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Full Length Research Paper

Ecological features of *Tricholoma anatolicum* in Turkey

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***Tricholoma anatolicum* H.H. Doğan & Intini was first published as a new species in 2003, and it is known as "Katran Mantarı" in Turkey. It has great importance in trading and is also exported to Japan. However, there is no extensive information on its ecological status. To reveal its features of ecological status, we studied eight different places in Turkey in the years of 2005 and 2009. According to our results, this species makes an ectomycorrhizal association with *Cedrus libani* trees. The distribution area of the species is Taurus Mountain between 1,400 and 1,700 m elevations from the Mediterranean region. The morphological features of the species are closer to *Tricholoma magnivelare* (Peck) Redhead than the other members of Matsutake group. Its characteristic features are white to cream-coloured fruiting body, a special odour like tar, different aroma and cyanophilic spores. In general, it grows on well-drained and infertile sandy soil in *C. libani* forests, which are more than 25 years old. The fruiting period is from October to November and also grows in Mediterranean climate type.**

Key words: Ectomycorrhizal fungi, Matsutake group, Mediterranean region, *Tricholoma anatolicum*, Turkey.

INTRODUCTION

Some ectomycorrhizal fungi have edible fruiting bodies, which are harvested and sold on a considerably large market in the world. This trading is especially important in the northern hemisphere countries in Asia, the USA, Canada and Japan. The volume of this trade in these countries is higher than 3 billion US$ per year (Yun et al., 1997).

Tricholoma genus is an important ectomycorrhizal edible fungal genera of large economic value, and some important taxa in that respect are as follows: *T. matsutake* (S. Ito et Imai) Sing. (hong or true matsutake) from Japan, China and Korea; *T. magnivelare* (Peck) Redhead (white matsutake) in Canada, Mexico and the USA; *T. caligatum* (Viv.) Ricken, which mainly occurs in Europe and North Africa, particularly in Algeria, Morocco and the USA; *T. bakamatsutake* Hongo (false matsutake); *T. quercicola* M. Zang; *T. dulciolens* Kytöv.; *T. fulvocastaneum* Hongo, *T. robustum* (Alb. & Schwein.) Ricken, *T. focale* (Fr.) Ricken and *T. zelleri* (D.; *T. robustum* (Alb. & Schwein E. Stuntz & A. H. Sm.) Ovrebo & Tylutki in all northern hemisphere countries (Zeller and Togashi, 1934; Redhead, 1984; Arora, 1986; Kytövuori, 1988; Bon, 1991; Hosford et al., 1997; Wang et al., 1997; Intini, 1999; Intini et al., 2003; Kranabetter et al., 2002; Bidartondo & Bruns, 2002 Galli, 2003).

T. *matsutake* produces the most valued mushroom (matsutake) in association with pines, including *Pinus densiflora* Sieb. et Zucc. in the Far East and *Pinus sylvestris* L. in Scandinavia, and with both pines and oaks in the foothills of Tibet. Other matsutake mushrooms, such as *T. anatolicum* in Turkey and *T*. *magnivelare* from the North Pacific Coast area of Canada and North America as well as Mexico, respectively produce fruit bodies morphologically similar to matsutake in association with other *Pinaceae* plants in their natural habitats. *T. bakamatsutake* and *T*. *fulvocastaneum* from Asia are solely associated with *Fagaceae*. None of these matsutake mushrooms has been cultivated yet, and the mechanisms involved in their symbioses remain inadequately studied; neither has the systematics of these apparently related mushroom species been definitively established (Yamada et al., 2010). The best-known species between them are *T. matsutake* and *T.*

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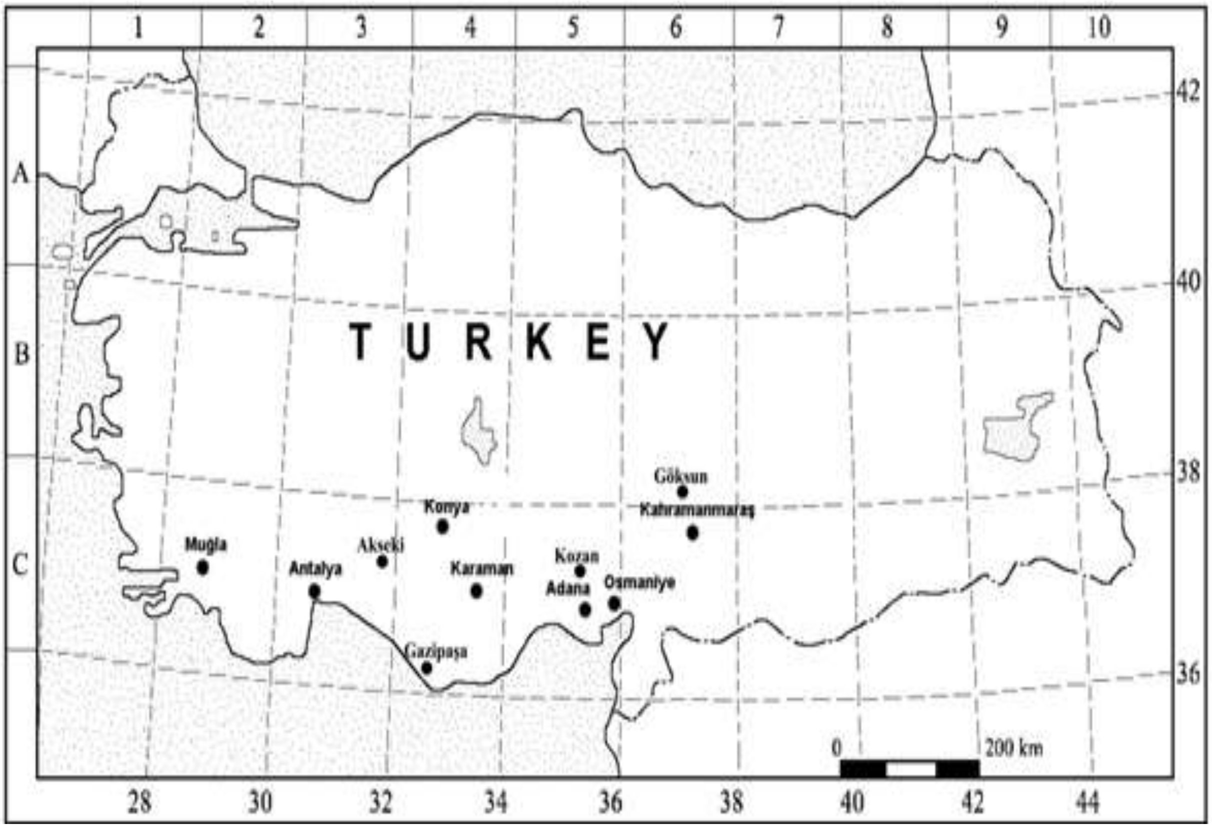

Figure 1. Distribution map of *Tricholoma anatolicum* in Turkey.

magnivelare, which are known as matsutake. The popularity and high economic value of these two species are due to their special aroma and taste (Intini, 1999; Intini et al., 2003). Harvesting and sales (domestic and/or international) of *T. anatolicum* is a major trade in Turkey. Its habitat, morphological characteristics, odour and flavour are different from *T. matsutake* and *T. magnivelare* (Viviani, 1834; Ito and Imai, 1925; Zeller and Togashi, 1934; Bon, 1984; Riva, 1988a, b, 1998; Kytövuori, 1988; Hosford et al., 1997; Yun et al., 1997; Mankel et al., 1998; Berguis and Danell, 2000; Kranabetter et al., 2002).

MATERIALS AND METHODS

The material of the present study was collected in eight different localities from Karaman-Başyayla; Adana-Kozan, Göller; Adana-Kozan, Görbiyes; Adana-Feke; Adana-Aladağ; Antalya-Gazipaşa, Karatepe; Antalya-Gazipaşa, Asarbaşı; Kahramanmaraş-Andırın, Elmadağ (Figure 1). Ecological observations of the studied localities were performed in 2005 and 2009. The last decade climatic features were obtained from the Meteorology Station, and the climatic features of the studied areas were determined according to Emberger (Akman, 1999). The tree age, height, site and stand characteristics in the forest were observed according to Oner et al. (2009). The soil temperatures were measured by a digital thermometer. The pH of the soil was also measured by a digital pH meter. The chemical features of the soil were determined according to Doğan et al. (2006). The soils were measured by a ruler at the different depth to find the mycelial growth and mycorrhizal roots. Thin layer sections of the roots were prepared to reveal the mycorrhizal position of the species and their pictures were taken. Microscopical features were examined with an optical microscope at different magnifications. Spores, basidia and hyphae were examined and measured with an ocular micrometer. Plant species were identified by Muhittin Dinç (Biology Department, Selçuk University, Literature Faculty, Konya).

Collected specimens are kept at Mushroom Application and Research Centre, Selcuk University, Konya/Turkey.

RESULTS

Morphological description

Tricholoma anatolicum H.H. Doğan & Intini

Pileus: 4 to 20 cm in diameter at first hemispherical, then convex to plane (Figure 2); surface: weakly viscid when moist, shining and silky when dry, smooth and whitish to pale cream in the centre, white to pale cream when

Figure 2. A mature fruit body with completely opened pileus.

young, light brownish to brown-ochreous with age by the soil remnants, radial fibrillose, often adpressed scales; margin: rolled in and with whitish fibrils, attached to the stipe by a cortinate like veil when young; cortinate like veil: persistent and very variable, but it exists all the time; lamellae: white to whitish when young, light yellowish with age, narrow, slightly notched-adnexed, edges smooth; stipe: 4 to 10 (15) cm long, 1 to 3 (5) cm diameter, cylindric to conic, tapered to the base, stiff and very hard; annulus: superior, patent or slightly hanging, persistent annulus white, fibrillose-membranous; flesh: 2 to 5 cm thick, white, very solid; odour: fragrant, very distinct and similar to the cedar of Lebanon (known as Katran = Tar); taste: very mild and pleasant; spores: broadly elliptic, smooth, hyaline with oil drops, cyanophilic, 6 to 7.5 (8.5) × 4 to 5 (5.5) µm (Figure 3a). Basidia: 35 to 42 (48) × 7.5 to 8.5 (9) µm, clavate, 4-spored, cystidia sparse (Figure 3b); pileal surface: formed by more or less flat hyphae 7 to 28 µm wide, hyaline to light brownish-brown in Melzer's reagent (Figure 4).

Species examined

Turkey; Karaman-Başyayla, Katranlı plateau, elevation 1,400 to 1,700m in *A. cilicica* subsp.*cilicica-C. libani* forest, where the type species was collected. This species was also identified in the following localities: Adana-Kozan, Göller, Çamboğazı, in *A. cilicica* subsp. *cilicica-C. libani* forest, under *C. libani*, 1,515 m, 26.10.2008, HD3929; Adana-Kozan, Görbiyes, Ahır kuyusu, in *A. cilicica* subsp. *cilicica-C. libani* forest, under *C. libani*, 1,500 m, 27.10.2008, HD4054; Adana-Feke, Aytepesi, in *C. libani* forest, 1,600 m, 28.10.2008, HD4147; Adana-Aladağ, Katran çukuru, in *C. libani* forest, 1,400 m, 24.11.2007, HD3043; Antalya-Gazipaşa, Karatepe, in *C. libani-A. cilicica* subsp. *isaurica* forest, under *C. libani*, 1,450 m, 09.10.2006, HD2533; Antalya-Gazipaşa, Asarbaşı, in *A. cilicica* subsp. *isaurica-C. libani* and *J. excelsa*, under *C. libani*, 1,520 m, 18.10.2009, HD3709; Kahramanmaraş-Andırın, Elmadağ, in *A. cilicica* subsp.*cilicica-C. libani* forest, under *C. libani*, 07.11.2008, HD4257 (Figure 1). It was also found from Kahramanmaraş-Göksun, Soğukpınar (Kaya et al., 2009), Adana-Feke, Hıdıruşağı village; Muğla-Fethiye, Arpacık village, Yaylakoru and Gedre; Muğla-Fethiye, Babadağ, Antalya-Kaş, Sütleğen village, Osmaniye-Kaypak, Yarpuz and Çulhalı villages (Solak, 2009).

Habitat and fruiting body formation

T. anatolicum primarily grows under *C. libani* in the Mediterranean region, particularly in Taurus Mountain.

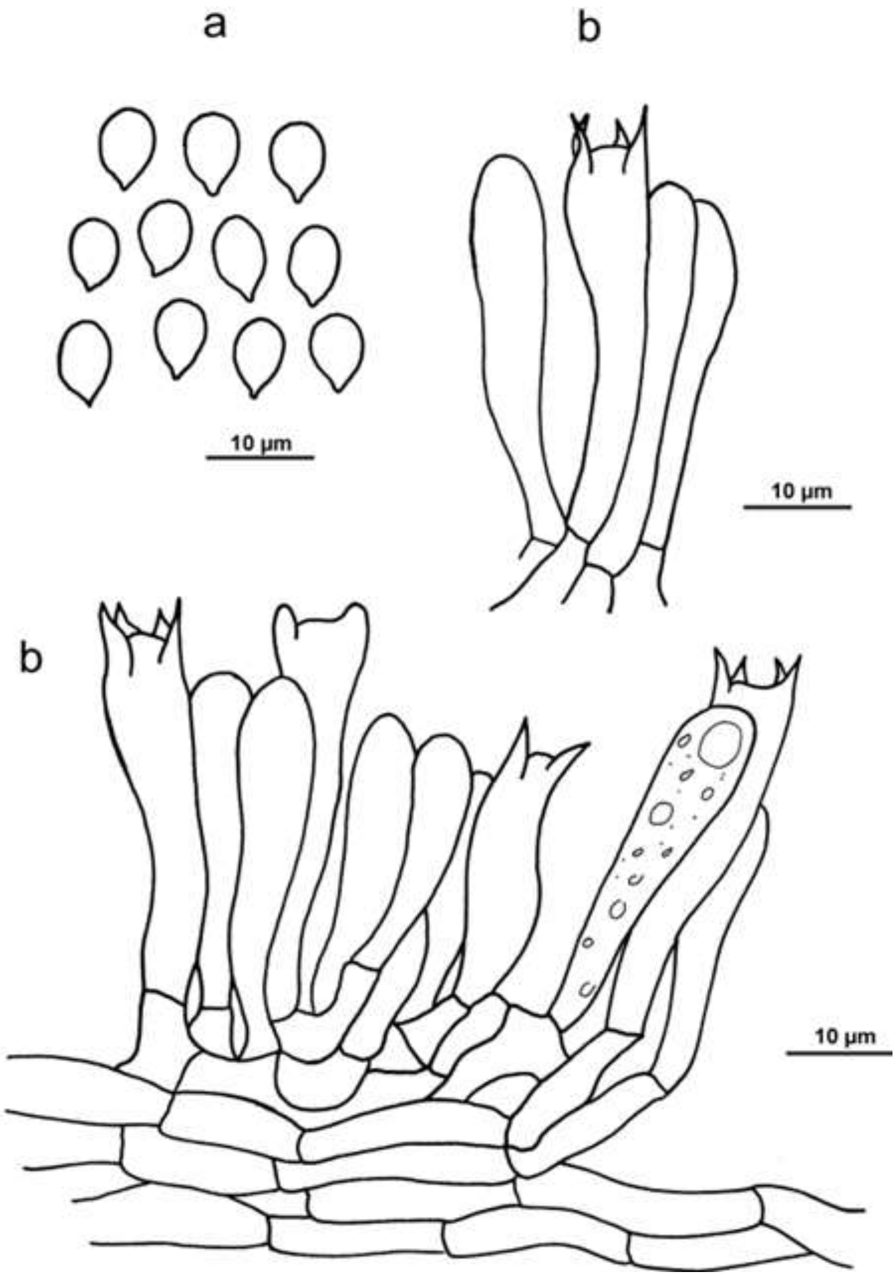

Figure 3. (a) Spores; (b) basidia and cystidia (scale bar = 10 µm).

The elevation of the forest is between 1,400 to 1,700 m. The soil features are sandy and well-drained. It can also overgrow with bushes of *Astragalus microcephalus* Willd. in *C. libani* fores t in October to November. *C. libani* forest can con-stitute pure stands to mixed with *Abies cilicica* (Ant. & Kotschy) Carr. subsp. *isaurica* Coode & Cullen., *A. cilicica* (Ant. & Kotschy) Carr. subsp. *cilicica* and rarely *Juniperus excels* M. Bieb. Nevertheless, *T. anatolicum* always occurs in pure stands of *C. libani* or mixed with herb layers of *A. microcephalus*, which is considered an indicator plant for the growth areas of *T. anatolicum*. *C. libani* and *A. microcephalus* may also grow in stony places, but it is impossible to find *T. anatolicum* in such areas.

T. anatolicum has distinctive fungal colonies in the soil and produces a dense mycelial mass; the Japanese have termed such compact mass of mycelia as ‘shiro’, which are formed between host trees or occasionally around them (Yun et al., 1997). It is white to pale and consists of a compact mycelial mass that colonises everything in the

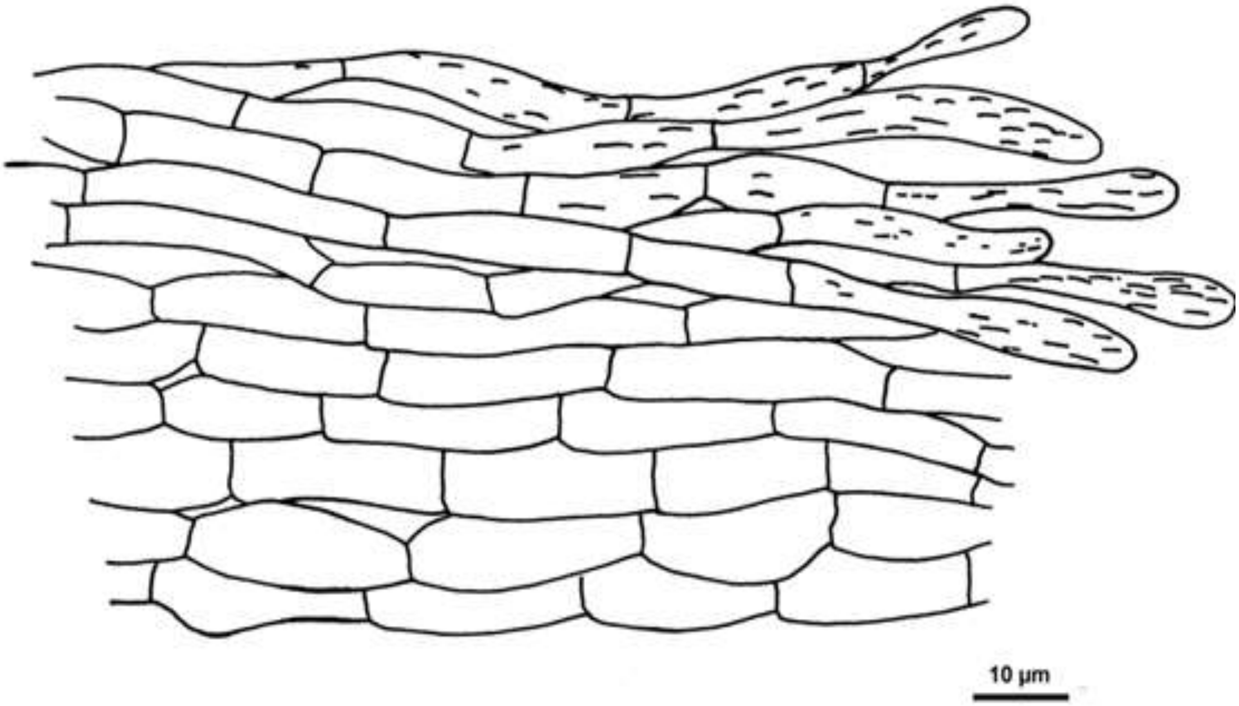

Figure 4. Hyphae of the pileus (scale bar = 10 µm)

soil including plant roots, soil granules and rocks, and gaps between soil granules. The surface of the mycelial mass is just below the litter layer, and in deep soils it can be 10 to 15 cm from top to bottom. Typically, the mycelial mass of *T. anatolicum* develops mainly in soils under *C. libani* and *A. microcephalus*. Mycelial mass usually develops when forest trees are about 20 to 30 years old. However, the best-developed phase can be found with trees more than 30 years old. The mycelial mass and fruiting body of *T. anatolicum* is smaller with young trees (under 20 years) because these forests are not well-developed and it is not a pure stand; therefore the soil is not of good quality for *T. anatolicum* in such places.

The fungus normally begins to grow when trees are about 30 years old and more than 10 m in height. Ectomycorrhizal fungi are abundant, and, generally, the shrub and herb layers are poorly developed. Production reaches the maximum in a 50 to 100-year-old forests. *T. anatolicum* production is the greatest when the forest is pure and old, with its habitat sandy soil. *C. libani* can also grow on stony and calcareous spots in the same localities but it is impossible to find *T. anatolicum* on such spots. Some fungi and plant species accompany to *T. anatolicum* in the same area. More than 50 species of higher fungi were determined in *C. libani* and other stands on soil, some of them being the following: *Agaricus langei* (F. H. Møller & Jul. Schäff.) Maire, *Boletopsis leucomelaena* (Pers.) Fayod, *Cortinarius bulliardii* (Pers.) Fr., *C. elegantissimus* Rob. Henry, *C. europaeus* (M. M. Moser) Bidaud, Moënne-Locc. & Reumaux, *C. latus* (Pers.) Fr., *C. odorifer* Britzelm., *C. splendens* Rob. Henry ssp. *meinhardii* (Bon) Brandrud & Melot, *C. venetus* (Fr.) Fr. var. *montanus*, *Geastrum fimbriatum* Fr., *G. rufescens* Pers., *G. triplex* Jungh., *Geopora arenicola* (Lèv.) Kers, *Gomphus clavatus* (Pers.) Gray, *Hebeloma mesophaeum* (Pers.) Fr., *Hygrophorus marzuolus* (Fr.) Bres., *Lepista nuda* (Bull.) Cooke, *Lycoperdon perlatum* Pers., *Lyophyllum infumatum* (Bres.) Kühn., *L. semitale* (Fr.) Kühn., *Macrolepiota excoriata* (Schaeff.) M. M. Moser, *Melanoleuca cognata* (Fr.) Konrad & Maubl. var. *cognata* Kühner, *M. exscissa* (Fr.) Singer, *M. humilis* (Pers.) Pat., *M. paedida* (Fr.) Kühner & Maire, *M. polioleuca* (Fr.) G.Moreno, *M. stridula* (Fr.) Singer, *M. substrictipes* Kühner, *Ramaria flava* (Schaeff.) Quél., *Russula ochroleuca* (Pers.) Fr., *R. pallidospora* J.Blum ex Romagn., *Sarcodon glaucopus* Maas Geest. & Nannf., *S. imbricatus* (L.) P. Karst., *Tricholoma album* (Schaeff.) P.Kumm., *T. apium* J. Schff., *T. equestre* (L.) P. Kumm., *T. orirubens* Quél., *T. pardalotum* Herink & Kotl., *T. portentosum* (Fr.) Quél., *T. cedretorum* (Bon) A.Riva var. *cedretorum*, *T. scalpturatum* (Fr.) Quél., *T. stans* (Fr.) Sacc., *T. virgatum* (Fr.) P. Kumm. and *Tulostoma fimbriatum* (Fr).

Distinct plants growing in *C. libani* forest are as follows: *Achillae spp., Alyssum spp., Ballota spp., Barbarea spp., Carthamus spp., Cotoneaster nummularia* Fisch. & Mey., *Craetagus spp., Crocus spp., Dianthus zonatus* Fenzl., *Euphorbia spp., Marrubium spp., Phlomis spp., Pilosella hoppeana* (Schultes) C.H. & F.W.Schultz*, Poa bulbosa* L.*, Polygonum spp.* and *Silene italica* (L.) Pers.

Soil features

The soil is generally sandy and moist but not very wet, and the litter layer is about 3 cm in depth. *T. anatolicum* is most likely to be found in stands that appear to be in rich condition for needle litter of *C. libani* and *A. microcephalus* stands. *T. anatolicum* was found in well-drained, sandy loams with rich soils for organic substance including litter layers situated in the northwest part and with 20 to 45% slope. The litter layer varies in thickness from 0.5 to 3 cm. Generally, the most productive soils are acidic to neutral, well-drained, and infertile. The soil features are as follows: pH 5 to 7, 0.03% salt, 1.5 to 3% $CaCO_3$ and organic matter is about 3%.

Climatic features

The climate types of the areas were determined according to Emberger (Akman, 1999). Climatic data from the studied areas were used for climatic analysis (Figure 5).

The climatic results are as follows: Adana is under the influence of rather rainy-mild Mediterranean climate and the ombrothermic diagram shows that the arid period starts from May until September; Akseki is under the influence of rainy-cold Mediterranean climate and the ombrothermic diagram shows that the arid period starts from June until September; Gazipaşa is under the influence of rainy Mediterranean climate and the ombrothermic diagram shows that the arid period starts from April until September; Göksun is under the influence of semi arid-upper glacial Mediterranean climate and the ombrothermic diagram shows that the arid period starts from May until September; Kahramanmaraş is under the influence of semi arid and upper cool Mediterranean climate and the ombrothermic diagram shows that the arid period starts from May until September; Karaman is under the influence of arid upper and very cold Mediterranean climate and the ombrothermic diagram shows that the arid period starts from May until September; Kozan is under the influence of rather rainy Mediterranean climate and the ombrothermic diagram shows that the arid period starts from May until September.

T. anatolicum fruits between October and November (mainly during October), though yields are closely tied to the climate. Like many other macrofungi, primordia begin to form when temperatures drop after summer and soil moisture rises. The average temperatures and precipitations for the month of October are 21.9°C and 43.1 mm for Adana, 15.6°C and 17.9 mm for Akseki, 10.5°C and 40.1 mm for Göksun, 19.6°C and 32.6 mm for Kahramanmaraş, 13°C and 19.2 mm for Karaman and 22.3°C and 49 mm for Kozan. The average temperatures and precipitations for the month of November are 15.10°C and 59.5 mm for Adana, 9.6°C and 152.7 mm for Akseki, 3.9°C and 66.4 mm for Göksun, 11.9°C and 84.5 mm for Kahramanmaraş, 6.4°C and 35.1 mm for Karaman and 16.2°C and 66.2 mm for Kozan. The best month for the yield of *T. Anatolicum* is October. In this month, the temperature is neither very high nor low; it is usually between 10 to 20°C and days under 0°C are much rarer than in November. In November, the temperature is between 5 to 18°C, lower than that in October. There are also more days under 0°C in November than in October.

The optimum soil temperature for primordial formation is between 10 to 20°C. However, expansion of the primordia can occur at much lower soil temperatures. *T. anatolicum* can be picked until lower temperatures occur; it can be found when night air temperature is around 0 to 10°C, and soil temperatures decrease below 0°C. Fruiting bodies can be found in November when the soil temperature is close to 0°C. It was collected many times in frozen soil but if this situation persists for a long time, the yields will suddenly decrease and *T. anatolicum* season will finish. Overall, *T. anatolicum* yields are highest when there is plenty of rain in spring, a relatively mild summer, and a moist, warm autumn. Primordia usually begin to form in October when the soil temperature between 5 to 10 cm is approximately 15 to 20°C, and there has been about 30 to 40 mm of mild precipitation. From then on, 4 to 10 mm of rain every week is enough to ensure further growth of fruiting bodies. Nevertheless, there can be much fewer rainy days in some years or much more. If the rainy days are more and plentiful, the production will be greater. However, if the soil temperature climbs higher than 20 or drops below 15°C, primordia will abort. Good harvesting time is between 15 and 20°C and 50 to 100 mm of rainfall in 10 to 15 showers between November and until mid October.

Morphology and anatomy of *T. anatolicum* mycorrhizal colonisation

T. anatolicum makes an ectomycorrhizal colonisation with *C. libani* roots. There is an outer zone at the "mycorrhizal colonisation" where only mycelia are found which advances 5 to 10 cm per year. This is followed by a zone of maximum mycelial growth and mycorrhizal colonisations on the roots where the soil is extremely hydrophilic, a zone where fruiting bodies are produced

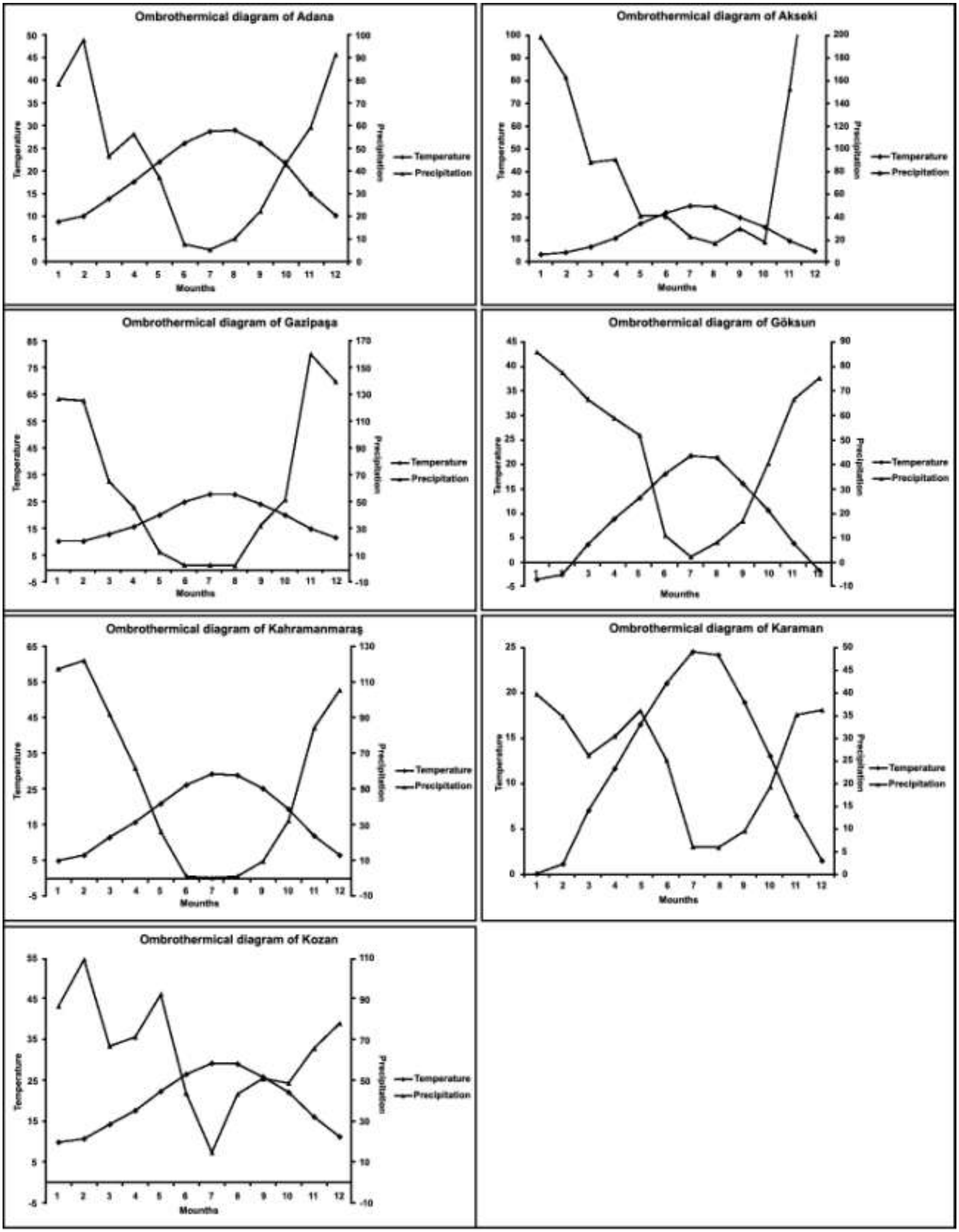

Figure 5. The Ombrothermic diagrams of the localities.

Figure 6. Hartig net covers on root. The arrow shows the mycelia.

about 5 cm under the topsoil, a powdery mycelial zone where the roots have begun to collapse, one where the soil is beginning to recover its normal state and structure, and the oldest zone (10 to 15 cm) from the mycorrhizal colonisation where the soil has returned to normal. There is also a mantle and well developed Hartig net. White thick layer of hyphae covers the lateral and main roots (Figure 6). Sometimes labyrinthine hyphal systems occur between cortical cells similar to those formed by typical ectomycorrhizal fungi. From this, hyphae penetrate between the outer layers of cells of rootlets and short and long lateral roots (Figure 7).

Harvesting and grading

T. anatolicum fruiting bodies begin to open when they break through the soil surface. Before this period, it is impossible or very difficult to see them outside due to the fact that the litter layer completely covers them. Therefore, considerable expertise is required to recognize the cracks and bulges of the soil, which indicates that a fruiting body is just below the soil surface. To find these highly-valued fruiting bodies, collectors often use rakes, sticks, or small adzes to remove the litter layer, dig through the topsoil, and expose the immature fruiting bodies. This process causes considerable damage not only to the mycelial mass but also to other young primordia and to the soil structure. There is no advice available to collectors on the best ways of collection with minimal disturbance to the ecosystem or any penalty to prevent this collection method. The collectors pick the mushrooms without following any rules and by applying very ordinary methods. It must be prevented as soon as possible to stop the ecological damage. Thereafter, individual collectors, who are villagers from the mountain places, sell to wholesalers who set up purchase points in the villages. *T. anatolicum* are then taken overnight to the special collection centre. After enough quantity is taken, they are cleaned from the soil remnants and put into plastic bags without use of any process and are then exported to Japan by airplane. Prices are largely determined by supply and demand. Shape and colour are important attributes as well as its smell, taste, and flavour for the value of *T. anatolicum* for collectors.

One specimen of *T. anatolicum* can grow up to 20 cm in diameter, but they do not reach as high a price, apparently due to an unsatisfactory texture. Once the mushroom begins to open, it is downgraded to second quality. The lowest grading is being awarded to fully-opened mushrooms, badly affected by insect larvae and worms. Lower prices are paid for the lower grades despite first quality *T. anatolicum* having the best taste. Normally, *T. anatolicum* is white with light cream to dirty cream or light brown patches but both handling and storage cause discoloration, turn it to brown, and reduces its value. Its surface can also be dirty and turn to light brown by the soil texture if the soil is wet or damp. The grading system for *T. anatolicum* is not exactly clear and it is very ordinary in Turkey. Nevertheless, there are

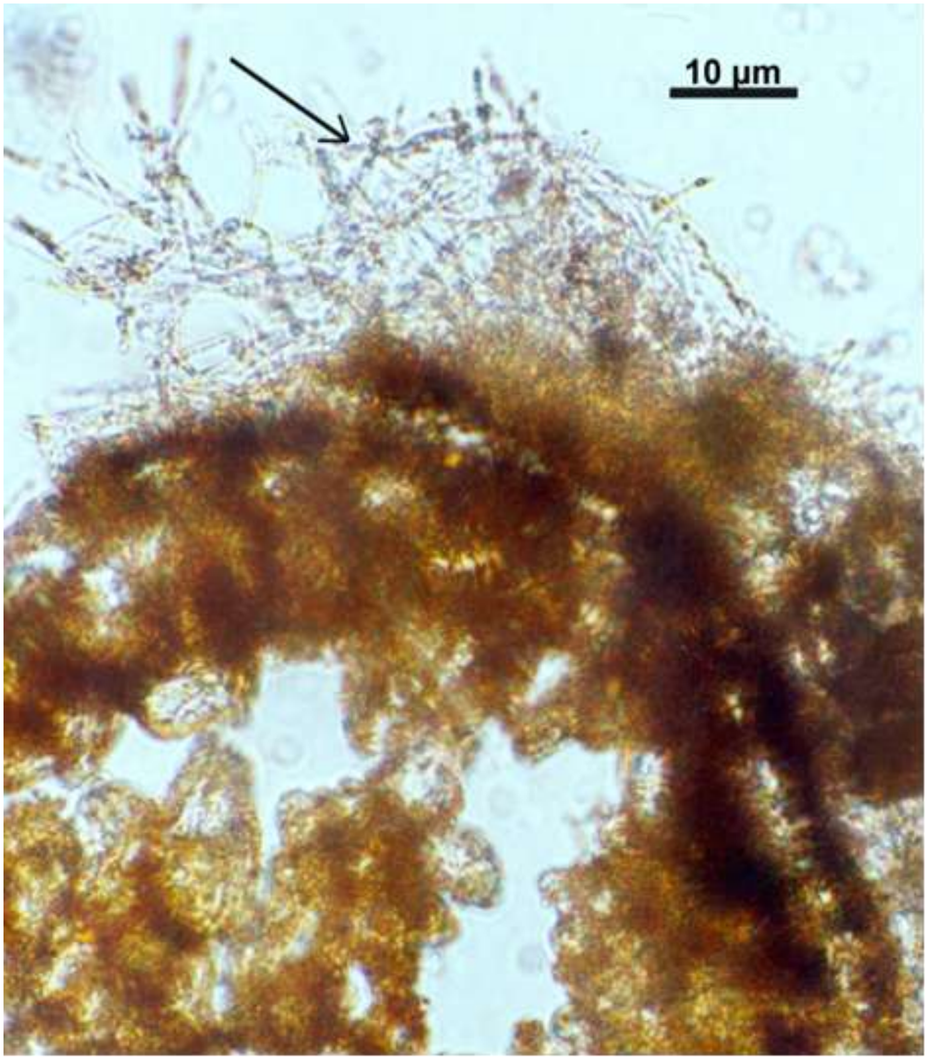

Figure 7. The lateral section of root. The arrow shows the mycelia.

mainly 4 grades for first quality (Figure 8); it is very important to have unopened caps for the grading system. Grade 1 is unopened caps about 8 to10 cm diameter, grade 2 is 6 to 8 cm, grade 3 is 4 to 6 cm and grade 4 is about 4 cm or just started to open (Figure 9). The second quality is out of grade, which are half partly or fully opened, broken, attacked by insects or very small-unopened caps or opened and more than 10 cm diameter. Out of grade is not bought by the wholesalers; they primarily prefer grades 1 and 2 categories.

Prices and production of *T. anatolicum*

Exportation of *T. anatolicum* to Japan commenced in late 1990. The current production and exportation values are scarcely known because there is not any official control system for their export. Certain special collectors manage the collection and exportation and they do not want to explain how many kilos of *T. anatolicum* are collected and exported per year. Nevertheless, approximately more than 50 tonnes are exported to Japan per year. There is no orderly production, but amount depends on the climatic conditions in the collection season. Some years the climatic conditions can be rainless and dry, while other years can be very wet and rainy. During the rainless season, *T. anatolicum* can grow without any rain by using the root system of the host plant but the yield decreases and the mushroom quality is very low, while when the rainy season is good enough, mushroom quality will be exceptional and yield increases steadily.

More also, collectors often receive a relatively low price than mushroom wholesalers since the entire mushroom must be sold as fresh and exported as soon as possible.

Figure 8. The first quality grading.

While the average wholesale price is 100 $ per one kilo, which is the price for exportation from Turkey to Japan, local collectors can gain about 10 $ for one kilos of *T. anatolicum*. These prices however vary during the season or depend on its abundance or scarcity.

DISCUSSION

T. anatolicum grows in *C. libani* forest and makes an ectomycorrhizal association with this tree's roots. This fungus prefers sandy and rich soil for organic matter in the forest. The fruiting time is from October until late November. There are some mycorrhizal species growing in the same habitat and they play an indicator role to find *T. anatolicum* in the Cedrus forest. These species are as follows: *Boletopsis leucomelaena, Cortinarius* spp*., Russula* spp*.* and *T. cedretorum* var. *cedretorum.* It is sometimes possible to confuse *T. anatolicum* with *T. cedretorum* var. *cedretorum*, but there are some differences between them. First, *T. cedretorum* has a white colour when young, which changes white to pink when old, and secondly, it has no cortinate-like velar remnant.

Kytövuori (1989), Wang et al. (1997), Kranabetter et al. (2002) and Hosford et al. (1997) provided the habitat and the morphological features of *T. caligatum, T. nauseosum, T. matsutake* and *T. magnivelare*. Features of *T. anatolicum* and similar species are given in (Table 1). Bergius and Danell (2000) reported that *T. matsutake* and *T. nauseosum* should be treated as the same species. The oldest is *T. nauseosum*, but they suggested that the name of *T. matsutake* should be retained. For this reason, *T. nauseosum* and *T. matsutake* are given in the same column. *T. anatolicum* has been known erroneously as *T. caligatum* somewhere in Turkey. The taste of *T. caligatum* is bitter, strong, and repellent. Additionally, the brown scales and fibres on *T. caligatum* tend to be darker, which is more similar to chestnut brown and more prominent. *T. caligatum* is mycorrhizal with hardwoods or pine trees as opposed to the conifer-loving matsutake group. In contrast, *T. anatolicum* has a mild and pleasant taste and special smell that comes from *Cedrus libani's* extract (Katran = Tar). Therefore, its

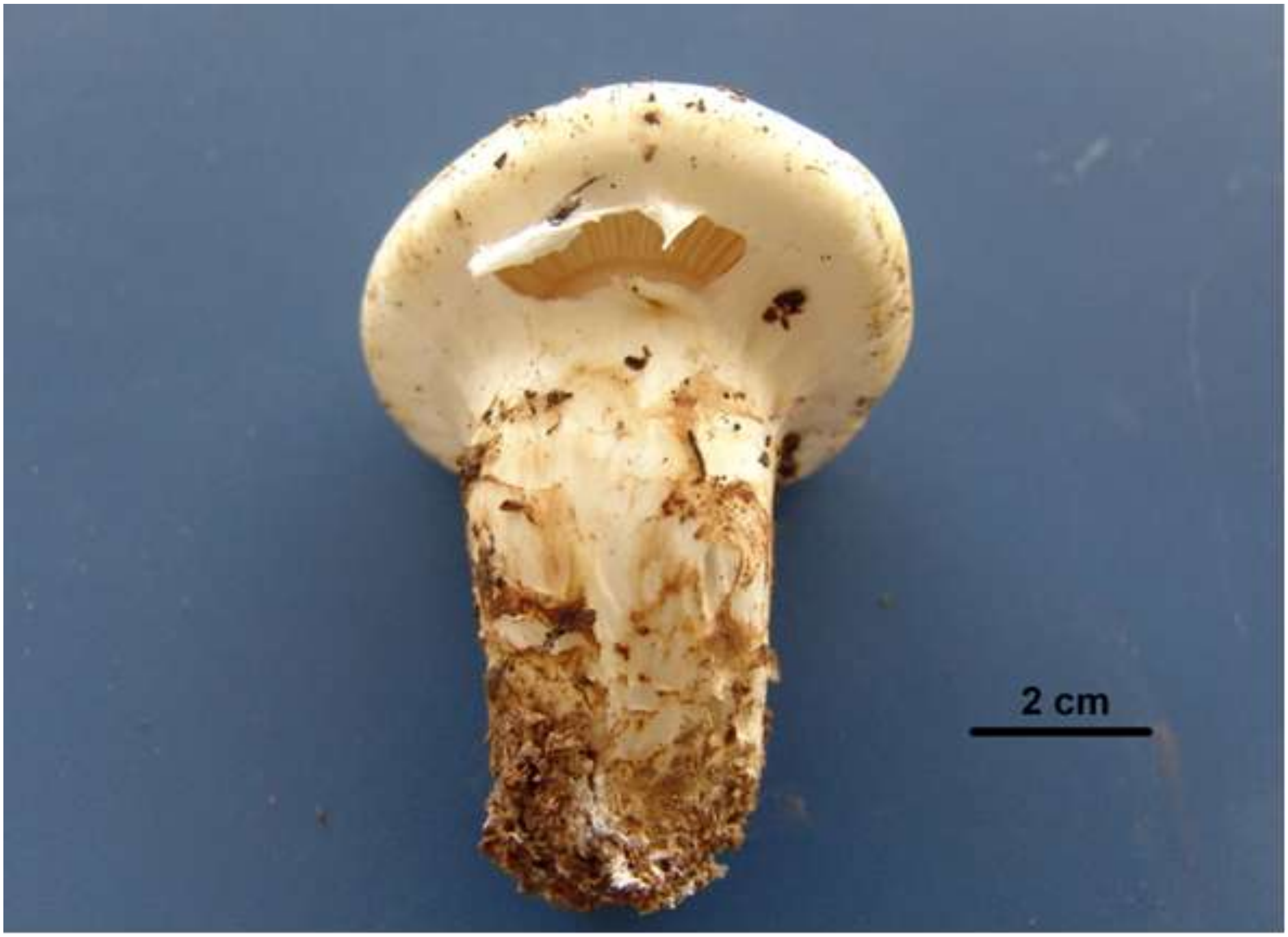

Figure 9. A fruit body that just started opening.

local name is “Katran-Sedir Mantarı”. The meaning of ‘Katran’ is a special extract taken from *C. libani* (Tar), and the meaning of ‘Mantarı’ is Mushroom. *T. anatolicum* is also different from *T. caligatum* by its special habitat, which is *C. libani* and *A. microcephalus*. It is very difficult to find *T. caligatum* in *C. libani* forest. *T. anatolicum* can also be easily recognised from *T. caligatum* by its bigger and whiter pileus, thick and white stipe, bigger and cyanophilic spores, long hyphae and special habitat.

T. anatolicum is also different from *T. matsutake* according to DNA analysis (Intini et al., 2003) and it has some morphological and ecological difference such as: pileus colour of *T. matsutake* is more brown than *T. anatolicum,* smell and taste is different, stipe has brown scales, basidia are bigger and last and the habitat is quite different. The habitat of *T. anatolicum* is restricted to *C. libani*, while *T. matsutake* can grow in very large habitats such as deciduous and conifer forest. According to DNA analysis, the closest species to *T. anatolicum* is *T. magnivelare* (Intini et al., 2003). Nevertheless, there are important differences between them. First, pileus colour is darker than *T. anatolicum,* secondly, *T. anatolicum* has fragrant odour like Cedar tree, while *T. magnivelare* has spicy odour and taste, thirdly, the lamellae are white and no trace of spotted brown on it in age while *T. magnivelare* has spotted brown on lamellae in age, also the spores of *T. anatolicum* are cyanophilic and longer than *T. magnivelare*, and lastly their habitats are different; *T. anatolicum* grows only in *C. libani* forest and it is restricted to the Mediterranean region, while *T. magnivelare* grows in deciduous and conifer forests and its distribution area is very large in northern America. In addition, the fruiting period for *T. anatolicum* is also later than the other relative species.

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Table 1. Comparison of *T. anatolicum, T. caligatum, T. nauseosum-matsutake* and *T. magnivelare.*

Character	*T. anatolicum*	*T. caligatum*	*T. nauseosum-matsutake*	*T. magnivelare*
Pileus	4 to 20 cm, hemispherical, convex to plane, white to pale creamy when young, brown to brownish-ochraceous with age.	3 to 12 cm, subumbonate, blackish brown, with dark brown scales.	6 to 20 (30) cm, convex to plano-convex, radially fibrillose, with adpressed scales, centre brown to light brown	5 to 25 cm, convex to plano-convex, white when young, yellow to orange or brownish stains in age
Odour and taste	Fragrant, like that cedar of Lebanon (*C. libani*), taste very mild, pleasant	Strong, just like that *Inocybe corydalina*, taste sweetish-bitter to bitter	Strong, sweetish, like that *I. corydalina,* taste very mild, pleasant	Spicy smell, distinctly fragrant, very mild
Lamellae	Narrow, adnexed, whitish, yellowish with age	Close, broad, sinuate, whitish	Close, broad, straight, emarginated, white	White, spotted brown in age, crowded, adnate to adnexed to sinuate.
Stipe	4 to 10(15) × 1 to 3(5) cm, cylindric to conic, tapered to base, annulus superior, very close the lamellae, fibrillose, membranous, above the annulus white, below the annulus ochraceous-brown zones	4 to 10 × 1 to 2.5 cm, with persistent and ascending annulus 7 to 25 mm down from the lamellae, more or less transverse, blackish brown zones on a lighter background	5 to 20 (25) × 1.5 to 2.5 cm, even thickness or slightly tapering or enlarging downwards, persistent annulus on the upper part of the stipe, 5 to 15(30) mm downwards from lamellae more or less transverse brown zones on the lighter background	Stipe 4 to 15 × 1 to 6 cm, similar colours as the cap, veil sheathing from the base, thick, white, forming a cottony annulus
Spores	6 to 7.5 (8.5) × 4 to 5 (5.5) µm, broadly elliptic, cyanophilic	5.7 to 7.3 × 4.3 to 5.4 (5.9) µm, broadly ellipsoid	6.6 to 8.4 (9.1) × 5.0 to 6.3 µm, broadly ellipsoid, hyaline	5 to 7 × 4.5 to 5.5 µm, subglobose to short elliptic
Basidia	Clavate, 35 to 42 (48) × 7.5 to 8.5 (9) µm	Clavate, 27 to 42 × 5.5 to 7.5 µm	Clavate, 35-50 × 6.5 to 9 µm	
Pileal surface	More or less flat hyphae, 7 to 28 µm wide, hyaline to light brownish-brown in Melzer's reagent	More or less flat hyphae, 7 to 16 µm wide	Flat and very thin-walled, 7 to 25 µm wide	
Distribution and ecology	On Toros Mountain in Turkey, elevation 1400 to 1700 m, *C. libani* and *A. microcephalus*	Mediterranean region, South France, Spain, NW Africa, *Pinus* forests, *Abies, Picea* and *Quercus.*	Fennoscandia, Japan, China, Korea, *Pinus sylvestris, P. densiflora, P. thunbergii, P. pumila, Tsuga sieboldii, T. divesifolia, Picea jezoen-sis, Quercus mongolica*	Canada to the Western United States, Mexico, Canada *Abies magnifica, A. grandis, Tsuga heterophylla, Pseudotsuga menziensii, Pinus* spp. *Quercus* spp.
Growing time	October to November	October to December	July to October	June to October

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