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Relationship of the genus Kuehneola*

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The genus *Kuehneola* was established by Magnus† some twenty years ago to better emphasize the peculiar rust on *Rubus* having white and delicate-walled teliospores, a rust that had previously for a decade been called *Phragmidium albidum*. The colorless telia with their catenulate teliospores, so unlike rusts in general, were placed in the genus *Oidium* by Link in 1824, and in the genus *Torula* by Fries in 1832.

For a brief interval after the fungus was recognized as a rust, and before it was assigned to *Phragmidium*, or its close ally *Kuehneola*, it passed under the name of *Chrysomyxa albida*. In giving this name Julius Kühn,‡ with his usual thoroughness and insight, clearly set forth the characteristics of both urediniospores and teliospores, pointing out that in the shape and manner of formation of the delicate, cylindrical teliospores, as well as in the absence of paraphyses around the uredinial sorus, and in the general appearance of the urediniospores, there was indicated a closer relationship with *Chrysomyxa* (*Melampsoropsis*) than with *Phragmidium*.

The original *Kuehneola albida* (Kühn) Magn., now better

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† Bot. Centr. **74**: 169. 1898.

‡ Bot. Centr. **16**: 154. 1883.

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called *K. Uredinis* (Link) Arth., if the earliest specific name is to be adopted (which happens to be one founded upon the telia), is now known to occur on many species of *Rubus* throughout Europe and North America, and another species, *K. andicola* (Diet. & Neg.) Diet., is found in South America on *Rubus geoides* Sm. In 1912 Dietel and the writer added three species to the genus on other rosaceous hosts, and between 1912 and 1914 Butler, Sydow and the writer added eight other species, whose hosts belong to the families Vitaceae, Artocarpaceae, Burseraceae, Anacardiaceae, Verbenaceae and Bignoniaceae. Of all these species the full life history is known for only the first species, *K. Uredinis* on *Rubus* (Rosaceae), and the last one, *K. Markhamiae* (P. Henn.) Syd. on *Markhamia* (Bignoniaceae).

The last species occurs in German East Africa. A good description is given in Sydow's Monographia Uredinearum (3: 318), but without mentioning the pycnia. These were found on an original specimen in my own herbarium. They are epiphyllous, in small groups opposite the primary uredinia, punctiform, subcuticular, 100–110 μ in diameter, the hymenium flat; ostiolar filaments wanting. The urediniospores are borne singly on pedicels, sparsely echinulate-verrucose, and with three equatorial pores.

It will be seen that the general characters of *K. Uredinis* and *K. Markhamiae* coincide, and the two species can be considered genuine representatives of the genus *Kuehneola*. Although the pycnia of *K. andicola* have not been detected, yet the similarity of the known characters, and the host being a species of *Rubus*, that species can also be included in the genus without hesitancy.

The other recorded species on rosaceous hosts are *K. japonica* Diet., on three species of *Rosa* in Japan, *K. Duchesneae* Arth., on *Duchesnea indica* (Andr.) Focke (*Fragaria indica* Andr.), in North America, and *K. obtusa* (Strauss) Arth., on three or more species of *Potentilla*, in Europe, and on *P. canadensis* L. in North America. No specimen of the species on *Rosa* has been seen by the writer, but the description, for telia only, appears to warrant its inclusion under *Kuehneola*.

In studying the species on *Potentilla*, or two species as maintained by some uredinologists, it was brought out some time since that the relationship with species of *Kuehneola* on *Rubus* is not

as close as had been assumed. The matter was especially brought to my attention by Dr. F. D. Fromme, while a member of my laboratory force, and has since been considerably elucidated. Recently the statement of Dietel,* made a number of years since, was brought to mind, and as he has covered the chief item in question very succinctly, I can not do better than present his words in English form. Dietel says: "The so-called teliospores of *Kuehneola* are spore-chains, series of one-celled single spores, which are successively abstricted one after the other from the apex of a common hypha, and remain united fast with one another." This statement by Dietel applies to the members of the genus *Kuehneola* as represented by the forms on *Rubus* and *Markhamia*, but not to the forms on *Potentilla* and *Duchesnea* that the writer placed under that genus, although there is much similarity in appearance between the two. The latter have the teliospores distinctly stalked. They are morphologically in regard to their septation like the teliospores of *Phragmidium*, under which genus they are usually placed, but have single, apically placed pores in each cell, and the spores are smooth. For such forms I propose the following new genus, named in honor of Dr. F. D. Fromme, professor of botany in the Virginia Polytechnic Institute, whose clear thinking and cogent reasoning have much enriched botanical science.

Frommea gen. nov.

Cycle of development includes pycnia, primary and secondary uredinia and telia; autoecious. Pycnia subcuticular, other sori subepidermal.

Pycnia with flat hymenium and without ostiolar filaments.

Uredinia with few or no paraphyses, the urediniospores borne singly on pedicels, pale, and with pores indistinct, usually equatorial.

Telia without paraphyses, the teliospores free, pedicelled, serially several-celled, rarely one-celled, colored, the wall smooth, the pores single and apically placed in each cell.

Type *Uredo obtusa* Strauss, on *Tormentilla erecta*.

Frommea obtusa (Strauss) comb. nov. (*Uredo obtusa* Strauss, *Phragmidium Tormentillae* Fckl., *P. Potentillae-canadensis*

* Ann. Myc. 10: 205. 1912.

Diet., *Kuehneola obtusa* Arth.), on *Potentilla sylvestris* (*P. Tormentillae, Tormentilla erecta*), *P. procumbens, P. mixta, P. reptans, P. canadensis*, Europe and North America.

In Sydow's Monographia Uredinearum (3: 105, 106), where the primary uredinia are described as aecia, the European and American forms are assigned to separate species distinguished by the different number of cells in the teliospores, but in the examination of a large number of collections of each no such difference has been detected. The description of the type species by Strauss is that of the telia, and his illustration shows a teliospore, although Strauss placed his species under Uredo.

Frommea Duchesneae (Arth.) comb. nov. (*Kuehneola Duchesneae* Arth., *Phragmidium Duchesneae* Syd.), on *Duchesnea indica*, North America.

Frommea Polylepidis sp. nov., on *Polylepis* sp., Corazon, Ecuador, October, 1891, *G. Lagerheim.*

Uredinia hypophyllous, scattered, round or oblong, 80–160 μ across, soon naked, somewhat pulverulent, dirty white, ruptured epidermis evident; paraphyses none, urediniospores obovoid or ellipsoid, 10–16 by 19–25 μ; wall light yellow to colorless, 1–2 μ thick, evenly and moderately verrucose-echinulate, the pores obscure.

Telia unknown.

The genus *Frommea* differs from *Phragmidium*, not only in having nearly or quite smooth teliospores, with one apical pore in each cell, instead of tuberculate teliospores with more than one pore and lateral in each cell, but also in possessing no aecia proper with catenulate spores, but instead having primary uredinia with pedicellate spores. The primary uredinia are circinnate about the pycnia, epiphyllous, large and much resembling in gross appearance the caeoma of a *Phragmidium.*

The next group of species to be considered consists of the two species on Malvaceae, placed by the writer under *Kuehneola* in 1912 (N. Am. Flora 7: 187), and accepted as such by subsequent writers. The discovery of the telia in this group was made in March, 1911, by Mr. C. R. Orton, then a member of the laboratory force, now assistant professor of botany in the Pennsylvania State College, who found them on *Malvaviscus Drummondii* T. &

G., collected at Austin, Texas, October 31, 1909, *Heald & Wolf 372*. Since then they have been found on two collections of *Malvaviscus*, *M. arboreus* and *M. mollis*, from Guatemala. These three collections are the only ones yet known to show telia for *K. malvicola*.

All three collections show abundance of the telia, which agree in their appearance and form with the published description. The long filiform spore chains do not readily separate into single cells, even after germination. They spread apart, however, even to the hymenial point of attachment in the sorus, showing that there is no tendency to lateral agglutination. The walls are distinctly cinnamon-brown, and in this character, as well as the negative fact that pycnia are unknown, the species fails to accord with the species of *Kuehneola* on *Rubus* and *Markhamia*, but the agreement is so marked in the more essential characters, that the species may for the present be considered correctly placed under the genus *Kuehneola*.

When telia on *Gossypium* were found by Mr. Orton in May, 1911, it was natural to suppose they would fall readily into the same genus as the other malvaceous form had done, especially as the characters of the uredinium were practically in agreement. Both species have delicate, uniseriate teliospores. In the *Gossypium* rust, however, the spores are adherent laterally, and the end-cells of all the spore chains fall away readily, producing a short columnar telium that becomes pulverulent at the extremity. In the form of the telium it simulates that of *Cronartium*, only being short, scarcely higher than broad, instead of being excessively long. The teliospores are colorless, not tinted as in *K. malvicola*.

The telia of the *Gossypium* rust in color, habit of spores, and general form, agree well with those of *Cerotelium*, the only fully recognized species of which, *C. Canavaliae*, is on a fabaceous host. The uredinia of the *Gossypium* and *Canavalia* rusts are not unlike, except that the former has delicate, peripheral paraphyses, imbricated over the sorus, most readily seen when still unopened while the latter has a delicate peridium of polygonal cells, also most readily seen in the unopened sorus. In both cases the uredinial envelope breaks away and becomes more or less evanescent after the sorus opens.

There remain the following species assigned to *Kuehneola: K. Vitis* (Butl.) Syd. (Vitaceae), *K. Butleri* Syd. and *K. aliena* Syd. & Butl. (both Anacardiaceae), *K. Fici* Butl. (Artocarpaceae), and *K. peregrina* Syd. & Butl. (Verbenaceae), for none of which has the writer seen an authentic collection. In the case of *K. Fici* the writer has already followed the lead of Butler* and Sydow† and accepted the statement made by Butler that the uredinial stage so common on the cultivated fig and other species of *Ficus* in the tropics is identical with the form associated with telia occurring in India on *Ficus tomentosa*, and has so listed collections from the West Indies.‡ Carefully reviewing the excellent description and figures given by Butler, it seems that the *Ficus* rust has a telial structure essentially the same as that of the *Gossypium* rust, and should be assigned to the same genus. The same reason holds for a similar treatment of *K. Vitis* and *K. Butleri.* In the case of *K. aliena* and *K. peregrina* no paraphyses for the uredinium are described, but in all other respects the descriptions indicate a similar rust. Whether in this case paraphyses are entirely absent, or only to be seen by special manipulation, the writer has no way of ascertaining.

By this interpretation of generic characters only five species remain in the genus *Kuehneola*, out of the dozen or more which have heretofore been assigned to it. They are three with hosts in Rosaceae (*K. Uredinis*, *K. andicola*, *K. japonica*), one in Bignoniaceae (*K. Markhamiae*), and one in Malvaceae (*K. malvicola*). The greatest importance is here attached to the structure of the telium, less to the urediniospores, and least to the absence or presence of peridium or paraphyses in the uredinium.

This last item indicates an entire change of opinion by the writer regarding the value of characters drawn from the protective structures of the uredinium for generic diagnoses. A strong factor in founding the genera *Physopella* and *Bubakia* in 1906§ was the belief that the nature of the paraphyses or peridium, or their absence, was of high generic value, and the same opinion has more than once been reaffirmed.‖ Recent studies of rusts with in-

* Ann. Myc. 12: 76. 1912.
† Monog. Ured. 3: 323. 1914.
‡ Mycol. 8: 174. 1916.
§ Result. Sci. Congr. Bot. Vienne 338.
‖ Mycol. 7: 173. 1915; 9: 59. 1917.

dehiscent, lenticular telia of the *Schroeteriaster-Phakopsora* appearance have entirely reversed this view. It has been found that with all other characters in essential agreement, the uredinium may have a membranous peridium opening by a central pore (e. g., *Phakopsora punctiformis* Diet.), or imbricated paraphyses united at their bases forming a pseudo-peridium opening by a central pore (e. g., *Phakopsora Pachyrhizi* Syd.), or a circle of hyphoid or incurved paraphyses often not higher than the spore mass (e. g., *Phakopsora Vitis* Syd.), or neither peridium nor paraphyses (e. g., *Bubakia Crotonis* Arth.).

The same situation appears to prevail in the genus *Cronartium*, as indicated by recent studies not yet published of tropical American material. The same appears to be true of the expanded genus *Cerotelium* and to some extent of the contracted genus *Kuehneola*, as here outlined. These four genera appear to be closely related, having a like development of the uredinium with its several forms of protective envelope or none, and a characteristic telium for each. Only in *Kuehneola* has the life cycle for some species been completed, and when this is done for the other genera, of course it is possible that some further shifting or emendation may be required.

The following outline is presented to bring together in closer view the several groups of rusts considered in this paper. All short-cycle forms are excluded from consideration. The type species of the genus is given in each instance, and also the type species of genera reduced to synonymy. Under *Cerotelium*, *Kuehneola*, and *Frommea*, all species known to the writer which may be correctly placed under these genera, are here listed, but under *Phakopsora* and *Cronartium* only such species are given as are considered especially illustrative, or call for transfer from other genera. Other species heretofore published and accepted under *Phakopsora* and *Cronartium*, possessing known telia, such as given in the third volume of Sydow's Monographia Uredinearum, have not been listed.

Only in a few instances is it possible to assign forms to their respective genera when only the uredinia are known. The attempts to do so by the Sydows (*Kuehneola Garugae* and *Phakopsora Juelii*), as well as those by the writer under the genus *Physopella*

(*P. Maclurae*, *P. Cherimoliae*, and *P. Artocarpi*), must be considered premature and exceedingly hazardous. Many forms described under *Uredo*, which almost certainly belong under one of the genera here presented, must await the discovery of telia for further assortment.

UREDINACEAE (MELAMPSORACEAE)

Telia laterally expanded, lenticular or discoid, indehiscent, the teliospores one-celled, catenulate with few spores in a chain, compacted; uredinia with delicate, cellular peridium, with peripheral, free or imbricated paraphyses or neither, the urediniospores sessile, apparently produced in chains with one spore maturing at a time and falling away before the next one enlarges..... PHAKOPSORA

PHAKOPSORA PUNCTIFORMIS (Barcl. & Diet.) Diet. (type of *Phakopsora*), on *Galium Aparine* (Rubiaceae), India.

Phakopsora alpina (Schröt.) comb. nov. (*Uromyces alpinus* Schröt., type of *Schroeteriaster*), on *Rumex alpinus* (Polygonaceae), eastern Europe.

PHAKOPSORA VITIS (Thüm.) Syd. (type of *Physopella*), on *Parthenocissus* and *Vitis* spp. (Vitaceae), Japan, possibly including all forms in tropical America where no teliospores have yet been found.

Phakopsora fenestrala (Arth.) comb. nov. (*Uredo fenestrala* Arth.), on *Phyllanthus distichus*, *P. grandifolius* and *P. Niruri* (Euphorbiaceae), Porto Rico.

Phakopsora Crotonis (Burr.) comb. nov. (*Schroeteriaster Crotonis* Diet., type of *Bubakia*), on *Croton* and *Crotonopsis* spp. (Euphorbiaceae), North America.

Phakopsora mexicana (Arth.) comb. nov. (*Bubakia mexicana* Arth., *Schroeteriaster mexicanus* Syd.), on *Croton* spp. (Euphorbiaceae), Mexico.

Phakopsora argentinensis (Speg.) comb. nov. (*Schroeteriaster argentinensis* Syd.), on *Croton* sp. (Euphorbiaceae), South America.

Phakopsora stratosa (Cooke) comb. nov. (*Schroeteriaster stratosus* Syd.), on *Croton sylvaticus* (Euphorbiaceae), Southern Africa.

Phakopsora Glochidii (Syd.) comb. nov. (*Schroeteriaster Glochidii* Syd.), on *Glochidium zeylanicum* (Euphorbiaceae), Formosa.

Phakopsora Brideliae (Koord.) comb. nov. (*Uredo Brideliae* Koord., *Schroeteriaster cingens* Syd.), on *Bridelia* spp. (Euphorbiaceae), Philippines, Java, India.

Phakopsora Meibomiae (Arth.) comb. nov. (*Physopella Meibomiae* Arth.), on *Meibomia* spp. (Fabaceae), West Indies.

Phakopsora Vignae (Bres.) comb. nov. (*Uredo Vignae* Bres., *Physopella concors* Arth.), on *Vigna lutea* (host of type), *Phaseolus lunatus*, *Dolichos Lablab*, *Teramnus uncinatus* (Fabaceae), West Indies. The teliospores of this species are not yet known.

Phakopsora Crotalariae (Diet.) comb. nov. (*Uredo Crotalariae* Diet.), on *Crotalaria* sp. (Fabaceae), Rio Janeiro. The telia were found on a part of the original collection, made by E. Ule at Copacabana, on the bay of Rio de Janeiro, Brazil, in August, 1897. They are subepidermal, inconspicuous, lenticular, about 4 or 5 spores deep, the spores compact, angular, about 10–15 μ in diameter, the wall 1.5 μ thick, cinnamon-brown. The uredinia have imbricated paraphyses and urediniospores very similar in size and form to those of *Phakopsora Vignae*.

Phakopsora Aeschynomenis (Arth.) comb. nov. (*Uredo Aeschynomenis* Arth.), on *Aeschynomene* spp. (Fabaceae), Mexico, West Indies and South America. The teliospores are not yet known.

Telia erect, verruciform, not much longer than broad, erumpent, somewhat waxy, becoming pulverulent at the surface, the teliospores one-celled, catenulate with few spores in a chain, the terminal spores readily separating upon germination; uredinia as in the preceding..... CEROTELIUM

CEROTELIUM CANAVALIAE Arth. (type of *Cerotelium*), on *Canavalia ensiformis* and *C. gladiata* (Fabaceae), Porto Rico.

Cerotelium Fici (Cast.) comb. nov. (*Uredo Fici* Cast., *Uredo ficina* Juel, *Physopella Fici* Arth., *Kuehneola Fici* Butl.), on *Ficus* spp., *Toxylon pomiferum*, *Broussonetia papyrifera*, *Morus indica* (Artocarpaceae), in all tropical regions, chiefly as uredinia.

Cerotelium Vitis (Butl.) comb. nov. (*Chrysomyxa Vitis* Butl., *Kuehneola Vitis* Syd.), on *Ampelocissus latifolia* (Vitaceae), India.

Cerotelium Gossypii (Lagerh.) comb. nov. (*Uredo Gossypii* Lagerh., *Kuehneola Gossypii* Arth.), on *Gossypium* spp. (Malvaceae), tropical Asia and America.

Cerotelium peregrinum (Syd. & Butl.) comb. nov. (*Kuehneola peregrina* Syd. & Butl.), on *Clerodendron* sp. (Verbenaceae), India.

Cerotelium Lanneae (Höhn.) comb. nov. (*Uredo Lanneae* Höhn., *Kuehneola Butleri* Syd.), on *Odina Wodier* (Anacardiaceae), India and Java.

Cerotelium Spondiadis (Petch) comb. nov. (*Uredo Spondiadis* Petch, *Kuehneola aliena* Syd. & Butl.), on *Spondias mangifera* (Anacardiaceae), India.

Cerotelium Eviae (Rac.) comb. nov. (*Dietelia Eviae* Rac.), on *Spondias* (*Evia*) spp. (Anacardiaceae), Java. It is possible that this and the preceding species, *C. Spondiadis*, may be identical.

Telia erect, filiform, erumpent, waxy, becoming corneous, the teliospores one-celled, in long, indistinguishable chains, not separating upon germination; uredinia as in the preceding..... CRONARTIUM

CRONARTIUM FLACCIDUM (A. & S.) Wint. (type of *Cronartium*), on *Asclepias* spp., etc. (Asclepiadaceae, etc.), Europe and Japan.

CRONARTIUM BYRSONIMATIS P. Henn., on *Brysonima coccolobifolia* (Malpighiaceae), South America, a species with uredinia having imbricated paraphyses.

CRONARTIUM ZIZYPHI (Pat.) Syd. & Butl., on *Zizyphus* sp. (Rhamnaceae), India, a species with uredinia having imbricated paraphyses.

Telia erumpent, velvety, the teliospores one-celled, catenulate with many spores in spreading, free chains; uredinia apparently as in the preceding, but the paraphyses hyphoid, inconspicuous, or none; pycnia accompanying primary uredinia. KUEHNEOLA

KUEHNEOLA URÉDINIS (Link) Arth. (type of *Kuehneola*), on *Rubus* spp. (Rosaceae), North America, Europe, and Southern Africa.

KUEHNEOLA ANDICOLA (Diet. & Neg.) Diet., on *Rubus geoides* (Rosaceae), South America.

KUEHNEOLA JAPONICA Diet., on *Rosa* spp. (Rosaceae), Japan.