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Identification of *Lophodermium* Species Associated with Needle-cast Disease of Pines in Korea[1]

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韓國 소나무類에 잎떨림병을 일으키는 *Lophodermium* 屬菌의 同定[1]

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ABSTRACT

Fallen and living pine needles bearing ascocarps were collected throughout the country from February, 1987 to October, 1988 to identify and describe *Lophodermium* species associated with *Lophodermium* needle cast disease of pines in Korea. All of the observed characteristics of given species were compared with published descriptions of the *Lophodermium* species.

As a result of this study, six *Lophodermium* species were identified and described. *L. pinastri* was previously recorded while the other five species, i.e., *L. australe*, *L. durilabrum*, *L. nitens*, *L. pini-excelsae* and *L. pini-pumilae*, were unrecorded in Korea. One *Lophodermium* species has not been fully identified in this study, and tentatively named as *L.* sp-1.

L. australe was observed on the needles of *Pinus rigida*, *P. rigida* x *taeda* and *P. taeda*, *L. pini-excelsae* on *P. parviflora* and *P. strobus*, *L. nitens*, *L. durilabrum* and *L. pini-pumilae* on *P. koraiensis*, *L. sp*-1 on *P. thunbergii* and *L. pinastri* on *P. densiflora* and *P. taeda*. *L. sp*-1 was collected from the diseased regions of 2-year-old needles of *P. thunbergii* and *L. durilabrum* from *P. koraiensis*, suggesting pathogenic nature of these fungi.

Key words : Lophodermium ; *needle cast disease* ; *pines*

要 約

소나무類의 잎떨림病을 일으키는 *Lophodermium* 屬菌을 同定하기 위하여 1987년 2월부터 1988년 10월까지 全國의 9個 調査地域에서 子囊盤이 形成된 잎을 採集하여, 子囊盤의 解部 및 形態學的 特性을 調査하였다.

이 硏究의 結果, *Lophodermium pinastri*, *L. australe*, *L. durilabrum*, *L. nitens*, *L. pini-excelsae*, *L. Pini-pumilae* 等 6種이 同定되었으며, 旣存의 文獻報告와 一致하지 않는 種을 假稱 *L.* sp-1으로 命名하였다. *L. pinastri*는 적송과 테다소나무에서, *L. australe*는 리기다, 테다, 리기테다 소나무類에서, *L. pini-excelsae*는 섬잣나무와 스트로부스잣나무에서, *L. durilabrum*, *L. nitens*, 그리고 *L. pini-pumilae*는 잣나무에서, *L.* sp-1은 해송에서 각각 觀察되었다. 特히, *L. sp*-1은 해송 幼苗의 生葉에서, *L. durilabrum*은 잣나무 造林地의 生葉에서 각각 發見되었으므로 이 菌의 病原性 및 胞子飛散 時期에 對한 試驗이 必要하다고 생각된다.

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INTRODUCTION

The Genus *Lophodermium*, fungi of Phacidiales, Ascomycetes, has been well-known to forest pathologists and studied as pathogens which cause needle cast of pines. *Lophodermium* needle-cast has been widely distributed throughout temperate and tropical regions, and found in about 50 species of pines as saprophyte or parasite (Boyce, 1951 ; Minter, 1981). *Lophodermium pinastri* Chev. has been recognized as the causal fungus of *Lophodermium* needle-cast of pines. Many studies on pathogenicity of *Lophodermium pinastri* have been carried out in Europe and North America where *Lophodermium* needle-cast is a major cause of economic losses in nurseries and in Christmas tree plantations. But there were many disagreements on pathogenicity and spore dispersal periods of *L. pinastri*, suggesting the presence of another species (Minter and Millar, 1981 a). Through the detailed study on secondary needles of *P. sylvestris*, Minter *et al.* (1978) identified and described four *Lophodermium* species, *L. pinastri*, *L. conigenum*, *L. seditiosum*, *L. pini-excelsae*, according to the embedding positions of their ascocarps in needle tissue and their ability to produce different types of stromatic lines (zone lines) across the needle. Subsequently, they reported (1980) that three species among the above four species had obviously different spore dispersal periods, very particular ecological habitats and pathogenicity. *L. pinastri* occurred on the senescent needles, *L. conigenum* on needles of dying trees or branches, and *L. seditiosum* on young needles of seedlings. *L. seditiosum* was suggested to be the causal fungus of *Lophodermium* needle-cast in Europe. Minter(1979) reported conidiomata, Leptostroma stage of *Lophodermium*, could be classified into 3 groups by the depth which they are embedded in needles and the way to open. In 1981, Minter identified and described 16 species in Europe and published his work under the title of "*Lophodermium* on Pines". Thereafter, two *Lophodermium* species were identified from the Indian Subcontinent.

Damage by *Lophodermium* needle-cast is the increasing trend in younger trees of *Korean pine* plantations in Kangwon-Do and Kyonggi-Do. *L. pinastri* is the only species that has been identified and described in Korea, but the presence of *L. pinipumilae* and one new species, presumably not identified in Europe and North America, were proposed by Yi *et al.* in 1986. The objectives of this study were to identify and describe *Lophodermium* species associated with needle-cast disease of pines in Korea, and to find out their host ranges.

MATERIALS AND METHODS

Study areas

Nine main sampling sites over the country were selected in this study. Three sites were from the arboreta of Provincial Forestry Research Institutes in three provinces. Cheolipo Arboretum and coast of Kangreung were particularly chosen for *P. thunbergii*, because this species are known to be very susceptible to *Lophodermium* needlecast (Chiba, 1967 and personal observation). Institute of Forest Genetics in Suwon and its branch in Suanbo were selected because these two sites have various pine species for provenance tests. Pine species examined were *P. densiflora*, *P. banksiana*, *P. rigida*, *P. taeda*, *P. rigida x taeda*, *P. strobus* and *parviflora*.

Materials and methods

Fallen and living pine needles bearing mature or half-mature ascocarps were collected from February 1987 to October, 1988 and stored in the dark condition at 4℃. For the observation of inner features of mature ascocarp, ten to fifteen mature ascocarps were fixed in F.A.A. solution (formalin : acetic acid : ethyl alcohol=13 : 5 : 200(v/v/v)), then dehydrated by Tertiary Butyl Alcohol series. After dehydration, needles were embedded in paraffin, sectioned 10~12μm thick, and

counterstained with fast green FCF in 95% ethanol and aqueous safranin solution (Johanson, 1946 ; Berlyn and Mische, 1976). From the crush-mounted hymenium in lactophenol-cotton blue, morphological characteristics of hymenium components and their sizes were observed and measured. Dried needles were used for the observation on outer appearances of mature ascocarps, pycnidia and zone lines. The main keys used in this study for identification of *Lophodermium* species were Minter's (1981, 1986).

Given *Lophodermium* species were identified and described through the careful comparisons of all observed macro- and microscopic features with the existing descriptions.

RESULTS

I. *L. australe* Dearn

Lophodermium on pines 32~33p, 1981.
C.M.I. Descr. Path. Fungi & Bact. Nos. 563, 1984.
Mycological paper 155 : 54-55p, 1986.

Ascocarps abundantly on the abaxial side, when dry, seen like black narrow lines between two lines of stomata, and flattened at the level of needled surface, when wet, slightly raising the neecle surface, not accompanied with stromatic lines, 600~1950μm long, lip cells present and hyaline, not conspicuous under the naked eyes, clypeus partly embedded under the epidermal cells at the split region, and hypodermal cells remained under the epidermal cells at the both edges of upper wall. upper wall darkly thickened (about 40μm thick) at the slit region, and then slightly becoming paler on both sides, not extended to meet the basal wall which is not developed, two to three epidermal cells displaced and scattered under the subhymenium, asci cylindrical, unitunicate, 8-spored, 50~150 x 10~13μm, ascus tips blunt to slightly acute, ascospores filiform, hyaline, tapered toward the base, born in a fascicle or sometimes helically, covered with gelatinous sheath, 65~110 x 0.5~1.5μm, paraphyses filiform, 5~7 septate, straight or hooked at the apex, long as the asci, swollen or not at the apex, covered with thick gelatinous sheath, pycnidia seen as like rectangles which have a tiny spot at the central region, sometimes coalescing to each other lateraly or longitudinally, embedded subepidermally, 200~350μ m long.
Host examined : *P. rigida*

II. *L. durilabrum* Darker

Mycological paper 147, 41-42p, 1981,
C.M.I. Descr. Path. Fungi & Bact. Nos. 796, 1984.

Ascocarps on all sides of needles, when dry, concolous with needle or dark grey, and when wet, darkened and raising the needle surface, elliptical with sharpend edge at both ends, with thin perimeter line, sometimes not conspicuous, opening by a single longitudinal slit, lip cells absent, stromatic lines not visible, 800x1800μm, clypeus embedded centrally subhypodermally, upper wall dark-thickend at the slit region, lower part of this thickening strongly concaved and then abruptly tapered to meet the basal wall which is more or less well developed, host tissue below basal wall slightly tanned, two to three hpodermal cells remained on the both edges of basal wall, asci cylindrical, unitunicate, ripenening sequentially, ascus tips strongly beaked, 90~150 x 9~13 μm long, ascospores filiform, non-septate, tapered toward the base, hyaline, bron in a fascicle, 60~115 x 1.5~2 μm, with gelatinous sheath, paraphyses filiform (2μm thick), straight and not branched, usually swollen at the tip, not hooked at the apex, sometimes slightly recurved, long as the asci, with gelatinous sheath, pycnidia not observed.

III. *L. nitens* Darker

Lophodermium on Pines p.17-19, 1981.
C.M.I. descr. Path. Fungi & Bact. Nos. 566, 1986.

Ascocarps observed on the litter, elliptical with the well defined perimeter line, slightly sinked at the slit region, shiny black when wet or dry, appear like semi-sphere, opening by a longitudinal

slit, abundantly accompanied with very thin and clearly marked black stromatic lines, 500~1500 x 500~750μ m, clypeus totally embedded under the cuticle, upper wall thickened at the split zone as like a flange and also slightly swollen in the middle, extended to meet the basal wall which was very poorly developed, tanned epidermal cells below basal wall seen as black line, lip cell present, not seen under the naked eyes, but seen faintly under the microscope (x600~800), asci cylindrial, unitunicate, 8-spored, spores born in a fascicle or sometimes helically, short-stalked, ascus tips slightly acute to rostrate, 80~110 x 9~13μm, ascospores filiform, non-septate and tapered toward the base, with gelatinous sheath, 60~105 x 2μm, paraphyses filiform, non-septate, not branched and straight, their tips usually thickened, and not hooked, or rarely recurved at the apex, long as the asci, pycnidia totally embedded under cuticle cells, more or less circular in outer appearance, mainly on the abaxial side, sometimes coalescing to others, seen as black spots in naked eyes, 50~150μm in diameter.

IV. *L. pinastri* Chev.

Lophodermium on pines 23-27p, 1981.

C.M.I. Descr. Path. Fungi & Bact. Nos. 785, 1984.

Ascocarps on both sides of needles, but rarely on the adaxial side, elliptical, frequently accompanied with black stromatic lines, opening by a longitudinal slit, when dry, about two-thirds to a half of total ascocarps black, remainder grey with black and well conspicuous perimeter line, when wet totally black, raising the needle surface, lip cells present, grey or sometimes pale yellow, clypeus embedded subepidermally, upper wall constant in thickness and extended faintly to meet the basal wall, eight to ten epidermal cells displaced and lay in groups on the hypodermis, asci cylindrical, 105~133 x 9~11μm, unitunicate, ascus tips obtuse to subacute, short stalked, ascospores 80~100μm, filiform, tapered toward the base, with well developed gelatinous sheath, hyaline, aseptate, paraphyses filiform, 5~7 septate, smooth, not branched and usually straight, but slightly recurved at the apex, usually swollen at the apex, pycnidia elliptical to oblong between two lines of stomata, opening by one or two lateral slits, slightly raising the needle surface, embedded under the host epidermis, 150~450 x 150~250μm.

Host examined : *P. taeda*.

V. *L. pini*-excelsae Ahmad

Lophodermium on pines. 37-38, 1981.

C.M.I. Pscr. Path. Fungi & Bact. Nos. 785, 1984.

Mycological paper No. 155 : 81-83, 1986.

Ascocarps usually occur on the abaxial side, sometimes on the other side, usually single or sometimes coalesced with 2 to 3 ascocarps, elliptical with very diffused black (thick) perimeter line, raising the host tissue slightly, opening by a single longitudinal fissure at the central legion, not accompanied with stromatic lines, 550~900 x 350~500μm, lip cells present, grey, clypeus embedded partly subepidermally, eight to ten epidermal cells displaced in groups on the basal wall, upper wall slightly tapered toward the basal wall to meet the both edges of them, asci cylindrical, 80~120 x 9~12μm, ascus tips blunt, 8-spored, ascospores filiform, non-septate, hyaline, with gelatinous sheath, born in a fascile, 53~86 x 115 x 2μm, paraphyses filiform, septate, not branched, straight or hooked at the apex, slightly swollen at the tip, long as the asci, pycnidia predominantly on the abaxial side, not coalesced with others, seen like tiny black spots because of their small sizes.

Host examined : *P. koraiensis*.

VI. *L. pini-pumilae* Sawada

Lophodermium on pines 38-39, 1981.

Ascocarps predominantly on abaxial side, more or less long elliptical, surrounded with brownish -black perimeter line, but not conspicuous, opening by a single longitudinal slit, when dry, flattened at the level of needle surface and dark

grey, when wet, abruptly raising the needle surface and totally black, not accompanied with stromatic lines, 650~1550μm long, lip cells present, hyaline, clypeus totally subepidermally embedded, upper wall very thickened at the split region and sharphly extended to meet the basal wall, which is more or less well developed, about 50μm thick at the slit region, asci cylindrical, ripening sequentially, ascus apex round to acute, 100~150(~170) x 11~13(~15)μm, ascospores filiform, non-septate, born in a fascicle or born helically, slightly toward the base, hyaline, covered with very thick gelatinous sheath (about 1~3μm thick), 80~110 x 2μm, paraphyses very fine filiform (<1μm thick), simple, septate, tips variable, slightly swollen or not, and hooked or not, long as the asci, pycnidia mainly on the abaxial side, elliptical, but infrequently irregular, in the mid-vertical section subepidermal, sometimes coalescing to others laterally or longitudinally, 150~550μm long.

Host examined : *P. koraiensis*.

Ⅶ. *L.* sp-1

Ascocarps occur on either side of needles, but usually on the adaxial side, elliptical, surrounded by conspicuous or faint perimeter line, but sometimes not by this line, accompanied with black stromatic lines or sometimes not, when wet, totally black, but when dry, appeared like ellipse which have narrow line at the center region, opening by a single longitudinal split, 950~1900μm long, lip cells present, hyaline or grey, clypeus embedded partly subepidermally, upper wasl of clypeus thickened at the slit region and becoming paler to meet both edges of basal wall, four to six epidermal cells displaced and scattered on the basal wall, asci cylindrical, unitunicute, ascus tips subacute to slightly rostrate, 8-spored, 100~130 x 9~11μm, ascospores filiform, covered with gelatinous sheath, born ina fascicle, sometimes born helically, paraphyses filiform, septate, thickened at the apex, about 1 μm thick, pycnidia embedded subepidermally, oblong, four to five pycnidia very often coalescing to each others.

Host examined : *P. thunbergii*

DISCUSSION

L. australe was easily recognized from other *Lophodermium* species by its characteristic outer appearance of thin and black lines between lines of stomata. Minter wrote that pycnidia did not coalesce with others, but it was observed that pycnidia of this species were sometimes coalesced with each other. There were two points of

Table 1. Comparisons of *L.* sp-1 and two recorded *Lophodermium* species

	L. sp-1	*L. indianum**	*L. conigenum***
Embedding	Partly subepidermal	Partly subhypodermal	Partly subepidermal
Ascocarps (μm)	950~1900	(500~)700x1100(~1500)	900~2000
asci (μm)	100~140x9.5~13	77~88x1~1.5	160~210
ascospores (μm)	70~110x1.5~2	70~110(~125)	90~130x2~3
stromatic lines	black	black	diffused brown
displaced epidermal cells	4~6	1~4	less than 7
perimeter line	conspicuous frequently, or sometimes infrequently	conspicuous frequently to infrequently	conspicuous frequently

* from Minter's, 1981, 1984.

** from Minter's, 1981, Minter and Millar, 1984.

difficulty in identifying Korean species because of slight differences between descriptions. One is the presence of perimeter line. Cannon and Minter (1986) reported, in their descriptions on Indian Subcontinental species, that *L. australe* generally did not show perimeter line, but sometimes this lines was faintly visible. In the picture of *L. australe* by Bega *et al.*(1978), perimeter line was shown to be well-marked. As this point was very confusing, Korean samples of *L. australe* which did not show the perimeter line were used for observation of inner features of ascocarps. The other point was whether hypodermal cells remain under the epidermal cells at the both sides of upper wall or not. Minter reported European species, in mid-vertical sections, observed to be embedded partly subhypodermally, but Indian sub-continental species to be totally sub-hypodermally. Authors' samples were similar with European species in that several hypodermal cells remained at both sides of upper wall. Bega *et al.* (1978) observed this species on the green needles as well as old and dead needles. Based on their observation, they considered this species to be mild pathogenic.

L. durilabrum had the dark grey ascocarps which did not show lip cells and stromatic lines. By these appearances, this species could be easily distinguished from others. The very unique features of this species were the centrally subhypodermal embedding of ascocarps and the typical beaked (rostrate) ascus tips. When sectioned mid-vertically, the depth of upper wall was more or less varied to sectioned ascocarps. In some ascocarps, only 2~3 hypodermal cells were remained at the slit region, but 2~3 of them were displaced at the both edges of basal wall in others. Several ascocarps were also observed to be embedded between the seperated hypodermal cells below one-fourth of upper wall. Despite of these slight differences in embedding of ascocarps, they were thought to be same species because of similarity in other micro-and macro features.

In Korea, Lee and Yang (1987) reported the presence of *L. durilabrum*-like species named as *L.* sp² in the needles of *P. koraiensis* in Hongchun. They reported *L.* sp² to have black stromatic lines and totally subhypodermal embedding of ascocarps. And also, Zhang et al.(1986) reported a new species in China, *L. maximum*, with the totally subhypodermal embedding of ascocarps, but did not describe zone lines and ascus tips. A given Lophodermium species with the same embedding position was observed, but found to have beaked ascus tips and not to be accompanied with zone lines. Minter(1981) reported that "the black zone lines reported by Tehon (1935) for *L. durilabrum* arise from a misinterpretation of the type specimen on which *L. nitens* is also present". In authors' study, only one out about 40 ascocarps lied between two black stromatic lines. But it was not determined whether this species formed this line or not, because black stromatic line was not present between two ascocarps in the examined needles. In these respects, it is difficult to recognize *L. sp²* and *L. maximum* as new species, and more careful examinations on micro- and macro-features of these species are needed. Darker(1932) considered *L. durilabrum* was weak parasite (Minter, 1981), and Miller(1969) found this species in the dead needles collected from a living trees (*P. monticola*) in California, but the intensity of infection was light.

L. durilabrum was usually observed on the diseased legions of living needles of *P. koraiensis*, suggesting the involvement of this fungus in needlecast disease in Korea. However, fungus which causes the needlecast disease in *P. koraiensis* has been suggested as *L. pinastri* (Lee *et al.*, 1986) in Korea. Through the careful pathogenic test of both species, the causal fungus of needle cast in *P. koraiensis* plantations should be clarified.

L. nitens was different from Minter's description in several fine features. Shapes of ascus tips were acute to rostrate in Korean species, but Minter(1984) reported ascus tips were blunt. These beaked tips were consistently observed

through the examination of *L. nitens*. Also Minter recorded no lip cells at the slit region of upper wall, but in authors' study, fine (about one cell thick) lip cells were observed in this region under the microscope (x 600~800). About the tips of paraphyses, Minter described "Paraphyses tips hooked-" rather than straight. But, through the careful observations on them from five ascocarps most paraphyses tips were discovered to be straight in Korean samples. All the measurements on hymenium components of the examined samples were more or less smaller than Minter's. *L. nitens* has very different features in contrast to other species. These were the large flange-like thickening at the split region, shiny black ascocarps totally covered only by cuticle, and presence of the thin black zone lines. Minter (1981) reported that *L. nitens* occured abundantly on the litter of Haploxylon pines. This species was also abundantly observed on the litter of *P. koraiensis* in all of the nine sampling sites.

L. pinastri is well known to tree pathologists. *L. pinastri* could be easily recognized by the frequent black stromatic lines and inner fine structures of ascocarps. In the mid-vertical sections of this species, Minter(1981, 1984) reported that more than five epidermal cells were displaced and lay in groups on the hypodermis and the number of displaced epidermal cells was different among pine species. Minter also showed that the displaced epidermal cells were grouped in eleven in *P. radiata*, *nine* in *P. rigida* and *P. densiflora*, and sixteen in *P. koraiensis*. Ascocarps from the needles of *P. taeda* in Korea showed eight to nine displaced epidermal cells in mid-vertical sections. As mentioned in introduction, *L. pinastri* has been accepted as a pathogen which caused *Lophodermium* needle-cast of pines. However, according to Minter and Millar (1980 b), *L. seditiosum*, not examined in this study, was the most pathogenic species and *L. pinastri* a weak parasite or saprophyte in Europe. In this respect, *L. pinastri* is not likely to be a pathogen of *Lophodermium* needlecast disease of *P. koraiensis* plantations. This inconsistency must be clarified for the effective control of this disease.

L. pini-excelsae could be easily distinguished from other species by the well-marked black and thick perimeter line, and smaller sizes of ascocarps and hymenium components. Minter (1981, 1984) reported that this species usually occured on dead needles of five-needled pines, meaning this species is not pathogenic. This species was collected from the dead needles of *P. parviflora* and *P. strobus* at the nine sampling sites.

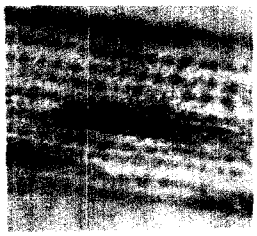
L. pini-pumilae was first identified by Sawada from *Pinus pumila* and was considered as the native species to Asia. Korean species had larger asci and ascospores than Sawada's. In his descriptions, Minter(1981) wrote that *L. pini-pumilae* might form lip cells, but authors' careful microscopic examination revealed the one cell thick and hyaline lip cells. The major difference from Minter's description was the extended upper wall to meet the both edges of basal wall. About this feature, Minter recorded as follow, "the clypeus becoming paler on either side and not extending as far as the basal wall". In 1986, Lee *et al*. first reported this species without the illustration of its outer appearances. In their descriptions, ascocarps of this species were accompanied with black stromatic lines. But the presence of these stromatic lines was not observed in authors' examined needles. Minter(1981) did not describe these lines, either. Because *L. pini-pumilae* was often observed to be mixed with *L. nitens*, these zone lines might come from the misinterpretation of *L. niten*. Nothing was known about this species except morphology and host, and more detailed studies on its fine structures, pathogenicity and other features are needed.

The observed characteristics of *L. sp*-1 were very similar with those of *L. conigenum* as shown in Table 1 except the color of stromatic lines. Although color of stromatic lines could be seen more or less differently according to moist conditions, Minter (1978, '86) claimed that the presence of these lines, if any, and their colors were very specific to species and they are

significant criteria for the identification of *Lophodermium*. Furthermore, *L. conigenum* was known to be non-pathogenic and *P. thunbergii* was not recorded as host in Europe. But, *L. sp*-1 was abundantly observed on both living needles and litters of *P. thunbergii* which was known to be very succeptible to needle cast disease in Japan (Chiba and Zinno, 1967). In these respects, *L.* sp -1 is considered to be a new species unrecorded up to the present. Further examination on its pathogenical nature is necessary to clarify this species.

REFERENCES

1. Berlyn, G.P. and J.P. Miksche. 1976. Botanical Microtechnique and Cytochemistry. 19-101p. The Iowa State Univ. Press, Iowa.
2. Bega, R.V., R.S. Smith Jr., A.P. Martinez, and C.J. Pavis, 1978. Severe damage to *Pinus radiata* and *P. pinaster* by *Diplodia pinea* and *Lophodermium* Spp. on Molokai and Lanai in Hawaii. Plant D. Reptr. 62 : 329-331.
3. Boyce, J.S. 1951. *Lophodermium pinastri* and needle browning of sourthern pines. Journal of Forestry 49 : 20-24.
4. Cannon, P.E. and D.W. Minter. 1986. The *Rhytismataceae* of the Indian Subcontinent. Comm . Mycol . Inst . Mtcological paper No . 155.
5. _____ and _____. 1984. *L. durilabrum*. Comm. Mycol. Inst. Descr. Path. Fungi & Bact. No. 786.
6. Chiba, O. and Y. Zinno. 1967. Studies on *Lophoderimum* needle-cast of pines. Bull. Gov. For. Exp. Stat. 201 : 175-194.
7. Darker, G.D. 1966. A revision of the genera of the *Hyphodermataceae*. Can. J. Bot. 45 : 1399-1443.
8. Zhang, H.B. *et al*. 1986. *Lophodermium* on Korean pines. Acta Mycologica Sinica 5(2) : 71-74.
9. Johanson, D.A. 1964. Plant Microtechnique. 40-98p. Mcgraw-Hill Book Company, New York.
10. Millar, D.R. 1969. *L. durilabrum* found on foxtail in California, Plant D.Reptr. 53 : 271.
11. Minter, D.W. 1979. *Leptostroma* on pine needles. Can. J. Bot. 58 : 906-917.
12. Minter, D.W. 1981. *Lophodermium* on pines. Comm . Mycol . Inst., Mycological Paper No. 147. 54pp.
13. Minter, D.W. 1984. *Lophodermium indianum*, *L. orientale*, *L. pini-excelsae*, *L. pinastri*. C. M.I. Descr. Path. Fungi & Bact. Nos. 787, 788, 567, 785.
14. Minter, D.W. and C.S. Millar. 1980 a. Ecology and biology of three *Lophodermium* species on secondary needles of *Pinus sylvestris*. Eur. J. For. Path. 10 : 169-181.
15. Minter, D.W. and C.S. Millar. 1980 b. A Study of three pine inhabiting *Lophodermium* species in culture. Nova Hedwigia Band XX : 361-368.
16. _____ and _____. 1984. *L. conigenum*, *L. australe*, *L. kumaunicum*, *L. nitens*. C. M.I. Descr. Path. Fungi & Bact. Nos. 565, 563, 786.
17. Minter, D.W. and M.P. Shama. 1982. Three species of *Lophodermium* from the Himalayes. Mycologia 74 : 702-711.
18. Minter, D.W., J.M. Staley and C.S. Millar. 1978. Four species of *Lophodermium* on *Pinus sylvestris*. Trans. Br. Mycol. Soc. 71(2) : 295-301.
19. Yang, S.I., C.K. Yi and W.H. Yeo. 1986. Studies on the ecology and control of needle cast on Korean pine (*Pinus koraiensis* S. et Z.). The Research Reports of the Forestry Research Institute. 33 : 140-148.



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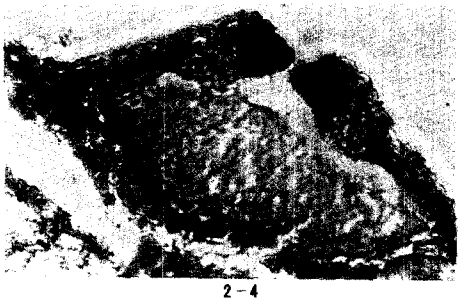

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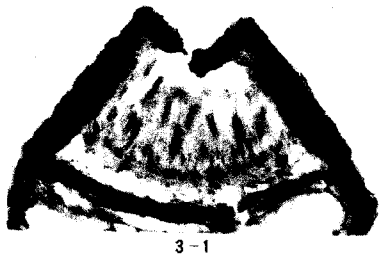

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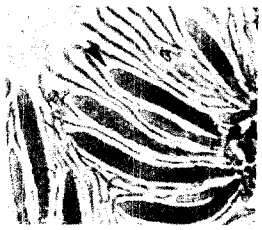

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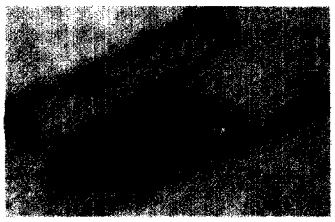

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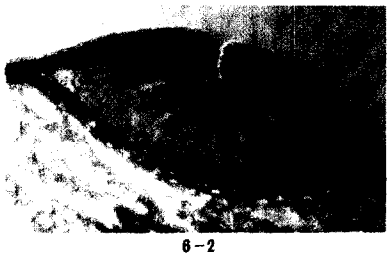

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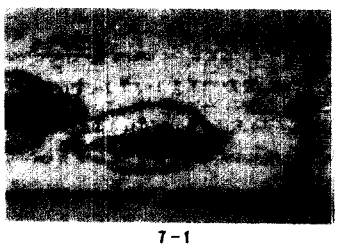

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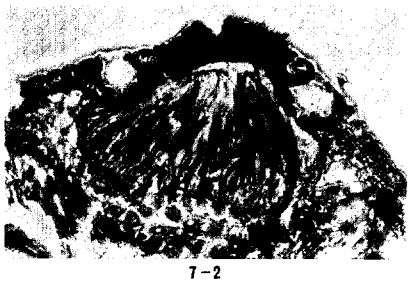

7-2

EXPLANATION OF PLATES

1-1 Ascocarp of *L. australe* on needle of *P. rigida* (x20)

1-2 Ascocarps in mid-vertical section (x250)

2-1 Ascocarp of *L. duriabrum* on needles of *P. koraiensis* (x20)

2-2 Asci with ascospores and paraphyses (x600) (arrows indicate the rostrate ascus tips)

2-3 Detail of ascocarp in mid-vertical section (x600) (arrows indicate the displaced hypodermal cells)

2-4 Ascocarp of *L. duriabrum* in mid-vertica section (x250)

3-1 Ascocarp of *L. nitens* in mid-vertical section (x250)

3-2 Ascocarp of *L. nitens* and thin black zon line on needle of *P. koraiensis* (x20)

3-3 Asci with ascospores and paraphyses (x600) (arrows indicate the rostrate ascus tips)

3-4 Detail of lip cells (arrows, x600)

4-1 Ascocarps of *L. pini-excelsae* on needles of *P. koraiensis* (x20)

4-2 Ascocarp in mid-vertical section 8x200) (arrows indicate the nine epidermal cells in group)

5-1 Ascocarp of *L. pinastri* and black zone line on needle of *P. taeda* (x20)

5-2 Ascocarp in mid-vertical section (x200) (arrows indicate the nine epidermal cells displaced in group)

6-1 Ascocarp of *L. pini-pumilae* and pycnidia on needle of *P. koraiensis* (x20)

6-2 Ascocarp in mid-vertical section (x200)

7-1 Ascocarp of *L.* sp-1 and black stromatic line on needle of *P. thunbergii* (x20).

7-2 Ascocarp in mid-vertical section (x200) (arrows indicate the displaced epidermal cells)