NOTES ON NEW FORMOSAN FOREST FUNGI[2]
I. BLACK MILDEWS ON *ABIES KAWAKAMII*

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Abstract: Descriptive notes and an account of future potentiality of damage on the host are given for two black mildew fungi, *Phaeocryptopus nudus* and *Dimeriella balsamicola* on needles of *Abies kawakamii* (HAY.) Ito in Taiwan. Both fungi are reported for the first time in this Island.

Additional hosts for *P. nudus* are *Abies kawakamii* from Taiwan and *A. firma* from Japan, and a new host for *D. balsamicola* is *A. kawakamii*.

INTRODUCTION

During the field expedition for fungal flora in the subalpine forests on Hsueh-shan in the central part of Taiwan in the fall of 1973, several needle-casting fungi were discovered on a plantation of *Abies kawakamii* (HAY.) Ito. None of these fungi have been previously recorded from Taiwan. The major portion of this paper deals with the black mildew fungi on the needles of the Formosan fir.

Peck first reported two pyrenomyceteous fungi, *Meliola balsamicola* Peck (1881) and *Asterina nuda* Peck (1885) on 'living or languishing leaves' of *Abies balsamea* in the Catskill Mountains in the United States. These two separate fungi have caused some confusion since Saccardo in 1915, considered *Meliola balsamicola* Pk. synonymous with *Asterina nuda* Pk., however, this was clarified by Röhde in 1937 by pointing out the structural differences between these two fungi. He suggested that the name *Meliola balsamicola* Peck be discarded because of its inadequate diagnosis, that the name *Adelopus nudus* (Peck.) Theiss. be used for *Asterina nuda* found on *Abies*, and that the name *Adelopus gaeumanni* Röhde be used for *Asterina nuda* found on the needles of Douglas fir. The following year, Petrak recognized that the genus *Phaeocryptopus* Naoumoff had a priority over the genus *Adelopus* Theissen and that the genus contained the following three species: *Phaeocryptopus nudus* (Peck) Petr., *P. gaeumanni* (Röhde) Petr., and *P. pinastri* (Sacc. et. Ell.) Petr. (=*Asterina pinastri* Sacc. et. Ell.). The original description of *Asterina nuda* Peck mentioned hyaline ascospores and this concept was accepted by Saccardo, Theissen, Wilson & Waldie, and Röhde. Naoumoff (1914), reported that, on the needles of *Abies sibirica*, were ascocarps of *Asterina nuda* Peck [which Theissen (1914) had renamed as *Cryptopus nudus* (Peck) Theiss.] which were almost of the same type except for the brown-colored ascospores and paraphyses.

Based on these two distinguishable characteristics the new genus *Phaeocryptopus* was established, and *Phaeocryptopus abietis* Naoum, was the name used for the brown colored spore type of fungus on *Abies sibirica*. Wilson and Waldie in 1928, found *P. abietis* Naoum. on the needles of *Pinus armandi*, and *Abies faxoniana* from

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Yunnan, China. However, Hahn in 1947, after critical examination of two type specimens described by Peck, confirmed the conclusions of Röhde and Petrak and recognized that *Asterina nuda* Peck and *Meriola balsamicola* Peck were different taxa but he was still of the opinion that *Phaeocryptopus abietis* Naoum. and *Asterina nuda* Peck [which he renamed as *Adelopus nudus* (Peck) Höhn] were different fungi based primarily on the lack of paraphyses in the latter species.

Thus, the genus *Adelopus*, in Höhn's concept includes fungi having both hyaline and brown colored ascospores but lacking paraphyses. Müller and Arx, in 1962, recognized the presence of paraphysoid in ascocarps of both species and concluded that *Asterina nuda* Peck and *Phaeocryptopus abietis* Naoum. were the same species, and used the name of *Phaeocryptopus nudus* (Peck) Petr. Kobayashi (1967), after the examination of Japanese collections of this species, which caused the needle-cast disease of *Abies sachalinensis*, *A. veitchii*, *A. homolepis* and *Tsuga diversifolia* in Japan, identified that fungus as *Phaeocryptopus nudus* (Peck) Petr.

Dimeriella balsamicola (Peck) Petr. has the following synonyms: *Asterina balsamicola* (Pk.) in herb.; *Meliola balsamicola* Pk. (1881); *Zukalia* (?) *balsamicola* (Pk.) Sacc. (1891); *Dimerosporium balsamicolum* (Pk.) Ell. & Ev. (1892); *Dimerosporium tsugae* Dearn. (1924); *Dimerosporium abictis* Dearn. (1926); *Dimerella pseudotsugae* Mill. & Bon. (1941); *Dimeriella tsugae* (Dearn.) Petr. (1947); and *Dimeriella terrieri* Petr. ap. Terr. (1947). The host range of this fungus includes *Abies balsamea* (Northeastern U. S. A.), *A. grandis*, *A. amabilis* (Northwestern North America), *A. alba* (Switzerland), *Tsuga heterophylla* (Northeastern, North America), *T. canadensis* (Eastern U. S. A.) and *Pseudotsuga taxifolia* (Northwestern U. S. A.).

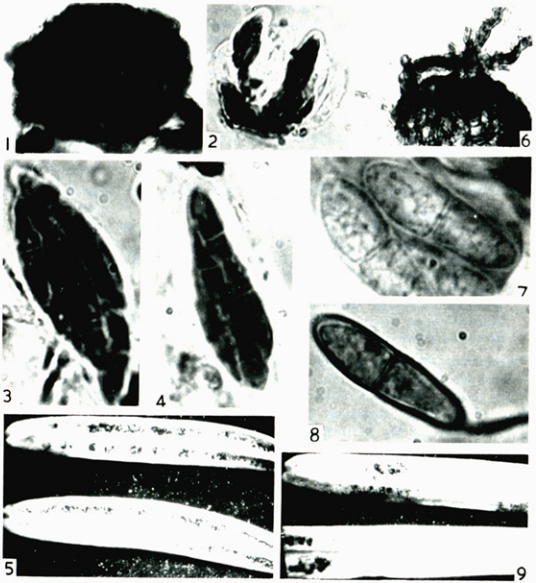
DESCRIPTIONS

1. Phaeocryptopus nudus (Peck) Petr., Ann. Myc. **36**: 15, 1938. Figs. 1–7.

Asterina nuda Peck, N. Y. State Mus. Nat. Hist. Ann. Rep. **38**: 102, 1885.
Asterella nuda (Peck) Sacc., Syll. Fung. **9**: 397, 1891.
Cryptopus nudus (Peck) Theiss., Ann. Myc. **12**: 73, 1914.
Dimerosporium balsamicola (Peck) Sacc., Ann. Myc. **13**: 115, 1915.
Adelopus balsamicola (Peck) Höhn. Sitzb., Akad. Wiss. Wien, Math. Nat. Kl. Abt. 1, **127**: 619, 1918.
Phaeocryptopus abietis Naoumov, Bull. Soc. Myc. France **30**: 421, 1914.

Perithecia appear in a row on the undersurface of brown, dead needles on the twigs; globose, subglobose, depressed, navel-like, black, or brownish-black, shining, often with a white wax plug at the apex; wall tenacious and elastic, fragile when old, 50–125 μ in diameter (50–125 μ high, 60–125 μ wide), the central foot (hypostroma) 10–30 μ wide, penetrating through the stroma, funnel-like, with or without forming dark hyphal ball in the stomatal cavity.

Superficial mycelium sometimes present; asci, clavate, elliptical, ovate, frequently swollen, 30–42 μ×12–15 μ, in clusters of 13–16, on the basal matrix, sessile to short pedicellate, octosporous; ascus side walls thin, thicken above; paraphysoid, cylindrical, or corniform, hyaline; 35–45 μ × 4–7 μ; ascospores hyaline before being discharged, infrequently colored at maturity or after being discharged, smooth, subfusiform, elliptical to obclavate, uniseptate, slightly constricted at the medium septum, upper cell slightly broader, 9–18 μ×4–7 μ; imperfect stage not observed.



Figs. 1-5. ***Phacocryptopus nudus*** on ***Abies kawakamii***. 1. a perithecium develops from stomata. 400×. 2. centrum of perithecium, most of asci are empty. 400×. 3. obclavate ascus with matured ascospores. 1,200×. 4. ventricose ascus, with matured ascospores and thick wall in upper portion. 1,200×. 5. perithecia on the undersurface of dead ***Abies*** needles. 9×. 6-9. ***Dimeriella balsamicola*** on ***Abies kawakamii***. 6. crushed perithecium with appendage. 400×. 7. matured ascospores in an ascus. 1,200×. 8. germinating ascospore. 1,200×. 9. perithecia on the undersurface of green ***Abies*** needles. 9×.

Habitat and Distribution:

On languishing or dead needles particularly on the lower branches of the tree.

North America: *Abies balsamea* (L.) Mill., *A. amabilis* (Loud.) Forbes., *A. lasiocarpa* (Hook.) Nutt., *A. grandis* Lindl., *A. sibirica* Ledeb., *Tsuga canadensis* (L.) Carr.
Great Britain; Siberia, USSR; Switzerland: *Abies alba* Mill.
Yunnan, China: *Abies faxoniana* Rehd & Wils., *Pinus armandi* Franchet.
Japan: *Abies sachalinensis* (Fr. Schm.) Mast., *A. veitchii* Lindl., *A. homolepis* Sieb. et. Zucc., *A. firma* Sieb. et. Zucc., *Tsuga diversifolia* (Maxim.) Mast.
Taiwan: *Abies kawakamii* (Hay.) Ito.

Specimens examined:

Taiwan: Hsueh-shan, on *Abies kawakamii, Z.C. Chen. 71*, (NTU). **Japan:** Mt. Kirisima, Kyusyu, on herbarium specimen No. 012845, on *Abies firma* (NTU).

2. Dimeriela balsamicola (Pk.) Pett., Ann. Mycol. **36**: 25, 1938. Figs. 8–12.

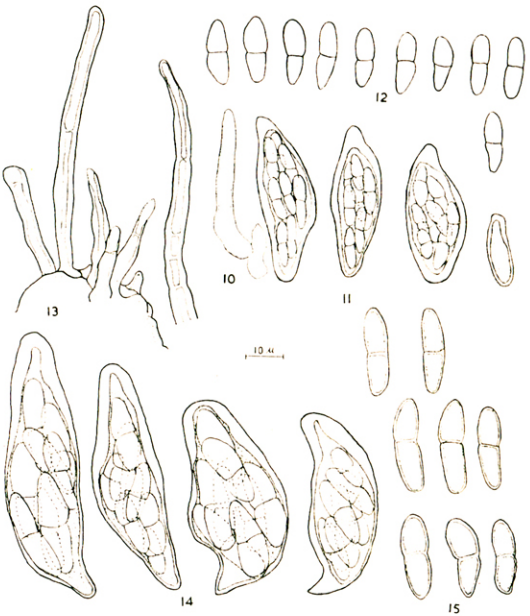
Asterina balsamicola Peck, in herb.
Meliola balsamicola Peck, N.Y. State Mus. Nat. Hist. Ann. Rep. **34**: 52, 1881.
Zukalia ? *balsamicola* (Pk.) Sacc. Syll. Fung. **9**: 432, 1891.
Dimerosporium balsamicolum (Pk.) Ell. & Ev. North Am. Pyr., p. 728, 1892.
Dimerosporium tsugae Dearn. Myc. **16**: 153-154, 1924.
Dimerosporium abietis Dearn. Myc. **18**: 243, 1926.
Dimeriella pseudotsugae Mill. & Bon. Univ. Cal Publ. Bot. **19**: 405, 1941.
Dimeriella tsugae (Dearn) Petr., Bull. Soc. Bot. Suisse, **57**: 164-173, 1947.
Dimeriella terrieri Petr. ap. Terr. Bull. Soc. Bot. Suisse. **57**: 164-173, 1947.

Epiphyllous mycelium, on both sides of needles, forming black or dark brown patches of subiculum, dark brown, smooth or slightly wavy, thick-walled, 2.5–4 μ in diameter, lack of hypopodia, frequently agglutinated in strands of two to several hyphae. Intercellular mycelium in the mesophyll, hyaline, smooth, thin-walled, 1.5–2 μ in diameter; the perithecial appendage, similar to the subiculum hyphae, dark brown, thick-walled when old, unbranched, frequently septate, tip portion appearing rather paler and thinner, thin-walled, broadly rounded or obtuse, subulate in shorter ones, varying greatly in length and number per ascocarp, longer ones when mature, tend to fall down on the subiculum or break off, 7–70 μ×5–7 μ, but sometimes tapering to 3 μ at the apex. Perithecia, few, gregarious, ovate, subconical, black to dark brown, not shining, seated on subiculum, a circular apical pore can be seen under 20–40× magnification, 80–195 μ in diameter. Asci, sessile to short pedicellate, straight or curved, elliptical, obclavate to ventricose, wall thicker in the upper part, 40–60 μ×22–26 μ, crowded with eight ascospores per ascus, sometimes irregularly arranged in a biseriate row, rarely uniseriate; ascospores hyaline to colored, uniseptate, varied in shape from cylindrical to subfusiform or clavate, not or very slightly constricted at the median septum, one cell usually broader and longer than the other, 22–30 μ×8–10 μ, sometimes germinating inside the ascocarp; paraphyses and the imperfect stage, not observed.

Habitat and Distribution:

On green needles attached to twigs and young shoots of the following trees.

North America: *Abies balsamea* (L.) Mill., *A. grandis* Lindl., *A. amabilis* (Loud.) Forbes., *Tsuga heterophylla* (Raf.) Sarg., *T. canadensis* (L.) Carr., *Pseudotsuga taxifolia* (Lam.) Br.



Figs. 10-12. ***Phaeocryptopus nudus***. 10. paraphysoid. 11. asci. 12. ascospores. 13-15. ***Dimeriella balsamicola***. 13. ascocarp appendages. 14. asci. 15. ascospores.

Switzerland: ***Abies alba*** Mill.
Taiwan: ***Abies kawakamii*** (Hay.) Ito.

Specimens examined:

Taiwan: Hsueh-shan, on ***Abies kawakamii, Z.C. Chen. 294, 1606, 1577***, (NTU). Mt. Kilay, South Peak, on deposit herbarium, No. 012821, of ***Abies kawakamii***, (NTU).

DISCUSSION

Both fungi are distributed among the natural stands of *Abies kawakamii* around 3,000 m, along the trail to the main peak of Hsueh-shan. It was not uncommon to find the two fungi on the same tree, or on the same twig, or even on the same surface of a needle. *Dimeriella balsamicola* appeared to be the less harmful parasite. In contrast *P. nudus* which has been considered to be a harmless fungi, in North America but was reported by Hama as attacking *Abies* needles resulting in the sporadic outbreak of the needle cast disease in Japan (Hama, 1966). The *Phaeocryptopus* fungi which has been recently discovered in Taiwan, is infecting *Abies* needles and persisting on the twigs. Trees with heavily infected needles have thinner foliage than uninfected trees. It suggests that the fungus in question is an endemic parasite in this Island and may be harmful to future plantations of *Abies*.

The infectious nature of *Phaeocryptopus* fungi appeared in the past, only in *P. gaeumanni* which exclusively attacked the Douglas-fir in North America and Europe. This pathogenicity and host specificity played a key role in the separation of *P. gaeumanni* from *P. nudus*. The *Phaeocryptopus* fungi in Japan and Taiwan, thus, as far as pathogenicity is concerned, are closer to *P. gaeumanni*. Interspecific, morphological differences in the genus Phaeocryptopus, as shown in Table 1, are not very distinct, particularly between *P. nudus* and *P. gaeumanni*. However, the two species differ in the characteristics listed in Table 2.

The Formosan species appears to be on the border between the two species. This intermediate nature of Formosan species indicates that separation of *P. gaeumanni* and *P. nudus* into different taxa needs to be reconsidered. At this moment, based on their morphological similarity, the Formosan *Phaeocryptopus* on *Abies Kawakamii* as well as on *A. firma* collected from Japan can be identified as *Phaeocryptopus nudus* (Peck.) Petr.

Table 1. Variation in ascocarp morphology in *Phaeocryptopus* spp. (μ)

	Perithecium diam.	Ascus	Ascospore	Central foot (width)
A. gaeumanni(1)	40-110	18-48×5-15	9-15×3-5.2	7-22
A. nudus(2)	65-155	27-69×8.7-15	10-15.5×3-6	4-10
A. nudus (Japan)(3)	60-150	33-63×9.5-15	10-20×3-6.5	9-15
Formosan sp.	50-126	30-42×12-15	9-18×4-7	10-30

(1) Röhde (1937), Barr. (1968), Chen (1972).
(2) Röhde (1937), Petrak (1938), Barr. (1968).
(3) Uozumi (1959), Kobayashi (1967).

Table 2. Comparison of main differences in *Phaeocryptopus* spp.

P. pinastri (Sacc. et Ell.) Petr.(1)	*P. gaeumanni* (Rohde) Petr.(2)	*P. nudus* (Peck) Petr.(3)	Formosan *Phaeocryptopus*
1. Host—*Pines*	Douglas-fir	*Abies* spp.	*Abies Kawakamii*
2. On dead needles.	On living and languishing needles.	On dead needles.	On languishing and dead needles.
3. Perithecia on whole surface of the needle.	Only on underside of the needle.	On both surface of the needle.	On underside of the needle.
4. Perithecia subglobose.	Globose.	Oblong, depressed navel-like.	Subglobose, depressed navel-like.
5. —	Perithecia nonshining.	Shining as if vanished.	Shining in young.
6. —	Dead perithecia fragil.	Tenacious and elastic.	Fragil.
7. Central foot penetrating through the stoma, hyphal ball in stomatal cavity.	Central foot not penetrating through the stoma, no hyphal ball.	Central foot penetrating through the stoma, has hyphal ball.	Central foot not penetrating through the stoma, no evident hyphal ball.
8. Few asci per ascocarp.	Less than 15 asci.	15-30 asci.	13-16 asci.

(1) Saccardo (1891), Petrak (1938), Barr (1968).
(2) Röhde (1937), Petrak (1938), Barr (1968).
(3) Saccardo (1883), Wilson and Waldie (1928), Röhde (1937), Petrak (1938), Barr (1968).

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LITERATURE CITED

Barr, M. E., 1968. The Venturiaceae in North America. Can. J. Bot., **46**: 795-864.
Chen, Z. C., 1972. *Adelopus* needle cast disease of Douglas-fir in central New York. Tech. Bull. 103, Experimental Forest, NTU, Taiwan.
Dearness, J., 1924. New and noteworthy fungi. III. Mycologia, **16**: 143-176.
———, 1926. New and noteworthy fungi. IV. Mycologia, **18**: 236-255.
Ellis, J. B., & B. M. Everhart, 1892. The North American Pyrenomycetes. 793 p., 41 pl., Newfield, N. J.
Farr, M. L., 1963. The systematic position of some *Dimeriella* species and associated fungi on Pinaceae. Mycologia, **55**: 226-246.
Hahn, G. G., 1947. Analysis of Peck's types of *Meliola balsamicola* and *Asteruna nuda*. Mycologia, **39**: 479-490.
Hama, T., 1966. Studies on the subalpine forest diseases. IV. *Adelopus* disease of Abies. Proc. 77 Jap. For. Soc. Conf. 318-321.
Hepting, G. H., 1971. Disease of Forest and Shade Trees of the United States. USDA, Agriculture Handbook No. 386, 658 pp.
Kobayashi, T., 1967. Problems on the identification of *Adelopus*-needle-cast fungi of conifers. J. Jap. For. Soc., **49** (8): 328-333.
Miller, V. M., & L. Bonar, 1941. A study of the Perisporiaceae, Capnodiaceae, and some other sooty molds from California. Univ. Cal. Publ. Bot., **19**: 405-428.

Müller, E., & J. A. von Arx, 1962. Die Gattungen der didymosporen Pyrenomyceten. Beitr. Kryptg-fl. Schweiz, Bd. XI, Ht. 2.

Naoumoff, N., 1914. Description ce quelaues nouvelles especes. Bull. Soc. Myc. France, **30**: 423-432.

Peck, C. H., 1881. Report of the botanist. N. Y. State Mus. Nat. Hist. Ann. Rep., **34**: 24-58; 1885, **38**: 102.

Petrak, F., 1938. Beitrage zur Systematik und Phylogenie der Gattung ***Phaeocryptopus*** Naumov. Ann. Mycol., **36**: 9-26.

Röhde, T., 1937. Uber die "Schweizer" Douglasienschütte und ihren vermuteten Erreger ***Adelopus*** spec. Mitt. Forstwirt. u. Forstwiss., **8**: 487-514.

Saccardo, P. A., 1891. Sylloge fungorum. **9**: 432.

———, 1915. Notae Mycologicae. Ann. Mycol., **13**: 115-138.

Terrier, C. A., 1947. Un nouveau champignon parasite des aiguilles du Sapin blanc: ***Dimeriella terrieri*** Petrak nov. spec. in litt. Bull. Soc. Bot. Suisse, **57**: 164-173.

Theissen, F., 1914. Uber ***Pclystomella, Microcyclus*** u. a. Ann. Myc., **12**: 63-75.

———, & H. Sydow, 1917. Synoptische Tafeln. Ann. Mycol., **15**: 389-491.

Uozumi, T., 1959. ***Adelopus*** on ***Abies*** in Japan. J. Jap. For. Soc., **41**: 243-245.

Wilson, M., & J. S. L. Waldie, 1928. Notes on new or rare forest fungi. Brit. Mycol. Soc. Trans., **13**: 151-156.