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REVUE ROUMAINE DE BIOLOGIE

SÉRIE DE BIOLOGIE VÉGÉTALE

TOME 33 1988 N° 2

juillet—décembre 1988

SOMMAIRE

SOME AMEROSPOROUS AND DIDYMOSPOROUS ASCOMYCETES ON ERICALES IN ROMANIA

ANGHEL RICHIȚEANU * and VERA BONTEA **

Five species of amerosporous and didymosporous *Ascomycetes* occurring on members of the Ericales are reported for the first time in Romania. These fungi are: *Physalospora arctostaphyli* B. Erikss. on *Arctostaphylos uva-ursi* (L.) Spreng., *Lembosina aulographoides* (Bomm., Rouss. et Sacc.) Theiss. on *Arctostaphylos uva-ursi* (L.) Spreng., *Pyrenobotrys conferta* (Fr.) Theiss. et H. Syd. on *Vaccinium oxycoccos* L. subsp. *microcarpum* (Turcz) M. N. Blytt, *Epipolaeum andromedae* (Rehm) von Arx on *Andromeda polifolia* L., and *Polytrichiella polyspora* (Barr) Barr on *Empetrum nigrum* L.

The *Ericales* are inhabited by a specific flora of parasitic and saprophytic microfungi. In this paper there are reported 5 species of amerosporous and didymosporous ascomycetes which occur on leaves, twigs and branches of members of *Ericales*. Three species of *Protoventuria* and a new species of *Epipolaeum* were treated in two previous publications (Richițeanu and Bontea, 1987; Richițeanu and Negrean, 1986).

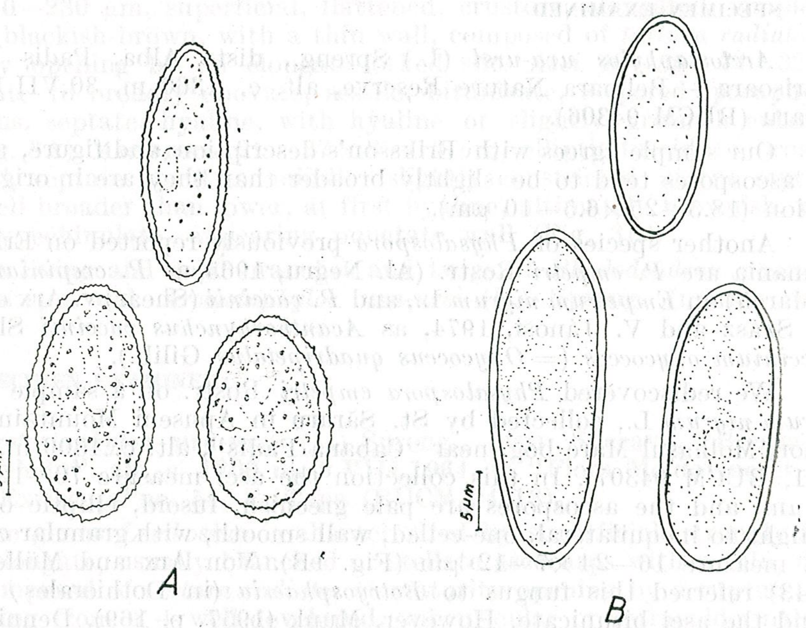

Fig. 1. — A — *Physalospora arctostaphyli* B. Erikss.; B — *Physalospora empetri* Rostr.; ascospores.

The ascomycetes studied were obtained by the examination of plant collections brought from the various regions of the country by several botanists. The hosts examined here were determined by the collectors. Because all of these taxa are new for Romania, detailed descriptions and synonymy are provided. Specimens are deposited and registered in the Mycological Herbarium of the Biological Research Institute, Bucharest (BUCM).

Physalospora arctostaphyli B. Erikss., Svensk. Bot. Tidskr., **68**: 219, 1974.

Ascocarps epiphyllous, scattered, 250–350 µm in diam., globose to conic, immersed, apex erumpent; wall 20–30 µm wide, composed of few layers of yellowish-brown, thin-walled, flattened cells, around the ostiolum of dark-brown, more thick-walled, angular-globose cells, apical canal periphysate. *Asci* 90–120 ×12–25 µm, cylindric to oblong, short stipitate, unitunicate, apical annulus refractive, 8-spored, paraphyses 2–2.5 µm thick, filiform, with slightly enlarged, gelatinized tips. *Ascospores* 15–23 ×(6) 8–16 µm, greenish, elliptic – fusiform to broadly obovoid, straight, one-celled; wall finely roughened, with granular contents (Fig. 1A), uniseriate to partially biseriate in the ascus.

On dead leaves of *Arctostaphylos uva-ursi* (L.) Spreng., Europe (Finland, Norway, Sweden).

SPECIMEN EXAMINED

Arctostaphylos uva-ursi (L.) Spreng., distr. Alba, Padiş Plateau, Scărişoara – Belioara Nature Reserve, alt. c. 1360 m, 30.VII.1971, St. Săraru (BUCM 94306).

Our sample agrees with Eriksson's description and figure, although the ascospores tend to be slightly broader than they are in original collection (18.5–25 ×6.5–10 µm).

Another species of *Physalospora* previously reported on Ericales in Romania are *P. empetri* Rostr. (Al. Negru, 1965, as *P. crepiniana* Sacc. et March) on *Empetrum nigrum* L., and *P. vaccinii* (Shear) v. Arx et Müller (E. Szász and V. Jánosi, 1974, as *Acanthorhynchus vaccinii* Shear) on *Vaccinium oxycoccos* (= *Oxycoccus quadripetalus* Gilib.).

We rediscovered *Physalospora empetri* Rostr. on a sample of *Empetrum nigrum* L., collected by St. Săraru in Apuseni Mountains (distr. Bihor, Molhaşul Mare bog, near "Cabana Padiş", alt. c. 1300 m, 28.VII. 1971, BUCM 94307). In this collection the asci measure 70–120 ×16–24 µm, and the ascospores are pale greenish, fusoid, elliptic or ovoid, straight to inequilateral, one-celled, wall smooth, with granular contents, and measure 16–24 ×7–12 µm (Fig. 1B). Von Arx and Müller (1954, p. 43) referred this fungus to *Botryosphaeria* (in Dothiorales) as they found the asci bitunicate. However, Munk (1957, p. 169), Dennis (1968, p. 258), Barr (1970, p. 392) and B. Eriksson (1974, p. 220) considered it a true *Physalospora* (Sphaeriales). Barr (1970, p. 383) described *Botryosphaeria hyperborea* on the same host from North America, similar in sizes of ascocarps, asci, and ascospores with *Physalospora empetri*.

We examined, too, a sample of *Vaccinium oxycoccos* L., collected by the same colleague (St. Săraru) in the same place, and at the same date (BUCM 94308) and we found *Physalospora vaccinii* (Shear) v. Arx et Müller, a species with a wide distribution both in Europe and North America. It has been reported on various species of *Vaccinium* (*V. macrocarpon*, *V. microcarpon*, *V. oxycoccos*) and also on *Andromeda polifolia* and *Cassandra calyculata*. In our collection the spores are pale yellowish, elliptic to broadly obovoid, wall finely prickled, at times surrounded by a gelatinous coating 3–5 µm wide, and they measure 25–42 ×10–20 µm (Fig. 2). This fungus is certainly identical with *Acanthorhynchus vaccinii* Shear described and illustrated by Szász and Jánosi (1974, p. 51) from Mohoş peat bog (distr. Harghita).

Lembosina aulographoides (Bomm., Rouss. et Sacc.) Theiss., Ann. Mycol. **11**: 437, 1913.

Syn.: *Lembosia aulographoides* Bomm., Rouss. et Sacc., Syll. Fung. **9**: 1107, 1891.
Lembosia copromya Bomm., Rouss. et Sacc., Syll. Fung. **9**: 1107, 1891
Lembosina copromya (Bomm., Rouss. et Sacc.) Theiss., Ann. Myc. **11**: 437, 1913.

Mycelium scarse, subcuticular, composed of brown, septate, 3–4 µm thick hyphae, forming stromatic crusts. *Ascocarps* usually scattered, 300–450 ×180–230 µm, superficial, flattened, crustose, elongated, simple or forked, blackish-brown, with a thin wall, composed of *textura radiata*, at maturity opening by an elongate-forked slit. *Asci* 40–55 × 24–32 µm oval-ovate to broadly obovate, sessile, bitunicate, 8-spored; paraphyses numerous, septate, hyaline, with hyaline or slightly greenish enlarged tips (Fig. 3A). *Ascospores* 21–27 × 8–13 µm, elliptic-fusoid to broadly elliptical, septate about in middle, slightly constricted at the septum, upper cell broader than lower, at first hyaline, ultimately brownish, with minutely echinulate, appearing punctate wall (Fig. 3B).

On living and dead branches and twigs of *Rhododendron ponticum* L., *Tilia* sp., and *Arctostaphylos uva-ursi* (L.) Spreng. (matrix nova, Europe.

SPECIMEN EXAMINED:

Arctostaphylos uva-ursi (L.) Spreng., distr. Suceava, "Breaza, in monte Glodu", alt. c. 1200 m, 9.VIII.1964, in "Flora Moldaviae et Dobrogae Exsiccata"no. 54, E. Ţopa (BUCM 94313).

The genus *Lembosina* is characterized by superficial, strongly flattened, elongate, usually branched or stellate ascocarps with a thin, dark wall, composed of *textura radiata*, at maturity opening by a rupture and originating from a ± well-developed, subcuticular or intraepidermal hypostroma. Its asci, born on a thin basal layer of isodiametrical cells, are bitunicate, broadly ellipsoidal to obovate and contain 1– septate, ellipsoidal ascospores, at first hyaline, then brownish.

According to Müller and von Arx (1962) and von Arx and Müller (1975), *Lembosina* Theiss. belongs to *Leptopeltidaceae*. This family, arranged in Dothiorales by Müller and von Arx (1962), Hemisphaeriales by Luttrell (1973), Dothideales (Dothideineae) by von Arx and Müller (1975) and Myriangiales by Barr (1976), was shown to comprise taxa with unitunicate

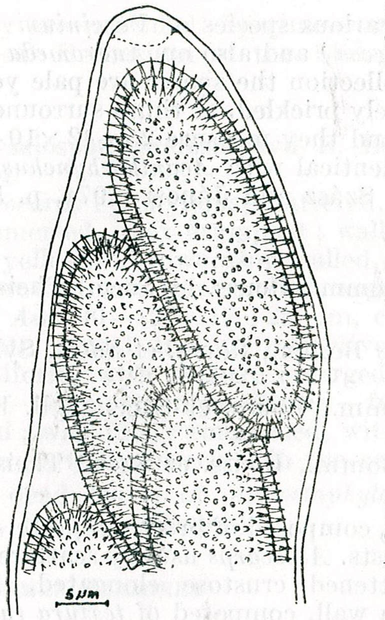

Fig. 2. — *Physalospora vaccinii* (Shear) v. Arx et Müller, ascus ← apex.

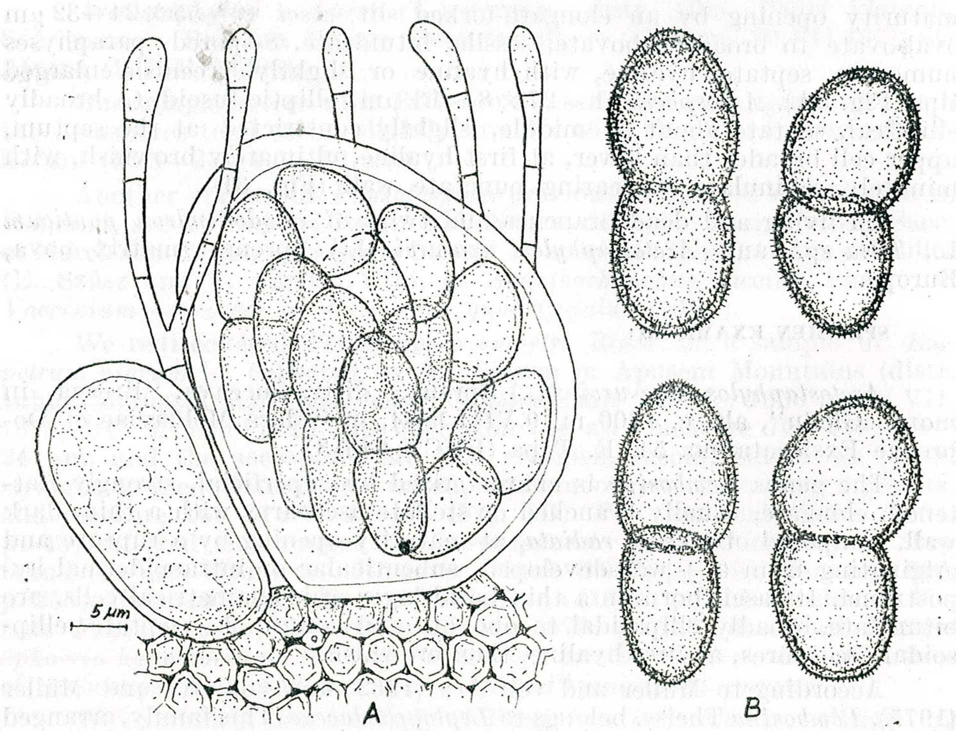

Fig. 3. — *Lembosina aulographoides* (Bomm., Rouss. et Sacc.). Theiss. A — young and mature asci with paraphyses ; B — ascospores.

asci (Holm and Holm, 1973), and is removed from the Loculoascomycetes. Barr (1979) included *Lembosina* in Asterinaceae (Asterinales — Loculoascomycetes).

This genus has a world-wide distribution, but most of the species are found only in the warmer parts of the world. *Lembosina* species have been found on a large number of host families, dicotyledonous as well as monocotyledonous (Müller and von Arx, 1962, pp. 119–124). To our knowledge, four species of this genus have been previously described on members of *Ericales*. The oldest, *Lembosina aulographoides*, is known as saprophytic on branches of *Rhododendron ponticum* L. in Europe (Theissen, 1913, p. 437 ; Müller and von Arx, 1962, p. 119). Because an additional host of this species is *Tilia* sp., the fungus appears to be not restricted to one or a few closely related species of a host genus, or to members of closely related genera.

In 1963 Müller described and illustrated *Lembosina gontardi* as occurring on leaves of *Arctostaphylos uva-ursi* (L.) Spreng., based upon a specimen collected from France, and also mentioned by him from Switzerland. Later, this species has been discovered on the same host in Fennoscandia (Finland, Norway and Sweden) by B. Eriksson (1974, p. 213). Consequently, this fungus seems to be confined to *Arctostaphylos uva-ursi*. The last author (B. Eriksson, 1974, p. 212) has also described two new species of *Lembosina* on members of Ericales, one on twigs of *Empetrum nigrum (L. empetri)* and the other on dead leaves of *Erica cinerea* and *Erica tetralix (L. ericae)*, both species having probably a northern distribution.

Our collection on *Arctostaphylos uva-ursi* agrees in all respects with Theissen and Müller and von Arx's description for *Lembosina aulographoides*, and differs from *L. gontardi* mainly in sizes of ascospores. According to Müller (1963, p. 149), *L. gontardi* has 22–26 × 7–9 µm ascospores, while in our sample the ascospores are evidently broader (21–27 × 8–13 µm). In addition, our fungus shows the ascospores with minutely, but visibly echinulate wall, while in *L. gontardi* the wall surface is completely smooth. Finally, Müller's species appears to be a leaf-spotting parasitic fungus, while we found our species as occurring only as saprophytic on dead twigs. This fungus is very easily overlooked on account of its minute ascocarps, which are dark as the substrate. The genus *Lembosina* is here for the first time reported from Romania.

Pyrenobotrys conferta (Fr.) Theiss. et H. Syd., Ann. Myc., **12** : 182 1914.

Syn. : *Sphaeria conferta* Fr., Syst. Myc., **2** : 435, 1823
Stigmatea conferta (Fr.) Fr., Summa. Veget. Scand. : 421, 1849
Gibbera conferta (Fr.) Petrak, Sydowia, **1**: 200, 1947.

Ascocarps 70–200 µm in diam., superficial, from a foot-like hypostroma, globose, black, thickly grouped in visible areas on lower leaf surface, wall thick, c. 20 µm wide, composed of blackish-brown rows of polygonal cells, externally with numerous setae over upper half of wall; setae 25–70 µm long, 5–8 µm wide near the base, blackish brown, thick-walled, pointed, straight, simple or a few septate. *Asci* 40–65 × 10–15 µm, cylindric, oblong or saccate. *Ascospores* 11–17 × 4–7 µm, olivaceous green, fusoid, elliptical or obovate, straight to inequilateral, 1-septate lower hemispore 2—3 times as long as the upper one, slightly constricted at the septum, wall smooth, becoming finely roughened at maturity (Fig. 4).

On living leaves of *Vaccinium* ssp., Europe, North America.

SPECIMEN EXAMINED:

Vaccinium oxycoccos L. ssp. *microcarpum* (Turcz.) M. N. Blytt, distr. Harghita, Mohoş peat bog, 21.VII.1966, M. Danciu (BUCM 94311).

This genus belongs to *Venturiaceae*. B. Eriksson (1974, pp. 204 and 223—224) stated availability of generic name *Pyrenobotrys* Theiss. et Syd., and discussed this genus in relation to the other relevant venturia-

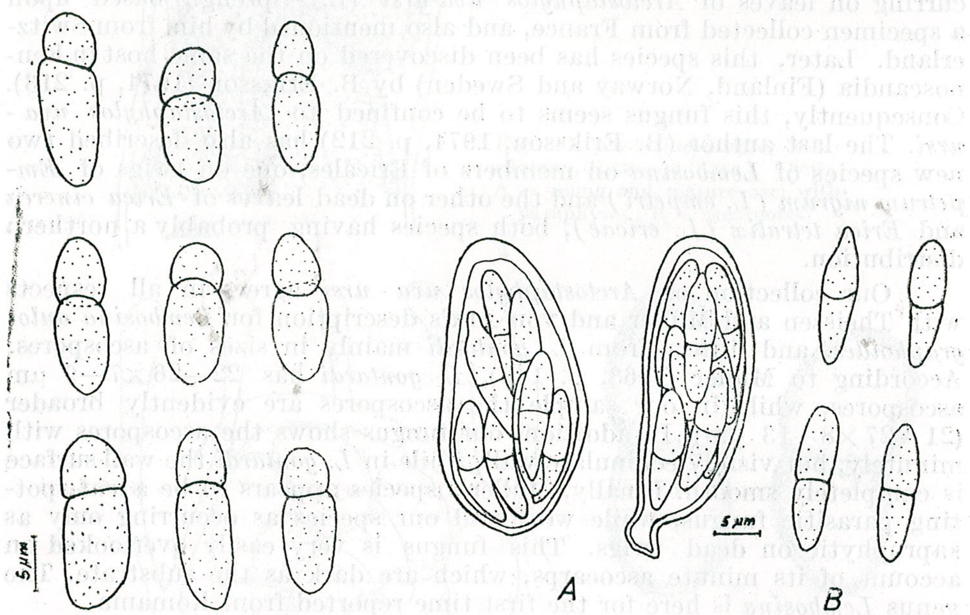

Fig. 4. — *Pyrenobotrys conferta* (Fr.) Theiss. et H. Sydow, ascospores.

Fig. 5. — *Epipolaeum andromedae* (Rehm) v. Arx, A — asci; B — ascospores.

ceous genera. *Pyrenobotrys compacta* (Peck) B. Erikss. (1974, p. 224), known as occurring on various species of *Vaccinium*, both in North America and Europe, is very similar to *P. conferta*. Barr (1968, p. 827) regarded these two species as morphologically indistinguishable.

Epipolaeum andromedae (Rehm) von Arx in Müller and von Arx, Beitr. Kryptogamenfl. Schweiz, **11** (2): 487, 1962.

Syn.: *Stigmatea andromedae* Rehm, Ascomyceten Nr. 542, 1879, and in Nat-Hist. Ver. Augsburg, **26**: 130, 1881.
Epiploca andromedae (Rehm) Klebahn, Haupt. u. Nebenfr. Ascom.: 167, 1918.

Leaf spots none. *Mycelium* reduced to a few superficial, thin-walled, 2.5—3.5 µm wide, brownish, branched hyphae. *Ascocarps* hypophyllous free from each other, 50—90 µm in diam., shining black, globose to depressed, apex opening by an ostiolare pore, 10—20 µm in diam.; wall thin, externally glabrous, *textura angularis*, composed of two or three layers of greyish-brown, isodiametrical cells, 5—7 µm in diam., blackened around the ostiolum. *Asci* 25—35 ×10—15 µm, oblong to saccate, sessile or short stipitate, apex rounded, bitunicate, thickened above, 8—spored (Fig. 5A); pseudoparaphyses sparse, filamentous, hyaline. *Ascospores* 13—16×3—4 µm, fusiform-elliptical, straight to slightly curved, obtuse ends, septate in the middle, not constricted, greyish or yellowish hyaline, wall smooth (Fig. 5B).

Epiphytic on living leaves of *Andromeda polifolia* L., Europe.

SPECIMENS EXAMINED:

Andromeda polifolia L., distr. Suceava, "in sphagnetis ad Poiana Stampei", alt. c. 900 m, 28.VIII.1936, G. P. Grinţescu in "Flora Romaniae Exsiccata" nr. 5816 (BUCM 94309); "in turfosis and Poiana Stampei" 11.VIII.1964, E. Ţopa in "Flora Moldaviae et Dobrogae Exsiccata" nr. 155 (BUCM 94310).

This genus belongs to the *Dimeriaceae* von Arx et Müller (1975, p. 104), including epiphytic fungi (usually on leaves) with a quite superficial mycelium. The ascocarps are thin-walled, smooth or provided with setae or hyphae; the ascospores are hyaline, greenish or brownish, usually 1-septate. Until now are known about 30 species of *Epipolaeum* recorded from a wide range including both Gymnospermae and Angiospermae. Only two species have hitherto been found in Romania: *E. hippophaes* O. Constantinescu et G. Negrean on *Hippophaë rhamnoides* L. subsp. *carpatica* Roussi (Constantinescu and Negrean, 1983), and *E. bruckenthaliae* A. Richiţeanu et G. Negrean on *Bruckenthalia spiculifolia* (Salisb.) Rchb. (Richiţeanu and Negrean, 1986). *E. andromedae* appear to be the third species reported from Romania.

Polytrichiella polyspora (Barr) Barr, Contr. Univ. Mich. Herb., **9**: 617, 1972.

Syn.: *Herpotrichiella polyspora* Barr, Contr. Inst. Bot. Univ. Montréal, **73**: 29, 1959.

Ascocarps 60—110 µm in diam., globose to conical, superficial, seated on a thin brown subiculum, scattered to gregarious, setose over upper wall; setae 23—45 µm long, 3.5—6 µm wide near base, blackish-brown pointed, straight or curved, simple or septate; wall thin, 9—13 µm wide, composed of two or three layers of polygonal cells, light brown below, blackened toward apex. *Asci* 55—75 ×11—18 µm, oblong to saccate, bitunicate, short, stipitate thickened above, polysporous (apparently 64), aparaphysate (Fig. 6A). *Ascospores* 8—13×3—4.5(—6) µm, greenish hyaline when young, olive-grey to olivaceous when mature, ellipsoidal to fusoid, ends rounded or obtusely pointed, straight to inequilateral, 1-septate (rarely 2-septate), slightly constricted at the septum, wall smooth (Fig. 6 B).

On dead leaves and twigs of *Calluna vulgaris* (L.) Hull, *Cassiope tetragona* (L.) D. Don, and *Empetrum nigrum* L., North America, Europe. Barr (1959, p. 29) reported also *P. polyspora* as saprophytic on fruiting bodies of *Leptosphaeria hyperborea* and *Wettsteinina andromedae* in the leaves.

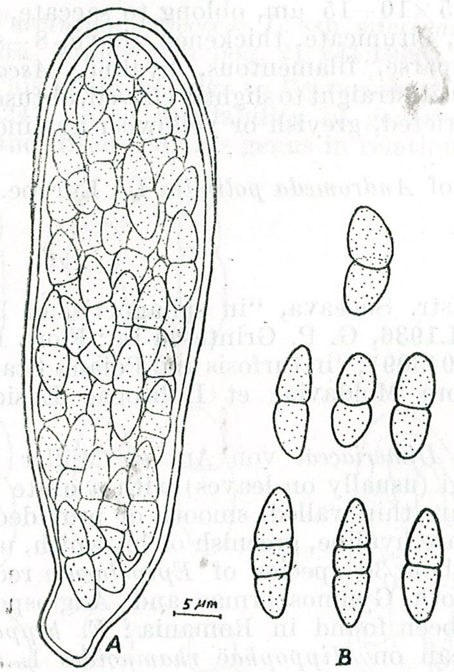

Fig. 6. — *Polytrichiella polyspora* (Barr) Barr. A — ascus ; B — ascospores.

SPECIMEN EXAMINED:

Empetrum nigrum L., distr. Vîlcea, Mt. Paring near lake Cilcescu, alt. c. 2000 m, 20.VIII.1960, Al. Buia, C. Maloș, and M. Păun (BUCM 94312).

The genus *Polytrichiella* was erected by Barr (1972, p. 616) to accommodate *Herpotrichiella polyspora* Barr (1959, p. 29), described originally from Labrador, on *Cassiope*. This species deviates from the generic diagnosis in having polysporous asci (as in *Capronia*) but the ascospores resemble those of species of *Herpotrichiella*.

Polytrichiella belongs to *Herpotrichiellaceae*, a family established by Munk (1953), for *Herpotrichiella* and some closely related genera. He stressed as characteristic the minute size and often hypersaprobic nature of the ascocarps, as well as the dull greyish or olivaceous brown colors of the wall and of the ascospores. According to von Arx and Müller (1975), "the Herpotrichiellaceae differ from all other bitunicate ascomycetes by the elongated part of the asci and by the dark, short setae or protuberances covering the ascomata". However, species of *Polytrichiella* can be easily

mistaken for a *Protoventuria*. The absence of a well developed basal hypostroma and the presence of polysporous asci in *Polytrichiella* can be regarded as reliable characters for generic separation. A correct identification requires a careful microscopic examination.

Only three species are known as belonging to this genus (Barr, 1972, p. 617). One of them, *P. polyspora*, has also been reported by B. Eriksson (1974, p. 211) as occurring on *Calluna* in Finland, and on *Empetrum* in Finland, Norway and Sweden. It seems to be of common occurrence in the northern and in alpine regions.

Our collection agrees in all respects with descriptions in the literature (Barr, 1959, 1961, 1972 ; B. Eriksson, 1974) except for the number of ascospores in the ascus (32 in original Barr's description, apparently 64 in our sample). Despite the discrepancy noted, we have no doubt of the identity of this fungs.

In our collection *P. polyspora* is associated with *Protoventuria varisetosa* (Barr) Barr.

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Received February 26, 1986

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TWO NEW PLANT ASSOCIATIONS

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In this paper two new vegetal associations are described : *Eragrostio (poaeoidis)-Panicetum capillaris* nov. ass., a ruderal association growing on the stony soil along the railways and *Kochio (laniflorae)-Secalietum silvestris* nov. ass., a psammophyte association growing on fluvial sands.

1. *Eragrostio (poaeoidis)-Panicetum capillaris* nov. ass. (Foed. *Eragrostion* Tx. 50 ; Ord. *Eragrostetalia* J. Tx. 61 ; Cl. *Chenopodietea* Br.-Bl. 51 ; Table 1 ; nomenclatural typus : relevé no. 7).

Table 1

Eragrostio (poaeoidis) — Panicetum capillaris nov. ass.

Number of relevé/constance (K)	1	2	3	4	5	6	7	8	9	10	K
Total estimate/coverage %	70	65	75	65	60	60	60	60	75	80	
Charact. ass. / (A+D)											
Panicum capillare	4	3	4	3	2	3	3	3	3	4	V
Eragrostis poaeoides	+	1	+	2	3	+	1	+	+	+	V
Erigeron canadensis	+	+	+	+	+	1	1	1	1	1	V
Eragrostion											
Amaranthus blitoides	+	—	+	+	+	+	+	+	+	+	V
Eragrostis pilosa	—	—	—	—	—	+	—	—	+	—	I
Eragrostetalia											
Amaranthus albus	+	+	—	—	—	—	+	—	—	—	II
Convolvulus arvensis	—	—	+	—	+	—	+	—	—	—	II
Cynodon dactylon	+	+	+	—	—	+	+	+	+	+	IV
Digitaria sanguinalis	+	+	+	+	+	+	+	+	+	+	V
Diplotaxis muralis	—	—	—	—	—	—	—	+	+	—	I
Portulaca oleracea	+	—	—	—	—	+	+	—	—	—	II
Salsola kali ssp. *ruthenica*	—	—	—	—	—	+	+	+	—	—	II
Chenopodietea											
Agropyron repens	+	—	—	—	—	—	—	—	—	—	I
Amaranthus crispus	+	—	+	+	+	—	—	—	—	—	II
Amaranthus deflexus	—	—	+	—	—	—	—	—	—	—	I
Amaranthus hybridus	+	—	+	+	+	—	—	—	—	—	II
Amaranthus retroflexus	—	—	—	+	+	+	+	+	1	+	IV
Artemisia annua	—	—	—	—	—	—	—	+	+	+	II
Atriplex oblongifolia	+	—	+	—	—	—	—	—	—	—	I
Atriplex patula	+	—	+	+	+	—	—	—	+	+	III
Atriplex tatarica	+	+	+	+	+	+	+	—	—	—	IV
Bilderdykia convolvulus	+	—	+	+	+	+	—	—	—	—	II
Brachyactis ciliata	—	—	—	—	—	—	—	—	+	—	I
Bromus sterilis	—	—	—	—	—	+	+	—	—	—	I
Capsella bursa pastoris	—	—	—	—	+	—	—	—	—	—	I
Cardaria draba	—	—	—	—	—	+	—	—	—	—	I
Chenopodium album	+	—	+	—	+	—	—	+	+	+	III
Chenopodium hybridum	—	+	—	+	—	—	—	—	—	—	I
Chenopodium murale	+	—	—	—	—	—	—	—	—	—	I

Cichorium intybus	—	—	—	—	—	—	—	—	+	+	I
Echinochloa crus-galli	—	—	—	+	—	—	—	—	—	—	I
Hordeum murinum	+	—	—	—	—	—	—	—	—	—	I
Lepidium ruderale	—	—	—	—	+	—	—	+	+	+	II
Matricaria chamomilla	—	+	—	—	—	—	—	—	—	—	I
Polygonum aviculare	+	—	+	+	+	—	—	+	+	+	IV
Polygonum lapathifolium	—	—	+	—	—	—	—	—	—	—	I
Senecio vulgaris	—	—	—	—	—	—	—	—	+	+	I
Setaria lutescens	+	+	—	+	+	—	—	+	+	+	IV
Setaria verticillata	+	+	+	+	+	—	—	—	—	—	III
Sisymbrium officinale	+	—	—	—	—	—	—	—	—	—	I
Taraxacum officinale	—	—	—	—	—	+	+	+	+	—	II
Tripleurospermum inodorum	—	—	—	—	—	—	—	+	+	—	I
Xanthium spinosum	—	—	—	—	—	—	—	—	+	—	I
Festuco-Brometea											
Achillea setacea	—	+	—	—	—	+	+	+	+	+	III
Arenaria serpyllifolia	—	—	—	—	—	+	+	—	—	—	I
Asperula humifusa	—	—	—	—	—	+	+	—	—	—	I
Berteroa incana	—	—	—	—	—	+	+	—	—	—	I
Crepis foetida ssp. rhoeadifolia	—	—	—	—	—	+	+	—	—	—	I
Plantago lanceolata	—	—	—	—	—	+	+	—	—	—	I

Locality and date of relevées : 1. Rîmnicu Sărat, district Buzău (28.VII.1981). 2. idem (20.VII.1984). 3. idem (30.IX.1983). 4. idem (4.VIII.1987). 5. idem (4.VIII.1987). 6. Hanu Conachi, district Galaţi (20.VIII.1987). 7. idem (20.VIII. 1987). 8. Vaslui, district Vaslui (20.VIII. 1987). 9. Podu Iloaiei, district Iaşi (18.IX.1986). 10. idem (18.IX.1986).

It is a ruderal association growing along the railways, especially on the stony soil between the rails in the stations. This anthropogenous habitat has a skeletal substratum formed by the broken rocks with a rich content of cinder, ashes and coal. According to V. Jehlik (2), the soil formed in these conditions is discontinuous, of low acidity, the ground water is not accessible and the temperature is higher than that of the normal soils from the surroundings, because of its dark colour. This fact favoured by circumstances goes to the spread of some southern thermofilous plants along the railways. At the same time, due to the human activities in the stations and the good stores surroundings, there are spread various diaspores of some adventitious or cosmopolitan plants and the vegetation is discontinuous and unstably disturbed.

Actually, the analysis of life forms of synanthropic associations indicates that 76 % of these species are therophytes, 12 % hemicryptophytes, 6 % therohemicryptophytes and only 6 % geophytes. That is why the phytocoenoses have a reduced phytocoenotical stability and a floristic composition which is unhomogeneous. The phytogeographical analysis shows that over the basic background of the eurasiatic (40 %) and circumpolare (4 %) species, which have a small constancy, cosmopolitan (26 %) and adventitious (22 %) plants invaded this biotope. These plants have higher ecological exigencies and they are easily adaptable at the stony habitat on the railways. Very few pontic (4 %) and submediterraneous (4 %) species appeared here, but they have a low frequency. All the localities where this association was identified are situated in the forest steppe with an average annual temperature of 9.2 to 10.5 °C and average annual

Table 2

Kochio (laniflorae) — Secalietum silvestris nov. ass.

Number of relevé/constance (K)	1	2	3	4	5	K
Total estimate/coverage %	70	70	60	60	70	—
Charact. ass. / (A+D)						
Kochia laniflora	2	3	2	2	3	V
Secale silvestre	3	2	2	2	2	V
Festucion vaginatae	+	+	+	+	+	V
Achillea ochroleuca	+	+	+	+	+	V
Centaurea arenaria	+	+	+	+	+	V
Polygonum arenarium	+	+	—	+	+	IV
Stachys recta ssp. nitens	+	+	+	+	+	V
Festucetalia vaginatae						
Allium flavescens ssp. flavescens	+	+	—	+	—	III
Corispermum nitidum	—	+	+	—	+	III
Euphorbia seguieriana	+	+	+	+	+	V
Lithospermum arvense ssp. glandulosum	—	+	—	+	—	II
Myosotis stricta	—	+	—	+	+	III
Syrenia cana	+	+	—	+	—	III
Veronica praecox	—	+	+	+	+	IV
Festucetea vaginatae						
Agropyron cristatum ssp. dunensis	+	—	+	+	—	III
Alyssum desertorum	+	—	—	—	+	II
Chondrilla juncea	+	—	+	+	—	III
Koeleria glauca ssp. glauca	+	—	+	+	+	IV
Minuartia viscosa	—	—	—	+	+	II
Plantago indica	+	+	+	+	+	V
Tribulus terrestris	+	—	+	—	+	III
Festuco-Brometea						
Berteroa incana	+	—	—	+	—	II
Euphorbia cyparissias	+	—	—	—	+	II
Hypericum elegans	+	—	—	—	+	II
Linaria genistifolia ssp. dalmatica	+	—	+	—	+	III
aliae						
Cuscuta campestris (on *Centaurea arenaria*)	+	—	—	—	+	II
Digitaria sanguinalis	+	—	+	+	—	III
Eragrostis poaeoides	+	+	—	—	+	III
Thalictrum minus	+	—	—	—	—	I

Locality and date of relevées : 1. Hanu Conachi, district Galaţi (9. VIII.1986). 2. idem (9.VIII.1986). 3. idem (20.VIII.1987). 4. Lieşti, district Galaţi (16.VIII.1982). 5. Iveşti, district Galaţi (20.VIII.1987).

precipitations varying between 400 mm (Hanu Conachi) and 562 mm (Rîmnicu Sărat). The altitudes of the stations vary between 125 m (Rîmnicu Sărat), 90 m (Vaslui and Podu Iloaiei) and 30 m (Hanu Conachi).

2. *Kochio (laniflorae)-Secalietum silvestris* nov.ass. (Foed. *Festucion vaginatae* Soó 29 ; Ord. *Festucetalia vaginatae* Soó 56 ; Cl. *Festucetea vaginatae* Soó 68 em. Vicherek 72 ; Table 2 ; nomenclatural typus : relevé no. 4).

It is a psammophyte association growing on the fluvial sands, unestablished, especially at the margin of *Robinia pseudacacia* plantations or in the lighty clearings of these plantations being 30–40 years old, they came into being for the establishment of sands dune. According to C. Chiriţă (1), these psammosoils are formed of fine sand : over 70 % from quartz particles having 0.2–0.02 mm size, with pH = 5.4, humus content = 0.14–0.83 % and a capacity of retaining water = 19.2–22.5 % of the weight. Phreatic water is deeper than 7 m. The sands microclimate from Iveşti-Lieşti-Hanu Conachi (where there is a botanical reserve too) is equal to the semidesert one, with a high albedo and an average temperature of 24.4 °C in July (that in hot days can be of 50–70 °C) ; the average annual precipitations are under 400 mm, and the interval without precipitations is of 80–100 days. That is why at 25–30 cm depth the sand is almost permanently dry. The altitudes of habitats vary between 30–50 m. Phytocoenoses are spread on surfaces of 50–250 m² and they are formed by 20–30 species predominantly psammophyte among which 20 species have the constancy of a value between V–III. The life forms analysis shows that 52 % are therophytes, 41 % are hemicryptophytes, 4 % are therohemicryptophytes and 3 % are geophytes. After the phytogeographical origin the majority of them are eurasiatic (48.3 %), 24.1 % are pontic, 13.8 % are submediterraneous or ponto-mediterraneous, 10.3 % are cosmopolitan and only 3.4 % are adventitious. Being watched for 5 years (1982–1987) this association has proved a constant stability in the preferred biotope.

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Received January 22, 1988

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PHYTOCOENOLOGICAL CONSIDERATIONS ON THE *QUERCUS CERRIS* L. AND *Q. FRAINETTO* Ten. FORESTS OF OLTENIA

GH. POPESCU

The vegetal associations in which the two submesophylic-thermophylic species play an important phytocoenotic role are presented. They are widely spread between 110 (130) and 530 m altitude. Certain associations are re-considered from the viewpoint of nomenclature (*Quercetum polycarpae-cerris, Quercetum frainetto-polycarpae*), while *Quercetum robori-frainetto* is described as a new association. Certain subvariations in *Quercetum frainetto-cerris* and *Quercetum polycarpae-cerris* associations are described on ecologic and floristic bases. For each association or subassociation lists of species, ecologic data and spreading within the investigated zone and in Romania are given.

The two species of submesophylic-xerophylic oak trees, *Quercus cerris* L. and *Q. frainetto* Ten., are widely spread throughout Oltenia (district Dolj, Gorj, Mehedinţi, Olt and Vilcea). Depending on certain phytohistorical as well as present climate and soil factors, associated with anthropogenic * influences, these two species make up pure or mixed phytocoenoses or are part of other plant communities in the higher plain of Oltenia up to the Subcarpathian Hills at 110 (130)–450 (530) m altitude. Mixed forests of those consisting mainly of one of the two species which have been mostly studied are better known as far as floristics, habitat and geographical distribution (between the Carpathians, the Danube and the river Olt) are concerned. Important data on the abovementioned plant communities were published by C. C. Georgescu (1941, 1945), C. C. Georgescu et Constantinescu (1945), A. Buia, M. Păun (1957), M. Păun (1966, 1977), N. Roman (1974), Gh. Popescu et al. (1980) and others.

Having expanded our investigations on the phytocoenological role of the two species in other plant communities from the Getic Plateau and Subcarpathian Hills (between 1975–1987), we may say that the two species have an important part in the following plant associations included in the phytocoenological system (P. Jakucs, 1960 ; R. Soó, 1968 ; W. Rothmaler, 1978 ; V. Sanda et al., 1979).

QUERCETEA PUBESCENTI-PETRAEAE (Oberd. 1948) Jakucs 1960
(xerothermal forests in Eastern and Central Europe)
Orno-Cotinetalia Jakucs 1960
Quercion fraientto – I. Horv. 1954 cerr. Soó 1960
1. *Quercetum frainetto-cerris* Georg. et Const. 1945 apud Paşc. et Leandru 1958

* Preferential culling of the *Quercus frainetto* whose wood is harder and more resistant in opposition with *Q. cerris* whose wood is softer containing much alburn and is more subject to putrefaction.

2 – c. 2435

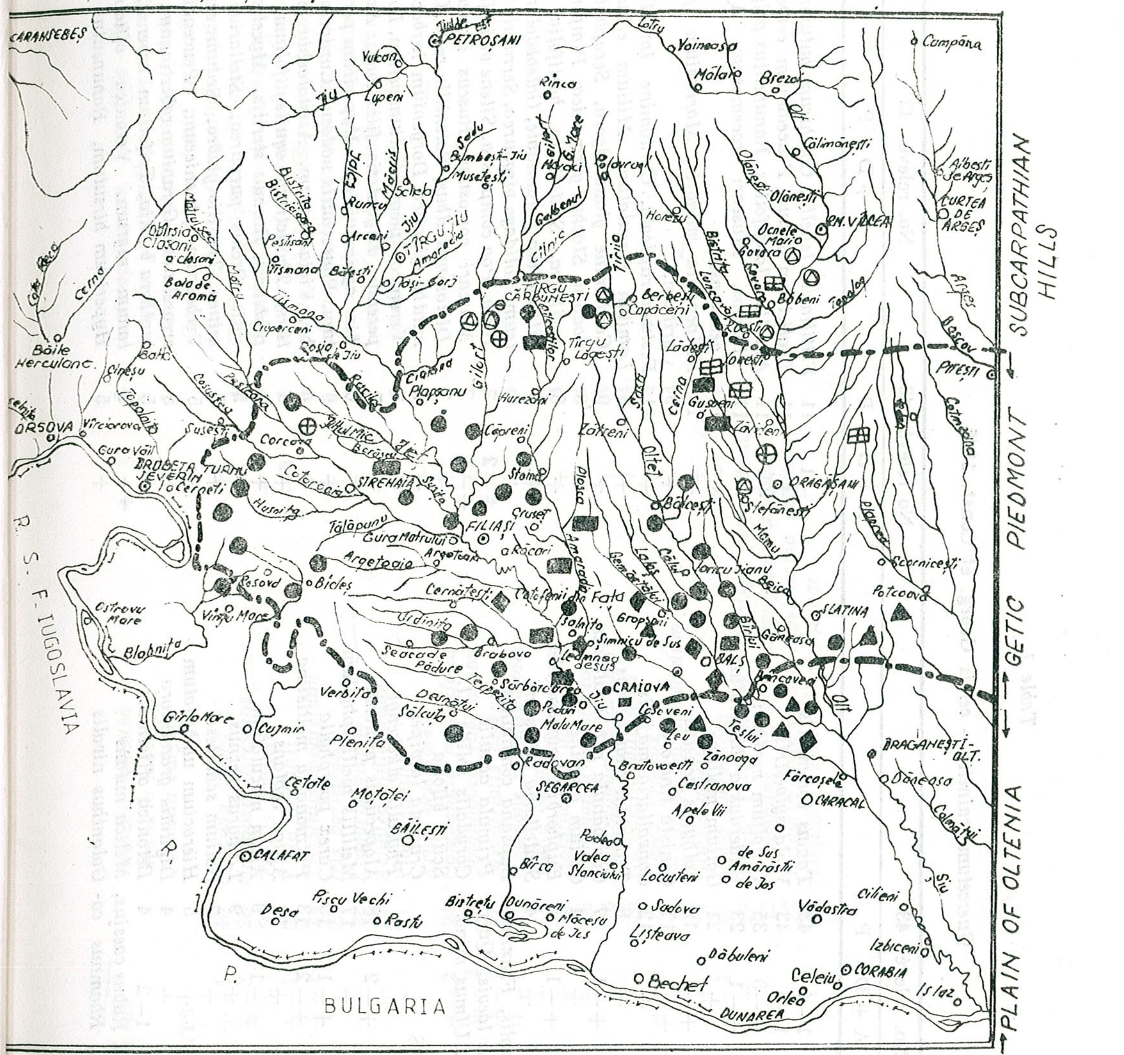
2. *Quercetum cerris* Georg. 1941
3. *Quercetum frainetto* Păun 1964, 1966
   Quercetalia petraeae-pubescentis Jakucs 1960
   Quercion petraeae Zoly. et Jakucs 1957
4. *Quercetum polycarpae-cerris* nom. nov (syn. *Quercetum cerris polycarpicae* Georg. et Const. 1945 apud Pasc. et Leandru 1958, ? *Quercetum petraeae-cerris* Soó 1957
   — *quercetosum*
   (Nomenclature type : Table 2 A, relevé, 8)
   — *fagetosum moesiacae* nova subass.
   (Nomenclature type : Table 2 B, relevé, 2)
   — *carpinetosum orientalis* nova subass.
   (Nomenclature type : Table 2 C, relevé, 6)
5. *Quercetum robori-cerris* Csapody ex Soó 1969
6. *Quercetum robori-frainetto* nova ass.
   (Nomenclature type : Table 4, relevé, 1)
7. *Quercetum frainetto-polycarpae* nom. nov. (syn. *Querco (petraeae)*-Carpinetum Soó et Pocs 1957 *frainettosum* Gh. Popescu 1974, 1975.

Description of Associations

1. *Quercetum frainetto-cerris* Georg. et Const. 1945. The forests consisting of the two species of xerophylic-submesophylic oak trees are the most interesting plant communities as far as physiognomic and horizontal and vertical floristics are concerned. Geographically they are largely distributed in the northern part of the high plain of Oltenia as well as in the middle and southern part of the Getic Piedmont, between 140 and 275 m altitude (Fig. 1). The area of these forests coincides, as a whole, with the distribution of the reddish-brown soil. Although forests of low productivity (16), usually situated in the vicinity of rural or urban localities, they are worth mentioning because of their complex protective, sanitary, esthetic, antierosive and scientific functions. To the data already published in literature (10, 11, 15) here we report our studies on the following forests, distributed in : *the Dolj District* : forests : Fralostita and Filiaşi ; Mihăiţa, Obedin, Radovan, Bucovăţ, Cîrligei-Palilula ; Ciutura, Criva, Sopot (forest Vălceaua lui Mihai) ; Leamna, Gogoşu-Ştefănel in forest Galbena ; Melineşti-Bodăeşti in forest "Melineasca" ; Fărcaşu (forest Valea Stanului and Udrica) ; Predeşti-Pleşoi (forest Găbriţa and Brăceni) ; Brabova (forest Mitrică Barbu) ; *the Olt District* : forests Albota and Sarului ; the *Gorj District* : Corneşti, Comăneşti, Daia, Coşani, Tg. Cărbuneşti, Ticleni, Stoina, Peşceana-Bîlteni ; forest Tunşi between Ticleni and Tg. Cărbuneşti ; *the Vîlcea District* : Tepeşti (forest "La Cismaru") ; Bălceşti-Goruneşti (forest Ursoi) ; *the Mehedinţi District* : Corlăţel (forest Fulga), Balota, Corcova, Rogova (forest Vlădaia), Halînga, Bîcleş, Dealul Viilor, Drobeta Tr. Severin (forest Muşa).

Although in the floristics there are various species, especially herbaceous plants (Table 1), a number of frequently recurring species characterize the forests of Oltenia : *Lithospermum purpureo-coeruleum*, *Lychnis coronaria*, *Peucedanum cervaria*, *Lathyrus niger*, *Potentilla micrantha*, *Asparagus tenuifolius*, *Helleborus odorus*, and not so frequently : *Acanthus lon-*

The spreading of vegetal associations in Oltenia



OLTENIA

● *Quercetum frainetto-cerris* Georg. et Const. 1945
▲ *Quercetum frainetto* Păun 1964
◆ *Quercetum cerris* Georg. 1941
■ *Quercetum polycarpae-cerris* nom. nov.
⊕ *Quercetum robori-cerris* Csapody ex Soó 1969
⊞ *Quercetum robori-frainetto* nova ass.
⊗ *Quercetum frainetto-polycarpae* nom. nov.

Table 1

Quercetum frainetto — cerris Georg. et Const. 1945

	No. relevé 43			No relevé 43	
TREES	A + D	P		A + D	P
Quercus cerris	1–4	43	*Tamus communis*	+–1	11
Quercus frainetto	1–5	43	*Viola sylvestris*	+	11
Crataegus monogyna	+–3	35	*Trifolium medium*	+	11
Acer campestre	+–1	23	*Bilderdykia dumetorum*	+	11
Pyrus pyraster	+	21	*Galium mollugo*	+	11
Acer tataricum	+–1	19	*Lathyrus venetus*	+	11
Fraxinus ornus	+–1	17	*Genista tinctoria*	+	9
Ulmus glabra	+	12	*Convallaria majalis*	+	11
Carpinus betulus	+	8	*Teucrium chamaedrys*	+	9
Quercus polycarpa	+–1	7	*Campanula rapunculoides*	+	9
Malus sylvestris	+	4	*Galium aparine*	+	8
Tilia tomentosa	+–1	4	*Euphorbia amygdaloides*	+	8
Crataegus pentagyna	+	4	*Scutellaria altissima*	+	8
In 1–3 relevés : *Carpinus orientalis, Fraxinus excelsior, Tilia platyphyllos, Ulmus laevis, Quercus corcyrensis, Sorbus torminalis, Ulmus minor.*			*Lapsana communis*	+	8
			Primula acaulis	+–2	7
			Corydalis solida s.l.	+–1	7
			Scilla bifolia	+	7
SHRUBS and SHRUBLETS			*Cruciata laevipes*	+	7
			Physalis alkekengi	+	7
Cornus mas	+–2	18	*Alopecurus pratensis*	+	7
Sorbus domestica	+	17	*Melittis mellisophyllum*	+	6
Prunus spinosa	+–1	15	*Carex polyphylla*	+	6
Ligustrum vulgare	+–2	13	*Pulmonaria mollisima*	+	6
Rosa gallica	+	13	*Ajuga reptans*	+	6
Quercus frainetto (juv.)	+–1	9	*Arum maculatum*	+	6
Viburnum lantana	+	9	*Lathyrus vernus*	+	5
Euonymus europaeus	+	7	*Galium schultesii*	+	5
Euonymus verrucosa	+	5	*Hieracium umbellatum*	+	5
Rosa corymbifera	+	4	*Digitalis grandiflora*	+	5
Quercus cerris (juv.)	1–2	4	*Betonica officinalis*	+	5
In 1–3 relevés : *Frangula alnus, Rubus caesius,*			*Melica nutans*	+	5
Hedera helix, Cytisus leucotrichus, Rhamnus ca-			*Galanthus nivalis*	+	5

No. relevé 43 — A + D P

Fritillaria tenella, Colchicum autumnale, Thalictrum minus, Peucedanum cervaria, Acanthus longifolius, Ranunculus polyanthemos, Muscari racemosum, Ajuga genevensis, Filipendula vulgaris, Marrubium peregrinum, Festuca rupicola, Cardamine impatiens, Lamium maculatum, Milium effusum, Cardamine glanduligera, Scrophularia nodosa, Stachys germanica, Pimpinella saxifraga, Scutellaria hastifolia, Ornithogalum pyramidale, Galeobdolon luteum, Solidago virgaurea, Serratula tinctoria, Poa compressa, Silene viridiflora, Muscari comosum, Ruscus aculeatus, Dictamnus albus, Potentilla recta, Calamintha sylvatica, Dorycnium herbaceum, Veronica spicata, Galium verum, Lolium perenne, Dryopteris filix-mas, Aremonia agrimonioides, Hypericum perforatum, Physocaulis nodosus, Cardaria draba, Vicia sepium, Aristolochia clematitis, Thalictrum aquilegiifolium, Poa pratensis, Bromus sterilis, Mycelis muralis, Orchis purpurea, Stellaria graminea, Turritis glabra, Sedum cepaea, Verbascum phoeniceum, Peucedanum oreoselinum, Geranium robertianum, Platanthera bifolia, Trifolium arvense, Solanum nigrum, Veronica officinalis, Hypericum hirsutum, Ranunculus cons-

thartica, Clematis vitalba, Cytisus albus,			*Stellaria holostea*	+–1	5
Acer tataricum (juv.)			*Stellaria media*	+	5
HERBACEOUS PLANTS			*Prunella vulgaris*	+	4
Heleborus odorus	+–1	40	*Cruciata glabra*	+	4
Festuca heterophylla	+–3	28	*Oryzopsis virescens*	+	4
Lathyrus niger	+	27	*Torilis arvensis*	+	4
Geum urbanum	+–1	26	*Viola jordanii*	+–2	4
Polygonatum latifolium	+–1	24	*Trifolium montanum*	+	4
Chrysanthemum corymbosum	+	23	*Iris variegata*	+	4
Lychnis coronaria	+	22	*Fragaria viridis*	+	4
Potentilla micrantha	+	21	*Achillea millofolium*	+	4
Glechoma hirsuta	+	21	*Viola canina*	+	4
Lithospermum purpureo coeru-			*Arum orientale*	+	4
leum	+–2	21	*Campanula persicifolia*	+	4
Corydalis bulbosa. s.l.	+–2	21	*Symphytum tuberosum*	+	4
Fragaria vesca	+–1	20	*Mercurialis perennis*	+–1	4
Poa nemoralis	+–1	19	*Anemone ranunculoides*	+	4
Asparagus tenuifolius	+	18	*Inula conyza*	+	
Viola odorata	+	18	*Ranunculus auricomus*	+	4
Viola alba	+	16	*Agrimonia eupatoria*	+	4
Dactylis polygama	+	16	*Peucedanum alsaticum*	+	4
Cynanchum vincetoxicum	+	16	*Cardamine bulbifera*	+	4
Ficaria verna	+–3	14	*Carex praecox*	+	4
Calamintha vulgaris	+	14	*Ornithogalum umbellatum*	+	4
Viola elatior	+	14	*Crocus moesiacus*	+	4
Brachypodium sylvaticum	+–1	13	*Vicia sparsiflora*	+–1	4
Verbascum nigrum	+	13	In 1–3 relevés : *Thalspi perfoliatum,*		
Galium pseudaristatum	+	12	*Cardamine hirsuta, Eryngium campestre,*		
Alliaria petiolata	+	12	*Lathyrus halersteinii, Lysimachia punctata,*		
Veronica hederifolia	+–1	12	*Digitalis lanata, Vinca minor*		
Melica uniflora	+–1	11			

tantinopolitanus, Potentilla alba, Astragalus glycyphyllos, Agropyron repens, Althaea cannabina, Lathyrus tuberosus, Carex tomentosa, Inula hirta, Euphorbia lingulata, Campanula rapunculus, Trifolium alpestre, Erigeron annuus, Isopyrum thalictroides, Lysimachia nummularia, Sedum maximum, Carex digitata, Neottia nidus-avis, Pulmonaria officinalis, Senecio jacobaea, Silene vulgaris, Vicia lathyroides, Lepidium campestre, Veronica spicata, Parietaria officinalis, Cleistogenes serotina.

gifolius (forests : Obedin, Radovan, Criva) ; *Nectaroscordum siculum* (forest Galbena, Ştefănel-Gogoşu). All the above-mentioned species are differential for the *subass. lithospermetosum* nova subass.

On the sunny Southern slopes, *Carpinus orientalis* (forests Bucovăţ-Leamna, Palilula, Cîrligei) also grows, phytocoenoses attributed to the *subass. carpinetosum orientalis*, of large distribution in our country. As a consequence of the influence of the temperate-continental climate in the exterior of the Carpathian Arch, compared to the temperate-oceanic climate within the Carpathian Arch (4), these species reflect the more xerophilic character of the plant associations in Oltenia ; therefore several sub-associations are distinguished within this large association (12, 19).

2. *Quercetum cerris* Georg. 1941. *Quercus cerris* rarely makes up pure stands in the plain of Oltenia or on the low hills (150–260 m altitude), on the inferior course of the river Olteţ at Vulpeni, Călui, Curtişoara, Cotmeana, Vîrtina, Gropşani, Mărgăriteşti, Popînzăleşti, Dobridor the district of Olt (11). As we have already seen in the study of the Drocaia Forest at Gogoşu (district of Dolj) the pure *Quercus cerris* stands favour a very rich substand and the basal diameter of the *Quercus cerris* trees is betwén 0.30–0.80 m. The floristic composition of this forest on two relevés is the following : TREES : *Quercus cerris* 2–4 ; *Q. frainetto* + ; *Acer campestre* + ; *Crataegus monogyna* 1–2 ; *Fraxinus angustifolia* +1 ; *Ulmus glabra* +. In 1 relevé : *Tilia tomentosa, Ulmus minor, Fraxinus ornus, Carpinus betulus*. SHRUBS : *Cornus mas* + ; *Ligustrum vulgare* +. In 1 relevé : *Quercus cerris* (juv.) 1–3 ; *Q. frainetto* (juv.) + ; *Acer campestre* (juv.) + – 1. HERBACEOUS PLANTS : *Lithospermum purpureo-coeruleum* (1–2) ; *Erysimum cuspidatum, Melica uniflora, Lamium galeobdolon, Lathyrus venetus, Helleborus odorus, Glechoma hirsuta, Galium pseudaristatum, Dactylis polygama, Fragaria vesca, Brachypodium sylvaticum, Poa nemoralis, Carex polyphylla, Geum urbanum, Viola alba.*

3. *Quercetum frainetto* Păun 1964. The association was described for the district of Olt in the places called Curtişoara, Gropşani, Mărgăriteşti, Horezu, between 110–150 m altitude (11). I have found only two forests Ghimpeţeanca, (Olt district) and Forest Maşu-Coşoveni, (Dolj district) in which *Quercus frainetto* dominates exclusively : TREES : *Quercus frainetto* 5 (4 relevés). *Pyrus pyraster* + (4 relevés) ; *Crataegus monogyna* + (4 relevés) ; *Acer campestre* + 2 relevés) ; *A tataricum* + (2 relevés) ; *Quercus cerris* + (1 relevé) ; *Crataegus pentagyna* + (1 relevé) SHRUBS ; *Prunus spinosa* + – 2 (4 relevés) ; *Sorbus domestica* + (2 relevés) HERBACEOUS PLANTS : *Lychnis coronaria* + (4 relevés) *Alliaria petiolata* 1–2 (4 relevés) ; *Silene vulgaris* + (3 relevés), *Bilderdykia dumetorum* + (3 relevés), *Campanula persicifolia* + (3 relevés) ; *Verbascum phoeniceum* + (3 relevés) ; *Cynanchum vincetoxicum* + (3 relevés) ; *Lathyrus niger* + (3 relevés). *Helleborus odorus* + (3 relevés) ; *Betonica officinalis* + (3 rel.) ; *Verbascum nigrum* + (3 relevés) ; *Dictamnus albus* + (3 relevés) only in forest Coşoveni) ; *Cruciata glabra* + (3 relevés) ; *Muscari racemosum* + (3 relevés) ; *Cynoglossum officinale* + (3 relevés). In 1–2 relevés : *Viscaria vulgaris, Lithospermum officinale, Ajuga genevensis, Potentilla argentea, Dorycnium herbaceum, Festuca valesiaca, Campanula patula, Prunella laciniata, Digitalis lanata, Viola alba, V. odorata, Euphorbia salicifolia, Asparagus tenuifolius, Scilla bifolia, Pulmonaria mollissima,*

Inula salicina, Glechoma hirsuta, Cytisus albus, Geum urbanum, Carex polyphylla, Peucedanum alsaticum, Teucrium chamaedrys, Calaminta vulgaris, Ornithogalum boucheanum, Hieracium umbellatum, Galium mollugo, Nectaroscordum siculum, Galium pseudaristatum, Fragaria vesca, Viola elatior, Ranunculus constantinopolitanus, Thalictrum aquilegiifolium, Iris variegata, Milium effusum, Melica uniflora, Ajuga laxmannii, Arabis glabra, Sedum maximum.

4. *Quercetum polycarpae-cerris* nom. nov. Mixtures of common oak *(Quercus polycarpa)* and *Quercus cerris* (less *Q. frainetto)* were first mentioned by C. C. Georgescu et Constantinescu in 1945 (apud 10) in the high and low plains of Oltenia under the name of *Quercetum cerris polycarpiceae, Quercetum polycarpiceae – Tilietum.*

Indeed, there are many places in Oltenia ; Bucovăţ at Cîrligei and "Fîntina lui Ghiţă ; Fărcaşu-Melineşti at "Valea Stanului" and Udrica forests (district of Dolj) ; Crainici (district of Mehedinţi) ; Cărbuneşti (district of Gorj) ; Guşoeni (district of Vîlcea) ;Forests Sarului (district of Olt) where this combination of oak trees in which *Quercus cerris* predominates can be met. The other important species, with an important role as it was found and determined by C. C. Georgescu, is *Quercus polycarpa*, on the basis of form and frequency : leaves, nervures of acorns and scales of the crown (always hunched and pubescent).

Floristic studies performed in all vegetation seasons, based on 19 relevés (Table 2), enabled the identification of two subassociations differing floristically and ecologically from the typical association.

Querco polycarpae-cerris fagetosum moesiacae may be found in the forest of Bucovăţ in a few sites, a few kilometers one from another always in similar ecological conditions : northern steep shady morst slopes. Besides the data in literature on *Fagus moesiaca* (2) we may add 2 other sites in the forest of Bucovăţ : Cirligei at "Gura Cosacului" and "Fîntina lui Ghiţă" at about 8 km one from another. In both places there are monumental samples of *Fagus moesiaca* of about 40 m high and with the basal diameter between 0.40–1.20 m. ((Fîntina lui Ghiţă a former halting place (the well is dry in summer time because of droughts) on a steep slope of about 80 m there are 20 high *Fagus moesiaca* as well as a large number of seedlings of about 0.50–2.50 m high, which may suggest a possible regeneration of this typically Balken species. The Balkan beech tree with the species of wood or herbaceous mesohygrophylic or mesophylic, appears as an isolated isle in the area of the association *Querceum polycarpae-cerris*. Besides *Fagus moesiaca*, at the basis of the slope towards the river there are many hornbeams *(Carpinus betulus)* and rare *Quercus polycarpa. Quercus cerris* is situated in the upper third of the slope but where the valley is larger it may grow down to the level of the dale where *Fagus moesiaca* no longer appears.

At a place called Gura Cosacului near Cirligei covering an area of about 150 m/40 m there are some 30 individuals of beech trees, some of which are exceptionally beautiful and fructify every 2–3 years. Although the seedlings are fewer than at the place called Fîntina lui Ghiţă, in the spring of 1987 we noticed a large number of self-sown crops. In the ground vegetation there are the differential species for this subassociation : *La-*

Table 2

Quercetum polycarpae-cerris nom. nov.

A — *quercetosum*
B — *fagetosum moesiacae* nova subass.
C — *carpinetosum orientalis* nova subass.

			A									B					C							
		TREES	1	2	3	4	5	6	7	8	K	1	2	3	4	K	1	2	3	4	5	6	7	K
		Quercion petraeæ and *Quercetalia pubescenti-petraeae*																						
MPh	sMd	*Quercus cerris*	4	3	4	4	3	2	2	2	V	1	+	+	2	V	1	1	2	4	1	3	4	V
MPh	Balc-Pan	*Quercus polycarpa*	+	1	+	1	1	+	3	3	V	1	1	2	1	V	2	3	1	1	3	1	1	V
Mph	Eu (sMd)	*Pyrus pyraster*	.	.	+	+	.	.	.	.	III	+	+	+	.	IV	.	.	.	.	+	+	.	II
		Quercion frainetto																						
MPh	sMd	*Quercus frainetto*	+	+	+	.	+	.	1	.	IV	+	.	.	.	I	+	+	.	+	+	+	.	IV
mPh—MPh	sMd	*Carpinus orientalis* (diff. sousass.)	.	.	.	.	.	.	.	.	—	.	.	.	.	—	2	+	2	3	1	3	1	V
MPh	Balc	*Fagus moesiaca* (diff. sousass.)	.	.	.	.	.	.	.	.	—	2	2	1	1	V	.	.	.	.	.	.	.	—
		Orno Cotinetalia and *Quercetea pubescenti-petraeae*																						
mPh—MPh	Eua	*Crataegus monogyna*	+	1	.	1	1	+	+	+	V	.	.	.	.	—	+	+	.	.	+	2	.	III
MPh—mPh	sMd	*Fraxinus ornus*	.	.	.	.	.	.	+	+	II	+	+	.	+	IV	.	1	+	+	1	+	.	IV
mPh—MPh	Ct	*Acer tataricum*	.	.	.	.	.	.	.	+	I	.	.	.	.	—	.	+	.	+	+	.	.	III
MPh	Balc—Pan	*Tilia tomentosa*	+	.	.	.	.	.	.	+	I	.	.	.	.	—	.	.	.	.	.	.	.	—
MPh	Eu—sMd	*Sorbus torminalis*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	.	.	.	+	.	.	.	I
		Quercetea and *Carpino-Fagetea*																						
MPh	Eu	*Acer campestre*	+	+	+	+	.	.	.	.	III	+	.	+	+	IV	+	1	1	+	1	+	.	V
MPh	Ec	*Carpinus betulus*	+	+	2	1	.	+	+	.	IV	2	1	3	+	V	.	.	+	.	.	.	.	I
MPh	Eu	*Fraxinus excelsior*	.	.	+	.	.	+	+	.	II	.	.	.	.	—	.	+	.	.	+	+	.	III
MPh	Ec	*Tilia platyphyllos*	.	+	.	.	.	.	.	.	I	.	+	+	.	III	.	+	.	.	.	.	.	I
MPh	Eua	*Ulmus glabra*	.	.	+	.	.	.	.	+	II	+	.	.	.	I	.	.	+	.	.	.	.	I
MPh	Eua	*Prunus avium*	.	.	.	.	.	.	.	.	—	.	.	+	+	III	.	.	.	.	.	.	.	—
MPh	Eu	*Acer platanoides*	.	.	.	.	.	.	.	.	—	.	+	+	.	III	.	.	.	.	.	.	.	—
MPh	Eu—sMd	*Malus sylvestris*	.	.	.	.	.	.	.	.	—	.	.	+	.	I	.	.	.	.	.	.	.	—
MPh	Eua	*Salix fragilis*	.	.	.	.	.	.	.	.	—	.	+	.	+	III	.	.	.	.	.	.	.	—
MPh	Eu	*Populus canescens*	.	.	.	.	.	.	.	.	—	.	+	+	.	III	.	.	.	.	.	.	.	—
		SHRUBS and SHRUBLETS																						
		Quercion frainetto and *Quercetalia pubescenti-petraeae*																						
mPh	Ec	*Cornus mas*	+	2	+	+	.	+	+	.	IV	+	+	.	+	IV	.	+	+	+	2	.	.	III
	Balc	*Fagus moesiaca* (*juv.*)	.	.	.	.	.	.	.	.	—	.	+	1	2	IV	.	.	.	.	.	.	.	—

Table 2 (continued)

			A1	A2	A3	A4	A5	A6	A7	A8	AK	B1	B2	B3	B4	BK	C1	C2	C3	C4	C5	C6	C7	CK
	sMd	*Quercus frainetto* (juv.)	.	.	.	.	+	.	+	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
	sMd	*Quercus cerris* (*juv.*)	.	.	.	.	.	.	.	.	—	.	.	.	.	—	.	+	.	1	.	.	.	II
nPh	Ec	*Viburnum lantana*	+	1	.	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
In A :	nPh—mPh, Eu	*Sorbus domestica* + ; nPh, sMd *Staphyllea pinnata* (+) In B : nPh, sMd—P *Rosa corymbifera*																						
		Quercetalia and *Carpino — Fagetalia*																						
nPh	Eu—sMd	*Prunus spinosa*	+	+	+	1	.	+	+	.	IV	.	.	.	.	—	.	.	.	.	.	.	.	—
mPh—nPh	Ec	*Corylus avellana*	.	+	+	.	.	.	.	.	II	+	.	+	.	III	.	.	.	.	.	.	.	—
	Ec	*Carpinus betulus* (juv.)	1	.	1	2	.	.	.	.	II	.	.	1	.	I	.	.	.	.	.	.	.	—
nPh—mPh	Eu	*Ligustrum vulgare*	.	.	.	+	+	.	+	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
nPh	Eu	*Rubus procerus*	.	.	.	.	.	+	+	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
Ln	Ec	*Hedera helix*	.	.	.	.	.	.	.	.	—	.	+	.	.	I	+	.	+	.	.	.	.	—
nPh	Balc-Pan	*Cytisus leucotrichus*	.	.	.	.	+	.	.	.	—	.	.	.	.	—	.	.	.	.	.	.	.	—
		HERBACEOUS PLANTS																						
		Quercion petraeae and *Quercetalia pubescenti-petraeae*																						
H	sMd—Ct	*Festuca heterophylla*	+	+	+	+	.	.	.	2	IV	.	+	.	.	II	.	.	.	.	.	+	.	I
H	Eua	*Viola elatior*	.	+	+	.	.	.	.	.	II	.	.	.	.	—	+	+	.	.	+	.	+	III
H (6)	Ec—sMd	*Lithospermum purpureo-coeruleum*	.	1	.	1	.	.	+	.	II	.	.	.	.	—	.	+	.	.	+	.	.	II
H	Ec	*Chrysanthemum corymbosum*	+	+	.	+	.	.	.	.	II	.	+	.	.	II	.	.	.	.	.	.	.	—
Ch	Eu—sMd	*Genista tinctoria*	.	+	.	+	+	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
G	Ec	*Galium schultesii*	.	.	.	.	+	+	+	+	III	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Eua	*Trifolium medium*	.	.	.	.	+	+	.	.	II	.	.	.	.	—	.	.	.	.	+	.	.	I
H	Cp	*Hieracium umbellatum*	.	.	.	.	+	+	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
		In A : *Sedum maximum* (+) *Cynanchum vincetoxicum* (+);																						
		Quercion frainetto and *Quercetalia*																						
H	sMd	*Potentilla micrantha*	.	+	.	+	+	+	+	+	IV	.	+	.	.	II	.	.	.	.	.	.	.	—
Th	Eua	*Veronica hederifolia*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	+	+	1	.	+	1	+	V
G	P—sMd	*Asparagus tenuifolius*	+	+	.	.	.	.	.	.	II	.	.	.	.	—	+	.	.	.	.	+	+	III
G	Eu	*Corydalis bulbosa* ssp. *marschalliana*	.	.	.	.	.	.	.	.	—	+	.	.	.	II	.	.	+	.	.	+	+	III
H	sMd—sAtl	*Primula acaulis*	+	+	1	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
		Pulmonaria mollissima	+	+	.	.	.	.	.	+	II	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Eua (Ct)	*Lychnis coronaria*	.	.	.	.	.	.	.	+	I	.	.	.	.	—	.	.	.	+	+	.	.	II
H	Carp—B	*Galium pseudaristatum*	.	.	.	.	.	+	.	.	I	.	+	.	.	II	.	.	.	.	.	.	.	—
H	sMd—Ec	*Melittis mellisophyllum*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	.	.	+	.	+	.	.	II

Table 2 (continued)

		TREES	A 1	2	3	4	5	6	7	8	K	B 1	2	3	4	K	C 1	2	3	4	5	6	7	K

In A : H, Eu *Peucedanum alsaticum* + ; H, sMd *Aremonia agrimonioides* ; H, Eua (sMd) *Carex polyphylla* (+) ; H, Balc-Pan, *Vicia sparsiflora* + ;In B : G, Ec *Arum orientale* + .

Quercetalia pubescenti-petraeae and *Quercion roboris*

			A 1	2	3	4	5	6	7	8	K	B 1	2	3	4	K	C 1	2	3	4	5	6	7	K
H	Eua	*Ranunculus auricomus*	+	1	+	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
H	sMd	*Asperula laurina leucanthera*	.	.	.	+	.	.	.	.	I	1	.	.	.	II	.	.	.	+	+	.	.	II
Th	Eua	*Alliaria petiolata*	.	.	.	.	.	.	.	.	—	.	.	.	+	II	.	.	.	.	.	+	+	II
H	sMd	*Scutellaria altissima*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	+	.	.	.	.	.	.	I
Th	Eua	*Cardamine impatiens*	.	.	.	.	.	.	.	.	—	.	.	.	+	II	.	.	.	.	.	.	.	—
G	Eu	*Convallaria majalis*	2	+	.	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
G	Balc. P	*Fritillaria orientalis*	.	+	+	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
		Quercetalia and Carpino-Fagetalia																						
G	sMd	*Scilla bifolia*	.	+	+	+	+	.	.	.	III	+	1	.	.	III	+	+	+	.	.	+	+	IV
H	Alp-B	*Helleborus odorus*	.	.	+	.	.	.	.	.	I	+	+	+	+	V	+	+	+	+	+	+	+	V
Ch	sMd—P	*Glechoma hirsuta*	+	.	+	+	+	.	+	.	IV	.	.	.	.	—	.	.	+	.	.	.	.	I
H	Eu (sMd)	*Melica uniflora*	.	.	.	.	.	.	+	+	II	+	2	.	.	III	2	.	.	1	.	.	+	III
G	Eua	*Corydalis solida*	.	.	.	.	.	.	.	.	—	.	.	1	1	III	.	.	+	.	.	+	.	II
G	Ec	*Lathraea squamaria*	.	.	.	.	.	.	.	.	—	+	+	+	+	IV	.	.	+	.	.	.	.	I
H	Eua (sMd)	*Campanula rapunculoides*	.	.	.	.	.	.	.	.	—	.	+	.	+	III	.	.	.	.	.	+	.	I
H	Ec	*Viola reichenbachiana*	.	+	.	+	.	.	.	.	—	.	.	.	+	II	.	.	.	.	.	.	.	—
H	Ec	*Lamium galeobdolon*	.	.	.	.	.	.	.	.	—	+	.	+	.	III	.	.	+	.	.	.	.	I
H	Ec	*Isopyrum thalictroides*	.	.	.	.	.	.	.	.	—	1	.	.	.	II	.	.	+	.	+	.	.	II
Ch (H)	Ec—sMd	*Euphorbia amygdaloides*	.	.	.	.	.	.	.	.	—	.	+	.	+	III	+	.	.	.	.	.	.	I
H (Ch)	Eua	*Stellaria holostea*	.	.	+	.	.	.	.	+	II	1	.	.	.	II	.	.	.	.	.	.	.	—
H	Eua	*Brachypodium sylvaticum*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	+	.	.	.	+	.	.	II
C	Eu	*Allium ursinum*	.	.	2	.	.	.	.	.	I	.	.	.	+	I	.	.	.	.	.	.	.	—
G	Cp	*Anemone nemorosa*	+	.	+	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—

In : A : Ch, Cp *Veronica officinalis* (+) ; H, Eua (sMd) : *Campanula persicifolia* (+) ; H Eua *Hypericum hirsutum* (+) ; H (G) Eua *Asarum europaeum* (+) ; H, Ec *Pulmonaria officinalis* (+). In B : H, Eua *Sanicula europaea*

Quercetea and *Carpino — Fagetea*

			A 1	2	3	4	5	6	7	8	K	B 1	2	3	4	K	C 1	2	3	4	5	6	7	K
Ch (H)	Ec	*Geum urbanum*	+	+	+	+	+	+	+	+	V	+	+	.	+	IV	.	.	.	.	.	+	.	I
H (G)	Eua	*Ficaria verna*	3	2	2	1	2	2	1	3	V	2	2	3	3	V	+	+	+	1	+	+	.	V

			A 1	2	3	4	5	6	7	8	K	B 1	2	3	4	K	C 1	2	3	4	5	6	7	K
H (G)	sMd—P	*Lathyrus venetus*	+	+	+	+	+	+	+	+	IV	.	.	.	.	—	.	.	.	.	.	.	.	—
G	Ec	*Arum maculatum*	.	.	.	.	.	.	.	.	II	+	+	.	+	IV	.	.	.	.	.	+	.	I
H	Eua	*Fragaria vesca*	.	1	.	1	+	+	.	.	III	.	.	.	.	—	+	.	.	.	1	.	.	II
G	Eua	*Anemone ranunculoides*	+	+	.	.	.	.	.	.	II	.	+	+	+	IV	.	.	.	.	.	.	.	—
H	Cp	*Circaea lutetiana*	.	.	.	.	.	.	.	.	—	+	.	+	+	IV	.	.	.	.	.	.	.	—
H (G)	Eu	*Mercurialis perennis*	.	.	+	.	.	.	.	.	I	+	.	.	.	II	.	.	.	.	.	.	.	—
Th	Cp	*Bilderdykia dumetorum*	.	.	.	.	.	.	.	.	—	.	.	.	.	—	+	+	.	.	.	.	.	—
G	Eua	*Cardamine bulbifera*	.	.	.	.	.	.	.	.	—	.	.	+	+	III	.	.	.	.	.	.	.	—
H (G)	Eua	*Lathyrus vernus*	+	+	.	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—

In A : H, Eu ; *Melica nutans* (+) ; In B : H (Ch), Eua *Lamium maculatum* (+) H, Cp *Adoxa moschatellina* (+ —2) ; G, Eua *Erythronium dens-canis* (+) ;

Other species

			A 1	2	3	4	5	6	7	8	K	B 1	2	3	4	K	C 1	2	3	4	5	6	7	K
H	sAtl—sMd	*Viola odorata*	+	.	.	+	.	+	.	+	III	+	+	+	.	IV	2	.	.	+	.	.	.	II
H (Ch)	Eu	*Veronica chamaedrys*	+	.	+	+	.	+	.	+	IV	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Cp	*Poa nemoralis*	.	.	.	.	+	+	+	+	III	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Eua	*Aegopodium podagraria*	+	+	+	.	.	.	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
TH—H	Eua	*Verbascum nigrum*	.	.	.	+	+	+	.	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Eu	*Hieracium pilosella*	.	.	.	.	+	+	+	.	II	.	.	.	.	—	.	.	.	.	+	.	.	I
H	Eua	*Ajuga reptans*	.	.	.	.	.	.	.	+	I	.	+	.	.	—	.	.	+	.	.	.	.	I
H	sMd	*Parietaria officinalis*	.	.	.	.	.	+	.	+	II	.	.	.	.	—	.	.	.	.	.	.	.	—
H	Cp	*Poa pratensis*	.	.	.	.	.	+	.	+	II	.	.	.	.	—	.	.	.	.	.	.	.	—
Th	Eu	*Lepidium campestre*	.	.	.	+	.	.	+	.	II	.	.	.	.	—	.	.	.	.	.	.	.	—

In A : H, sMd—Ec *Viola alba* + ; H, Cosm *Prunella vulgaris* (+) ; H, Eua *Cruciata laevipes* (+) ; H, Eua *Galium mollugo* (+) ; H, Eua *G. verum* (+) ; H, Alp-Carp—B *Peltaria alliacea* + — 1 ; H, Ct (Eua) *Festuca valesiaca* (+) ; H, Eua *Silene vulgaris* (+) ; G, P—Balc *Ornithogalum pyramidale* (+) ; H, Eu (sMd) *Serratula tinctoria* (+). In C : H, Eu *Mycelis muralis* (+) ; H, Balc *Ranunculus constantinopolitanus* (+).

mium galeobdolon, Stellaria holostea, Adoxa moschatellina, Cardamine bulbifera, Erythronium dens-canis ssp. *niveum, Allium ursinum.* At the level of the shrubs the presence of *Coryllus avellana* could be seen (Table 2). In the upper third of the slope at the level of the arborescent stratum *Quercus cerris* and *Q. polycarpa* predominate, while among shrubs *Carpinus orientalis*, a mediterranean species differential for the *subassociation carpinetosum orientalis* (Fig. 2). In the other sites, *Fagus moesiaca* and *Carpinus orientalis* are not present while these relevés are attributed to the typical subassociation.

In all these forests crossed by deep valleys mainly oriented W–E, *the relief energy up to* 60 m (Bucovăț, Valea Stanului-Fărcașu Pd. Sarului-Balș) a succession of associations ecologically and floristically delimited (Figs. 2 and 3) can be seen. The embowering phenological stage in the woody species is 8–10 days late. Thus, in the spring of 1987; in the first 10 days of May, *Fagus moesiaca, Carpinus betulus* and *Quercus polycarpa*, were embowered. *Quercus frainetto* was at the middle of the embowering stage, while *Q. cerris* and *Carpinus orientalis* at the beginning. Although the embowering stage was tardy in all species the associations could be well recognized on both slopes of the valley, their succession as can be established from vegetation profiles could also be well distinguished.

5. *Quercetum robori-cerris* Csapody ex Soó 1969. This association was first seen in Muntenia and Banat (19). In Oltenia, phytocenoses from the hillocks of Corcova-Mehedinți and Somănești-Gorj have been found to belong to this association (Table 3).

6. *Quercetum robori-frainetto* nova ass. The phytocenoses investigated over the areas of the places Dejești at a place called "La Culme" (district of Olt), Băbeni, Gușoeni and Fumureni, in the forest of Cernișorul (district of Vîlcea) between 280 and 360 m in the Getic Piedmot, have been attributed to this association. These are situated on a plain ground and slope with a slight S–W or S–E inclination. They are forests well compacted (as far as the trees among which *Quercus frainetto* predominates) and shrubbery are concerned rich young wood. Herbaceous species are fewer in number (Table 4) though of high coenotic value are: *Poa nemoralis, Lithospermum purpureo-coeruleum, Cruciata glabra, Festuca heterophylla, Carex polyphylla, Dactylis polygama* a.s.o.

7. *Quercetum frainetto-polycarpae* nom. nov. The mixtures of *Quercus polycarpa* and *Q. frainetto* in the middle and high parts of the Getic Piedmont and the Subcarpathian Hills were formerly interpreted (13, 14) as the subassociation *frainettosum* to the large association *Querco (petraeae)-Carpinetum.* Reviewing older data and comparing them to newer ones these forests from the Getic Piedmont, we consider more adequate to consider them independent associations on the basis of a species nucleus belonging to the order of *Quercetalia pubescenti-petraeae*: *Lathyrus niger, Chrysanthemum corymbosum, Lithospermum purpureo-coeruleae, Fraxinus ornus, Acer tataricum, Sorbus torminalis, Tilia tomentosa, Sedum maximum, Lychnis coronaria, Hieracium bauhini, Genista tinctoria* (Table 5).

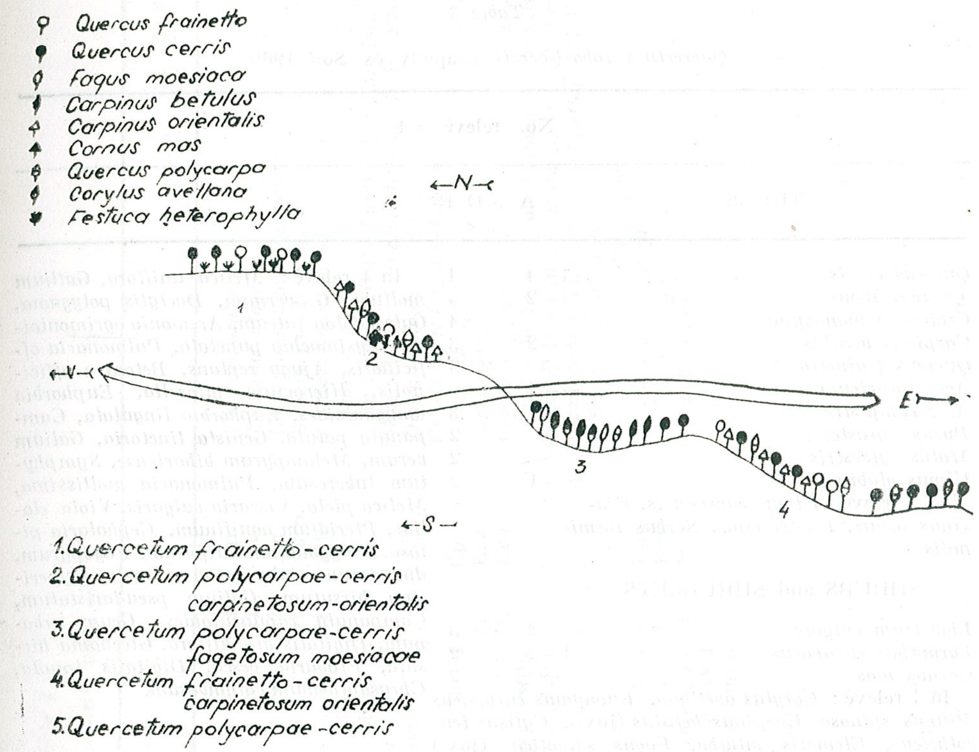


Fig. 2

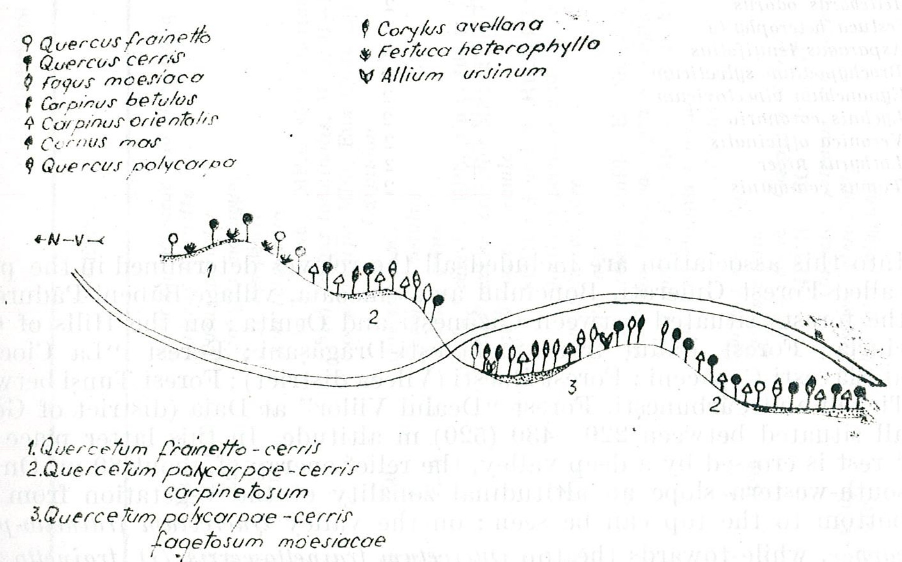


Fig. 3

Table 3

Quercetum robori-cerris Csapody ex Soó 1969

No. relevé = 4

TREES	A + D	P
Quercus cerris	1–4	4
Quercus robur	1–2	4
Crataegus monogyna	+	4
Carpinus betulus	+–2	3
Quercus frainetto	+	3
Acer tataricum	+–1	3
Acer campestre	+	3
Pyrus pyraster	+	2
Malus sylvestris	+	2
Ulmus glabra	+–1	2

In 1 relevé : *Ulmus campestris, Fraxinus ornus, F. excelsior, Sorbus torminalis.*

SHRUBS and SHRUBLETS		
Ligustrum vulgare	+–2	3
Loranthus europaeus	1–2	2
Cornus mas	+	2

In 1 relevé : *Corylus avellana, Euonymus europaeus Prunus spinosa, Carpinus betulus* (juv.), *Cytisus leucothricus, Clematis vitalba, Fagus sylvatica* (juv.) *Quercus cerris* (juv.)

HERBACEOUS PLANTS		
Lithospermum purpureo-coeruleum	+–2	2
Helleborus odorus	+	2
Festuca heterophylla	+–1	2
Asparagus tenuifolius	+	2
Brachypodium sylvaticum	+	2
Cynanchum vincetoxicum	+	2
Lychnis coronaria	+	2
Veronica officinalis	+	2
Lathyrus niger	+	2
Tamus communis	+	2

In 1 relevé : *Melica uniflora, Gallium mollugo, G. vernum, Dactylis polygama, Galeobdolon luteum, Aremonia agrimonioides, Lysimachia punctata, Pulmonaria officinalis, Ajuga reptans, Betonica officinalis, Hieracium pilosella, Euphorbia amygdaloides, Euphorbia lingulata, Campanula patula, Genista tinctoria, Galium verum, Melampyrum bihariense, Symphytum tuberosum, Pulmonaria mollissima, Melica picta, Viscaria vulgaris, Viola elatior, Pteridium aquilinum, Cephalaria pilosa, Polygonatum latifolium, Fagopyrum, dumetorum, Calamintha vulgaris, Hypericum hirsutum, Galium pseudaristatum, Campanula rapunculoides, Geum urbanum, Digitalis grandiflora, Glechoma hirsuta, Fragaria vesca, Digitalis lanata, Chrysanthemum corymbosum.*

Into this association are included all the relevés determined in the place called Forest Gulerați, Bonciului and Smeoaia, village Băbeni-Păduretu; the forests situated between Căzănești and Ocnița; on the Hills of Chiciurla; Forest Răduț from Ștefănești-Drăgășani; Forest "La Ciocan" at Slăvești-Copăceni; Forest Roești (Vîlcea district); Forest Tunși between Ticleni and Cărbunești, Forest "Dealul Viilor" at Daia (district of Gorj), all situated between 220–430 (520) m altitude. In this latter place the forest is crossed by a deep valley, the relief energy of about 80 m. On the south-western slope an altitudinal zonality of the vegetation from the bottom to the top can be seen: on the valley *Quercetum frainetto-polycarpae*, while towards the top *Quercetum frainetto-cerris* (*Q. frainetto* predominates because of a stronger necessity for light of the latter). Through

Table 4

Quercetum robori-frainetto nova ass.

		TREES	1	2	3
		Quercion patraeae and *Quercetalia*			
MPh	B	*Quercus frainetto*	4	3	1
MPh	Eu (sMd)	*Pyrus pyraster*	+	+	+
MPh	Eua	*Crategus monogyna*	+	+	+
MPh	Eu	*Acer campestre*	.	+	+
MPh	Ct	*Acer tataricum*	1	+	.
		In 1 relevé : MPh, sMd *Fraxinus ornus*, MPh, Eu (sMd) *Sorbus torminalis*, MPh, B–Pan *Quercus polycarpa* MPh, Eua *Crataegus pentagyna.*			
		Carpinion			
MPh	Eu	*Quercus robur*	+	+	4
MPh	Eu	*Carpinus betulus*	+	2	.
MPh	Eua	*Prunus avium*	+	+	+
		In 1 relevé : MPh, Eu (sMd) *Malus sylvestris*, MPh, Eu, *Fraxinus excelsior* MPh, Eua, *Ulmus minor*, MPh, Eua *Populus tremula*			
		SHRUBS and SHRUBLETS			
		Quercion petraeae and *Quercetalia*			
MPh	Eu	*Ligustrum vulgare*	3	1	1
		Cornus mas	+	3	.
		In 1 relevé : mPh, Eu *Sorbus domestica*, mPh, Ec *Viburnum lantana, Cornus sanguinea*, nPh, P–sMd *Rosa gallica*, E, sMd–P *Loranthus europaeus*, mPh, sMd (Eu) *Prunus spinosa*			
		Carpinion			
mPh	Ec	*Corylus avellana*	+	+	.
nPh	Eua	*Rubus caesius*	.	+	+
		In 1 relevé : *Carpinus betulus*			
		HERBACEOUS PLANTS			
		Quercion petraeae and *Quercetalia*			
H	Ec(sMd)	*Festuca heterophylla*	1	2	2
H (G)	Ec	*Dactylis polygama*	+	+	+
H	Cp	*Poa nemoralis*	+	1	2
H	Eu	*Lathyrus niger*	+	+	.
H	Ec	*Chrysanthemum corymbosum*	+	+	.
H	Carp–B	*Galium pseudaristatum*	+	+	.
H	sMd	*Lithospermum purpureo-caeruleum*	1	2	.
		In 1 relevé : G,P–Pan *Polygonatum latifolium*, H, Ec *Silene viridiflora*, H, B–Pan-*Digitalis lanata*			
		Carpinion et Carpino-Fagetea			
Ch	Cp	*Geum urbanum*	+	+	+
H	Eua	*Carex polyphylla*	+	+	+
H	Eua	*Cruciata glabra*	.	2	+
		In 1 relevé : H, Eua *Pulmonaria mollissima*, H, Eu *Mycelis muralis*, H, Eua *Festuca gigantea*, H, Cp *Circaea lutetiana*, H, Eu (sMd) *Carex sylvatica*			
		Other species			
H	Eua	*Verbascum phoeniceum*			
TH	Eua	*Verbascum nigrum*			
H	Eua	*Carx tomentosa*			

Table 5

Quercetum frainetto-polycarpae nom. nov.

No relevé = 18	A + D	P	K
TREES			
Quercetalia pubescenti-petraeae			
Quercus polycarpa	1–5	18	V
Quercus frainetto (and var. *minor*)	+–3	18	V
In 1–2 relevees : *Quercus dalechampii, Quercus cerris*			
Quercetea pubescenti-petraeae			
Crataegus monogyna	+–2	9	
Fraxinus ornus	+	5	
Acer tataricum	+	3	
In 1–2 relevees : *Sorbus torminalis, Pyrus pyraster.*			
Carpinion and *Carpinio-Fagetalia*			
Carpinus betulus	+–2	12	
Fraxinus excelsior	+	4	
Quercus robur	+–1	3	
Fagus sylvatica	+	3	
In 1–2 relevees : *Populus tremula, Ulmus glabra, Malus sylvestris, Prunus avium, Acer platanoides*			
SHRUBS and SHRUBLETS			
Quercetalia pubescenti-petraeae			
Quercus polycarpa (juv.)	+9		
Cornus mas	+–2	4	
Rosa gallica	+	3	
In 1–2 relevees : *Quercus frainetto*			
Carpinion and *Carpino-Fagetalia*			
Cytisus leucotrichus	+	3	
Carpinus betulus (juv.)	+	3	
In 1–2 relevees : *Hedera helix, Corylus avellana, Ligustrum vulgare*			
HERBACEOUS PLANTS			
Quercetalia pubescenti-petraeae			
Festuca heterophylla	+–2	13	IV
Lathyrus niger	+	9	
Hieracium bauhini	+	9	
Lychnis coronaria	+	7	
Genista tinctoria	+	6	
Campanula persicifolia	+	5	
Chrysanthemum corymbosum	+	4	
Potentilla micrantha	+	4	
In 1–2 relevees : *Betonica officinalis, Digitalis lanata, Lithospermum purpureo-coeruleum, Silene viridiflora, Hieracium umbellatum*			

No relevé = 18	A + D	P	K
Quercetea and *Carpino-Fagetea*			
Poa nemoralis	+	9	
Veronica officinalis	+	6	
Cruciata glabra	+	6	
Viola reichenbachiana	+	4	
Dactylis polygama	+	4	
Cardamine glanduligera	+	3	
Lathyrus venetus	+	3	
Melica uniflora	+	3	
Ficaria verna	+	3	
Luzula albida		3	
In 1–2 relevees : *Stachys sylvatica, Solanum dulcamara, Polygonatum odoratum, Euphorbia amygdaloides, Glechoma hirsuta, Geum urbanum, Galium shultesii, Trifolium medium, Campanula rapunculoides, Clinopodium vulgare, Hypericum hirsutum Digitalis grandiflora, Bilderdykia dumetorum, Stellaria holostea, Melampyrum bihariense, Cynanchum vincetoxicum.*			
Carpino – Fagetalia			
In 1–2 relevees : *Hieracium murorum, Galium odoratum, Rumex sanguineus, Epipactis helleborine, Tamus communis, Scrophularia nodosa, Impatiens noli-tangere, Mycelis muralis, Brachypodium sylvaticum, Cephalanthera longifolia, Lapsana communis, Trifolium strepens.*			
Other species			
In 1–2 relevees : *Filipendula vulgaris, Trifolium campestre, Torilis arvensis, Carex remota, Epilobium hirsutum*			

its floristic structure this association constitutes the transition to al. Carpinion from the order Carpino-Fagetalia as among its floristic species there are some typical for al. Carpinion.

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Received March 21, 1988

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LES ASSOCIATIONS DE LA CLASSE *SALICETEA HERBACEAE* BR.—BL. 47 DES CARPATES ROUMAINES

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The paper analyses the vegetation in snow gorges grouped in the class *Salicetea herbaceae* Br.—Bl. 47. The phytocoenosis of this class is characterized by chionophilous, oligothermophilous species, vegetating in a uniform microclimate, with annual extremes varying within narrow limits. They grow on skeleton soils with a high content of humic substances under a weak process of pit formation.

A number of 21 associations with the main synonymies are presented. The ecological, chorological and coenotaxionomical data, presented for each analysed group, contribute to a better delimitation of the vegetation units presented in the Romanian Carpathians.

Les terrains longtemps enneigés, situés à l'étage aplin où la couche de neige se maintient pendant 8—10 mois de l'année sont peuplés d'une végétation du type arctique, formée d'espèces chionophiles. Celles-ci sont adaptées à une vie latente prolongée sous la pression de la couche de neige et à une succesion rapide des phases de végétation. Chez nous, c'est Al. Borza (1934) qui effectua les premières études à l'égard des combes de neige, dans les monts de Retezat. Les études réalisées par D. Puşcaru et ses collaborateurs (1956) et Al. Beldie (1967) fournissent de nouvelles informations concernant la caractérisation des associations chionophiles et chionohygrophiles. Celles-ci végètent dans les endroits à eaux stagnantes, provenues de la fonte des neiges. La végétation spécifique de ces stations n'est pas due à la longue durée de l'enneigement mais à l'humectation accentuée du sol à cause de l'eau stagnante, dans les conditions climatiques spécifiques de l'étage alpin supérieur. Sur les pentes faiblement inclinées et ensoleillées, la végétation s'installe seulement à la base ou dans les microdépressions, sur un substrat difficilement perméable, là où les eaux peuvent s'accumuler. Ni sur les versants nord, où la neige reste plus longtemps, on ne rencontre pas ces groupements si les conditions de microrelief requises ne sont pas remplies. C'est pourquoi, Al. Beldie propose l'emploi de l'expression « combes à eaux provenues de la fonte des neiges ». La flore de ces stations se confond à la flore des neiges en fonte. Celle-ci comprend les espèces qui fleurissent immédiatement après la fonte de la neige, indiféremment de leur manière d'association et des conditions édaphique. En conclusion, la flore des neiges en fonte ne constitue pas d'associations caractéristiques du point de vue floristique ou stationnel, mais seulement des groupements phénologiques compris dans la végétation des prairies, des toundra ou des moraines alpines.

Parmi les espèces chinonhygrophiles (obligées à végéter souvent en submersion dans les eaux stagnantes) nous rappelons : *Cerastium cerastoides*, *Gnaphylium supinum*, *Polytrichum sexangulare*, *Salix herbacea*, *Sedum alpestre*, *Soldanella pusilla*, *Veronica alpina*, etc.

1. SALICETALIA HERBACEAE Br.—Bl. 26

Les conditions stationnelles des combes à eaux provenues de la fonte des neiges situées sur les pentes des cirques glaciaires favorisent le développement d'une convergence floristique entre les associations chinophiles et celles pétrophiles. Les associations de cet ordre présentent donc des séries de transition ou des mosaïques et des complexes avec celles de l'ordre *Androsacetalia alpinae*. Malgré le caractère intensément squelettique du sol où se développent ces groupements, le contenu élevé en colluvionnaires humiques offre quand même des conditions plus ressemblantes à celles des combes à eaux provenues de la fonte des neiges.

Les espèces de reconnaissance de l'ordre sont les suivantes : *Salix herbacea, Soldanella pusilla, Gnaphalium supinum, Chrysanthemum alpinum, Luzula alpino-pilosa (= spadicea), Carex pyrenaica, Polytrichum sexangulare.* Sur les espèces régionales daco-balkaniques nous mentionnons : *Ranunculus crenatus* et *Plantago gentianoides*, et comme espèces différentielles, *Ligusticum mutellina* et *Geum montanum*.

1.1. Salicion herbaceae Br.—Bl. 26

Les associations de cette alliance représentent les unes des plus spécifiques unités de végétation des hautes montagnes et leurs stations ont été nommées dans la littérature allemande « Schneetälchen » ce qui signifiait, même pour O. Herr (1935), les surfaces faiblement inclinées, orizontales ou faiblement dépressionnaires, au sol imbibé d'eau provenue de la fonte des neiges.

Les espèces caractéristiques de l'alliance sont identiques à celles plus haut mentionnée pour cet ordre. Les phytocénoses de cette alliance s'installent sur un substrat cristallin, mais on les rencontre dans les Bucegi aussi, sur les grès et les microconglomérats riches en matériel silicieux.

1.1.1. *Anthelietum juratzkanae* Krajina 33

C'est une association muscinale signalée dans les Bucegi (D. Puşcaru et al. 1956) de l'étage alpin supérieur (2000—2500 m) qui se développe sur un substrat sablonneux, fin, humide, avec peu d'humus. C'est une association pionnière qui prépare le sol pour l'installation de la végétation alpine de salicètes et, plus loin, vers les prairies, de graminées et cypéracées alpines. On a rencontré, selon l'endroit d'installation, deux variantes : l'une dans les vallées et les dépressions et l'autre sur les plateaux et les arêtes alpines.

1.1.2. *Polytrichetum sexangulare* Br.—Bl. 26

Décrite dans le massif du Bucegi (D. Puşcaru et al. 1956) où elle végète en petites surfaces, sur les sables et le gravier des vallées glaciaires, humides et ombrageuses, avec ou sans humus, aux altitudes comprises entre 2150 et 2350 m. L'association représente l'un des groupements alpins pauvres en espèces et se caractérise par la dominante silicicole *Polytricum sexangulare*, dont les exemplaires de Bucegi sont dépourvus de sporogones. Elle est associée fréquemment aux suivantes bryophytes : *Kiaeria starkei, K. falcata, Pohlia commutata, P. cuccullata, Polytrichum juniperinum,* etc., et aux phanérogammes : *Salix herbacea, Gnaphalium supinum* et *Arenaria biflora*.

L'association évolue difficilement dans les endroits érodés par les ruissellements des eaux et longtemps couverts de neiges, vers des agglomérations de *Salix herbacea, Primula minima* ou *Carex curvula*.

Tableau 1

La structure de l'association *Salicetum herbaceae* Br.—Bl. 13 des Carpates Méridionales

Relevés *	1		2		3		4		5	
Nombre des relevés	5		15		5		5		8	
Surface (m^2)	6		—		1		10		—	
Recouvrement (%)	65		—		70		25		85	
Exposition	SE		—		NE		NE		N	
Pente (^{0})	5		—		10		25		20	
Hauteur de la végétation (cm)	5		3		—		—		—	
	AD	K	AD	K	AD	K	AD	K	AD	K
Salicion herbaceae + Salicetalia herbaceae										
Salix herbacea	1—3	V	2—4	V	1—3	V	1—3	V	3—4	V
Soldanella pusilla			+	II	+	I			+	III
Gnaphalium supinum			+	I	+	II	+—1	III	+	II
Chrysanthemum alpinum							+	IV	+	IV
Luzula alpino-pilosa (= spadicea)					+	II	+—1	II	+	IV
Carex pyrenaica							+	I		
Polytrichum sexangulare	1	II	+—2	III					1	II
Ranunculus crenatus					+	III	+	I	+	II
Geum montanum							+	I	+	II
Primula minima	+—1	IV	+—1	V	+	V	+	II	+—2	V
Minuartia recurva	+—1	II								
Pedicularis oederi	+	II	+	I						
Ligusticum mutellina	+	II								
Arenaria biflora			+	I						
Salicetea herbaceae										
Cerastium cerastoides			+	I	+	I	+—1	III		
Sedum alpestre	+	IV	+	II	+	I			+	III
Veronica alpina			+	I			+	II		
Plantago atrata			+	I						
Caricion + Caricetalia curvulae										
Carex curvula	+	I	+	I	+—1	II	+—1	IV	+	I
Festuca supina	+	I			+—1	V	+—1	IV	+—1	IV
Phyteuma nanum	+	I	+	I	+	II	+	III	+—2	V
Polygonum viviparum	+—2	II	+	III	+	IV	+	III	+	II
Luzula spicata	+	I					+	I	+—1	II
Oreochloa disticha					+	IV	+	II	+	III
Senecio carpaticus									+	I
Potentilla ternata	+	I			+	I	+	II	+	I
Senecio carniolicus									+	II
Campanula alpina	+—1	III	+—2	IV					+	III
Agrostia rupestris	+	I	+—1	I	+	II	+—1	III		
Elyna myosuroides	+—1	II								
Minuartia sedoides	+—1	III	+	II						
Armeria alpina			+	I						
Saxifraga moschata	+	II	+	I						
Erigeron neglectus	+	I								

Tableau 1 (continuation)

Relevés *	1	2	3	4	5
Minuartia gerardi		+ I			
Thamnolia vermicularis	+ II		+ III		+ III
Juncetea trifidi					
Juncus trifidus	+—1 II	+ I	+ III		
Hieracium alpinum			+ II	+ II	+—1 III
Loiseleuria procumbens					+ I
Vaccinium gaultherioides			+ II		+ I
Thalictrum alpinum	+ I				
Androsacion alpinae					
Festuca bucegienis (= F. glacialis)	+ III	+ III			
Anthemis carpatica ssp. pyrethriformis	+ III	+ II			
Silene acaulis	+ II	+ II			+ I
Erigeron uniflorus		+ I			
Saxifraga bryoides			+ I		+ II
Veronica baumgartenii			+ I	+ I	+ II
Seslerion bielzii					
Sesleria bielzii					+ III
Sesleria coerulans	+ I				
Compagnes					
Cerastium alpinum	+ II	+ I			+ II
Taraxacum alpinum					+ I
Achillea schurii			+ II		
Poa alpina			+ III		
Rhododendron myrtifolium			+ II		+ I
Cerastium lanatum			+ II		+ III
Poa molinerii ssp. glacialis					+ I
Vaccinium vitis-idaea					+ I
Thymus pulcherrimus			+ I		
Solorina crocea			+ II		
Lecanora crassa			3 IV		
Alectoria ochroleuca			+—2 II		
Cetraria islandica			+—3 III		+—2 III
Cladonia rangiferina			+—3 II		
Centraria nivalis			+ II		+ III

* = Lieu de relevés : 1 — Monts Bucegi (Puşcariu et al., 1956) ;
2 — Monts Bucegi (Beldie, 1967) ;
3 — Monts Făgăraş (Voik, 1976) ;
4 — Monts Godeanu (Boşcaiu, 1971) ;
5 — Monts Retezat (Resmeriţă, 1976).

1.1.3. *Salicetum herbaceae* Br.—Bl. 13

L'association se présente en formations restreintes ou souvent fragmentaires végétant sur les graviers et les sables ou sur des sols superficiels, des squelettes du type renker alpin, formés de grès et de conglomérés riches en matériel silicieux, dans de stations bien éclairées et fortement ventées. A cause du microrelief, dans ces stations, au cours du printemps se produisent des stagnations temporaires d'eaux provenues de la fonte des neiges et, pendant la saison de végétation, les eaux des pluies qui innondent complètement le tapis végétal présentent quand même un niveau assez bas. Souvent les cénoses de *Salix herbacea* forment des mosaïques avec les prairies de *Carex curvula* qui ont la tendance à les invader. C'est ainsi que de l'alliance de *Caricion curvulae* on rencontre fréquemment : *Primula minima*, *Festuca supina*, *Phyteuma nanum*, etc. (tableau 1).

1.1.4. *Salicetum hastatae* Buia et al. 62 n.n.

L'association a été identifiée sur les rochers de Muntinul Mic (le massif de Parîng) où elle végète sur le versant nord, dans les endroits humides. La plante dominante et caractéristique *Salix hastata* se trouve accompagnée de : *Geum montanum*, *Senecio papposus*, var. *sulphureus*, *Saussurea alpina*, *Chrysanthemum alpinum*, *Ligusticum mutellina*, *Hedysarum hedysaroides*, *Festuca supina*, *Nardus stricta*, etc.

1.1.5. *Arenarietum biflorae* Voik 76

Est répandue surtout à l'étage alpin, descendant parfois jusqu'aux altitudes de 1700 m. Elle se développe sur de petites surfaces, fortement inclinées (25—60), parmi les rocailles sur un substrat sablonneux, provenu de la désagrégation des schistes cristallins, elles ne sont pas des cénoses typiquement chionophiles. Les phytocénoses d'*Arenaria biflora* se développent dans les endroits où la neige persiste longtems et grâce aux grandes inclinations l'eau ne stagne pas et le substrat sèche plus rapidement. A part *Arenaria biflora* on remarque comme principaux édificateurs de ces cénoses : *Gnaphalium supinum*, *Luzula alpino-pilosa (spadicea)*, *Poa alpina*. Dans les cénoses d'altitude plus réduites d'un substrat argileux-sablonneux, on trouve des bryophytes ayant AD=2—3. La présence de l'espèce *Nardus stricta* dans les groupements d'*Arenaria biflora* dénote la tendance d'évolution vers *Nardo-Gnaphalietum supini* Bartsch 40.

L'association a été décrite dans les monts de Făgăraş (Valea Şerbotei, Surul, Căldarea Sărată, Ciortea et Negoiu).

1.1.6. *Poo supinae-Cerastietum cerastoidis* (Söry 54) Oberd. 57

Les cénoses chionopétrophiles, ayant un caractère mésohygrophile, formées de *Cerastium cerastoides*, végètent sur les roches broyés des niches nivales, dans les cirques glaciaires ainsi que sur les cônes des moraines situées à la base des torrents alpins. Elles ont été signalées par N. Boşcaiu (1971) dans les monts de Ţarcu et Godeanu.

Les espèces caractéristiques de l'association sont *Cerastium cerastoides*, *Poa supina* et *Poa alpina* f. *vivipara* associées à *Gnaphalium supinum*, *Soldanella pusilla*, *Plantago gentianoides*, *Geum montanum*, *Sedum alpestre*, *Taraxacum alpinum*, *Alchemilla glaucescens* et *Nardus stricta*.

Dans l'association, Gh. Coldea (1985) décrit la sous-association *-chrysosplenietosum alpinae*.

1.1.7. *Nardo-Gnaphalietum supini* Bartsch 40

L'association est répandue chez nous dans les massifs de Țarcu, Godeanu et Retezat (N. Boșcaiu, 1971 ; I. Resmeriță, 1976). Elle est représentée par des cénoses pionnières chionoterricoles, qui colonisent le substrat sablonneux-argileux dénudé des terrasses. Par rapport à celles des Alpes, nos phytocénoses diffèrent par la présence de la différentielle daco-balkaniques *Potentilla ternata*.

Quoique pendant les premiers stades de colonisation, le rôle principal fût détenu par *Gnaphalium supinum* c'est *Nardus stricta* qui se multiple plus vite, et à la fin on reconstitue les phytocénoses initiales de *Nardus* qui ont été éloignées à la suite de la dénudation du sol.

I. Resmeriță (1976) fut la seul à présenter dans notre pays la structure de l'association sur la base de 8 relevés provenus de massif de Retezat. N. Boșcaiu (1970) décrit l'association *Nardo-Geetum montani* des monts de Țarcu et Godeanu qui n'a plus été reprise dans sa monographie publiée (1971), que nous classons comme synonime de *Nardo-Gnaphalietum supini*.

1.1.8. *Soldanello (pusillae)-Ranunculetum crenati* (Borza 31 n.n.) Boșcaiu 71 (Syn : *Soldanello (pusillae-Plantaginetum gentianoides* Boșcaiu 71)

L'existence de ces cénoses daco-balkaniques a été signalée par Al. Borza (1931, 1963) dans les Carpares Meridionales, mais sans les décrire. L'association a été décrite dans les monts de Țarcu (N. Boșcaiu, 1971) et signalée ensuite dans les monts de Retezat (I. Resmeriță, 1976) et Pietrosul Mare de Rodna (Gh. Goldea et al., 1981). C'est une association chionopétrophile à caractère mésophile qui végète sur les moraines aux neiges prolongées mais drainées après la fonte et sur des versants protégés contre les vents dans les cirques glaciaires. Elle s'entrepénètre souvent aux cénoses pétrophiles de l'ordre *Androsacetalia alpinae*. Parmi les espèces différentielles présentées dans les phytocénoses de Retezat, nous mentionnons : *Geum montanum, Ligusticum mutellina, Plantago gentianoides*.

Le cénotaxon synonime, *Soldanello (pusillae)-Plantaginetum gentianoides* Boșcaiu 71 est décrit dans le mont de Țarcu et signalé ensuite par I. Resmeriță (1976) dans les monts de Rodna et par W. Woik (1976) dans le massif de Făgăraș (la vallée Șerbota). Ana Paucă et Doina Rădulescu (1960) décrivent ces cénoses du massif de Făgăraș sous le nom « d'association de Plantago gentianoides » et St. Csűrös (1956) signale de pareilles phytocénoses aussi dans le massif de Făgăraș où dominent *Plantago gentianoides* et *Soldanella pusilla*.

1.1.9. *Caricetum pyrenaicae* A. Paucă et Răd.-Ivan 60

Sur les pentes faiblement inclinées des vallées glaciaires, occupées par les moraines, et surtout sur les plaques en pierre semifixées, riches en colluvions humiques, se développent, à exposition de règle nord et est, des phytocénoses édifiées de *Carex pyrenaica*. Décrites dans les cirques glaciaires de Bilea et Podragu sous le nom d'« associacion de *Carex pyrenaica* », ces phytocénoses sont identifiées par Erika Schneider-Binder (1977) aussi sur le versant est de la cime de Buteanu, dans la vallée d'Arpășelul. A part l'espèce édificatrice, dans son cortege à abondance—dominance élevée, on remarque *Plantago gentianoides* et *Soldanella pusilla* ; il y existe des interférences avec l'association édifiée par celles-ci.

1.1.10. *Luzuletum alpino-pilosae* Br.—Bl. 26 *retezaticum* Borza 34 (Syn : *Luzuletum spadiceae* Br.—Bl. 26 *retezaticum* Borza 34)

C'est un groupement chionopétrophile, qui végète sur les moraines silicieuses assez inclinées, sur lesquelles la neige stagne plus longtemps. L'association est rencontrée à la base des moraines semifixées, là où il existe la possibilité de l'accumulation de l'humus. Al. Borza (1934) décrit, dans le massif de Retezat, la variante régionale *retezaticum* au fondement des caractéristiques *Ranunculus crenatus* et *Soldanella pusilla*.

Les recherches ultérieures effectuées dans l'entière chaîne carpatique ont mis en évidence l'existence de ces groupements dans la plupart des massifs. Le sol sur lequel se développent ces phytocénoses, même superficiel, est assez riche en humus, ce qui permet l'existence d'un tapis végétal presque continu. Parmi les espèces compagnes et qui présentent un recouvrement și une constance élevés, nous mentionnons *Poa alpina* et *Festuca supina*.

1.1.11. *Festucetum pictae* Krajina 33

Chez nous, a été identifié pour la première fois par Al. Borza (1934) dans le massif de Retezat et puis par Al. Buia (1943) dans les massifs de Făgăraș, Rodna et Retezat et, plus tard, avec les collaborateurs (1962) dans le massif de Paring aussi, où elle pousse sur de petites surfaces, ayant un degré de recouvrement réduit. Du massif de Rarău, P. Raclaru (1967) la signale en quelques endroits, végétant sur des surfaces planes ou faiblement inclinées, situées au-dessus de la limite supérieure de la forêt. *Festuca picta* (AD = 4) s'associe à : *Festuca rubra, Anthoxanthum odoratum, Potentilla aurea, Thymus pulegioides, Festuca saxatilis, Luzula luzuloides* var. *cuprina, Alchemilla xanthochlora, Carex montana, Primula leucophylla*, etc.

1.1.12. *Poaetum nyárádyanum* Borza 63 (Syn : *Poaetum pruinosae* Borza 34)

L'association est décrite par Al. Borza (1934) dans le massif de Retezat, végétant sur le gravier granitique, étant spécifique de ce massif. Initialement elle a été classée, dans l'*Androsacetalia alpinae*. Les espèces caractéristiques sont : *Poa laxa* var. *caesio-glauca (Poa nyàràdyana), Cardamine resedifolia, Veronica baumgartenii*. L'auteur mentionne que l'association doit être étudiée de près (pg. 19).

1.1.13. *Festuco pictae-Senecionietum carniolicae* Lungu et Boșcaiu 81

Colonise les moraines alpines provenues de la désagrégation des granodiorites en cours de fixage. C'est une association pionnière, lithophile, signalée dans le Parc National de Retezat (La Porte de Bucura et la Cime Zănoaga). Le cénotaxon est adapté à un régime microtherme confirmé par l'installation de certaines populations chionophiles (*Soldanella pusilla, Chrysanthemum alpinum, Sedum alpestre*). Le commencements du fixage des moraines favorisent l'augmentation du rôle édificateur des espèces caractéristiques de l'alliance *Caricion curvulae* Br.—Bl. 25, à savoir : *Oreochloa disticha, Festuca supina, Carex curvula, Hieracium alpinum, Phyteuma nanum, Juncus trifidus, Anthoxanthum alpinum, Primula minima, Campanula alpina, Agrostis rupestris*.

Egalement *Luzuletum spadiceae* et *Festucetum pictae* ont été comprises par V. Krajina (1933) dans l'alliance *Festucion pictae*, l'ordre *Androsace-*

talia alpinae Br.—Bl. 26. En prenant en considération les stations de ces phytocénoses et le comportement chiono-pétrophile des espèces édificatrices, il est mieux de les placer dans l'alliance *Salicion herbaceae* Br.—Bl. 26.

1.1.14. *Ranunculus glacialis-Saxifraga oppositifolia* ass. Evd. Puşcaru et al. 77 n.n.

Cénotaxon signalé comme « nomen nudum » dans le massif de Făgăraş ; il nécessite des investigations ultérieures.

1.1.15. *Soldanello hungaricae-Ranunculetum crenati* Coldea 85 (Syn : *Agrosteto(alpinae)-Gnaphalietum supini* Resmeriţă 75 ; *Agrosteto(alpinae)-Ranunculetum crenati* Resmeriţă 75)

C'est un groupement chionophile qui se développe dans les cirques glaciaires de Pietrosul Mare (le massif de Rodna). Il végète dans des écotopes silicieux, au drainage satisfaisant, approvisionnés tout le temps de l'eau provenue des précipitations. L'association comprend surtout des espèces chino-oligothermes mais aussi quelques-unes méso-oligothermes A part les deux codominantes : *Soldanella hungarica* et *Ranunculus crenatus*, une participation plus accentuée ont : *Agrostis rupestris*, *Gnaphalium supinum*, *Geum montanum*, *Ligusticum mutellina*, *Festuca supina*, *Primula minima*, *Homogyne alpina*, etc.

2. ARABIDETALIA COERULEAE Rübel 33

Comprend la végétation des terrains calcaires aux neiges prolongées. Les espèces caractéristiques de l'ordre sont : *Ranunculus alpestris*, *Saxifraga androsacea*, *Salix retusa*, *Plantago atrata*, *Carex ornithopodioides*.

2.1. Salicion retusae Horv. 49

Groupe les cénoses de saules nains des moraines de la base des rochers calcaires et quelquefois même des parois rocheuses où elles viennent en contact avec les associations de l'ordre *Seslerietalia*. Le régime hydrique est variable, passant, surtout vers la fin de la période de végétation, par une phase de sécheresse. Les espèces caractéristiques : *Salix retusa*, *S. reticulata*, *Dryas octopetala*, *Saxifraga oppositifolia*.

2.1.1. *Aubrietietum croaticae* Horv. 59

L'association est citée par Al. Borza (1963) dans le massif de Parîng, sans donner des relevés.

2.1.2. *Salicetum retusae* (Buia et al. 62 n.n.) Erika Schneider-Binder et Voik 79

Al. Buia et les collaborateurs (1962) l'identifient sur les terrasses étroites du versant abrupt nord des cimes Mîndra et Cîrja. La plante dominante *Salix retusa* var. *retusa* et var. *kitaibeliana* pousse ensemble avec : *Geum montanum*, *Gnaphalium supinum*, *Sedum roseum*, *Phyteuma nanum*, *Swertia punctata*, *Oreochloa disticha*, *Juncus trifidus*, *Hieracium villosum*, *Anthemis carpatica*, *Festuca supina*, *Nardus stricta*.

L'association se développe aussi sur les petites terrasses des abrupts du massif de Făgăraş (Erika Schneider-Binder et W. Voik, 1979), occupant les stations protégées contre l'action xérique des vents de la cime. A part *Salix retusa*, parmi les espèces caractéristiques rencontrées ici, nous rappelons : *Polygonum viviparum* et *Saxifraga paniculata*. Pour ces phytocénoses nous considérons, de même qu'Erika Schneider-Binder et W. Voik (1979), que la dénomination la plus conforme serait *Salicetum retusae*.

N. Boşcaiu (1971) identifie dès les massifs de Ţarcu-Godeanu le cénotaxon *Anemono-Salicetum retusae* Horv. 49, puis W. Voik (1976) le signale aussi pour le massif de Făgăraş. A cause du manque ou de la fréquence réduite de l'espèce *Anemone narcissiflora*, Erika Schneider-Binder et W. Voik (1979) situent ces phytocénoses dans *Salicetum retusae* subass. avec *Anemone narcissiflora*.

Pour la même raison, les phytocénoses décrites par nous (1976, 1977) du massif Piatra Craiului sous le nom d'*Anemono-Salicetum retusae* Horv. 49 subass. *salicetosum reticulatae* Sanda et Popescu 76 sont classées par Erika Schneider-Binder et W. Voik (1979) dans l'association *Salicetum retusae* subass. avec *Dryas octopetala*, cénotaxon identifié par eux dans le massif de Făgăraş végétant au bord des pentes et des crêtes ventées, étant, en réalité, un anneau de liaison entre les phytocénoses de *Salix retusa et* celles de *Dryas octopetala*.

2.1.3. *Salicetum reticulatae* Puşcaru et al. 56

Les phytocénoses de l'association ont été décrites dans le massif de Bucegi (Puşcaru et al., 1956 ; Al Beldie, 1967) et identifiées aussi dans le massif de Făgăraş (W. Voik, 1976). Elles se développent sur les terrasses des versants abrupts, la crête des montagnes, sur les sols squelettiques avec une certaine quantité d'humus. L'abondance des lichens dans les phytocénoses signalées par W. Voik (1976), dans la vallée de Şerbota (le massif de Făgăraş), indique un haut degré de sécheresse pendant la période de végétation.

L'abondance—dominance élevée de l'espèce *Saxifraga oppositifolia* dans certaines phytocénoses a déterminé la description du facies avec cette espèce (W. Voik, 1976), considéré ensuite comme subass. avec *Saxifraga oppositifolia* Erika Schneider-Binder et Voik 79.

Les groupements de *Salix reticulata* évoluent vers des prairies caractéristiques de l'ordre *Seslerietalia*, et dans les cas de l'acidification du sol, vers rhodoraies ou des prairies de l'alliance *Caricion curvulae*.

2.1.4. *Dryadetum octopetalae* Csűrös et al. 56

Les phytocénoses édifiées de *Dryas octopetala* ont été décrites dans la partie sud du massif de Retezat (St. Csűrös et al., 1956) et, plus récemment, identifiées par nous (1977) aussi dans le massif Piatra Craiului.

Dans le massif Piatra Craiului, l'association s'installe sur les rochers calcaires où s'est déposée une couche de sol assez superficielle, provenue des débris des rocs, de la poussière et de l'humus résulté de la dégradation des restes végétaux. Elle pousse à la limite entre les prairies alpines et les buissons caractéristiques de cet étage, ce qui explique la présence des espèces caractéristiques de ces deux formations végétales dans l'association respective.

Parmi les espèces caractéristiques des prairies alpines, nous mentionnons : *Carex sempervirens*, *Phyteuma orbiculare*, *Festuca versicolor*, *Ranunculus oreophilus*, *Polygonum viviparum*, et parmi celles de buissons nous rappelons : *Rhododendron myrtifolium*, *Vaccinium vitis-idaea*, *Pinus mugo*.

Conformément à ce que nous avons affirmé dès 1977 (pp. 126—127), point de vue adopté aussi par Erika Schneider-Binder et W. Voik

(1979), l'association est située dans l'alliance *Salicion retusae* et non pas dans *Papavero-Thymion pulcherrimae* (à voir I. Pop, 1968, p. 270).

V. Zanoschi (1972) décrit du massif Ceahlău la sous-association *salicetosum retusae* que nous plaçons dans *Salicetum retusae* subass. avec *Dryas octopetala* Erika Schneider-Binder et Voik 79.

2.1.5. *Salicetum retuso-reticulatae* Br.—Bl. 26

Les phytocénoses édifiées de *Salix retusa* et *Salix reticulata* végètent, surtout au bord des terrasses des pentes abruptes et vers les cimes où la régime xérique est plus accentué que dans les stations occupées seulement de *Salix retusa*. Dans l'association sont comprises aussi les phytocénoses contenant, à part les deux codominantes, les espèces *Dryas octopetala* et *Saxifraga oppositifolia*, parfois avec une constance plus élevée. De tels groupements ont été décrits par St. Csűrös (1957) de la partie centrale du massif de Făgăraş, et par al. Beldie (1967) dans le massif de Bucegi sous le nom d'ass. *Salix reticulata-Dryas octopetala*. Ces phytocénoses sont classées par Erika Schneider-Binder et W. Voik (1979) en tant que subass. avec *Dryas octopetala*.

2.2. Arabidion coeruleae Br.—Bl. 26

Comprend les associations caractéristiques des vallées alpines calcaires, à substrat basique, humide. Les espèces caractéristiques sont : *Arabis alpina*, *Ranunculus alpestris*, *Saxifraga androsacea*, *Plantago atrata*, *Saxifraga retusa*, *Carex ornithopodioides*.

2.2.1. *Arabidetum alpinae* Br.—Bl. 13 *carpaticum* Evd. Puşcaru et al. 77 n.n.

La sous-association est mentionnée dans le conspectus des associations du massif de Făgăraş (Evdochia Puşcaru-Soroceanu et al., 1977).

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Reçu le 24 novembre 1987

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TOXIC EFFECTS OF ZINC, CADMIUM AND THEIR MIXTURES ON THE GROWTH OF TWO UNICELLULAR GREEN ALGAE

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Monoraphidium contortum and *Kirchneriella subcapitata* have been used as models for the study of Zn and Cd toxicity and cation interaction. Batch cultures were analysed for cell number, optical density, chlorophyll and carbohydrates. After 14 days of culture, the cell number of *M. contortum* suspensions decreased with 50% at 0.75 mg Zn . l^{-1} and 1.5 mg Cd. l^{-1}, respectively. The mixtures of Zn and Cd, which were added at the same gravimetrical concentrations as single metals, exhibited their inhibiting effects in larger doses (60% inhibition at 3 mg . l^{-1}). At those concentrations, the optical density was more slowly reduced. The metal concentrations increased the cell content in chlorophyll and carbohydrates, as compared to control. These increases were interpreted in direct relation with cell volume and inhibition of cell division. The results plead for an antagonistic interaction between the two metals. Similar results have been also obtained with *K. subcapitata*.

It is well known that pollution with heavy metals in fresh waters leads to important changes within vegetal and animal communities. The recent increase in pollution, alongside of the intense use of waters for various fields of economy, and the progressive increase in accuracy of research methods have all led to the accumulation of a large amount of information about heavy metals in aquatic medium (8, 13, 19, 37, 47).

Many studies concerning the effects of heavy metals on algal cultures refer to metals added individually to the culture medium. Yet, in natural ecosystems heavy metals can be found as mixtures of several species rather than isolated. Extension and application of laboratory-obtained results to the complexity of aquatic ecosystems supposes, as an intermediate stage, the ascertainment of the ways in which different metals may interact for determining the toxic effect.

Antagonistic, additive or synergic interactions have already been mentioned when determining toxic effects or interconditioning phenomena at the level of metal ions incorporation by algal cells (1, 5, 6, 21, 22, 23, 25, 26, 33, 42).

The present amount of information does not allow the formulation of firm conclusions on the interactions among heavy metals and their role in toxicity. Quite often the final result of the interaction depends on the algal species, the metal concentrations and especially the criteria for estimation (5, 6, 42).

The aim of the present paper is to evince the effects of different concentrations of Zn and Cd ions, added individually or in mixture on the growth of algal cultures, as well as to establish the type of interaction between these two metals.

REV. ROUM. BIOL. — BIOL. VÉGÉT., TOME 33, Nº 2, P. 103—110, BUCAREST, 1988

MATERIAL AND METHODS

Experiments were carried out on unialgal cultures of the species *Monoraphidium contortum* (Thuret in Bréb.) Komárkova-Legnerova (strain Mco 3) and *Kirchneriella subcapitata* Kors. (strain Ksu 8). They have been isolated from unpolluted biotops and are preserved in the Algal Collection of the Biological Research Centre of Cluj-Napoca. The nutritive medium no. 11 (48), modified by omitting Na_2EDTA, was used for growth. Iron was added as ferric chloride. After 14 days of growth (27± 1°C, approx. 4,500 lux, 16/8 h light/dark cycles), optical density, cell number and chlorophyll ($a + b$) were determined (27,41). Each test was repeated ten times. Total carbohydrates were determined by the phenol--sulphuric method (18).

Zn and Cd were added as nitrates in four distinct final concentrations, from supply solutions acidulated with HCl.

For standardization, the data obtained were expressed in relative units as compared to the average of control tests.

RESULTS

The effects of Zn on M. contortum. Zn added to the culture medium in various concentrations inhibits cellular multiplication. After 14 days of growth the cell number of suspensions is lower and the average generation time increases according to dose. The concentration of 0.75 mg . l^{-1} reduces with about 50 % the cell number and increases about twice the average generation time (Fig. 1 and Table 1). A stronger inhibition is best evinced by cell number and chlorophyll. The optical density is not similarly affected. The dose of 0.75 mg . l^{-1}, which reduces the number of cells to almost half, decreases the optical density to about 88 % (Fig. 1). Zn also increases the cell content in chlorophyll. These data suggest a more pronounced inhibition of cellular multiplication as compared to the synthesis of chlorophyll.

The effects of Cd on M. contortum. The influence of Cd is similar to that of Zn, with the difference that the inhibitory effect is more pregnant in larger concentrations (Fig. 2 and Table 1). Cellular density is reduced to about its half only at 1.5 mg . l^{-1}. For the same concentration, the average generation time increases approximately two times. For 0.75 mg . l^{-1} the growth is approx. 85 % of the control. Chlorophyll is more affected by higher concentrations of Cd.

The effects of Zn and Cd mixtures on M. contortum. In order to trace the effect of Zn and Cd interaction on toxicity, the two metals were simultaneously added at the beginning of growth. The concentrations of metal mixtures are gravimetrically equal to those used in the above-described experiments. So, each metal contributes to achieving half of the final concentration.

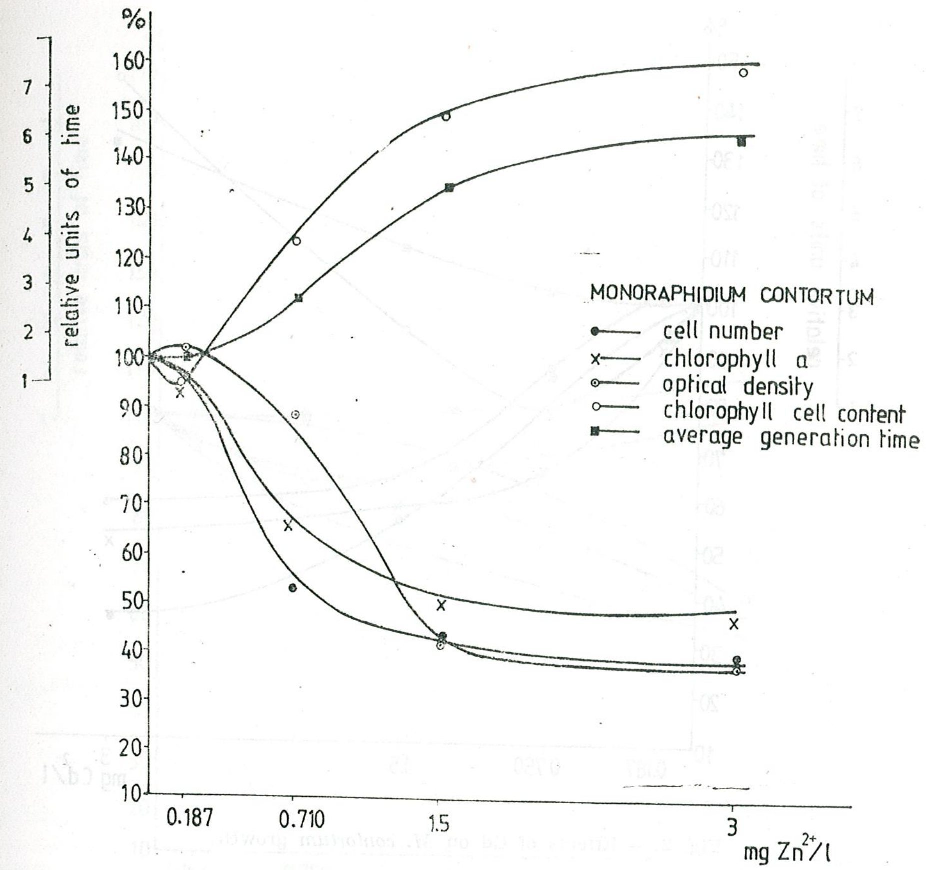

Fig. 1. — Effects of Zn on *M. contortum* growth.

Table 1

The influence of Zn and Cd concentrations on the average generation time of *Monoraphidium contortum* cultures (relative units ± standard error)

Metal (mg . l^{-1})	0	0.187	0.75	1.5	3.0	4.0
Zn	1	1.016±0.04	2.17±0.08	4.45±0.12	5.52±0.23	—
Cd	1	1.080±0.05	1.20±0.07	2.05±0.08	4.07±0.21	59.90±3.59
Zn + Cd	1	1.030±0.03	1.06±0.04	1.11±0.05	1.70±0.06	4.23±0.24

The combinations exhibit their inhibiting effect in larger doses than those of single metal (Fig. 3, Table 1). Cellular multiplication is inhibited (to about 60 % of the control) only at 3 mg . l^{-1}. The cellular content in chlorophyll is larger in the control test but smaller when compared to similar variants described above. Under the influence of 1.5 and 3 mg . l^{-1}

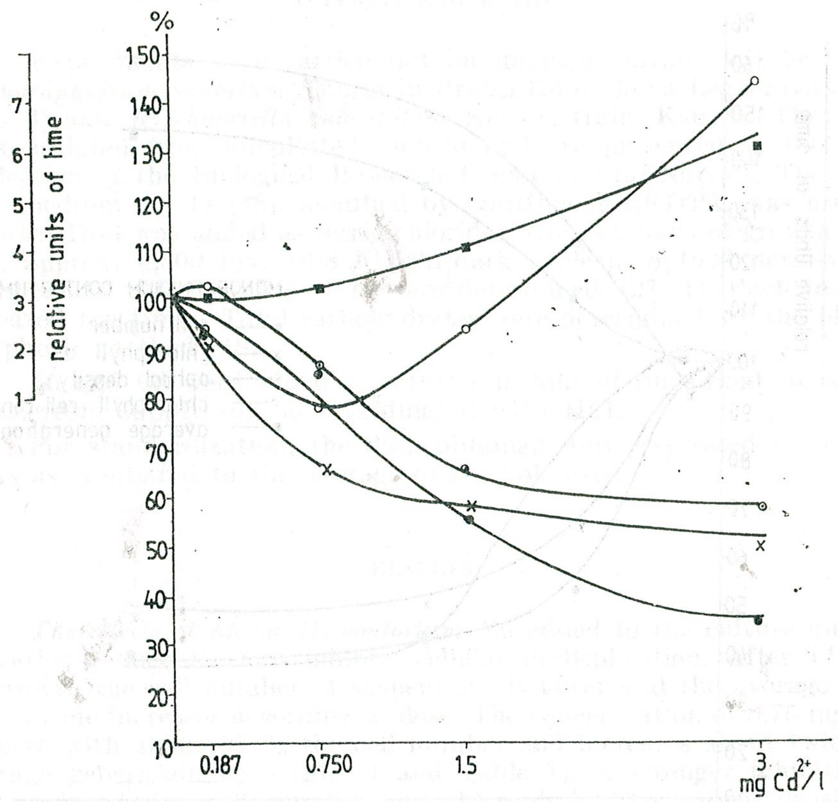

Fig. 2. — Effects of Cd on *M. contortum* growth.

doses cellular multiplication is less inhibited as compared to the same doses of Zn or Cd. As a result, the average generation time is less increased. These effects reveal an antagonism between Zn and Cd in inducing toxicity.

The effects of Zn and Cd on K. subcapitata. Subsequently, similar experiments were carried out on another test alga of the same taxonomic group. The results obtained from the analysis of the same parameters are similar to those obtained with the preceding species. Table 2 shows the variation of the average generation time under the influence of Zn and Cd, added separately or as mixtures. Both Zn and Cd increase the generation time according to dose. Cd increases more the generation time in *K. subcapitata* than in *M. contortum*. This fact could be due to a difference in sensitivity between these two species. In this situation again the combined effects of Zn and Cd plead for an antagonistic interaction. This interaction is best evinced by 1.5 $mg \cdot l^{-1}$. In higher concentrations the antagonism becomes uncertain.

The effects of Zn on the carbohydrates content. In the experiments described above, the inhibition of cellular multiplication was accompanied by an increase in the chlorophyll content of the algal cells. With

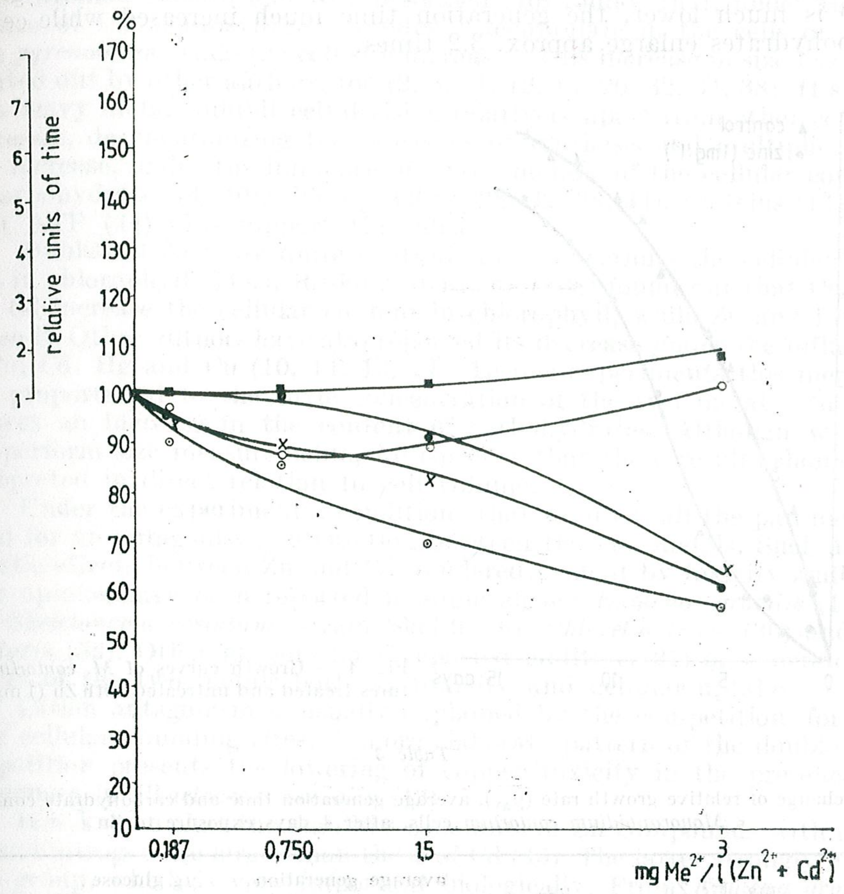

Fig. 3. — Effects of Zn and Cd mixtures on *M. contortum* growth.

Table 2

The influence of Zn and Cd concentrations on the average generation time of *Kirchneriella subcapitata* cultures (relative units ± standard error)

Metal $mg \cdot l^{-1}$	0	0.187	0.75	1.5	3.0	4.0
Zn	1	1.15±0.04	1.35±0.03	2.99±0.12	4.07±0.20	4.71±0.09
Cd	1	1.10±0.05	1.10±0.03	4.91±0.13	5.73±0.24	10.53±0.55
Zn + Cd	1	1.07±0.06	1.12±0.05	1.42±0.03	4.48±0.17	9.38±0.37

another experiment we tried to prove a similar behaviour in carbohydrates. The results of this experiment are shown in Fig. 4 and Table 3. The influence of Zn leads to a prolonged lag phase, which is recovered in a couple of days only. After 14 days in the presence of Zn, the average growth rate is much lower, the generation time much increased while cellular carbohydrates enlarge approx. 3.2 times.

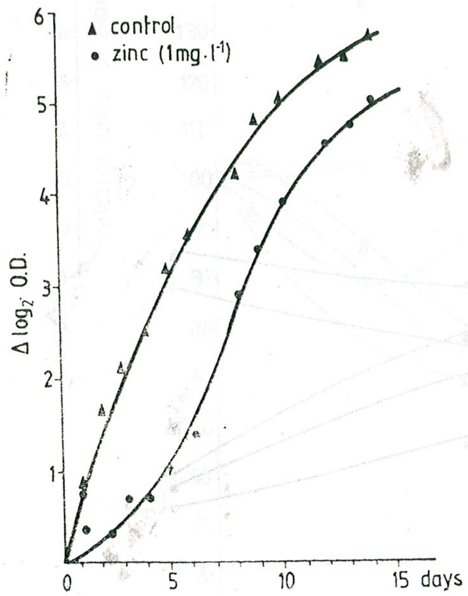

Fig. 4. — Growth curves of *M. contortum* cultures treated and untreated with Zn (1 mg . l^{-1}).

Table 3

The change of relative growth rate (μ_{av}), average generation time and carbohydrate content of *Monoraphidium contortum* cells, after 4 days exposure to Zn

mg . l^{-1} Zn	μ_{av}	average generation time (days)	µg glucose . 10^{-6} cells
0	0.569±0.049	1.169±0.019	2.630±0.212
1	0.047±0.003	14.801±0.721	8.365±0.192

DISCUSSIONS

The two metals differ essentially from one another by their biological role. Zn appears in the structure of several metalo-enzymes, thus being absolutely necessary for life. Cd does not seemingly accomplish any biological function. Perhaps this is one of the reasons why its toxicity for algae has been more thoroughly studied (2, 4, 7, 9, 10, 25, 26, 29, 33, 35, 36, 38, 44, 46). The toxicity of Zn is also well known, and the fact that Zn is less toxic than Cd is well established, too (7, 9, 14, 15, 16, 17, 26, 31, 35, 38). If we had expressed our results in molar concentration, this conclusion would have been more obvious.

Steeman Nielsen and Kamp-Nielsen (40) found that, under the influence of Cu, photosynthesis products accumulate in the cells of *Chlorella pyrenoidosa* while the cell size increases. This increase in size has been pointed out by other authors, too (2, 3, 11, 12, 14, 20, 32, 34, 38). It seems that heavy metals inhibit cell division relatively apart from other cellular processes, desynchronizing the processes of synthesis and multiplication. The increase, under the influence of heavy metals, of the cellular content in carbohydrates (4, 40), chlorophyll (2, 28, 32, 38, 44), proteins (14) and even ATP (44) also support this idea.

Published data are quite contradictory concerning the cellular content in chlorophyll. Thus, Rosko and Rachlin (38) found out that Cu, Hg and Cd increase the cellular content in chlorophyll, while Zn and Pb decrease it. Other authors have also reported its decrease under the influence of Zn, Cd, Hg and Cu (10, 14, 16, 24). In our experiments this increase was proportional to the toxic concentration of the two metals. Zn also induces an increase in the content of carbohydrates. Although we did not perform size measurements, we consider that these results should be interpreted in direct relation to cell volume.

Under the experimental conditions that we used, all the parameters plead for an antagonistic interaction between the two metals. Such antagonistic effects between Zn and Cd, rendered evident by toxicity and cellular uptake, have been reported in some algae : *Euglena gracilis* (1, 32, 33), *Skeletonema costatum* (strain Skel-0) (6), *Chlorella fusca* (30) and *C. regularis* (39). Other authors have reported additive (21) or synergic (6) effects of the two metals both on toxicity and cellular uptake.

Cation antagonism is usually explained by the competition for the same cellular bounding sites. A more elaborate pattern of the double site competition presents the lowering of copper toxicity in the presence of manganese in *Chaetoceros socialis* (43).

It is known that the stability constants of Zn compounds with oxygen and nitrogen are larger than those of Cd (45). The latter strongly binds thiol group, which is very important biologically. From *Euglena gracilis* cells cultivated in the presence of Cd, a compound with a high molecular weight was isolated (1). It was able to bind both Zn and Cd. This fact partly proves that Zn and Cd compete for the same binding sites. As this competition takes place at the level of several cellular sites, it is difficult not only to draw up an explanatory pattern but also to express metals antagonistic interaction at the experimental level.

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Received February 8, 1988

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THE EFFECT OF NITRATE FERTILIZERS TREATMENTS UPON THE ULTRASTRUCTURE OF *LOLIUM PERENNE* L. CHLOROPLASTS

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VERONICA CRĂCIUN, *** V. SORAN * and I. PUIA **

The effect of nitrate fertilizers upon the ultrastructure of *Lolium perenne* L. chloroplast was studied in different doses : a) suboptimum (100 kg . ha^{-1}) ; b) optimum (200 and 400 kg. ha^{-1}) and c) superoptimum (800 kg . ha^{-1}). It has been ascertained that the suboptimum dose determines few changes in the ultrastructure ; the optimum doses do determine some starch grains accumulation in the chloroplast, as well as the increase of the granae/chloroplast number ; the superoptimum dose proved to be toxic, because of the ammonium ion in the composition of the administered fertilizer, fact that became obvious by the chloroplast ultrastructure deterioration. On the basis of the microphotographs by electron microscopy, the hypothesis has been advanced that the ammonium nitrate (the experimented fertilizer), by the effect of the ammonium ion, determines an alteration of sugars' metabolism in the chloroplast.

Several experiments performed in our country and abroad proved the decisive part of ammonium in the production increase, on natural and cultivated lawns. As a consequence of the applied treatments, an increase of fertilizer's rough protein content and, at the same time, of its nitric ammonium, has been recorded.

This last substance, accumulated beyond certain limits, may determine the poisoning of the animals foddered from the lawns, intensively fertilized with ammonium (17). Under the influence of the ammonium fertilizers, the ratio between the chemical compounds with and without ammonium, in plants, shifts in favour of those with ammonium (6). The investigations concerning the influence of ammonium fertilizers upon different fodder plants – especially graminaceae (8) – also revealed the fact that, in certain concentrations, an important increase of the biomass has been recorded. This increase may be correlated with the changes in the chemical composition and the structure of the photosynthesizer apparatus, not only in the mentioned plants, but in other cultivated ones as well (1, 2, 3, 5, 7, 13, 14, 15, 16, 22, 24.)

It has been proved that the insufficiency of the NO_3^- ion, from the nutritive medium of the plant, does determine alterations of the photosynthesizer apparatus structure and function, increasing, thus, the intensity of the photosynthesis and of the proteins synthesis (3, 12). Research studies performed by means of electron microscopy (14, 15, 22, 24, 25) have revealed changes of the photosynthesizer apparatus, in the case of ammonium insufficiency. The effects of the ammonium fertilize' and superoptimum doses, upon the ultrastructure of chlo not yet been cleared up wholly.

The object of the present study is the effect of ammonium fertilizers upon the ultrastructure of the *Lolium perenne* L. chloroplasts (English ryegrass).

MATERIAL AND METHOD

The effect of the ammonium fertilizers' treatments was studied on plants grown in Mitcherllich vegetation jars, on a forest brown-reddish soil, under hydric and nutritive controlled conditions. Four ammonium fertilizer concentrations were administered :

N_0 = control
N = 100 kg. ha^{-1} (variant further referred to as N_{100}) ;
N = 200 kg. ha^{-1} (variant further referred to as N_{200}) ;
N = 400 kg. ha^{-1} (variant further referred to as N_{400}) ;
N = 800 kg. ha^{-1} (variant further referred to as N_{800}).

The fertilizers were administered only once, while sowing, as ammonium nitrate (35 % active substance), on the fund P_2O_5 = 100 kg. ha^{-1} and K_2O = 200 kg. ha^{-1}. During vegetation, the plants were kept under proper humidity, in order to provide the maximum efficiency for the administered fertilizers. The vegetation jars were kept under natural conditions (The Agrobotanical Garden of Cluj-Napoca Agronomical Institute). The sowing was carried out in May 1982, with already germinated seeds; after three days, the plants sprang in all variants, 70 %. After 33 days of growing, the material was gathered (fresh leaves). For electron-microscopical investigations, samples of foliated tissue, from the mesophilus, have been fixed, for 2 hours, in 3 % glutaraldehyde, buffered on pH = 7.2, with natrium cacodyl solution. After fixation, the glutaraldehyde was removed through washing, for an hour, with buffer solution, which was 3–4 times replaced. Post-fixation was performed in 1 % osmic acid, at pH = 7.2, during an hour. After postfixation, the material was newly washed in the buffer solution, in increasing concentrations, up to absolute acetone. All the fixation operations were carried out at a 4°C temperature. After dehydration, the vegetal material was included in Westopal and sectioning was carried out in the L.K.B–III ultramicrotome. The sections were double coloured with uranyl acetate and lead citrate and were examined by a TESLA BS–500 electron microsocope.

RESULTS AND DISCUSSIONS

The electronic microsocopic images of the control *Lolium perenne* L. plants are shown in Plate 1, Figs. 1 and 2. The chloroplasts have specific structure; they have been marked by a double membrane; inside the stroma, there are granae with thylakoids granae and inter granae, plastoglobuli and starch grains. On the 20–30.000 times magnified microphotos, measurements of chloroplast and thylakoid/granae have been carried out. Observations (table 1) revealed that the thylakoids/granae number is, on an average, 10, varying between 2 and 20. The granae/section chloroplast number varies between 30 and 40 (on an average 30).

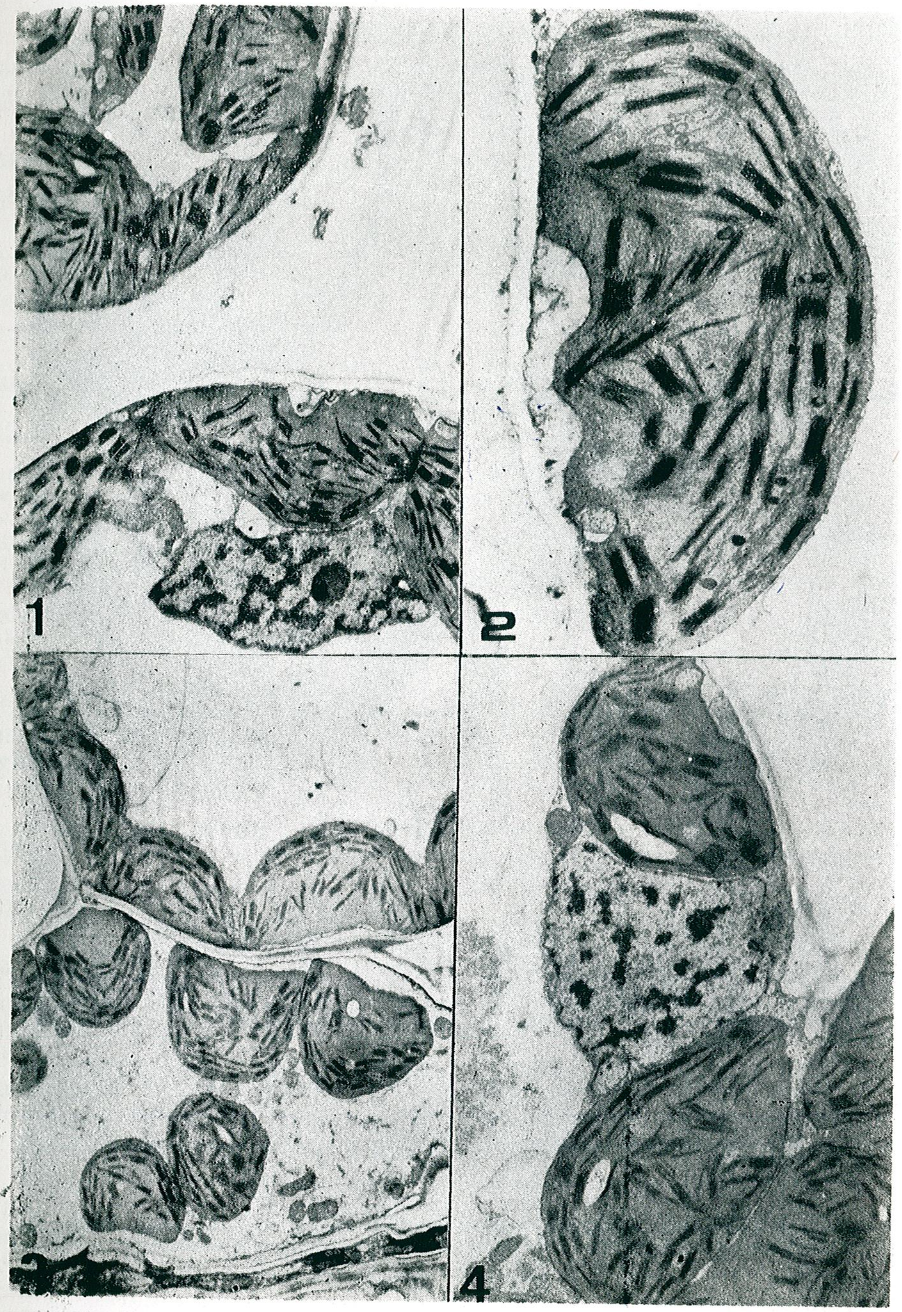

Plate 1. Fig. 1 and 2 — The ultrastructure of the *Lolium perenne* chloroplasts in control plants (×5600; × 13.600).
Fig. 3 and 4 — The effect of ammonium at N 100 kg. ha^{-1} concentration upon the ultrastructure of the *Lolium perenne* L. chloroplasts (×3200; ×6000).

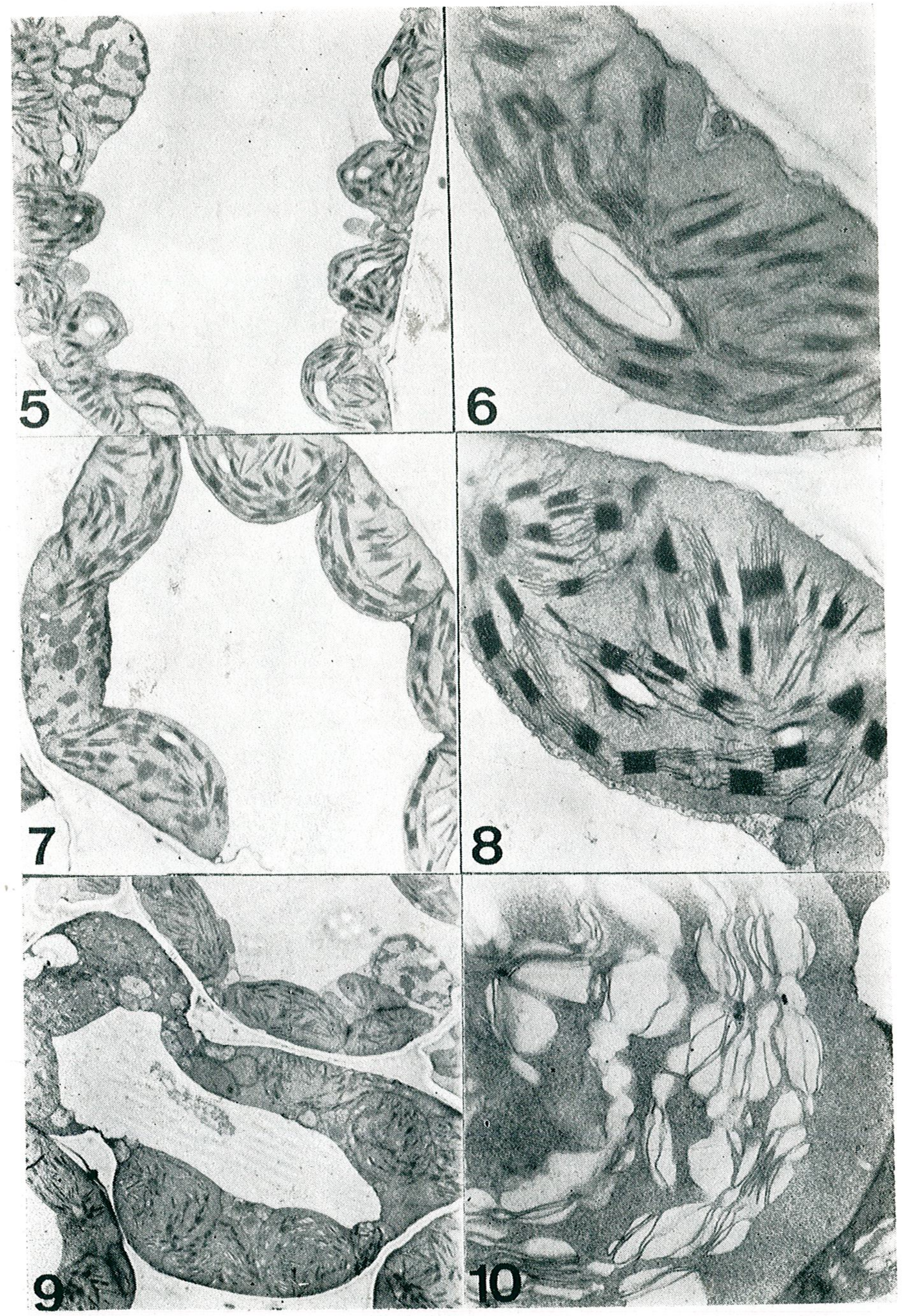

Plate II. Fig. 5 and 6 — The effect of the N 200 kg . ha^{-1} dose upon the ultrastructure of the *Lolium perenne* L. chloroplasts (×3500 ; ×10.000).
Fig. 7 and 8 — The alterations occurred in the ultrastructure of the *Lolium perenne* L. chloroplast, at the N 400 kg . ha^{-1} dose (×4500 ; ×10.000).
Fig. 9 and 10. — The toxic effect of the N 800 kg . ha^{-1} dose upon the ultrastructure of the *Lolium perenne* L. chloroplast (×300 and ×19.000).

The effects of the treatments upon the *Lolium perenne* L. chloroplasts ultrastructure are shown in Plate 1, Figs. 3 and 4 and Plate 2, Figs. 5—10.

The microphotos of the variants treated with N_{100} (see Plate 1, Figs. 3 and 4) reveal the starch grains appearance (1, 2 grains), in the chloroplast. Their presence allows the supposition that the ammonium nitrate interferes in the sugars metabolism (9), diminishing thus the consumption of sugars, during night respiration. The structural elements of the chloroplast are also present, but unlike the control, the number of thylakoids/granae, as well as that of granae/chloroplast, increases nonsignificantly.

Table 1

The variation of the thylakoids/grana and of the grana/chloroplast number, after the ammonium nitrate treatments

Dose	*Lolium perenne*	
	Thylakoid/ grana number	Thylakoid/ chloroplast section number
Control	10	30
N 100	14	36
N 200	16	30
N 400	18	38
N 800	13	30

Plate 2, Figs. 5 and 6, variant N_{200} reveals the presence, in a greater number, of the starch/chloroplast grains. The number of thylakoids/grana is increasing, while the number of the grana/chloroplast section is decreasing. In other chloroplast structural elements do not show any alteration.

The ammonium fertilizers, at a concentration of 400 kg. ha^{-1}, do not determine obvious alterations in the chloroplast ultrastructure, as compared to the previous dose (Plate 2, Figs. 7 and 8). An increase of the thylakoids/grana and of the granae/chloroplast section number may still be noticed (see Table 1 and [14]).

The ultrastructure of chloroplasts, at 800 kg. ha^{-1} dose, is shown in Plate 2, Figs. 9 and 10. In the case of this superoptimum dose, the toxic effect of the ammonium nitrate upon the chloroplast ultrastructure is easily revealed.

The starch grains, present in all small dose treatments, are very rare, in the case of 800 kg. ha^{-1} dose. Pathological alterations of the chloroplast ultrastructure take place ; it becomes round, its shape gets spherical from ellipsoidal. The decrease of the thylakoid/grana number and that of the grana/chloroplast section must also be mentioned (Table 1). Another process may be distinguished in the chloroplast with an altered ultrastructure : the vesiculation of grana and intergrana thylakoids (see Plate II, Fig. 10) ; the fact was also mentioned by other researchers (18).

The reference material (4, 10, 11, 19, 20, 21, 23) proved that the effect of ammonium's absence upon the chloroplast ultrastructure was the most frequent research topic. The presence of ammonium and the influence of the superoptimum doses of ammonium fertilizers was not so much investigated. Still, the works of G. S. Purrich and A. V. Barker, (18), show that the NO_3^- anion and the NH_4^+ cation are toxic, at greater concentrations, for many plant species. This toxicity was obvious in tomatoes *(Lycopersicum esculentum)*, by the vesicles that appeared, the swollen and destruction of granae thylakoids, and, finally, by the complete degradation of granae.

FINAL REMARKS

(1) The electron microscopic investigations on the *Lolium perenne* L. leaves bring about a series of anatomical-structural proofs, regarding the optimum applying conditions for ammonium fertilizers.

(2) The electron microscopic images reveal that the general ultrastructure of the chloroplast undergoes but few alterations, at optimum doses ($N_{200}-N_{400}$) ; the starch grain accumulation in the chloroplasts and the increase of the granae/chloroplast number.

(3) The maximum N_{800} dose (superoptimum) determines essential deteriorations of the chloroplast ultrastructure, fact that enables the hypothesis that the experienced fertilizer, by its toxical effect of the ammonium ion, produces an alteration of sugars' metabolism in the chloroplasts.

(4) The optimum ammonium doses for *Lolium perenne* L., at which the photosynthesizer apparatus efficiently functions, are those included between N_{200} and N_{400} depending on the ecological conditions.

Received January 19, 1988

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CALLUS INDUCTION AND PLANT REGENERATION OF *CYNARĂ SCOLYMUS* L.

TATIANA ONISEI, ECATERINA T. TÓTH, DOINA AMARIEI

The callus of *C. scolymus*, obtained from different explants, grew slowly, had a reduced organogenetical potential and a tendency to necrosis.
The plantlets were obtained only from the mesocotyl and are, probably, of embryogenetical origin. They were extremely recalcitrant to rooting. Using "Radistim" and a soil, sand and peat mixture proved to be good. Plant accommodation was easier in reduced luminosity conditions.
Along the "in vitro" culture, the new formed tissues presented obvious tendencies towards vitrification.

Artichoke is a species of great pharmacological interest because of its coleretic and hepato-regenerative action induced by the aqueous extracts of leaves.

Although the feeding qualities of the receptacles and bud scales determine its growth as a vegetable in the mediterranean area, we cultivate it in Romania for medicinal purposes (2).

Due to its marked protandry, the plant is essentially allogamous, which determines an obvious heterogeneity of the populations obtained from seeds (4). The difficulty of the selecting and meliorating attempts increases also because of the reduced resistance towards diseases, parasites and frost.

As the traditional vegetative propagation has a low efficiency (7), the "in vitro" culture proves to be the only method capable to assure the storation of valuable individuals. Avoiding – during winter – the influence of frost and lack of snow, may assure the survival and multiplication of some genotypes of great economical interest. In the meantime, by prelevation of shoot apices and plant regeneration, we may proceed the imbetterment and virus elimination of cultures.

Our investigation aimed at testing the behaviour of the *C. scolymus* explants on different medium variants, outlining the optimum conditions required by multiplication and evaluating the "in vitro" culture efficiency of this species.

MATERIAL AND METHODS

To start the tissue cultures, seeds of *C. scolymus* were aseptically germinated, after 10 minutes disinfection in sodium hypochlorite 1–2 %. From 14 days old plants we harvested organ and cotyledon fragments and inoculated them into Erlenmeyer flasks that contained 35 ml medium.

From field individuals, in the first vegetation year, we prelevated –before fluorishing – leaves, shoot apices and inflorescences. The explants were sterilized with "T" chloramine, 15–20 minutes, rinsed with distilled water and then placed on the medium.

Different variants of the MS basal medium were used, variants that underwent modifications of the hormone balance and of the carbon source.

The morphogenetic reaction of explants was checked as much as the time necessary up to callus appearance, its aspect, the behaviour of the shoots regenerated "in vitro" and their reaction to rooting (Table 1).

The passages were performed at intervals of 21—28 days.

The regenerated plants, 2,5—4 cm length, were placed on a free hormone (or supplemented with 0.5 mg/l NAA) MS medium or propagated by cuttings and directly put into sterile soil after "Radistim" treatment.

The accommodation was performed under glass flasks under low luminosity. The temperature was constantly 23 ($\pm$2)°C and 16 hours of light alternated with 8 hours of darkness.

RESULTS AND DISCUSSIONS

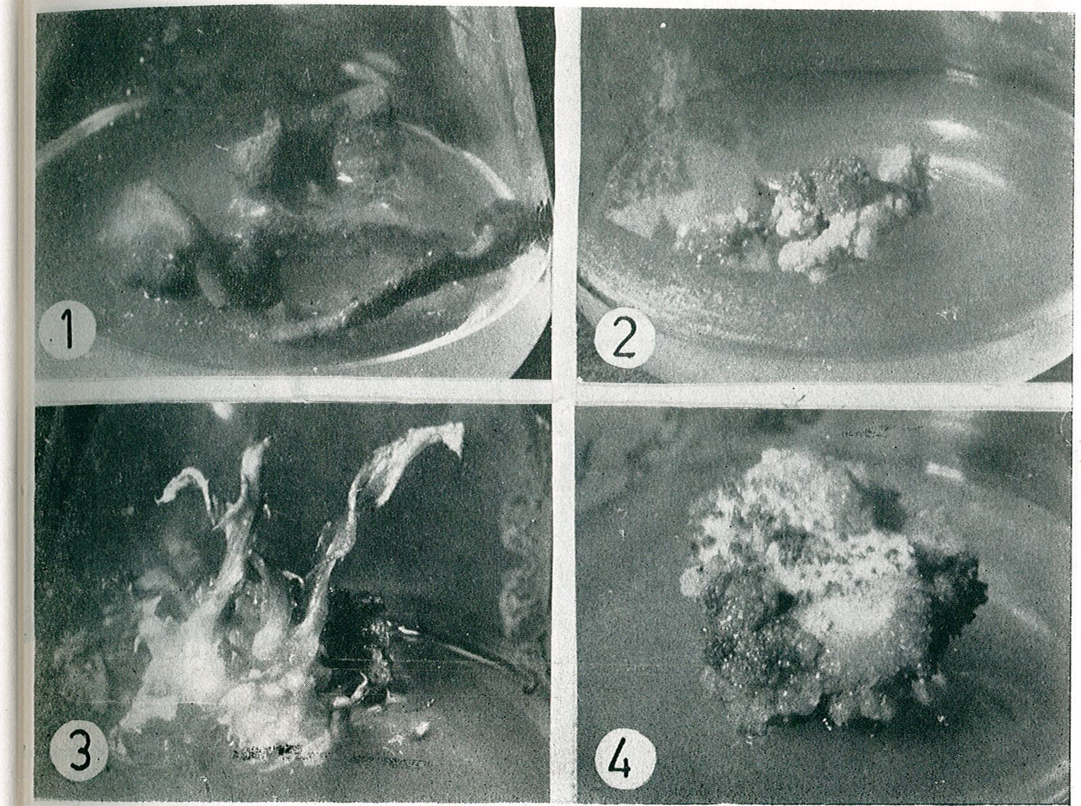
From the "in vitro" germinated plants there were isolated and inoculated on the culture medium hypo and mesocotyls, fragments of shoots, leaves and cotyledons. As shown in Table 1, their reaction was different, depending on the origin and medium variant.

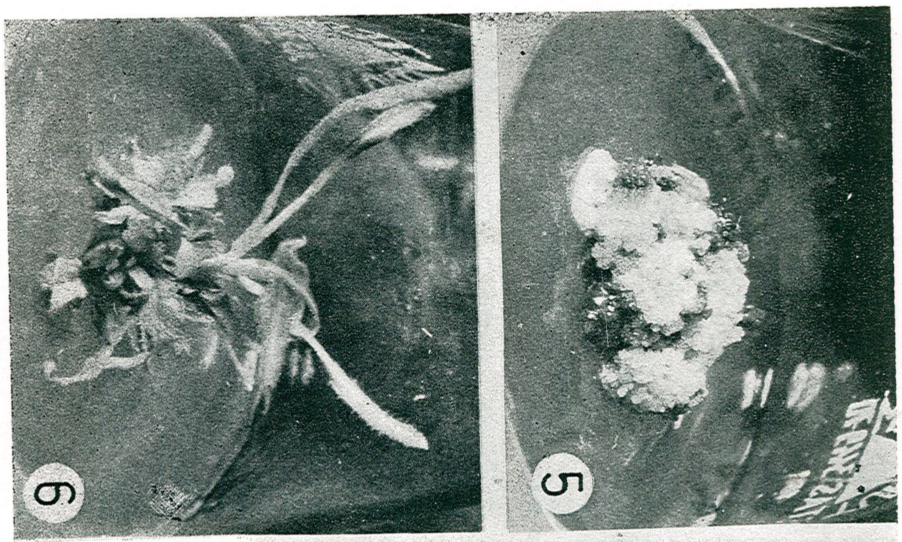
If some explants (e.g. cotyledons, photo. I) had no morphogenetic reaction, others (leaf, root, meso and hypocotyl) produced callus (photo 2) after 4—6 weeks. From a sample to another the callus characteristics differed in colour (white-yellowish, green or brown), consistency (friable or hard) and aspect (compact, glomerulous, normal or vitrous). The appearance of necrosed tissues was rather frequent and made us to reduce the passage interval (down to 21 days). The low biomass accumulation and the early vitrification of the regenerants determined us to check different hormone balances and carbon sources.

One could notice that the callus formation was favoured by the presence of BAP or K in the medium (1—2 mg/l) and also by their combination with 2,4—D (1 mg/l). As the cytokinins stimulate morphogenesis, the cell division in general, and especially the bud formation and the auxins the meristem growth (3), their coexistence proved absolutely necessary in artichoke. The ratio greater than one, recommended by Skoog and Miller (8), really caused callus and later shoots formation.

Both sucrose (20—30 g/l) and glucose (15—30 g/l) were used as carbon source, as it is known that the plants of the Asteraceae family prefer the latter one (5). Good results were obtained with both sugars at 30 g/l and their combination (25 g sucrose and 5 g glucose). Regarding the organogenetical reaction it seems to be stimulated by higher concentrations of sugar in the medium (over 25 g/l).

Unfortunately, vitrification appears rapidly, producing "glassy" areas on the callus or causing curled, decoloured, translucent and breakable leaves (photo. 3). Once vitrified, the tissue does not easily recover and such our efforts aimed at preventing this phenomenon. Increasing the agar concentration, as Zimmerman (9) recommended, glassiness lowered but the efficiency of the culture was simultaneously reduced, be-





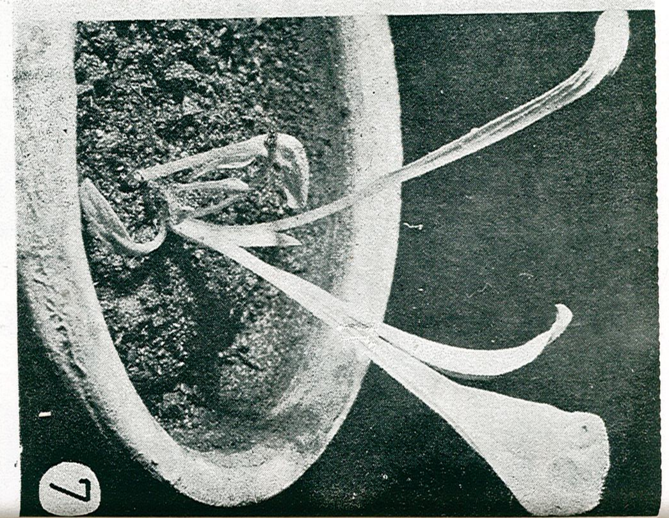


Photo. 1 — Cotyledons ; photo 2 — Callus originat from leaves ; photo. 3 — Callus and shoot trification ; photo. 4 — Inflorescence callus ; pho 5 — Organogenetic callus (mesocotyl origi photo. 6 — Cluster of shootlets ; photo. 7 — A commodated plant.

Table 1

The *C. scolymus* explants morphogenetic reaction depending on the origin and the compounds of the culture medium

Explant	Basal medium	Carbon source	Hormones BAP	K	2,4D	NAA	Morphogenetic reaction	Number of passages	Characteristics
A. Field plants									
1-shoots	MS	sucrose	—	0.5	1	0.5	callus +	1	compact, white-yellow
2-inflorescence	MS	,,	2	—	—	—	callus ++	1	green, glomerulous
3-leaf	MS	glucose	1.5	—	0.5	—	callus +	1	whitish, slightly necrosable
B. Aseptically germinated plants									
1. leaf									
— petiole	MS	sucrose	1.5	—	0.5	—	callus +	2	green, "glassy"
— limb	,,	,,	1.5	—	0.5	—	callus +	2	green, granulous
2-cotyledons	MS	sucrose	—	0.5	1	0.5	callus +	1	compact, brown, necrosable
	,,	,,	2	—	1	—			
	,,	,,	—	2	—	—	callus +	2	,,
	,,	,,	—	2	1	—	callus +	2	,,
3-mesocotyl	MS	sucrose	—	2	1	—	callus +	2	light green
	,,	,,	2	—	—	—	embryo-genesis ++	3	green, many embryos
	,,	glucose +	1.5	—	0.5	—			
		sucrose	1.5	—	0.5	—	organogenesis	2	green, compact with buds
4-hypocotyl	MS	sucrose	—	0.5	1	0.5			
	,,	,,	—	2	1	—	callus +	2	brown, compact
	,,	,,	—	1	—	0.1	callus ++	2	heterogeneous aspect, "glassy "areas
5-roots	MS	glucose	1.5	—	—	—			
	,,	sucrose	—	0.5	1	0.5	callus +		brown, compact
	,,	,,	—	2	1	—	callus ++	2	brown
	,,	,,	1.5	—	0.5	—	callus +	2	grey, friable
							callus ++	2	friable, brown
							—	2	no reaction
C. "In vitro" regenerated plants							—	4	no rooting
	MS	sucrose	—	—	—	—	—	4	,,
	,,	glucose	—	—	—	—	—	4	,,
	,, "Radistim"	sucrose	—	—	—	0.5	" in vivo" rhizogenesis	4	difficult rooting, slow accommodation

cause the number of shoots/explant was smaller (below 6) and the medium grew more expensive.

The explants harvested from the field plants raised serious problems at the moment of sterilization and immediately after inoculation, as they turned brownish and determined the medium to colour the same shade. The colouring is due to the oxidation of the phenolic compounds set free at the level of the explant wound surface; the reaction is catalysed by light and seems to be stimulated by higher concentrations of NAA (4).

3–4 weeks after inoculation the inflorescence fragments formed a hard, green callus, with glomerulous aspect (photo. 4), which maintained its characteristics along the whole experiment. Subsequently passed on the regeneration medium, the callus did not prove organogenetical potencies although its colour and consistency could have suggested the existence of some buds on its surface.

The other explants (leaf fragments and shoot apices) produced a light coloured callus exactly at the wound surface level. This suffered a rapid necrosis no matter it was kept on its developing place or it was separately subcultivated.

In fact, the only explant that permitted plant regeneration was the mesocotyl (photo. 5). Taking into account the easiness of separating one from another and especially their configuration, we suppose that plants originated through somatic embryogenesis. The efficiency of the organogenesis may be considered to be relatively good, as 20–25 plants/explant were harvested. Although the regeneration capacity kept unaltered in the next passage, it progressively diminished, along the subcultivation period, ending with 4–6 individuals/explant, after 7–8 passages.

The plantlets (photo. 6) were isolated when they reached 2.5–4 cm in length and proved extremely recalcitrant to rooting, both on the hormone free MS medium and on the NAA variant.

It seems that, in case of *C. scolymus*, there is a normal behaviour, because Heinz (4) also found a zero rooting ratio at the direct passage of the explants from a proliferation to a rooting medium. This might be due to either the maintaining of the negative kynetin effect on rhizogenesis or to the too small concentrations of the auxin used, taking into account the short period—usually 14 days — of the contact between the explants and the medium. The results could be embettered by using some pretreatment solutions (associating an auxin with sucrose), by supplementing the medium with mineral salts (KNO_3) and vitamins (D_2) or by passing the plants onto a preparatory medium for rhizogenesis (6, I, 3). The modification of the hormonal balance, diminishing the quantity of cytokinins or eliminating them totally concomitantly with the progressive increase of the quantity of auxins favours the rooting ratio up to 80–90 % (3).

As to ourselves, we tried to overcome these difficulties attempting to the "in vivo" rooting with "Radistim" and a convenient soil, sand and peat mixture. Although accommodation under glass flasks was difficult and lasting, it was the only method that helped us rooting the "in vitro" regenerated plants (photo. 7). We noticed that the decrease of light intensity along the accommodation period favours the obtaining of vigorous plants. Similar observations determined Moncousin (6) to assert that a

passage into obscurity (no longer than 10 days) is absolutely necessary in case of *C. scolymus* if one aims at increasing the number and quality of rooted plants.

The results we obtained, although promising, are not ready for a large scale application in the technology of micropropagation or melioration of the species. We shall further aim at improving the efficiency of the "in vitro" culture of artichoke and investigating the biosynthesis capacity of the callus and plants obtained from it.

CONCLUSIONS

Cynara scolymus proved to be a difficult species for "in vitro" culture; different types of explants used by us formed a callus with a slow growing, a reduced organogenetical potential and a tendency to necrosis.

The regenerants were obtained only from the mesocotyl and are, probably, of embryogenetical origin. They were extremely recalcitrant to rooting, both on the MS hormone free medium and on the NAA variant. Using "Radistim" and a convenient soil, sand and peat mixture proved to be a good solution for "in vivo" rooting. The plant revigoration was easier under reduced luminosity.

We noticed that callus and regenerated plants vitrification appears already in the 2nd passage. Increasing the agar concentration of the medium, up to 1.2 %, diminished the phenomenon, but determined a great reduction of the number of individuals obtained from one explant.

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Received February 18, 1988

VIABILITY OF WHEAT MESOPHYLL PROTOPLASTS AND HOMOKARYONS IN RESPONSE TO ELECTROFUSION PARAMETERS

LENUȚA RÁKOSY-TICAN, * C. M. LUCACIU **, I. TURCU **, DORINA CACHITA-COSMA *, P. VARGA ***, D. STANA ** and V. V. MORARIU **

The effect of alternating current (AC) field and direct current (DC) pulse treatment on the viability of wheat mesophyll protoplasts was experimented systematically and quantitatively. AC frequencies in the range of 20 Hz — 1 MHz did not influence protoplast viability, but 5 pulses of 22 μs, 1.8 kV/cm each given at 3-s intervals decreased protoplast viability over 50 %. The increase of pulse number in two electrofusion treatments was observed in relation with protoplast fusion and viability, as well as homokaryon viability. The use of fluorescein diacetate proved to be suitable for estimating homokaryon viability.

Researches in genetics and plant genetic engineering have become more and more interested in obtaining cell hybrids and hybrids between sexually incompatible species. Such researches have an applied character, aiming at obtaining male-sterile crop plants, more resistant to stress, more productive, able to use more efficiently mineral resources a.s.o.

Classical fusion techniques for plant protoplasts, using chemical fusing agents such as polyethylene glycol (PEG), polyvinyl alcohol (PVA), sodium nitrate (15), dextran (6, 7) and others, and high pH — high Ca^{2+} method, yield fusion rates ranging between 20—35 % (seldom 50 %).

Considerable attention has been recently attracted by demonstrations of cell and protoplast fusion using electric fields (18, 24, 26, 27, 28, 29). This completely physical method consists in the application of a highly inhomogeneous alternating electric field, which causes "pearl chain" formation, a phenomenon known as dielectrophoresis. Additional application of an intense field pulse of very short duration leads to the reversible electrical breakdown of the membrane, and therefore to cell fusion.

Electrical fusion has been reported to be rapid, highly efficient (over 50 %), noncytotoxic and effective with a wide variety of protoplast types (4, 7, 17, 19, 20, 23). Unfortunately, little attention has been payed to such aspects like heterogeneity of protoplast preparations, types and number of protoplasts fused, regeneration capacity (1, 2, 8, 9, 19), and especially to protoplast (16) and fusion product viability.

Cereal protoplasts can regenerate only in a few cases (3, 5, 10, 13, 14) and for this reason it is important to establish an effective test in protoplast viability estimation.

In this paper we report the effects of alternating current (AC) and direct current (DC) fields, single and combined, on the viability of wheat mesophyll protoplasts and homokaryons as well as the percent of protoplasts fused after electrofusion treatments.

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MATERIAL AND METHODS

Plant Material. The caryopses of wheat (*Triticum aestivum* L. cv. Transilvania) were put to germinate on Linhard's germinators on a cheesecloth layer moistened with tap water. They were maintained the first two days in dark. The next days the plantlets were grown at 500 lux and 23±2°C temperature, and were harvested 7 days after germination.

Preparation of Protoplasts. Protoplasts were isolated from the mesophyll tissue of the first leaf with 3 % (w/v) Cellulase Onozuka SS, 0.5 % (w/v) Macerozyme R–10,10 mM $CaCl_2 \cdot 2H_2O$, 2mM ascorbic acid in 0.6M sorbitol (pH 5.8). Leaf longitudinal slices of about 1–2 mm were incubated in the dark at room temperature for 16 h. Protoplasts were harvested by filtration through capron filter (100 μm) and by centrifugation (100 g for 3 min) 3 times in 0.6 M sorbitol. Then they were resuspended in 0.6 M sucrose covered by a layer of 0.6 M sorbitol. The two step gradient was centrifuged (200 g, 5 min) in a swinging bucket, and the protoplasts were collected from the sorbitol layer at the top of the gradient.

Electrofusion Device and Protoplast Viability Determination. The electric field sequence was generated by an apparatus SPEC–1 made up at the Institute of Isotopic and Molecular Technology. The apparatus could generate, in a sequence, up to 9 square pulses with amplitudes varying between 0 and 200 V and lengths varying between 1 and 99 μs. An Orion 1552 Oscilloscope was used to accurately record the AC field sine wave and DC square wave pulse.

The microfusion chamber consists in a microscope glass slide with two metallic (aluminium or gold) electrodes which have been evaporated to the slide surface. The electrode configuration was obtained by means of a microphotolithographic (photoresist) method. The thickness of electrodes was about 1 μm and the distance between electrodes was 500 μm. The protoplast suspension was pipetted on the surface of the electrodes and covered with a cover slide. The sample was exposed to a 200 V/cm AC field of a specific frequency for 1 min. For samples subjected to both fields, 1 min of AC field was followed by 5 DC square pulses of 22 μs, 1.8 kV/cm each given at 3-s intervals. The electrofusion treatments consist in : 3 s of AC sine wave of 360 V/cm at 1 MHz frequency and 1–6 DC pulses of 22 μs, 800 V/cm each given at 20-ms intervals or AC sine wave of 320 V/cm at 1 MHz frequency and 3-s duration followed by 3–6 DC pulses of 22 μs, 880 V/cm each given at 20-ms intervals.

Protoplast viability was estimated by adding 0.1 ml fluorescein diacetate (FDA) (0.5% w/v in acetone) to 5 ml protoplast suspension in 0.6 M sorbitol. After 5 min, the FDA was washed by centrifugation (100 g, 3 min) and protoplasts were resuspended in isotonic sorbitol. This is a modification of the commonly used technique for cell viability estimation (12, 21). FDA absorbed by cells is cleaved in the presence of intracellular esterases into acetate and fluoresceine. When the membrane is intact, fluoresceine accumulates inside the cell and becomes visible in UV light exhibiting a yellow-green fluorescence. Protoplasts were examined under bright field and epifluorescent illumination in a MC–5A microscope (made in Romania). During the experiments protoplasts were maintained on ice.

Viability was estimated after 10 min for at least 200 protoplasts and resulted homokaryons for each treatment. To determine viability of untreated protoplasts, controls were run prior to the application of electrofusion parameters in each experiment. The percent of protoplasts fused was determined for at least 200 protoplasts immediately after the electrofusion treatment.

RESULTS

Viability of wheat protoplasts 10 min after AC field and DC pulse treatment, single and combined, is shown in Fig. 1. The AC field of 200 V/cm applied for 1 min brought about a slight decrease in protoplast viability, regardless of frequency in the range of 20 Hz – 1 MHz. On the other hand 5 pulses of 22 μs, 1.8 kV/cm each given at 3-s intervals decreased the viability of protoplasts with over 50 %, as compared to control. Combined treatment with AC field and DC pulses also decrease protoplast viability regardless of AC field amplitude and frequency.

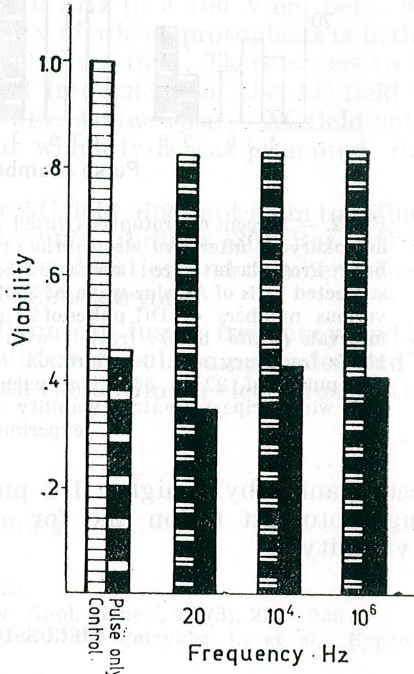

Fig. 1. – The viability of wheat protoplasts in response to AC field and DC pulse application. Bar with narrow stripes represents untreated controls ; bar with wide stripes stands for protoplasts pulsed with five DC square pulses of 22 μs, 1.8 kV/cm each given at 3-s intervals ; bars with mixed stripes represent protoplasts subjected to 1 min of AC sine wave of 200 V/cm at various frequencies ; solid bars are protoplasts subjected to the AC treatment followed by the DC treatment. The viability of the untreated protoplasts was normalized to 1.0 for each experiment. The data represent the average of 2 different experiments.

In order to detect how the number of pulses influences wheat protoplast and homokaryon viability, we chose, after several attempts, two electrofusion treatments. They differed in AC field and DC pulse amplitude.

The percent of protoplasts fused was relatively small for both treatments (Fig. 2). The maximum fusion value (18 %) was attained with 6 pulses of 22 μs, 880 V/cm each given at 20-ms intervals and after a 3-s

AC field treatment of 320 V/cm and 1 MHz frequency. The gradual increase in pulse number from 1 to 6 caused a decrease in the viability of homokaryons and mostly of protoplasts (Fig. 2). A lower AC field ampli-

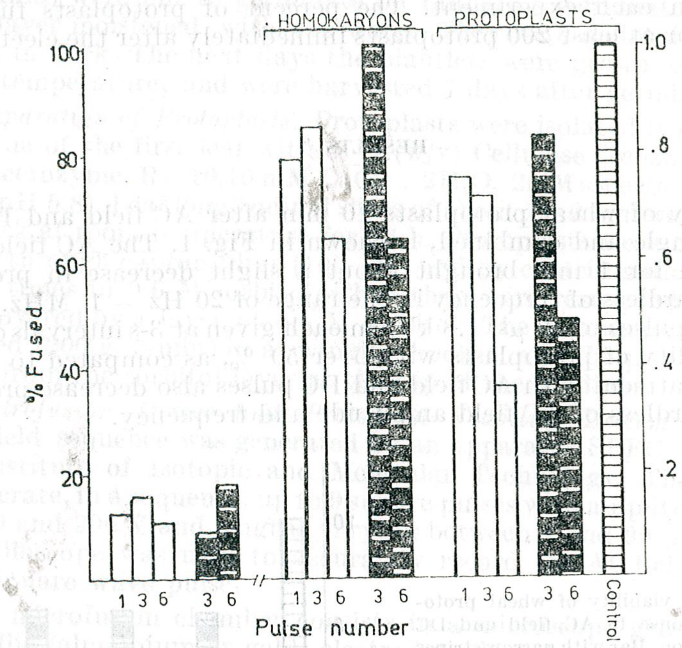

Fig. 2. — Percent of protoplasts fused and viability of protoplasts and homokaryons after two electrofusion treatments of various pulse numbers. Protoplasts were: untreated controls (bar with narrow stripes), subjected to 3s of AC sine wave of 360 V/cm at 1 MHz frequency and various numbers of DC pulses of 22 μs, 800 V/cm each given at 20-ms intervals (white bars); treated with AC sine wave of 320 V/cm at 1MHz frequency and 3-s duration followed by various numbers of DC pulses of 22 μs, 880 V/cm each given at 20-ms intervals (bars with wide stripes). Control viability was normalized to 1.0 for each experiment.

tude accompanied by a higher DC pulse one is more suitable both for achieving protoplast fusion and for maintaining protoplast and homokaryon viability.

DISCUSSION

There are few systematic and quantitative investigations on protoplast viability in response to electrical treatments. Saunders et. al (16) carried out such an experiment on tobacco protoplasts. They applied a large scale of frequencies (1 Hz — 8 MHz) and found that only the very low and very high ones reduced tobacco protoplast viability. We have found that the frequencies used for wheat, in the range of 20 Hz — 1MHz, have no effect on protoplast viability.

Saunders et al. (16) showed that optimum frequency for tobacco protoplast alignment was 1 MHz. These data correspond with our results in wheat.

The AC field and DC pulse amplitude and the pulse duration we experimented were higher than those for tobacco. These differences correspond to differences in species reactivity.

Like other authors (16, 25, 27, 31) we observed that nonviable protoplasts aligned with viable ones.

We also noticed that in the presence of FDA, the increase in pulse number accompanied by the formation of more membrane pores (23) allow the fluorescent substance discharge into the medium. When the pores occur only on the contact area between two or more viable protoplasts, the substance remains inside the fusion product. We, therefore, consider that FDA could be successfully used in estimating homokaryon viability in other plant species as well.

It is interesting to note that in *Brassica*, Zachrisson and Bornman (22) observed protoplast lysis at 40 V/cm for all sine wave frequencies below 500 kHz. In tobacco, Saunders et. al (16) report reduction of protoplast viability at frequencies below 10 kHz in a 100 V/cm field. From our results it is evident that the viability of wheat protoplasts is little affected at frequencies of 20 Hz in a 200 V/cm field. There seems to be a correlation between the amplitude and frequencies of the AC field that induced protoplast lysis or loss of viability. An increase in AC field voltage caused a decrease in the frequencies at which lysis was promoted. But it may also be a species characteristic.

The exposure time to a particular AC field does not seem to influence protoplast viability despite Zimmermann's findings (30). But AC field amplitude and mostly DC pulse amplitude, duration and number influence the viability of both protoplasts and homokaryons.

Further quantitative experiments on cell fusion frequency and protoplast and homokaryon viability at different pulse amplitudes and durations are required in order to establish the optimum electrofusion treatment for wheat protoplasts.

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Received February 8, 1988

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HEAVY METAL DISTRIBUTION IN SEVERAL LICHEN SPECIES IN A POLLUTED AREA

KATALIN BARTÓK

Up- and downstream of the polluting source, the epiphytic lichens *Parmelia conspersa* and *Lecanora subfusca* as well as the terricolous species *Peltigera canina* have been transplanted from a control forest. The accumulation of Pb, Mn, Cu and Zn in their thallus, depending on species, distance from polluting source, as well as duration of exposure (4 and 12 months), has been recorded. The present data have been compared to those recorded 5 years ago, and a slight decrease in the accumulation of noxae can be noticed.

The use of lichens as bioindicators of pollution has become a complementary element of physico-chemical methods evaluating air pollution, acid rain impact, heavy metal accumulation a.s.o. Moreover, the presence or absence of lichens may be an accurate control of the ways pollutants disperse into the environment.

Starting from the observation that lichens disappear in highly polluted zones and a so-called "lichen desert zone" sets in, the most efficient method for studying the accumulation of different chemical elements in plants, the method of lichen transplantation, has been elaborated (7).

The present paper studies the accumulation of heavy metals (Pb, Mn, Cu and Zn) in lichens transplanted from a control forest, correlated with both the distance from the polluting source and exposure duration (4 and 12 months), as well as the species of lichens transplanted. Our experiment also aimed at comparing the present situation with the data recorded 5 years ago (2,3).

MATERIAL AND METHODS

Lichen samples of 20×20 cm were taken from a beech forest on the Arieș valley (Control) as follows: two epiphytic species *Parmelia conspersa* and *Lecanora subfusca*, together with the bark they were attached to, and a terricolous species, *Peltigera canina*, together with the moss on which it vegetated.

These lichen samples, together with their support, were transplanted to the Ampoi valley, at graded distances from the polluting source (site 1) : upstream of site 2, downstream of site 3 and site 4. Lichens were again sampled for analysis 4 and 12 months, respectively, after the transplantation.

Heavy metals were determined in an AAS IN spectrophotometer with atomic absorption.

RESULTS AND DISCUSSION

Polluting heavy metals accumulate differently in lichens, depending on species, distance from the polluting source and exposure time.

(i) *Species influence*

The 3 lichen species used (transplanted in August 1984 and sampled in July 1985) accumulated a different amount of heavy metals, the highest being recorded in *Parmelia conspersa*. It is worth mentioning that under different conditions, i.e. the urban atmosphere of Budapest, the epigenous species *Cladonia convoluta* accumulated much more heavy metals than the corticolous species *Hypogimnia physodes* (4).

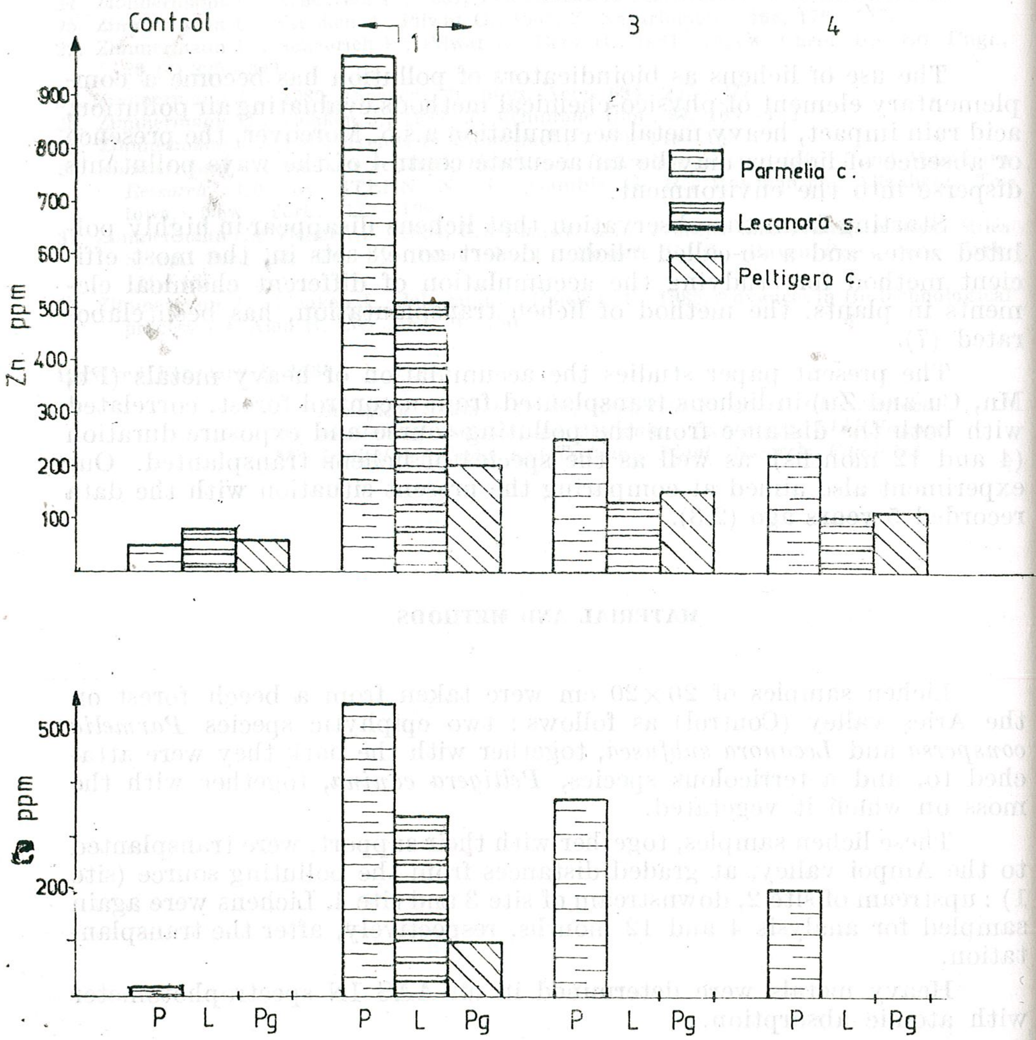

Fig. 1. — Accumulation of Cu and Zn depending on lichen species in the sites studied.

Zinc accumulation is recorded in Figure 1. The amounts accumulated in *Parmelia conspersa* are about 2 times larger than those in *Lecanora subfusca* and 5 times larger than those in *Peltigera canina*. These differences levelled the farther from the polluting source the lichens were transplanted.

Copper was well assimilated and strongly bound into complex structures by the organic tissues (10) or accumulated on the thallus surface as large grains (5). In our experiment (Fig. 1), copper could be recorded in all the 3 species only in the neighbourhood of site 1. *Parmelia conspersa* was found to contain 1.6 times more copper than *Lecanora subfusca*, and 5.5 times more than *Peltigera canina*.

The largest accumulations were recorded for lead (Fig. 2). It was not traced either in the control or in the lichens sampled in the Retezat

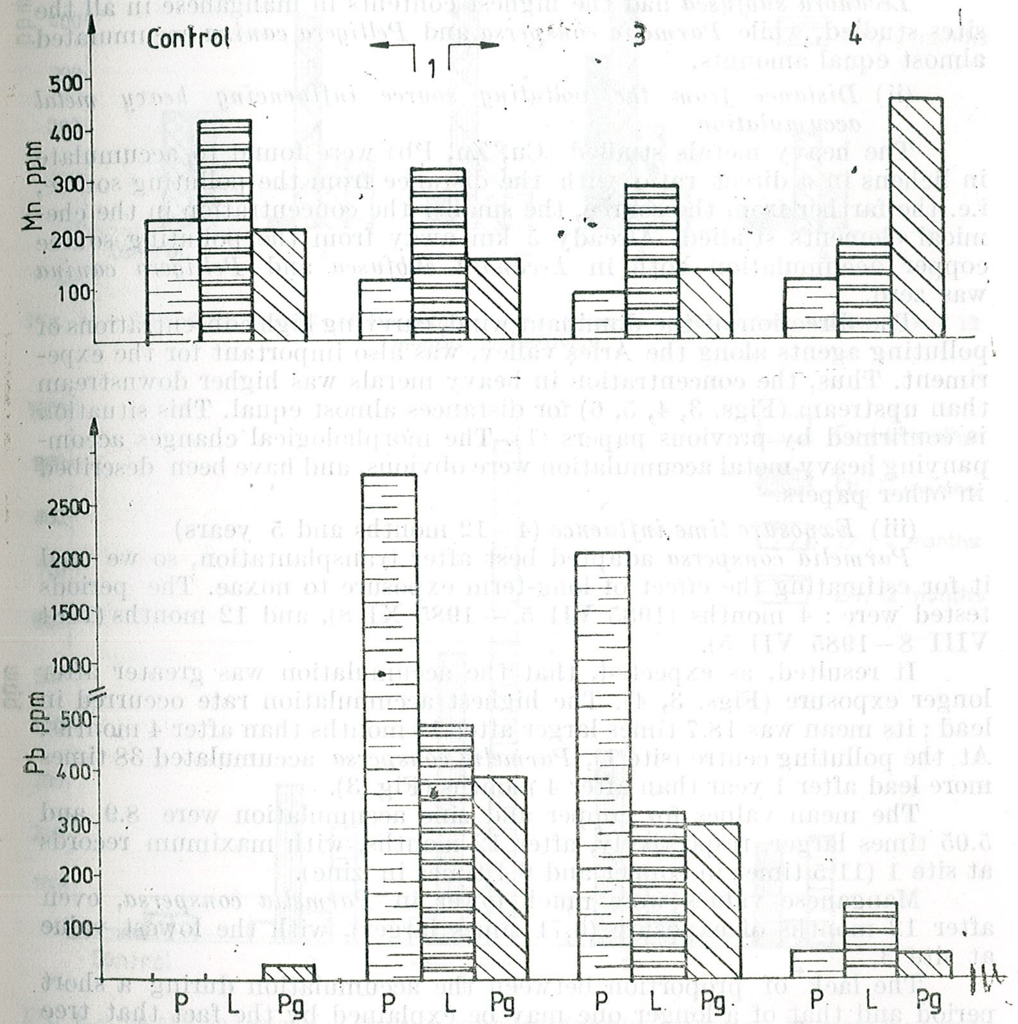

Fig. 2. — Accumulation of Pb and Mn depending on lichen species in the sites studied.

Mts, but it was found to reach 2500 ppm in *Parmelia conspersa*, close to the polluting source, and about 2000 ppm at 5 km from the source. The other 2 lichen species (*Lecanora subfusca* and *Peltigera canina*) accumulated about 400, 300 ppm lead, respectively. These data agree with the pollution level recorded in the area.

A paradoxical situation occurred in the case of manganese (Fig. 2): the manganese amounts recorded in control were larger than those in samples exposed for 12 months to pollution, minimum values occurring in the highest polluted spots. Almost identical values were recorded at site 1 and site 3. According to Westman (10), whose opinion we support, the contents in manganese is not a good indicator of pollution, as large amounts of this metal enter exchange reactions with other elements occurring in large quantities.

Lecanora subfusca had the highest contents in manganese in all the sites studied, while *Parmelia conspersa* and *Peltigera canina* accumulated almost equal amounts.

(ii) *Distance from the polluting source influencing heavy metal accumulation*

The heavy metals studied (Cu, Zn, Pb) were found to accumulate in lichens in a direct ratio with the distance from the polluting source, i.e. the farther from the source, the smaller the concentration in the chemical elements studied. Already 5 km away from the polluting source copper accumulation both in *Lecanora subfusca* and *Peltigera canina* was zero.

The direction of the dominant wind, carrying high concentrations of polluting agents along the Arieş valley, was also important for the experiment. Thus, the concentration in heavy metals was higher downstream than upstream (Figs. 3, 4, 5, 6) for distances almost equal. This situation is confirmed by previous papers (1). The morphological changes accompanying heavy metal accumulation were obvious, and have been described in other papers.

(iii) *Exposure time influence* (4–12 months and 5 years)

Parmelia conspersa adapted best after transplantation, so we used it for estimating the effect of long-term exposure to noxae. The periods tested were: 4 months (1985 VII 5 – 1985 XI 8), and 12 months (1984 VIII 8–1985 VII 5).

It resulted, as expected, that the accumulation was greater after longer exposure (Figs. 3, 4). The highest accumulation rate occurred in lead; its mean was 18.7 times larger after 12 months than after 4 months. At the polluting centre (site 1), *Parmelia conspersa* accumulated 38 times more lead after 1 year than after 4 months (Fig. 3).

The mean values for copper and zinc accumulation were 8.9 and 5.05 times larger, respectively, after 12 months, with maximum records at site 1 (11.5 times in copper and 6.4 times in zinc).

Manganese values were much lower in *Parmelia conspersa*, even after 12 months of exposure (0.71 times larger), with the lowest value at site 3.

The lack of proportion between the accumulation during a short period and that of a longer one may be explained by the fact that tree crowns partially protect the lichens from noxae during the short period

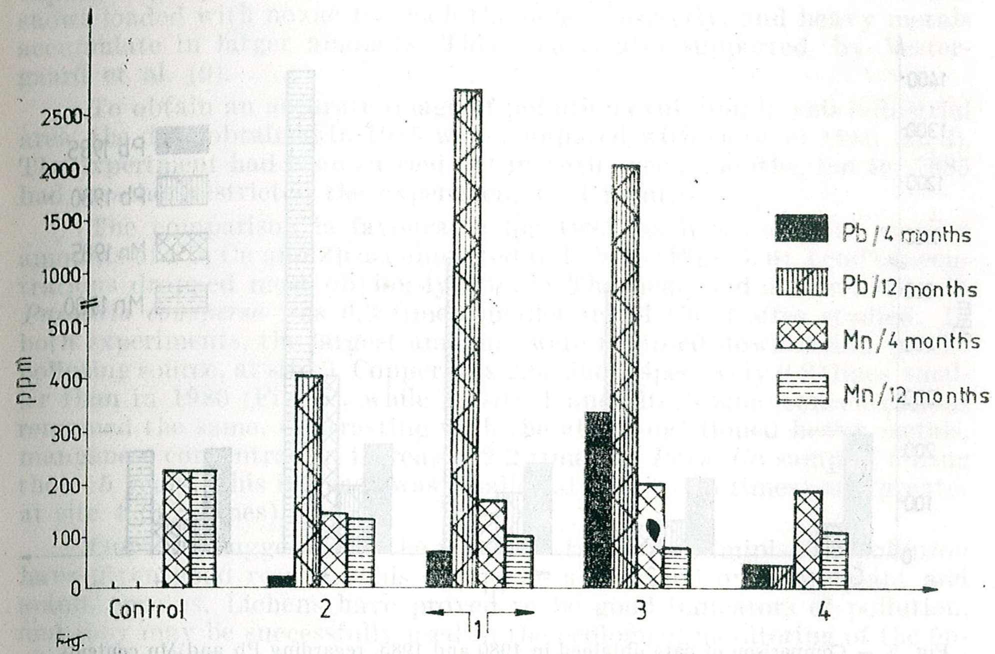

Fig. 3. — Pb and Mn contents of *Parmelia conspersa* following exposure to noxae for 4 and 12 months, respectively.

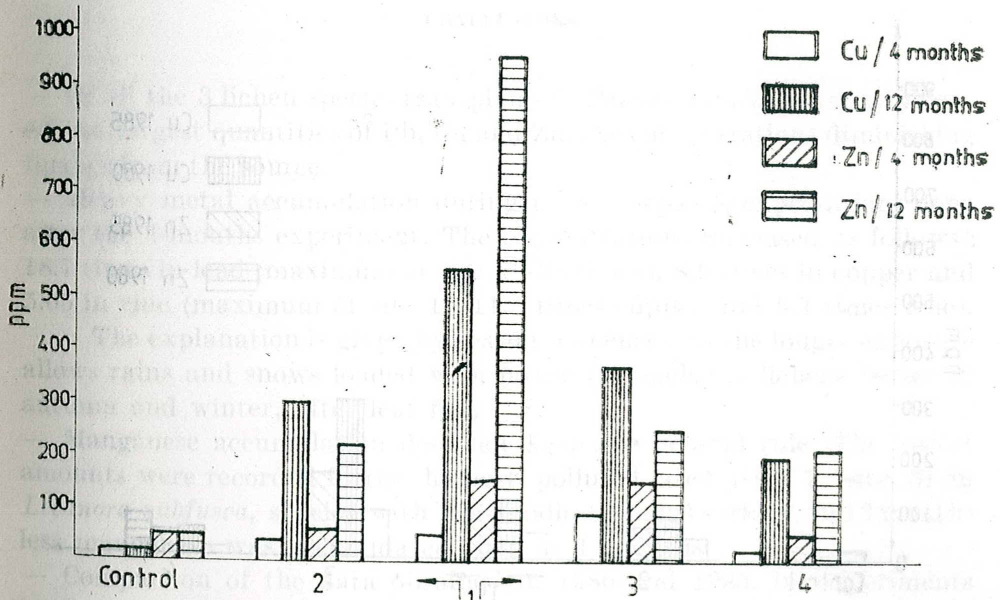

Fig. 4. — Cu and Zn contents of *Parmelia conspersa* following exposure to noxae for 4 and 12 months, respectively.

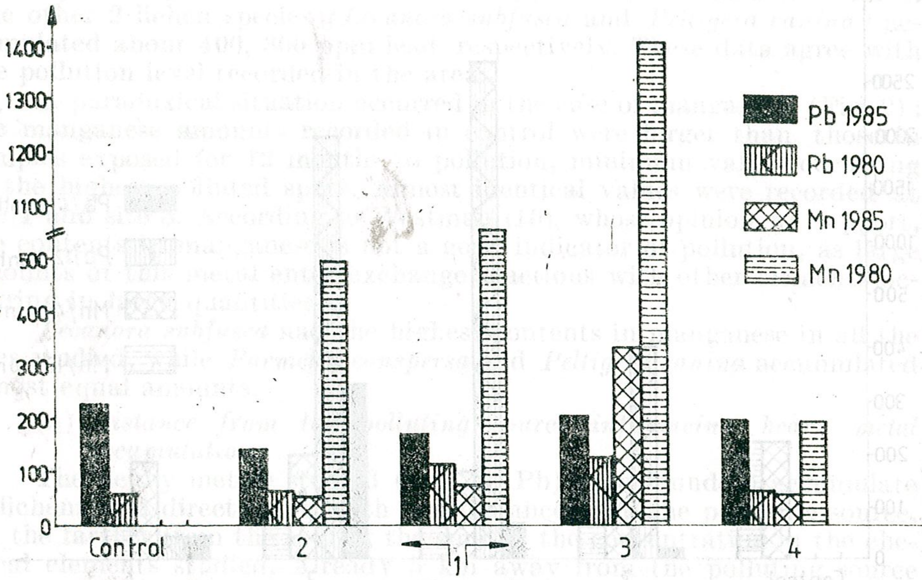

Fig. 5. — Comparison of data obtained in 1980 and 1985, regarding Pb and Mn contents.

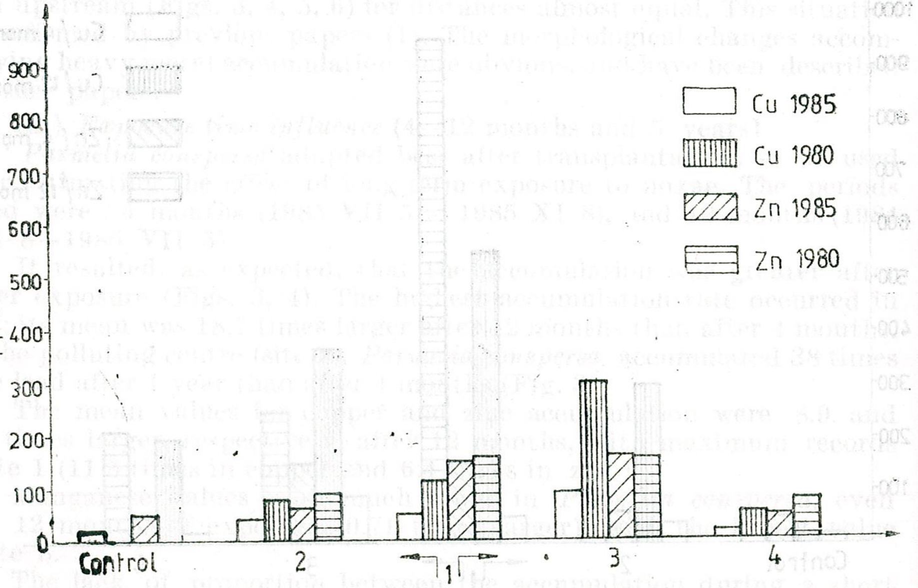

Fig. 6. — Comparison of data obtained in 1980 and 1985, regarding Cu and Zn contents.

exposure (July-November). The longer exposures allow the rains and snows loaded with noxae to reach the lichens directly, and heavy metals accumulate in larger amounts. This idea is also supported by Vestergaard et al. (9).

To obtain an accurate image of pollution evolution in this industrial area, the data obtained in 1985 were compared with those of 1980 (2, 3). The experiment had been carried out in 1980 over 5 months, but in 1985 bad weather restricted the experiment to 4 months.

The comparison is favourable for 1985, as it shows that smaller amounts of Pb, Cu and Zn accumulated in lichens (Figs. 5, 6). Lead concentrations dropped most obviously (Fig. 5). The mean lead accumulation in *Parmelia conspersa* was 6.3 times smaller in all the 4 sites studied. In both experiments, the largest amounts were recorded downstream of the polluting source, at site 3. Copper was 2.6, zinc respectively 0.8 times smaller than in 1980 (Fig. 6), while at site 1 and site 3 zinc concentrations remained the same. Contrasting with the above-mentioned heavy metals, manganese concentration increased 2.2 times in *Parmelia* samples during those 5 years. This increase was smaller at site 1 (1.5 times) and greater at site 4 (3.2 times).

Our data suggest that the measures taken for diminishing pollution have given good results. This should be also tested on other plant and animal groups. Lichens have proved to be good indicators of pollution, and they may be successfully used in the ecological monitoring of the environment (6,8).

CONCLUSIONS

— Of all the 3 lichen species transplanted, *Parmelia conspersa* accumulated the largest quantities of Pb, Cu and Zn, the concentrations diminishing further from the source.

— Heavy metal accumulation during a year surpasses expectations done after the 4-months experiment. The concentrations increased as follows: 18.7 times in lead (maximum at site 1—38 times), 8.9 times in copper and 5.05 in zinc (maximum at site 1—11.5 times copper and 6.4 times zinc).

The explanation is given by season sequences, as the longer exposure allows rains and snows loaded with noxae to reach the lichens better in autumn and winter, after leaf fall.

— Manganese accumulation does not keep the general rule. The lowest amounts were recorded in the highest polluted area (site 1, site 3) in *Lecanora subfusca*, species with the smallest thallus surface. In 12 months less manganese was accumulated than in 4 months.

— Comparison of the data obtained in 1980 and 1985, in experiments carried out on the same lichen species, has shown a decrease in pollution with lead, copper and zinc.

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Received February 25, 1988

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UWE BRAUN, *A monograph of the Erysiphales (powdery mildews)*. Beiheft 89 zur Nova Hedwigia, J. Cramer, Berlin — Stuttgart, 1987 (700 pages, 315 plates)

The Erysiphales — parasite fungi on the plants — made up the object of numerous researches concerning the mycoflora, morphoanatomy, cytology, genetics and to a great extent the epidemiology, as well as the control of the pathogenic fungi on the plants.

Uwe Braun's vast work "is a taxonomy monograph that provides up-to-date world-wide coverge of the taxonomy and nomenclature of the powdery mildews", as the author himself remarks in the preface of the book.

After a short history of the writings referred to this group, starting from Linné (1753) to those recently published all over the world, the work presents : the morphology — anatomy, biology, ecology, epidemiology, distribution, host range and control. There are also included : the position in the fungal classification, taxonomy and phylogeny of the Erysiphaceae family, delimitation of the genera and some actual data on the fossil Erysiphaceae.

With reference to the phylogeny of this group, following the ample discussions on the different schemes of development of the genera, the author conceives an original scheme of the phylogenetical relationships in the Erysiphales.

The exposed concept of species is very interesting : morphological variants and specialized races on hosts of the same family with slight morphological differences, often also geographically distinguished, are usually treated as variety. The term subspecies is not used.

In the special part (pp. 47–620) there are presented : the keys of determination of the genera *(Cystotheca, Sphaerotheca, Podosphaera, Erysiphe, Setoerysiphe, Blumeria, Brasiliomyces, Medusosphaera, Arthiocladiella, Sawadaea, Uncinula, Uncinulliella, Bulbouncinula, Typhulochaeta, Leveillula, Pleochaeta, Phyllactinia, Oidium, Oidiopsis* and *Ovulariopsis)* ; the keys of determination of the species on the basis of the host families (p. 148) and then in order the keys of determination of the species inside the different genera (for every genus, a key to determine the European species, as well as a key for the North American species).

For every species there are indicated : the name of the species, the author, the basic work in which the species has been published, the synonyms, the name of the anamorph stage, the illustration, the literature and the exsiccata. The species are described fully, followed by the consulted nomenclatural types, the hosts, the geographical distribution.

For some species there are presented the author's critical notes, well documented and precise.

There are described 520 species with 85 varieties of the Erysiphales known from all the continents, including 150 European species and the rest from the other continents. A number of 75 species, 28 new combinations and 35 varieties are described by the author.

The work may be consulted easily, due to the index of host genera and the index of fungus scientific names.

The illustration includes almost all the species in 315 plates with clear drawings, which present faithfully the typical distinguished characters of the different morphological traits proving taxonomical value.

The bibliography comprises over 700 titles.

This unique vast monograph of the Erysiphales of everywhere is useful for all the researchers concerned with the problems in which this interesting group of fungi is implied.

Eugenia Eliade

LE BOTANISTE DR. GH. GRINȚESCU

Botaniste passionné et fécond, collaborateur érudit à l'œuvre nationale « La flore de la R. S. de Roumanie », I—XIII, 1952—1976, Georges Grinţescu (lire Grintzescou) fut aussi le pharmacien en chef et le premier général pharmacien de l'Armée Roumaine. Il est né en 1878, dans le village de Petricani (district de Neamţ) dans la famille du maître d'école Petre Grinţescu (originaire de Broşteni—Suceava) et de sa femme Profira, née Pruteanu (originaire de Fălticeni—Suceava). Cette famille a eu six enfants. Le fils aîné est devenu le professeur dr. Ioan Grinţescu, à l'Université de Cluj.

Gh. Grinţescu a fréquenté les cours de l'école primaire à Petricani et du lycée à Piatra Neamţ. En 1898 il est admis à l'École Supérieure de Pharmacie qu'il a terminée en 1899 à Bucarest. En 1900 il entre à L'Institut Médico-Militaire et en même temps il suit les cours de la Section de Pharmacie de la Faculté de Médecine de Bucarest, qu'il termine en 1903 ; cette année-ci il devient sous-lieutenant pharmacien. Après des stages effectués dans les pharmacies des diverses localités il est promu lieutenant en 1904 et capitaine en 1911. Il participe à la campagne de 1913 et pendant les années 1914—1915 il travaille à Craiova. Dès 1915 il travaille au Service pharmaceutique central de l'armée, à Bucarest. Durant la guerre de 1916—1919 il est mobilisé en Moldavie. Dès 1919 il est le chef du Service pharmaceutique de l'armée, en grade de colonel et en 1933 il obtient le grade de général pharmacien. En 1934 Gh. Grinţescu obtient le titre de docteur en pharmacie avec la thèse « L'étude du genre Aconitum » (publiée, en trois parties, en 1920, 1934, 1936). Entre les années 1928—1937 il a été professeur à l'Ècole d'officiers pharmaciens de l'Institut Médico-Militaire de Bucarest, où il a donné des cours sur la culture des plantes pharmaceutiques, les industries pharmaceutiques, l'organisation du service pharmaceutique militaire, la botanique pharmaceutique. Après 34 années de carrière, il passe à la retraite, en 1937. Gh. Grinţescu a écrit le premier traité roumain de botanique pharmaceutique (1923, 750 pages et 53 planches), ouvrage primé par l'Académie Roumaine en 1926. En 1915 il est devenu membre de l'Académie Internationale de Géographie Botanique de la France et en 1932 il fut délégué de la Roumanie au Congrès International de Médecine et de Pharmacie Militaire de La Haye. En 1937 il fut élu membre correspondant de l'Académie Roumaine des Sciences. Il a reçu de nombreuses distinctions militaires et le « Mérite Culturel ». Gh. Grinţescu a fait de nombreuses excursions botaniques (de 1896 à 1940) dans toutes les provinces du pays ; à cette occasion il a herborisé un très riche matériel d'herbier et a publié de nombreuses notes floristiques bien consistantes. Ce n'est que pour l'herbier national « Flora Romaniae exsiccata », I—XXXII, 1920—1969, qu'il a recueilli environ 15.000 feuilles d'herbier (166 espèces, dont deux furent publiées après sa mort). Il a collaboré aussi à la « Flora Chersonensis exsiccata ». En 1955 il a donné son riche herbier personnel à l'Académie de la R. S. de Roumanie. Pharmacien compétent mais aussi botaniste passionné et érudit, Gh. Grinţescu a publié 62 articles, études et volumes dans les domaines suivantes : botanique floristique et taxonomique, pharmacie, ethnobotanique et l'utilisation des plantes médicinales. En tant que pharmacien il a publié : « Les plantes médicinales du peuple roumain » (1936), « La pharmacie chez les Daces » (1907), « Projet d'organisation d'une Station pour la culture des plantes médicinales » (1920), « Étude sur l'industrialisation et sur les sources de matières premières pharmaceutiques pour l'armée » (1933), « Préparation des solutions injectables » (1931), etc. En tant que botaniste il fait son début pendant qu'il est étudiant, en 1902, avec « La flore de Bicaz » et « Les plantes de la région alpine des Carpates » (voir ci-bas la liste de ses travaux botaniques). Botaniste reconnu, Gh. Grinţescu est coopté (en 1950) dans le collectif de rédaction de la « Flore de la République Populaire Roumaine », rédigeant le texte pour 199 espèces, 22 genres et 7 familles (Tome I, 1952 ; Tome II, 1953). Dans les différentes notes floristiques publiées, Gh. Grinţescu cite 23 espèces d'angiospermes nouvelles dans la flore de la Roumanie et décrit quelques taxons nouveaux (*Aconitum firmum* ssp. *rigidum* Gh. Grinţ.). C'est pour sa compétence et pour son érudition que le grand botaniste roumain Iuliu Prodan lui a dédié quelques espèces (*Centaurea X grinţescui* Prod. ; *Dianthus X grintzescui* Prod.). Gh. Grinţescu a été non seulement un botaniste passionné et un taxonomiste érudit, mais aussi un militant actif pour la protection de la nature et pour la recherche floristique du pays. C'est ainsi qu'il a participé au premier Congrès des Naturalistes de Roumanie (1929) avec la communication : « Deux espèces nouvelles pour la Roumanie » et à la VI[e] Excursion Phytogéographique Internationale en Roumanie, où il a conduit l'étape du district de Neamţ (1931). Le 8 septembre 1956 Gh. Grinţescu est mort à Bucarest.

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