Choanephora cucurbitarum, (B. and Rav.) Thaxter, on Chillies (*Capsicum* spp.).

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With Plate XIX.

IN 1917 considerable damage was for the first time observed in chilli plants at Pusa and other chilli-growing tracts, north of the Ganges (India), by a new disease, caused by a species of *Choanephora*. In previous years it had not been found to be parasitic on this host, though it had been seen on fading flowers and dead twigs. In 1917 conditions of high humidity were generally prevalent in the last week of September and in the first week of October, when the plants had commenced to flower, and these conditions are believed to be correlated with the epidemic caused by this facultative parasite. It was first found on a few plants on September 30th, and was present in the fields till about the end of November. It was most virulent in about the second week of October. In 1918 careful search was made for this disease in Pusa and in the neighbouring villages, but not a single case was found. This may be due to the abnormally dry weather conditions prevalent in September and October.

The general appearance of the infected crop in the early stage of attack is not much unlike another disease, which does great damage in Behar, and which is caused by *Vermicularia capsici*, Syd., an account of which will be published later. There is the same drooping of the topmost tender parts of the plants and the dying back of the branches. But on a closer examination the effects of the *Choanephora* disease are very characteristic. The diseased parts show a distinct wet rot and are soon covered by a luxuriant crop of shining silvery conidiophores, without any trace of external vegetative mycelium. Unlike *Vermicularia capsici*, *Choanephora* attacks the leaves as well as stems; it does not produce on the infected stem the chalk-white areas, delimited by a black border, so characteristic of *V. capsici*.

The first evidence of the attack is generally when the flowers have opened; the infection starts from the flowers, as a rule, and sometimes also through the flower-buds. The flower first turns brown and then black, and

begins to rot. The rot then rapidly extends downwards, attacking buds and tender leaves. The affected tender parts of the stem hang limply. As the disease travels downwards the whole plant, in a severe case of attack, may be killed. The infected part of the stem shows a very marked wet green colour, and the bark easily peels off in shreds.

CHARACTERS OF THE FUNGUS.

Conidial stage. The conidiophores are erect and project at right angles to the epidermis. They are up to 5 mm. in length. They are whitish at first, but have a silvery metallic lustre when they are mature. They end in a capitate vesicle from which a few more ramuli arise, which in turn become vesicular (Fig. 1). These secondary conidiophores remain unbranched. From the capitella arise dense, black clusters of conidia, each seated on a short sterigma. Conidia are elliptical to oval in shape, finely striated, and light brown in colour (Fig. 2). The base of each conidium is provided with a hyaline appendage. The conidia measure $13.2-24 \times 8.8-13.2 \mu$.

The conidia germinate readily in water. Before germinating they increase considerably in size and become slightly lighter in colour. As a rule, a single lateral germ-tube is developed.

Sporangial stage. On the host in nature the conidial stage only is found, but the other stages, viz. sporangial, chlamydospore, and zygospore, have been developed in cultures. In fact, except the conidial stage, no other stage in the life-history of this genus has as yet been observed on the host plant under natural conditions. Cunningham¹ found that the sporangia of *C. infundibulifera*, (Curr.) Cunn., developed only when the fungus was cultivated under unfavourable conditions; Thaxter² failed to get the sporangia of *C. Americana*, which is the same as *C. cucurbitarum*, (B. and Rav.) Thaxter; but Wolf³ succeeded in inducing them to form in cultures. The sporangia of the chilli *Choanephora* have been developed not necessarily under unfavourable conditions of nutrition. They are formed in cultures always along with the conidia, though Wolf has found the sporangia of *C. cucurbitarum* apart from the conidia. Sporangia cease to develop when the fungus is grown for a long time in cultures. Like *C. infundibulifera*, the fungus also loses after a time its vigour of growth in artificial media.

Mature sporangia are evident as pendulous, large, black, globular bodies, but when young they are white in colour. They have big round columella (Fig. 5). The sporangial wall is smooth and colourless, the black

¹ Cunningham, D. D.: On the Occurrence of Fructification in the Mucorini, illustrated by *Choanephora*. Trans. Linn. Soc., London, Ser. 2, Bot. i, 1879, p. 417.

² Thaxter, R.: A New English *Choanephora*. Rhodora, v, No. 52, 1903, p. 101.

³ Wolf, A.: A Squash Disease caused by *Choanephora cucurbitarum*. Journ. Agr. Res., viii, No. 9, 1917, p. 323.

colour of the sporangia is due to the enclosed mass of brown spores. The sporangia vary a great deal in diameter, but usually they measure between 47.6 and 170 μ . The spores are of the same colour as the conidia, and they are of about the same size (16.5–24 $\times$ 7.7–11 μ), but the epispore is thicker and not striated. The spores have no hyaline appendage at the base, but they have a cluster of fine cilia at both ends (Fig. 6). They are equilateral, rarely three-cornered.

The spores germinate in the same way as do the conidia.

Chlamydospores. In cultures the hyphae at times develop intercalary vesicles. The vesicular walls either remain unthickened or, as in true chlamydospores, become thickened. The chlamydospores are highly vacuolar. Germinating spores also develop chlamydospores (Fig. 4).

Zygospores. The development of the sexual fructification of certain algae and aquatic fungi depends, according to Klebs,¹ primarily upon factors of nutrition and environment. Kauffmann² has found that the formation of oospores of some *Saprolegnia* can be influenced by definite chemical and physical conditions which can be readily controlled. Shear and Wood³ believe that the perithecial-forming faculty in the numerous cases of *Glomerella*, studied by them, is evidently a fairly well fixed hereditary racial character, because if once a race or strain which produces perithecia in culture media is obtained other generations grown from this race or strain continues to produce perithecia indefinitely. Pethybridge and Murphy⁴ have found the same racial hereditary character in the formation of the oospores of *Phytophthora infestans*; but in *Phytophthora parasitica* the author⁵ has found that the oospore-producing faculty is an hereditary racial character only if each generation of the oospore-forming strain is grown on a medium different from the one on which the immediate parent was cultivated. But the formation of zygospores of the chilli *Choanephora* does not depend on the development of a strain which would in subsequent subcultures continue to give the sexual spores, nor upon other conditions mentioned above, but, curiously enough, the zygospores of this *Choanephora* are developed in cultures only when the mycelium arises from conidia taken directly from the host plant and not from the fungus growing on nutrient medium. This peculiarity in the production of zygospores has been observed by Wolf. The development of the sexual spores (Figs. 7–9) is similar to that of *C. infundibulifera* and *C. cucurbitarum*. The zyo-

¹ Klebs, G.: Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen, 1896.

² Kauffmann, C. H.: A Contribution to the Physiology of the Saprolegniaceae, with Special Reference to the Variations of the Sexual Organs. Ann. Bot., xxii, 1908, p. 377.

³ Shear, C. L., and Wood, A. K.: Studies of Fungous Parasites belonging to the Genus *Glomerella*. U.S. Dept. of Agric., Bur. of Pl. Industry, Bul. No. 252, 1913, p. 72.

⁴ Pethybridge, G. H., and Murphy, P. A.: On Pure Cultures of *Ph. infestans*, de Bary, and the Development of Oospores. Proc. Roy. Dub. Soc., xiii (N.S.), No. 36, 1913, p. 581.

⁵ Dastur, J. F.: On *Phytophthora parasitica*, nov. spec. Mem. Dept. of Agr. India, Bot. Ser., v, No. 4, 1913, p. 204.

spores are more or less globular, with a thick, smooth, and brown episporium. They measure 56–88 μ .

Three species of *Choanephora* have so far been known to be parasitic. Of these *C. Simsoni*, Cunningham,¹ on *Ipomoea rubro-coerulea* and *C. infundibulifera*, (Curr.) Cunningham,² on *Hibiscus* spp. and *Zinnia* spp. (synonymous with *C. Cunninghamiana*, Curr.), are Indian species, while *C. cucurbitarum*, (B. and Rav.) Thaxter,³ which is the same as *C. Americana*, on *Cucurbita* spp., is American. The *Choanephora* under study is distinct from its Indian allies. Not only in the smaller measurements of the sexual and asexual fructifications does *C. infundibulifera* disagree with the chilli fungus, but there is another very characteristic difference. In the *Choanephora* on *Zinnia* the persistent portion of the capitella after the ripe conidia have become detached appear as a series of pedicellate funnels, from which the specific name, *infundibulifera*, is derived. This characteristic is wanting in the chilli fungus. Again, the sporangial wall of the former is conspicuously tuberculated, while that of the latter is smooth. *C. Simsoni* has smaller spores, conidia, and zygospores, but the most important difference is that its capitella are abruptly truncate, while those of the species here dealt with are dilated and globular.

The *Choanephora* on chilli, however, resembles very closely the American species, *C. cucurbitarum* on *Cucurbita* spp. These two forms not only agree in their various spore measurements except those of the sporangiophores—the Cucurbit *Choanephora* having slightly bigger sporangiospores (18–30 $\times$ 10–15 μ)—but also in other characteristics. The capitella of both are rounded, the conidia have hyaline appendages at the base (these appendages are absent in the two Indian species), both have the same peculiarity in the development of the sexual spores, viz. that they are formed in cultures only when the conidia for making these cultures are taken direct from the host plant.

For these reasons the chilli parasite has been identified as *C. cucurbitarum*, (B. and Rav.) Thaxter.

SUMMARY.

A new disease of chillies caused by *C. cucurbitarum*, (B. and Rav.) Thaxter, is described.

It produces a wet rot and drooping of the infected tender parts and a dying back of the branches.

¹ Cunningham, D. D.: A New and Parasitic Species of *Choanephora*. Ann. Bot. Gard., Calcutta, India, 1895, p. 169.

² Ibid.: On the Occurrence of Conidial Fructification in the Mucorini, illustrated by *Choanephora*. Trans. Linn. Soc., Ser. 2, Bot. i, 1879, pp. 409–22.

³ Thaxter, R.: loc. cit., p. 102.

The infection as a rule starts from the flowers, but sometimes also from the flower-buds.

Only conidia are developed in nature on the host, but sporangia, chlamydospores, and zygospores have been observed in cultures. The conidia bear a hyaline appendage at the base.

The sporangiospores have a cluster of appendages ('cilia') at each end. They are almost of the same size as the conidia.

The zygospores are developed in cultures only when the mycelium arises from conidia taken directly from the host plant.

EXPLANATION OF PLATE XIX.

Illustrating Mr. Dastur's Paper on *Choanephora cucurbitarum*.

- Fig. 1. Conidial head with primary and secondary columella. $\times 490$.
Fig. 2. Conidia. $\times 710$.
Fig. 3. Surface view of a secondary columella bearing conidia. $\times 490$.
Fig. 4. Germinating conidia. $\times 490$.
Fig. 5. Sporangiphores with columella and remnants of the sporangial wall. $\times 490$.
Fig. 6. Sporangiospores. $\times 710$.
Fig. 7. Mature zygospore. $\times 490$.
Fig. 8. Immature zygospore. $\times 490$.
Fig. 9. An early stage in the development of the zygospore. $\times 490$.

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