Do some Tuber species endanger the natural *Tuber aestivum/uncinatum* habitats in Carpatho-Panno Region?

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1 Introduction

Tuber aestivum is the truffle of the Carpatho-Pannon Region, which is collected in the largest quantity. Its natural habitats may be endangered not only by the exceeding truffle hunting (Bratek et al., 2009), but probably by turning up of some invasive fungal species. In contrast with the plants, the animals and the pathogens, the invasive character of macrofungi has been started to study just in the last few years (Desprez et al., 2007; Murat et al., 2008). The apperance of an invasive species in the habitat of an autochton species or additionally the elimination of autochtons by invasive ones are due to the same environmental and ecological demands of both species. This time the most commonly found hypogea species which coexist with *T. aestivum* are the next Tuber species: *T. excavatum aggr., T. brumale, T. rufum aggr.* Hollós (1911) and Szemere (1970) considered *T. excavatum* and *T. rufum* as common species. According to the subsequent herbarial data *T. brumale* became widespread just in the last 30 years. To better understand the interactions among the Tuber species, the natural occurences, botanical and pedological data of habitats of the above mentioned species were investigated, involving of *T. macrosporum*.

3 Soil

Except *T. rufum* all the species generally avoid the loess soils, the sandy soils and the acidic soils. To regard the soil genetic type in the cases of *T. aestivum, T. brumale* and *T. macrosporum* the most frequent type is the brown forest soils with clay illuviations. The number of significatly different soil parameters of the compared species is not clearly correlates with their coexistence frequency (Figure 1.). The only soil parameter seems to be correlated with the coexintence of species is the significance of SPA (Figure 2.). The number of common occurences is lower, if the difference in SPA values was becoming higher. Only except is *T. rufum*, which is living in soils with very different SPA values, at the same time this species is commonly found together with *T. aestivum*, which may due to its wide tolerance and may indicate its invasive ability, respectively it may testify the different ecological demands of the species belong to the *T. rufum* species aggregatum.

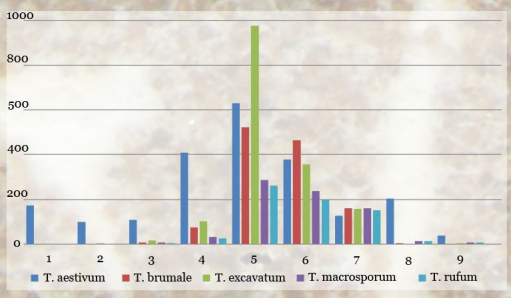

Figure 3.: The distribution of the relative groundwater or soil moisture values (WB) calculated from the frequences of the occurences of different herb species in the habitats of examined Tuber species.

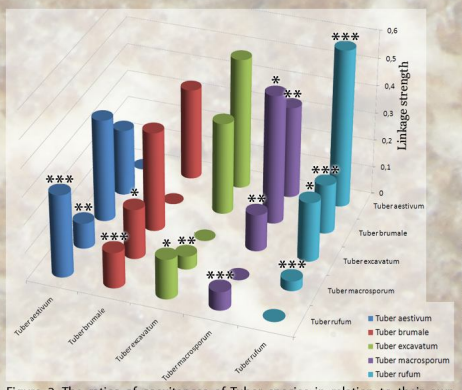

Figure 2. The ratios of coexitences of Tuber species in relation to their own connections. The stars show the significant differences of the soils SPA values (<0,05=*) (<0,01=**)(<0,001=***) .

2 Matherial and methods

The data of 1380 herbarial materials of 5 Tuber species from database of First Hungarian Trüffling Society were used (Merényi et al., 2008), including:
- 585 coenological descriptions (10 x 10 m)
- 590 soil analysis (pH/KCl/, SPA, humus and certain micro-, macro elements)

Statistical analysis were made by Kruskal-Wallis test, Dunnett's post test of the GraphPad InStat programm.

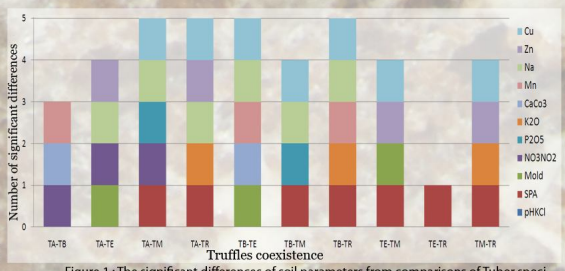

Figure 1.: The significant differences of soil parameters from comparisons of Tuber species in couples.

6 Discussion

Based on the mycothecae of the surrounding countries and some papers (Urban, 2007; Marjanovic, 2007; mycothecae: Misky Mihály, Pap Géza and Mader) *T. brumale* was probably spreading in Central-Europe just during the second part of the previous century. Hence it can be concluded that this species is an adventive fungus for the region. Its fast spreading was due to favourable environmental conditions, but this environment was colonized previously by other closely related species. Our results reveal, that majority of the environmental, ecological demands of *T. aestivum* and *T. brumale* are the same. Significant difference can be found just in higher productivity of *T. aestivum* in far drier habitats, on the contrary *T. brumale* mainly found adequate habitats for its life in more wet (colder) hilly habitats, where it can be occasionally living together with *T. aestivum*. *T. rufum* was being considered as a common fungus already from the early 1900's. There are no data at all of its fast spreading in the nature, but its wide tolerance to soils and plant habitats may indicate its good competitive abilities. *T. excavatum* is the most common partner of *T. aestivum* and it has the most similar ecological demands to *T. aestivum*, but it can be found just very rarely together with *T. aestivum* in young truffle orchards. *T. macrosporum* mainly found together with *T. brumale* has special soil and plant society preference which relevantly differs from *T. aestivum's*. *T. brumale* and *T. rufum* have a strong ability for mycorrhiza-substitution in truffle plantations, but it has not yet been justified in natural truffle sites. A truffle orchard is significantly different from natural truffle habitat, so it is hard to predict in which extent they have competitive habit in natural truffieres. It is likely that the intensive harvesting of *T. aestivum* for commercial aims and the caused strong disturbance of natural habitats favours to the actually less demanding species which have similar environmental demands, but have better stress tolerant and competitive abilities.

7 Conclusion

The results above accord with the observations in trufle orchards of often substitution of *T. aestivum* mycorrhizae by mycorrhizae of *T. brumale* and of *T. rufum*. Our results verify the strong superimposition of *T. aestivum* and its more common coexistant Tuber species in their microclimatic, soil demands and in their habitat preferences. These results may partly explain their invasive abilities experienced in truffle orchards and may pay for attention of their competitive role in natural *T. aestivum* habitats.

4 Coenology

All the 5 species occure mostly in the forests belonging to the Fagetalia sylvaticae order. The Carici-pilosae carpinetum is the plant association where the examinated species can be found most frequently, regarding *T. macrosporum* 46 % of its habitats can be found in a closely related plant society, which is Melampyro bihariensi-Carpinetum (Figure 6.). The society of Circeo-Carpinetum, which is rich in humus and has good water supply and has 80 to 100% canopy coverage, plays an important role in the case of *T. brumale* (19%), while the occurance of *T. aestivum* is very rare (1%). *T. aestivum* prefers two societies as well, which ones belong to the Quercetea pubescentis class. T. macrosporum can be never found, furthermore *T. brumale* and *T. rufum* can be gathered just from time to time in these more dry societies. 40.3% of coenological descriptions of *T. rufum* can be categorized to the societies below 5 % frequency, which can refer to its wide habitat preference. On the other hand only 6% of the coenological descriptions of *T. brumale* belong to the societies below 5 % frequency.

5 Botany

Carpinus betulus is the more frequent ectomycorrhiza forming tree in the habitats of all 5 species (constancy values of 3 to 5) (Figure 5). Futher common ECM-forming tree species are Quercus robur (constancy values of 2 to 3) and Q. cerris (constancy values of 2 to 3). Q. robur preferring wet habitats can be found more frequently (42.3 %) in habitats of T. macrosporum, but where the xerotherm Q. cerris is more rare (15.4%). The wide ecological tolerence of Tuber rufum can be pointed out regarding host plants as well, because the coenological tables are reporting more potential host plants with lower constancy values. It can be stated that the spectra of potential host plants in the habitats of the examined Tuber species, except T. macrosporum, are very similar, futhermore the three most common host plants are the same (Carpinus betulus, Quercus cerris, Q. robur). The distribution curves of the phytoindication parameters of the examined species show generally the same maximum places, TB-scale (index of relative heat demand): montane mesophilous broad-leaved forest belt, WB-scale (Figure 3.) (index of relative groundwater or soil moisture): plants of semihumid habitats, under intermediate conditions, RB-scale (index of soil reaction of the habitats): plants on neutral or weakly basic soils, NB-scale (index in relation to the ammonia and nitrate supply of the habitats): distribution with 2 peaks (mesotrophic soils and soils rich in mineral nitrogen). The plants indicating the habitats poor in nutrients are more typical in the habitats of T. aestivum, while the plants indicating the habitats rich in nutrients are more frequent in the habitats of the other 4 species. The maximum places of the soil reaction values of T. aestivum and T. brumale are quite similar (6-7), but T. aestivum is more frequent on basic soils (8) and T. excavatum prefers neutral soils. Based on the indication of herbs T. aestivum habitats show the highest variencies, which can be resulted from its general occurances in hornbean-beech (hilly-mountainous) habitats, futhermore it is extraordinary productive in plain, dryer (from WB 1 = extreemly dry), warm (TB 8 = submediterraneous) societies. The distributions of TWR values also reflect the higher affinity of the winter truffle (WB up to 6, 7) of T. macrosporum and of T. rufum to the habitats which are wetter, more shaded and richer in nutrients.

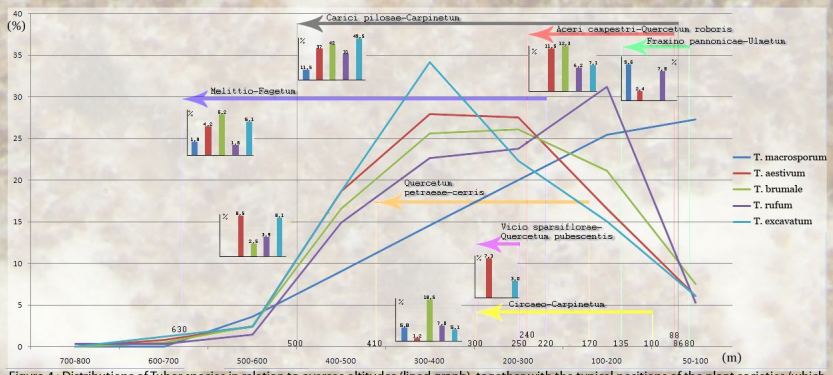

Figure 4.: Distributions of Tuber species in relation to oversee altitudes (lined graph), together with the typical positions of the plant societies (which have more than 5% constancy at least at one species) occur in Hungary in relation to oversee altitudes (arrows) and the species occurances in these societies expressed as distributions in percentages (column graphs).

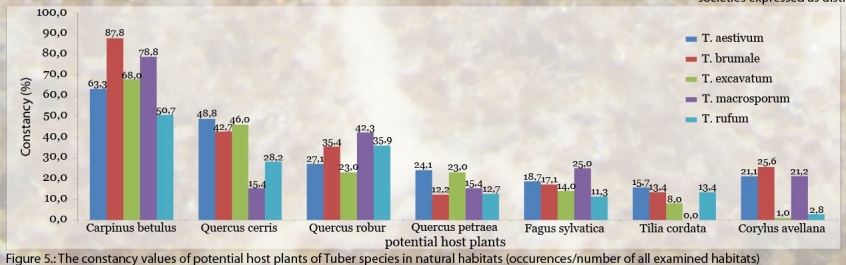

Figure 5.: The constancy values of potential host plants of Tuber species in natural habitats (occurences/number of all examined habitats)

68% of the territory of Hungary is plain, 31% of its territory is hilly (200-500m) and only 1% is higher than 500 m (Bozó, 1999). The figure of 4. shows the distribution of Hungarian habitats of the examined species in relation to the oversee altitudes (grouped by 50 meters). The occurance of species can be divided into three main altitude intervals, which are the following: (1) *T. excavatum*; (2) *T. aestivum T. brumale T. rufum*; (3) *T. rufum T. macrosporum*. Indeed their occurance are defined first of all by the presence of certain plant societies. *T. brumale, T. aestivum* and *T. excavatum* are somewhat more common in the beech forests dominant at the higher altitudes, which is also correlated with the distributions of the oversee altitudes. The summer truffle is more frequent in the warmer plain forests, while the winter truffle is more common in montainous areas.

Acknowledgements

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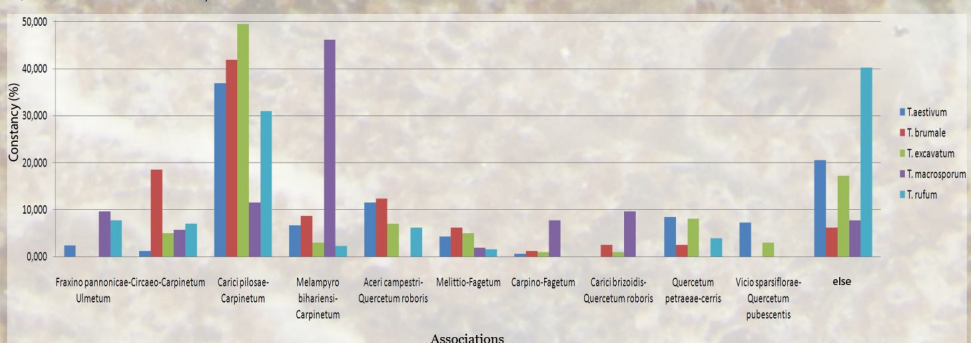

Figure 6.: The plant societies mostly prefered by 5 Tuber species in Carpatho-Pannon Region, in which at least one of the species has more than 5% constancy (in taxonomic order).