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THE FIRST RESULTS OF THE POLLEN MONITORING PROGRAMME IN THE CAUCASUS MOUNTAINS (GEORGIA)

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ABSTRACT. Pollen accumulation in 10 pollen traps over a twelve month period showed that the total pollen influx in Lagodekhi was greatest in mixed broad-leaved forest with a predominance of *Carpinus caucasica*, at an altitude of 500 m a.s.l. The lowest influx was recorded in the alpine belt at 2900 m. Among broad-leaved species *Quercus iberica* was characterized by producing the greatest quantities of pollen.

KEY WORD: pollen influx, pollen traps, Lagodekhi, pollen monitoring programme

INTRODUCTION

Investigations of pollen sediments accumulated in pollen traps in Northern Finland showed that the percentages of spectrum components were not sufficient on their own for determining the position of the timberline. For this purpose the results of the determination of pollen influx (Hicks 1994) become of great importance. They reveal that the influx of arboreal pollen as well as that of other species is a good indicator for distinguishing between unforested and forested types of vegetation and determining the local absence or presence of particular taxa.

In the high mountain systems of Europe, as well as in northern latitudes, the process of distant pollen transfer frequently hinders a correct interpretation of pollen spectra, especially above the forest limit (Knaap 1987, Kvavadze 1993). In this connection investigations of pollen influx in the above-mentioned regions become of special importance.

In the Caucasian Mountains (Georgia) such investigations of pollen influx began as far back as autumn 1996, after the first meeting of the Working Group of the INQUA Holocene Studies Commission on the European Pollen Monitoring Programme held in July 1996 in Finland. Ten pollen traps were placed within the Lagodekhi Reservation at altitudes ranging from 450 to 2900 m (Figs 1, 2).

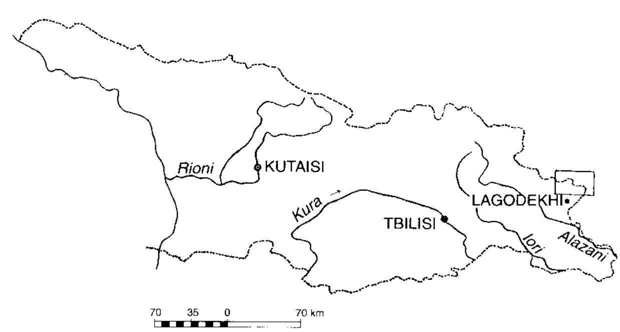

Fig. 1. Map of Georgia with location of the Lagodekhi Reservation

Orographically the mountains of the Lagodekhi Reservation (area 12 146 ha) are distinguished by their very steep slopes which are of fault origin and tower above the neighbouring Alazani Valley. In altitude they range from 450 to 3426 m over a distance of 22 km. It should be mentioned that this fault character in the relief is visible only at this one site in the Main Caucasian Range which extends for 170 km (Maruashvili 1970)

The peculiarities of the relief, geological structure and climate combine to produce a rather unusual vegetation cover here. In deep gorges of steep mountains with high humidity the elements of ancient, particularly Tertiary, floras have been preserved. In the Caucasus, Tertiary relicts are represented in the form of two floristic groups. These are the Colchis and Gircan or Lenhkoran centres. In Lagodekhi the elements of both groups occur, although in reduced amounts (Dolukhanov 1941, 1989).

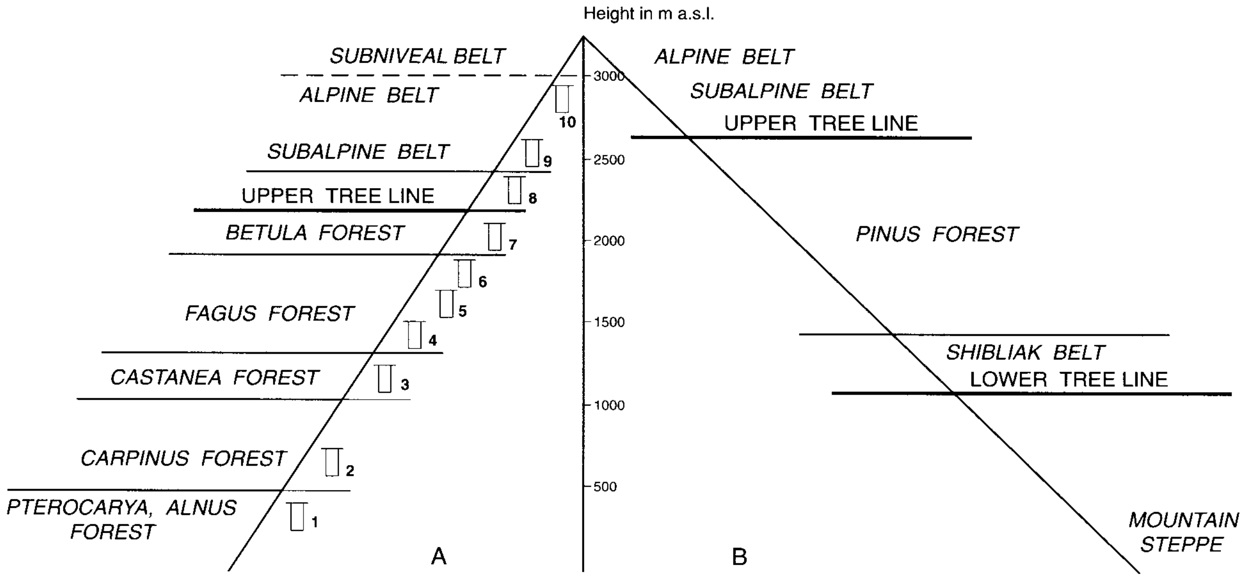

Fig. 2. The structure of the altitudinal vegetation belts of the Lagodekhi Reservation (A) and Daghestan (B). (Rectangles denote trap location)

Additionally, high endemism and a number of other peculiarities are to be seen, which are very important and interesting for investigations both the recent and Holocene flora and vegetation of the Reservation.

Forest vegetation prevails and occupies two thirds of the area within the altitude range from 450 to 2100–2200 m. The forest itself consists mostly of broad-leaved formations, where *Fagus orientalis* is predominant ahead of *Carpinus caucasica*. Of lesser importance are *Acer velutinum, Tilia caucasica* and *Ulmus elliptica,* followed by *Quercus iberica, Acer platanoides, Alnus barbata, Pterocarya pterocarpa, Castanea sativa* and other species (Lachashvili & Mamukelashvili, 1986).

It should be mentioned that whereas vegetation in the lower Lagodekhi mountain belt has been slightly changed as a result of human impact before the Reservation was created, the forests of the central belt are still virgin due to the very steep slopes and absence of roads. As for the subalpine meadows, ungrazed and conserved for nearly 100 years, their vegetation should be regarded as natural.

MATERIALS AND METHODS

In October 1996, at various hypsometric levels along the transect from 450 to 2900 m, 10 modified Tauber pollen traps were placed (Hicks and Hyvarinen, 1986) with 5 cm holes at ground level. The trap capacity was 5 l. According to the instructions the traps were to contain a mixture of glycerin, formalin and thymol (Hicks et al, 1996). For the whole of the warm season the traps were periodically cleared of leaves covering the trap hole.

After a full twelve months the greatest quantities of water (up to 5l) were found to have accumulated in those places where the traps had been placed in glades. Unfortunately, in the traps, many dead animals were found. Besides insects there were earthworms, mice, fieldvoles lizards, a shrew, a weasel and a bird. This material was fixed in formalin solution and is being kept for further investigations.

Laboratory treatment of the trapped pollen was performed by the usual methods (Hicks et al, 1996). Excess water was removed by precipitation. Mineral particles were separated from the pollen by centrifuging in cadmium liquid. To count the pollen influx three *Lycopodium* tablets (batch No. 124961) were added, each containing 12 542 *Lycopodium* spores (Stockmarr 1971, 1973).

In September 1997, at the beginning of the mushroom season, pollen trap No. 3 placed at an altitude of 1000 m disappeared so data from this station were missing.

The vegetation at the test sites was described in the same manner as in the previous work (Kvavadze & Stuchlik 1996) devoted to study of the pollen spectra of the Lagodekhi Reservation soils according to the Braun-Blanquet system (1951).

RESULTS AND DISCUSSION

In my presentation I shall discuss only the essentially arboreal pollen in the pollen spectra because this is the main aim of the Pollen Monitoring Programme.

POLLEN TRAP No 1 was placed on the lowest terrace of the right hand bank of the Shromis Tskali river in flood-plain forest with a predominance of *Pterocarya pterocarpa* at an altitude of 450 m. In the primary layer, besides *Pterocarya*, also grew *Alnus barbata, Fraxinus excelsior* and *Fagus orientalis. Acer pseudoplatanus* and *Carpinus caucasica* occurred occasionally. In the undergrowth *Hedera* and *Rubus* prevailed.

As can be seen from the diagram (Figs 3, 4), the pollen influx was 24770 grains cm^2 $year^{-1}$ among which 15852 grains, i.e. 64%, belonged to arboreal species. In the spectrum, as well as on the test site, *Pterocarya* pollen was prevalent. The roles of *Fagus, Alnus* and *Acer* were truly reflected. The *Carpinus* pollen content was slightly overestated, while that of *Fraxinus* was significantly under-represented. As for shrubs, the pollen content was an accurate measure of their relative incidence in the community.

Among transported pollen, the percentage values of pollen grains of *Tilia* and *Quercus* in the spectrum, which were absent from the site, were rather high. Their pollen influx, however, was negligible. Birch, pine, chestnut, elm and hazel were present as single grains. The pollen of these plants had been transported from the upper vegetation belts.

POLLEN TRAP No 2 was established at an altitude of 500 m in hornbeam forest on a south-east facing slope. *Carpinus caucasica* and *Tilia caucasica* grew there as first and second dominants while *Fraxinus* excelsior, *Acer velutinum* and *Fagus orientalis* also occured. In the undergrowth there were large quantities of *Cornus, Corylus, Thelycrania* and *Hedera*.

In the spectrum of trap 2 the pollen influx was greatest (62327 grains cm^2 $year^{-1}$), 82.7% of it arboreal, amounting to 51544 pollen grains. Among these, grains of *Quercus* (up to 29.6%) were predominant, although this plant did not grow on the test site at all. Nevertheless, its pollen influx reached enormous values and amounted to 14120 grains. *Quercus* trees grew further up the slope. The *Carpinus* content was 23.8% and *Tilia* 20.6%. It should be mentioned that the hornbeam pollen influx was a good indicator of the existence of *Carpinus* forest here. It attained its maximum value and amounted to 12243 grains (Fig. 4). The subdominance of *Tilia* was also reflected in its large pollen influx (8762 grains). As for pollen transportation, the highest values were observed for *Pterocarya, Juglans, Pinus* and *Alnus. Castanea, Ulmus* and *Salix* were represented by single grains.

POLLEN TRAP No 4 was placed at an altitude of 1250 m in beech forest on a north facing slope. The composition of the stand was *Fagus* 50%, *Tilia* 25% and *Carpinus* 25%. In the undergrowth only *Rubus* occured. Here the total arboreal pollen influx was significantly lower than in the hornbeam forest and amounted to 20625 grains cm^2 $year^{-1}$, 61% of the total influx. Beech predominance was reflected in the pollen content both in percentage and absolute terms, reaching its maximum for the whole transect, some 7837 grains. The proportion of *Tilia* pollen in the spectrum overestated its incidence compared with *Carpinus*. The same situation was observed in the pollen spectrum of trap 2. The role of transported pollen here was insignificant. There were single grains of *Pinus, Betula, Juglans, Pterocarya, Alnus, Castanea* and *Fraxinus*.

POLLEN TRAP No 5 was sited at an altitude of 1500 m on the top of a ridge in beech-hornbeam forest containing *Corylus colurna* and *Acer laetum*. All the components were present in nearly equal numbers. In the undergrowth *Sorbus caucasigena* and *Mespilus germanica* grew.

The quantity of arboreal pollen, as a whole, decreased and amounted to 14972 grains, 64% of the total pollen content (23395 grains).

In the pollen spectra beech and hornbeam were represented accuarately in nearly equal quantities (Figs 3, 4).

However, the amounts of *Acer* and *Corylus* pollen were somewhat understated and *Mespilus* pollen grains were not found at all. Here the amount of transported arboreal pollen was low like the spectrum at 1250 m, except that *Tilia* pollen was strongly over represented in spite of the fact that lime trees were absent from the site. However, they were found on higher adjacent slopes at altitudes up to 1650–1675 m (Kvavadze & Stuchlik, 1996).

POLLEN TRAP No 6 was established at an altitude of 1850 m on a north-west slope in subalpine open woodland consisting of *Quercus macranthera, Fagus orientalis* and *Acer trautvetteri*. In the undergrowth *Sorbus caucasigena* and *Rhododendron flavum* occured.

At this altitude the arboreal pollen influx significantly increased and accounted for 80%

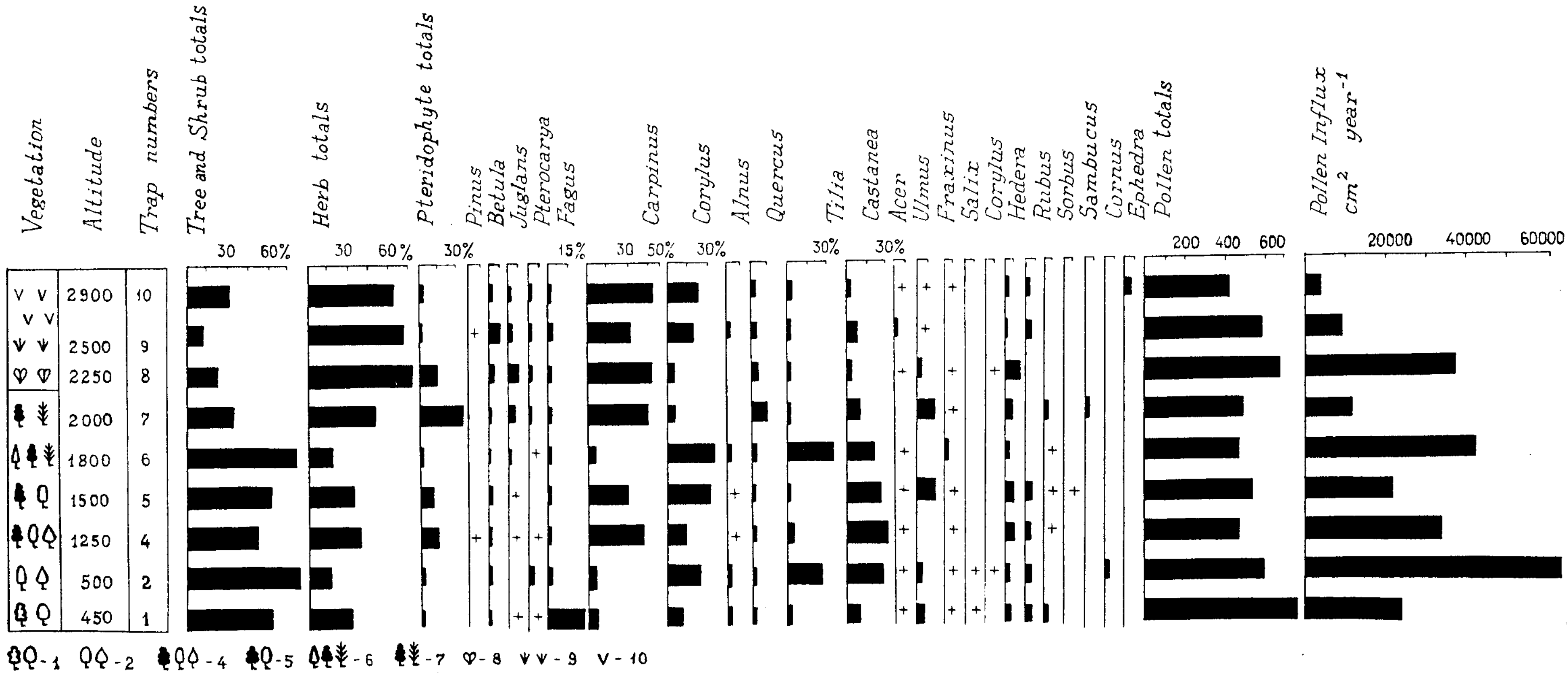

Fig. 3. Spore-pollen diagram showing the percentage content of pollen accumulated for a year (1996–1997) from nine altitudinal levels of mountains in the Lagodekhi Reservation. **1** – *Pterocarya* and *Alnus* forest; **2** – *Carpinus* and *Tilia* forest; **4** – *Fagus, Carpinus* and *Tilia* forest; **5** – *Fagus* and *Carpinus* forest; **6** – *Quercus, Fagus* and *Acer* subalpine forest; **7** –*Fagus* and *Acer* subalpine forest; **8** – upper forest line (subalpine tall herbaceous vegetation); **9** – lower alpine meadow; **10** – upper alpine meadow

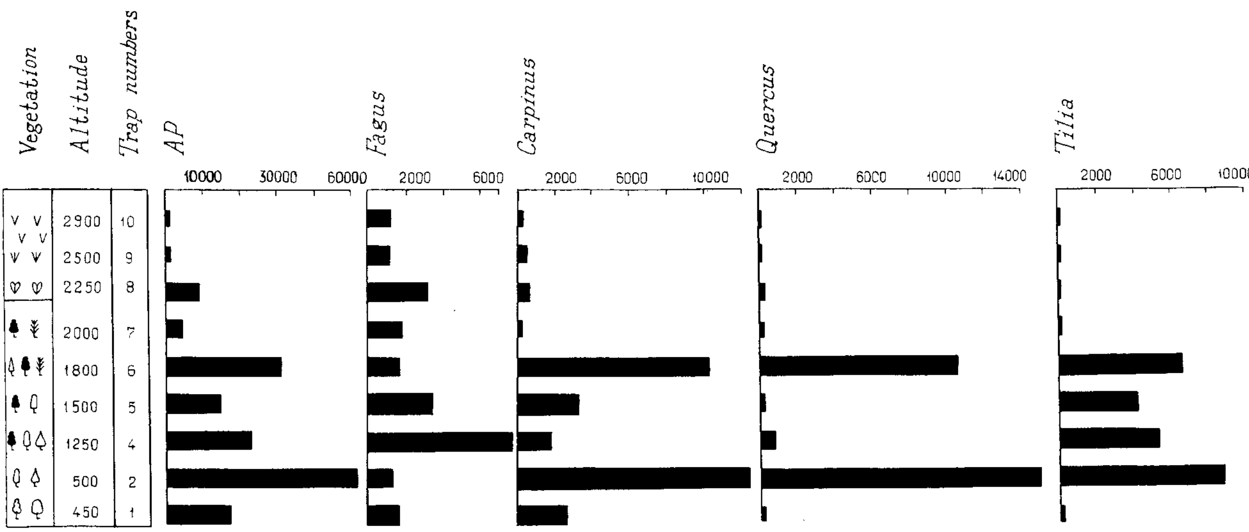

Fig. 4. Pollen diagram showing the total arboreal pollen influx and the influx of dominants in the Lagodekhi Reservation forests for 1996–1997 from nine altitudinal levels (symbols as in Fig. 3)

(32620 grains) in a total influx of 40776 grains. The spectrum dominant was *Quercus* pollen (32.4%), while the subdominant was the transported pollen of *Carpinus* (31.8%) and *Tilia* (19.7%) growing on a neighbouring slope. In open woodland the pollen of these species can spread more freely compared, e.g., with the dense stand of beech forest, where pollen transportation is limited.

The incidence of beech pollen was understated due to the abundance of transported pollen. Pollen grains of *Rhododendron* and *Acer* growing near the traps were not found in the spectra at all.

POLLEN TRAP No 7 was placed at an altitude of 2000 m, a short distance from the local meteorological station on a west facing slope. The vegetation surrounding the trap also consisted of subalpine open woodland, but here only beech and high-mountain maple were present in equal quantities. In the undergrowth *Sorbus, Rhododendron* and *Rubus* grew. There were patches of subalpine tall herbaceous vegetation.

The pollen influx in the trap fell sharply, the role of herbaceous pollen increased and the arboreal pollen became less important. The arboreal pollen amounted to only 4135 grains which was 34% of the total – 12057 grains. Among arboreal species *Fagus* pollen prevailed representing 46% with *Acer* 11%. The role of *Carpinus* and *Tilia* transported pollen was much reduced, but the content of *Betula* and *Alnus* rose. It should be mentioned that pollen grains of rhododendron growing round the test site could not be found in the sample.

As for herbaceous species, these were represented by a predominance of grass pollen and fern spores.

POLLEN TRAP No 8 was established at the very tree limit in subalpine tall herbaceous vegetation at an altitude of 2250 m on a slope exposed to the north. Down the slope, at the distance of 5–8 m from the trap, there were birch and rhododendron thickets and at the distance of 80–100 m *Sorbus* and *Salix*. The pollen spectrum was characterized by a high content of herbaceous pollen (up to 79%). Here the total pollen influx (36690 grains) also increased. However, the arboreal pollen influx was low (7998 grains) and accounted for only 21.8% of the total amount of pollen accumulated per cm^2. Among arboreal species the pollen transported from a neighbouring high ridge prevailed (up to 40%) with an influx of 3279 grains, nearly the same as in beech forest (e.g. the spectrum from trap No 5).

The spectrum of the forested areas (trap 5) contained 14972 grains of arboreal pollen, almost twice as much as that of trap 8 set among subalpine tall herbaceous vegetation. As for local vegetation, the presence of *Betula* was rather pronounced, while *Salix* was very poorly represented.

No rhododendron pollen was also recorded in the spectrum of trap 8.

The herbaceous species pollen content was dominated by Poaceae, Apiaceae and Asteraceae. Polypodiaceae and *Botrychium* spores were also abundant here.

POLLEN TRAP No 9 was established at an altitude of 2500 m on a north-west facing slope in the alpine belt. There were patches of tall herbaceous meadow vegetation. The total pollen influx was sharply reduced (8936 grains) and the arboreal pollen content reached its overall fowest value (16.5%). The arboreal pollen influx did not exceed 1474 grains cm^2 $year^{-1}$. Among arboreal species *Fagus* (34.3%) and *Carpinus* (19.1%) pollen were predominant. Followed by *Pinus* (9%) and *Alnus* (8%) with *Tilia, Quercus, Betula, Fagus, Corylus* and *Hedera* in somewhat smaller quantities. *Acer, Juglans regia, Castanea* and *Picea* were found as single grains.

Among herbaceous species, Poaceae, Polygonaceae and Asteraceae were abundant. Sporous species were present in small quantity with single grains of Polypodiaceae and *Botrychium.*

POLLEN TRAP No 10 was placed at 2900 m on an east facing slope in the alpine meadow short grassland belt. There were many rocks here and vegetation was rather scanty. The trap was sited in one of the rock cracks.

The following features were characteristic for the pollen spectrum. The arboreal pollen content doubled when compared with the lower alpine belt (trap 9) and accounted for 35.3% of the total. But the pollen influx, in contrast, decreased. The total influx amounted to 3980 grains, 1404 of them arboreal. These quantities were the lowest for the whole transect. Among arboreal species the percentage of *Fagus* pollen was higher than in the lower belt (trap 9) and reached 43.3%. The second dominant was *Carpinus* (22.3%) and the third *Quercus* (7.6%). *Alnus, Tilia, Pinus* were of lesser importance. *Betula, Acer, Ulmus, Pterocarya, Castanea, Juglans regia* and *Ephedra* occurred as single grains. Among herbaceous species grasses were predominant while the roles of *Carex* and *Campanula* increased. Polypodiaceae and *Botrychium* spores were recorded in low numbers.

After consideration of the pollen spectra along the whole transect it became evident that the peculiarities of these spectra allowed one to discuss not only the question of pollen influx but also pollen transfer and preservation and the productivity of different species within one genus of trees or shrubs.

CONCLUSION

The pollen influx, as a whole, and that of the arboreal species are good indicators for distinguishing between forested and unforested landscapes. For mountain forest in the Lagodekhi Reservation the values of the total pollen influx for 1996–97 varied between 24770 and 62327 grains and for the group of arboreal species between 14–972 and 51544 grains cm^2 $year^{-1}$.

It should be noted that, in addition to the taxonomic composition of communities, the pollen influx is affected by stand density, especially of the first and second layers. The pollen influx increases sharply in thin hornbeam and open subalpine forest and decreases in beech forests with litter. Lower values of pollen influx are also recorded in dense flood plain forest of *Pterocarya* and *Alnus*.

In complex orographic conditions a high pollen influx of a particular species does not always indicate its presence in the immediate neighbourhood. In such situations the pollen source may be vegetation from a higher steep slope or neighbouring ridge with different aspect and degree of exposure, and accordingly with different coenoses. Nevertheless, the upper limit of occurrence of any particular arboreal species is clearly indicated by the influx index in combination with that for the group of arboreal species as a whole.

As far as pollen carried by wind and the distance of its transportation are concerned, the following should be noted. The former belief that *Fagus orientalis* pollen was not transported over great distances in the conditions of the Caucasian mountains (Kvavadze 1993) has now proved to be invalid. The earlier conclusion was based on the study of pollen from recent highland soil sediments. However, the trap material has shown quite a different situation, since in the spectrum of the upper alpine belt *Fagus* pollen dominated significantly over other arboreal species. The absence of large quantities of beech pollen in the soil samples may be explained either by poor preservation of its pollen, or by the impossibility of pollen accumulation due to continuous high winds.

In the Caucasus the amounts of oak pollen in the spectra of mineral formations, both of recent and Holocene age, can also be explained by poor preservation conditions. This low incidence, suggested, however, that pollen productivity of Cauca sian oaks was low when compared with hornbeam (Kvavadze 1993), but the spectra of the pollen traps did not confirm this opinion. The oak pollen influx in oak forest was nearly the same as that of hornbeam in hornbeam forest.

Among the studied taxa which are forest dominants *Fraxinus excelsior* was characterized by the lowest pollen productivity. *Acer velutinum* and *Corylus colurna* also gave low quantities of pollen despite the fact that the latter was tree-like, forming a hazel-grove 15–20 m tall.

Comparison of the pollen influxes of *Fagus, Quercus, Carpinus* and *Tilia* for a whole year (1996–97) suggested that *Fagus orientalis* produced least pollen. By contrast, *Tilia caucasica* was characterized by the highest pollen productivity, which was over represented in the studied spectra compared with its incidence in the coenosis.

A previous conclusion that *Rhododendron flavum* pollen was poorly transported by wind over long distances (Kvavadze & Stuchlik, 1996) was confirmed by the trap material. Its pollen was not even found in places where the trapd were only 5–10 m from rhododendron bushes.

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