogno, a mountain site in the Western Ligurian Alps. Some aspects of beech woods are dealt by Ubaldi (1974) and Ubaldi *et al.*, (1991) together with other forest types in the Romagna and Veneto regions. Recently, Antonini *et al.* (1999) and Venturella *et al.* (1999) presented their mycofloristic research studies on Tuscan and Sicilian beech forests respectively.

Nevertheless, it was felt that a more extensive analysis of beech woods in Liguria should be carried out for the following three main reasons:
– the Liguria region is characterised by a very peculiar climate due to the presence of mountains quite close to the coast and to the influence of the sea, mitigating the harshness of winter and the heat of summer;
– the phytosociological interest of Ligurian beech forests is due to the particular climate, which induces a typical beech wood association (Gentile, 1974), differing from other woods of central and northern Europe;
– this kind of biocoenosis is common and is known to be very productive in terms of the Fungi collected.

For our study we selected a very good fungus-producing wood, although it was partially affected by intense management practices. The study area was close to the sea and relatively low in altitude (800 m). It is a part of the forests around Savona that have been always exploited for timber production (Franchello, 1972) and/or mushrooming. This latter activity was already documented in some 19th century reports: Cougnet (1879) indicated the number of edible fungi found in the areas selected by us and pointed out that the quantity was so great that mushrooms were exported to the United States.

The aim of this paper is to contribute towards the knowledge of Liguria beech wood Macrofungi. It also includes a statistical analysis from the phenological point of view. Furthermore, the results obtained have been compared with data referred to other beech woods in Italy and in Northern and Central Europe.

This study is a structural part of a large beech wood mycosociology project.

The paper is organised in several sections, dealing respectively with the climatic and geomorphological features of the area (II); a description of the study areas (III); main identification literature and reference iconography used (IV); criteria for attribution of the species to an ecological group (V); statistical results of the fungal occurrence analysis including a comparison with other Italian and

European beech woods (VI); conclusions (VII). A complete list of the species collected (sorted according to the main taxa, according to Hawksworth et al, 1995) is provided in Table 1.

Table 1. List of all the species collected arranged by taxa. The names of the species, along with the ecological class, and their abundance (evaluated on the eight years of observation) are indicated in the first and the second column respectively. The number in third column specifies how many times the species was recorded. If it was observed only once or twice, the recording date is given instead. The last column contains remarks. Whenever a genus is specified in the first column, the number in the second column refers to the maximum value of the fructification index.

BASIDIOMYCOTA *Basidiomycetes*				
Auriculariales				
AURICULARIACEAE				
Auricularia		**5.0**		
Auricularia auricula-judae (Bull.: Fr.) Wettst.	s l	**3**	31.08.92, 14.09.96	on dead branches of *Fagus sylvatica* L., *Sambucus nigra* L.
Tremellales				
TREMELLACEAE				
Tremella		**4.0**		
Tremella mesenterica Retz.: Fr.	s l	**2**	**4**	on dead branches of *Fagus sylvatica* L
Dacrymycetales				
DACRYMYCETACEAE				
Calocera		**4.0**		
Calocera cornea (Batsch: Fr.) Fr.	s l	**3**	**4**	
Cantharellales				
CLAVARIADELPHACEAE				
Clavariadelphus		**4.0**		
Clavariadelphus pistillaris (L.: Fr.) Donk	s t	**2**	02.11.97	
CANTHARELLACEAE				
Cantharellus		**9.0**		
Cantharellus cibarius Fr.	m	**5**	**17**	
Cantharellus friesii Quél.	m	**1**	08.10.92	
Cantharellus lutescens (Pers.) Fr.: Fr.	m	**3**	**5**	
Cantharellus melanoxeros Desm.	m	**1**	18.10.92	
Cantharellus tubaeformis (Bull.) Fr.: Fr.	m	**2**	01.11.88, 13.10.92	
CRATERELLACEAE				
Craterellus		**5.0**		
Craterellus cornucopioides (L.) Pers.	m	**5**	**7**	
Pseudocraterellus		**4.0**		
Pseudocraterellus sinuosus (Fr.) Corner	m	**2**	18.10.92	

CLAVULINACEAE			
Clavulina		**6.0**	
Clavulina rugosa (Bull.: Fr.) J. Schröt.	s t	**2**	08.10.92, 18.10.92
Clavulina cristata (Holmsk.: Fr.) J. Schröt.	s t	**4**	**6**
HYDNACEAE			
Hydnum		**5.0**	
Hydnum repandum L.: Fr.	m	**5**	**19**
Hydnum rufescens Pers.: Fr.	m	**0.5**	12.11.89
SCUTIGERACEAE			
Albatrellus		**3.0**	
Albatrellus cristatus (Schaeff.) Kotl. & Pouzar	m	**2**	24.09.89, 08.10.92
Albatrellus pes-caprae (Pers.: Fr.) Pouzar	s l	**2**	**3**
Thelephorales			
THELEPHORACEAE			
Sarcodon		**2.5**	
Sarcodon scabrosus (Fr.) P. Karst.	m	**0.5**	13.10.91
Gomphales			
RAMARIACEAE			
Ramaria		**3.2**	
Ramaria botrytis (Pers.: Fr.) Ricken	s t	**2**	**3**
Ramaria formosa (Pers.: Fr.) Quél.	s t	**0.5**	01.12.88
Ramaria flava (Schaeff.: Fr.) Quél.	s t	**1**	15.10.91
Ramaria obtusissima (Peck) Corner	s t	**0.5**	08.10.92
Ramaria sanguinea (Pers.) Quél.	s t	**1**	26.10.96, 2.11.97
Ramaria stricta (Pers.: Fr.) Quél.	s l	**3**	**6**
Schizophyllales			
SCHIZOPHYLLACEAE			
Schizophyllum		**4.0**	
Schizophyllum commune Fr.: Fr.	s l	**4**	**6**
Stereales			
STEREACEAE			
Stereum		**6.0**	
Stereum rugosum Pers.	s l	**1**	02.11.97
Stereum hirsutum (Willd.: Fr.) Gray	s l	**5**	**9**
Hymenochaetales			
HYMENOCHAETACEAE			
Coltricia		**4.0**	
Coltricia perennis (L.) Murrill	m	**4**	**9**

Fistulinales				
FISTULINACEAE				
Fistulina		**2.5**		
Fistulina hepatica (Schaeff.) Fr.: Fr.	p l	**0.5**	**4**	on *Fagus sylvatica* L. trunks
Poriales				
POLYPORACEAE				
Polyporus		**3.0**		
Polyporus ciliatus Fr.: Fr.	s l	**2**	10.06.90	found on branches on the soil or trunks of broad-leaved trees
Polyporus varius (Pers.) Fr.: Fr.	s l	**2**	**3**	on trunk of *Fagus sylvatica* L. and on the soil
CORIOLACEAE				
Abortiporus		**2.5**		
Abortiporus biennis (Bull.) Singer	s l	**0.5**	02.11.97	on *Fagus sylvatica* L dead wood.
Hapalopilus		**2.5**		
Hapalopilus rutilans (Pers.) P. Karst.	s l	**0.5**	04.09.92	on dead wood
Tyromyces		**2.5**		
Tyromyces chioneus (Fr.: Fr.) P. Karst.	s l	**0.5**	04.09.92	
Trametes		**7.0**		
Trametes versicolor (L.) Pilát	s l	**5**	**19**	on *Fagus sylvatica* L. dead wood
LENTINACEAE				
Pleurotus		**2.5**		
Pleurotus ostreatus (Jacq.: Fr.) P. Kumm.	s l	**2**	**4**	
Boletales				
BOLETACEAE				
Boletus		**5.6**		
Boletus aereus Bull.: Fr.	m	**2**	**7**	
Boletus calopus Pers.: Fr.	m	**4**	**13**	
Boletus edulis Bull.: Fr.	m	**5**	**22**	
Boletus erythropus Pers.	m	**4**	**12**	
Boletus fragrans Vittad.	m	**1**	15.10.91, 14.10.95	
Boletus luridus Schaeff.: Fr.	m	**0.5**	**3**	
Boletus pinophilus Pilát & Dermek	m	**2**	**7**	
Boletus pulverulentus Opat.	m	**0.5**	**3**	
Boletus queletii Schulzer	m	**2**	**6**	
Boletus radicans Pers.: Fr. (= *albidus* Roq.)	m	**2**	28.06.91, 19.07.92	
Boletus regius Krombh.	m	**0.5**	28.09.91	
Boletus reticulatus Schaeff.	m	**0.5**	18.06.89	
Boletus satanas Lenz	m	**0.5**	29.09.89	
Suillus		**2.5**		
Suillus granulatus (L.: Fr.) Kuntze	m	**0.5**	09.07.89	
Leccinum		**4.0**		

Leccinum carpini (R. Schultz) M. Moser	m	**4**	9	in beech wood mixed with *Ostrya carpinifolia* Scop.
Leccinum crocipodium (Letell.) Watling	m	**0.5**	09.09.89	
Aureoboletus		**2.5**		
Aureoboletus gentilis (Quél.) Pouzar [=*Pulveroboletus gentilis* (Quél.) Singer] - [=*Pulveroboletus cramesinus* (Secr.) Singer]	m	**0.5**	13.10.91	
STROBILOMYCETACEAE				
Chalciporus		**2.5**		
Chalciporus piperatus (Bull.: Fr.) Bataille	m	**1**	**5**	
Porphyrellus		**2.5**		
Porphyrellus porphyrosporus (Fr.) J.E. Gilb.	m	**0.5**	13.10.91	
Strobylomyces		**4.0**		
Strobylomyces strobilaceus (Scop.: Fr.) Berk.	m	**4**	**7**	
Tylopilus		**2.5**		
Tylopilus felleus (Bull.: Fr.) P.Karst.	m	**1**	19.07.92, 18.10.92	
GYRODONTACEAE				
Gyroporus		**4.0**		
Gyroporus cyanescens (Bull.: Fr.) Quél.	m	**3**	**6**	
XEROCOMACEAE				
Xerocomus		**7.8**		
Xerocomus armeniacus (Quél.) Quél.	m	**1**	**3**	
Xerocomus badius (Fr.: Fr.) J.E.Gilbert	m	**2**	**5**	
Xerocomus chrysenteron (Bull.) Quél.	m	**4**	**10**	
Xerocomus ferrugineus (Schaeff.) Bon	m	**3**	**4**	
Xerocomus subtomentosus (L.: Fr.) Quél.	m	**5**	**30**	
Xerocomus rubellus (Krombh.) Quél.	m	**2**	**7**	
Phylloporus		**3.0**		
Phylloporus rhodoxanthus (Schwein.) Bres.	m	**1**	**9**	
HYGROPHOROPSIDACEAE				
Hygrophoropsis		**3.0**		
Hygrophoropsis aurantiaca (Wulfen) Maire	s lt	**1**	10.09.89	
PAXILLACEAE				
Paxillus		**4.0**		
Paxillus involutus (Batsch: Fr.) Fr.	m	**4**	**14**	
Agaricales				
HYGROPHORACEAE				
Camarophyllus		**2.5**		
Camarophyllus virgineus (Wulfen: Fr.) P. Kumm.	s t	**1**	17.11.91, 28.09.96	
Hygrophorus		**4.0**		
Hygrophorus chrysodon (Batsch: Fr.) Fr.	m	**0.5**	**3**	
Hygrophorus cossus (Sowerby) Fr.	m	**3**	**8**	
Hygrophorus eburneus (Bull.: Fr.)	m	**2**	13.08.89, 08.10.92	
Hygrophorus nemoreus (Pers.: Fr.) Fr.	m	**0.5**	**3**	

Hygrophorus poetarum R. Heim	m	**0.5**	15.10.91	
Hygrophorus russula (Schaeff.: Fr.) Quél.	m	**2**	**4**	
Hygrocybe		**6.5**		
Hygrocybe chlorophana (Fr.) Wünsche	s t	**0.5**	18.10.92	
Hygrocybe coccinea (Schaeff.: Fr.) P. Kumm.	s t	**1**	18.10.92	at the edges of paths, in thin woods
Hygrocybe conica (Schaeff.: Fr.) P. Kumm	s t	**1**	08.10.92, 28.09.96	
Hygrocybe helobia (Arnolds) Bon	s t	**2**	08.10.92	
Hygrocybe psittacina (Schaeff.: Fr.) P. Kumm	s t	**0.5**	18.10.92	at the edges of paths, in thin woods
TRICHOLOMATACEAE				
Mycena		**15.4**		
Mycena crocata (Schrad.: Fr.) P. Kumm.	s lt	**2**	19.10.97	
Mycena epipterygia (Scop.: Fr.) Gray	s lt	**5**	**12**	
Mycena galericulata (Scop.: Fr.) Gray	s l	**2**	**3**	
Mycena galopus (Pers.: Fr.) P. Kumm.	s lt	**3**	**4**	
Mycena galopus (Pers.: Fr.) P. Kumm. var. ***candida*** J.L.Lange (= *galopus* var. *alba* Rea; = *galopus* var. *annae* Benedix)	s lt	**0.5**	08.10.92	
Mycena inclinata (Fr.) Quél.	s l	**4**	**7**	
Mycena maculata P. Karst.	s l	**2**	29.10.89	
Mycena metata (Fr.) P. Kumm. [= *phyllogena* (Pers.) Sing.]	s lt	**0.5**	01.11.88	
Mycena pelianthina (Fr.) Quél.	s lt	**0.5**	15.10.90, 19.10.97	
Mycena polygramma (Bull.: Fr.) Gray	s l	**5**	**14**	
Mycena pura (Pers.: Fr.) P. Kumm.	s lt	**5**	**16**	
Mycena renati Quél. (= *flavipes* Quél.)	s lt	**1**	15.10.91	
Mycena rosea (Bull.) Gramberg (= *pura var. rosea* Gill.)	s lt	**5**	**10**	
Mycena stipata Maas Geest. et Schwöbel	s l	**0.5**	15.10.91	
Mycena sanguinolenta (Alb. & Schwein.: Fr.) P.Kumm	s lt	**2**	19.10.97, 18.10.95	
Marasmiellus		**4.0**		
Marasmiellus ramealis (Bull.: Fr.) Singer	s l	**2**	03.06.90	
Marasmius		**2.7**		
Marasmius epiphyllus (Pers.: Fr.) Fr.	s lt	**3**	03.09.89, 19.10.97	
Marasmius oreades (Bolton: Fr.) Fr.	s t	**1**	21.10.90	
Marasmius scorodonius (Fr.: Fr.) Fr.	s lt	**2**	02.07.89, 28.09.91	
Collybia		**7.3**		
Collybia alkalivirens Singer (= *obscura* A. Favre)	s lt	**0.5**	13.10.91	
Collybia butyracea (Bull.: Fr.) P. Kumm.	s t	**5**	**16**	
Collybia cirrhata (Pers.) Quél.	s lt	**1**	15.10.89 , 14.10.97	
Collybia confluens (Pers.: Fr.) P. Kumm.	s lt	**2**	10.09.89, 24.09.89	
Collybia dryophila (Bull.: Fr.) P. Kumm.	s lt	**3**	03.06.90, 06.07.97	
Collybia erythropus (Pers.: Fr.) P. Kumm. [= *Collybia marasmioides* (Britz.) Brsky. & Stangl]	s lt	**4**	31.08.92, 13.08.89	

Collybia fuscopurpurea (Pers.: Fr.) P. Kumm.	s lt	**1**	31.08.92, 04.09.92	
Collybia fusipes (Bull.: Fr.) Quél.	s l	**2**	02.10.88, 14.10.95	
Collybia maculata (Alb. & Schwein.: Fr.) P. Kumm.	s t	**0.5**	24.09.89	
Collybia peronata (Bolton: Fr.) P. Kumm.	s lt	**5**	**20**	
Megacollybia		**4.0**		
Megacollybia platyphylla (Pers.: Fr.) Kotl. & Pouzar	s l	**2**	**3**	
Xerula		**5.5**		
Xerula longipes (Bull.) Maire	s l	**4**	**13**	
Xerula radicata (Relhan: Fr.) Dörfelt	s l	**5**	**16**	
Oudemansiella mucida (Schrad.: Fr.) Höhn.	s l	**3**	**11**	
Clitocybe		**7.8**		
Clitocybe candicans (Pers.: Fr.) P. Kumm.	s lt	**2**	12.11.89, 30.09.95	
Clitocybe clavipes (Pers.: Fr.) P. Kumm.	s lt	**2**	13.10.92, 28.09.96	
Clitocybe ericetorum Bull.: Quél.	s t	**0.5**	15.11.90	
Clitocybe flaccida (Sowerby : Fr.) P. Kumm.	s lt	**5**	**12**	
Clitocybe gibba (Pers.: Fr.) P. Kumm. [Syn.: C. *infundibuliformis* (Schaeff.) Quél.]	s lt	**1**	**3**	
Clitocybe hydrogramma (Bull.: Fr.) P. Kumm.	s lt	**0.5**	17.10.89	
Clitocybe nebularis (Batsch: Fr.) P. Kumm.	s t	**5**	**11**	
Clitocybe odora (Bull.: Fr.) P. Kumm.	s lt	**4**	**5**	
Clitocybe phyllophila (Pers.: Fr.) P. Kumm.	s lt	**0.5**	01.11.91	
Clitocybe umbilicata (Schaeff.) P. Kumm.	s lt	**2**	15.10.91, 19.10.97	
Laccaria		**12.0**		
Laccaria amethystea (Bull.) Murrill	m	**5**	**22**	
Laccaria laccata (Scop.: Fr.) Berk. & Broome	m	**5**	**23**	
Armillaria		**4.5**		
Armillaria mellea (Vahl: Fr.) P. Kumm.	p l	**4**	**11**	on *Fagus sylvatica* L.stumps
Armillaria tabescens (Scop.) Emeland	s l	**0.5**	10.11.91, 18.10.92	
Ripartites		**2.5**		
Ripartites tricholoma (Alb. & Schwein.: Fr.) P. Karst.	s t	**0.5**	17.10.89	
Tricholoma		**12.9**		
Tricholoma album (Schaeff.: Fr.) P. Kumm.	m	**2**	**5**	
Tricholoma columbetta (Fr.) P. Kumm.	m	**4**	**10**	
Tricholoma filamentosum Alessio	m	**0.5**	17.10.89	
Tricholoma lascivum (Fr.) Gillet	m	**0.5**	10.11.91	
Tricholoma portentosum (Fr.) Quél.	m	**5**	**6**	
Tricholoma psammopus (Kalchbr.) Quél.	m	**1**	24.10.88, 14.09.96	
Tricholoma saponaceum (Fr.) P. Kumm.	m	**5**	**8**	
Tricholoma saponaceum (Fr.) P. Kumm. var. ***squamosum*** (Cooke) Rea	m	**0.5**	02.11.97	
Tricholoma scalpturatum (Fr.) Quél	m	**2**	**3**	
Tricholoma sciodes (Pers.) C. Martin	m	**1**	13.10.91, 08.10.92	

Tricholoma sejunctum (Sowerby: Fr.) Quél.	m	**0.5**	10.11.91
Tricholoma terreum (Schaeff.: Fr.) P. Kumm.	m	**2**	**3**
Tricholoma tigrinum (Schaeff.: Fr.) P. Kumm.	m	**2**	03.09.89, 14.09.96
Tricholoma ustale (Fr.: Fr.) P. Kumm.	m	**5**	**6**
Tricholoma ustaloides Romagn.	m	**2**	14.10.92, 13.10.92
Tricholoma virgatum (Fr.: Fr.) P. Kumm.	m	**0.5**	15.10.91
Lyophyllum		**3.0**	
Lyophyllum decastes (Fr.: Fr.) Singer	s t	**3**	**3**
Lyophyllum fumosum (Pers.: Fr.) P.D. Orton	s t	**0.5**	02.11.97
Rhodopaxillus		**7.0**	
Rhodopaxillus nudus (Bull.: Fr.) Maire	s t	**5**	**10**
ENTOLOMATACEAE			
Rhodocybe		**2.5**	
Rhodocybe nitellina (Fr.) Singer	s t	**0.5**	12.11.89
Clitopilus		**6.0**	
Clitopilus prunulus (Scop.: Fr.) P. Kumm.	s t	**5**	**18**
Entoloma		**4.7**	
Entoloma mougeotii (Fr.) Hesler	s t	**0.5**	19.10.97
Entoloma nidorosum (Fr.) Quél.	s t	**0.5**	24.11.91, 12.10.97
Entoloma rhodopolium (Fr.: Fr.) P. Kumm.	s t	**4**	**5**
PLUTEACEAE			
Pluteus		**1.5**	
Pluteus cervinus (Schaeff.) P. Kumm.	s l	**1**	**6**
Pluteus pellitus (Pers.: Fr.) P. Kumm.	s l	**0.5**	19.07.92
Volvariella		**1.5**	
Volvariella hypopithys (Fr.) M. Moser	s t	**0.5**	31.08.92, 31.09.92
Volvariella speciosa (Fr.: Fr.) Singer	s t	**0.5**	03.09.89
AMANITACEAE			
Amanita		**22.7**	
Amanita citrina (Schaeff.) Pers.	m	**5**	**40**
Amanita excelsa (Fr.: Fr.) Bertillon	m	**2**	**3**
Amanita junquillea Quél. [= *gemmata* (Fr.) Gillet]	m	**5**	**16**
Amanita muscaria (L.) Lam.	m	**5**	**19**
Amanita muscaria (L.) Lam. var. ***formosa*** (Pers.: Fr.) Gonn. et Rabenh.	m	**0.5**	29.09.89
Amanita pantherina (DC.: Fr.) Krombh.	m	**5**	**22**
Amanita phalloides (Fr.) Link	m	**5**	**23**
Amanita phalloides (Fr.) Link var. **alba** (Gillet) Bourdot	m	**3**	**8**
Amanita porphyria Alb. & Schwein.: Fr.	m	**1**	02.07.89, 19.10.97
Amanita rubescens Pers.	m	**5**	**44**
Amanita spissa (Fr.) P. Kumm.	m	**5**	**16**
Amanita vaginata (Bull.: Fr.) Lam.	m	**2**	**5**
Amanita verna Lam.	m	**1**	03.09.89, 17.11.91

Amanita vittadinii (Moretti) Vittad.	m	**0.5**	03.09.89, 24.09.89
Limacella		**4.0**	
Limacella guttata (Pers.: Fr.) Konrad & Maubl.	s t	**2**	**3**
AGARICACEAE			
Agaricus		**3.5**	
Agaricus excellens (Moell.) Moell.	s t	**0.5**	18.10.92
Agaricus sylvicola (Vittad.) Fr.	s t	**2**	**3**
Lepiota		**3.0**	
Lepiota aspera (Pers.: Fr.) Quél. [=*acutesquamosa* (Weinm.) P. Kumm.]	s t	**2**	**5**
Macrolepiota		**4.0**	
Macrolepiota mastoidea (Fr.) Singer	s t	**0.5**	09.09.89
Macrolepiota procera (Scop.: Fr.) Singer	s t	**5**	**14**
Macrolepiota rachodes (Vittad.) Singer	s t	**2**	**4**
Macrolepiota rachodes (Vittad.) Singer var. ***bohemica*** (Wichansky) Bellù & Lanzoni	s t	**0.5**	16.10.88
COPRINACEAE			
Coprinus		**6.3**	
Coprinus atramentarius (Bull.: Fr.) Fr.	s l	**2**	16.07.89, 10.09.89
Coprinus comatus (O.F. Müll.: Fr.) Gray	s t	**2**	**3**
Coprinus leiocephalus P.D. Orton	s t	**0.5**	12.11.89, 15.11.89
Coprinus micaceus (Bull.: Fr.) Fr.	s l	**5**	**8**
Coprinus plicatilis (Curtis: Fr.) Fr.	s t	**0.5**	19.10.97
Psathyrella		**2.8**	
Psathyrella candolleana (Fr.: Fr.) Maire	s l	**2**	**4**
Psathyrella piluliformis (Bull.: Fr.) P.D.Orton	s l	**1**	**2**
Psathyrella marcescibilis (Britzelm.) Singer	s t	**0.5**	19.07.92
BOLBITIACEAE			
Conocybe		**2.5**	
Conocybe tenera (Schaeff.: Fr.) Fayod	s t	**0.5**	17.10.89
Agrocybe		**2.5**	
Agrocybe praecox (Pers.:Fr.) Fayod	s t	**0.5**	06.07.97
STROPHARIACEAE			
Stropharia		**4.0**	
Stropharia aeruginosa (Curtis : Fr.) Quél.	s t	**2**	**3**
Hypholoma		**9.0**	
Hypholoma fasciculare (Huds.: Fr.) P. Kumm.	s l	**5**	**20**
Hypholoma sublateritium (Fr.) Quél.	s l	**5**	**21**
CORTINARIACEAE			
Inocybe		**3.7**	
Inocybe asterospora Quél.	m	**2**	**6**
Inocybe cookei Bres.	m	**0.5**	12.09.95, 14.09.96
Inocybe bongardii (Weinm.) Quél.	m	**2**	**5**
Inocybe descissa (Fr.) Quél	m	**1**	14.10.95, 02.11.97
Inocybe fastigiata (Schaeff.) Quél.	m	**2**	**4**

Inocybe geophylla (Sowerby : Fr.) P. Kumm. var. ***lateritia*** (Weinm.) J.E.Lange	m	**2**	10.11.91e 18.10.95
Inocybe patouillardii Bres.	m	**0.5**	26.10.97
Inocybe pyriodora (Pers.: Fr.) P. Kumm.	m	**0.5**	14.10.95
Inocybe umbrina Bres.	m	**0.5**	17.10.89, 10.06.90
Hebeloma		**3.5**	
Hebeloma sinapizans (Paulet) Gillet	m	**0.5**	19.10.97
Hebeloma radicosum (Bull.: Fr.) Ricken	s l	**2**	**5**
Alnicola		**2.5**	
Alnicola melinoides (Bull.: Fr.) Khüner	m	**0.5**	17.10.89
Gymnopilus		**2.5**	
Gymnopilus spectabilis (Fr.) Singer var. **junonius** (Fr.) J.E.Lange	s l	**0.5**	10.11.91
Dermocybe		**2.7**	
Dermocybe cinnabarina (Fr.) Wünsche	m	**0.5**	12.11.89
Dermocybe cinnamomea (L.: Fr.) Wünsche	m	**2**	12.11.89
Dermocybe phoenicea (Bull.) M. M. Mos.	m	**0.5**	18.10.92
Cortinarius		**6.7**	
Cortinarius anomalus (Fr.: Fr.) Fr.	m	**2**	**4**
Cortinarius armillatus (Fr.: Fr.) Fr.	m	**1**	09.09.89
Cortinarius auroturbinatus J.E. Lange	m	**0.5**	01.11.90
Cortinarius calochrous (Pers.: Fr.) Fr.	m	**0.5**	13.10.91, 18.10.92
Cortinarius claroflavus R. Henry	m	**0.5**	15.10.91, 18.10.95
Cortinarius cinnamomeus (L.: Fr.) Fr.	m	**1**	02.11.97
Cortinarius cotoneus Fr.	m	**0.5**	13.10.91
Cortinarius cristallinus Fr.	m	**0.5**	01.11.90
Cortinarius elatior Fr.	m	**0.5**	01.11.90
Cortinarius infractus (Pers.: Fr.) Fr.	m	**2**	02.11.97, 19.10.97
Cortinarius largus Fr.	m	**2**	18.10.92, 14.10.97
Cortinarius obtusus (Fr.) Fr.	m	**0.5**	01.11.90, 14.09.96
Cortinarius praestans (Cordier) Gillet	m	**3**	**3**
Cortinarius rubicundulus (Rea) A. Pearson	m	**0.5**	08.10.92
Cortinarius sebaceus Fr.	m	**2**	**6**
Cortinarius sodagnitus R. Henry	m	**1**	15.10.91, 28.09.96
Cortinarius subsertipes Romagn.	m	**0.5**	15.11.90
Cortinarius talus Fr.	m	**0.5**	18.10.92, 14.10.95
Rozites		**3.0**	
Rozites caperatus (Pers.: Fr.) P. Karst.	m	**2**	**3**
CREPIDOTACEAE			
Tubaria		**2.5**	
Tubaria furfuracea (Pers.: Fr.) Gillet	s lt	**1**	26.10.88, 14.09.96
Russulales			
RUSSULACEAE			
Russula		**36.1**	

Russula albonigra (Krombh.) Fr.	m	**5**	**9**
Russula alutacea (Pers.: Fr.) Fr.	m	**5**	**5**
Russula amoena Quél.	m	**2**	**4**
Russula atropurpurea (Krombh.) Britzelm.	m	**1**	**4**
Russula aurata (With.) Fr.	m	**0.5**	04.09.92
Russula chamaeleontina (Fr.) Fr.	m	**0.5**	09.07.89
Russula chloroides (Krombh.) Bres.	m	**3**	**5**
Russula cyanoxantha (Schaeff.) Fr.	m	**5**	**43**
Russula brunneoviolacea Crawshay	m	**0.5**	01.05.89, 14.10.97
Russula delica Fr.	m	**5**	**13**
Russula silvestris (Singer) Reumaux	m	**3**	**8**
Russula faginea Romagn.	m	**2**	3
Russula fellea (Fr.) Fr.	m	**5**	**27**
Russula foetens Pers.	m	**3**	**12**
Russula fragilis (Pers.: Fr.) Fr.	m	**0.5**	11.09.88
Russula heterophylla (Fr.) Fr.	m	**5**	**18**
Russula illota Romagn.	m	**1**	10.09.89
Russula integra (L.) Fr.	m	**1**	**3**
Russula laurocerasi Melzer	m	**1**	04.09.92
Russula lepida Fr.	m	**3**	**11**
Russula lutea (Huds.: Fr.) Gray	m	**2**	**5**
Russula mairei Singer	m	**2**	08.10.92
Russula nigricans (Bull.) Fr.	m	**5**	**15**
Russula ochroleuca Pers.	m	**3**	**7**
Russula olivacea (Schaeff.) Pers.	m	**0.5**	31.08.92
Russula romellii Maire	m	**1**	**3**
Russula rosea Quél.	m	**1**	**3**
Russula rubroalba (Singer) Romagn.	m	**2**	04.09.92
Russula solaris Ferd. & Winge	m	**2**	04.09.92
Russula vesca Fr.	m	**5**	**6**
Russula vinosobrunnea (Bres.) Romagn.	m	**3**	31.08.92, 08.10.92
Russula violeipes Quél.	m	**2**	**5**
Russula virescens (Schaeff.) Fr.	m	**3**	**11**
Lactarius		**8.4**	
Lactarius acris (Bolton: Fr.) Gray	m	**2**	**3**
Lactarius blennius (Fr.: Fr.) Fr.	m	**1**	09.07.89
Lactarius camphoratus (Bull.: Fr.) Fr.	m	**0.5**	24.09.89
Lactarius chrysorheus Fr.	m	**3**	**7**
Lactarius circellatus Fr.	m	**0.5**	13.10.91
Lactarius citriolens Pouzar	m	**0.5**	01.11.88
Lactarius fuliginosus (Fr.) Fr.	m	**0.5**	13.10.91
Lactarius glaucescens Crossl.	m	**1**	**4**
Lactarius mitissimus (Fr.) Fr.	m	**2**	**5**
Lactarius obscuratus (Latsch.: Fr.) Fr.	m	**2**	24.11.91

Lactarius pallidus (Pers.: Fr.) Fr.	m	**0.5**	**15.10.91**
Lactarius piperatus (L.: Fr.) Pers.	m	**4**	**7**
Lactarius quietus (Fr.) Fr.	m	**2**	01.05.89, 24.09.89
Lactarius rufus (Scop.: Fr.) Fr.	m	**2**	08.10.92, 14.10.92
Lactarius serifluus (DC.: Fr.) Fr.	m	**2**	10.11.91, 24.11.91
Lactarius subdulcis (Pers.: Fr.) Gray	m	**3**	**6**
Lactarius torminosus (Schaeff.: Fr.) Pers.	m	**0.5**	13.08.89, 26.10.96
Lactarius zonarius (Bull.) Fr.	m	**2**	**3**
Phallales			
PHALLACEAE			
Phallus		**7.0**	
Phallus impudicus L.: Pers.	s t	**5**	**21**
Nidulariales			
NIDULARIACEAE			
Crucibulum		**3.0**	
Crucibulum leave (Huds.) Kambly	s l	**2**	**3**
Cyathus		**4.0**	
Cyathus striatus (Huds.) Willd.: Pers.	s l	**2**	03.09.89, 16.10.94
Lycoperdales			
LYCOPERDACEAE			
Lycoperdon		**6.0**	
Lycoperdon echinatum Pers.: Pers.	s t	**0.5**	10.09.89
Lycoperdon foetidum Bonord	s t	**2**	15.10.90
Lycoperdon perlatum Pers.: Pers.	s t	**5**	**15**
Lycoperdon pyriforme Schaeff.: Pers.	s l	**0.5**	06.10.90
Bovista		**2.0**	
Bovista aestivalis (Bonord.) Demoulin	s t	**1**	15.10.89, 13.10.91
Bovista plumbea Pers.	s t	**2**	06.10.90, 14.09.96
Calvatia		**3.0**	
Calvatia excipuliformis (Scop.: Pers.) Perdeck	s t	**1**	15.11.90
Langermannia		**2.5**	
Langermannia gigantea (Batsch: Pers.) Rostk.	s t	**0.5**	04.09.88, 11.09.88
Sclerodermatales			
SCLERODERMATACEAE			
Scleroderma		**3.7**	
Scleroderma citrinum (L.) Pers.: Pers.	m	**5**	**22**
Scleroderma bovista Fr.	m	**2**	19.07.92, 04.09.92
Scleroderma polyrhizum J.F. Gmel.: Pers.	m	**0.5**	31.08.92

ASTRAEACEAE			
Astraeus		**3.0**	
Astraeus hygrometricus (Pers.) Morgan	s t	**2**	03.07.88 , 02.11.97

ASCOMYCOTA

Ascomycetes

Pezizales			
HELVELLACEAE			
Helvella		**3.0**	
Helvella lacunosa Afzel.: Fr.	s t	**1**	19.10.97
PEZIZACEAE			
Peziza		**4.0**	
Peziza badioconfusa Korf	s t	**2**	09.07.89, 14.10.95
Aleuria		**3.0**	
Aleuria aurantia (Pers.: Fr.) Fuckel	s t	**1**	28.09.91, 02.10.97
OTIDEACEAE			
Otidea		**3.0**	
Otidea onotica (Pers.: Fr.) Fuckel	s t	**1**	08.10.92
Leotiales			
LEOTIACEAE			
Leotia		**4.0**	
Leotia lubrica (Scop.) Pers.: Fr.	s t	**2**	08.10.92
GEOGLOSSACEAE			
Microglossum		**3.0**	
Microglossum viride (Pers.: Fr.) Gillet	s t	**1**	26.10.97
Hypocreales			
CLAVICIPITACEAE			
Cordiceps		**2.5**	
Cordiceps militaris (L.) Link	p l	**0.5**	18.10.92
Xylariales			
XYLARIACEAE			
Hypoxylon		**2.5**	
Hypoxylon fuscum (Pers.: Fr.) Fr.	s l	**0.5**	26.10.88
Xylaria		**3.0**	
Xylaria hypoxylon (L.) Grev.	s l	**2**	5
Xylaria polymorpha (Pers.: Fr.) Grev.	s l	**0.5**	30.09.95, 19.10.97

LOCATION OF THE AREA, CLIMATIC AND GEOMORPHOLOGICAL FEATURES

The area studied is part of the province of Savona (see Fig. 1), limited by the Cadibona Pass (459 m above sea level) to the west and by the Giovo pass (516 m) to the east (map reference: Regional Technical Maps, scale 1:25.000, table n° 229.4 Savona and table n° 212.3 Sassello) and located between the Tyrrhenian coast and the Po Valley. The altitude is approximately 500 meters, between the upper zone of the basal level and the lower zone of the mountain level. From a geological point of view, it is characterised by the Triassic-Liassic Unit made of red-violet micaceous quartz schists and by the Montenotte Ophiolitipherous Unit made of gabbrous breccia or crystalline limestone (Vanossi, 1991).

Measurement of metal ion saturation in some soil samples showed that the pH ranged from 4.8 to 7.

The Po valley is characterised by a Central European oceanic climate: the winters are quite cold and humid while the summers are cool. Maximum rainfall peaks occur in autumn and spring. The Tyrrhenian coast has a sub-mediterranean mountain climate, typical of the sub-mountain areas of the Ligurian Apennines (Gentile, 1984), with mild winters and summers featuring short periods of drought although these do not always occur.

On the Po valley side, the maximum temperature spread between summer and winter is 18 C°. On the marine side it is 14-15°C.

DESCRIPTION OF THE AREAS STUDIED

Since the beech forests are not uniformly distributed over the area, four separate stands were considered. Each stand covered an area of 1 km^2 and was chosen taking the physionomic characteristics of the beech-forest into account. The altitude ranged from about 670 m (above sea level) near the Montenotte Superiore area to 850 m at Monte San Giorgio. It is important to note that the areas selected were still partially exploited for timber production. Furthermore, the forest belongs to several different owners, so that maintenance of the beech trees was not uniform: areas in which coppices were cut regularly with a medium-short rotation alternated with others in which old coppices were no longer exploited or where conversions from coppices to high forest (and vice-versa) were in progress. Areas of high forest, being old or recently converted from coppices, were infrequent and the trees in them were quite small.

The beech woods considered had a limited variety of species of flora, with specific reference to the mesophilous species of *Fagetalia sylvaticae*. This probably depends on the relatively low altitude of the study areas as well as on the type of cultivation and on management practices which periodically modify the litters above and below ground and induce changes in luminosity and in the degree of ion saturation of the soil. Among the species of *Fagetalia sylvaticae*, *Fagus sylvatica* was the most frequent mainly in the arboreous layer, whereas *Luzula nivea* was abundant both in the herbaceous and in the shrub layer. Other species found sporadically were: *Dryopteris filix-mas, Festuca heterophylla, Prenanthes purpurea, Trochiscanthes nodiflora, Lamiastrum galeobdolon, Geranium nodosum, Euphorbia dulcis, Milium effusum, Paris quadrifolia* etc.

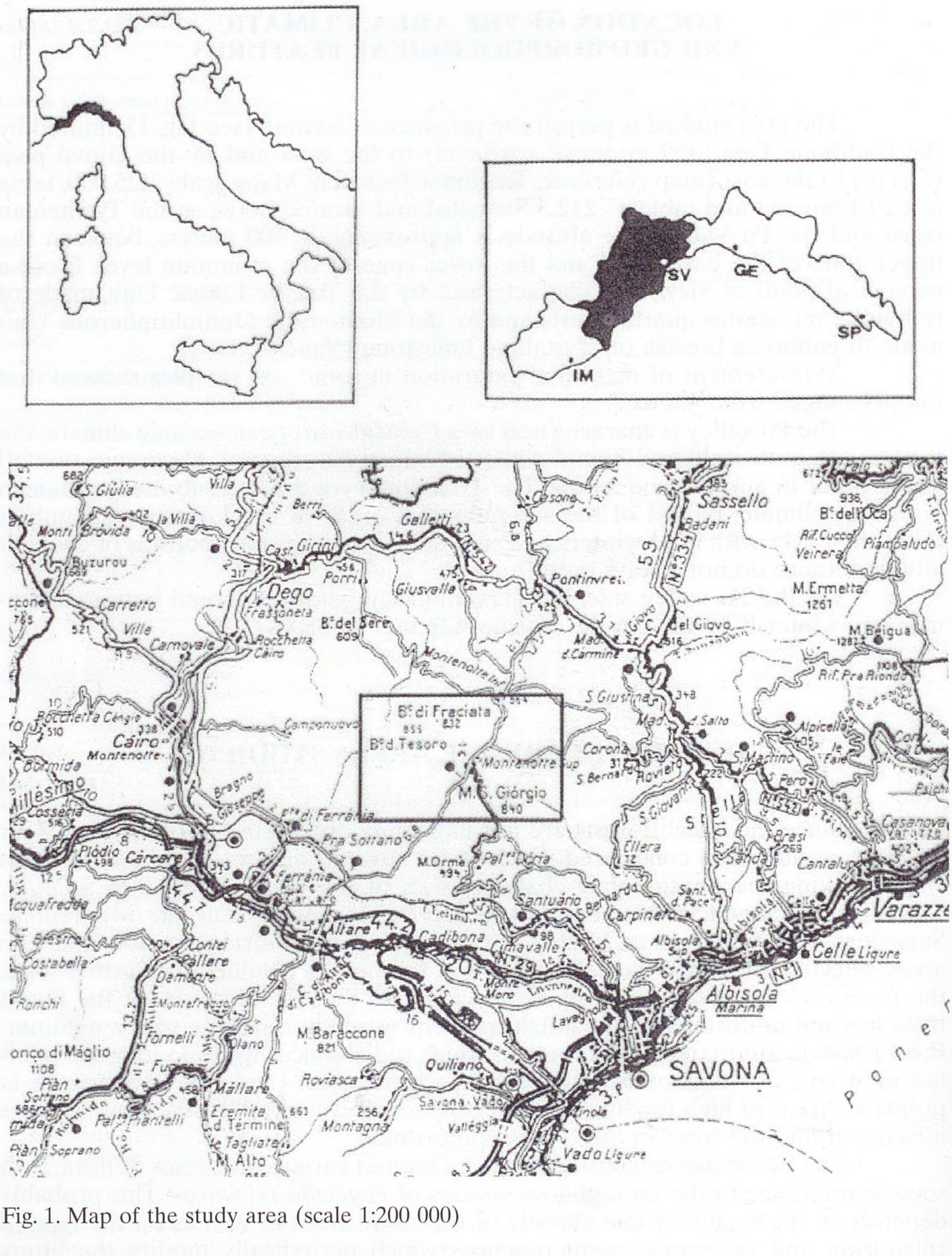

Fig. 1. Map of the study area (scale 1:200 000)

The presence of species of the *Querco-Fagetea* class was scarce, consistently with the limited variety of the flora in the woods studied. Only *Corylus avellana* was present to significant extent, although it occurred less frequently than in other parts of the Ligurian Apennines. Among the acidophilus species, *Avenella flexuosa* was quite common, followed by *Pteridium aquilinum, Physospermum cornubiense* and *Vaccinium myrtillus*. The mesophylous aspect of these formations was highlighted by the almost complete absence of any species of *Quercetalia pubescentis*, which could also be due to the continuous management practices. The considerable presence of *Rubus hirtus*, even with low cover values, can be considered a sign of the assiduous presence of man in the area.

To conclude, all the floristic characteristcs of the forest studied suggested that it could be classed as a *Trochischanto-Fagetum* association (Gentile, 1974). Indeed, our beech wood could be considered as an impoverished type of the association referred to above, mainly because of the past intensive cultivation. The *Trochischanto-Fagetum* association belongs to the *Geranio nodosi-Fagion* alliance, which is quite common in the Northern and Central Apennines of Italy.

MATERIALS AND METHOD

This study was carried out from 1988 to 1992 and from 1995 to 1997 and lasted for a total of eight years, during which period several excursions took place. Each area was uniformly time sampled in late spring, summer, autumn and early winter, although we decided to shorten the autumn sampling period in view of the evidence of a significant increase in fungal reproduction.

Identification was made on the basis of the following literature: Alessio & Rebaudengo, (1980); Alessio (1985, 1991); Balletto (1972); Bernicchia (1990); Bon (1980, 1984); Bourdot & Galzin (1927); Candusso & Lanzoni (1990); Cappelli, (1984); Dennis (1981); Jülich (1989); Kits van Waveren (1985); Kühner & Romagnesi (1953); Maas Geesteranus (1992); Merlo & Traverso (1983); Moser (1980); Noordeloos (1987, 1992); Orton (1986); Orton & Watling (1979); Pilát (1958); Riva (1988); Romagnesi (1967); Schaeffer (1952); Stangl (1991); Tartarat (1988); Watling (1982); Watling & Gregory (1987, 1989); Watling *et al.* (1993). Reference was also made to the following iconography: Cooke (1881-1891); Boudier (1905-1910); Bresadola (1927-1933); Konrad & Maublanc (1924-1937); Lange (1935-1940); Romagnesi (1956-1967); Phillips (1981); Marchand (1971-1986); Bon (1988); Courtecuisse & Duhem (1994); Breitenbach & Kränzlin (1981, 1986, 1991, 1995); Cetto (1976-1993); Montecchi & Lazzari (1993). As far as concerned the nomenclature, we adopted the rules of the International Code of Botanical Nomenclature (Greuter *et al.*, 1988) as well as suggestions by Kreisel (1987) and Bertéa *et al.* (1989). The systematic arrangement of taxa (structured according to division, class, order, family, genus) was based on Hawksworth *et al.* (1995) and works by Balletto (1972, 1981, 1990, 1992, 1993), Moser (1980), Dennis (1981), Singer (1986) and Jülich (1989). Author's names have been shortened according to Brummitt & Powell (1992).

For each species, the frequency with which it was found and its ecological group have been specified. The abbreviations for these ecological groups are as follows (the term saprotrophic is used in place of the older saprophytic - Hawksworth *et al.*, 1995).

m = ectomycorrhizal symbiotic species
st = saprotrophic species on soil or humus
sl = saprotrophic species on dead wood
s lt = saprotrophic species in the litter
pl = parasitic species on living trees

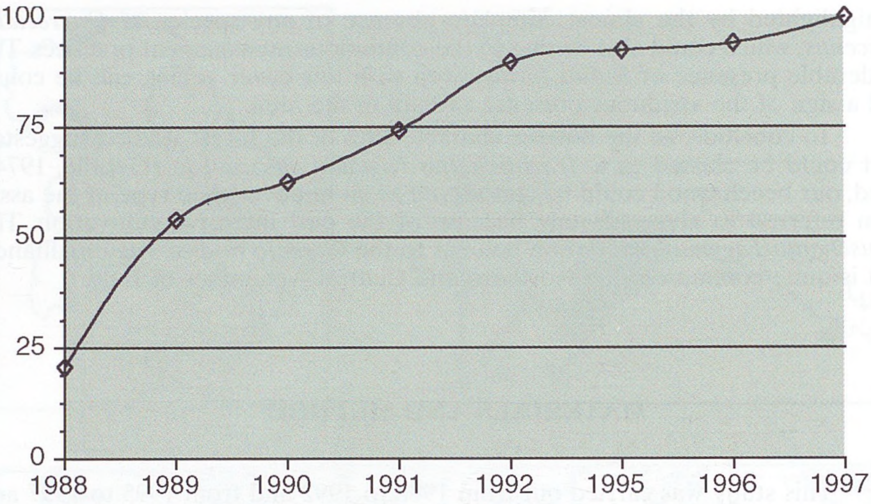

Fig. 2. The increase in the number of species in all the observation areas during 8 years of study

Because of the conflicting opinions about the classification of species to ecological groups, the ecological classification is based on data referring to several authors: Trappe (1962), Arnolds (1984), Singer (1986), Ceruti *et al.* (1987), Orsino & Traverso (1986, 1990), Orsino (1986, 1988, 1991, 1993), Orsino & Dameri (1989, 1991, 1996), Orsino *et al.* (1999).

The complete list is provided in Table 1.

RESULTS

The 8-year mycofloristic study enabled 302 different species of macrofungi to be collected and identified, of which four were recorded for the first time in Liguria. To be precise, *Mycena renatii*, *Cortinarius claroflavus* and *Cordyceps militaris* were observed for the first time, while *Oudemansiella mucida* had been already found in the 19th century (Pollacci, 1896), but no further findings had been reported until our own. From a systematic point of view, 292 species belonged to the Basidiomycota and the remaining 10 to the Ascomycota. The genera of which the greatest number of species were found were *Russula* (32), *Lactarius* (18), *Cortinarius* (18), *Tricholoma* (16), *Amanita* (14), *Mycena* (14), *Boletus* (13), and *Collybia* (11).

It should be noted (see Fig. 2) that the increase in the number of species in our stands was quite rapid and constant during the first five years of the study but slowed down in the last three years, once 89% of the total number of species had already been collected. This proved the relatively stable edaphic conditions as well as constant management of the beech woods and showed that no significant successional trends occurred.

The species were distributed among the ecological classes defined above as follows (see the black bars of Fig. 4): 164 ectomycorrhizal species (54.6%), 60 saprotrophic species on soil (20%), 44 saprotrophic species on dead wood (14.7%), 29 saprotrophytic species on decomposing litter (9.7%) (total percentage of saprotrophic species: 44.4%), 3 parasitic species on living trees (1%).

During the 8 years of observation, the total number of sporophores collected amounted to 20,146: from this point of view, it is reasonable to state that our beech woods were richer in quantitative rather than qualitative terms.

Many other interesting features of the woods studied were determined by means of a statistical analysis of data concerning the number, the time, the genus and species of the carpophores found. In order to estimate the productiveness of our beech wood, a suitable index was defined taking into account, for each genus, both the number of carpophores and the number of identified species (belonging to that genus) found during all the visits in a given month. In other words, the index we defined was a function of time expressing the fructification capability and rhythm of the currently considered genus.

More in detail, let $n_g(i)$ be the number of species belonging to the generic genus g found during the month i and $a_{gh}(i)$ be the abundance of carpophores belonging to the species h of the genus g estimated in the same period. The proposed fructification index $f_g(i)$ for the genus g was then defined as:

$$f_g(i) = k\frac{n_g(i)}{S_g} + \sum_{h=1}^{n_g(i)} a_{gh}(i)$$

where S_g is the total number of detected species belonging to the genus g and k is a constant we set at 2. Furthermore, the overall productivity index can be expressed as follows for each month i:

$$F(i) = \sum_{g=1}^{G} f_g(i)$$

G being the total genus number.

By analyzing the behavior of the F(i) index, the maximum fungal aspect (MFA) can be easily determined, and it is also possible to derive aspects of different genera by studying the set of $f_g(i)$ functions.

Function F(i) is ploted in Fig. 3. For each year it shows a pair of peaks, in July and October respectively. This peculiarity of the behaviour of the productivity index meets the observation mentioned in Fungal Ecology (Dix & Webster, 1995).

As far as concerned the Maximum Fungal Aspect, the period with the greatest abundance of fungi along with a great variety of species ranged from the first fortnight in October to the first fortnight in November.

It should be noted that in our regions, the MFA appeared to occur one month later than in the woods considered by Thoen (1971), and this is consistent with Thoen's comments that the MFA occurs earlier in Central Europe than in Western Europe. The fact that the MFA in our woods occurs later than in any other forest studied is due mainly due to the rather peculiar climatic conditions of the Ligurian Apennines, which are singular not only in Europe, but also in Italy itself.

The observations throughout the eight years of the study suggested that three main fructification periods (also called "aspects") can be defined. These are,

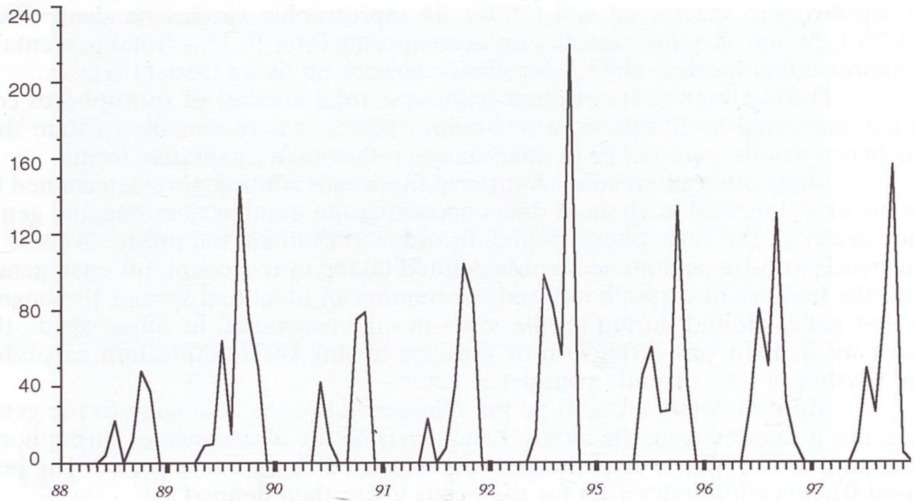

Fig. 3. Productiveness index F vs time (month) evaluated during the 8 years of study.

specifically, late spring/early summer (May and June), summer (July, August and September) and autumn (October, November and December).

Some ectomycorrhizal genera, such as *Russula* (*R. cyanoxantha, R. nigricans, R. fellea, R. foetens, R. delica*) and *Amanita* (*A. rubescens, A. citrina, A. muscaria, A. phalloides*), appeared to be quite abundant throughout all the periods defined above, with a slight downward trend in August. However, some species of these genera can be more easily found only during certain aspects.

With regard to saprotrophic species on dead and rotten wood, *Trametes versicolor*, *Stereum hirsutum*, *Hypholoma fasciculare*, *Schizophyllum commune* were almost uniformly distributed.

The late spring/early summer period was characterised by the significant presence of the *Boletus* genus (especially *B. erythropus, B. edulis*). Among the most abundant species of *Amanita* and *Russula* were *A. pantherina, A. spissa, A. junquillea and R. lutea.* Furthermore, this aspect featured a considerable number of *Phallus impudicus.*

In the summer period, the species *Gyroporus cyanescens, Collybia erythropus, Phyllophorus rhodoxanthus* could be considered typical of our beech wood. In July, the most common species of *Amanita* were *A. spissa, A. excelsa, A. porphyria,* while the genus *Russula* consisted of *R. ochroleuca, R. virescens* and, in September, *R. albonigra, R. solaris, R. chloroides and R. vesca*.

Moreover, in September we observed the beginning of the fructification of several genera, such as *Tricholoma, Cortinarius, Lactarius*, *Xerula, Laccaria, Collybia, Xerocomus, Hydnum, Mycena, Coprinus, Scleroderma* and *Lycoperdon,* which would dominate the next Autumn aspect.

Finally, the last period, Autumn, was characterized by the greatest abundance of carpophores as well as the greatest variety of genera and it was precisely in this time interval that the MFA occurred. The most significant species of the genera that began their fructification in September included *Tricholoma ustale, T. sciodes, T. portentosum* (especially in November); *Cortinarius sebaceum, C. anomalus; Lactarius subdulcis, L. piperatus, L. chrysorheus; Xerula radicata, X. longipes, Clitocybe nebularis, C. flaccida, Mycena pura, M. rosea, M. polygramma, etc.).*

Among the species found, the presence should be pointed out of a large group of typical or preferential species of beech-woods, such as: *Xerula mucida, X. radicata, Marasmius alliaceus, Lactarius blennius, L. pallidus, L. subdulcis, Clitocybe umbilicata, Mycena pelianthina, M. pura, M. rosea M. renati, M. galericulata, Hygrophorus cossus, H. poetarum, Tricholoma sciodes, T. portentosum, Cortinarius calochrous, C. elatior, Russula faginea, R. fellea, R. mairei, R. mairei var. fageticola, R. romelli, R. alutacea, R. solaris, Ramaria flava,* etc. Fungi that develop preferably and/or exclusively on dead beech stumps and logs constituted a very small group: *Xerula mucida, Polyporus varius, Xylaria polymorpha.*

Species typical not only of beech-woods, but also growing in other kinds of broad-leaved woods, such as oak, chestnut and mixed woods, were frequently observed. These included both acidophilous or neutro-basophilous species as well as others without any edaphic requirements. The most common and abundant fungi belonging to the species mentioned above were *Cantharellus cibarius, Hydnum repandum, Collybia butyracea, C. peronata, Laccaria laccata, Clitocybe nebularis, Hypholoma fasciculare, H. sublateritium, Phallus impudicus, Boletus edulis, B. calopus, Xerocomus chrysenteron, Tricholoma saponaceum, T. columbetta, Mycena polygramma, Coprinus micaceus, Pluteus cervinus, Amanita citrina, A. phalloides A. rubescens A. muscaria, Lactarius chrysorheus L. piperatus, Russula nigricans, R. foetens, Rhodopaxillus nudus* and *Scleroderma citrinum.*

Finally, the occurrence, albeit sporadic, of a small group of species such as *Hygrocybe conica, H. coccinea, H. psittacina, Marasmius oreades, Clitocybe ericetorum, Conocybe tenera, Bovista plumbea, Langermannia gigantea* should be mentioned as markers of poor, degraded habitats affected by human influence. In actual fact these are not nemoral species, instead they are typical of open grassy areas such as edges or clearings.

COMPARISON WITH OTHER ITALIAN AND EUROPEAN BEECH WOODS

A comparison was made with the beech forests in other Italian regions before considering some European beech woods studied by Thoen (1970, 1971), Lisiewska (1972, 1974) and Adamczyk (1996).

For the purposes of a comparison with other Italian woods, the few works published do not furnish much information either about the phytosociological classification or the soil characteristics and climate. We took the studies by Orsino & Dameri (1996), Antonini *et al.* (1999), Ceruti *et al.* (1987-88) and Venturella *et al.* (1999) into account.

The species observed in these works were grouped according to their ecological classes (see IV) and their percentage occurrences are indicated in the histogram in Fig. 4.

In the work by Orsino & Dameri (l.c.), the beech woods consisted of forest trees and were located in an area of the Ligurian Alps called Melogno, near the areas considered in our own study. These forests are belonging to the *Trochiscantho-Fagetum* association and without doubt they were the most similar to our woods, not only from the phytosociological point of view but also in terms of the climatic conditions and the soil features. Although Orsino & Dameri identified a greater number of species (536), most of which were also observed in our

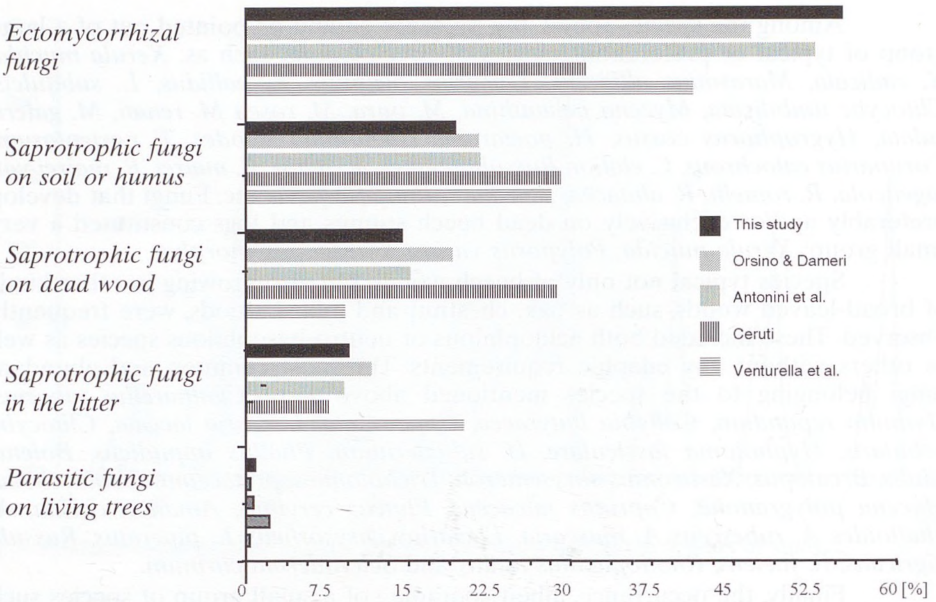

Fig. 4. Species distribution among four ecological classes (Ectomycorrhizal fungi, saprotrophic fungi on soil or humus, saprotrophic fungi on dead wood, saprotrophic fungi in the litter and parasitic fungi on living trees). The different bar fillings correspond to the carpophores collected by a different mycologist during his studies on Italian beech forests.

stands, the total number of carpophores collected was lower, thus revealing less intensive fructification.

Furthermore, Fig. 4 shows that there were significantly fewer ectomycorrhizal fungi (46 %) than non-symbiotic ones. This is probably due to the well-developed above/below-ground litters (the term litter is used here in a broader sense), that constitute good conditions for saprotrophic species to grow in. In our stands, on the contrary, the intense management practices (e.g. periodic clearing of the undergrowth, removal of wood and leaves, etc.) hampered the development of these litters and, consequently, the quantity saprotrophic species on decomposing litter and on dead wood was smaller, while the ectomycorrhizal fungal class (57 %) predominated over all the others (43 %). This proved that human activities can affect the mycoflora to a great extent, since the plant community, the climate and the characteristics of the soil were basically the same in the two study areas involved.

A similar ecological distribution was found in the beech woods located at Abetone, in the Northern Apennines of Tuscany (Antonini *et al.*, 1999). This beech forest consisted mainly of coppices or was in a stage of transition from coppices to high forests, and featured a significant level of management practices. It is interesting to note here again that the ectomycorrhizal fungi were the most abundant, thus confirming our previous hypothesis. With regard to the wide distribution of these species, most of them were also collected in our woods, such as *Laccaria laccata, L. amethystina, Xerula radicata, Lactarius blennius, L. pallidus, R. fellea*, ...

As to the study carried out by Cerruti *et al.* (1987-88) in the Palanfré National Park (Piedmont, Italy), the beech woods considered consisted mainly of

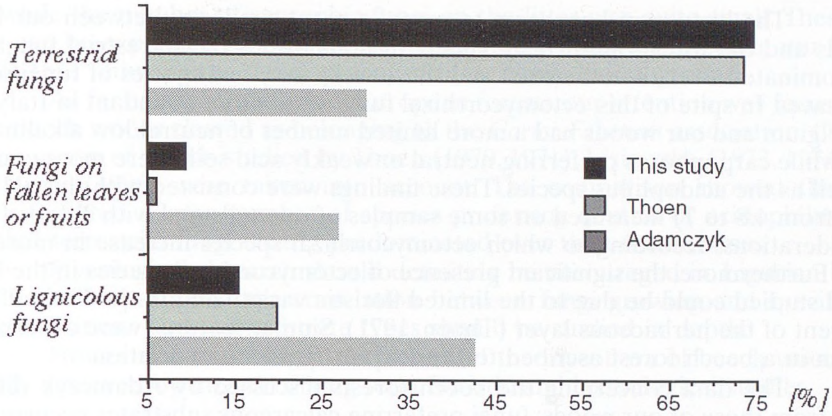

Fig. 5. Species distribution according to three ecological class (Terrestrial, lignicolous fungi and fungi on fallen leaves or fruits). The different fillings correspond to the carpophores collected by a different mycologist during his studies on beech forests.

two-centuries old forest trees not subjected to any management. In this area the saprotrophic species greatly outnumbered the ectomycorrhizal species.

Finally, the comparison with an interesting Sicilian beech wood (Venturella *et al.*, 1999) revealed that about 80 % of the 183 species collected there were also recorded in our stands, most of them belonging to saprotrophic species. In other words, the significant difference between the two woods seemed to be the greater variety of ectomycorrhizal fungi occuring in the Ligurian Apennines.

Comparing our beech woods with other European beech forests was quite a difficult task because of the different study methods employed by various authors as well as the different edaphic, climatic and environmental conditions (e.g. soil structure, floristic associations, temperature, etc.), occurring in each wood considered. Specifically, the very peculiar Ligurian habitat and climate greatly affect associations, so that it is possible to define a typical forest association, the *Trochiscantho-Fagetum* association, for the beech woods in our study. Since this association, typical of Italian Apennines, is sufficiently similar to the *Carici-Fagetum* association (Gentile, 1974), we decided to limit our comparisons only to other European beech forests attributed phytosociologically to this association.

On the basis of these considerations, we selected the following beech forests: the beech woods near Bois Banal (Belgium) described by Thoen (1970, 1971), the beech wood in the northern part of the Czestochowa upland (southern Poland), studied by Adamczyk (1996) and the beech forests taken into account by Lisiewska (1974).

In order to make it easier to compare data, the species collected were also classified according to ecological classes proposed by other authors. In Fig. 5 a histogram shows the occurrences of species recorded by the mycologists mentioned above, distributed among the following categories: terrestrial fungi, fungi on fallen leaves or fruits and lignicolous fungi. The histogram does not include the data relating to the *Carici-Fagetum* association studied by Lisiewska (1974), since in her paper the author only draws a final conclusion without furnishing a detailed list of the species collected.

The histogram bars seem to reveal a great similarity between our beech woods and the forests studied by Thoen: in both woods the terrestrial fungi class predominated over the other two and there were very few species of fungi on fallen leaves. In spite of this, ectomycorrhizal fungi were more abundant in Italy than in Belgium and our woods had a more limited number of neutral/low alkaline species while carpophores preferring neutral or weakly acid soils were more common as well as the acidophilus species. These findings were consisted with the pH (ranging from 4.8 to 7) measured on some samples of our soils and with Tyler's (1985) considerations, according to which ectomycorrhizal species increase in more acid soils. Furthermore, the significant presence of ectomycorrhizal species in the beech wood studied could be due to the limited floristic variety and to the limited development of the herbaceous layer (Thoen, 1971). Similar features were observed by Thoen in a beech forest ascribed to the *Luzulo-Fagetum* association.

The data concerning the beech forests discussed by Adamczyk differed most from those of our woods: fungi preferring calcareous substrates occurred frequently, lignicolous species were very predominant and terrestrial fungi were not adequately represented. These characteristics were probably due to the particular conditions of the *Carici-Fagetum* patches that were located near an industrial zone of Czestochowa, where pollution benefited parasitic species growing on trees weakened by the atmospheric conditions.

Finally, the beech forests studied by Lisieska featured a great number of terrestrial species, generally preferring neutral or low alkaline soils. For this reason, many of the considerations already discussed for Belgian woods also apply here. It should be pointed out that the species *Cortinarius cotoneus* and *Boletus luridus* [considered thermophilous by Adamczyk (1996)] collected in our woods were also mentioned by Lisiewska.

CONCLUSIONS

Our research, carried out in some beech woods near Savona (Liguria, Italy) yielded several categories of information.

From the phytosociological point of view, these woods were attributed to the association *Trochiscantho-Fagetum*.

During the eight years of observation, 20.146 carpophores belonging to 312 different species (292 Basidiomycota and 10 Ascomycota) were collected; moreover four of these species were new to Liguria. Most of the species found were typical or preferential of beech wood, such as *Xerula mucida, X. radicata, Marasmius alliaceus, Lactarius blennius, L. pallidus, L. subdulcis, Clitocybe umbilicata, Mycena pelianthina, M. pura, M. rosea, M. renati, M. galericulata, Hygrophorus cossus, H. poetarum, Tricholoma sciodes, T. portentosum, Cortinarius calochrous, C. elatior, Russula faginea, R. fellea, R. mairei, R. mairei* var. *fageticola, R. romellii, R. alutacea* and *R. solaris.*

The data recorded were statistically analysed in order to evaluate the MFA, the seasonal fungal aspects, the abundance of species and the most significant genera and species characterising our study areas.

Finally, we made several comparisons with other Italian and European beech forests . With regard to other Italian beech woods, it should be pointed out that our stands show the highest percentage occurrence of ectomycorrhizal species, while the number of saprophic fungi on the litter was quite small. These findings can be explained by the intense management practices affecting our beech woods, thus reducing the development of litter above/below ground.

As far as concerned other European forests, our attention was focused on some beech woods classed as belonging to the *Carici-Fagetum* association. On this basis, a group of woods studied by Thoen (1970, 1971), Lisiewska (1972, 1974) and Adamczyk (1996) were taken into account. The comparison showed that our woods featured a large number of species preferring neutral or acidophilus soils and that terrestrial fungi clearly predominated over the others classes.

Mycological research should definitely be encouraged in Ligurian beech woods, and in particular the correlation between fungi growing and specific climatic conditions and soil/substrate types should be studied in depth.

However, a more complete picture of the mycoflora of beech woods can be only achieved by means of long-term floristic and coenological studies.

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