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Vegetation history and human activity in 2nd millennium AD in NW Turkey: pollen analysis of a peat bog

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The vegetation history of the Ağı Dağı region in the Ida Massif (NW Turkey) was reconstructed on the basis of pollen analysis of a topogenic peat bog. The analysis provided evidence of human impact on the woodland environment in Byzantine times and the centuries that followed. The bog was probably formed as a result of extremely wet conditions due to excessive forest degradation. It appears that the initial chestnut–oak forest, after a period of intensive clearings, recovered at first artificially and then naturally. A sequence of events: deforestation–afforestation continues to the present day. Chestnut woodland displayed an optimal development between the 11th and 14th centuries due to human influence. However, due to negligence and destruction, the gradual destruction of the initial chestnut–oak forest at the mountain vegetation level resulted in the extension of black pine forests at this level, leading to acidification of the soil and disappearance of the ephemeral flora of the original leafy forest. Consequently, biological diversity declined and the forest ecosystem became more fragile. The chronology for the last 1250 years has been established on the basis of a ^{14}C dated pollen profile from the lowest peat layer.

Key words: chestnut woodland history, human activity, paleoecology, pollen analysis

Introduction

The Ida Massif in NW Turkey geographically constitutes the major part of the ancient Troad, a region with considerable human activity throughout millennia. The first human settlement in the region dates back to as early as 5000 BC (Gabriel 2006, Takaoğlu 2006). The Troad region has long been associated with well-known ancient sites such as Troia, Assos, Alexandria Troas and Lampsacus. The presence of extensive *maquis* (shrubby vegetation), surrounded by remnants of ancient cultures and degraded woodlands in the Troad, is an indication of ancient human activity in the region. As well as being of historical and botanical importance, this region is very rich in neoendemic and palaeoendemic plant species. Accordingly, much can be learnt from a palynological investigation of its past land use.

Previous palynological studies were carried out at sites (lakes and marshes) in SW Turkey (van Zeist *et al*. 1975, Bottema & Woldring 1984, Eastwood *et al*. 1999, Vermoere *et al*.

2002). In the first three studies, development of the local vegetation was discussed briefly after an extensive presentation of the regional vegetation's development. Most recently, Vermoere *et al*. (2002) completed a palynological study of the marsh at Gravgaz, and presented the local vegetation succession in detail.

The present study aims to investigate the local vegetation development of the Ida Massif. A pollen diagram was constructed by comparing fossil pollen curves from a peat bog profile with modern pollen curves of a surface sample collected from a site close to the sampling area.

Modern climate and vegetation

A description of the vegetation of the Ida Massif is rather lengthy, however, this gives us the opportunity to make comparisons with obtained data from the pollen spectra. The massif is situated in a transitional region between the Euro-Siberian and the Mediterranean area. Here, the mesophilic forests of northern Turkey and the xerophilic forests of western Turkey form mixed forests. On the southern slopes of the Ida Massif a Mediterranean climate prevails, while an oceanic climate prevails on its northern slopes. Generally, the massif belongs to the meso-Mediterranean area of the subtropical climatic zone, with a short and arid summer season.

Due to its geographical position and complex environmental factors, the massif displays variable climatic features as well as high floral diversity and numerous endemic plants. The present vegetation of the Ida Massif consists of five altitudinal levels (Quézel & Pamukçuoğlu 1969). The nomenclature used for vascular plants follows that of Davis (1965–1988).

The lower Mediterranean level of hard foliage bushes rises to 250–300 m and is typically situated in the southern part of the massif, though it is also partly seen in the northern parts. It is represented by fragments of a community of *Olea–(Pistacia) lentiscus* with thermo-Mediterranean elements.

The vegetation of the upper Mediterranean level of hard foliage bushes and forests consists mainly of *Quercus coccifera*, *Q. infectoria*, *Q. trojana*, *Q. ithaburensis*, *Pinus brutia*, *Phillyrea latifolia*, *Arbutus andrachne*, *A. unedo*, *Erica arborea*, and *Styrax officinalis*. *Pinus brutia* represents the most important plant community at this level. The massif's southern and northern slopes are covered with forests of *Pinus brutia* up to an altitude of 800–850 m, and 400 m, respectively.

The sub-Mediterranean vegetation level, which is constituted by xerothermic summer-green oaks, *Quercus cerris* var. *cerris* and *Quercus frainetto* in particular, rises up to 1000 m on the southern slopes and up to 600–700 m on the northern slopes.

The following plant communities are characteristic of the mountain vegetation level:

Pinus nigra subsp. *pallasiana*: Black pine forests begin to appear at an altitude of 800–850 m on the southern slopes and 400 m on the northern slopes and rise up to the forest's upper timberline, where sub-alpine vegetation occurs.

Abies nordmanniana subsp. *equi-trojani:* This fir species is endemic and grows exclusively on this massif. The community appears permanently on the northern slopes. Although it declines to 400 m in single cases, its optimal altitude is between 950–1300 m. It is mainly associated with *Fagus orientalis* and *Pinus nigra*.

Fagus orientalis: The beech has almost the same distributional area as the fir. The optimal distributional area of beech is between 600–1400 m.

Oak woods: Three species predominate: *Quercus cerris* var. *cerris*, *Q. frainetto* and *Q. petraea* subsp. *iberica*. Among these oak species, *Q. petraea* subsp. *iberica*, which appears between 400–1000 m, forms large mixed forests along with *Q. frainetto* and *Castanea sativa* at the Ağı Dağı (Rhododendron Mountain) located on the northeastern part of the Ida Massif. Both oak species and sweet chestnut opt for a humid environment. This area, being open to oceanic influence, corresponds with their ecological requirements. In the east and northeast of the massif, *Quercus cerris* predominates. Its communities, which appear between 300–1000 m, grow on the southern, eastern and western slopes; namely,

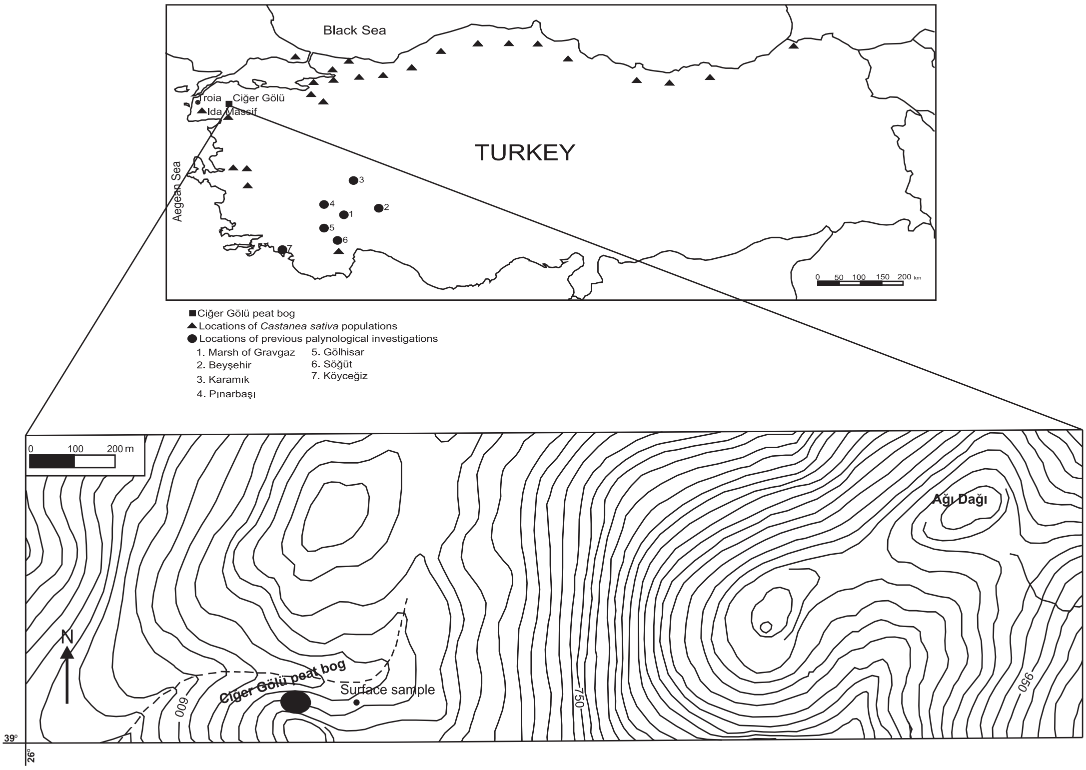

Fig. 1. Map of Turkey, showing the location of palynological investigations and distribution of *Castanea sativa* populations.

on the sunny and relatively arid sides of the massif. Generally, *Quercus cerris* and *Quercus frainetto* grow within the sub-Mediterranean level.

Carpinus betulus: Hornbeam occurs in mixed communities in the valleys; in the NE part of the massif between 400–650 m.

The subalpine vegetation level begins above the timberline and constitutes a zone of pasture land.

Site description

For the palynological investigation, we chose a site on Ağı Dağı (Rhododendron Mountain), situated in the NE part of the Ida Massif near the Byzantine ruins of Kızılelma (Arslan 2003). It is a dried-up peat bog called Ciğer Gölü (Liver Lake), which is 650 m above sea level (39°52´37´´N, 26°55´40´´E) (Fig. 1). This small topogenic feature in swampy ground (pH = 4.5), measuring 60–80 m in diameter, originated from the silting-up of a small lake (pond). The environment close to the peat bog is covered by a riparian forest and there is a stream nearby. Being open to oceanic influence, the location is at the level of mountain vegetation with mesophilic and xero-mesophilic oak, sweet chestnut, hornbeam, and black pine, as well as alder. In order of the species' dominance, the vegetation surrounding the peat bog is formed by *Pinus nigra* subsp. *pallasiana*, *Castanea sativa*, *Quercus petraea* subsp. *iberica*, *Quercus frainetto, Alnus glutinosa*, *Carpinus betulus*, *Abies nordmanniana* subsp. *equi-trojani* (a few trees), *Rhododendron luteum*, *Sorbus umbellata* var. *paniculata*, *Erica manipuliflora*, *Rosa canina*, *Rubus caesius*, *Molineriella minuta*, *Athyrium filix-foemina*, *Pteridium aquilinum*, *Dryopteris pallida*, *Osmunda regalis*, *Euphorbia amygdaloides*, *Prunella vulgaris*, *Galium* sp., *Juncus* sp., and *Sphagnum* sp.

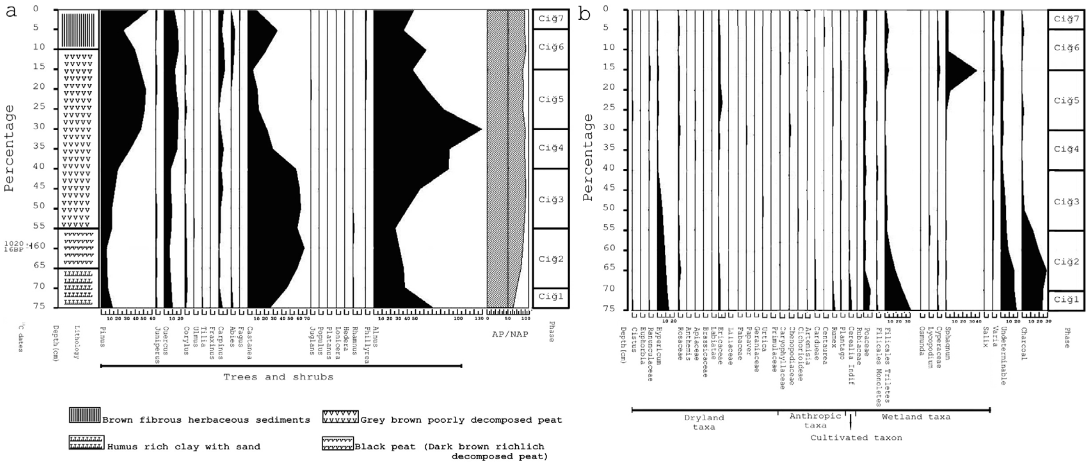

Fig. 2. Pollen diagram from Ciğer Gölü peat bog.

In the bog, situated on the western part of the Ağı Dağı between two small hills in the vicinity of a riparian forest by a stream, due to its sheltered position local pollen rain predominates. Therefore, the local vegetation is better represented than the regional one in the pollen diagram.

Material and methods

For collection of the material, a profile pit was constructed in the dried-out peat bog. Next, peat samples were taken from the wall at intervals of 5 cm (*see* Fig. 2). The samples taken for analysis were treated with potassium hydroxide (KOH), hydrofluoric acid (HF) and acetolysis (Straka 1970).

Pollen types were identified using the pollen reference collection of the Department of Biology at Çanakkale Onsekiz Mart University and also Moore's Identification Key (1991). Ericaceae consist of two taxa: *Erica* and *Rhododendron*. *Pinus* also contain two species: *P. brutia* and *P. nigra*. The percentage of the calculation of the pollen is based on the sum of pollen [arboreal pollen (AP) + non-arboreal pollen (NAP)]; excluding alder, willow and Cyperaceae as well as local riparian forest and swamp forest moor elements, spores (pteridophytes and mosses) and indeterminate pollen, whose percentage calculation is based on the total sum. Charcoal fragments were counted on a scale of 20–80 μm. Percentage calculation for the extent of coal is based on the total pollen sum. The pollen diagram (Fig. 2) is divided into local pollen assemblage zones (Ciğ. 1 to Ciğ. 7) to facilitate description and understanding of the vegetation succession. Zonation of the pollen diagram is based on changes in the AP/T ratio and trends in the percentages of *Pinus, Alnus, Quercus* and *Castanea* that characteristically dominate the pollen successions obtained from the site.

Study of the modern pollen rain

Modern pollen rain data were obtained from a moss sample collected at a distance of ca. 100 m from the alder grove in the peat bog. The location of the moss sample is shown on the topographic map (Fig. 1).

The modern pollen spectrum consisted of: *Pinus* (54.60%), *Quercus* (13.83%), *Castanea* (15.38%), *Corylus* (1.15%), *Carpinus* (0.76%), *Abies* (1.54%), *Platanus* (0.38%), *Phillyrea* (0.76%), *Alnus* (8.33%), *Salix* (0.66), ferns monoletes (0.33%), ferns triletes (1.33), Cyperaceae (0.33%), Poaceae (0.76%), *Artemisia* (0.76%), *Cardueae* (0.76%), Ranunculaceae (1.53%), Papaveraceae (0.38%), Chenopodiaceae (0.38%), *Hypericum* (0.76%), *Erica* (0.76%), *Rhododendron* (1.15%), Primulaceae (0.38%), Apiaceae (0.76%), *Rumex* (0.76%), *Plantago* (1.15%), Brassicaceae (0.76%), Liliaceae (0.38%), other (1.33%), undeterminable (1.33%).

With the exception of *Alnus* and *Pinus*, the percentages are largely in accordance with the present constitution of the forest. The value of *Alnus* was higher in the surface sample collected in the grove in the peat bog (ca. 45%). On the other hand, it was lower at a distance of ca. 100 m from the grove in peat bog (ca. 8%).These data indicate that generally tree pollen values over 8% were recorded only in case of tree groups growing at a distance of less than ca. 100 m from the sampling point. Although *Pinus* groups occurred in the surrounding of the peat bog, their pollen percentags were a little high (ca. 55%). *Pinus* pollen appeared to be overrepresented due to dispersal from elsewhere by wind.

Results

The starting point for the Ciğer Gölü pollen record is based on a single ^{14}C date of 1020 ± 16 BP obtained from the bottom level at 60 cm, suggesting that the record goes back to ca. 1000 BP (Fig. 2). This date shows that — assuming a constant rate of peat accumulation — the profile down to 75 cm developed during approximately the last 1250 years. Thus, approximative dating of different phases becames possible. The diagram can be arranged roughly in seven local pollen zones characterized by changes in the damp biotope.

Zone Ciğ. 1 (75–70 cm, ca. AD 750–835)

Among the tree pollen taxa (AP), *Alnus*, *Corylus*, *Salix* and *Rhamnus* belong to the local riparian vegetation. *Quercus*, *Castanea*, *Fagus*, *Fraxinus*, *Tilia*, *Pinus* and *Abies* represent forest in dry locations. *Carpinus* occurs in mixed communities in damp valleys.

The percentage of tree pollen (AP) increases in this first zone from 60% to 69%, due to the development of *Castanea* at the expense of alder. The percentage of chestnut pollen increases towards the present time from 27% to 47%, while that of alder falls from 70% to 35%. At the base of the profile, the presence of a thinned chestnut–oak forest mixed with alder and pine is observed. The landscape in that zone can, therefore, be considered as more or less wooded.

The pollen assemblage zone is characterized by high percentages of *Alnus* pollen and the fall of its percentage from 70% to 35%. The modern pollen rain data confirm that *Alnus* pollen values over 8% are only registered when an alder grove grows at a distance of less than 100 m from the sampling point. The relatively high percentages of alder in this zone suggest a more extensive development of local riparian vegetation than present around the peat bog, located in the small valley at a distance of less than 100 m from the stream. During this period, alder trees occupied probably a wider area in the small valley. At present, the trees are very restricted in number and exist only on the surface of the peat bog and the banks of the stream nearby.

In this part of the zone, there is a maximum occurrence of fern pollen (32% at 75 cm), followed by its decrease. The high frequency of fern and alder pollen in the lower part of the profile is presumably related to a rise in the local water table due to a prior destruction of the initial chestnut–oak forest. The extremely wet environment at this time probably caused the formation of the peat bog. Furthermore, the absence of a considerable heathland phase, as well as the relative frequency of *Rhamnus*, justifies the indication of a thinned-out and damp character of the location. An increase of *Hypericum* in the lower part of the diagram is also clear. Some *Hypericum* species appear particularly in degraded and damp areas of forests.

The percentage of *Quercus* pollen (around 9%) indicates the development of oak forests surrounding the Ciğer Gölü site. The presence of oak pollen is constant throughout the pollen diagram, suggesting a continuous presence of this taxon in the vegetation of Ağı Dağı.

Among the conifers, the presence of *Pinus, Abies* and *Juniperus* pollen is notable. In the sheltered position of the site, the value of pine suggests possible and restricted spreading of pine into the area at this time. However, the pollen percentage falls from 14% to 8% at the bottom of the profile. It appears that pine regressed in the area. In other words, the lower percentage of the *Pinus* pollen at the bottom of diagram may indicate an increase in local pollen rain as a consequence of locally increased cover of leafy forest. On the other hand, *Abies* and *Juniperus* values did not even reach 2%. This data clearly indicate that fir and juniper grew at a quite considerable distance from the bog.

In this zone, the increase of chestnut pollen is clearly related to the reduction of *Alnus, Pinus*, dwarf shrubs (Ericaceae), *Hypericum*, Poaceae, and ferns.

Concerning grass and herb vegetation, Poaceae, with values to 7%–8%, prevail. Pollen of the Cerealia type is present in small quantities (2%–3%). The herb spectrum is rich in species, but proportionately, its is only weakly represented. *Rumex* (1%–3%), Asteraceae (2%–4%) Ericaceae (2%–3%) and Rosaceae (2%) are the most abundant. The proportion of herbaceus taxa (about 40%) and values of the cereal pollen curve in the lower part of the diagram are significant. The values for *Rumex*, *Plantago*, Chenopodiaceae, *Urtica* and Cardueae show the onset of agriculture and residential areas. Thus, an assumption of increased anthropogenic activity in this period is justified.

The presence of microscopic charcoal particles at the bottom of the profile indicates the existence of repeated fires at this time. The forest remnants underwent selective clearings. Fires destroyed mainly alder groves at the lower elevations and probably groupings of pine at the upper elevations. On the other hand, the oak underwent destruction by fire later in the second pollen zone. These fires disturbed certainly pollen spectra in the deposit. For that reason, a quantity of damaged pollen was counted as undeterminable at the bottom of the profile. At that time the alder groves and groupings of pine were completely cut down and then burnt. Before regeneration of these from stocks, man intervened and reafforested the burnt spaces using chestnut seeds or seedlings, which were abundant in the area. The chestnut was artificially favoured during the spreading of human settlements in the area.

This zone, therefore, forms the first section of the chestnut's afforestation phase.

Zone Ciğ. 2 (70–55 cm, ca. AD 835–1085)

Tree pollen values (AP) rise from approximately 69% to 85% at the top of the zone mainly due to *Castanea*. The percentage of *Castanea* increases and reaches 68% at 60 cm, which is the maximum of its development in the whole profile, Percentages of alder, Poaceae, *Hypericum* and ferns decrease continually towards the present.

The share of pine decreases at the bottom of this zone and at 60 cm indicates the minimum of pine development (about 6%). The lower values for pine (under 8%) clearly indicate that pine trees were not present at the site and grew at a considerable distance from the site. Despite increased cover and the sheltered position of the vegetation, *Pinus* abundance increases to a value over 8% (about 13%) in the top section of the pollen zone (55 cm). This suggests a possible recolonization of the burnt spaces or cleared areas by pine. The increase in pine at the 55 cm level is clearly related to the regression of chestnut. The percentage of oak in this zone remains stable at 7%–8%.

Cereal pollen is rare in this zone; the culmination of cultivation or an increasingly dense screen of emerging trees hindering the pollen transport. The pollen of heliophilic and ruderal plants also becomes very rare in this zone, therefore, signs of agricultural activity and settlement are no longer notable.

The presence of microscopic charcoal particles is evidence of the existence of recurrent fire events in this zone too. It appears that selective clearings by fire during this time affected the alder and, partially, oak. Charcoal values are higher at the bottom of the zone than at the top.

Finally, this zone establishes the second section of the chestnut's afforestation phase.

Zone Ciğ. 3 (55–40 cm, ca. AD 1085–1340)

In this zone, the chestnut curve becomes stable, whereas the curves of pine and alder show a rising trend. The rise in alder and pine is remarkable in this zone. It can be assumed that alder started to develop again at the bottom of the small valley from existing stumps after intensive cutting-down and burning practice in the preceding period. Its pollen percentage increases in this zone and reaches ca. 90% at the top. With regard to pine, it settled spontaneously on the burned spaces or areas cleared of forest for grazing or agriculture. Its pollen percentage rises and reaches 20% at 40 cm. The percentage of oak stabilizes at between 8%–9%.

Cereal pollen is completely absent form this zone. The pollen of heliophilic and ruderal plants is also very rare in this zone. Charcoal particles decrease suddenly and almost disappear at the top of the zone. Then, fire events remain marginal.

It appears that forest regeneration occurred naturally in this third zone after cession of agricultural activity.

Zone Ciğ. 4 (40–30 cm, ca. AD 1340–1505)

Abundance of tree pollen (AP) remains almost constant. The percentage of *Castanea* falls from 58% to 23%, while that of *Alnus* increases from 90% to 125% (*see* Material and methods). Pine and oak pollen abundances increases from 20% to 48% and 8% to 16%, respectively. At 30 cm, the percentage of alder shows the maximum for the whole diagram.

In this zone, man cleared chestnut in a selective and excessive way to obtain its valuable wood in preference to pine, alder and oak. Spontaneously, black pine at upper elevations and alder at lower elevations settled unhindered in a pioneering manner on the cleared areas. The progressive installation of black pine at the site caused acidification of soils and the disappearance of existing plant communities, above all, the ephemeric flora of the chestnut–oak forest.

Accordingly, this zone composes the first section of the chestnut's deforestation phase, which was caused by man.

Zone Ciğ. 5 (30–15 cm, ca. AD 1505–1755)

The proportion of woodland falls from 88% to 80%. In this zone, chestnut continued to regress due to intensive clearings. The heaviest and most significant decline in chestnut is in favour of pine; Ericaceae (*Rhododendron* and *Erica*), as well as Poaceae, can be noticed. At 15 cm the percentage of chestnut shows the minimum of its development (ca. 6%) in the whole diagram. Man-cleared alder too in this zone. Its percentage falls from 125% to 45% at the top of the zone. The percentage of oak stabilizes at 14%–16%. As the groupings of pine became more extensive, it appears in higher percentage (53% at 20 cm) though slightly decreases at the top of the zone.

The higher presence of *Sphagnum* (mosses), ferns, and Cyperaceae at 15-cm level can be explained by the increasing dampness of the location as a result of clearing and, above all, the strong decline in alder.

Cereal pollen is not represented in this zone either. The pollen of heliophilic and ruderal plants is represented marginally. Nevertheless, signs of anthropogenic influence are considerable due to the selective and excessive clearing of chestnut.

Finally, this zone establishes the second stage of the chestnut's deforestation phase, which was caused by man too.

Zone Ciğ. 6 (15–5 cm, ca. AD 1755–1930)

During this time, the development of more competitive species like *Castanea* and *Quercus* is observed. In contrast to the aforementioned species, black pine continues to decrease in this zone at 10 cm, and the percentage of alder rises slightly due to an increase in the local water table. It then falls gradually with decreasing dampness. At the top of the zone, the increase of chestnut is clearly related to the regression of alder and pine. The marginal presence of charcoal particles is an evidence of limited selective burning practice, which affected mainly alder and pine. The severe decline in *Sphagnum* and different herbal and heliophilic species is a result of increased woodland. Remarkably, the percentages of fir (*Abies)* rise slightly in this zone. Signs of human influence remain marginal in this phase.

Accordingly, this zone composes the second phase of chestnut's afforestation.

Zone Ciğ. 7 (5–0 cm, ca. AD 1930–present)

This zone is marked by selective and excessive clearing of chestnut. The decline in chestnut and oak corresponds to the highest value of *Pinus* (ca. 55%). After this, pine and alder, above all, settled spontaneously in the manner of a pioneer species on the clearing areas without hindrance as a result of the destruction of the chestnut–oak stands. At 0 cm, with the exception of alder and pine, the percentages are largely in accordance with the present constitution of the forest. The signs of anthropogenic influence in this pre-contemporary period are prominent due to the selective clearing of chestnut. During this most recent period (the last 10–15 years), the pond dried out followed by an alder grove of young trees establishing itself. As a result, the present swampy forest moorland was formed as an azonal ecosystem. The percentage of *Alnus* at the sampling point is higher (40%) due to the presence of the current young alder grove in place of the former peat bog.

Finally, this zone establishes the chestnut's second degradation phase, which was also caused by man.

Discussion

Comparison of previous studies carried out in SW Turkey with the present work show some similarities. The whole pollen diagram of this study agrees with the last regional pollen assemblage zone recorded simultaneously at other sites in SW Turkey. This last regional zone is considered to be a secondary forest phase. It followed a human occupation phase, which involved great forest clearance and then cultivation. This human occupation phase is recorded to some extent at different dates at all sites of SW Turkey. For example, at the site of Gölhisar Gölü, it began around 3000 BP (Eastwood *et al*. 1999) and terminated with lower values of arboreal pollen (AP) and pine around 1300 BP, when pine appeared to be again the dominant forest tree. This period is discernible at the bottom of our pollen diagram and confirms the end of an intensive deforestation period. The expansion of pine in our area began a little later, approximately after the chestnut's afforestation phase, with a delay of ca. three centuries. Human impact on the landscape continued in this part of NW Turkey up until now. Pine appears to have been the major beneficiary from deforestations of chestnut-woodland that took place in the area during the last millennium.

Eastwood *et al*. (1999) considered chestnut a primary anthropogenic indicator. Chestnut pollen appears in lower percentages as an effect of long-distance pollen transport in the human occupation phase of their percentage pollen diagram for core GHA from Gölhisar Gölü. However, it is completely absent in the secondary forest phase during the last ca. 1300 years. It is also totally absent in the pollen diagrams of Vermoere *et al*. (2002). Our pollen diagram indicates a recent chestnut woodland succession in the Ida Massif (NW Turkey). Chestnut is one of the most widespread forest species in Turkey and southern Europe. Its present distribution includes the majority of Mediterranean countries. This is probably due to the secondary domestication during the Roman period (Planchais *et al*. 1974, Öner & Planchais 1976). Turkey represents an area of special interest due to its complex biogeography and also because it is thought to be one of the centres of origin for *Castanea sativa* (Zohary & Hopf 1988). In Turkey, chestnut is distributed along an altitudinal belt from the eastern Black Sea coast to the Mediterranean coast (Fig. 1). In the Ida Massif and in north Turkey, chestnut constructs with deciduous oak species to form zonal leafy forests. In west Turkey, however, its distribution is rather local.

Conclusions

The palynological investigation of the topogenic peat bog situated in the region of the Ida Massif in NW Turkey allowed the reconstruction of a brief section of the vegetation history of the area. Sweet chestnut (*Castanea sativa*) and oak (*Quercus* spp.) found their ecological optimum at the site and composed the initial chestnut–oak wood. When increasing anthropogenic influence over the past 1250 years is taken into consideration, the pollen diagram shows a degraded woodland landscape changing versus an undisturbed natural condition. The forest was already strongly degraded and had lost its originality at the beginning of the formation of the peat bog.

In the Byzantine period the forest was already deeply degraded. It is likely that the rise in the local water table added to an acceleration of the run off due to deforestation, which contributed to the formation of this swampy area. As a result, the present peat bog was formed (during ca. the last 10–15 years) after the silting-up of the pond.

Chestnut, supported by man in this area through selective burnings between the 8th and 12th centuries, began spreading out, at first artificially, then spontaneously. It displayed an optimal development between the 11th and 14th centuries. This was followed by a gradual retreat during the following centuries, if we accept its renewed weak progress, always in correspondence with selective burning practice, during the recent epoch (19th or 20th century). These burning practices have certainly disturbed pollen spectra and worsened soil erosion. Agricultural activity was observed in a brief section of the diagram, lasting until the 11th century, and then discontinued. Regardless of this, pastoral agriculture has a long unbroken history at the site due to the continuous existence of the chestnut's fruit.

Research on the palaeo-environment of the mountain vegetation level of Ağı Dağı (NW Turkey) is indirectly connected with the development of chestnut woodland, as it reflects the history of agriculture, pasture, deforestation and afforestation during the last millennium.

Finally, palynological data indicate that the destruction of the initial chestnut–oak wood in the zonal character on the mountain vegetation level caused the extension of black pine (*Pinus nigra* subsp. *pallasiana*) forests with accompanying acidification of the soil. As a result, the original plant communities and especially the ephemeral flora of the original leafy forest disappeared in the presence of shadowy coniferous forest. Therefore, the biological diversity weakened and the forest ecosystems on this vegetation level became more fragile. This is very important considering the environmental degradation. It appears that selective and continual clearings of chestnut are a serious hindrance towards the progressive evolution of a chestnut–oak wood.

For the period between the 8th century and the present time, this palynological study in NW Turkey provides a more detailed image of the dynamics of chestnut and vegetation in general, which was missing in previous palynological investigations of SW Turkey.

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