

THE GENUS CYSTOPUS IN SOUTH AFRICA.

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A CLEAR account of the history of this genus, and the reasons for adopting the name *Cystopus* rather than *Albugo*, was given by Ramsbottom in the *Journal of Botany*, No. 54, 1916, p. 77. The chief points may be briefly recapitulated here.

The first species of the genus to be described was the so-called "white rust" of cruciferous plants, which was named *Aecidium candidum* by Persoon (1791). Later (1795), Persoon proposed the genus *Uredo* to include this species and two others. In his "Synopsis Methodica Fungorum" (1801) the genus *Uredo* is divided into four sections, the third of which is *Albugo*, characterized by having white spores, and including *Uredo candida* (with forms α *U. Thlaspeos*, β *U. Tragopogi*, γ *U. Alyssi*) and *U. Cheiranthi*.

In "Fries Systema Mycologicum," from which, according to the International Rules of Nomenclature, the nomenclature of the Phycomycetes starts, none of the species included in Persoon's section *Albugo* is mentioned. The next important date is 1847, when L  veill   founded the genus *Cystopus*, to include *Uredo candida* Pers., *U. cubica* Mart., *U. Portulacae* DC., *U. Bliti* Bivon, *U. floriformis* M  rat, etc., though no combinations were made. De Bary in 1860 confirmed the statement made earlier by Pr  vost that the spores on germination in water give rise to zoospores, and pointed out the true affinities of the genus. Three years later he discovered the sexual organs, and gave a full account of the life-history. Specimens showing oospores, accompanied by a descriptive label, were distributed by De Bary in Rabenhorst's "Fungi Europaei Exsiccata, ed. ii, ser. ii, Cent. 5, 1862.

From this it is clear that the generic name *Cystopus* is the correct one to use, according to the International Rules, and Kuntze's revival of Persoon's sectional name *Albugo* in 1891 was contrary to those rules.

The greater difficulty, as Ramsbottom pointed out, occurs in the nomenclature of the species; for if *Cystopus* L  v., 1847, is taken as the starting point, it would necessitate the changing of several well-known and universally used names. On the other hand, this difficulty is obviated by agreeing to start from De Bary, and in accordance with the ruling that the first name given to the "perfect" stage (the sexual organs being regarded as the perfect stage in the *Phycomycetes*) is valid, it is in fact correct to do so. *Cystopus* de Bary is, therefore, the valid name for the complete fungus, including the oosporic stage, while *Cystopus* L  v. is invalid as having been applied to the conidial stage only. The nomenclature of both genus and species starts with De Bary.

The genus is represented in South Africa by eight species, of which five are practically cosmopolitan, while three are so far known only from South Africa.

The type species is *C. candidus*, the well-known "white rust" of Cruciferous plants. Morphologically no constant distinction can be found between the forms which occur on various genera of the order *Cruciferae*, but recent work has tended to show that there probably exist "biological species" or races, as in the case of the true Rusts. The form occurring on *Heliophila* in South Africa was distinguished by P. Hennings as *C. candidus* f. *Heliophilae* on the ground that its conidia were slightly larger than in the type form. Measurements taken from numerous specimens, both European and South African, have shown, however, that the distinction does not hold, the limits of variation being practically the same in all.

Nothing is known as to the existence of biological forms in the other species of *Cystopus*, but there is sometimes, as in the case of *C. cubicus*, a difference on various hosts in regard to the readiness with which oospores are formed.

Morphological distinction between the species rests mainly on the characters of the oospores, and in a lesser degree on conidial characters. Not all the South African material has yielded oospores, but where the conidia correspond to those occurring on the same host in Europe it is assumed that the oospores will also be similar.

Descriptions of the species occurring in South Africa are given below. These have been compiled actually from South African specimens, with the addition of known oospore characters when these have not been found in the South African material. In all cases the details have been taken from dried specimens, the spores being examined by mounting either in lactic acid or in water to which has been added a little dilute potassium hydrate solution. The numbers in brackets following the specimens cited are those of the Mycological Section of the National Herbarium.

CYSTOPUS de Bary, "Ann. Sci. Nat." Sér. 4, t. xx, 1863, p. 31 (and 129).

Mycelium parasitic, endophytic, branched, provided with vesicular haustoria. *Sori* sub-epidermal, at length exposed through rupture of the epidermis. *Conidiophores* simple, cylindrical or clavate, crowded. *Conidia* borne in chains, globose or somewhat rectangular, smooth, hyaline or with light yellowish contents, germinating to produce zoospores. *Sexual organs*, oogonia and antheridia, formed on mycelial branches within the host tissues. *Oospores* globose, epispore usually deeply coloured, and with tuberculate or reticulate thickening. Germination by means of zoospores.

Type species: *Cystopus candidus* de Bary.

KEY TO THE SOUTH AFRICAN SPECIES OF *CYSTOPUS*.

I. Aequales.—Conidial wall thin, equally thick throughout.

- (a) Conidia all alike; oospore wall with thickenings in the form of flattened warts or short ridges..... *C. candidus*.
- (b) Terminal conidia larger and thicker-walled than the others :
 - (a) Oospore wall reticulate, with warts in centre of meshes *C. Portulacae*.
 - (β) Oospore wall finely warted..... *C. austro-africanus*.

II. Annulati.—Conidial wall with a more or less distinct internal ring-like thickening at the equator; terminal conidia always distinct from the rest, and sterile:

- (i) Oospores known :
 - (a) Oospore wall reticulate, the angles of the network produced into more or less distinct warts (on *Compositae*)..... *C. cubicus*.
 - (b) Oospore wall papillate or with irregular ridges (on *Convolvulaceae*)..... *C. Ipomoeae-panduranae*.
 - (c) Oospore wall coarsely reticulate..... *C. Bliti*.
- (ii) Oospores not known :
 - (a) On *Hypoestes verticillata*. Conidia distinctly "cuboid" *C. quadratus*.
 - (b) On *Nemesia* sp. Conidia only slightly "cuboid".... *C. Evansii*.

Cystopus candidus de Bary in "Ann. Sci. Nat.," Sér. 4, xx, 1863, p. 31 and 130.

Syn. *Aecidium candidum* Pers. in Gmel. Syst. Nat. 2, 1791, p. 1473.

Uredo candida Pers. Syn. Fung. 1801, p. 223.

Cystopus candidus Lév., Ann. Sci. Nat. Sér. 3, viii, 1847, p. 371.

Albugo candida Kuntze, Rev. Gen. Plant. 2, 1891, p. 658.

Sori developed on all above-ground parts of the host plant, whitish, variable in size, often producing distortion or gall-like swellings. *Conidiophores* hyaline, clavate, $28-40 \times 12-15$ (-18) μ . *Conidia* all alike, hyaline, globose or sub-globose, with uniformly thin walls, $12-20$ (-22) μ in diameter, average $15-18$ μ . *Oospores* developed usually in the tissue of stems and fruits, rarely in the leaves, globose, dark brown, $40-55$ μ ; epispore ornamented with coarse flattened warts or low ridges, which are often irregularly branched.

The form on *Heliophila*, which was named forma *Heliophilae* by Hennings, does not differ from that on other hosts. Its sole distinction was said to be in the larger conidia, but conidia up to 20 μ occur quite frequently on all the hosts examined. Immature oospores are present in the type material of forma *Heliophilae* Henn.

On *Cruciferae* :—

Brassica napus : Brooklyn, Pretoria, A. M. Bottomley, April, 1925 (20400).

Brassica nigra Koch : Equefa, Zululand, C. Fuller, 24.4.11 (1537).

Brassica sp. : Natal, J. Medley Wood (10453).

Brassica sp. : Port Elizabeth, E. M. Doidge, 23.3.11 (1232).

Cardamine capensis L. : Somerset East, MacOwan, (*Thuemen*, *Myc. Univ.* 1314, in *Herb. Kew*, and MacOwan, *Austro-africanae* 1199, *Herb. Kew*).

Cardamine africana Th. : Boschberg, 1287 ex *Herb. Kalchbrenner* (*Herb. Kew*).

Cochlearia Armoracia L. : Constantia, Cape Province, C. P. Lounsbury, 27.8.09 (718); Capetown, C. W. Mally, 20.12.18 (11822).

Heliophila sp. : Capetown, C. P. Lounsbury, 23.9.06 (192).

Heliophila Meyeri Ld. : Van Rhynsdorp, 600 ft., Schlechter, July, 1896 (*Herb. Kew*, co-type of forma *Heliophilae* Henn).

Sisymbrium garipepinum Burch. : Bloemfontein, O.F.S., Professor Potts, Dec., 1915 (9756).

Cystopus Portulacae de Bary in "Ann. Sci. Nat.," Sér. 4, xx, 1863, p. 31 and 131

Syn. *Uredo Portulacae* DC., "Fl. France," vi, 1815, p. 88.

Cystopus Portulacae Lév., "Ann. Sci. Nat.," Sér. 3, viii, 1847, p. 371.

Albugo Portulacae Kuntze, "Rev. Gen.," Pl. 2, 1891, p. 658.

Sori developed on all above ground parts of host, whitish to yellowish, rounded or irregular, up to 5 mm. in diameter. *Conidiophores* clavate, hyaline, $40-50$ (-75) \times $14-15$ μ . *Conidia* of two kinds; terminal conidia sub-globose, yellowish, $13-15 \times 15-20$ μ , rather thick-walled, with a basal invagination of the wall which gives the appearance of a thick inner peg in lateral view, or a central ring when seen from above. *Oospores* occurring in stems and leaves, globose, dark brown when mature, up to 70 μ in diameter; epispore reticulate, with meshes $8-12$ μ in diameter, and usually a papilla or short ridge in the centre of each mesh.

On *Portulaca oleracea* :—

Skinner's Court, Pretoria District, 22.12.05 (101).

Pretoria, J. Burt-Davy, 8.1.04 (148); 21.1.05 (157).

Lyttelton Junction, Pretoria District, 30.4.11, Miss J. Erasmus (1515). [Shows oospores.]

Garstfontein, Pretoria District, P. J. Pienaar, 15.2.12 (2145).

Somerset East, 1877, MacOwan 1303, ex *Herb. Kalchbrenner* (*Herb. Kew*).

Somerset East, MacOwan, in Rabenhorst, Winter Fungi Europaei 3775, and in Thuemen, *Myc. Univ.* 252b (*Herb. Kew*). [Thuemen's specimen with oospores.]

Cystopus austro-africanus (Syd.) Wakef. comb. nov.

Syn. *Albugo austro-africana* Syd. in *Ann. Myc.* x, 1912, p. 437.

Sori amphigenous, rounded or elliptical, yellowish, $\frac{1}{2}$ –1 mm. in diameter. *Conidiophores* clavate, hyaline, $35-50 \times 16-18$ (-20) μ . *Conidia* of two kinds; terminal conidia globose

or sub-globose, thick-walled ($2\ \mu$), yellowish, $18-25\ \mu$ in diameter, probably sterile; fertile conidia hyaline, thin-walled, globose or sub-globose, $14-20\ \mu$ in diameter. *Oospores* developed in tissue of leaf, globose, chestnut-brown, about $50\ \mu$ in diameter, epispore with densely crowded minute papillae.

On leaves of *Aizoon rigidum*: Port Elizabeth, E. M. Doidge, 22.3.11 (1234). Co-type material examined.

Cystopus cubicus de Bary in "Ann. Sci. Nat.," Sér. 4, xx, 1863, p. 32 and 132.

Syn. *Uredo cubica* v. Strauss, Ann. Wetterau Ges. f. naturk. II, 1810, p. 86.

Uredo Tragopogi DC., Fl. Fr. II, 1805, p. 237.

Cystopus cubicus Lév. Ann. Sci. Nat., Sér. 3, viii, 1847, p. 371.

Cystopus Tragopogonis Schroet, Krypt. Fl. Schles III, 1, 1886, p. 234.

Albugo Tragopogonis S. F. Gray, Nat. Arr. Brit., Pl. 1, 1821, p. 540.

Cystopus spinulosus de Bary in Rabenh. Fung. Eur. No. 479, 1862.

Sori forming prominent blisters on leaves or stems, whitish or yellowish, rounded or elongate. *Conidiophores* hyaline, clavate, $50-80 \times 15-20\ \mu$. *Conidia* of two kinds; terminal conidia globose, hyaline or yellowish, evenly thick-walled, slightly larger than the others, sterile; fertile conidia shortly cylindrical, hyaline, $15-22$ (-25) $\times 15-18\ \mu$, membrane with a distinct internal equatorial thickening. *Oospores* occurring in stems or leaves, on some hosts freely, in others less so, dark-brown or almost black and opaque when mature, $44-75\ \mu$ in diameter, epispore finely reticulate with meshes $2-5\ \mu$ in diameter, and the network produced into more or less prominent tubercles at the angles.

On *Compositae*:—

Senecio angustifolia Willd, Pretoria, I. B. Pole Evans, Oct. 1919 (11325). Immature oospores present.

Senecio orbicularis Sond., Pretoria, Miss A. M. Bottomley, 26.5.16 (9744); Irene, Pretoria District, I. B. Pole Evans, Dec. 1924 (20365).

Scenecio inaequidens DC., Maritzburg, Natal, I. B. Pole Evans, 7.4.11 (1428); Mooi River, Natal, A. O. D. Mogg, 30.10.18 (12242). Oospores present in 12242.

Gerbera Jamesoni Bolus, Barberton, I. B. Pole Evans, 4.2.11 (1159); Pretoria, May, 1914, I. B. Pole Evans (7803); Johannesburg, A. Kelly, 17.3.17 (10020); Brooklyn, Pretoria, Mar., 1925, E. M. Doidge (20366).

Gerbera plantaginea, Harv., Garstfontein, Pretoria District, P. J. Pienaar, 20.12.11 (1986); Garstfontein, Miss J. Erasmus, 15.1.12 (2081).

The oospores present in Nos. 11325 and 12242 are of the medium type described by Magnus, with tubercles more distinct than in the common European form on *Scorzonera*, but not so prominent as in the form on *Cirsium* described by De Bary as *C. spinulosus*. In No. 12242 the oospores are sometimes larger than the measurements given for European and American forms of the species.

Cystopus Ipomoeae-panduranae (Schw.), Stev. and Swingle in "Trans. Kan. Acad. Sci.," II, 1889, p. 67.

Syn. *Albugo Ipomoeae-panduranae* (Schw.), Swing in Journ. Myc. 7, 1891, p. 112.

Cystopus Convolvulacearum Speg., Ann. Soc. Ci. Arg. 17, 1884, p. 128.

C. Convolvulacearum Otth. in Zalew. Bot. Cent. 15, 1883, p. 223.

Sori occurring on leaves or stems, whitish to pale-yellow, prominent and blister-like, on the leaves usually hypophyllous, and in small or large groups on discoloured areas. *Conidiophores* hyaline, clavate, $20-50 \times 15\ \mu$. *Conidia* all alike, cuboid, with equatorial thickening either slight or sometimes very marked, $15-20 \times 12-18\ \mu$. *Oospores* (not seen in South African material) borne on stems, causing distortion, yellowish-brown, $25-55\ \mu$; epispore papillate or with irregular curved ridges.

On *Convolvulaceae* :—

- Ipomoea cardiosepala*, Hochst, Inanda, Natal, J. M. Wood (*Herb. Kew*)
Ipomoea obscura, Tzaneen, Northern Transvaal, E. M. Doidge, 12.1.25 (20338).
Ipomoea ficifolia, Tzaneen, Northern Transvaal, E. M. Doidge, 11.1.25 (20319).
Ipomoea sp., Barberton, I. B. Pole Evans, 4.2.11 (No. 1160).

Cystopus Bliti de Bary in "Ann. Sci. Nat.," Sér 4, t. 20, 1863, p. 131.

Syn. *Uredo Bliti* Bivon., Stirp. Rar. Sicilia III, 1815, p. 11.

Cystopus Amaranthi Berk. in Grevillea 3, 1874, p. 58.

C. Amaranthacearum Zalew., Bot. Cent. 15, 1883, p. 223.

C. Cyathulae Wint. in Roum. Rev. Myc. 11, 1889, p. 66.

Albugo Bliti Kuntze., Rev. Gen., Pl. 2, 1891, p. 658.

Sori on leaves, whitish or yellowish, prominent, 1–2 mm. diameter or larger by becoming confluent, prominent. *Conidiophores* hyaline, more or less cylindrical, $30\text{--}50 \times 12\text{--}15 \mu$. *Conidia* of two kinds; the terminal sub-globose, slightly yellowish, with thick even walls, and slightly smaller than the others; fertile conidia elliptical or angularly obovate, sometimes truncate or umbilicate at the base, and with a strong internal equatorial thickening, $12\text{--}16 \times 15\text{--}19 \mu$. *Oospores* (not seen in South African specimens) produced in leaves of host, dark-brown, about 55μ diameter; epispore coarsely reticulate, with meshes $6\text{--}8 \mu$ diameter.

In the absence of oosporic material on *Amaranthus Blitum*, which would assist in settling the question, the author has followed G. W. Wilson (Bull. Torr. Bot. Club, XXXIV, 1907, p. 77) in regarding *C. Amaranthacearum* Zalew as a synonym of *C. Bliti*.

On *Amaranthaceae* :—

Achyranthes aspera, Garstfontein, Pretoria District, P. J. Pienaar, 19.2.11 (1205);

P. J. Pienaar, 26.3.11 (1310); E. M. Doidge, 11.4.11 (1477); Duivelskloof, Northern Transvaal, E. M. Doidge, 11.1.25 (20334).

Cyathula globulifera, Garstfontein, Pretoria District, P. J. Pienaar, 26.3.11 (1268).

Cyathula lappulacea, Somerset East, MacOwan, ex *Herb. Thuemen*. (*Herb. Kew*).

C. lappulacea, Somerset East, No. 1313, ex *Herb. Kalchbrenner* (*Kew*).

Cystopus quadratus Kalchbr. and Cooke in Grevillea ix, 1880, p. 22.

Syn. *Albugo quadrata* (K. and C.) Kuntze, Rev. Gen. Pl. 2, 1891, p. 658.

Sori hypophyllous, whitish, prominent and crowded, up to 1 mm. diameter. *Conidiophores* cylindrical or clavate, $40\text{--}60 \times 15 \mu$. *Conidia* in long chains of two kinds, the terminal sub-globose, thick-walled, yellowish, $16\text{--}20 \mu$ diameter; the rest cylindrical, with equatorial thickening, $18\text{--}22 \times 16\text{--}20 \mu$.

On *Hypoestes verticillata* (*Acanthaceae*) :—

Cape, MacOwan, No. 1314 (*Kew Herb.*—type); Garstfontein, Pretoria District, P. J. Pienaar, 8.4.11 (1425).

The conidia resemble closely those of *C. Bliti*, but are somewhat larger. No oospores are present either in the type or in the more recent specimen, and in their absence it is not possible to say whether the species is really distinct.

Cystopus Evansii (Syd.) Wakef. comb. nov.

Syn. *Albugo Evansii* Syd. in Ann. Myc. x, 1912, p. 437.

Sori developed on leaves or stems, rounded or oblong, white, $\frac{1}{2}\text{--}1\frac{1}{2}$ mm. in diameter. *Conidiophores* oblong-clavate, $35\text{--}45 \times 14\text{--}17 \mu$, hyaline. *Conidia* of two kinds; terminal conidia sub-globose or globose, evenly thick-walled ($1\text{--}2 \mu$), about 18μ in diameter, probably sterile; fertile conidia sub-globose or somewhat cylindrical, hyaline, with equatorially thickened membrane, $16\text{--}28 \times 13\text{--}20 \mu$. *Oospores* not seen.

On leaves and stems of *Nemesia* sp.: Hoogfontein, Ladybrand District, Orange Free State, C. P. van der Merwe, 17.2.11 (1472). Co-type material examined.